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TREATABILITY MANUAL

VOLUME II. Industrial Descriptions

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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PREFACE

In January, 1979, EPA's Office of Enforcement and Office of Water and Waste Management requested help from the Office of Research and Development in compiling wastwater treatment performance data into a "Treatability Manual". This Manual was to be used in developing NPDES permit limitations for facilities which, at the time of permit issuance, were not fully covered by promulgated, industry-specific effluent guidelines authorized under Sections 301, 304, 306, 307, and 501 of the CWA.

A planning group was set up to manage the treatability program under the chairmanship of William Cawley, Deputy Director, Industrial Environmental Research Laboratory - Cincinnati. The group includes participants from: 1) the Industrial Environmental Research Laboratory - Cincinnati, 2) Effluent Guidelines Division, Office of Water and Waste Management; 3) Permits Division, Office of Enforcement; 4) Municipal Environmental Research Laboratory - Cincinnati; 5) R. S. Kerr, Environmental Research Laboratory - Ada; 6) Industrial Environmental Research Laboratory - Research Triangle Park; 7) Monsanto Research Corporation; and 8) Aerospace Corporation.

The objectives of the treatability program are:

- To provide readily accessible data and information on treatability of industrial and municipal waste streams for use by NPDES permit writers, enforcement personnel, and by industrial or municipal permit holders;
- To provide a basis for research planning by identifying gaps in knowledge of the treatability of certain pollutants and wastestreams;
- To set up a system allowing rapid response to program office requirements for generation of treatability data.

The primary output from this program is a five-volume Treatability Manual. The individual volumes are named as follows:

Volume I - Treatability Data
Volume II - Industrial Descriptions
Volume III - Technologies
Volume IV - Cost Estimating
Volume V - Summary

6/23/80

ACKNOWLEDGEMENT

The sheer size and comprehensiveness of this document should make it obvious that this had to be the effort of a large number of people. It is the collection of contributions from throughout the Environmental Protection Agency, particularly from the Office of Enforcement, Office of Water and Hazardous Materials and the Office of Research and Development. Equally important to its success were the efforts of the employees of the Aerospace Corporation, MATHTECH, INC., and the Monsanto Research Corporation who participated in this operation.

No list of the names of everyone who took part in the effort would in any way adequately acknowledge the effort which those involved in preparing this Manual made toward its development. Equally difficult would be an attempt to name the people who have made the most significant contributions both because there have been too many and because it would be impossible to adequately define the term "significant." This document exists because of major contributions by the contractor's staff and by members of the following:

Effluent Guidelines Division
Office of Water and Waste Management

Permits Division
Office of Water Enforcement

National Enforcement Investigation Center
Office of Enforcement

Center for Environmental Research Information

Municipal Environmental Research Laboratory

Robert S. Kerr Environmental Research Laboratory

Industrial Environmental Research Laboratory
Research Triangle Park, NC

Industrial Environmental Research Laboratory
Cincinnati, OH
Office of Research and Development

The purpose of this acknowledgement is to express my thanks as Committee Chairman and the thanks of the Agency to the Committee Members and others who contributed to the success of this effort.

William A. Cawley, Deputy Director, IERL-Ci
Chairman, Treatability Coordination Committee

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GLOSSARY

AAP: Army Ammunitions Plant.

AN: Ammonium Nitrate.

ANFO: Ammonium Nitrate/Fuel Oil.

BATEA: Best Available Technology Economically Achievable.

BAT: Best Applicable Technology.

BDL: Below Detection Limit.

BEJ: Best Engineering Judgement.

BOD: Biochemical Oxygen Demand.

clarification: Process by which a suspension is clarified to give a "clear" supernatant.

cryolite: A mineral consisting of sodium-aluminum fluoride.

CWA: Clean Water Act.

cyanidation process: Gold and/or silver are extracted from finely crushed ores, concentrates, tailings, and low-grade mine-run rock in dilute, weakly alkaline solutions of potassium or sodium cyanide.

comminutor: Mechanical devices that cut up material normally removed in the screening process.

effluent: A waste product discharged from a process.

EGD: Effluent Guidelines Division.

elutriation: The process of washing and separating suspended particles by decantation.

extraction: The process of separating the active constituents of drugs by suitable methods.

fermentation: A chemical change of organic matter brought about by the action of an enzyme or ferment.

flocculation: The coalescence of a finely-divided precipitate.

fumigant: A gaseous or readily volatilizable chemical used as a disinfectant or pesticide.

GAC: Granular Activated Carbon.

gravity concentration: A process which uses the differences in density to separate ore minerals from gangue.

gravity separation/settling: A process which removes suspended solids by natural gravitational forces.

grit removal: Preliminary treatment that removes large objects, in order to prevent damage to subsequent treatment and process equipment.

influent: A process stream entering the treatment system.

intake: Water, such as tap or well water, that is used as makeup water in the process.

lagoon: A shallow artificial pond for the natural oxidation of sewage or ultimate drying of the sludge.

LAP: Loading Assembly and Packing operations.

MGD: Million Gallons per Day.

MHF: Multiple Hearth Furnace.

NA: Not Analyzed.

ND: Not Detected.

neutralization: The process of adjusting either an acidic or a basic wastestream to a pH near seven.

NPDES: National Pollutant Discharge Elimination System.

NRDC: National Resources Defense Council.

NSPS: New Source Performance Standards.

photolysis: Chemical decomposition or dissociation by the action of radiant energy.

PCB: PolyChlorinated Biphenyl.

POTW: Publicly Owned Treatment Works.

PSES: Pretreatment Standards for Existing Sources.

purged: Removed by a process of cleaning; take off or out.

screening process: A process used to remove coarse and/or gross solids from untreated wastewater before subsequent treatment.

SIC: Standard Industrial Classification.

SS: Suspended Solids.

SRT: Solids Retention Time.

starved air combustion: Used for the volumetric and organic reduction of sludge solids.

terpene: Any of a class of isomeric hydrocarbons.

thermal drying: Process in which the moisture in sludge is reduced by evaporation using hot air, without the solids being combusted.

TKN: Total Kjeldahl Nitrogen.

TOC: Total Organic Carbon.

trickling filter: Process in which wastes are sprayed through the air to absorb oxygen and allowed to trickle through a bed of rock or synthetic media coated with a slime of microbial growth to removed dissolved and collodial biodegradable organics.

TSS: Total Suspended Solids.

vacuum filtration: Process employed to dewater sludges so that a is produced having the physical handling characteristics and contents required for processing.

VSS: Volatile Suspended Solids.

WQC: Water Quality Criterion.

II.1 INTRODUCTION

Volume II of the Treatability Manual provides generic process descriptions for the industrial categories listed in Table 1-1. This table also presents those categories currently included and those categories with additional data added. The categories not currently included will be added as sufficient information becomes available.

The objective of this volume is to characterize the wastewaters discharged from the above categories on a facility by facility basis, prior to treatment and after treatment. The pollution control methods used with the treated final effluent pollutant concentrations are also provided.

Each industrial category is defined according to the Standard Industrial Classification (SIC) Codes of the U.S. Department of Commerce and by the general industrial descriptions found in current contractor draft development documents and published development documents on each industry. The categories are generally divided into subcategories which are described when sufficient data are available. The total number of facilities in each category discharging an aqueous effluent either directly to a receiving stream or indirectly to a publicly owned treatment works (POTW) is given in an industrial summary table.

Wastewater characteristics are provided for each category/subcategory when sufficient information is available. Subcategory wastewater characteristics are broken into separate processes when sufficient data are available. These descriptions include the complete pollutant analyses available in the references. These analyses generally consist of conventional pollutants, the 129 toxic pollutants, and other miscellaneous pollutants found in the wastewater. The data presented should be assumed screening quality unless specifically labeled verification quality.

Plant specific descriptions are also presented in this volume. These descriptions generally include a treatment system description, plant production, and wastewater flow. Conventional and toxic pollutant concentration data, as well as treatment system removal efficiency are presented in site-specific tables.

TABLE 1-1. INDUSTRY CATEGORIES FOUND IN VOLUME II

Section	Category	Included	Revised
II.2	Auto and Other Laundries	X	X
II.3	Coal Mining	X	X
II.4	Electroplating	X	
II.5	Inorganic Chemicals Manufacturing	X	X
II.6	Iron and Steel Manufacturing	X	X
II.7	Leather Tanning and Finishing	X	X
II.8	Machinery and Mechanical Products		
II.8.1	Aluminum Forming		
II.8.2	Battery Manufacturing		
II.8.3	Coil Coating	X	X
II.8.4	Copper Forming		
II.8.5	Electrical and Electronic Components		
II.8.6	Foundries	X	X
II.8.7	Mechanical Products		
II.8.8	Photographic Equipment and Supplies		
II.8.9	Plastics Processing		
II.8.10	Porcelain Enameling		
II.9	Miscellaneous	X	X
II.9.1	Adhesives and Selants		
II.9.2	Explosives Manufacture	X	X
II.9.3	Gum and Wood Chemicals	X	X
II.9.4	Pesticide Manufacturing		
II.9.5	Pharmaceutical Manufacturing	X	X
II.10	Nonferrous Metals Manufacturing	X	X
II.11	Ore Mining and Dressing	X	X
II.12	Organic Chemicals Manufacturing		
II.13	Paint and Ink Formulation	X	X
II.14	Petroleum Refining	X	X
II.15	Plastic and Synthetic Materials Manufacturing	X	
II.16	Pulp and Paperboard Mills and Converted Products	X	X
II.17	Rubber Processing	X	X
II.18	Soap and Detergent Manufacturing	X	
II.19	Steam Electric Power Plants	X	X
II.20	Textile Mills	X	X
II.21	Timber Products Processing	X	X
II.22	Publicly Owned Treatment Works (POTW)	X	X

Pollutant removability achievable by currently used treatment systems is presented in the final section of each category. Currently used treatment methods are described and the removal efficiencies are reported. Potential treatment technologies suggested in the reference documents are also presented. Complete wastewater treatment alternative descriptions are given in Volume III of this manual.

This volume is a general reference to be used in the decision making process for NPDES permit applications. It should be noted that no industrial description provided here takes into account every plant within that industry; rather this volume presents a general overview. Plant specific descriptions are not exemplary plants within an industry but have been selected based on the completeness of the available data. Treatment technologies presented may not be the only control methods currently in use.

References are located on the final page of each report. Data from these references are reported unchanged except reduced to reasonable significant figures. Average pollutant removability has often been calculated to provide a complete efficiency table. If it is necessary to review these documents contact IERL-Cincinnati which is retaining copies of each document.

II.2 AUTO AND OTHER LAUNDRIES

II.2.1 INDUSTRY DESCRIPTION [1, 2]

II.2.1.1 General Description

The Auto and Other Laundries Industry in the United States is a nonhomogeneous industrial group whose members are linked by the fact that they provide cleaning services for their clients. Some portions of the industry additionally provide the garments, rags, rugs, or other products they clean to their customers instead of cleaning customer-owned items. Because of this heterogeneity the industry is covered by the standard industrial classification (SIC) codes found in Table 2-1.

TABLE 2-1. SIC CATEGORIES OF THE LAUNDRY INDUSTRY [1, 2]

Category title	SIC code number	Approximate number of establishments
Power laundries, family and commercial	7211	3,100
Linen supply	7213	1,300
Diaper service	7214	300
Coin-operated laundries and dry cleaning	7215	32,000
Dry cleaning plants, except rug cleaning	7216	28,400
Carpet and upholstery cleaning	7217	2,700
Industrial laundries	7218	1,000
Laundry and garment services, not elsewhere classified	7219	2,700
Car wash establishments	7542	40,000

There are four basic process divisions in this industry: water wash (laundering), dry cleaning, dual-phase processing, and carpet-upholstery cleaning. Brief descriptions of these processes and the car wash variation of the water wash process are provided below.

Water Wash

In this portion of the industry, the primary cleaning is accomplished by a water wash. Soiled materials are first sorted according to the processing required. If necessary, stains which may set during washing must be removed. This can involve a simple cold water soak or the use of acids, bleaches, and/or multiple organic solvents. Once laundry is loaded into a machine it undergoes a series of cleaning steps. These steps vary according to the different types of desired final product and range from wetting, sudsing, and rinsing the fabric, to souring (reducing pH to about 5 to remove yellowing sodium bicarbonate), blueing, bleaching, and finishing.

Dry Cleaning

In this group of processes the primary cleaning is accomplished by an organic-based solvent rather than an aqueous-based detergent solution. There are three different processes in the dry cleaning industry. The first uses a controlled amount of water and detergent throughout the cleaning cycle, in addition to the solvent, to dissolve the water-soluble solids. The second is similar but adds detergent only at the beginning of the cycle. The third uses only solvent. This process requires prespotting to remove water-soluble spots.

Solvents are generally filtered and recovered for further use. Distillation purifies the solvent and removes odor-causing contaminants. Less expensive solvents are vented to the atmosphere in some cases.

Dual-Phase Processing

In dual-phase or dual-stage processing the water/detergent wash is preceded or followed by a separate solvent wash. This is used almost exclusively by industrial laundries to clean items that contain large amounts of both water-soluble soils and oil and grease, such as work shirts and wiping rags.

Carpet and Upholstery Cleaning

Carpet and upholstery cleaning may be done on location or in a plant. On-location cleaning is done by the powder, dry foam, rotary brush, or hot water extraction method. In all of these on-location methods, the carpet or upholstered item is vacuumed and prespotted to remove stains before any other cleaning is attempted.

These on-location methods are similar processes that involve working a medium into the soiled item, followed by vacuum extraction. They each use a different amount of water. The hot water extraction process differs in that hot detergent solution is injected and immediately wet vacuumed out.

In-plant carpet cleaning is done on a rug cleaning machine or on a special cleaning floor, depending on carpet size. The rug is mechanically beaten or vacuumed to remove loose soil, and stains are removed by prespotting with various solvents. This is followed by a prewash in which a detergent solution is worked into the pile. The carpet is then scrubbed, rinsed, and moved to a drying room.

In a few plants dry cleaning machines are used for very delicate and dye-sensitive rugs and tapestries. In these the only wastewaters are cooling water from the solvent distillation unit and the moisture removed from the carpet with the solvent.

Car Washes

Car washes are considered a variation of the water wash process. The variation comprises facilities designed for the automatic or self-service washing of vehicles. There are three main types of car washes: tunnels, rollovers, and wands. The tunnel wash, the largest of the three, is usually housed in a long building. The vehicle is pulled by conveyor or driven through the length of the building, passing through the separate washing, waxing, rinsing, and drying areas. A trench, usually running the length of the building, collects the wastewaters. Installation of a dam in the trench permits separation of rinse wastewaters, facilitating their treatment and reuse.

At a rollover wash, the vehicle remains stationary while the equipment passes over it. Similar in design are the exterior pressure washes which utilize high-pressure streams of water in lieu of brushes. At both types, all the wastewater is collected in a single trench, usually situated beneath the car.

The car also remains stationary at a wand wash, but here the customer washes his own car with a high-pressure stream of water from a hand-held wand. As at a rollover, both the wash and rinse waters are collected in a single trench or sump. Because many self-service washes are unmanned, the customer is able to wash both vehicles and other objects. These can include engines and undercarriages, motorcycles, farm equipment, animals; anything that can be brought into the bay. Furthermore, it is possible to change oil in the bay and to pour the used oil into the sump. The waste load at such a facility can therefore vary tremendously.

Since the laundry and dry cleaning industries are almost exclusively confined to the urban and suburban areas where their customers are located, more than 99% of all plants discharge to publicly owned treatment works (POTW's). Table 2-2 lists the number of subcategories and the type and number of dischargers found in the Auto and Other Laundries Industry.

TABLE 2-2. INDUSTRY SUMMARY [3]

Industry: Auto and Other Laundries
Total Number of Subcategories: 9
Number of Subcategories Studied: 8

Number of Dischargers in Industry:

- Direct: 350
- Indirect: 90,000
- Zero: 20,000

II.2.1.2 Subcategory Descriptions

The modern Auto and Other Laundries Industry is grouped into the following subcategories:

(1) Power Laundries, Family and Commercial
(2) Linen Supply
(3) Diaper Service
(4) Coin-Op Laundries and Dry Cleaning
(5) Dry Cleaning Plants Except Rug Cleaning
(6) Carpet and Upholstery Cleaning
(7) Industrial Laundries
(8) Car Washes
(9) Laundry and Garment Services, Not Elsewhere Classified

Seven of the nine subcategories have been submitted for exclusion under Paragraph 8 of the NRDC Consent Decree. These subcategories are Power Laundries, Diaper Service, Coin-Op Laundries and Dry Cleaning, Dry Cleaning Plants, Carpet and Upholstery Cleaning, Car Washes, and Laundry and Garment Services, not elsewhere classified.

II.2.1.2.1 Power Laundries, Family and Commercial [1]

Power laundries are defined as establishments primarily engaged in operating mechanical laundries with steam or other power. Excluded are laundries using small power equipment of the household type as well as establishments that have power laundries but are primarily engaged in specialty work such as diaper services, linen supplies, or industrial laundries.

Currently, 75% of power laundry receipts are from traditional family and bachelor-type work, but almost 18% is derived from dry cleaning.

II.2.1.2.2 Linen Supply [1]

Linen suppliers are defined as establishments engaged primarily in supplying, on a rental basis, laundered items such as bed linens, towels, table covers, napkins, aprons, and uniforms. These establishments may operate their own power laundry facilities or they may contract the actual laundering of the items they own.

Because linen supply laundries are more efficient in water, chemical, and energy usage than are on-premise laundries, sales in the linen supply business have been increasing at a moderate (14.6%) rate over the 1963-1974 period. One avenue of growth being tapped by the linen supply subcategory is the light-to-medium industrial laundry market. Currently, 80% of the dollar value of the work done fits in the linen supply category, while 12% of the work is of the type usually handled by industrial laundries.

This subcategory is being considered for possible exclusion under Paragraph 8 of the NRDC Consent Decree.

II.2.1.2.3 Diaper Service [1]

Diaper service establishments are those primarily engaged in supplying diapers (including disposables) and other baby linens to homes, usually on a rental basis. Diaper services may or may not operate their own power laundry facilities. There are approximately 300 such firms in the United States, which account for about 0.6% of total laundry receipts.

The diaper service industry has not diversified as have many of the other laundry categories. Traditionally, diaper services have rented diapers and other baby linens to household users. This role has remained essentially unchanged except that disposable diapers are now also supplied to customers. Approximately 95% of the receipts are derived from the traditional sources. The number of establishments and receipts for this industry have been declining due to the falling birth rate and the increasing popularity of disposable diapers.

This subcategory is being considered for possible exclusion under Paragraph 8 of the NRDC Consent Decree.

II.2.1.2.4 Coin-Operated Laundries and Dry Cleaning [1]

The coin-op category is made up of establishments primarily engaged in providing coin-operated laundry and/or dry cleaning equipment on their own premises. Included are establishments that install and operate coin-operated laundry machines in apartment houses, motels, etc.

In 1967 this subcategory encompassed 28% of all laundry establishments and accounted for almost 9% of total laundry revenues. Over the past decade coin-op receipts have increased by 10% per year, and it is expected that future growth will continue at a moderate rate.

This subcategory is being considered for possible exclusion under Paragraph 8 of the NRDC Consent Decree.

II.2.1.2.5 Dry Cleaning Plants Except Rug Cleaning [1]

Establishments belonging to this subcategory are those primarily engaged in dry cleaning or dyeing apparel and household fabrics, other than rugs, for the general public. There are about 28,000 such establishments, most of them relatively small. Dry cleaning plants accounted for 54% of all laundry establishments and about 41% of all laundry receipts in 1967.

The number of dry cleaning establishments and real receipts in this segment of the industry have both declined by 29% from 1963 to 1974. This is largely due to the new clothing fabrics developed over the past 20 years. Many of these fabrics do not require dry cleaning, or they shed soil more easily and hence require it less often than the old fabrics. Dry cleaners have diversified into related fields such as shirt cleaning and laundering in order to provide customers with one-stop cleaning services. Relatively recent developments are drapery, rug, and furniture cleaning and the sale and/or rental of working apparel.

This subcategory is being considered for possible exclusion under Paragraph 8 of the NRDC Consent Decree.

II.2.1.2.6 Carpet and Upholstery Cleaning [1]

Carpet and upholstery cleaners are defined as establishments primarily engaged in cleaning carpets and upholstered furniture at a plant or on a customer's premises. It is estimated that 25% of these businesses operate in-plant cleaning facilities. The number of in-plant operations has declined significantly over the last 10 years with a corresponding growth in the on-location type cleaners. This is a result of the increase in the use of wall-to-wall carpeting.

Firms in this category are not very diversified. Their basic services include carpet and rug cleaning, repairing, and dyeing, and upholstered furniture cleaning. Approximately 85% of the receipts are from these activities. A small number of these firms offer in-plant dry cleaning services for specialty items such as Orientals, Aubussons, Savonneries, and tapestries.

This subcategory is being considered for possible exclusion under Paragraph 8 of the NRDC Consent Decree.

II.2.1.2.7 Industrial Laundries [1]

Industrial laundries are establishments primarily engaged in supplying laundered or dry cleaned work uniforms; wiping towels; safety equipment (gloves, flame-resistant clothing, etc.); dust control items such as treated mats or rugs, mops, tool dust covers and cloths; and similar items to industrial or commercial users. These items may belong to the industrial launderers and be supplied to users on a rental basis, or they may be the customers' own goods. Establishments included in this SIC category may or may not operate their own laundry and dry cleaning services.

Most industrial launderers offer their customers a variety of textile maintenance services, but approximately 88% of the receipts are derived from the activities defined above. Although there is some overlap in the work done by industrial launderers and linen suppliers, industrial launderers can generally be distinguished because they rent personalized garments fitted and labeled for the individual, while linen suppliers provide rental garments by size.

II.2.1.2.8 Car Washes [1, 2]

Car wash trade associations have estimated that the total number of car washes is about 40,000. Approximately 40% of these are rollovers, 40% are wands, and 20% are tunnels. The industry continues to grow at a rate of 3% to 4% a year, although the different types are growing at different rates. The number of new tunnel facilities built each year is fairly constant. Rollovers are primarily found at service stations where oil companies have often used them as promotional devices. Sales are therefore dependent on such things as the availability of gas.

The largest increases in sales have been for the self-service wand-type car washes. The resurgence in sales is partly due to a general upgrading of merchandise and facilities. Furthermore, wand washes offer the best return for the least investment. The number of bays sold for a location is generally tuned to what the market requires, and the tendency is to begin with four bays.

This subcategory is listed for possible consideration for exclusion under Paragraph 8 of the NRDC Consent Decree.

II.2.1.2.9 Laundry and Garment Services Not Elsewhere Classified [1]

This subcategory, Laundry and Garment Services NEC, is defined as those establishments primarily engaged in furnishing other laundry services, including both repairing, altering, and storing clothes for individuals and the operation of hand laundries. Additional services provided by these firms include fur garment cleaning, repairing, and storage; glove mending; hosiery repair; pillow cleaning and renovating; and tailoring. There are approximately 2,700 establishments in this category, most of which are very small.

This subcategory is being considered for a Paragraph 8 exclusion. No data on discharges are available because this subcategory was not studied, and it will not be considered further.

II.2.1.3 Wastewater Flow Characterization [1, 2]

The volume of wastewater produced by plants in this industry range from 0.9 to 1,400 m^3/d (240 to 360,000 gpd). This excludes two subcategories: (1) Carpet and Upholstery Cleaning, for which figures are not available, and (2) Dry Cleaning, which uses a negligible amount of water (20 to 200 cm^3 [0.023 to 1.0 gal] of water per pound cleaned). Table 2-3 indicates water discharge rates of those subcategories for which data are available.

TABLE 2-3. PROCESS WASTEWATER DISCHARGE RATES, BY SUBCATEGORY

	m^3/kg (gal/lb)			m^3/day (gpd)		
Subcategory	Minimum[a]	Maximum[a]	Average	Minimum[a]	Maximum[a]	Average
Industrial laundries	0.008 (0.9)	0.080 (9.6)	0.038 (4.6)	32 (8,600)	1,100 (290,000)	260 (68,000)
Linen supplies	0.014 (1.7)	0.086 (10.3)	0.030 (3.6)	14 (3,600)	1,400 (360,000)	410 (110,000)
Power laundries	0.018 (2.2)	0.043 (5.1)	0.029 (3.5)	6.8 (1,800)	1,100 (290,000)	230 (61,000)
Diaper services	0.006 (0.7)	0.045 (5.4)	0.029 (3.4)	12 (3,100)	680 (180,000)	160 (41,000)
Coin-operated laundries	0.007 (0.8)	0.093 (11.2)	0.032 (3.8)	0.9 (240)	77 (20,000)	14 (3,600)
Car washes	(35)[b]	(80)[b]	(-)[b]	1.2 (300)	185 (48,000)	

[a]Minimum and maximum values apply only to the laundries surveyed and do not necessarily reflect absolute minima and maxima for the industry as a whole.

[b]Gallons per car ( ).

Note: Blanks indicate data not available.

II.2.2 WASTEWATER CHARACTERIZATION

The physical and chemical characteristics of laundry wastewaters are influenced by three primary factors: the general type of cleansing process employed (i.e., water versus solvent wash), the types and quantity of soil present on the textiles being laundered, and the composition of the various chemical additives used in the process. Water wash effluents contain all of the soil and lint removed from the textiles, as well as the laundry chemicals employed in the process. On the other hand, wastewaters from dry cleaning processes tend to contain water-soluble materials; lint, grit, and insoluble organic and inorganic compounds are largely removed by the solvent filter or confined to the still bottoms. However, dry cleaning effluents also contain appreciable quantities of solvent, which are not normally present in water-wash effluents.

Tables 2-4 and 2-5 present subcategory wastewater descriptions for conventional and toxic pollutants found in this industry.

II.2.2.1 Industrial Laundries

In comparison to domestic sewage, industrial laundry wastewaters typically contain high loadings of BOD_5, COD, TOC, suspended solids, and oil and grease. BOD_5 concentrations as low as 91 mg/L and as high as 7,800 mg/L were observed, which attests to the extreme variability in industrial laundry wastewater strength. The median TSS concentration in 69 wastewater effluents was 700 mg/L. Suspended solids loadings were also quite variable, however, ranging from 68 mg/L to 6,100 mg/L. Oil and grease concentrations ranged from 17 mg/L to 7,900 mg/L in 66 industrial laundry effluents, with a median value of 730 mg/L.

The high concentrations of oil and grease, suspended solids, and biodegradable organics in industrial laundry wastewaters are primarily attributable to the nature of the workload handled by industrial laundries. Heavily soiled uniforms, shop towels, and gloves used in the chemical and manufacturing industries often comprise a substantial portion of the business handled by these establishments. Pollutant loadings vary extremely from plant to plant because of differences in equipment and in customers served. This variability is at least partially attributable to the soil loading on the articles being water washed. The highest pollutant loadings are found in wastewaters from plants processing a high percentage of wiping towels used in print shops, machine shops, automotive repair shops, chemical plants, and other heavy industrial operations. Much lower pollutant concentrations are found in the wastewaters from plants handling a high percentage of uniforms and dust control items used in light manufacturing concerns.

Factors such as water usage per pound of material washed and the application of dual-phase or dry cleaning processes also affect the concentrations at which various pollutants are found in industrial laundry wastewaters. For example, oil, grease, and many other organic substances are more soluble in organic solvents than in water, and, thus, they are not present to a large extent

TABLE 2-4. WASTEWATER CHARACTERIZATION OF AUTO AND OTHER LAUNDRIES [1, 2]

Pollutant	Number analyzed	Maximum	Median	Mean	Number analyzed	Maximum	Median	Mean
	Industrial laundries				Linen laundries			
BOD_5, mg/L	51	7,800	920	1,300	50	1,500	610	620
COD, mg/L	60	7,000	3,800	5,000	26	4,000	1,500	1,600
TOC, mg/L	24	6,800	1,200	1,400	28	1,200	300	400
TSS, mg/L	69	6,100	700	1,000	59	1,200	360	400
Total phosphorus, mg/L	12	41.6	9.1	12.2	5	48.5	14.5	18.7
Total phenols, mg/L	19	1.5	0.18	0.32	7	0.26	0.12	0.12
Oil and grease, mg/L	66	7,900	730	1,100	52	910	300	330
pH, pH units	62	11.9	10.5	10.4	58	12.3	10.2	10.1
	Power laundries				Diaper laundries			
BOD_5, mg/L	8	940	210	340	5	560	240	320
COD, mg/L	11	1,400	580	660	8	1,100	520	580
TOC, mg/L	4	240	160	150	2	400	390	390
TSS, mg/L	11	410	230	220	8	280	130	150
Total phosphorus, mg/L	6	23.5	4.0	7.3	2	30.0	22.8	22.8
Total phenols, mg/L	5	0.97	0.073	0.31	3	0.080	0.036	0.040
Oil and grease, mg/L	9	370	52	110	7	330	85	120
pH, pH units	14	11.1	9.6	9.4	9	11.0	10.4	9.9
	Coin-operated laundries				Carpet cleaning plant			
BOD_5, mg/L	31	500	120	140	1	99	-	-
COD, mg/L	18	930	270	340	1	280	-	-
TOC, mg/L	1	68	-	-	1	46	-	-
TSS, mg/L	28	630	85	140	1	100	-	-
Total phosphorus, mg/L	2	18.0	9.8	9.8	1	29.0	-	-
Total phenols, mg/L	3	0.30	<0.002	0.10				
Oil and grease, mg/L	13	74	23	26	1	19	-	-
pH, pH units	29	9.2	8.0	7.9	1	7.1	-	-
	Dry cleaning plants				Car washes			
BOD_5, mg/L	1	<2	-	-	45	220	42	58
COD, mg/L	1	8	-	-	NA	-	-	-
TOC, mg/L	1	2	-	-	NA	-	-	-
TSS, mg/L	1	3	-	-	45	2,970	121	270
Total phosphorus, mg/L	1	0.2	-	-	NA	-	-	-
Total phenols, mg/L	2	<0.005	<0.003	<0.003	6	0.024	<0.002	<0.006
Oil and grease, mg/L	1	<2	-	-	45	655	68	26
pH, pH units	1	7.2	-	-	7	8.4	7.2	7.1

TABLE 2-5. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATER FROM AUTO AND OTHER LAUNDRIES [1, 2] (μg/L)

Toxic pollutant	Laundry feedwater				Industrial laundry			
	Number[a]	Maximum	Median	Mean	Number[a]	Maximum	Median	Mean
Metals and inorganics								
Antimony	7/29	27	<10	<10	20/22	1,800	140	240
Arsenic	4/29	11	<1	<1	14/24	1,600	17	77
Beryllium					1/14	5	<1	<1
Cadmium	9/31	20	<2	<2	32/36	520	66	88
Chromium	18/31	80	10	16	32/35	8,800	440	880
Copper	23/31	300	30	48	36/36	11,000	1,200	1,700
Cyanide					19/28	1,000	26	140
Lead	12/31	100	<20	<20	35/36	22,000	3,200	4,500
Mercury	10/31	8	<0.7	<0.4	22/24	19	1	2
Nickel	6/31	60	<5	<6	31/36	2,400	160	290
Selenium	2/28	4	<1	<1	2/16	120	<1	8
Silver	3/31	30	<5	<5	11/26	130	5	26
Thallium	2/28	6	<5	<5				
Zinc	22/31	300	94	72	36/36	9,000	2,400	3,000
Phthalates								
Bis(2-ethylhexyl) phthalate	25/36	1,200	≤10	≤50	16/19	17,500	560	3,100
Butyl benzyl phthalate	3/36	≤10	BDL	≤8	3/19	1,500	BDL	96
Di-n-butyl phthalate	20/36	14	≤10	≤5	8/19	820	BDL	100
Diethyl phthalate	7/36	≤10	BDL	≤2	1/19	≤10	BDL	≤0.5
Dimethyl phthalate	3/36	≤10	BDL	≤0.8				
Di-n-octyl phthalate	3/36	≤10	BDL	BDL	4/19	410	BDL	35
Nitrogen compounds								
N-nitrosodiphenylamine					1/19	1,800	BDL	95
Phenols								
2-Chlorophenol	1/36	≤10	BDL	≤0.3				
2,4-Dichlorophenol	2/36	≤10	BDL	≤0.6				
2,4-Dinitrophenol								
2,4-Dimethylphenol					2/19	460	BDL	25
4-Nitrophenol								
Pentachlorophenol								
Phenol	5/36	≤10	BDL	≤1	6/19	840	BDL	89
2,4,6-Trichlorophenol	1/36	≤10	BDL	≤0.3				
p-Chloro-*m*-cresol					1/19	≤10	BDL	≤0.5
Aromatics								
Benzene	4/33	40	BDL	≤2	11/18	23,400	12	2,500
Chlorobenzene	1/33	2	BDL	BDL				
Dichlorobenzenes[b]	2/36	≤10	BDL	≤0.6	1/19	1,100	BDL	58
Ethylbenzene	2/33	5	BDL	0.3	8/18	17,500	BDL	1,100
Toluene	13/33	140	BDL	≤8	17/18	50,900	1,000	5,200
Polycyclic aromatic hydrocarbons								
Anthracene/phenanthrene[b]	1/36	≤10	BDL	≤0.3	4/19	470	BDL	47
Benzanthracene[b]								
Benzopyrene[b]								
Benzofluoranthene[b]								
2-Chloronaphthalene					1/19	17	BDL	0.9
Fluoranthene								
Naphthalene	2/36	≤10	BDL	≤0.6	10/19	4,800	23	790
Pyrene								
Halogenated aliphatics								
Carbon tetrachloride					2/18	1,700	BDL	95
Chlorodibromomethane	8/33	20	BDL	≤2				
Chloroform	22/33	140	12	≤25	14/18	34,600	15	3,300
Dichlorobromomethane	15/33	88	BDL	9	2/18	20	BDL	0.2
1,2-Dichloroethane								
1,1-Dichloroethylene	4/33	≤10	BDL	BDL				
1,2-*Trans*-dichloroethylene	1/33	49	BDL	BDL				
Methylene chloride	16/33	14,700	BDL	≤600	7/18	540	BDL	46
Tetrachloroethylene	15/33	420	BDL	≤16	13/18	93,200	84	9,100
1,1,1-Trichloroethane	5/33	140	BDL	≤5	5/18	6,600	BDL	370
1,1,2-Trichloroethane								
Trichloroethylene	4/33	≤10	BDL	≤0.7	8/18	800	BDL	120
Trichlorofluoromethane	2/33	130	BDL	5	1/18	3	BDL	BDL
Pesticides and metabolites								
Chlordane								
4,4'-DDE								
4,4'-DDT								
Heptachlor								
Isophorone	1/36	≤10	BDL	≤0.3	1/19	190	BDL	10

(CONTINUED)

TABLE 2-5 (continued)

Toxic pollutant	Power laundries				Linen laundries			
	Number[a]	Maximum	Median	Mean	Number[a]	Maximum	Median	Mean
Metals and inorganics								
Antimony	5/6	570	16	160	5/7	37	7	10
Arsenic	2/6	20	<15	<15	4/7	26	6	7
Beryllium								
Cadmium	3/5	46	3	11	5/36	120	<2	9
Chromium	6/7	360	25	76	24/36	980	46	100
Copper	7/7	370	110	160	15/15	3,300	210	520
Cyanide	1/5	28	<28	<28	5/7	77	35	33
Lead	6/7	430	60	110	27/36	3,000	240	460
Mercury	5/8	3	0.6	0.7	12/36	51	0.2	3
Nickel	4/7	50	19	14	19/36	500	28	61
Selenium					1/7	3	2	2
Silver	2/7	8	<7	<7	4/7	47	2	8
Thallium					1/7	6	5	5
Zinc	6/6	540	430	430	36/37	2,800	700	900
Phthalates								
Bis(2-ethylhexyl) phthalate	4/4	300	100	150	4/5	9,000	160	1,900
Butyl benzyl phthalate	4/4	78	16	28	2/5	≤10	BDL	≤3
Di-n-butyl phthalate	4/4	22	18	15	3/5	26	≤10	≤9
Diethyl phthalate	1/4	≤5	BDL	≤1	1/5	≤5	BDL	≤1
Dimethyl phthalate					1/5	≤5	BDL	≤1
Di-n-octyl phthalate	3/4	75	46	42	1/5	≤5	BDL	≤1
Nitrogen compounds								
N-nitrosodiphenylamine								
Phenols								
2-Chlorophenol	2/4	1	BDL	0.7				
2,4-Dichlorophenol	1/4	1	BDL	0.2	2/5	≤10	BDL	≤3
2,4-Dinitrophenol								
2,4-Dimethylphenol	2/4	55	BDL	14				
4-Nitrophenol								
Pentachlorophenol	2/4	9	BDL	3				
Phenol	3/4	2	1	1	4/5	30	≤10	≤15
2,4,6-Trichlorophenol								
p-Chloro-*m*-cresol								
Aromatics								
Benzene								
Chlorobenzene								
Dichlorobenzenes[b]	1/4	≤5	BDL	≤1				
Ethylbenzene					1/5	11	BDL	2
Toluene	1/4	3	BDL	0.8	4/5	99	25	≤43
Polycyclic aromatic hydrocarbons								
Anthracene/phenanthrene[b]	2/4	≤10	BDL	≤3	3/5	16	≤10	≤7
Benzanthracene[b]								
Benzopyrene[b]								
Benzofluoranthene[b]								
2-Chloronaphthalene								
Fluoranthene	1/4	0.3	BDL	0.08				
Naphthalene	2/4	≤10	BDL	≤3	1/5	1,200	BDL	240
Pyrene	1/4	0.3	BDL	0.08				
Halogenated aliphatics								
Carbon tetrachloride								
Chlorodibromomethane								
Chloroform	3/4	41	27	24	4/5	180	20	63
Dichlorobromomethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene								
Methylene chloride	1/4	72	BDL	18	2/5	92	BDL	25
Tetrachloroethylene	3/4	310	15	85	2/5	≤10	BDL	≤3
1,1,1-Trichloroethane	1/4	2	BDL	BDL	1/5	≤10	BDL	≤2
1,1,2-Trichloroethane								
Trichloroethylene	2/4	12	BDL	4				
Trichlorofluoromethane								
Pesticides and metabolities								
Chlordane	1/4	≤3	BDL	BDL				
4,4'-DDE	1/4	≤3	BDL	BDL				
4,4'-DDT	1/4	≤3	BDL	BDL				
Heptachlor	1/4	≤3	BDL	BDL				
Isophorone								

(CONTINUED)

TABLE 2-5 (continued)

Toxic pollutant	Coin-operated laundries				Dry cleaning plants			
	Number[a]	Maximum	Median	Mean	Number[a]	Maximum	Median	Mean
Metals and inorganics								
Antimony	2/3	16	13	10				
Arsenic	1/3	11	<10	<10				
Beryllium								
Cadmium	1/3	23	<2	8				
Chromium	1/3	5	<5	<5				
Copper	3/3	70	70	67	1/2	50	25	25
Cyanide								
Lead	2/3	72	36	36	1/2	40	20	20
Mercury	2/3	2	2	1				
Nickel								
Selenium								
Silver								
Thallium								
Zinc	3/3	670	160	310				
Phthalates								
Bis(2-ethylhexyl) phthalate	2/2	840	800	800	1/2	≤10	≤5	≤5
Butyl benzyl phthalate								
Di-n-butyl phthalate	1/2	55	28	28	1/2	≤10	≤5	≤5
Diethyl phthalate	1/2	25	12	12	1/2	≤10	≤5	≤5
Dimethyl phthalate								
Di-n-octyl phthalate								
Nitrogen compounds								
N-nitrosodiphenylamine								
Phenols								
2-Chlorophenol								
2,4-Dichlorophenol								
2,4-Dinitrophenol								
2,4-Dimethylphenol								
4-Nitrophenol								
Pentachlorophenol								
Phenol					1/2	≤10	≤5	≤5
2,4,6-Trichlorophenol								
p-Chloro-*m*-cresol								
Aromatics								
Benzene	1/3	14	BDL	5	1/2	25	12	12
Chlorobenzene					1/2	12	6	6
Dichlorobenzenes[b]								
Ethylbenzene								
Toluene	1/3	1	BDL	0.3				
Polycyclic aromatic hydrocarbons								
Anthracene/phenanthrene[b]								
Benzanthracene[b]								
Benzopyrene[b]								
Benzofluoranthene[b]								
2-Chloronaphthalene								
Fluoranthene								
Naphthalene					1/2	≤10	≤5	≤5
Pyrene								
Halogenated aliphatics								
Carbon tetrachloride								
Chlorodibromomethane	1/3	12	BDL	4	1/2	4	2	2
Chloroform	2/3	70	20	30	1/2	2,300	1,200	1,200
Dichlorobromomethane	1/3	19	BDL	6	1/2	3	1.5	1.5
1,2-Dichloroethane					1/2	500	250	250
1,1-Dichloroethylene	1/3	3	BDL	BDL	1/2	23	12	12
1,2-*Trans*-dichloroethylene	1/3	5	BDL	BDL	1/2	460	230	230
Methylene chloride	1/3	6	BDL	2	1/2	30	15	15
Tetrachloroethylene	1/3	25	BDL	8	2/2	58,600	29,400	29,400
1,1,1-Trichloroethane					1/2	2,500	1,200	1,200
1,1,2-Trichloroethane					1/2	3,000	1,500	1,500
Trichloroethylene					1/2	440	220	220
Trichlorofluoromethane								
Pesticides and metabolities								
Chlordane								
4,4'-DDE								
4,4'-DDT								
Heptachlor								
Isophorone								

(CONTINUED)

TABLE 2-5 (continued)

Toxic pollutant	Diaper laundries				Car washes			
	Number[a]	Maximum	Median	Mean	Number[a]	Maximum	Median	Mean
Metals and inorganics								
Antimony					7/7	17	5.2	7.9
Arsenic					7/7	1,560	<10	230
Beryllium					7/7	<15	<5	<5
Cadmium	2/4	40	<6	11	7/7	26	20	17
Chromium	1/5	22	<10	<10	7/7	64	30	34
Copper	4/4	100	80	79	7/7	860	140	340
Cyanide	1/2	60	<50	<50				
Lead	2/4	35	<24	<24	45[c]	4,200	510	890
Mercury	1/3	0.9	<0.9	<0.9	7/7	26	4	<1
Nickel	2/4	100	<35	<35	7/7	690	120	260
Selenium					7/7	<5	<5	<5
Silver					7/7	<10	<5	<5
Thallium					7/7	<5	<1	<2
Zinc	5/5	10,000	4,000	5,700	45[c]	2,420	590	750
Phthalates								
Bis(2-ethylhexyl) phthalate					4/5	1,000	56	280
Butyl benzyl phthalate					2/5	31	22	22
Di-n-butyl phthalate					1/5	15	15	15
Diethyl phthalate								
Dimethyl phthalate								
Di-n-octyl phthalate					2/5	16	16	16
Nitrogen compounds								
N-nitrosodiphenylamine								
Phenols								
2-Chlorophenol								
2,4-Dichlorophenol								
2,4-Dinitrophenol					1/5	19	19	19
2,4-Dimethylphenol								
4-Nitrophenol					3/5	15	14	13
Pentachlorophenol								
Phenol	1/1	38	NA	NA				
2,4,6-Trichlorophenol								
p-Chloro-*m*-cresol								
Aromatics								
Benzene								
Chlorobenzene								
Dichlorobenzenes[b]								
Ethylbenzene								
Toluene								
Polycyclic aromatic hydrocarbons								
Anthracene/phenanthrene[b]					1/5	34	34	34
Benzanthracene[b]					1/5	12	12	12
Benzopyrene[b]					1/5	12	12	12
Benzofluoranthene[b]					1/5	12	12	12
2-Chloronaphthalene								
Fluoranthene					1/5	14	14	14
Naphthalene					1/5	170	170	170
Pyrene					1/5	11	11	11
Halogenated aliphatics								
Carbon tetrachloride								
Chlorodibromomethane					1/5	12	12	12
Chloroform	1/1	72	NA	NA	3/5	83	37	47
Dichlorobromomethane					1/5	33	33	33
1,2-Dichloroethane								
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene								
Methylene chloride					4/5	640	240	280
Tetrachloroethylene								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene					1/5	13	13	13
Trichlorofluoromethane					1/5	120	120	120
Pesticides and metabolities								
Chlordane								
4,4'-DDE								
4,4'-DDT								
Heptachlor								
Isophorone								

[a]Number of times detected/number of analyses performed.
[b]Reference reported compound in this form.
[c]Number of times detected; no indication of number of analyses.
Note: Blanks indicate pollutant not detected.

in the wastewaters from solvent cleaning and some dual-phase cleaning processes.

In addition to plant-to-plant variability, wastewater strength at any given industrial laundry may be quite variable from day to day and from hour to hour. This is caused by the changing nature of the workload and, on an instantaneous basis, by the particular wash cycle effluents that are being discharged. For example, the initial rinse, break, and wash waters contain much higher pollutant loadings than the final rinse waters.

Table 2-6 presents pH, BOD_5, TSS, and oil and grease data for the wastewater from one industrial laundry sampled on 30 separate days over a several-year period. These data clearly illustrate the fluctuating characteristics of industrial laundry wastes.

TABLE 2-6. VARIABILITY OF CONVENTIONAL POLLUTANT LOADINGS IN WASTEWATER FROM ONE INDUSTRIAL LAUNDRY [1]

Day	pH	Pollutant, mg/L		
		BOD_5	TSS	Oil and grease
1	11.9	1,700	2,300	490
2	12.0		2,100	1,800
3	12.6	2,500	2,400	2,200
4	11.6		1,900	240
5	12.2		1,900	5,300
6	11.8		2,100	2,100
7	11.8		5,000	2,800
8	10.0		2,800	2,600
9	11.5		3,600	3,400
10	11.6		4,000	3,400
11	11.7		3,800	3,800
12	11.4		2,700	
13	11.6		2,300	
14	10.7	710	810	400
15	10.8	650	650	510
16	10.9	1,300	3,500	1,600
17	10.7		1,700	970
18	10.1	690	1,800	720
19	10.4			1,200
20	10.2	940	2,600	1,200
21	11.0	680	4,400	2,600
22	12.0		3,800	3,500
23	11.9		5,300	3,900
24	9.4			1,500
25	10.2			1,400
26		930	1,300	2,400
27		1,400	2,400	2,300
28		1,600	2,000	2,400
29		2,200	2,000	1,300
30		3,700	2,600	2,400
Minimum	9.4	650	650	240
Maximum	12.6	3,700	5,300	5,300
Mean	11.2	1,500	2,700	2,100

Note: Blanks indicate data not available.

Ten toxic pollutant metals were found in more than 50% of the industrial laundry effluents. Lead, zinc, and copper were detected in virtually all of the samples and were present at higher concentrations than any of the other metals. Chromium, nickel, antimony, cadmium, arsenic, silver, and mercury were also detected in the majority of the plant wastewaters, but generally at much lower concentrations.

A total of 25 toxic organic pollutants were detected in one or more of the 19 industrial laundry effluents analyzed for these substances. Six toxic organic pollutants were detected in more than 50% of the wastewater samples: toluene, bis(2-ethylhexyl) phthalate, tetrachloroethylene, naphthalene, chloroform, and benzene; however, only toluene and bis(2-ethylhexyl) phthalate were consistently present at concentrations greater than 0.1 mg/L in the wastewaters.

Ethylbenzene, 1,1,1-trichloroethane, methylene chloride, phenol, di-n-butyl phthalate, di-n-octyl phthalate, anthracene, and trichloroethylene were also found in 20% to 50% of the plant effluents.

II.2.2.2 Linen Supply

Linen supply wastewaters typically contain higher concentrations of BOD_5, COD, TOC, suspended solids, and oil and grease than does domestic sewage, but much lower concentrations of these pollutants than do industrial laundry wastewaters. This is attributed to the lighter soil loading on items such as bed sheets, pillowcases, towels, napkins, tablecloths, and uniforms, which comprise the majority of the linen supply business. Phosphorus and pH were found at similar levels in industrial laundry and linen supply effluents, which reflects the fact that these pollutants are introduced to the wastewater by process additives rather than by soil on the articles being laundered.

Many linen supplies service industrial-type garments and flatwork articles as well as the more traditional linen supply items. Plant-to-plant differences in the amount of "industrial laundry" work performed is a major cause for variable pollutant concentrations. However, BOD_5, TSS, and oil and grease loadings are also influenced by the particular types of "linen supply work" performed. For example, the wastewaters from laundries washing a high percentage of aprons, tablecloths, napkins, etc., used in restaurants contain higher levels of oil and grease than do wastewaters from laundries washing a high percentage of sheets or towels used in hotels.

Laundering chemicals are not considered a major source of BOD_5, TSS, or oil and grease in industrial laundry wastewaters. However, detergents, soaps, starches, and other organic process chemicals contribute BOD to the wastewater; soap is also a source of oil and grease. These pollutant sources are considerably more significant in comparison to soil loading in the linen supply subcategory than in the industrial laundry subcategory. Variable oil and grease concentrations in linen laundry wastewaters are at least partially attributable to the fact that some establishments use soap while others use synthetic detergents. Seven toxic pollutant metals were detected in 50% or more of the wastewater samples analyzed for these substances. However, only zinc, lead, and copper were found at average concentrations greater than 100 µg/L.

Sixteen toxic organic pollutants were detected in at least one of five linen laundry effluents analyzed for these compounds. With few exceptions, these were the same compounds found in the industrial laundry wastewaters. Much lower concentrations were observed in the linen supply effluents, however; only bis(2-ethylhexyl) phthalate, naphthalene, and chloroform were found in any of the effluents at concentrations greater than 100 µg/L.

II.2.2.3 Power Laundries, Family and Commercial

Power laundry wastewaters typically contain lower concentrations of BOD_5, COD, TOC, suspended solids, and oil and grease than either industrial laundry or linen supply wastewaters. Much narrower ranges in concentration are also indicated.

Both of these observations are related to the types of customers serviced by power laundries. Family wash has been traditionally the largest source of business for these establishments, but many power laundries now service commercial businesses and service organizations. However, very little industrial-type work is performed; hence, the soil loadings on garments washed in these laundries tend to be light.

The median and mean concentrations of BOD_5, COD, TOC, TSS, oil and grease, and phosphorus are comparable to the levels at which these pollutants are found in domestic sewage. However, power laundry wastewaters tend to be more alkaline than does domestic sewage due to the use of alkali in the washing process.

Only five toxic pollutant metals (antimony, zinc, lead, copper and chromium) were present in any of the effluent samples at concentrations greater than 100 µg/L. Except for zinc and copper, median concentrations of these metals were all much less than 100 µg/L, in the range of detection limits.

Twenty-five toxic organic pollutants were present in one or more of the four wastewaters analyzed for these compounds, but only bis(2-ethylhexyl) phthalate and tetrachloroethylene were found in any of the samples at concentrations greater than 100 µg/L.

II.2.2.4 Diaper Services

In terms of BOD_5, COD, and oil and grease, these wastewaters appear to be roughly equivalent to the wastewater discharged by power laundries. Higher concentrations of TOC and phosphorus, and lower concentrations of suspended solids were present in the diaper service effluents, but these observations are based on limited data and may not represent the entire industry.

Median and mean concentrations of all conventional pollutants, excluding pH, are roughly comparable to the levels at which these pollutants are present in domestic wastewaters.

Seven toxic pollutant metals were detected in at least one sample, but only zinc was present at more than 100 µg/L in any of the samples. No other toxic pollutants were found at significant levels, which is understandable in light of the types of soil present on diapers.

II.2.2.5 Coin-Operated Laundries

Coin-op wastewaters are less heavily polluted than are the wastewaters from any of the four commercial laundry subcategories previously discussed, and they are comparable to low-strength domestic wastewaters. Lightly soiled family wash accounts for nearly all of the business at these establishments.

Eight toxic pollutant metals and 12 toxic organic pollutants were detected in at least one of these effluent samples, but only zinc, total phenol, and bis(2-ethylhexyl) phthalate were present at concentrations greater than 100 µg/L in any of the samples.

II.2.2.6 Carpet and Upholstery Cleaners

Except for phosphorus, all pollutant concentrations in this subcategory are comparable to or less than the median and mean pollutant loadings shown for coin-operated laundry wastewaters.

Zinc, copper, lead, and tetrachloroethylene were the only toxic pollutants found at a concentration greater than 100 µg/L.

II.2.2.7 Dry Cleaning Plants

Conventional and toxic pollutant data from the dry cleaning industry were obtained from two plants that use perchloroethylene (tetrachloroethylene) solvent. All pollutant concentrations are extremely low--in the range of or below analytical detection limits. The source of process wastewater at these plants was condensate from the steam regeneration of carbon columns used for solvent vapor emission control.

Eighteen toxic organic pollutants were detected in one of the wastewater samples, but none was found in both effluents except, as expected, tetrachloroethylene.

Chlorinated ethanes, ethylenes, and chloroform were the only toxic pollutants, other than tetrachloroethylene, found at concentrations greater than 50 μg/L.

II.2.2.8 Car Washes

The primary wastes present in car wash wastewater are suspended and dissolved solids, oil and grease, BOD_5, lead, and zinc. Other priority metals are sometimes encountered (especially in wand wash effluents) in small amounts.

The sources of solids are road grit, dust or mud, salt, snow, and ice, as well as plant and animal materials. Solids may also be picked up from suspended particles in the air.

Oil and grease may enter the wastewater either from the vehicle wash equipment and operation, or the vehicle itself. Much of the equipment used for car washing at tunnel and rollover facilities is hydraulically operated and may leak hydraulic fluid into the drain trench. Surfactants and waxes used in the washing operations may account for a portion of the measured oil and grease. Leaky crankcases and the washing of undercarriages and engines will account for much of the oil and grease measured in car wash effluents. The dumping of oil down the drains at unsupervised wand washes may also occur.

The main sources of BOD_5 are the detergents and waxes used for cleaning purposes, although it may also result from organic plant and animal materials carried into the wash on car bodies and tires.

The presence of lead in the wastewater results from the use of lead additives in gasoline. Significant lead levels accumulate in crankcase oil and the exhaust fumes of automobiles, and lead may be introduced into the carwash via these sources. Gasoline deposits on the body of the car and on tire treads may also act as sources of lead.

Zinc may be used in the manufacture of automobile tires which may then act as a source of this metal.

Other trace metals such as arsenic, cadmium, chromium, copper, mercury, and nickel are often detected in car wash effluents. However, the concentrations found are generally quite low.

The variations encountered in waste loads are great and may be seasonal as well as regional. Winter conditions will increase the suspended solids load due to ice, grit, and mud accumulations.

Lead may also increase as a result of the use of fly ash as part of the road sanding material. Fly ash analysis usually shows a high lead content. Dusty soils will be turned into hard-to-remove mud during rainy seasons. Geographical differences will be due to soil types, type and extent of industry, road conditions, etc. Variations in waste loads will also be found among the different types and locations of car washes. Wand washes tend to produce the heaviest loads, as vehicles other than cars (four-wheel drive vehicles, trucks, RV's, motorcycles), parts of the car other than the body (engines, undercarriages), and a wide variety of other objects, may be washed. At unattended sites customers may perform oil changes in the bay, and may dump the oil down the drain. Rollovers tend to exhibit a lighter waste load than either tunnels or wands. Many rollovers are situated at rental agencies and car dealerships where cars are washed with more than average frequency.

II.2.3 PLANT SPECIFIC DESCRIPTIONS

II.2.3.1 Car Washes

The sampling done at these plants was completed over a 4-hour period when road conditions were dry.

Plant 1B is a total recycle tunnel facility at which 75 cars were processed during the study. In this plant suspended solids and oil and grease concentrations were low compared to domestic sewage. Metal concentrations were generally low, with seven metals at less than 10 µg/L. Of the remaining six metals only zinc, nickel, and lead concentrations exceeded 100 µg/L. In this plant no analyses were performed to measure the toxic organics.

Wash water and rinse water are treated by different methods at this plant. The wash water is processed solely by settling in settling tanks. The rinse water is processed by settling followed by filtration through turbidity filters. Plant 1B plant specific data are presented in Tables 2-7 and 2-8.

Plant 2A is a total recycle wand facility where 57 cars were processed during sampling. The sampling results at this plant showed high suspended solids concentrations and low oil and grease concentrations compared to domestic sewage. Metal concentrations were generally low, with four metals at less than 10 µg/L and six metals at less than 100 µg/L. Only copper, lead, and zinc were present at high concentrations ranging from 860 to 1,230 µg/L. Several groups of toxic organics appeared in the waste, but no organic was at a higher concentration than 100 µg/L. The groups concerned were the phthalates, phenols, ethers, nitrogen compounds, polycyclic aromatics, and halogenated aliphatics.

TABLE 2-7. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR AUTO LAUNDRY 1B [1]

Pollutant	Concentration, mg/L[a]		Percent	Concentration, mg/L[a]		Percent
	Raw wash	Treated wash	removal	Raw rinse	Treated rinse	removal
BOD_5	42	42	0	42	42	0
TSS	56	24	57	64	9.3	85
TDS	690	700	-[b]	600	650	-[b]
Total phenols	<0.002	<0.002	-	<0.002	<0.002	-
Oil and grease	21	20	5	24	4.7	80
pH	7.3	7.4	-	7.3	7.2	-

[a]Except pH values, which are given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 2-8. PLANT SPECIFIC TOXIC METALS FOR AUTO LAUNDRY 1B [2]

Toxic pollutant	Concentration, µg/L		Percent	Concentration, µg/L		Percent
	Raw wash	Treated wash	removal	Raw rinse	Treated rinse	removal
Metals and inorganics						
Antimony	5.2	4.4	15	3.4	1.7	50
Arsenic	5.0	10	-[a]	5.0	3.0	40
Beryllium	<0.1	<0.1	-	<0.1	<0.1	-
Cadmium	25.3	30.8	-[a]	20.5	8.7	58
Chromium	64.3	86.2	-[a]	63.9	53.8	16
Copper	85.2	114	-[a]	623	20.6	97
Cyanide	<0.002	<0.002	-	<0.002	<0.002	-
Lead	470	910	-[a]	362	62	83
Mercury	<1	<1	-	<1	<1	-
Nickel	690	331	52	682	39.5	94
Selenium	<1	<1	-	<1	<1	-
Silver	<1	<1	-	<1	<1	-
Thallium	<1	<1	-	<1	<1	-
Zinc	720	1,000	-[a]	587	55	91

[a]Treated effluent concentration exceeds raw wastewater concentration.

Wastewater treatment at this plant is carried out in the following sequence: settling storage, centrifugal separation, and turbidity filtration. At this point the stream is divided with part being stored for use as wash water. The remainder is treated by activated charcoal filtration and stored for use as rinse water. Plant 2A plant specific data are presented in Tables 2-9 and 2-10.

Plant 3A is a total recycle rollover facility. During the sampling period 24 cars were processed. At this facility the suspended solids concentration was moderate and the oil and grease concentration was low compared to domestic sewage. Metal

TABLE 2-9. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR AUTO LAUNDRY 2A [2]

Pollutant	Concentration, mg/L[a] Raw wastewater	Treated wastewater	Percent removal
BOD_5	120	35	71
TSS	520	36	93
TDS	1,300	880	30
Total phenols	<0.002	<0.002	-
Oil and grease	20.5	18	12
pH	7.2	7.2	-

[a]Except pH values, which are given in pH units.

TABLE 2-10. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR AUTO LAUNDRY 2A [2]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated wastewater	Percent removal
Metals and inorganics			
Antimony	11	7	36
Arsenic	28	11	61
Beryllium	<5	<5	-
Cadmium	26	2.5	90
Chromium	30	<5	83
Copper	860	150	83
Cyanide	<0.004	<0.004	-
Lead	1,120	55	95
Mercury	26	5.6	78
Nickel	75	23	69
Selenium	<5	<5	-
Silver	5	5	0
Thallium	<5	<5	-
Zinc	1,230	93	92
Ethers			
Bis(2-chloroethoxy)methane	ND	11	-[a]
Phthalates			
Bis(2-ethylhexyl) phthalate	80	20	75
Butyl benzyl phthalate	12	11	8
Nitrogen compounds			
1,2-Diphenylhydrazine	ND	30	-[a]
Phenols			
2,4-Dinitrophenol	19	ND	100
4-Nitrophenol	14	ND	100
Polycyclic aromatic hydrocarbons			
Anthracene	17	ND	100
Benz(a)anthracene	12	ND	100
Benzo(a)pyrene	12	17	-[a]
Benzo(k)fluoranthene	12	ND	100
Fluoranthene	14	ND	100
Phenanthrene	17	ND	100
Pyrene	11	ND	100
Halogenated aliphatics			
Chlorodibromomethane	12	ND	100
Chloroform	83	44	47
Dichlorobromomethane	33	ND	100
Methylene chloride	16	ND	100
Trichloroethylene	13	ND	100

[a]Treated effluent concentration exceeds raw wastewater concentration.

concentrations were generally low with nine metals at less than 10 μg/L. Only copper, lead, nickel, and zinc concentrations exceeded 100 μg/L. Only a very small number of toxic organic compounds were found in the wastewater and, with the exception of methylene chloride, at concentrations less than 100 μg/L. The only toxic groups found were the phthalates, phenols, and halogenated aliphatics.

Wastewater treatment in this plant consists of the following sequence of steps: settling, centrifugal separation, and turbidity filtration. At this point the stream is split, and one portion is used as wash water. The other portion is filtered through activated charcoal and iodinated before it is used as rinse water. Plant specific information for this facility is shown in Tables 2-11 and 2-12.

II.2.3.2 Other Laundries

Plant B is an industrial laundry without wastewater recycle. COD, suspended solids, and oil and grease concentrations found during sampling were high compared to domestic sewage. Concentrations of three metals (copper, lead, and zinc) were high, ranging from 1,600 to 9,400 μg/L. Of the other metals analyzed for, four were found in concentrations of less than 100 μg/L and four were not detected. Toxic organic compounds were not present in a wide variety, but those found tended to high concentrations, with 10 of 11 at greater than 100 μg/L. Two of these, N-nitrosodiphenylamine and naphthalene, were present at 1,600 μg/L and 4,000 μg/L, respectively. At least one representative of each organic group except ethers, cresols, and polychlorinated biphenyls was detected.

The wastewater treatment used by this plant consists of calcium chloride coagulation of the solids with polymer addition, followed by dissolved air flotation. The floc from the flotation step is then skimmed from the surface and transferred to a sludge pit. Plant specific information for this plant is presented in Tables 2-13 and 2-14.

Plant G is a linen supply laundry with wastewater recycle. The wastewater from this plant exhibited very high levels of BOD, COD, TOC, and TSS concentrations as compared to domestic sewage. On the same basis, the phosphorus level was low and the oil and grease level was in the medium range. Metal concentrations tended to be high, although concentrations of six metals were below 100 μg/L and two metals were not detected. Copper, mercury, and zinc were present at concentrations from 2,000 to 5,800 μg/L. Only five toxic organics were detected, three of them at concentrations of less than 100 μg/L. Only one, naphthalene, had a concentration greater than 1,000 μg/L. The compound classes detected were phthalates, phenols, and polycyclic aromatics.

TABLE 2-11. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR AUTO LAUNDRY 3A [2]

Pollutant	Concentration, mg/L[a] Raw wastewater	Treated wastewater	Percent removal
BOD_5	8	<3	62
TSS	210	7.0	97
TDS	510	450	12
Total phenols	Sample broken	<0.002	-
Oil and grease	6.0	30	-[b]
pH	6.2	5.8	-

[a]Except pH values, which are given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 2-12. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR AUTO LAUNDRY 3A [2]

Toxic pollutant	Concentration, μg/L Raw wastewater	Treated wastewater	Percent removal
Metals and inorganics			
Antimony	2.5	1	60
Arsenic	<10	<10	-
Beryllium	<5	<5	-
Cadmium	2	<1	50
Chromium	10	<5	50
Copper	140	130	7
Cyanide	<0.004	<0.004	-
Lead	460	11	98
Mercury	<1	<1	-
Nickel	160	40	75
Selenium	<5	<5	-
Silver	<5	<5	-
Thallium	<2	<2	-
Zinc	340	140	59
Phthalates			
Bis(2-ethylhexyl) phthalate	31	ND	100
Di-n-octyl phthalate	16	ND	100
Phenols			
Pentachlorophenol	ND	58	-[a]
Halogenated aliphatics			
Methylene chloride	470	1,200	-[a]
Trichlorofluoromethane	ND	150	-[a]

[a]Treated effluent concentration exceeds raw wastewater concentration

TABLE 2-13. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR INDUSTRIAL LAUNDRY B [1]

Pollutant	Concentration, mg/L[a] Raw wastewater	Treated wastewater	Percent removal
COD	3,800	1,300	66
TSS	700	48	93
Total phenols	0.016	<0.001	94
Oil and grease	440	190	57
pH	11.6	7.0	-

[a]Except pH values, which are given in pH units.

TABLE 2-14. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR INDUSTRIAL LAUNDRY B [1]

Toxic pollutant	Concentration, μg/L Raw wastewater	Treated wastewater	Percent removal
Metals and inorganics			
Antimony	41	<20	51
Arsenic	12	<10	17
Cadmium	170	23	86
Chromium	270	≤130	52
Copper	1,600	330	79
Lead	9,400	230	98
Mercury	2	<0.2	90
Nickel	150	<50	67
Thallium	<5	<5	-
Zinc	4,500	200	96
Phthalates			
Di-n-butyl phthalate	ND	290	-[a]
Nitrogen compounds			
N-nitrosodiphenylamine	1,800	620	66
Phenols			
Phenol	600	120	80
Aromatics			
Ethylbenzene	260	110	58
Toluene	750	790	-[a]
Polycyclic aromatic hydrocarbons			
Naphthalene	4,000	790	80
Halogenated aliphatics			
Chloroform	10	8	20
Methylene chloride	540	500	7
Tetrachloroethylene	880	1,000	-[a]
Trichloroethylene	210	30	86
Pesticides and metabolites			
Isophorone	190	ND	100

[a]Treated effluent concentration exceeds raw wastewater concentration.

Wastewater treatment in this plant consists of polyelectrolyte coagulation and dissolved air flotation (with skimmers pushing the solids into a sludge hopper). All or part of this clarified water is passed through a multimedia filter and recycled. When 100% recycle is not employed the excess is discharged. Plant specific information is presented for plant G in Tables 2-15 and 2-16.

Plant J is a power laundry utilizing wastewater recycle. During sampling wastewater from this plant had low to medium concentrations of all the classical pollutants compared to domestic sewage. Metal concentrations also tended to be low with only the zinc concentration above 100 µg/L. There were 19 toxic organics from 4 toxic pollutant categories present, but none at a higher concentration than 100 µg/L, and most at less than 10 µg/L. The four categories of organics are phthalates, phenols, polycylic aromatics, and halogenated aliphatics.

The wastewater treatment used in this facility is polyelectrolyte coagulation followed by dissolved air flotation equipped with skimmers. All or part of this clarified water may be filtered via a multimedia filter and recycled. Plant specific information for this facility is presented in Tables 2-17 and 2-18.

Plant N is a service laundry with no wastewater recycle. The concentrations of classical pollutants observed were all in the low range compared to domestic sewage. Metal concentrations also tended to be low, with six metals not detected and concentrations of only two (copper and zinc) greater than 100 µg/L. A small number of toxic organics was present with only one above 10 µg/L. The classes of organics detected were phthalates, phenols, monocyclic aromatics, and halogenated aliphatics.

The wastewater treatment process used in this plant is: alum coagulation and clarification by settling, and treatment of the clarified effluent by carbon adsorption, filtration, and chlorination/dechlorination. Plant specific information for Plant N is shown in Tables 2-19 and 2-20.

II.2.4 POLLUTANT REMOVABILITY [1, 2]

Treatment technology for this industry falls into two distinct groups, methods employed at car washes and methods employed at other laundries. Because of the large difference in the treatment methods, they are described separately below.

II.2.4.1 Car Washes [1, 2]

Settling is used by a large majority of car washes before recycle or discharge. New tunnel facilities are almost always equipped for recycle of their wash water after treatment by settling. The solids and oil and grease are removed from the settling tank

TABLE 2-15. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR LINEN SUPPLY FACILITY G [1]

Pollutant	Concentration, mg/L[a] Raw wastewater	Treated wastewater	Percent removal
BOD_5	2,000	1,100	45
COD	2,600	1,800	31
TOC	1,100	530	52
TSS	1,300	210	84
Total phosphorus	5.7	3.7	35
Total phenols	0.082	0.21	-[a]
Oil and grease	130	240	-[a]

[a]Treated effluent concentration exceeds raw wastewater concentration (3-day composite).

TABLE 2-16. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR LINEN SUPPLY FACILITY G [1]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated wastewater	Percent removal
Metals and inorganics			
Antimony	45	4	91
Arsenic	33	15	55
Cadmium	240	<2	99
Chromium	670	170	75
Copper	2,000	200	90
Cyanide	63	88	-[a]
Lead	4,000	720	82
Mercury	5	1	80
Nickel	880	50	94
Selenium	2	7	-[a]
Silver	10	<1	90
Zinc	5,800	580	90
Phthalates			
Bis(2-ethylhexyl) phthalate	280	96	66
Di-n-butyl phthalate	26	11	58
Phenols			
Phenol	24	24	0
Polycyclic aromatic hydrocarbons			
Anthracene/phenanthrene[b]	16	12	25
Naphthalene	1,200	520	57

[a]Treated effluent concentration exceeds raw wastewater concentration.
[b]Reference reported compound in this form.

TABLE 2-17. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR POWER LAUNDRY FACILITY J [1]

Pollutant	Concentration, mg/L[a]		Percent removal
	Raw wastewater	Treated wastewater	
BOD_5	113	118	-[a]
COD	497	378	24
TOC	135	94	30
TSS	50	40	20
Total phosphorus	0.8	0.7	12
Total phenols	0.432	0.264	39
Oil and grease	39	16	59

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 2-18. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR POWER LAUNDRY FACILITY J [1]

Toxic pollutant	Concentration, μg/L		Percent removal
	Raw wastewater	Treated wastewater	
Metals and inorganics			
Antimony	<10	<10	-
Cadmium	<2	<2	-
Chromium	26	16	38
Copper	55	52	5
Cyanide	29	11	62
Lead	<22	<22	-
Nickel	<36	<36	-
Silver	<5	<5	-
Zinc	290	105	64
Phthalates			
Bis(2-ethylhexyl) phthalate	82	54	34
Butyl benzyl phthalate	17	8	53
Di-n-butyl phthalate	2	0.9	55
Di-n-octyl phthalate	28	4	86
Phenols			
2-Chlorophenol	3	2	33
2,4-Dichlorophenol	1	2	-[a]
2,4-Dimethylphenol	2	29	-[a]
Pentachlorophenol	3	10	-[a]
Phenol	2	7	-[a]
Polycyclic aromatic hydrocarbons			
Anthracene/phenanthrene[b]	0.9	2	-[a]
Fluoranthene	0.3	0.4	-[a]
Naphthalene	0.9	0.9	0
Pyrene	0.3	0.3	0
Halogenated aliphatics			
Chloroform	41	12	71
Methylene chloride	5.7	52	-[a]
1,1,2,2-Tetrachloroethane	ND	9	-[a]
Tetrachloroethylene	2	2	0
1,1,1-Trichloroethane	2	ND	100
Trichlorofluoromethane	ND	5	-[a]

[a]Treated effluent concentration exceeds raw wastewater concentration.
[b]Reference reported compound in this form.

TABLE 2-19. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR SERVICE LAUNDRY N [1]

Pollutant	Concentration, mg/L		Percent removal
	Raw wastewater	Treated wastewater	
BOD_5	163	23	86
COD	240	59	75
TOC	63	21	67
TSS	40	37	8
Total phosphorus	7.0	0.9	87
Total phenols	0.038	0.013	66
Oil and grease	15	0.75	95

TABLE 2-20. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR SERVICE LAUNDRY N [1]

Toxic pollutant	Concentration, µg/L		Percent removal
	Raw wastewater	Treated wastewater	
Metals and inorganics			
Cadmium	51	14	73
Chromium	39	25	36
Copper	138	32	77
Cyanide	<2	<2	-
Lead	71	31	56
Nickel	55	37	33
Silver	14	7	50
Zinc	609	244	60
Phthalates			
Bis(2-ethylhexyl) phthalate	ND	16	-[a]
Butyl benzyl phthalate	ND	4	-[a]
Di-n-butyl phthalate	ND	3	-[a]
Di-n-octyl phthalate	ND	2	-[a]
Phenols			
Phenol	1.8	ND	100
Aromatics			
Toluene	5	6	-[a]
Halogenated aliphatics			
Chlorodibromomethane	0.6	ND	100
Chloroform	ND	9.5	-[a]
Dichlorobromomethane	ND	1.0	-[a]
1,1,2,2-Tetrachloroethane	ND	0.7	-[a]
Tetrachloroethylene	2	31	-[a]
Trichloroethylene	0.5	3.0	-[a]

[a]Treated effluent concentration exceeds raw wastewater concentration.

periodically for disposal. Hydrocyclones are gaining popularity and have been used quite sucessfully at some installations. Sand and multimedia turbidity filters may also be used to remove finely divided suspended solids, almost always in conjunction with settling. It is estimated that 5% to 10% of all car washes use this technology.

Activated charcoal filters are used to remove detergents and other organics from water to be used for rinsing purposes, but they are installed less frequently than turbidity filters. Foam fractionators are used in some car washes to remove surfactants from the wastewaters. Pollutant removal efficiencies for systems incorporating these technologies are included in Section II.2.3.1.

II.2.4.2 Other Laundries [1]

Table 2-21 indicates the technologies being used in the other laundries segment and the estimated percentage of plants utilizing each. Tables 2-22 through 2-24 provide removability data for the three most common systems.

Bar screens are used in a small percentage at industrial and linen supply laundries to remove large solids (6.3 mm to 19 mm). Lint screens are used in the majority of industrial, linen supply, and power laundries and by more than a third of diaper service laundries to remove lint and particles such as sand and grit (in the range of 3.2 mm to 9.5 mm). Catch basins are used in approximately the same proportions in the industry to provide for settling of solids, with retention times of 15 to 40 minutes being typical. The only other technology in common use (approximately the same proportions) is countercurrent heat exchange between the wastewater and the incoming feedwater; this serves to reduce both fuel consumption for water heating and the temperature of the final effluent.

The following technologies are used by very small numbers of plants but provide greater reductions in pollutant concentrations than the common technologies. Equalization tanks having retention times of 2 to 4 hours smooth the discharge flow and remove solids and grease from the wastewater stream. These tanks are used in a small percentage of industrial, linen supply, and power laundries, as is pH adjustment. Dissolved air flotation (DAF) with chemical addition is used in a small percentage of industrial, linen supply, and power laundries to destabilize and remove the colloidal suspensions which contain most of the pollutants that result from plant operations in this industry segment. In the small proportion of the industry utilizing wastewater recycle, multimedia filters are used for removal of fine particulates remaining after dissolved air flotation. Removability data for systems containing these components are

TABLE 2-21. ESTIMATED PERCENT OF LAUNDRIES (BASED ON TECHNICAL SURVEY DATA) HAVING CONTROL TECHNOLOGY [1]

Control technology	Industrial laundries	Linen supply laundries	Power laundries	Coin-op laundries	Diaper service
Pretreatment technology					
(Number of responses)	(74)	(59)	(20)	(1)[a]	(75)
Bar screens	2.7	5.1	0		0
Lint screens	70	81	65		36
Catch basins	72	78	55		20
Heat reclaimers	70	81	25		32
Oil skimmers	15	0	0		0
Equalization tanks	1.2[b]	2.1[c]	0.033[d]		0
pH adjustment	4.1	5.1	15		0
Physical-chemical systems[e]	1.3[b]	0.38[c]	0.033[d]		0
Other[f]	8.1	3.4	0		4.0
Treatment technology for discharge other than to municipal treatment systems					
(Number of responses)	(0)	(0)	(2)[a]	(33)	(0)
Physical-chemical systems[e]			6.3[g]	0	
Biological				42	
Other[h]				27	
None				31	

Note: Blanks indicate data not available.

[a]Number of responses not sufficient to provide valid estimate.

[b]Estimate based on 12 physical-chemical system with equalization tanks operating at the 1,013 industrial laundry indirect dischargers.

[c]Estimate based on 5 physical-chemical systems with equalization operating at the 1,308 linen supply indirect dischargers, plus the 1.7% of linen supplies that have equalization tanks based on survey responses.

[d]Estimate based on 1 physical-chemical system with equalization operating at the 3,078 power laundry indirect dischargers.

[e]Major unit operations consist of chemical addition and floc removal.

[f]Other includes filtration, separators, oil hold back devices, and miscellaneous operations.

[g]Estimate based on 1 physical-chemical system operating at the 16 power laundry direct dischargers.

[h]Other includes filtration, settling, chlorination, and miscellaneous operations.

TABLE 2-22. RESULTS OF CONVENTIONAL TREATMENT - SYSTEM I[a,b] [1]

Pollutant parameter	Number of data points	Concentration				Percent removal	
		Washroom discharge		Sewer discharge			
		Median	Range	Median	Range	Median	Range
Oil and grease, mg/L	9	620	190 - 1,350	480	140 - 1,360	19	0 - 65
BOD_5, mg/L	9	310	170 - 660	300	190 - 970	6	0 - 18
TSS, mg/L	9	500	210 - 1,300	480	270 - 1,600	0	0 - 20
Copper, μg/L	8	120	30 - 690	100	10 - 420	28	0 - 66
Lead, μg/L	9	520	220 - 2,400	270	50 - 1,300	32	0 - 91
Zinc, μg/L	5	450	380 - 860	420	5 - 830	0	0 - 99

[a]Data based on sampling results from three laundries.

[b]System uses a bar screen, lint screen, catch basin, and heat reclaimer.

TABLE 2-23. RESULTS OF CONVENTIONAL TREATMENT - SYSTEM II[a,b] [1]

Pollutant parameter	Number of data points	Concentration				Percent removal	
		Washroom discharge		Sewer discharge			
		Median	Range	Median	Range	Median	Range
Oil and grease, mg/L	3	760	420 - 850	460	420 - 550	51	0 - 72
BOD_5, mg/L	3	310	150 - 540	240	230 - 500	7	0 - 23
TSS, mg/L	3	420	230 - 470	390	280 - 630	17	0 - 33
Copper, µg/L	2	310	220 - 400	270	220 - 320	9	0 - 18
Lead, µg/L	3	700	100 - 1,100	450	350 - 600	40	0 - 50
Zinc, µg/L	3	750	430 - 890	570	370 - 610	14	0 - 29

[a]Data based on sampling results from one laundry.
[b]System uses a bar screen, lint screen, catch basins, oil skimmer, and heat reclaimer.

TABLE 2-24. RESULTS OF CONVENTIONAL TREATMENT - SYSTEM III[a,b] [1]

Pollutant parameter	Number of data points	Concentration				Percent removal	
		Washroom discharge		Sewer discharge			
		Median	Range	Median	Range	Median	Range
Oil and grease, mg/L	3	770	890 - 1,260	740	340 - 1,070	41	0 - 42
BOD_5, mg/L	3	610	450 - 650	710	690 - 730	0	0
TSS, mg/L	3	280	220 - 340	340	240 - 1,450	0	0 - 14
Copper, µg/L	3	300	260 - 350	340	320 - 920	0	0 - 9
Lead, µg/L	3	310	250 - 43,000	450	350 - 600	0	0
Zinc, µg/L	3	960	780 - 2,000	1,500	920 - 1,700	4	0 - 15

[a]Data based on sampling results from one laundry.
[b]System uses a lint screen, catch basins, equalization tank, and heat reclaimer.

found in Section II.2.3 and listed in Tables 2-25 through 2-31. These systems are the most efficient currently in use.

In addition, three other technologies are potentially applicable to this segment of the industry: ultrafiltration, diatomaceous earth filtration, and electrocoagulation.

Both bench- and pilot-scale tests have shown that ultrafiltration (UF) using tubular modules is feasible, but it is not technically or economically feasible to use spirally wound membranes. From a technical standpoint UF systems with tubular modules have advantages over physical-chemical systems utilizing chemical addition and DAF. UF does not incorporate coagulation; thus it does not require chemical additives. Since laundry wastewater is highly variable, it can be difficult to provide an effluent of consistent quality based on a specific coagulant or

TABLE 2-25. RESULTS OF LAUNDRY WASTEWATER TREATMENT WITH ALUM COAGULATION AND DAF[a] [1]

Pollutant parameter	Number of data points	Concentration: Equalization tank Range	Median	Mean	Effluent Range	Median	Mean	Percent removal Range	Median	Mean
Oil and grease, mg/L	3	150 - 260	175	195	11 - 50	43	35	72 - 94	81	82
BOD_5, mg/L	3	180 - 352	340	290	63 - 120	65	83	65 - 81	66	71
TSS, mg/L	3	51 - 510	487	349	16 - 118	24	53	69 - 95	77	80
Phosphorus, mg/L	2	23 - 25	24	24	1.5 - 2.6	2.1	2.1	80 - 93	87	87
Copper, µg/L	3	620 - 1,000	620	660	360 - 130	340	280	45 - 66	64	58
Lead, µg/L	3	100 - 1,300	800	730	10 - 300	60	120	77 - 92	90	86
Zinc, µg/L	3	1,000 - 3,300	1,800	2,000	500 - 1,300	1,000	930	45 - 61	50	52
pH[b]	5	9.9 - 11.0	10.6	-[c]	4.6 - 7.2	7.0	-[c]	-	-	-

[a]Results based on sampling and analysis of laundry effluent from one industrial laundry.
[b]Given in pH units.
[c]Not reported.

TABLE 2-26. RESULTS OF LAUNDRY WASTEWATER TREATMENT WITH CALCIUM CHLORIDE COAGULATION AND DAF[a] [1]

Pollutant parameter	Number of data points	Concentration: Equalization tank Range	Median	Mean	Effluent Range	Median	Mean	Percent removal Range	Median	Mean
Oil and grease, mg/L	13	212 - 1,600	477	647	9 - 230	116	116	57 - 99	77	79
BOD_5, mg/L	7	460 - 2,400	657	1,212	130 - 1,000	345	447	6 - 78	68	59
TSS, mg/L	10	390 - 950	835	741	18 - 240	89	104	71 - 98	88	85
Phosphorus, mg/L	2	13 - 42	27	27	1.7 - 23	12	12	0 - 96	48	48
Copper, µg/L	5	1,000 - 1,700	1,500	1,200	200 - 500	340	300	67 - 80	78	73
Lead, µg/L	10	2,600 - 9,400	4,800	5,400	50 - 700	170	210	89 - 99	98	96
Zinc µg/L	10	1,000 - 4,500	3,200	3,000	10 - 780	150	210	76 - 99	94	93
pH[b]	5	11.0 - 11.6	11.4	-[c]	6.5 - 7.5	7.0	-[c]	-	-	-

[a]Data from sampling of six industrial laundries.
[b]Given in pH units.
[c]Not reported.

TABLE 2-27. RESULTS OF LAUNDRY WASTEWATER TREATMENT WITH FERRIC SULFATE AND DAF[a] [1]

Pollutant parameter	Number of data points	Concentration: Equalization tank Range	Median	Mean	Effluent Range	Median	Mean	Percent removal Range	Median	Mean
Oil and grease, mg/L	8	160 - 580	375	412	13 - 428	24	100	0 - 97	91	76
BOD_5, mg/L	8	485 - 2,000	1,550	1,420	100 - 2,400	235	187	0 - 87	80	87
TSS, mg/L	8	300 - 840	535	536	22 - 770	64	61	0 - 96	89	89
Phosphorus, mg/L	3	12 - 23	22	19	0.05 - 0.49	0.35	0.30	97 - 99	98	98
Copper, µg/L	3	200 - 300	200	230	300 - 500	400	110	0	0	0
Lead, µg/L	6	200 - 600	350	330	20 - 200	750	90	66 - 90	70	73
Zinc, µg/L	8	420 - 1,100	600	670	500 - 1,100	1,100	910	0	0	0
pH[b]	5	-[c]	-[c]	-[c]	5.8 - 7.0	6.1	-[c]	-	-	-

[a]Results are obtained from sampling and analysis of one linen supply laundry.
[b]Given in pH units.
[c]Not reported.

TABLE 2-28. RESULTS OF LAUNDRY WASTEWATER TREATMENT WITH FERROUS SULFATE COAGULATION AND DAF[a] [1]

Pollutant parameter	Number of data points	Concentration: Equalization tank Range	Median	Mean	Effluent Range	Median	Mean	Percent removal Range	Median	Mean
Oil and grease, mg/L	8	347 - 2,600	735	915	12 - 41	27	28	93 - 99	97	97
BOD_5, mg/L	8	757 - 1,900	1,235	1,312	85 - 370	215	209	77 - 91	87	84
TSS, mg/L	8	260 - 1,405	635	710	34 - 190	75	86	58 - 93	90	88
Phosphorus, mg/L	3	17 - 27	21	21	0.05 - 0.33	0.05	0.14	99	99	99
Copper, µg/L	3	800 - 8,000	2,000	3,600	30 - 100	90	730	87 - 99	96	80
Lead, -µg/L	8	3,000 - 13,000	6,700	7,200	20 - 300	100	130	90 - 99	99	98
Zinc, µg/	8	940 - 3,400	2,600	2,500	70 - 300	110	130	85 - 90	95	95
pH[b]	5	10.6 - 11.7	11.3	-[c]	6.6 - 7.7	7.0	-[c]	-	-	-

[a]Results obtained from sampling and analysis at one industrial laundry.
[b]Given in pH units.
[c]Not reported.

TABLE 2-29. RESULTS OF LAUNDRY WASTEWATER TREATMENT WITH POLYELECTROLYTE AND DAF[a] [1]

Pollutant parameter	Number of data points	Concentration: Equalization tank Range	Median	Mean	Effluent Range	Median	Mean	Percent removal Range	Median	Mean
Oil and grease, mg/L	5	400 - 560	420	418	68 - 216	150	193	50 - 88	64	54
BOD_5, mg/L	10	725 - 2,600	1,185	1,385	545 - 1,500	931	944	0 - 62	25	32
TSS, mg/L	9	390 - 3,000	615	904	110 - 670	410	387	0 - 96	32	57
Phosphorus, mg/L	3	1.1 - 6.6	3.6	3.8	0.05 - 0.49	0.35	2.3	97 - 99	98	39
Copper, µg/L	5	90 - 2,000	580	740	70 - 480	180	200	0 - 96	35	73
Lead, µg/L	5	40 - 2,000	950	810	50 - 950	210	320	0 - 84	51	60
Zinc, µg/L	10	170 - 2,000	590	900	70 - 1,000	390	410	0 - 80	45	54
pH[b]	5	8.6 - 10.1	9.7	-[c]	7.5 - 10.0	8.5	-[c]	-	-	-

[a]Results obtained from sampling and analysis of three linen supply laundries.
[b]Given in pH units.
[c]Not reported.

TABLE 2-30. CONCENTRATIONS OF SELECTED ORGANICS IN LAUNDRY WASTEWATER BEFORE AND AFTER TREATMENT, BY TYPE OF CHEMICAL ADDITION[a] [1] (μg/L)

Organic pollutant	System A[b]		System B[c]		System C[d]		System E[e]	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
Anthracene/phenanthrene[f]			20	10	380	70	470	10
Bis(2-ethylhexyl) phthalate	120[g]	100[g]	4,700[g]	450[g]	1,900[g]	610[g]	5,100	110
Butyl benzyl phthalate					310		1,500	40
Chrysene								200
Carbon tetrachloride	1,700	30						40
Pentachlorophenol						30		10
Chloroform					20			
2-Chloronaphthalene	20[g]	20[g]	20	10				
Dichlorobenzenes[f]					1,100	260		20
Chlorobenzene								60
Di-n-butyl phthalate	300[g]	270[g]	30	10	50[g]	150[g]	660	20
1,1-Dichloroethylene								1,000
Di-n-octyl phthalate					150	30	410	
Dichlorobromoethane								290
2,4-Dimethylphenol					460			
1,2-Dichloropropane			10[g]	30[g]				930
Ethylbenzene					1,000[g]	80[g]		
1,2-*Trans*-dichloroethylene							50	
Isophorone					190			
Methylene chloride			220[g]	2,600[g]	320[g]	3,300[g]		
Naphthalene	40		1,200	520	4,000[g]	790[g]	410	100
N-nitrosodiphenylamine					1,800	630		80
Tetrachloroethylene			10[g]	30[g]	190[g]	650[g]		
1,1,1-Trichloroethane	6,600	100			20	10		
Trichloroethylene					210	30		
Toluene			20[g]	80[g]	1,600[g]	840[g]		
Phenol	20[g]	20[g]	20	20	100[g]	100[g]		190
Benzene					90	160		120
Pyrene								20

[a]Blanks indicate concentrations were below 10 μg/L or compound was not detected. Values represent one data point only.

[b]Physical-chemical treatment with alum coagulation and DAF for floc removal.

[c]Physical-chemical treatment with polyelectrolyte coagulation and DAF for floc removal.

[d]Physical-chemical treatment with calcium chloride coagulation and DAF for floc removal.

[e]Physical-chemical treatment with ferrous sulfate coagulation and DAF for floc removal.

[f]Reference reported compound in this form.

[g]Values are median concentrations for two or more data points.

TABLE 2-31. SUMMARY OF LAUNDRY WASTEWATER TREATMENT FOR REMOVAL OF ORGANIC CONTAMINANTS WITH PHYSICAL CHEMICAL SYSTEMS[a] [1]

	Concentration, µg/L								
	Equalization tank			Effluent			Percent removal		
Organic pollutant	Range	Median	Mean	Range	Median	Mean	Range	Median	Mean
Anthracene/phenanthrene	160 - 470	380	290	10 - 66	12	29	25 - 98	83	69
Benzene	130	65	65	120 - 200	160	160	0	0	0
Bis(2-ethylhexyl) phthalate	820 - 9,000	740	2,300	35 - 1,000	140	310	0 - 98	68	63
Butyl benzyl phthalate	170 - 1,500	310	610	42		17	53 - 99	97	83
Carbon tetrachloride	1,700	850	850	30 - 36	33	33	0 - 88	49	49
Chloroform	180	20	38	28	12	15	0 - 76	41	41
2-Chloronaphthalene	14 - 20	17	17	15 - 19	17	17	0 - 5	2	2
Dichlorobenzene	1,100	55	550	18 - 260	140	140	0 - 76	38	38
Di-n-butyl phthalate	660	160	230	11 - 350	100	150	0 - 97	55	48
Di-n-octyl phthalate	28 - 410	150	200	33		12	78 - 99	86	88
2,4-Dimethylphenol	46	230	230	29	15	15	0 - 99	50	50
Ethylbenzene	17,500	25	2,700	970	44	250	0 - 99	3	37
Isophorone	-[b]	190	190	-[b]				99	99
Methylene chloride	10 - 540	57	120	6,000	220	1,400	0 - 91	0	19
Naphthalene	4,800	810	1,700	840	500	450	0 - 99	78	66
N-nitrosodiphenylamine	1,800	900	900	84 - 620	350	350	0 - 66	33	33
Phenol	600	28	110	16 - 190	45	70	0 - 80	0	19
Tetrachloroethylene	880	30	190	1,000	57	350	0 - 94	0	13
1,1,1-Trichloroethane	18 - 6,600	3,300	3,300	14 - 100	57	57	22 - 98	60	60
Trichloroethylene	-[b]	210	210	-[b]	30	30	-[b]	86	86
Toluene	19 - 2,600	250	720	14 - 8,300	380	1,400	0 - 65	0	19

[a]Blanks indicate concentration was below 10 µg/L.

[b]Medians and means represent one data point.

based on a set coagulant dosage rate. UF systems also require less space than comparable physical-chemical systems with DAF.

Removability data for the tubular ultrafiltration module is given in Table 2-32.

TABLE 2-32. RESULTS OF LAUNDRY WASTEWATER TREATMENT USING A TUBULAR ULTRAFILTRATION MODULE [1]

Pollutant parameter	Average concentration, mg/L		Average percent solids of sludge concentration, mg/L	Average percent removal
	Influent	Effluent		
Oil and grease	2,100	86	1.9	96
BOD_5	3,500	310	4.5	91
TSS	1,500	5	-[b]	99

[a]Results obtained from laboratory bench-scale unit.

[b]Not applicable.

Diatomaceous earth (DE) filters applied to treatment of laundry wastewater were found to be generally capable of excellent removal of suspended solids but not of colloidal matter. Wastewater at a linen supply laundry with an average flowrate of 530 m^3/day (140,000 gpd) was treated by DE filtration. Effluent from an equalization tank was injected with DE and a proprietary oil adsorbent, then pumped through precoated pressure filters. Capabilities of this system, in terms of removing pollutants, are given in Table 2-33. The system was in full-scale operation; however, it has since been replaced by a treatment system using calcium chloride coagulation and DAF.

TABLE 2-33. RESULTS OF LAUNDRY WASTEWATER TREATMENT USING DIATOMACEOUS EARTH FILTRATION[a] [1]

Pollutant parameter	Number of data points	Concentration				Percent removal	
		Equalization tank		Effluent			
		Median	Range	Median	Range	Median	Range
Oil and grease, mg/L	5	390	250 - 430	210	180 - 350	43	0 - 53
BOD_5, mg/L	5	610	460 - 680	460	350 - 340	32	0 - 43
TSS, mg/L	5	460	330 - 680	200	140 - 210	65	39 - 75
Lead, µg/L	4	300	200 - 600	200	50 - 300	45	0 - 99
Zinc, µg/L	5	570	430 - 1,100	430	340 - 500	35	0 - 55

[a]Data obtained from 1 laundry; system is no longer in operation.

Electrocoagulation (EC) systems are designed to treat laundry wastewater through two mechanisms. With the first, electrolysis includes coagulation by neutralizing or imparting a positive charge to negatively charged colloidal material. With the second, microbubbles formed as a result of electrolysis float the resulting floc to the surface of the contained effluent where it can be skimmed off.

In EC pilot tests chemical addition was required prior to electrolysis to achieve removal of pollutants. Alum, sulfuric acid, and polymer were added to the laundry effluent. Test results of laundry wastewater treatment using chemical addition and electrolysis are given in Table 2-34.

TABLE 2-34. RESULTS OF LAUNDRY WASTEWATER TREATMENT USING A PILOT ELECTROCOAGULATION SYSTEM[a] [1]

Pollutant parameter	Number of data points	Concentration				Percent removal	
		Influent		Effluent			
		Median	Range	Median	Range	Median	Range
Oil and grease, mg/L	4	530	380 - 690	79	74 - 146	80	75 - 89
BOD_5, mg/L	4	770	660 - 960	270	140 - 600	70	9 - 82
TSS, mg/L	4	290	250 - 330	140	120 - 170	53	48 - 51
Copper, µg/L	4	200	200 - 300	100	100 - 200	50	33 - 50
Lead, µg/L	1	1,100	-	20	-	98	-
Zinc, µg/L	4	640	460 - 760	350	300 - 440	40	35 - 53

[a]System incorporates chemical addition with alum, sulfuric acid, and polymer at average dosage rates of 1,100 mg/L, 850 mg/L, and 4 mg/L, respectively.

Other technologies have been tested on laundry wastewaters with varying degrees of success. In general, these techniques are not applicable to the pollutants present or are not considered economically competitive. They include reverse osmosis, foam separation, distillation and carbon adsorption.

II.2.3 REFERENCES

1. Technical Support Document for Auto and Other Laundries Industry (draft contractor's report). Contract 68-03-2550, U.S. Environmental Protection Agency, Washington, D.C., August 1979.

2. Status Report on the Treatment and Recycle of Wastewaters from the Car Wash Industry (draft contractor's report). Contract 68-01-5767, U.S. Environmental Protection Agency, Washington, D.C., July 1979.

3. NRDC Consent Decree Industry Summary - Auto and Other Laundries.

II.3 COAL MINING

II.3.1 INDUSTRY DESCRIPTION [1, 2]

II.3.1.1 General Description

Coals are classified into several ranks or types related to chemical composition and physical characteristics. The standard classes are anthracite, bituminous, subbituminous, and lignite. All ranks of coal are mined by the coal industry, which can be divided into the following two segments: (1) the production of anthracite, and (2) the production of bituminous coal, subbituminous coal, and lignite. The industry can also be divided by production processes into coal mining and coal services (coal cleaning and coal preparation), as indicated by the major SIC categories for this industry:

SIC 1111 Anthracite Mining
SIC 1112 Anthracite Mining Services
SIC 1211 Bituminous Coal and Lignite Mining
SIC 1213 Bituminous Coal and Lignite Mining Services

Once historically significant in the economic and industrial growth of the United States, the importance of anthracite coal as an energy source in this nation has been declining in recent years. Consequently, the anthracite industry is currently under consideration by the EPA for exemption from BATEA regulations.

The mining of bituminous coal and lignite constitutes the major portion of the coal mining industry. U.S. Geological Survey estimates indicate that bituminous coal and lignite currently comprise over 99% of the nation's total coal reserves.

According to the Bureau of Mines there were 6,168 active bituminous coal and lignite mines in the industry in 1975. The majority of the mines were small operations, with individual production of less than 90,700 Mg (100,000 tons) per year. Although these small mines comprised over 80% of the active facilities in 1975, they accounted for less than 20% of the bituminous coal production. Large mines producing greater than 90,700 Mg per year represented less than 20% of the facilities, but produced almost 81% of the coal. The recent trend has been toward larger mines and consolidation of mining companies.

The coal mining industry currently operates in 25 states located in Appalachia, the Midwest, and the Mountain and Pacific regions. The six leading coal producing states in 1975 were, in order of output, Kentucky, West Virginia, Pennsylvania, Illinois, Ohio, and Virginia. Production in these states accounted for 74% of the total U.S. output.

Table 3-1 presents industry summary data for the Coal Mining point source category in terms of the number of subcategories, number of dischargers, pollutants and toxics found in significant quantities, total number of toxic pollutants detected, and candidate treatment and control technologies [1, 3].

TABLE 3-1. INDUSTRY SUMMARY [1, 3]

Industry: Coal Mining
Total Number of Subcategories: 3
Number of Subcategories Studied: 3

Number of Dischargers in Industry:

- Direct: 6,000
- Indirect: 0
- Zero: Not available

Pollutants and Toxics Found in Significant Quantities

Methylene chloride	2,6-Dinitrotoluene
Chloroform	Chlorobenzene
Bis(2-ethylhexyl) phthalate	Suspended solids
Benzene	Iron
Toluene	Manganese
1,1,2,2-Tetrachloroethylene	Antimony
1,2-*Trans*-dichloroethylene	Arsenic
Di-n-butyl phthalate	Chromium
1,1,1-Trichloroethane	Copper
Trichlorofluoromethane	Lead
Ethylbenzene	Mercury
1,2-Dichloroethane	Nickel
Anthracene/Phenanthrene	Thallium
	Zinc

Number of Toxic Pollutants Found in:

	Raw wastewater	Treated effluent
Acid or ferruginous mines	15	16
Alkaline mines	29	48
Preparation plants	54	28

Candidate Treatment and Control Technologies:

Aeration	Carbon adsorption
Neutralization	Filtration
Sedimentation	Flocculation
Ozonation	Ion exchange
Reverse osmosis	Starch xanthate

II.3.1.2 Subcategory Descriptions

Based on similarities in raw materials, final products, manufacturing processes, and waste characteristics, the following subcategories of the coal mining industry were established [1]:

1. Acid or Ferruginous Mines
2. Alkaline Mines
3. Coal Preparation Plants and Associated Areas

Since wastewater characteristics within each of the subcategories are similar, these three subcategories are adequate to characterize the coal mining and preparation industries for the purpose of establishing effluent guidelines for the best available technology economically achievable (BATEA).

Subcategory 1 - Acid or Ferruginous Mines

Characterizing the industry according to the quality of mine drainage is difficult because of the lack of readily available information on a mine-by-mine basis. However, the 1976 Development Document for the Coal Mining point source category generally categorizes mines in Maryland, Ohio, Pennsylvania, and northern West Virginia as being potentially acid or ferruginous [1]. According to the Bureau of Mines, there are an estimated 2,605 mines located in acid areas. Mines that are potentially acid make up a large portion of the bituminous surface mining facilities. Almost 50% of the surface mines reported by the Bureau of Mines in 1975 could be classified as potentially acid or ferruginous. Acid drainage, however, does not appear to be as much of a problem among deep mines in the bituminous industry. Approximately 70% of these mines can be categorized as having alkaline drainage.

Acid mine drainage is generated under natural conditions when pyritic coal seams are mined. The pyrites or iron sulfides contained in the coal and associated strata are exposed to the atmosphere during the mining process. In the presence of oxygen, water, and certain species of oxidizing bacteria (*Thiobacillus ferroxidans* and *Ferrobacillus ferroxidans*), these sulfides oxidize to ferrous sulfate, forming an acidic, ferruginous leachate.

Subcategory 2 - Alkaline Mines

Most bituminous and lignite coal mines are located in areas where the potential for the formation of acid mine drainage does not exist. According to estimates made by the Bureau of Mines, there are 3,563 bituminous coal and lignite mines which can be classified as having alkaline drainage (50% of the surface mines and 70% of the underground mines).

Alkaline mine drainage can be generated under natural conditions similar to those found in mines with acid drainage. Iron sulfides, however, are transformed into ferrous bicarbonates, and an alkaline iron-bearing water is produced. Additionally, there are large areas of coal reserves where the naturally occurring associated groundwaters are alkaline. The coal in these areas is usually lower in pyritic sulfur, and the resulting mine drainages do not develop the low pH characteristic of acid mine drainage.

Subcategory 3 - Coal Preparation Plants and Associated Areas

The physical coal cleaning processes used today are oriented toward product standardization and reduction of ash, with increasing attention being placed on sulfur reduction. Coal preparation in commercial practice is currently limited to physical processes. In a modern coal cleaning plant, the coal is typically subjected to: (1) size reduction and screening, (2) gravity separation of coal from its impurities, and (3) dewatering and drying.

The commercial practice of coal cleaning is currently limited to separation of the impurities based on differences in the specific gravity of coal constituents (i.e., gravity separation process) and on the differences in surface properties of the coal and its mineral matter (i.e., froth flotation).

Coal preparation can be classified into five general levels. Levels 1 to 3 are generally used in the preparation of steam coal. Level 4 is used for metallurgical grade coal, and Level 5 has not yet been commercially demonstrated in this country. The five general levels of coal preparation are described below.

Level 1 - Crushing and Drying. Level 1 plants use rotary breaker crushers and screens for top size control and for the removal of coarse refuse. No washing is done and the entire process is dry. Since most removal of pyritic sulfur is accomplished by hydraulic separation, this level of cleaning is inefficient for reducing sulfur levels.

Level 2 - Coarse Size Coal Beneficiation. Level 2 cleaning plants, in addition to crushing and screening raw coal, also perform wet beneficiation of the coarse material with a jig or dense medium vessel. The fine material is mixed with the coarse product without washing. A finer sizing of the coal is accomplished than in Level 1. This system provides removal of only coarse pyritic sulfur material and is therefore recommended for a moderate pyritic sulfur content coal.

Level 3 - Coarse and Medium Size Coal Beneficiation. Level 3 cleaning is basically an extension of Level 2. Coal is crushed and separated into three size fractions by wet screening. The coarse material is cleaned in a coarse coal circuit. Medium fractions are beneficiated by hydrocyclones, concentrating tables, or dense medium cyclones. Fine coal is dewatered and shipped with the clean coal or discarded as refuse. However, the level of beneficiation is not substantially greater than that of Level 2 with respect to sulfur removal and this system is recommended for use on low and medium sulfur coals which are relatively easy to wash. This process provides rejection of free pyrite and ash, as well as enhancement of energy content.

Level 4 - Coarse, Medium, and Fine Size Coal Beneficiation. In Level 4 preparation, coal is crushed and separated into three or more size fractions by wet screening. All size fractions are beneficiated. Heavy media processes are used for cleaning coarse and medium size fractions. Froth flotation processes or hydrocyclone processes are used for cleaning fine particles. Level 4 coal preparation systems provide high efficiency cleaning of coarse and fine coal fractions with lower efficiency cleaning of the ultrafines. This method accomplishes free pyrite rejection and improvement of Btu content.

Level 5 - "Deep Cleaning" Coal Beneficiation. Level 5 cleaning is basically Level 4 preparation in which one size fraction is rigorously cleaned to meet a low sulfur-low ash product specification. Two or three coal products are produced to various market specifications. This level also uses a fine coal recovery circuit to increase total plant recovery. Coal preparation processes are discussed in greater detail in the open literature.

There were 388 preparation plants processing bituminous coal and lignite in 1975 according to the Bureau of Mines [1]. Ninety-five percent of the preparation plants listed in the 1976 Keystone Coal Industry Manual used wet processing methods [1]. Only 21 plants were found to use dry processes. The majority of the wet processing plants use either heavy media separation or froth flotation, or both.

Wastewater from coal preparation emanates from two different sources: (1) process-generated wastewater, and (2) wastewater from associated areas which include coal preparation plant yards, immediate access roads, slurry ponds, drainage ponds, coal refuse piles, and coal storage piles and facilities.

The liquid discharges from coal preparation plants are often combined with discharges of the associated storage piles, refuse areas, and plant areas prior to final effluent treatment. The wastewater from these areas is characterized as being similar to the raw mine drainage at the mine being served by the preparation plant. Consequently, some refuse piles produce an acid leachate and others produce an alkaline leachate. The origin of the acid leachate is the same as that for acid mine drainage, and its prevention is the same; i.e., keep water away from the pyrites.

II.3.2 WASTEWATER CHARACTERIZATION [1]

This section describes the sources and characteristics of wastewater from the coal mining industry. No wastewater is purposely generated in the extractive portion of coal mining because water is almost always a hindrance and an extra expense to pump and treat. A minor exception is the use of water for dust suppression and equipment cooling. Water enters coal mines via precipitation, groundwater infiltration, and surface runoff, and it can become polluted by contact with materials in the coal, overburden, or mine bottom. Most water entering underground mines passes through the mine roof from overlying strata (rock units). These rock units generally have well developed joint systems, which tend to cause vertical flow. Chemicals used in mining and repair of mining machinery may also be wastewater pollutants. Mine water is therefore considered a wastewater for the mining segment of the coal industry. It is discharged as mine drainage which may require treatment before it can enter into surface waters.

Based on these considerations and the industry categorization, it is possible to characterize wastewater from the coal mining industry in the following way.

- I. Mining of Anthracite, Bituminous Coal, and Lignite
  - A. Acid or Ferruginous Mines
    - 1. Raw Mine Drainage (untreated mine drainage definitely requiring neutralization and sedimentation treatment)
    - 2. Treated Mine Drainage
  - B. Alkaline Mines
    - 1. Raw Mine Drainage
    - 2. Discharge Effluent (untreated mine drainage of generally acceptable quality; i.e., not requiring neutralization or sedimentation)
    - 3. Sediment-Bearing Effluent (mine drainage which has passed through settling ponds or basins without a neutralization treatment)
- II. Mining Services for Anthracite, Bituminous Coal, and Lignite
  - A. Coal Preparation Plant Wastewater
  - B. Coal Storage, Refuse Storage, and Coal Preparation Plant Ancillary Wastewater

II.3.2.1 Subcategory 1 - Acid or Ferruginous Mines

Drainage from acid mines presents the most serious threat to the environment from the coal mining category. Acidity is deleterious to a variety of forms of life including fish and benthic organisms. The ferruginous components (ferric ion and ferrous ion), though not highly toxic in themselves, do contribute to the formation of insoluble hydroxides which coat benthic organisms, cover other aquatic food sources, and block fish gills. The acidic nature of this wastewater creates a strong solvent for many metals and minerals, and the data base confirms the elevated levels of many classical pollutants and heavy metals derived from both the coal seams and the associated strata.

All operations studied dewater their mines either on an intermittent or continual basis. The amount of wastewater discharged from these facilities varies considerably, ranging from approximately 3,800 to 265,000 m^3/d (1 to 7 Mgal/d).

II.3.2.2 Subcategory 2 - Alkaline Mines

The data base for this study shows that heavy metals and other toxic pollutants are seldom present in elevated concentrations in alkaline mine drainage, but alkaline wastewaters may be high in suspended solids and require settling.

Over 50% of the facilities studied in this subcategory dewater their mines on a continual basis. Of the rest, dewatering occurs only infrequently or not at all. The amount of wastewater discharged from these facilities ranges from 0 to 9,500 m^3/d (0 to 2.5 Mgal/d).

II.3.2.3 Subcategory 3 - Coal Preparation Plants and Associated Areas

Since cleaning techniques generally require an alkaline medium for efficient and economic operation, process water does not dissolve appreciable quantities of the metallic minerals present in raw coal. On the other hand, some minerals and salts such as chlorides and sulfates of the alkalies and the alkaline earth metals found in raw coal dissolve easily in water. The principal pollutant present in preparation plant process water, however, is suspended solids. Process water from plants using froth flotation (Level 4 preparation plants) typically contains less suspended solids than such water from plants that do not recover coal fines.

All preparation plants studied use water in their cleaning processes, and 17 of 18 recycle at least 50% of their process water. The total process water circulated varied from 830 to 12,700 L/Mg

(240 to 3,700 gal/ton) of coal processed, and process water discharges to surface waters ranged from no discharge to 1,630 L/Mg of coal produced (475 gal/ton).

Tables 3-2 through 3-4 present the toxic pollutants detected for raw wastewater and secondary effluents, by subcategory. Tables 3-5 through 3-7 present conventional and classical pollutant raw wastewater and treated effluent concentrations, by subcategory. Values are generated from plant specific verification data presented in Section II.3.3.

II.3.3 PLANT SPECIFIC DESCRIPTION [1]

Reference 1 cites verification data for approximately 18 sample locations representative of 7 plants. Nine of the 18 sample locations (representative of 7 plants) had data for both untreated and treated wastewater, and 9 (representative of 3 plants) had data for treated wastewater only. Tables 3-8 through 3-18 present toxic pollutant and classical pollutant data for these 18 sample locations on a plant specific basis, by subcategory.

Verification data were not available to describe "associated areas," which is consequently defined based on screening data alone. Table 3-19 presents plant specific data for "associated areas."

Unless otherwise noted, all values are averages based upon a 3-day sampling period. Whenever a less-than value was encountered, its limit value was used to compute the given average. Unless present in all of the initial values, the less-than symbol (<) was dropped from the final average.

II.3.4 POLLUTANT REMOVABILITY

Full-scale treatment methods that have been cited in the literature, but for which no data were presented, include: neutralization sometimes followed by aeration and oxidation of Fe (II) to Fe (III), reverse osmosis, ion exchange, settling, ozonation, mixed media filtration, and engineering design (planning) to prevent acid formation (entailing oxygen, water, and contact time exclusion).

II.3.5 REFERENCES

1. Technical Assistance in the Implementation of the BAT Review of the Coal Mining Industry Point Source Category (draft contractor's report). Contracts 68-01-3273, 68-01-4762, and 68-02-2618, U.S. Environmental Protection Agency, Washington, D.C., March 1979.

2. Development Document for Interim Final Effluent Limitations Guidelines and New Source Performance Standards for the Coal Mining Point Source Category. EPA 440/1-75/057 Group II, U.S. Environmental Protection Agency, Washington, D.C., October 1975.

3. NRDC Consent Decree Industry Summary - Coal Mining.

TABLE 3-2. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN ACID OR FERRUGINOUS MINE WASTEWATER [1]

	Raw wastewater			Treated effluent		
Toxic pollutants	Number of sample locations	Range	Median	Number of sample locations	Range	Median
Metals and inorganics, mg/L						
Antimony	1	0.034	0.034	1	0.016	0.016
Arsenic	1	0.028	0.028	1	0.027	0.027
Asbestos	NA	NA	NA	NA	NA	NA
Beryllium	1	0.009	0.009	1	<0.001	<0.001
Cadmium	1	0.010	0.010	1	<0.002	<0.002
Chromium	1	0.080	0.080	1	0.020	0.020
Copper	1	0.043	0.043	1	<0.006	<0.006
Cyanide	1	<0.005	<0.005	1	<0.006	<0.006
Lead	1	0.100	0.100	1	<0.020	<0.020
Mercury	–[a]	–[a]	–[a]	–[a]	–[a]	–[a]
Nickel	1	1.000	1.000	1	<0.005	<0.005
Selenium	1	0.002	0.002	1	0.003	0.003
Silver	1	0.003	0.003	1	0.003	0.003
Thallium	1	0.008	0.008	1	<0.005	<0.005
Zinc	1	2.00	2.00	1	<0.060	<0.060
Phthalates, μg/L						
Bis(2-ethylhexyl) phthalate				1	<6.7	<6.7
Di-n-butyl phthalate	1	<10	<10	1	<10	<10
Diethyl phthalate	1	<10	<10	1	<10	<10

[a]Analysis not received.

TABLE 3-3. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN ALKALINE MINE WASTEWATER [1]

Toxic pollutants	Raw wastewater: Number of sample locations	Raw wastewater: Range	Raw wastewater: Median	Treated effluent: Number of sample locations	Treated effluent: Range	Treated effluent: Median
Metals and inorganics, mg/L						
Antimony	5	<0.002 - 0.006	<0.002	14	<0.002 - 0.016	<0.005
Arsenic	1	<0.002	<0.002	13	<0.002 - 0.009	0.002
Asbestos	NA	NA	NA	NA	NA	NA
Beryllium	1	<0.001	<0.001	9	<0.001	<0.001
Cadmium	1	0.002	0.002	9	<0.002 - 0.004	<0.002
Chromium	1	0.100	0.100	9	0.020 - 0.070	0.048
Copper	1	<0.006	<0.006	9	<0.006 - 0.008	<0.006
Cyanide	5	<0.005	<0.005	14	<0.005 - <0.050	<0.005
Lead	1	<0.020	<0.020	9	<0.020 - 0.267	<0.020
Mercury	-[a]	-[a]	-[a]	4	<0.001	<0.001
Nickel	1	<0.005	<0.005	9	<0.005 - 0.027	<0.005
Selenium	5	<0.002 - <0.005	0.002	14	<0.002 - 0.005	<0.002
Silver	5	<0.005 - 0.01	<0.005	14	<0.005 - <0.01	<0.005
Thallium	5	<0.005	<0.005	14	<0.005 - 0.006	<0.005
Zinc	1	<0.060	<0.060	14	<0.060 - 0.073	<0.060
Phthalates, μg/L						
Bis(2-ethylhexyl) phthalate	4	ND - <10	<1.7	13	ND - <10	<6.7
Butyl benzyl phthalate	4	ND - <10	ND	13	ND - <10	ND
Di-n-butyl pthalate	4	<10	<10	13	<3.3 - <10	<10
Diethyl phthalate	4	ND - <10	ND	13	<6.7 - <10	<10
Di-n-octyl phthalate				13	ND - <10	ND
Nitrogen compounds, μg/L						
3-3'-Dichlorobenzidine				13	ND - <6.7	ND
1,2-Diphenylhydrazine				13	ND - <10	ND
N-nitrosodiphenylamine				13	ND - <6.7	ND
Phenols, μg/L						
2,4-Dinitrophenol				1	<3.3	<3.3
Pentachlorophenol				1	<3.3	<3.3
Phenol	4	ND - <10	ND	13	ND - <10	ND

(continued)

TABLE 3-3 (continued)

Toxic pollutants	Raw wastewater: Number of sample locations	Raw wastewater: Range	Raw wastewater: Median	Treated effluent: Number of sample locations	Treated effluent: Range	Treated effluent: Median
Monocyclic aromatics, µg/L						
Benzene				13	ND - <6.7	ND
1,2-Dichlorobenzene	4	ND - <10	ND	13	ND - <10	ND
1,4-Dichlorobenzene	4	ND - <10	ND	13	ND - <10	ND
Ethylbenzene				13	ND - <6.7	ND
Toluene				13	ND - <6.7	ND
Polycyclic aromatic hydrocarbons, µg/L						
Anthracene	4	ND - <10	ND	13	ND - <10	ND
Benz(a)anthracene				13	ND - <10	ND
Benzo(ghi)perylene	4	ND - <10	ND	13	ND - <3.3	ND
Dibenz(ah)anthracene	4	ND - <10	ND	13	ND - 8	ND
Fluoranthene				13	ND - <6.7	ND
Indeno(1,2,3-cd)pyrene	4	ND - <10	ND	13	ND - 6.3	ND
Naphthalene				13	ND - <10	ND
Pyrene				13	ND - <3.3	ND
Halogenated aliphatics, µg/L						
Carbon tetrachloride	4	ND - <10	ND	13	ND - <6.7	ND
Chloroform				13	ND - <10	ND
1,2-Dichloroethane	4	ND - <10	ND	13	ND - <3.3	ND
1,1-Dichloroethylene				13	ND - <10	ND
Hexachloroethane				13	ND - <6.7	ND
Methylene chloride	4	ND - <10	<1.7	13	ND - 21	<3.3
1,1,1-Trichloroethane	4	ND - <10	ND	13	ND - <10	ND
1,1,2-Trichloroethane				13	ND - <3.3	ND
Trichloroethylene				13	ND - <3.3	ND
Pesticides and metabolites, µg/L						
Aldrin				9	ND - <3.3	0.003
α-BHC				9	ND - 0.02	ND
δ-BHC				9	ND - 0.05	ND
γ-BHC	3	ND - <10	ND	9	ND - <10	ND
Heptachlor				9	ND - <3.3	ND
Heptachlor epoxide				9	ND - <6.7	ND

[a]Analysis not received.

TABLE 3-4. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN PREPARATION PLANT WASTEWATER [1]

Toxic pollutants	Raw wastewater: Number of sample locations	Raw wastewater: Range	Raw wastewater: Median	Treated effluent: Number of sample locations	Treated effluent: Range	Treated effluent: Median
Metals and inorganics, mg/L						
Antimony	3	0.002 - 0.034	<0.005	3	<0.005 - 0.007	0.006
Arsenic	3	0.051 - 0.253	0.18	3	0.002 - 0.035	<0.005
Asbestos	NA	NA	NA	NA	NA	NA
Beryllium	3	<0.010 - 0.057	<0.01	3	<0.001	<0.001
Cadmium	3	<0.020	<0.020	3	<0.002 - 0.003	<0.002
Chromium	3	0.233 - 0.530	0.367	3	0.013 - 0.043	0.013
Copper	3	0.233 - 1.33	0.687	3	0.006 - 0.009	0.008
Cyanide	3	<0.005	<0.005	3	<0.005	<0.005
Lead	3	0.400 - 0.967	0.467	3	<0.020 - 0.053	0.023
Mercury	-[a]	-[a]	-[a]	-[a]	-[a]	-[a]
Nickel	3	0.217 - 1.23	0.30	3	0.003 - 0.100	0.01
Selenium	3	<0.003 - 0.034	<0.005	3	0.003 - 0.006	0.003
Silver	3	<0.002 - <0.005	<0.005	3	<0.002 - <0.005	<0.005
Thallium	3	<0.005 - 0.015	0.006	3	<0.005	<0.005
Zinc	3	<0.600 - 5.33	<0.600	3	<0.060 - 0.06	<0.060
Ethers, µg/L						
Bis(2-chloroethoxy) methane				3	ND - <3.3	ND
4-Chlorophenyl phenyl ether	3	ND - 3.3	ND			
Phthalates, µg/L						
Bis(2-ethylhexyl) phthalate	3	<10 - 50	<10	3	<3.3 - <6.7	<6.7
Butyl benzyl phthalate	3	<3.3 - <10	<10	3	ND - <3.3	ND
Di-n-butyl phthalate	3	<3.3 - <10	<6.7	3	<3.3 - <10	<3.3
Diethyl phthalate	3	<3.3 - <10	<3.3	3	<3.3 - <10	<3.3
Dimethyl phthalate	3	ND - <3.3	ND			
Di-n-octyl phthalate	3	ND - <3.3	ND			
Nitrogen compounds, µg/L						
1,2-Diphenylhydrazine	3	ND - <3.3	ND			
N-nitrosodiphenylamine	3	ND - 30	ND			
Phenols, µg/L						
2-Chlorophenol	3	ND - 36	ND			
2,4-Dimethylphenol	3	ND - 22	ND			
2-Nitrophenol	3	ND - 19	ND			
Phenol	3	ND - <10	<10	3	ND - <6.7	<3.3
Cresols, µg/L						
4,6-Dinitro-o-cresol	3	ND - 194	ND			

(continued)

TABLE 3-4 (continued)

Toxic pollutants	Raw wastewater: Number of sample locations	Raw wastewater: Range	Raw wastewater: Median	Treated effluent: Number of sample locations	Treated effluent: Range	Treated effluent: Median
Monocyclic aromatics, µg/L						
Benzene	3	ND - 15	<3.3			
2,4-Dinitrotoluene	3	ND - 6	ND			
Ethylbenzene	3	ND - <6.7	ND	3	ND - <3.3	ND
Nitrobenzene	3	ND - 7	ND			
Toluene	3	ND - 8	ND	3	ND - 7.3	ND
Polycyclic aromatic hydrocarbons, µg/L						
Acenaphthene	3	ND - <10	<3.3			
Acenaphthylene	3	ND - 8	ND			
Anthracene	3	<10 - 132	33	3	ND - <3.3	<3.3
Benz(a)anthracene	3	6 - 10.3	<10			
Benzo(a)pyrene	3	<10 - 12	<10			
Benzo(ghi)perylene	3	<3.3 - 12	<10			
Benzo(k)fluoranthene	3	<3.3 - 12	<10			
Chrysene	3	ND - 29	ND			
Dibenz(ah)anthracene	3	ND - <3.3	ND			
Fluoranthene	3	<6.7 - 16	<10			
Fluorene	3	<6.7 - 42	<10			
Indeno(1,2,3-cd)pyrene	3	ND - <6.7	ND			
Naphthalene	3	<10 - 402	43.5			
Pyrene	3	<3.3 - 19	<10			
Polychlorinated biphenyls and related compounds, µg/L						
2-Chloronaphthalene	3	ND - <3.3	ND			
Halogenated aliphatics, µg/L						
Chloroform	3	ND - <6.7	ND	3	ND - <6.7	ND
Methylene chloride	3	ND - 82	ND	3	ND - 19	<3.3
1,1,2,2-Tetrachloroethane				3	ND - <3.3	ND
Tetrachloroethylene				3	ND - <3.3	ND
1,1,1-Trichloroethane	3	ND - 7.67	ND	3	ND - <3.3	ND
Trichloroethylene	3	ND - <10	ND	3	ND - <10	<10
Pesticides and metabolites, µg/L						
α-Endosulfan	3	ND - <6.7	ND			
β-Endosulfan	3	ND - <6.7	ND			
Isophorone	3	ND - 307	ND			

[a]Analysis not received.

TABLE 3-5. WASTEWATER CHARACTERIZATION, ACID OR FERRUGINOUS MINES[1]

Influent flowrate, gpd: 5,970,000

	Raw wastewater			Treated effluent		
Characteristics	Number of sample locations	Range	Median	Number of sample locations	Range	Median
COD, mg/L	1	62.7	62.7	1	4.6	4.6
TOC, mg/L	1	8.0	8.0	1	3.9	3.9
pH	1	4.4	4.4	1	8.2	8.2

TABLE 3-6. WASTEWATER CHARACTERIZATION, ALKALINE MINES [1]

Influent flowrate, gpd: 53,000 median (2,880 to 710,000 range at 5 sample locations)

	Raw wastewater			Treated effluent		
Characteristics	Number of sample locations	Range	Median	Number of sample locations	Range	Median
COD, mg/L	5	14.3 - 90.7	24.0	14	13.7 - 136	22.5
TOC, mg/L	5	7.2 - 57.0	23.3	14	2.9 - 65.3	7.8
Total phenols, mg/L	5	<0.010 - <0.020	<0.010	14	<0.010 - <0.020	<0.010
pH	5	6.6 - 8.2	7.6	14	6.3 - 8.5	7.8

Date: 6/21/79

TABLE 3-7. WASTEWATER CHARACTERIZATION, PREPARATION PLANTS [1]

Influent flowrate, gpd: 9,976,000 median (274,000 to 12,432,960 range at 3 sample locations)

	Raw wastewater			Treated effluent		
Characteristics	Number of sample locations	Range	Median	Number of sample locations	Range	Median
COD, mg/L	3	20,724 - 48,792	36,300	3	19.2 - 118.7	20.3
TOC, mg/L	3	1,492 - 8,447	2,868	3	6.8 - 96.8	19.1
Total phenols, mg/L	3	<0.010 - <0.020	<0.010	3	<0.010 - <0.020	<0.010
pH	3	6.6 - 7.3	6.87	3	6.8 - 7.4	6.9

TABLE 3-8. WASTEWATER CHARACTERIZATION, MINE NC-20 [1]

Category: Coal Mining
Subcategory: Acid or Ferruginous Mines
Raw wastewater flowrate, gpd: 5,790,000

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L	134.4	47
Total volatile solids, mg/L	391.3	90
Settleable solids, mL/L	1.4	<0.1
COD, mg/L	62.7	4.6
TOC, mg/L	8.0	3.9
pH	4.4[d]	8.2[d]
Phenol, mg/L	<0.010	<0.010
Metals, mg/L		
Aluminum	46.7	0.133
Antimony	0.034	0.016
Arsenic	0.028[d]	0.027
Barium	<0.005	<0.005
Beryllium	0.009	<0.001
Boron	0.333	0.267
Cadmium	0.010	<0.002
Calcium	367	570
Chromium	0.080	0.020
Cobalt	0.367	<0.005
Copper	0.043	<0.006
Iron	167	0.233
Lead	0.100	<0.020
Magnesium	100	57.3
Manganese	10	0.833
Mercury	-[e]	-[e]
Molybdenum	0.083	<0.005
Nickel	1.000	<0.005
Selenium	0.002	0.003
Silver	0.003	0.003
Sodium	403	427
Thallium	0.008	<0.005
Tin	0.093	0.020
Titanium	<0.020	<0.020
Vanadium	0.040	<0.010
Yttrium	0.167	<0.020
Zinc	2.00	<0.060
Cyanide	<0.005	<0.005
Toxic pollutants, µg/L		
Acenaphthene	-[e]	ND
Benzene	-[e]	ND
Carbon tetrachloride	-[e]	ND
Chlorobenzene	-[e]	ND
Hexachloroethane	ND	ND
1,2-Dichloroethane	-[e]	ND
1,1,1-Trichloroethane	-[e]	ND
1,1,2-Trichloroethane	-[e]	ND
1,1,2,2-Tetrachloroethane	-[e]	ND
2-Chloronaphthalene	ND	ND
Chloroform	-[e]	ND
2-Chlorophenol	ND	ND

(continued)

TABLE 3-8 (continued)

Pollutant	Wastewater characterization[a]: Raw wastewater characterization[b]	Wastewater characterization[a]: Treated effluent concentration[c]
Toxic pollutants, µg/L (cont'd)		
1,2-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
3,3'-Dichlorobenzidine	ND	ND
1,1-Dichloroethylene	-[e]	ND
2,4-Dimethylphenol	ND	ND
2,4-Dinitrotoluene	ND	ND
1,2-Diphenylhydrazine	ND	ND
Ethylbenzene	-[e]	ND
Fluoranthene	ND	ND
4-Chlorophenyl phenyl ether	ND	ND
Bis(2-chloroethoxy)methane	ND	ND
Methylene chloride	-[e]	ND
Bromoform	-[e]	ND
Trichlorfluoromethane	-[e]	ND
Isophorone	ND	ND
Naphthalene	ND	ND
Nitrobenzene	ND	ND
2-Nitrophenol	ND	ND
4,6-Dinitro-*o*-cresol	ND	ND
N-nitrosodiphenylamine	ND	ND
Phenol	ND	ND
Bis(2-ethylhexyl) phthalate	ND	<6.7
Butyl benzyl phthalate	ND	ND
Di-n-butyl phthalate	<10	<10
Di-n-octyl phthalate	ND	ND
Diethyl phthalate	<10	<10
Dimethyl phthalate	ND	ND
Benz(a)anthracene/chrysene	ND	ND
Benzo(a)pyrene	ND	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene	ND	ND
Acenaphthylene	ND	ND
Anthracene/phenanthrene	ND	ND
Benzo(ghi)perylene	ND	ND
Fluorene	ND	ND
Dibenz(ah)anthracene	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND
Pyrene	ND	ND
Tetrachloroethylene	-[e]	ND
Toluene	-[e]	ND
Trichloroethylene	-[e]	ND
Aldrin	ND	ND
α-Endosulfan	ND	ND
β-Endosulfan	ND	ND
Endrin	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
α-BHC	ND	ND
γ-BHC	ND	ND
δ-BHC	ND	ND

[a] All data based on 3-day sampling, except as noted.

[b] Raw mine water.

[c] Treated effluent.

[d] Data based on 2 days.

[e] Analysis not available.

TABLE 3-9. WASTEWATER CHARACTERIZATION, MINE NC-8 [1]

Category: Coal Mining
Subcategory: Alkaline Mines
Raw wastewater flowrate, gpd: 12,432,960

Pollutant	Raw wastewater Influent to pond 003	Treated effluent: Nondischarging active pond 002	Nondischarging active pond 003	Active pond 004 treated effluent[a]	Active pond 005 treated effluent[a]	Nondischarging active pond 006
Classical parameters[b]						
TSS, mg/L	7.9	16.4	26.0	4.1	118	26
Total volatile solids, mg/L	207	197	307	155	333	307
Settleable solids, mL/L	<0.1	0.1	0.2	0.2	0.43	0.2
COD, mg/L	24	13.9	17.8	41.3	23.9	17.8
TOC, mg/L	23.3	2.9	4.6	4.8	5.4	4.6
pH	6.6[c]	8.3	7.3[c]	7.9[c]	8.1[c]	8.1
Phenol, mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Metals, mg/L						
Aluminum	0.97	0.700	1.000	0.733	3.33	0.700
Antimony	<0.002	0.002	<0.002	0.002	0.012	0.002
Arsenic	<0.002	0.002	<0.002	0.002	0.008	0.002
Barium	0.013	0.009	0.010	0.030	0.026	0.020
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	0.43	0.300	0.367	0.157	1.00	0.400
Cadmium	0.002	<0.002	<0.002	<0.002	0.002	<0.002
Calcium	243	110	180	95.3	103.3	98
Chromium	0.100	0.037	0.067	0.020	0.06	0.030
Cobalt	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper	<0.006	<0.006	<0.006	<0.006	0.007	<0.006
Iron	0.630	0.367	0.733	0.400	3.47	0.467
Lead	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Magnesium	100	70	99	40	87	60
Manganese	4.000	0.200	0.97	83.3	0.17	0.133
Mercury	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]
Molybdenum	<0.005	<0.005	<0.005	<0.005	0.017	0.008
Nickel	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Selenium	<0.005	<0.005	<0.005	<0.005	<0.020	<0.005
Silver	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium	313	220	230	58	800	217
Thallium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Tin	0.030	0.015	0.030	0.010	0.033	0.010
Titanium	<0.020	<0.020	0.020	<0.020	0.037	<0.020
Vanadium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Yttrium	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc	<0.060	<0.060	<0.060	<0.060	0.073	<0.060
Cyanide	<0.005	<0.005	<0.005	<0.050	<0.005	<0.050

(continued)

TABLE 3-9 (continued)

Pollutant	Raw wastewater influent to pond 003	Treated effluent: Nondischarging active pond 002	Nondischarging active pond 003	Active pond 004 treated effluent[a]	Active pond 005 treated effluent[a]	Nondischarging active pond 006
Toxic pollutants, µg/L						
Acenaphthene	ND	ND	ND		—[f]	ND
Benzene	ND	ND	ND	—[f]	—[f]	ND
Carbon tetrachloride	ND	ND	ND	—[f]	—[f]	ND
Chlorobenzene	ND	ND	ND	—[f]	—[f]	ND
Hexachloroethane	ND	ND	ND	<6.7	—[f]	ND
1,2-Dichloroethane	ND	ND	ND	—[f]	—[f]	ND
1,1,1-Trichloroethane	ND	ND	ND	—[f]	—[f]	ND
1,1,2-Trichloroethane	ND	ND	ND	—[f]	—[f]	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	—[f]	—[f]	ND
2-Chloronaphthalene	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	—[f]	—[f]	ND
2-Chlorophenol	—[c]	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	<10	ND	ND	<6.7	ND	<10
1,4-Dichlorobenzene	<10	ND	ND	<6.7	ND	<10
3,3'-Dichlorobenzidine	—[c]	ND	ND	<6.7	ND	ND
1,1-Dichloroethylene	ND	ND	ND	—[f]	ND	ND
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND
2,4-Dinitrotoluene	ND	ND	ND	ND	ND	ND
1,2-Diphenylhydrazine	ND	ND	ND	ND	ND	<10
Ethylbenzene	ND	ND	ND	—[f]	<6.7	ND
Fluoranthene	ND	ND	ND	<6.7	ND	ND
4-Chlorophenyl phenyl ether	ND	ND	ND	ND	ND	ND
Bis(2-chloroethoxy)methane	ND	ND	<10	ND	ND	ND
Methylene chloride	ND	ND	ND	—[f]	<6.7	ND
Bromoform	ND	ND	ND	—[f]	ND	ND
Trichlorofluoromethane	ND	ND	ND	—[f]	ND	ND
Isophorone	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	<10
Nitrobenzene	ND	ND	ND	ND	ND	ND
2-Nitrophenol	—[c]	ND	ND	ND	ND	ND
4,6-Dinitro-*o*-cresol	—[c]	ND	ND	ND	<6.7	ND
N-nitrosodiphenylamine	ND	ND	ND	ND	ND	ND
Phenol	<10[c]	<10	<10	<10	<10	ND

(continued)

TABLE 3-9 (continued)

Pollutant	Raw wastewater influent to pond 003	Treated effluent: Nondischarging active pond 002	Treated effluent: Nondischarging active pond 003	Treated effluent: Active pond 004 treated effluent[a]	Treated effluent: Active pond 005 treated effluent[a]	Treated effluent: Nondischarging active pond 006
Toxic pollutants, µg/L (cont'd)						
Bis(2-ethylhexyl) phthalate	<10	<10	<10	<10	<10	<10
Butyl benzyl phthalate	<10	<10	<10	<10	<10	<10
Di-n-butyl phthalate	<10	<10	<10	<10	<10	<10
Di-n-octyl phthalate	ND	ND	ND	ND	<6.7	<10
Diethyl phthalate	ND	<10	ND	<10	<10	<10
Dimethyl phthalate	-[c]	ND	ND	ND	ND	ND
Benz(a)anthracene/chrysene	-[c]	ND	ND	<3.3	ND	ND
Benzo(a)pyrene	-[c]	ND	ND	ND	ND	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthane	-[c]	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND
Anthracene/phenanthrene	<10	<10	ND	<3.3	<3.3	ND
Benzo(ghi)perylene	<10	ND	ND	<3.3	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND
Dibenzo(ah)anthracene	<10	ND	ND	8	ND	ND
Indeno(1,2,3-cd)pyrene	<10	ND	ND	6.3	ND	ND
Pyrene	ND	ND	ND	<3.3	ND	ND
Tetrachloroethylene	ND	ND	ND	-[f]	ND	ND
Toluene	ND	ND	ND	-[f]	ND	ND
Trichloroethylene	ND	ND	ND	-[f]	ND	ND
Aldrin	NA	NA	NA	NA	-[f]	NA
α-Endosulfan	NA	NA	NA	NA	-[f]	NA
β-Endosulfan	NA	NA	NA	NA	-[f]	NA
Endrin	NA	NA	NA	NA	-[f]	NA
Heptachlor	NA	NA	NA	NA	-[f]	NA
Heptaclor epoxide	NA	NA	NA	NA	-[f]	NA
α-BHC	NA	NA	NA	NA	-[f]	NA
γ-BHC	NA	NA	NA	NA	-[f]	NA
δ-BHC	NA	NA	NA	NA	-[f]	NA
2,4-Dinitrophenol	ND	ND	ND	ND	<3.3	ND
Pentachlorophenol	ND	ND	ND	ND	<3.3	ND

[a]Data for toxic pollutants based on 2-day sampling, except as noted.

[b]All data for classical parameters and metals based on 3-day sampling, except as noted.

[c]Data based on 2-day sampling.

[d]Analysis not available.

[e]Data for toxic pollutants are based on 1-day sampling, except as noted.

[f]Data based on 1-day sampling.

TABLE 3-10. WASTEWATER CHARACTERIZATION, MINE V-8 [1]

Category: Coal Mining
Subcategory: Alkaline Mines
Raw wastewater flowrate, gpd: 53,000

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L	102.7	28.5
Total volatile solids, mg/L	243.3	365.3
Settleable solids, mL/L	0.13	0.10
COD, mg/L	90.7	76.0
TOC, mg/L	57.0	57.8
pH	7.6	8.1
Phenol, mg/L	<0.010	<0.010
Metals, mg/L		
Antimony	0.006	0.011
Arsenic	0.004	<0.002
Selenium	0.002	0.002
Silver	<0.005	<0.005
Thallium	<0.005	<0.005
Cyanide	<0.005	<0.005

[a] All data based on 3-day sampling, except as noted.

[b] Pond #4 influent.

[c] Pond #4 effluent.

TABLE 3-11. WASTEWATER CHARACTERIZATION, MINE V-8 [1]

Category: Coal Mining
Subcategory: Alkaline Mining
Raw wastewater flowrate, gpd: 2,880

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L	44.8	28.9
Total volatile solids, mg/L	168.0	123.1
Settleable solids, mL/L	<0.1	<0.1
COD, mg/L	80.0	38.7
TOC, mg/L	54.3	21.7
pH	7.9	8.5
Phenol, mg/L	<0.010	<0.010
Metals, mg/L		
Aluminum	0.027	0.015
Antimony	0.006	0.005
Arsenic		
Barium		
Beryllium		
Boron		
Cadmium		
Calcium		
Chromium		
Cobalt		
Copper		
Iron		
Lead		
Magnesium		
Manganese		
Mercury		
Molybdenum		
Nickel		
Selenium	0.002	<0.002
Silver	<0.005	<0.005
Sodium		
Thallium	<0.005	<0.005
Tin		
Titanium		
Vanadium		
Yttrium		
Zinc		
Cyanide	<0.005	<0.005
Toxic pollutants, μg/L		
Acenaphthene	ND	ND
Benzene	ND	ND
Carbon tetrachloride	<10	<6.7
Chlorobenzene	ND	ND
Hexachloroethane	ND	ND
1,2-Dichloroethane	ND	ND
1,1,1-Trichloroethane	<10	<10
1,1,2-Trichloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
2-Chloronaphthalene	ND	ND
Chloroform	ND	<6.7
2-Chlorophenol	ND	ND

(continued)

TABLE 3-11 (continued)

Pollutant	Wastewater characterization[a]: Raw wastewater characterization[b]	Wastewater characterization[a]: Treated effluent concentration[c]
Toxic pollutants, μg/L (cont'd)		
1,2-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
3,3'-Dichlorobenzidine	ND	ND
1,1-Dichloroethylene	<10	<10
2,4-Dimethylphenol	ND	ND
2,4-Dinitrotoluene	ND	ND
1,2-Diphenylhydrazine	ND	ND
Ethylbenzene	ND	<3.3
Fluoranthene	ND	ND
4-Chlorophenyl phenyl ether	ND	ND
Bis(2-chloroethoxy)methane	ND	ND
Methylene chloride	<10	13.2
Bromoform	ND	ND
Trichlorfluoromethane	ND	ND
Isophorone	ND	ND
Naphthalene	ND	ND
Nitrobenzene	ND	ND
2-Nitrophenol	ND	ND
4,6-Dinitro-*o*-cresol	ND	ND
N-nitrosodiphenylamine	ND	ND
Phenol	ND	ND
Bis(2-ethylhexyl) phthalate	ND	ND
Butyl benzyl phthalate	ND	ND
Di-n-butyl phthalate	<10	<6.7
Di-n-octyl phthalate	ND	ND
Diethyl phthalate	ND	ND
Dimethyl phthalate	ND	ND
Benz(a)anthracene/chrysene	ND	ND
Benzo(a)pyrene	ND	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene	ND	ND
Acenaphthylene	ND	ND
Anthracene/phenanthrene	ND	ND
Benzo(ghi)perylene	ND	ND
Fluorene	ND	ND
Dibenz(ah)anthracene	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND
Pyrene	ND	ND
Tetrachloroethylene	ND	ND
Toluene	ND	<6.7
Trichloroethylene	ND	<3.3
Aldrin	ND	<3.3
α-Endosulfan	ND	ND
β-Endosulfan	ND	ND
Endrin	ND	ND
Heptachlor	ND	<3.3
Heptachlor epoxide	ND	<6.7
α-BHC	ND	ND
γ-BHC	<10	<10
δ-BHC	ND	ND

Note: Blanks indicate data not received.

[a]All data based on 1-day sampling.

[b]Pond No. 6 influent.

[c]Pond No. 6 effluent.

TABLE 3-12. WASTEWATER CHARACTERIZATION, MINE V-8 [1]

Category: Coal Mining
Subcategory: Alkaline Mines

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L		61.9
Total volatile solids, mg/L		418
Settleable solids, mL/L		<0.1
COD, mg/L		136
TOC, mg/L		65.3
pH		8.1
Phenol, mg/L		<0.010
Metals, mg/L		
Aluminum		
Antimony		0.010
Arsenic		0.005
Barium		
Beryllium		
Boron		
Cadmium		
Calcium		
Chromium		
Cobalt		
Copper		
Iron		
Lead		
Magnesium		
Manganese		
Mercury		
Molybdenum		
Nickel		
Selenium		0.003
Silver		<0.005
Sodium		
Thallium		0.006
Tin		
Titanium		
Vanadium		
Yttrium		
Zinc		
Cyanide		<0.005
Toxic pollutants, µg/L		
Acenaphthene		ND
Benzene		<6.7
Carbon tetrachloride		ND
Chlorobenzene		ND
Hexachloroethane		ND
1,2-Dichloroethane		ND
1,1,1-Trichloroethane		<10
1,1,2-Trichloroethane		ND
1,1,2,2-Tetrachloroethane		ND
2-Chloronaphthalene		ND
Chloroform		ND
2-Chlorophenol		ND

(continued)

TABLE 3-12 (continued)

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Toxic pollutants, μg/L (cont'd)		
1,2-Dichlorobenzene		ND
1,4-Dichlorobenzene		ND
3,3'-Dichlorobenzidine		ND
1,1-Dichloroethylene		<10
2,4-Dimethylphenol		ND
2,4-Dinitrotoluene		ND
1,2-Diphenylhydrazine		ND
Ethylbenzene		ND
Fluoranthene		ND
4-Chlorophenyl phenyl ether		ND
Bis(2-chloroethoxy)methane		ND
Methylene chloride		12.7
Bromoform		ND
Trichlorfluoromethane		ND
Isophorone		ND
Naphthalene		ND
Nitrobenzene		ND
2-Nitrophenol		ND
4,6-Dinitro-*o*-cresol		ND
N-nitrosodiphenylamine		ND
Phenol		ND
Bis(2-ethylhexyl) phthalate		ND
Butyl benzyl phthalate		<3.3
Di-n-butyl phthalate		<3.3
Di-n-octyl phthalate		ND
Diethyl phthalate		ND
Dimethyl phthalate		ND
Benz(a)anthracene/chrysene		ND
Benzo(a)pyrene		ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene		ND
Acenaphthylene		ND
Anthracene/phenanthrene		ND
Benzo(ghi)perylene		ND
Fluorene		ND
Dibenz(ah)anthracene		ND
Indeno(1,2,3-cd)pyrene		ND
Pyrene		ND
Tetrachloroethylene		ND
Toluene		<6.7
Trichloroethylene		<3.3
Aldrin		ND
α-Endosulfan		ND
β-Endosulfan		ND
Endrin		ND
Heptachlor		<6.7
Heptachlor epoxide		ND
α-BHC		ND
γ-BHC		<3.3
δ-BHC		ND

Note: Blanks indicate data not received.

[a]All data based on 3-day sampling.

[b]Raw wastewater data not available.

[c]Grab composite from three ponds.

TABLE 3-13. WASTEWATER CHARACTERIZATION, MINE V-9 [1]

Category: Coal Mining
Subcategory: Alkaline Mines
Raw wastewater flowrate, gpd: 710,000

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L	61.0	78.6[d]
Total volatile solids, mg/L	99.0	52.5[d]
Settleable solids, mL/L	0.11	<0.1[d]
COD, mg/L	16.3	13.7
TOC, mg/L	10.8	9.6
pH	8.2	7.7
Phenol, mg/L	<0.010	<0.010
Metals, mg/L		
Aluminum	<0.002	
Antimony	0.002	<0.002
Arsenic		<0.002
Barium		
Beryllium		
Boron		
Cadmium		
Calcium		
Chromium		
Cobalt		
Copper		
Iron		
Lead		
Magnesium		
Manganese		
Mercury		
Molybdenum		
Nickel		
Selenium	<0.002	<0.002
Silver	0.01	<0.01
Sodium		
Thallium	<0.005	<0.005
Tin		
Titanium		
Vanadium		
Yttrium		
Zinc		
Cyanide	<0.005	<0.005
Toxic pollutants, µg/L		
Acenaphthene	ND	ND
Benzene	ND	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Hexachloroethane	ND	ND
1,2-Dichloroethane	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
2-Chloronaphthalene	ND	ND
Chloroform	ND	<3.3
2-Chlorophenol	ND	ND

(continued)

TABLE 3-13 (continued)

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Toxic pollutants, μg/L (cont'd)		
1,2-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
3,3'-Dichlorobenzidine	ND	ND
1,1-Dichloroethylene	ND	ND
2,4-Dimethylphenol	ND	ND
2,4-Dinitrotoluene	ND	ND
1,2-Diphenylhydrazine	ND	ND
Ethylbenzene	ND	ND
Fluoranthene	ND	ND
4-Chlorophenyl phenyl ether	ND	ND
Bis(2-chloroethoxy)methane	ND	ND
Methylene chloride	ND	ND
Bromoform	ND	ND
Trichlorfluoromethane	ND	ND
Isophorone	ND	ND
Naphthalene	ND	ND
Nitrobenzene	ND	ND
2-Nitrophenol	ND	ND
4,6-Dinitro-*o*-cresol	ND	ND
N-nitrosodiphenylamine	ND	ND
Phenol	ND	ND
Bis(2-ethylhexyl) phthalate	<3.3	ND
Butyl benzyl phthalate	ND	ND
Di-n-butyl phthalate	<10.0	<6.7
Di-n-octyl phthalate	ND	ND
Diethyl phthalate	<3.3	ND
Dimethyl phthalate	ND	ND
Benz(a)anthracene/chrysene	ND	ND
Benzo(a)pyrene	ND	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene	ND	ND
Acenaphthylene	ND	ND
Anthracene/phenanthrene	ND	ND
Benzo(ghi)perylene	ND	ND
Fluorene	ND	ND
Dibenz(ah)anthracene	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND
Pyrene	ND	ND
Tetrachloroethylene	ND	ND
Toluene	ND	ND
Trichloroethylene	ND	ND
Aldrin	ND	ND
α-Endosulfan	ND	ND
β-Endosulfan	ND	ND
Endrin	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
α-BHC	ND	ND
γ-BHC	ND	ND
δ-BHC	ND	ND

Note: Blanks indicate data not received.

[a]All data from 3-day sampling, except as noted.

[b]Pollack pond raw water.

[c]Pollack pond settling pond effluent.

[d]Data from 2 days.

TABLE 3-14. WASTEWATER CHARACTERIZATION, MINE V-9 [1]

Category: Coal Mining
Subcategory: Alkaline Mines
Raw wastewater flowrate, gpd: 41,000

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L	110.6	46.1
Total volatile solids, mg/L	122	75
Settleable solids, mL/L	0.33	0.17
COD, mg/L	14.3	18.3
TOC, mg/L	7.2	14.6
pH	7.6	7.5
Phenol, mg/L	<0.010	<0.011
Metals, mg/L		
Aluminum	<0.002	
Antimony	<0.002	<0.002
Arsenic		<0.002
Barium		
Beryllium		
Boron		
Cadmium		
Calcium		
Chromium		
Cobalt		
Copper		
Iron		
Lead		
Magnesium		
Manganese		
Mercury		
Molybdenum		
Nickel		
Selenium	0.003	<0.002
Silver	0.01	<0.01
Sodium		
Thallium	<0.005	<0.005
Tin		
Titanium		
Vanadium		
Yttrium		
Zinc		
Cyanide	<0.005	<0.005
Toxic pollutants, μg/L		
Acenaphthene	ND	ND
Benzene	ND	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Hexachloroethane	ND	ND
1,2-Dichloroethane	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
2-Chloronaphthalene	ND	ND
Chloroform	ND	ND
2-Chlorophenol	ND	ND

(continued)

TABLE 3-14 (continued)

Pollutant	Wastewater characterization[a] Raw wastewater characterization[b]	Treated effluent concentration[c]
Toxic pollutants, μg/L (cont'd)		
1,2-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
3,3'-Dichlorobenzidine	ND	ND
1,1-Dichloroethylene	ND	ND
2,4-Dimethylphenol	ND	ND
2,4-Dinitrotoluene	ND	ND
1,2-Diphenylhydrazine	ND	ND
Ethylbenzene	ND	ND
Fluoranthene	ND	ND
4-Chlorophenyl phenyl ether	ND	ND
Bis(2-chloroethoxy)methane	ND	ND
Methylene chloride	<3.3	ND
Bromoform	ND	ND
Trichlorfluoromethane	ND	ND
Isophorone	ND	ND
Naphthalene	ND	ND
Nitrobenzene	ND	ND
2-Nitrophenol	ND	ND
4,6-Dinitro-o-cresol	ND	ND
N-nitrosodiphenylamine	ND	ND
Phenol	ND	ND
Bis(2-ethylhexyl) phthalate	ND	<3.3
Butyl benzyl phthalate	ND	ND
Di-n-butyl phthalate	<10	<6.7
Di-n-octyl phthalate	ND	ND
Diethyl phthalate	ND	<6.7
Dimethyl phthalate	ND	ND
Benz(a)anthracene/chrysene	ND	ND
Benzo(a)pyrene	ND	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene	ND	ND
Acenaphthylene	ND	ND
Anthracene/phenanthrene	ND	ND
Benzo(ghi)perylene	ND	ND
Fluorene	ND	ND
Dibenz(ah)anthracene	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND
Pyrene	ND	ND
Tetrachloroethylene	ND	ND
Toluene	ND	ND
Trichloroethylene	ND	ND
Aldrin	ND	ND
α-Endosulfan	ND	ND
β-Endosulfan	ND	ND
Endrin	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
α-BHC	ND	ND
γ-BHC	ND	ND
δ-BHC	ND	ND

Note: Blanks indicate data not received.

[a]All data from 3-day sampling.

[b]Dugout pond raw water.

[c]Dugout pond settling pond effluent.

TABLE 3-15. WASTEWATER CHARACTERIZATION, MINE NC-22 [1]

Category: Coal Mining
Subcategory: Alkaline Mines

Pollutant	Raw wastewater[a]	Nondischarging active pond P 1371 AD-002	Nondischarging inactive pond P 485-001	Nondischarging active pond P 0063 AD-001	Nondischarging inactive pond P 0063 AD-002
Classical parameters					
TSS, mg/L		19.6	20.7	15.4	18.1
Total volatile solids, mg/L		217.7	86	247.7	160.3
Settleable solids, mL/L		NA	NA	NA	NA
COD, mg/L		17.6	21.1	29.4	58.1
TOC, mg/L		8.3	7.5	6.6	8.2
pH		7.4	6.3	7.3	7.7
Phenol, mg/L		<0.010	<0.010	<0.010	<0.010
Metals, mg/L					
Aluminum		<0.050	0.130	<0.050	<0.050
Antimony		0.016	0.010	0.007	<0.005
Arsenic		<0.005	<0.005	<0.005	0.009
Barium		0.037	0.060	0.010	0.008
Beryllium		<0.001	<0.001	<0.001	<0.001
Boron		0.093	0.067	0.867	0.083
Cadmium		<0.002	0.004	<0.002	<0.002
Calcium		250	58	307	228
Chromium		0.060	0.020	0.070	0.048
Cobalt		<0.005	0.006	<0.005	<0.005
Copper		<0.006	0.008	0.006	0.007
Iron		<0.200	0.833	<0.200	<0.200
Lead		0.020	0.083	0.200	0.267
Magnesium		91	23	110	66.7
Manganese		0.197	0.233	0.248	0.042
Mercury		<0.001	<0.001	<0.001	<0.001
Molybdenum		0.017	0.020	0.009	0.012
Nickel		<0.005	0.027	<0.005	<0.005
Selenium		0.003	0.003	<0.002	<0.002
Silver		<0.005	<0.005	<0.005	0.005
Sodium		59	<15	16	39
Thallium		<0.005	<0.005	<0.005	<0.005
Tin		0.008	0.030	0.040	0.033
Titanium		<0.020	<0.020	<0.020	<0.020
Vanadium		<0.010	<0.010	<0.010	0.133
Yttrium		<0.020	<0.020	<0.020	<0.020
Zinc		<0.060	<0.060	<0.060	<0.060
Cyanide		<0.005	<0.005	<0.005	<0.005

(continued)

TABLE 3-15 (continued)

Pollutant	Raw wastewater[a]	Nondischarging active pond P 1371 AD-002	Nondischarging inactive pond P 485-001	Nondischarging active pond P 0063 AD-001	Nondischarging inactive pond P 0063 AD-002
Toxic pollutants, μg/L					
Acenaphthene		ND	ND	ND	ND
Benzene		<3.3	<3.3	<3.3	<3.3
Carbon tetrachloride		ND	ND	ND	ND
Chlorobenzene		ND	ND	ND	ND
Hexachloroethane		ND	ND	ND	ND
1,2-Dichloroethane		<3.3	ND	ND	ND
1,1,1-Trichloroethane		<6.7	<10	ND	<3.3
1,1,2-Trichloroethane		ND	ND	ND	<3.3
1,1,2,2-Tetrachloroethane		ND	ND	ND	ND
2-Chloronaphthalene		ND	ND	ND	ND
Chloroform		ND	ND	<10	<6.7
2-Chlorophenol		ND	ND	ND	ND
1,2-Dichlorobenzene		ND	ND	ND	ND
1,4-Dichlorobenzene		ND	ND	ND	ND
3,3'-Dichlorobenzidine		ND	ND	ND	ND
1,1-Dichloroethylene		ND	ND	ND	<3.3
2,4-Dimethylphenol		ND	ND	ND	ND
2,4-Dinitrotoluene		ND	ND	ND	ND
1,2-Diphenylhydrazine		ND	ND	ND	ND
Ethylbenzene		ND	ND	ND	<3.3
Fluoranthene		ND	ND	ND	ND
4-Chlorophenyl phenyl ether		ND	ND	ND	ND
Bis(2-chloroethoxy)methane		ND	ND	ND	ND
Methylene chloride		21	<3.3	<6.7	<10
Bromoform		ND	ND	ND	ND
Trichlorfluoromethane		ND	ND	ND	ND
Isophorone		ND	ND	ND	ND
Naphthalene		ND	ND	ND	ND
Nitrobenzene		ND	ND	ND	ND
2-Nitrophenol		ND	ND	ND	ND
4,6-Dinitro-*o*-cresol		ND	ND	ND	ND
N-nitrosodiphenylamine		ND	ND	ND	ND
Phenol		ND	ND	<3.3	ND
Bis(2-ethylhexyl) phthalate		<3.3	<6.7	<3.3	<6.7
Butyl benzyl phthalate		ND	ND	ND	ND
Di-n-butyl phthalate		<10	<10	<10	<10
Di-n-octyl phthalate		ND	ND	ND	ND

(continued)

TABLE 3-15 (continued)

Pollutant	Raw wastewater[a]	Nondischarging active pond P 1371 AD-002	Nondischarging inactive pond P 485-001	Nondischarging active pond P 0063 AD-001	Nondischarging inactive pond P 0063 AD-002
Toxic pollutants, μg/L (cont'd)					
Diethyl phthalate		ND	ND	<10	<10
Dimethyl phthalate		ND	ND	ND	ND
Benz(a)anthracene/chrysene		ND	ND	ND	ND
Benzo(a)pyrene		ND	ND	ND	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene		ND	ND	ND	ND
Acenaphthylene		ND	ND	ND	ND
Anthracene/phenanthrene		ND	ND	ND	ND
Benzo(ghi)perylene		ND	ND	ND	ND
Fluorene		ND	ND	ND	ND
Dibenz(ah)anthracene		ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene		ND	ND	ND	ND
Pyrene		ND	ND	ND	ND
Tetrachloroethylene		ND	ND	ND	ND
Toluene		3.3	ND	ND	<3.3
Trichloroethylene		ND	ND	ND	ND
Aldrin		ND	ND	0.007	0.003
α-Endosulfan		ND	ND	ND	ND
β-Endosulfan		ND	ND	ND	ND
Endrin		ND	ND	ND	ND
Heptachlor		ND	ND	ND	ND
Heptachlor epoxide		ND	ND	ND	ND
α-BHC		ND	ND	ND	0.02
γ-BHC		ND	ND	ND	ND
δ-BHC		ND	ND	0.007	0.05

[a]Raw wastewater data not available.

TABLE 3-16. WASTEWATER CHARACTERIZATION, PLANT NC-8 [1]

Category: Coal Mining
Subcategory: Preparation Plants
Raw wastewater flowrate, gpd: 12,432,960

Pollutant	Wastewater characterization: Raw wastewater characterization[a]	Wastewater characterization: Treated effluent concentration[b]
Classical parameters[c]		
TSS, mg/L	34,400	8.9
Total volatile solids, mg/L	18,131	163.3
Settleable solids, mL/L	247	<0.1
COD, mg/L	36,300	19.2
TOC, mg/L	1,492	96.8
pH	7.3	7.4[d]
Phenol, mg/L	<0.020	<0.020
Metals, mg/L		
Aluminum	200	<0.050
Antimony	0.002	0.006
Arsenic	0.253	0.002
Barium	5.67	0.050
Beryllium	0.057	<0.001
Boron	3.00	0.767
Cadmium	<0.020	<0.002
Calcium	493	77
Chromium	0.530	0.013
Cobalt	0.500	<0.005
Copper	1.33	0.006
Iron	1,000	0.267
Lead	0.967	<0.020
Magnesium	87	25
Manganese	8.0	0.050
Mercury	NA	NA
Molybdenum	0.600	0.040
Nickel	1.23	<0.005
Selenium	<0.005	0.006
Silver	<0.005	<0.005
Sodium	293	283
Thallium	0.006	<0.005
Tin	0.200	<0.005
Titanium	3.67	<0.020
Vanadium	0.833	<0.010
Yttrium	0.333	<0.020
Zinc	5.33	<0.060
Cyanide	<0.005	<0.005
Toxic pollutants, µg/L[e]		
Acenaphthene	<10	-[d]
Benzene	15	-[d]
Carbon tetrachloride	ND	-[d]
Chlorobenzene	ND	-[d]
Hexachloroethane	ND	-[d]
1,2-Dichloroethane	ND	-[d]
1,1,1-Trichloroethane	ND	-[d]
1,1,2-Trichloroethane	ND	-[d]
1,1,2,2-Tetrachloroethane	ND	ND
2-Chloronaphthalene	ND	-[d]
Chloroform	ND	-[d]
2-Chlorophenol	ND	

(continued)

TABLE 3-16 (continued)

Pollutant	Wastewater characterization	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Toxic pollutants, mg/L (cont'd)		
1,2-Dichlorobenzene	ND	–[d]
1,4-Dichlorobenzene	ND	–[d]
3,3'-Dichlorobenzidine	ND	–[d]
1,1-Dichloroethylene	ND	–[d]
2,4-Dimethylphenol	ND	–[d]
2,4-Dinitrotoluene	ND	ND
1,2-Diphenylhydrazine	ND	ND
Ethylbenzene	ND	–[d]
Fluoranthene	<10	ND
4-Chlorophenyl phenyl ether	ND	ND
Bis(2-chloroethoxy)methane	ND	ND
Methylene chloride	ND	<3.3
Bromoform	ND	–[d]
Trichlorfluoromethane	ND	–[d]
Isophorone	ND	ND
Naphthalene	<10	ND
Nitrobenzene	ND	ND
2-Nitrophenol	ND	–[d]
4,6-Dinitro-*o*-cresol	ND	–[d]
N-nitrosodiphenylamine	ND	ND
Phenol	<10	<5.0
Bis(2-ethylhexyl) phthalate	<10	<3.3
Butyl benzyl phthalate	<10	<3.3
Di-n-butyl phthalate	<10	<3.3
Di-n-octyl phthalate	ND	ND
Diethyl phthalate	<10	<3.3
Dimethyl phthalate	ND	–[d]
Benz(a)anthracene/chrysene	<10	–[d]
Benzo(a)pyrene	<10	–[d]
Benzo(b)fluoranthene/ benzo(k)fluoranthene	<10	–[d]
Acenaphthylene	ND	ND
Anthracene/phenanthrene	<10	ND
Benzo(ghi)perylene	<10	ND
Fluorene	<10	ND
Dibenz(ah)anthracene	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND
Pyrene	<10	ND
Tetrachloroethylene	ND	–[d]
Toluene	ND	–[d]
Trichloroethylene	ND	–[d]
Aldrin	NA	ND
α-Endosulfan	NA	ND
β-Endosulfan	NA	ND
Endrin	NA	ND
Heptachlor	NA	ND
Heptachlor epoxide	NA	ND
α-BHC	NA	ND
γ-BHC	NA	ND
δ-BHC	NA	ND

[a] Slurry pond influent.

[b] Slurry pond decant.

[c] All data for classical parameters and metals representative of 3-day sampling, except as noted.

[d] Data from 2-day sampling.

[e] Data for toxic pollutants are for 1-day sampling, except as noted.

TABLE 3-17. WASTEWATER CHARACTERIZATION, PLANT NC-20 [1]

Category: Coal Mining
Subcategory: Preparation Plants
Raw wastewater flowrate, gpd: 9,976,000

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L	9,131	62.9
Total volatile solids, mg/L	7,567	254
Settleable solids, mL/L	56.3	0.2
COD, mg/L	20,724	118.7
TOC, mg/L	2,868	19.1
pH	6.87	6.8[d]
Phenol, mg/L	<0.010	<0.010
Metals, mg/L		
Aluminum	35	0.100
Antimony	0.034	0.007
Arsenic	0.051	0.035
Barium	0.353	0.167
Beryllium	<0.010	<0.001
Boron	0.600	0.300
Cadmium	<0.020	<0.002
Calcium	453	440
Chromium	0.367	0.013
Cobalt	<0.050	0.023
Copper	0.687	0.009
Iron	70	3.333
Lead	0.400	0.023
Magnesium	58	40
Manganese	2.67	2.00
Mercury	NA	NA
Molybdenum	0.100	0.008
Nickel	0.217	0.100
Selenium	<0.003	0.003
Silver	<0.002	<0.002
Sodium	480	397
Thallium	<0.005	<0.005
Tin	<0.060	<0.005
Titanium	0.767	<0.005
Vanadium	0.200	<0.010
Yttrium	<0.200	<0.020
Zinc	<0.600	0.060
Cyanide	<0.005	<0.005
Toxic pollutants, µg/L		
Acenaphthene	<3.3	ND
Benzene	ND	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Hexachloroethane	ND	ND
1,2-Dichloroethane	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
2-Chloronaphthalene	ND	ND
Chloroform	ND	ND
2-Chlorophenol	ND	ND

(continued)

TABLE 3-17 (continued)

Pollutant	Wastewater characterization[a]: Raw wastewater characterization[b]	Wastewater characterization[a]: Treated effluent concentration[c]
Toxic pollutants, μg/L (cont'd)		
1,2-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
3,3'-Dichlorobenzidine	ND	ND
1,1-Dichloroethylene	ND	ND
2,4-Dimethylphenol	ND	ND
2,4-Dinitrotoluene	ND	ND
1,2-Diphenylhydrazine	ND	ND
Ethylbenzene	ND	ND
Fluoranthene	<6.7	ND
4-Chlorophenyl phenyl ether	ND	ND
Bis(2-chloroethoxy)methane	ND	ND
Methylene chloride	ND	ND
Bromoform	ND	ND
Trichlorfluoromethane	ND	ND
Isophorone	ND	ND
Naphthalene	43.5	ND
Nitrobenzene	ND	ND
2-Nitrophenol	ND	ND
4,6-Dinitro-*o*-cresol	ND	ND
N-nitrosodiphenylamine	ND	ND
Phenol	ND	ND
Bis(2-ethylhexyl) phthalate	50	<6.7
Butyl benzyl phthalate	<3.3	ND
Di-n-butyl phthalate	<6.7	<10
Di-n-octyl phthalate	ND	ND
Diethyl phthalate	<3.3	<10
Dimethyl phthalate	ND	ND
Benz(a)anthracene/chrysene	10.3	ND
Benzo(a)pyrene	<10	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene	<3.3	ND
Acenaphthylene	ND	ND
Anthracene/phenanthrene	33	<3.3
Benzo(ghi)perylene	<6.7	ND
Fluorene	<6.7	ND
Dibenz(ah)anthracene	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND
Pyrene	<3.3	ND
Tetrachloroethylene	ND	ND
Toluene	ND	ND
Trichloroethylene	ND	ND
Aldrin	ND	ND
α-Endosulfan	ND	ND
β-Endosulfan	ND	ND
Endrin	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
α-BHC	ND	ND
γ-BHC	ND	ND
δ-BHC	ND	ND

[a]All data based on 3-day sampling, except as noted.

[b]Slurry.

[c]Recycled preparation plant water.

[d]Data from 2-day sampling.

TABLE 3-18. WASTEWATER CHARACTERIZATION, PLANT NC-22 [1]

Category: Coal Mining
Subcategory: Preparation Plants
Raw wastewater flowrate, gpd: 274,000

Pollutant	Wastewater characterization[a]	
	Raw wastewater characterization[b]	Treated effluent concentration[c]
Classical parameters		
TSS, mg/L	13,876	18.7
Total volatile solids, mg/L	17,908	200
Settleable solids, mL/L	202	NA
COD, mg/L	48,792	20.3
TOC, mg/L	8,447	6.8
pH	6.6	6.9
Phenol, mg/L	<0.010	<0.010
Metals, mg/L		
Aluminum	57	<0.050
Antimony	<0.005	<0.005
Arsenic	0.18	<0.005
Barium	2.0	0.06
Beryllium	<0.01	<0.001
Boron	0.200	0.167
Cadmium	<0.020	0.003
Calcium	270	187
Chromium	0.233	0.043
Cobalt	<0.050	<0.005
Copper	0.233	0.008
Iron	110	<0.200
Lead	0.467	0.053
Magnesium	100	63
Manganese	0.767	<0.005
Mercury	0.003[d]	<0.001
Molybdenum	0.12	<0.030
Nickel	0.30	0.01
Selenium	0.034	0.003
Silver	<0.005	<0.005
Sodium	<150	78
Thallium	0.015	<0.005
Tin	0.053	0.040
Titanium	0.433	<0.020
Vanadium	0.133	0.013
Yttrium	<0.200	<0.020
Zinc	<0.600	<0.060
Cyanide	<0.005[d]	<0.005
Toxic pollutants, μg/L		
Acenaphthene	ND	ND
Benzene	<3.3	ND
Carbon tetrachloride	ND	ND
Chlorobenzene	ND	ND
Hexachloroethane	ND	ND
1,2-Dichloroethane	ND	ND
1,1,1-Trichloroethane	7.67	<3.3
1,1,2-Trichloroethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	<3.3
2-Chloronaphthalene	<3.3	ND
Chloroform	<6.7	<6.7
2-Chlorophenol	86	ND

(continued)

TABLE 3-18 (continued)

Pollutant	Wastewater characterization[a] Raw wastewater characterization[b]	Treated effluent concentration[c]
Toxic pollutants, μg/L (cont'd)		
1,2-Dichlorobenzene	ND	ND
1,4-Dichlorobenzene	ND	ND
3,3'-Dichlorobenzidine	ND	ND
1,1-Dichloroethylene	ND	ND
2,4-Dimethylphenol	22	ND
2,4-Dinitrotoluene	6	ND
1,2-Diphenylhydrazine	<3.3	ND
Ethylbenzene	<6.7	<3.3
Fluoranthene	16	ND
4-Chlorophenyl phenyl ether	<3.3	ND
Bis(2-chloroethoxy)methane	ND	<3.3
Methylene chloride	82	19
Bromoform	ND	ND
Trichlorfluoromethane	ND	ND
Isophorone	307	ND
Naphthalene	402	ND
Nitrobenzene	7	ND
2-Nitrophenol	19	ND
4,6-Dinitro-*o*-cresol	194	ND
N-nitrosodiphenylamine	30	ND
Phenol	<10	<6.7
Bis(2-ethylhexyl) phthalate	<10	<6.7
Butyl benzyl phthalate	<3.3	ND
Di-n-butyl phthalate	<3.3	<3.3
Di-n-octyl phthalate	<3.3	ND
Diethyl phthalate	<3.3	<3.3
Dimethyl phthalate	<3.3	ND
Benz(a)anthracene/chrysene	6/29	ND
Benzo(a)pyrene	12	ND
Benzo(b)fluoranthene/ benzo(k)fluoranthene	12	ND
Acenaphthylene	8	ND
Anthracene/phenanthrene	132	<3.3
Benzo(ghi)perylene	12	ND
Fluorene	47	ND
Dibenz(ah)anthracene	<3.3	ND
Indeno(1,2,3-cd)pyrene	<6.7	ND
Pyrene	19	ND
Tetrachloroethylene	ND	<3.3
Toluene	8	7.3
Trichloroethylene	<10	<10
Aldrin	ND	ND
α-Endosulfan	<6.7	ND
β-Endosulfan	<6.7	ND
Endrin	ND	ND
Heptachlor	ND	ND
Heptachlor epoxide	ND	ND
α-BHC	ND	ND
γ-BHC	ND	ND
δ-BHC	ND	ND

[a]All data based on 3-day sampling, except as noted.

[b]Slurry.

[c]Slurry effluent.

[d]Data based on 2-day sampling.

TABLE 3-19. WASTEWATER CHARACTERIZATION, PLANT NC-15 [1]

Category: Coal Mining
Subcategory: Associated Areas (screening data)

Pollutant	Wastewater characterization[a]: Raw wastewater characterization[b]	Wastewater characterization[a]: Treated effluent concentration[c]
Classical parameters		
Total solids, mg/L	410	260
TSS, mg/L	11.4	62
Total volatile solids, mg/L	34	36
Volatile suspended solids, mg/L	2.2	19.6
COD, mg/L	15.5	29.1
TOC, mg/L	3.6	5.5
pH	4.0	9.7
Phenol, mg/L	<0.02	<0.035
Metals, mg/L		
Aluminum	1.47	<0.99
Antimony	0.002	0.002
Arsenic	0.003	0.004
Barium	0.127	0.17
Beryllium	<0.002	<0.02
Boron	0.024	0.11
Cadmium	<0.02	<0.2
Calcium	26.5	8.0
Chromium	<0.024	<0.24
Cobalt	0.038	<0.1
Copper	0.006	<0.04
Iron	0.509	1.0
Lead	<0.06	<0.6
Magnesium	15.5	3.0
Manganese	2.09	<0.2
Mercury	0.0048	0.0043
Molybdenum	<0.01	<0.1
Nickel	<0.05	<0.5
Selenium	0.003	0.004
Silver	<0.025	<0.250
Sodium	38.8	65.0
Thallium	<0.001	<0.001
Tin	<0.099	<0.99
Titanium	0.014	<0.1
Vanadium	<0.099	<0.99
Yttrium	<0.01	<0.1
Zinc	0.168	<0.25
Cyanide	<0.005	<0.005
Toxic pollutants, µg/L		
Benzene	48	6.3
Chlorobenzene	ND	ND
1,2-Dichloroethane	ND	ND
1,1,1-Trichloroethane	ND	1.7
1,1,2,2-Tetrachloroethane	ND	1.2
Chloroform	45	19
1,2-trans-Dichloroethylene	ND	1.7
2,6-Dinitrotoluene	ND	ND
Ethylbenzene	ND	ND
Methylene chloride	480	66,000
Trichlorfluoromethane	ND	22
Toluene	14	2.0
Bis(2-ethylhexyl) phthalate	ND	6,100
Di-n-butyl phthalate	ND	210
Diethyl phthalate	ND	ND
Anthracene/phenanthrene	ND	ND

[a]All data based on 1-day sampling.

[b]Refuse pile raw water.

[c]Refuse pile treated effluent.

II.4 ELECTROPLATING

II.4.1 INDUSTRY DESCRIPTION

II.4.1.1 General Description [1]

The Electroplating Industry includes those facilities that apply a metallic surface coating to a second material typically by electrodeposition to provide corrosion protection, wear or erosion maintenance, antifrictional characteristics, or for decorative purposes. Approximately 13,000 companies are engaged in some phase or type of metal plating in the United States. Of these, 74% are captive shops (i.e., facilities plating products made in shop), while the remaining companies are independent (job) platers.

Electroplating facilities vary greatly in size and character from one plant to another. A single facility for plating individual parts formed by stamping, casting, and machining may employ plating or processing solutions (excluding water rinses) ranging in volume from less than 0.4 m^3 (100 gal) to more than 20 m^3 (5,300 gal). The area of the products being plated in these facilities varies as much as three orders of magnitude, from less than 10 to more than 1,000 m^2/d (100 to 10,000 ft^2/d). The power consumed by a single facility varies from a few kWh/day to as much as 20,000 kWh/day. Products being plated vary in size from less than 6.5 cm^2 (1 $in.^2$) to more than 1 m^2 (10 ft^2) and in weight from less than 30 g (1 oz) to more than 9,000 kg (10 tons). Continuous strip and wire are plated in some plants on a 24-hr/d basis. Some companies have capabilities for electroplating 10 or 12 different metals and alloys, but others specialize in just 1 or 2. Because of differences in character, size, and processes, facilities are custom tailored to the specific needs of each individual plant.

Table 4-1 presents an industry summary for the Electroplating Industry including the total number of subcategories, number of subcategories studied, and the types of dischargers.

The industry dischargers in the table do not add up to the 13,000 initially estimated. This may be due to an overestimation by the first reference or to exclusion of some of the plants from the second reference.

TABLE 4-1. INDUSTRY SUMMARY

Industry: Electroplating
Total Number of Subcategories: 10
Number of Subcategories Studied: 10
Number of Dischargers in Industry:
· Direct: 2,932
· Indirect: 6,586
· Zero: 200

II.4.1.2 Subcategory Descriptions [1]

The industry summary (Table 4-1) notes that this industry has 10 subcategories. However, the primary reference used for this industry report (written in August 1979) lists only seven subcategories. The three missing subcategories may have been absorbed into other subcategories or may have been eliminated because of their insignificance in the industry. This report will be limited to the seven subcategories for which descriptions are available:

(1) Common Metals Plating
(2) Precious Metals Plating
(3) Anodizing
(4) Coating
(5) Chemical Milling and Etching
(6) Electroless Plating
(7) Printed Circuit Board Manufacturing

Although the subcategories are not mutually exclusive subdivisions of this industry, the categorization is based on the fact that distinctly different production processes are performed in each of the subcategories. The subcategory descriptions that follow provide an overview of the industry in the area of production processes and product descriptions.

Surface preparation, plating, and posttreatment are process steps common to nearly all the subcategories. To avoid repetition these three steps will be briefly described before the subcategory descriptions are presented.

Surface Preparation

The surface of the basic material must be cleaned or descaled prior to plating. Cleaning removes from the surface the oil, grease, and dirt that interefere with the plating step. Any of several cleaning methods may be used, including solvent, alkaline, acid, emulsion, and ultrasonic cleaning. Associated with each method are advantages and disadvantages that affect the cleaning potential, polluting potential, and type of metal to be plated.

Solvent cleaning of metals is classified as either hot cleaning, such as vapor degreasing, or cold cleaning, in which the solvent is used at room temperature. Hot cleaning is effective in removing lubricants high in nonsaponifiable oils or sulfurized or chlorinated components. Cold cleaning solvents are selected based on the type of soil to be eliminated.

Alkaline cleaning is used to remove oily soils or solid soil from workpieces. The detergent nature of the solution provides the majority of the cleaning action, with agitation of the solution being secondary. Pieces may be sprayed, soaked, or cleaned electrolytically. Electrolytic cleaning produces the cleanest surfaces available from conventional methods of alkaline cleaning as a result of solution agitation by the gas evolution and the oxidation-reduction reactions that occur.

Emulsion cleaners consist of common organic solvents dispersed in an aqueous medium by emulsifying agents. Emulsion cleaning is conducted in the same manner as solvent cleaning.

Ultrasonic energy is finding increased use for the agitation of cleaning solutions and may represent substantial savings in time and labor. Ultrasonic cleaning is used to remove difficult inorganic and organic soils from intricate parts.

Acid cleaning is used to remove oxides that are formed on the metal surfaces prior to plating. The removal involves the dissolution of the oxide in an acid. Sulfuric, hydrochloric, and phosphoric acids are most commonly used.

Each of the above cleaning processes potentially generates wastewater pollutants in the form of the soils on the materials and the cleaning solutions used. Normally several of the above processes are used to ensure that the surface is thoroughly cleaned.

Salt bath descaling uses as molten salt bath - water quench - acid dip sequence to clean hard-to-remove oxides from stainless steels and other corrosion-resistant alloys. The work is immersed in the molten salt (temperature range from 400°C to 540°C), water quenched, and then acid dipped. Oxidizing, reducing, and electrolytic baths are available; the oxide to be removed governs the choice of bath.

Plating

The electroplating processes apply a surface coating for functional or decorative purposes. In electroplating, metal ions in either acid, alkaline, or neutral solutions are reduced on cathodic surfaces (the surfaces of the workpiece being plated). The metal ions in solution are usually replenished by the dissolution of metal from anodes or small pieces contained in inert wire or expanded metal baskets. Replenishment with metal salts is also practiced, especially for chromium plating. In this case, an inert material must be selected for the anodes. Hundreds of different electroplating solutions have been adopted commercially, but only two or three types are utilized widely for any particular metal or alloy. Cyanide solutions are popular for copper, zinc, brass, and cadmium, for example, yet noncyanide alkaline solutions containing pyrophosphate or another agent have come into use in recent years for zinc and copper. Zinc, copper, tin, and nickel are plated with acid sulfate solutions, especially pieces with relatively simple shapes. Cadmium and zinc are sometimes electroplated from neutral or slightly acid chloride solutions.

The electroplating process is basically an oxidation-reduction reaction. Typically, the part to be plated is the cathode, and the plating metal is the anode. Thus, to plate copper on zinc parts, the zinc parts are the cathodes, and the anode is a copper bar. On the application of electric power, the copper bar anode will be oxidized, dissolving it in the electrolyte (which could be copper sulfate):

$$Cu = Cu^{+2} + 2e^-$$

The resulting copper ions are reduced at the cathode (the zinc part) to form a copper plate:

$$Cu^{+2} + 2e^- = Cu$$

With some exceptions, notably chromium plating, all metals are usually electroplated in a similar manner. In chromium plating, the typical anode material is lead, and the chromium is supplied to the plating baths as chromic acid.

Parts are most commonly plated either in barrels or on racks. Barrel plating is used for small parts that tumble freely in rotating barrels. Direct current loads up to several hundred amperes are distributed to the parts being plated. For rack plating, parts may be attached to plastic-coated copper frames designed to carry current equally to a few hundred small parts, several medium-size shapes, or just a few large products through springlike rack tips affixed to the rack splines. Racks fabricated for manual transfer from cleaning, plating, and rinsing tanks usually hold workpieces totaling 0.5 to 1 m^2 (5 to 10 ft^2) in area. Larger racks for heavier parts are constructed for use with mechanical hoist and transfer systems.

Posttreatment

After deposition of a metallic coating by either electro or electroless techniques, an additional coating is sometimes applied to prepare the metal surface for painting or the application of a colored finish or to improve lubricity or corrosion protection. These posttreatments are the chromating, phosphating, and metal coloring processes of chemical conversion coating which are discussed later in the coating subcategory description.

Subcategory 1 - Common Metals Plating

This subcategory covers the electroplating of the following common metals, or any combination of them, onto a surface: aluminum, cadmium, chromium, copper, iron, lead, nickel, or tin. The paragraphs below describe some of the individual characteristics of the different types of plating done in this subcategory.

Aluminum Electroplating. Application of aluminum on a commercial basis is limited. It has been used for coating uranium and steel strip and electroforming. Because it is more reactive than hydrogen, aluminum cannot be plated from aqueous solutions or any solution containing acidic hydrogen. Only plating from a hydride bath with the basic ingredients of diethyl ether, aluminum chloride, and lithium aluminum hydride has had any commercial applications.

Cadmium Electroplating. Cadmium electroplating provides a corrosion protection coating over the basis material. Iron and steel are the most commonly used basis materials. Since cadmium is relatively high priced, only thin coatings are applied. It is sometimes used as an undercoating for zinc. Cadmium plating is often used on parts consisting of two or more metals to minimize galvanic corrosion. Cadmium cyanide baths are by far the most popular because they cover completely and give a dense, fine-grained deposit which can be made very lustrous by the use of stable brighteners.

Chromium Electroplating. Chromium electroplating solutions contain chromic acid and silicate or fluoride ions. Three basis materials account for the bulk of the chromium plate work: steel, nickel-electroplated steel, and nickel-electroplated zinc. Solutions containing 150 to 400 g/L of chromic acid are the common baths for electroplating 0.0002 mm to 0.10 mm (0.000008 to 0.00040 in.) of decorative chromium or hard chromium (for resisting wear) on steel and aluminum. Unlike the copper and nickel plating processes, which utilize soluble copper or nickel anodes to replenish the metal deposited on the workpieces, chromium electroplating processes always use insoluble lead alloy anodes. Thus, some portion of the chromic acid added regularly for maintenance is consumed by reduction to chromium metal at cathode surfaces.

Copper Electroplating. Copper is electroplated from several types of baths, among them alkaline cyanide, acid sulfate, pyrophosphate, and fluoborate, which are prepared with the corresponding copper salt. The cyanide solutions contain sodium carbonate and may also contain sodium hydroxide or sodium potassium tartrate. All four types may also contain a small amount of an organic chemical for refining the grain or brightening the plate. Cyanide solutions are used extensively for copper electroplating, but acid copper solutions have been adopted for plating large numbers of steel, plastic, and zinc alloy products. Steel and zinc are customarily plated first in a cyanide strike bath to insure good electroplate adhesion.

Alloyed forms of copper also find use in electroplating, the most common being brass and bronze. Brass, a combination of copper and zinc, is often used as a decorative plate on furniture hardware. Several types of bronze solutions including copper-tin, copper-cadmium, and copper-zinc are utilized primarily as decorative finishes.

Iron Electroplating. The electroplating of iron is used for certain specialized purposes such as electroforming and buildup of worn parts. Iron does not alloy with solder, which has led to iron plating of soldering tips. While there are several difficulties in the maintenance of an iron electroplating line, the iron electroplating solutions are comparatively stable and simple to operate. Special noncorrosive equipment is needed to heat and agitate the plating bath. Also, care must be taken that the plating bath does not oxidize. However, these disadvantages may be offset by the great abundance of low cost iron. Iron may be deposited as a hard and brittle or soft and ductile coat. Almost all iron is plated from solutions of ferrous salts at low pH's. The most common baths contain sulfate, chloride, fluoborate, and sulfamate.

Lead Electroplating. Lead is most resistant to hydrofluoric and sulfuric acids and is used for protective linings as well as coatings on nuts and bolts, storage battery parts, and bearings. Lead is often an undercoat for indium plating. Lead-tin and lead-antimony alloys are used. Solder plating is a 40/60 lead-tin alloy which is widely used in the electronics field.

Fluosilicate and fluoborate baths are the most widely used. The fluoborate bath is more expensive, but it gives finer grained, denser deposites, adheres better to steel, and will not decompose as readily.

Nickel Electroplating. Nickel is electroplated from several baths; among these are Watts (sulfate-chloride-boric acid), sulfamate, all chloride, and fluoborate baths. Each type of solution is prepared with the corresponding nickel salt, a buffer such as boric acid, and a small concentration of a wetting agent. A small amount of another organic chemical may be added to brighten the deposits or control other properties. Nickel is extensively electroplated in a three-metal composite coating of copper, nickel, and chromium. Nickel is also electrodeposited on steel for decorative-protective finishes and on other materials for electroforming. In these applications, nickel electroplating is preceded by cleaning and activating operations in a sequence selected for a specific basis material.

Organic agents that refine the grain size of the deposit and brighten the plate are added to all nickel plating baths adopted for sequential nickel-chromium plating. Proprietary agents are supplied by metal finishing supply companies that have developed stable, effective chemicals for insuring mirrorlike, corrosion-protection deposits requiring no buffing.

Tin Electroplating. In terms of tonnage of product produced, continuous tin electroplating of coil steel represents the largest application of electroplating in the world. Resistant to corrosion and tarnish, tin is also solderable, soft, and ductile. These properties of tin make it excellent for food handling equipment, electronic components, and bearing surfaces where lubricity to prevent seizing and scoring is desired.

Tin electroplate can provide a mat or bright deposit. The common baths of alkaline stannate and acid fluoborate produce a mat finish while the acid sulfate process can result in either type of deposit. Commonly, mat finishes are brightened by a post-plating operation of melting the deposit. This method is called "reflowing."

Zinc Electroplating. Zinc is electroplated in (a) cyanide solutions containing sodium cyanide, zinc oxides, or cyanide and sodium hydroxide; (b) noncyanide alkaline solutions prepared with zinc pyrophosphate or another chelating agent such as tetrasodium pyrophosphate, sodium citrate, or the sodium salt of ethylene-diamine tetraacetic acid; (c) acid or neutral chloride baths prepared with zinc chloride and a buffer salt such as ammonium chloride; or (d) acid sulfate solutions containing zinc sulfate and a buffer salt such as aluminum chloride or sulfate. A small concentration of an organic compound such as glucose, licorice, or glycerin may be added to the chloride or sulfate baths for brightening purposes.

Subcategory 2 - Precious Metals Plating

This subcategory is very similar to subcategory 1 in that it uses the same surface preparation, plating, and posttreatment processes. The difference lies in the type of metals to be plated onto the surfaces, of which there are six in this subcategory:

gold, indium, palladium, platinum, rhodium, and silver. Since the processes are very similar to those described above, no repetitive description is presented here. Individual characteristics of the plating metals and their processes are briefly described below.

Gold Electroplating. Gold electroplating provides not only decorative finishes and corrosion protection; it is also important in providing electrical contact surfaces, bonding surfaces, and electroformed conductors. Plating baths have been developed for each of these uses. Four types of gold baths are used. Three of these are cyanide baths - unbuffered alkaline with a pH range of 8.5 to 13, acid buffered with a pH range of 3 to 6, and a neutral buffer with a pH range of 6 to 8.5. The fourth is noncyanide.

Indium Electroplating. Indium electroplating is used in the manufacture of aircraft engine bearings. Corrosion of the originally plated cadmium-silver-copper bearings is reduced by an indium overlayer and heat treating. Indium is often alloy plated with copper, tin, lead, cadmium, nickel, bismuth, or rhodium.

Initially, indium baths were composed of cyanide and sugar. Today the sulfate bath is the most widely used, along with alkaline, fluoborate, sulfamate, chloride, perchlorate, and tartrate baths.

Platinum Metals Electroplating. Of the six metals in the platinum group only platinum, rhodium, and palladium are electroplated to any extent. Of these, rhodium is most often deposited. Decorative coatings for silverware, jewelry, and watches are very thin (0.1 μm) and are used to prevent tarnish and excessive wear of silver and to enhance the color of gold and gold-filled products. When the basis metal is not a silver or a gold alloy an undercoat of nickel is generally used. Coatings 25 μm (0.001 in.) thick are used for wear and corrosion resistance in the electronics industry and provide a surface of high optical reflectivity.

Platinum is electroplated on titanium and similar metals which are used as insoluble anodes in other plating operations (e.g., rhodium and gold). Electroplated platinum is used as an undercoat for rhodium plate. Ruthenium electroplating is used on high intensity electrodes to improve electrical contact. Commercial electroplating of osmium and iridium are believed to be nonexistent.

Rhodium electroplating baths are supplied as phosphate or sulfate concentrates. The only additions made to the diluted concentrate are phosphoric and/or sulfuric acids at concentrations of

25 to 75 mL per liter of plating bath. A rhodium concentration of 2.0 g/L is used for decorative coatings. Concentration is increased to 10 to 20 g/L for achieving thicker deposits.

The pallaidum content in plating solutions ranges from 2.5 to 10 g/L in the form of an amino nitrite complex. Other constituents are 11 g/L sodium nitrite and 40 mL/L of concentrated ammonium hydroxide. Palladium deposition has been accomplished from chloride or bromide solutions and from a molten cyanide bath.

Silver Electroplating. The use of silver electroplating is expanding in both the engineering and the decorative fields. Silver is typically electroplated in two types of baths, a conventional low metal bath and the high speed bath with a much higher silver content. Most baths are now based on potassium formulations because they provide high plating speeds, better conductivity, increased tolerance to carbonates, and smoother deposits.

Subcategory 3 - Anodizing

Anodizing is an electrolytic oxidation process which converts the surface of the metal to an insoluble oxide. These oxide coatings provide corrosion protection, decorative surfaces, a base for painting and other coating processes, and special electrical and engineering properties. Aluminum is the most frequently anodized material, while some magnesium and limited amounts of zinc and titanium are also anodized.

Surface preparation for anodizing can be minor or extensive depending on the alloying elements in the basis material and the amount of oil, grease, or oxide present on the part. Generally, the surface is prepared by four sequential cleaning steps, each (except degreasing) followed by rinsing. The vapor degreasing step is required only if an excessive amount of oil and grease is present. The principal cleaning step, inhibited soak cleaning, follows the degreasing step. Acidic cleaning and an optional etching step complete the surface preparation. The etching step may form a smutlike surface when an alkaline etch is used on an alloying metal which is cleaned by a nitric acid bath. After a final rinse the piece is ready for anodizing.

For aluminum parts, the formation of the oxide occurs when the parts are made anodic in dilute sulfuric acid or dilute chromic acid solutions. The oxide layer begins formation at the extreme outer surface, and as the reaction proceeds, the oxide grows into the metal. The last formed oxide, known as the boundary layer, is located at the interface between the base metal and the oxide. The boundary is extremely thin and nonporous. The sulfuric acid process is typically used for all parts fabricated from aluminum alloys except for parts subject to stress or containing recesses in which the sulfuric acid solution may be retained and attack the aluminum.

Chromic acid anodic coatings are more protective than sulfuric acid anodic coatings. This is partly due to the retention of chromic acid in the coating and its relatively thick boundary layer. For these reasons, a chromic acid bath is used if a complete rinsing of the part cannot be achieved.

Subcategory 4 - Coating

This section deals with chemical conversion coating by chromating, phosphating, metal coloring, and immersion plating. These coatings are applied to previously deposited metal or basis materials for increased corrosion protection, lubricity, preparation of the surface for additional coatings, or formulation of a special surface appearance.

In addition to the surface preparation steps described earlier, polishing is often used in coating operations to obtain the desired surface prior to coloring. Mechanical polishing, electropoloshing, and chemical polishing are used to obtain specific surface finishes.

Anodic coatings once applied are usually improved by a sealing process, usually involving an acid mixture, that modifies the surface to give better corrosion protection and improved paint adhesion. Unsealed anodic coatings may be colored by immersion in inorganic or organic dyes followed by a sealing process. Other posttreatment processes include applying special surface characteristics and drying.

Chromating. Chromate conversion coatings are protective films formed on the metal surfaces. During the process of chromating, a portion of the base metal is converted to one of the components of the film by reaction with aqueous solutions containing hexavalent chromium and active organic or inorganic compounds. Chromating solutions are generally acidic and contain chromic acid or its sodium or potassium salts, plus organic or inorganic compounds such as activators, accelerators, or catalysts. Although chromate conversion coatings can be applied by chemical or electrochemical action, the bulk of the coatings are usually applied by a chemical immersion, spray, or brush treatment. Most chromate treatments used in industry employ proprietary solutions. Additional coloring of the coatings can be achieved by dipping the organic dye baths to impart red, green, blue, and other colors. Besides their use as protective or decorative films, chromate conversion coatings are extensively employed to provide an excellent base for paint and other organic finishes which do not adhere well to untreated metal surfaces.

Phosphating. Phosphate conversion coatings produce a mildly protective layer of insoluble crystalline phosphate on the surface of a metal. Phosphate coatings are used to (a) provide a good base for paints and other organic coatings, (b) condition the surfaces for cold forming operations by providing a base for drawing compounds and lubricants, and (c) impart corrosion resistance to the metal surface by the coating itself or by providing a suitable base for rust-preventive oils or waxes. Phosphate conversion coatings are formed by the immersion of iron, steel, or zinc-plated steel in a dilute solution of phosphoric acid plus other reagents.

The method of applying the phosphate coating is dependent upon the size and shape of the part to be coated. Small parts are coated in barrels immersed in the phosphating solution. Large parts, such as steel sheet and strip, are spray coated or continuously passed through the phosphating solution. Supplemental oil or wax coatings are usually applied after phosphating unless the part is to be painted.

Coloring. Metal coloring by chemical conversion methods produces a large group of decorative finishes. This section covers only chemical methods of coloring in which the metal surface is converted into an oxide or other insoluble metal compound. The most common colored finishes are used on copper, steel, zinc, and cadmium.

Application of the color to the cleaned basis metal involves only a brief immersion in a dilute aqueous solution. The colored films produced on the metal surface are extremely thin and delicate. Consequently, they lack resistance to handling and the atomsphere. A clear lacquer is often used to protect the colored metal surface.

Immersion Plating. Immersion plating is a chemical plating process in which a thin metal deposit is obtained by chemical displacement of the basis metal. In immersion plating, a metal will displace from solution any other metal that is below it in the electromotive series of elements.

The lower (more noble) metal will be deposited from solution while the more active metal (higher in the series) will be dissolved. A common example of immersion plating is the deposition of copper on steel from an acid copper solution.

The thickness of immersion deposits is usually of the order of 0.25 μm (0.00001 in.) although a few processes produce deposits as thick as 2.5 μm to 5 μm (0.001 in. to 0.0002 in.). This thinness limits the usefulness of immersion deposits as to applications other than corrosion protection such as decoration or preparation for further processing such as painting or rubber bonding. The most widely used immersion plating processes are (a) tin on brass, copper, steel, or aluminum, (b) copper on steel, (c) gold on copper or brass, (d) nickel on steel, and (e) zinc on aluminum.

Subcategory 5 - Chemical Milling and Etching

Chemical milling and etching processes are used to produce specific design configuration and tolerances on metal parts by controlled dissolution with chemical reagents or etchants. Included in this general classification are the specific processes of chemical milling, chemical etching, bright dipping, electropolishing, and electrochemical machining.

In addition to the normal surface preparation processes, masks are applied by dip, spray, brush, roll or flow coating, silkscreen techniques, or photosensitive resists to prevent metal removal where it is not desired. Typically photographic techniques are used for the blanking of small, intricately shaped parts or for the production of nameplates, dials, and fine-mesh screen. After masking, parts may be dipped in acid to activate the surface prior to chemical milling or etching.

Chemical Milling. Chemical milling is similar to the etching procedure used for decades by photoengravers, except that the rates and depths of metal removal are usually much greater. Chemical milling is especially suited for removing metal from shallow depths on formed complex shaped parts (e.g., forgings, castings, extrusions) from thin sections and from large areas. The amount of metal removed or the depth of removal is controlled by the immersion time in the milling solutions. The metal can be removed from an entire part or restricted to selected areas by masking.

Typical solutions for chemical milling include ferric chloride, nitric acid, ammonium persulfate, chromic acid, cupric chloride, hydrochloric acid, and combinations of these reagents. Aluminum is milled in ferric chloride or hydrochloric acid or sodium hydroxide solutions. Copper is milled in ferric chloride, cupric chloride, chromic acid, or ammonium persulfate solutions.

Etching. Chemical etching is the same process as chemical milling, except that relatively small amounts (1-5 mils) of metal are removed. Bright dipping, a specialized example of the etching process, is used to remove oxide and tarnish from ferrous and nonferrous materials. Bright dipping can produce a range of surface appearances from bright clean to brilliant depending on the surface smoothness desired in the finished part. A smoother surface results in a more brillant appearance.

Bright dipping solutions usually involve mixtures of two or more of sulfuric, chromic, phosphoric, nitric, and hydrochloric acids. The rate of attack on the metal is controlled by the addition of inhibiting materials. The quantity of these materials is dependent upon the metals that are to be dipped. The type and quantity of the parts to be bright dipped greatly influence the composition of the bath. For parts with simple shapes which can be easily removed from the dipping solution and quickly rinsed, fast-acting dips are used. Slow-acting dips are used for bulk loads of parts and parts with complex shapes.

Subcategory 6 - Electroless Plating

Electroless plating is a chemical reduction process which depends upon the catalytic reduction of a metallic ion in an aqueous solution containing a reducing agent and the subsequent deposition of metal without the use of external electrical energy. It has found widespread use in industry due to its several unique advantages over conventional electroplating. Electroless plating provides a uniform plating thickness on all areas of a part regardless of the part's configuration or geometry. This makes it possible to plate deep recesses and niches that electroplating cannot effectively reach due to current distribution problems. An electroless plate on a properly prepared surface is dense and virtually nonporous. Furthermore, certain types of electroless platings provide better hardness and corrosion protection than their electroplated counterparts. Copper and nickel electroless plating are the most common. Others found on a smaller scale are iron, cobalt, gold, palladium, and arsenic.

The basic ingredients in an electroless plating solution are:

- A source of metal, usually a salt.
- A reducer to reduce the metal to its base state.
- A chelating agent to hold the metal in solution (so the metal will not plate out indiscriminately).
- Various buffers and other chemicals designed to maintain bath stability and increase bath life.

Of particular interest among the constituents of electroless plating baths are the chelating agents. Chelation is an equilibrium reacton between a metal ion and a complexing agent characterized by the formation of more than one bond between the metal and a molecule of the complexing agent. This results in the formation of a ring structure incorporating the metal ion and thus holding it in solution. Chelating agents control metal ions by blocking their reactive sites, thus preventing them from carrying out their normal (and in many cases undesirable) reactions.

In the electroless plating processes, the purpose of the chelating agent is to hold the metal in solution, to keep it from plating out indiscriminately. Thus, the chelate can only be replaced by some material capable of forming an even more stable complex; that is, the part to be plated.

One of the drawbacks in the use of chelating agents is the difficulty in precipitating chelated metals out of wastewater during treatment. Quite often, plants which are engaged in plating activities that make use of chelating agents have treatment systems based on the precipitation and the settling out of heavy metals. Unfortunately, in the treatment system, the chelating agents continue to hold the metal in solution, and cause the chelated metal to pass through the treatment system without precipitation and settling. In some situations, particularly with the stronger chelates, special treatment is necessary to remove the bound metals.

Electroless plating is performed on two different types of surfaces, metal and plastic. For electroless metal plating, preparation consists of the conventional electroplating cleaning steps for metals with active surfaces. In addition, the smoother the surface, the better the resulting plating finish. Therefore, the parts usually undergo mechanical preparation, such as honing, and chemical treatment, such as acid dipping or alkaline cleaning. Some metals require an activation step which involves a flash deposit of a catalyst on the metal surface.

Surface preparation for electroless plastic plating, different from that for metal plating, involves roughening or etching and catalyst application. Roughnening is accomplished either by mechanical means such as tumbling or by chemical means such as etching. Following this step a catalyst is applied to allow metal deposition to occur. All plastics require this catalytic preparation prior to plating.

Two different catalyst application methods have been employed and both are based on the interaction of stannous and palladium salts. One method involves adsorbing stannous tin on the surface, then immersing the part in palladium chloride. This reduces the palladium to the metal form and oxidizes the tin from stannous to stannic. A molecular layer of palladium metal is deposited on the surface of the part and the tin remains in the solution. The other process used for catalyst application involves the application of a mixture of stannous and palladous compounds on the part. This activator is adsorbed on the part, and a reaction takes place when the part is exposed to a solution that dissolves tin on the surface. After the catalyst is applied, the part is immersed in the electroless bath and the desired metal plates out on the palladium. After the initial layer of metal is applied it becomes the catalyst for the remainder of the plating process.

Plating is completed by immersing the activated piece in a plating tank long enough for the desired thickness to accumulate.

Advantages of electroless plating over electroplating on metals include greater hardness values and greater resistance to wear and abrasion. Plastic electroless plating is done on nearly every type of plastic and allows for low cost pieces.

The most common operation carried out after electroless plating is electroplating. Virtually all of the electroless plating done on plastics is followed by some form of electroplating operation. Although an electroless plate has superior hardness and corrosion protection characteristics, it may be covered by some coating such as a lacquer.

Subcategory 7 - Printed Circuit Board Manufacturing

Printed boards are fabricated from nonconductive board materials such as plastic or glass on which a circuit pattern of conductive metal, usually copper, has been formed. The board not only provides a surface for the application of a conductive wiring path but also gives support and protection to the components it connects. As a means of packing and interconnecting electronic devices, printed boards find widespread use in business machines, computers, and communications and home entertainment equipment.

Printing Methods. The printed board industry is limited to three main production methods: subtractive, additive, and semiadditive.

The subtractive process derives its name from the large amount of material that is removed to make the circuit. The simplest of the subtractive techniques is the print and etch process which begins with a board of nonconductive materials, such as glass or plastic, which is clad with a copper foil. The circuit pattern is printed onto this foil in oil, cellulose, asphalt, vinyl, or resin based ink and then the board goes through an etching operation in which the area of the foil not covered by the ink is removed. Next, the ink is stripped from the foil, leaving only the desired circuit of copper on the board.

At this point, the board can be handled in one of two ways. If it is to be panel plated, the whole board is electroplated with copper. Then a plating resist is applied in such a form that only the desired circuit is left exposed (not covered by resist). This exposed area is then electroplated (by immersing the entire board in the plating solution) with an etch resist, usually solder. If it is to be pattern plated, the plating resist is applied directly after the electroless copper step, so only the circuit is copper electroplated and likewise solder plated.

Following the application of the solder plate by either method the plating resist is stripped off, exposing the copper in areas where the circuit is not required. This copper is then etched off, leaving only the desired circuit which was etch protected by solder plate. The tabs or fingers at the edges of the boards are now stripped of their solder in preparation for subsequent plating. These tabs are electroplated according to the specifications of the customer (in most cases with gold or nickel and gold). The solder plate in the circuit pattern is now reflowed to completely seal the copper circuitry and act as a corrosion preventive. The last steps are blanking and cutting of boards to size and final inspection.

The additive process involves deposition of plating material on the board in the pattern dictated by the circuit, rather than removal of metal already deposited (as in the subtractive process). There have been several "additive" methods for producing printed boards. The original method consisted of depositing a thin layer of electroless copper on a bare unclad board and following this up with conventional subtractive processing.

The additive process presently employed by some manufacturers is more totally additive than the original method. The process begins with a bare board which may or may not be impregnated with a catalyst. Holes are then formed by drilling or punching. An adhesion promotion operation (in which the surface is roughened or etched) is next, followed by the plating resist, describing the required circuit pattern, which is applied to the board in the noncircuit areas. The accelerator step necessary for electroless plating is then carried out, and the board goes into the electroless copper bath. Since the board does not initially have any copper in noncircuit areas and a resist is applied to these areas prior to electroless plating, a copper etching step is not necessary. Following copper deposition, the tabs are plated in the same manner as in the subtractive process. At this point, different finishing steps may be applied, such as application of a protective coating to the board.

A recently developed additive method involves sensitizing the entire board and then selectively activating the catalyst in the pattern of the circuit by means of ultraviolet light.

A semiadditive production process is a compromise between the additive and subtractive methods. The process sequence begins with an unclad board which undergoes hole fabrication (drilling or punching). An adhesion promotion operation is performed on the board just as in the additive process, the board being etched to obtain a microporous surface. At this point, the sequence follows the subtractive process. The entire board is catalyzed and activated, and electroless copper is applied to the entire board including the inside surfaces of the holes. The circuit pattern is then applied by conventional methods (screening or photoimaging). Copper electroplate is deposited to build up the circuit to the desired thickness. The solder plate for etch masking is then applied, and the plating mask is stripped from the noncircuit areas. The subsequent etching operation is a quick etch (as compared with the subtractive process etch) because only the electroless copper flash has to be removed. In the subtractive process, the copper foil on the board and the electroless copper have to be etched away, but this is not required for the semiadditive process. Thus its advantage over the subtractive process is a reduction in copper waste. After the etch operation, the solder stripping, tab plating, and any final fabrication processes are performed as in the conventional subtractive process.

Production Processes. Printed board production for all the above board types can be broken down into the following operations: cleaning and surface preparation, catalyst application and electroless plating, pattern printing and masking, electroplating, and etching. Brief descriptions of these processes are presented below.

Cleaning and surface preparation is a crucial step in printed board production. For a board to be plated correctly without flaws, it must be cleaned and properly treated. In many cases, the boards go through a mechanical scrubbing before they reach the plating lines. In the case of multilayer boards, after they are bonded or laminated they go through an acid hole-cleaning operation to remove any bonding epoxy which spilled over the holes.

Once on the plating line, all types of boards are alkaline cleaned to remove any soil, fingerprints, smears, or other substances which cause plating flaws. A mild etch step is then performed with ammonium or sodium persulfate to prepare the copper foil surface (for copper clad boards) for subsequent plating. The copper clad boards are then acid treated to roughen the exposed plastic surfaces (inside areas of holes) so they will readily accept the catalyst.

Electroless copper deposits quite readily on a copper clad board, but for a deposit to form on the exposed plastic or on a bare board (as in the additive process or in through-hole plating), a catalyst must be involved for the copper plate on the nonmetal. The application and activation of the catalyst is a two-step process. The catalyst application consists of the deposition of a thin layer of palladium on the surface of the part.

Three different catalyst application methods have been employed, and all are based on the interaction of stannous and palladium salts. One method involves adsorbing stannous tin on the surface, then immersing the part in palladium chloride. This reduces the palladium to the metal form and oxidizes the tin from stannous to stannic. A molecular layer of palladium metal is deposited on the surface of the part and the tin remains in the solution.

Another process used for catalyst application involves the application of a mixture of stannous and palladous compounds on the part. This activator is adsorbed on the part, and a reaction takes place when the part is exposed to a solution that dissolves tin, leaving only palladium on the surface. This step is commonly referred to as "acceleration."

In a recently developed method, specifically for printed boards, a catalyst is applied only to the area to be occupied by the circuit. Stannous chloride is adsorbed on the entire part's surface. Then the surface is exposed to ultraviolet light shone through a stencil. The light oxidizes the stannous tin to stannic in the area not to be plated. This area, when exposed to palladium chloride, undergoes no reaction, and no palladium is deposited. Only the unexposed area receives a palladium deposit.

Once the catalyst is applied, the metal in the electroless bath plates out on the palladium. After the initial layer of metal is applied, it becomes the catalyst for the remainder of the plating process.

After the boards have been catalyzed, they go into the electroless copper solution and are panel plated in the subtractive and semiadditive processes or pattern plated in the additive process. The electroless copper bath contains copper salts (copper sulfate being most prevalent), formaldehyde as a reducer, chelating agents to hold the copper in solution (in most cases either a tartrate or an ethylenediaminetetraacetic acid compound), sodium hydroxide as a pH buffer, and various polymers and amines which serve as brighteners and bath stabilizers. These chemicals vary according to each bath supplier and his own "proprietary" formulas.

Another key step in the manufacture of printed circuit boards is the pattern printing. The precision of this artwork is crucial since the quality of the final board can be no better than the image printed on it. There are three principal methods in which the image or pattern is applied to the board: screening, photosensitive resist techniques, and offset printing. All of the methods apply a resist material to the board.

Screening consists of selectively applying resist material through a stencil or screen. The screen material is placed over the work, and the ink or resist material is squeegeed through the screen. The screening method is highly acceptable for simple low density circuits because its low cost allows for high volume production.

Photosensitive resist is a light sensitive polymer which, after curing, has a significant chemical resistance. After the board has been cleaned and prepared, the polymer is applied by dipping or rolling. A light source (usually ultraviolet) is applied through a pattern onto the resist. The light sensitive material hardens, and the unexposed resist is then removed by one of several methods; usually a trichloroethylene degreaser is used. This is followed by a baking or curing step after which the resist is able to withstand plating solutions. This type of precision masking has made possible the production of high density and intricate circuits.

Offset printing is a high volume production technique similar to the operation of a printing press. An etched plate (the printing plate) serves as a master pattern. Ink is transferred from an ink roller to the plate on a rubber cylinder. The ink image is then deposited on the copper-covered board. Enough ink can be built up on the board in several passes to form a plating or etching resist.

Whether an additive, semiadditive, or subtractive process is used, masking is applied when the tabs are being plated. The simplest and most commonly used mask for such applications is a water repellent tape which can be easily applied to or removed from the board.

Electroplating is performed at several junctures in the production of printed boards. It is employed in the actual buildup of the circuit (in the subtractive and semiadditive processes); it applies the etch resist and anticorrosion layer to the circuit; and it covers the tabs or fingers of all boards.

To build up the desired circuit in the subtractive and semiadditive processes, copper electroplating is followed by solder electroplating. The copper bath itself is usually one of four types: cyanide copper, fluoborate copper, pyrophosphate copper, or sulfate copper. The solder electroplate serves a dual purpose: it acts as a mask during the etching process, and it protects the copper circuit from corrosion after final fabrication. This solder plate usually consists of 60-40 tin-lead, although tin-nickel and gold are used in some instances.

The tabs or fingers of the printed circuit boards are electroplated for most applications (additive, semiadditive or subtractive). In the subtractive and semiadditive processes, a solder strip operation precedes plating to ensure better adhesion; this step is unnecessary in the additive process. In most cases, nickel and gold or simply gold is used.

Etching is that process by which all the unwanted copper (i.e., any copper other than in the circuit) is removed from the board. This step follows, in sequence, the pattern print and pattern plate. Most companies make use of mechanical etchers which spray solutions from various tanks (containing etch solutions, solder brighteners or activators, and rinse waters) onto horizontally traveling boards.

The etch solutions include:

- Ferric chloride base - This provides good uniform etching but removal of the residual acid from the work is difficult.
- Cupric chloride - This is suitable for any resist and has the advantage of continued regeneration through addition of chemicals.
- Chromic acid base - This is the most expensive etchant listed here and requires special attention in waste treatment for chromium reduction. It is also very effective.
- Ammonium persulfate - This is clean and easy to handle, but the solution can be somewhat unstable.

Etching is always used in the subtractive production method, while an abbreviated etch is employed in the semiadditive process. The etching operation is not a part of the additive process.

After etching, the boards are ready for solder stripping and the electroplating of the tabs.

Table 4-2 presents best practicable control technology effluent limitations for several subcategories in the electroplating industry.

II.4.2 WASTEWATER CHARACTERIZATION [1]

Electroplating process wastewater is generated by (1) alkaline cleaning operations, (2) acid cleaning operations, (3) catalyst application and acceleration processes, (4) plating operations and posttreatment, and (5) auxiliary operations.

Wastewater constituents from the above sources include the basis material being finished as well as the components in the processing solutions. Predominant wastewater constituents for the industry include copper, nickel, chromium, zinc, lead, tin, cadmium, gold, silver, and platinum, as well as ions such as phosphates, chlorides, and various complexing agents.

The following paragraphs describe the major waste sources for normal plating operations.

II.4.2.1 Alkaline Cleaners

Cleaning solutions usually contain one or more of the following chemicals: sodium hydroxide, sodium carbonate, sodium metasilicate, sodium phosphate (di- or trisodium), sodium silicate, sodium tetraphosphate, and a wetting agent. The specific content of cleaners varies with the type of soil being removed. Waste waters from cleaning operations contain not only the chemicals

TABLE 4-2. BPT EFFLUENT LIMITATIONS FOR THE ELECTROPLATING INDUSTRY[a] [3]

TABLE 4-2. BPT EFFLUENT LIMITATIONS FOR THE ELECTROPLATING INDUSTRY

	Concentration, mg/m^2 (lb/$\bar{M}$ ft^2) per operation[b]									
	Common metals plating		Precious metals plating		Anodizing		Coating		Chemical milling and etching	
Parameter	Daily maximum	30-day average	Daily maximum	30-day average	Daily maximum	30-day average	Daily maximum	30-day average	Daily maximum	30-day average
Cadmium	96(19.2)	48(9.6)			54(8.8)	27(4.4)	48(9.8)	24(4.9)	72(14.8)	36(7.4)
Chromium, total	160(32.7)	80(16.4)	160(32.7)	80(16.4)	90(18.4)	45(9.2)	80(16.4)	40(8.2)	120(24.6)	60(12.3)
Chromium, VI	16(3.3)	8(1.6)	16(3.3)	8(1.6)	9(1.8)	4.5(0.9)	8(1.6)	4(0.8)	12(2.4)	6(1.2)
Copper	160(32.7)	80(16.4)			90(18.4)	45(9.2)	80(16.4)	40(8.2)	120(24.6)	60(12.3)
Cyanide, total	160(32.7)	80(16.4)	160(32.7)	80(16.4)	90(18.4)	45(9.2)	80(16.4)	40(8.2)	120(24.6)	60(12.3)
Cyanide, A	16(3.3)	8(1.6)	16(3.3)	8(1.6)	9(1.8)	4.5(0.9)	8(1.6)	4(0.8)	18(3.8)	9(1.9)
Fluoride	6,400(1,310)	3,200(654)			3,600(738)	1,800(369)	3,600(738)	1,800(369)	4,800(984)	2,400(492)
Gold			16(3.3)	8(1.6)						
Iridium			16(3.3)	8(1.6)						
Iron	320(65.4)	160(32.7)			180(36.8)	90(18.4)	160(32.8)	80(16.4)	240(49.2)	120(24.6)
Lead	160(32.7)	80(16.4)								
Nickel	160(32.7)	80(16.4)			90(18.4)	45(9.2)	80(16.4)	40(8.2)	120(24.6)	60(12.3)
Osmium			16(3.3)	8(1.6)						
Palladium			16(3.3)	8(1.6)						
Phosphorus	320(65.4)	160(32.7)	320(65.4)	160(32.7)	180(36.8)	90(18.4)	160(32.8)	80(16.4)	240(49.2)	120(24.6)
Platinum			16(3.3)	8(1.6)						
Rhodium			16(3.3)	8(1.6)						
Ruthenium			16(3.3)	8(1.6)						
Silver			16(3.3)	8(1.6)						
Tin	320(65.4)	160(32.7)			180(36.8)	90(18.4)	160(32.8)	80(16.4)	240(49.2)	120(24.6)
Zinc	160(32.7)	80(16.4)			90(18.4)	45(9.2)	80(16.4)	40(8.2)	120(24.6)	60(12.3)
TSS	6,400(1,310)	3,200(654)	6,400(1,310)	3,200(654)	3,600(738)	1,800(369)	3,600(738)	1,800(369)	4,800(984)	2,400(492)
pH	6-9.5		6-9.5		6-9.5		6-9.5		6-9.5	

Note: Blanks indicate data not available.

[a] For the electroless plating and printed circuit board subcategories, only pretreatment standards have been promulgated. Other subcategories are not mentioned in the Federal Register at this time.

[b] Except pH values (given in pH units).

found in the alkaline cleaners but also soaps from the saponification of greases left on the surface by polishing and buffing operations. Some oils and greases are not saponified but are, nevertheless, emulsified.

The raw wastes from cleaning process solutions and dissolution of basis metals show up in the rinse waters, spills, dumps of concentrated solutions, wash waters from air-exhaust ducts, and leaking heating or cooling coils and heat exchangers. The concentrations of dissolved basis metal in rinses following alkaline cleaning are usually small relative to acid dip rinses.

II.4.2.2 Acid Cleaners

Solutions for pickling or acid cleaning usually contain one or more of the following: hydrochloric acid (most common), sulfuric acid, nitric acid, chromic acid, fluoboric acid, and phosphoric acid. The solution compositions vary according to the nature of the basis metals and the type of tarnish or scale to be removed. These acid solutions accumulate appreciable amounts of metal as a result of dissolution of metal from workpieces or uncoated areas of plating racks that are recycled repeatedly through cleaning, acid treating, and electroplating baths. As a result, the baths usually have a relatively short life, and when they are dumped and replaced, large amounts of chemicals must be treated or reclaimed. These chemicals also enter the waste stream by way of dragout from the acid solutions into rinse waters.

II.4.2.3 Catalyst Application and Acceleration

In electroless plating on plastics, a catalyst must be applied to the plastic to initiate the plating process. The catalyst consists of tin and palladium, and in the acceleration process the tin is removed. A chromic acid surface preparation of the plastic usually precedes the catalyst application.

II.4.2.4 Plating Operations and Posttreatment

Plating and posttreatment baths contain metal salts, acids, alkalies, and various compounds used for bath control. Common plating metals include copper, nickel, chromium, zinc, cadmium, lead, iron, and tin. Precious plating metals include silver, gold, palladium, platinum, and rhodium. In addition to these metals, ammonia, sodium, and potassium are common cationic constituents of plating baths. Anions most likely to be present in plating and posttreatment baths are borate, cyanide, carbonate, fluoride, fluoborate, phosphates, chloride, nitrate, sulfate, sulfide, sulfamate, and tartrate.

Many plating solutions contain metallic, metallo-organic, and organic additives to induce grain refining, leveling of the plating surface, and deposit brightening. Arsenic, cobalt, molybdenum, and selenium are used in this way, as are saccharin and various aldehydes. These additives are generally present in a bath at concentrations of less than 1% by volume or weight.

Complexing and chelating agents are important constituents of some plating baths, especially electroless plating solutions. Most electroless plating baths in commercial use are proprietary and identification of complexing agents present is difficult. From a wastewater standpoint, the prime importance of the agents lies in the difficulties they present for effective metal removal since they hinder precipitation of metal ions.

Chromium, aluminum, and manganese are the metal constituents most common in anodizing baths; ammonia, sulfate, fluoride, phosphate, and various bases are the most important nonmetal constituents. Basis metal, usually aluminum, will also be present in the bath. Posttreatment for anodized surfaces often consists only of hot water rinsing. Occasionally, anodized parts are sealed with a chromium salt solution or colored with organic or inorganic dyes.

Chromating baths are nearly all proprietary and little information about their formulation is available. However, all baths have chromate and a suitable activator (an organic or inorganic radical) usually in an acid solution. Chromate conversions can be produced on zinc, cadmium, aluminum, magnesium, copper, and brass, and these metals will dissolve into the chromating baths. Posttreatment of chromate conversion coatings may include dipping in organic dips or sealing in a hot water rinse.

The phosphates of zinc, iron, manganese, and calcium are most often used for phosphate coatings. Strontium and cadmium phosphates are used in some baths, and the elements aluminum, chromium, fluorine, boron, and silicon are also common bath constituents. Phosphoric acid is used as the solvent in phosphating solutions. Phosphated parts may be colored in a posttreatment step, or conditioned in very dilute chromic or phosphoric acid.

Solutions for chemical milling, etching, and associated operations contain dissolved or particulate basis metals and either chemical agents for metal oxidation or electrolytes for electrical metal removal (as in electrochemical machining). Bath constituents for chemical removal of basis metals include mineral acids, acid chlorides, alkaline ammonium solutions, nitro-organic compounds, and such compounds as ammonium peroxysulfate. Common electrolytes are sodium and ammonium chloride, sodium and ammonium nitrate, and sodium cyanide. Posttreatment baths for chemical milling or etching would not contain constituents significantly different from those listed above.

Immersion plating baths usually are simple formulations of metal salts, alkalies, and complexing agents. The complexing agents are typically cyanide or ammonia and are used to raise the deposition potential of the plating metal. Parts plated by immersion are seldom posttreated except in the case of zinc immersion plating of aluminum. This process is used to form a base for subsequent electroplating, usually copper.

II.4.2.5 Auxiliary Operations

Auxiliary operations such as rack stripping, although essential to plant operation, are often neglected in considering overall pollutant reduction. Stripping solutions using a cyanide base can form compounds which are difficult to treat. One such compound is nickel cyanide, in which the cyanide is not readily amenable to chlorination. Frequent cleaning of stripping baths and use of alternative chemicals can significantly reduce the pollutants evolving from this type of source.

Water is used in the Electroplating Industry for rinsing workpieces; for plant washdown, air scrubbing, and auxiliary operation rinsing; and in preparing solutions. Approximately 90% of the water used is for rinsing, which removes the process solution film from the workpiece surface and from the racks used in rack stripping. The water becomes contaminated with the constituents of the process solutions and is not directly reusable.

Plant cleanup operations create dilute wastewater that is the result of spills and air scrubbing operations. This wastewater is usually added to acid/alkali wastestream prior to treatment.

Most wastewaters emanating from this industry are contaminated with the particular constituents of the solutions used at the individual plant sites. The ranges of wastewater concentrations for the subcategories studied are presented in Table 4-3. No additional information is available at this time.

II.4.3 PLANT SPECIFIC DESCRIPTION

No plant specific information is available at this time for the Electroplating Industry.

II.4.4 POLLUTANT REMOVABILITY [1]

This section reviews the technology currently available and used to remove or recover pollutants from the wastewater generated from 196 plants in the electroplating data base. The technology available includes both in-plant recovery and reuse of water and final wastewater treatment.

II.4.4.1 In-Plant Technology

The intent of in-plant technology for the overall electroplating point source category is to reduce or eliminate the waste load requiring end-of-pipe treatment and thereby improve the efficiency

TABLE 4-3. POLLUTANT CONCENTRATION RANGES FOR THE SUBCATEGORIES OF THE ELECTROPLATING INDUSTRY [1]

Pollutant parameter	Concentration range						
	Common metals plating	Precious metals plating	Electroless	Anodizing	Coating	Chemical milling and etching	Printed circuit boards
Conventional pollutants, mg/L							
TSS	0.1 - 10,000	0.1 - 10,000	0.1 - 39.0	36.0 - 920	19.0 - 5,300	0.1 - 4,300	1.0 - 610
Toxic inorganic pollutants, μg/L							
Cadmium	7 - 21,600						
Chromium, total	88 - 530,000			270 - 79,000	190 - 79,000	88 - 530,000	5 - 48,000
Chromium, VI	5 - 330,000			5 - 5,000	5 - 5,000	5 - 330,000	5 - 4,400
Copper	32 - 270,000		2 - 48,000			210 - 270,000	200 - 540,000
Cyanide, total	5 - 150,000	5 - 10,000	5 - 12,000	5 - 78,000	5 - 130,000	5 - 130,000	5 - 11,000
Cyanide, A	3 - 130,000	3 - 8,400	5 - 1,000	4 - 68,000	4 - 68,000	5 - 100,000	5 - 9,400
Lead	660 - 25,000						10 - 10,000
Nickel	19 - 3,000,000		28 - 47,000				27 - 13,000
Silver		50 - 180,000					1 - 480
Zinc	110 - 250,000				140 - 200	110 - 200,000	
Nontoxic pollutants, μg/L							
Fluoride	22 - 140,000		110 - 18,000			22 - 140,000	280 - 680,000
Gold		13 - 25,000					6 - 110
Iron	250 - 1,500,000				410 - 170,000	75 - 260,000	
Palladium		27 - 630					5 - 230
Phosphorus	20 - 140,000	20 - 140,000	30 - 109,000	180 - 33,000	60 - 53,000	60 - 140,000	51 - 54,000
Platinum		110 - 6,500					
Rhodium[a]		34					
Tin	60 - 100,000		60 - 90,000		100 - 6,600	340 - 6,600	60 - 54,000

Note: Blanks indicate data not available.

[a]Only one plant had a measurable level of this pollutant

of waste treatment. In-plant technology involves the selection of rinse techniques (with the emphasis on closed loop rinsing), plating bath conservation, recovery and/or reuse of plating and etch solutions, process modification, and integrated waste treatment.

Rinse Techniques

Reductions in the amount of water used in electroplating can be realized through installation and use of efficient rinse techniques. Cost savings associated with this water use reduction manifest themselves in reduced operating costs in terms of lower cost for rinse water and reduced chemical costs for wastewater treatment. An added benefit is that the waste treatment efficiency is also improved. It is estimated that rinse steps consume over 90% of the water used by a typical plating facility. Consequently, the greatest water use reductions can be anticipated to come from modifications of rinse techniques.

Several different methods of rinsing are available, with each method having a particular use, efficiency, and water usage rate. Methods may be combined to produce cleaner pieces. Other factors may also affect the choice and efficiency of a rinsing method. Recirculation of the rinse water is a possibility.

Plating Bath Conservation

If the overflow water from a rinse tank can be reused, it does not have to be treated, and additional water does not have to be purchased. One approach currently in use is to replace the evaporative losses from the plating bath with overflow from the rinse station. This way a large percentage of plating solution normally lost by dragout can be returned and reused. The usefulness of this method depends on the rate of evaporation from the plating bath and the overflow rate from the rinse tank. The evaporation from a bath is a function of its temperature, surface area, and ventilation rate, while the overflow rate is dependent on the dilution ratio, the geometry of the part, and the dragout rates.

Chemical Recovery

A number of techniques are utilized to recover and/or reuse plating solutions or etchants. The incentive to recover or reuse may be primarily economical, but the ecological impact of not having to treat these concentrated solutions for discharge should also be considered. The solutions can be reclaimed using any one of a number of techniques such as reverse osmosis, ion exchange, and evaporation.

Process Modification

Process modifications can reduce the amount of water required for rinsing and, thus, reduce the overall load on a waste treatment facility. As an example, for electroless plating, a rinse step can be eliminated by using a combined sensitization and activation solution followed by a rinse instead of a process sequence of sensitization-rinse, activation-rinse. Another potential process modification would be to change from a high concentration plating bath to one with a lower concentration. Parts immersed in the lower concentration bath require less rinsing (a dilution operation), which decreases water usage relative to high concentration baths. The use of noncyanide plating baths and phosphate-free and biodegradable cleaners, where possible, reduces the waste load on an end-of-pipe treatment system.

Integrated Waste Treatment

Waste treatment iself can be accomplished on a small scale in the plating room with constant recycling of the effluent. This process is generally known as integrated waste treatment. Integrated treatment uses a treatment rinse tank in the process line immediately following a process tank (plating, chromating, etc.). Treatment solution (usually caustic soda in excess) circulating through the rinse tank reacts with the dragout to form a precipitate and removes it to a clarifier. This clarifier is a small reservoir usually designed to fit near the treatment rinse tank and be an integral part of water use in the production process. Further treatment may take place in the clarifier (cyanide oxidation, chrome reduction), or settling alone may be used to separate the solids. Sludge is removed near the spillover plate on the effluent side of the clarifier, and the effluent is returned to the treatment rinse tank. Consequently, no pollutants are directly discharged by the waste treatment process. Although further rinsing of the parts is required to remove treatment chemicals, this rinse will not contain pollutants from the original process tank, and no further treatment is needed.

II.4.4.2 Individual Treatment Technologies

Table 4-4 summarizes the individual treatment technologies that are used by the plants in the electroplating data base. Some of them are described below.

Chemical Reduction of Hexavalent Chromium

Reduction of hexavalent chromium has proven effectiveness in the industry with up to 99.7% reduction efficiency possible. This technique is highly reliable because it can e controlled automatically and it operates at ambient conditions. Limitations

TABLE 4-4. INDIVIDUAL TREATMENT TECHNOLOGIES[a] [1]

Technology	Number of plants in data base
Chemical reduction of hexavalent chromium	120
pH adjustment	158
Clarification	151
Diatomaceous earth filtration	5
Flotation	6
Chemical oxidation (chlorine)	90
Ion exchange	11
Evaporation	12
Reverse osmosis	7
Ultrafiltration	2
Membrane filtration	1
Electrodialysis	1
Filter press	8
Sludge drying beds	3
Vacuum filtration	21
Centrifugation	12
Electrolyte oxidation	3

[a]Some plants use more than one treatment technology.

include possible chemical interference by other wastes, and the necessity for precise pH control.

pH Control

The control of pH is standard in most industries to provide controlled effluent acidity/alkalinity. Because of its extensive use the technology is well developed. A possible problem with this technique is the disposal of a substantial quantity of sludge.

Clarification

Clarification is also a well defined treatment technology. Capable of handling large amounts of wastewater, it is the most common technology used in this industry.

Diatomaceous Earth Filtration

Diatomaceous earth filtration, combined with pH adjustment and precipitation, is an alternative to settling for suspended solids removal. This technique, used to remove metal hydroxides and other solids from the wastewater, releases high quality effluent. Table 4-5 presents the information available for this technique.

TABLE 4-5. DIATOMACEOUS EARTH FILTER [1]

	Concentration, mg/L		
	Raw waste	Effluent	Percent removal
TSS	524	10	98
Zinc	13.4	0.139	99
Trivalent chromium	12.2	0.611	95
Iron	5.81	0.248	96
Copper	7.53	0.444	94
Nickel	2.57	0.044	98

Flotation

Flotation units are commonly used to remove emulsified oils and greases as well as dissolved solids with a specific gravity close to that of water. The performance of the unit depends on production of sufficient air bubbles to float the suspended solids. Only limited application of this method has been demonstrated in this industry.

Chemical Oxidation

Chlorine is used in treating industrial waste to oxidize cyanide. Advantages of this process include low cost, availability of automatic control, and operation at ambient temperatures. Disadvantages may include the release of toxic volatile components from intermediate reactions, chemical interference, and the potential hazard in using chlorine gas. Table 4-6 presents the available information from the Electroplating Industry on this treatment method.

TABLE 4-6. CHEMICAL OXIDATION (CHLORINE) [1]

Parameter	Percent reduction
Cyanide	99.6
Phenol	100
Color	99
Turbidity	99.4
Odor	85

Ion Exchange

Ion exchange is used extensively for water and wastewater treatment to allow for recovery of valuable waste materials or by-products, particularly ionic forms of precious metals such as silver, gold, and uranium. This compact, relatively inexpensive technique can often be installed with minimal production interruption. However, many materials may clog or foul the resin capacity, reducing efficiency. When operated properly, this method is highly efficient and generates a high quality effluent. Table 4-7 is an example of the effluent characteristics from an ion exchange column.

TABLE 4-7. ION EXCHANGE [1]

Pollutant	Concentration, mg/L Raw wastewater	 Treated wastewater	Percent reduction
Aluminum	5.60	0.24	96
Cadmium	1.05	0.00	100
Chromium	7.60	0.06	99
Copper	4.45	0.09	98
Iron	3.70	0.10	97
Nickel	6.20	0.00	100
Silver	1.50	0.00	100
Tin	0.50	0.00	100
Cyanide	0.80	0.20	75
Sulfate	21.0	2.0	90
Phosphate	3.75	0.80	79

Evaporation

Evaporation is advantageous because it permits recovery of a wide variety of plating and other process chemicals; the water recovered is of high purity, allowing for recycle; and it concentrates waste effluent, which is difficult by other means. However, this process is energy intensive and heating efficiency decreases as the heating plates scale up.

Others

Several other techniques, noted on Table 4-4, are available for treating wastewater from this industry. These techniques are currently being developed and at present are only being used in a few of the electroplating plants. Descriptions of these technologies are available in Volume III of this manual.

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II.4.5 REFERENCES

1. Final Development Document for Existing Source Pretreatment Standards for the Electroplating Point Source Category. EPA 440/1-79/003, U.S. Environmental Protection Agency, Washington, D.C., August 1979. 526 pp.

2. NRDC Consent Decree Industry Summary - Electroplating.

3. Environmental Protection Agency Effluent Guidelines and Standards for Electroplating. Environment Reporter, 135:0341-0351, as of 5 May 1980.

II.5 INORGANIC CHEMICALS MANUFACTURING

II.5.1 INDUSTRY DESCRIPTION [1]

II.5.1.1 General Description

In terms of Standard Industrial Classification (SIC) code numbers, the major industries included for application of effluent limitations, new source performance standards, and pretreatment standards within the Inorganic Chemicals Manufacturing Point Source Category are:

SIC 2812 - Alkalies and chlorine
SIC 2813 - Industrial gases
SIC 2816 - Inorganic pigments
SIC 2819 - Industrial inorganic chemicals, not elsewhere classified

Table 5-1 presents industry summary data for the Inorganic Chemicals point source category in terms of the number of subcategories defined for study by Effluent Guidelines Division (EGD), the number studied by EGD, and the number of dischargers in the industry.

TABLE 5-1 INDUSTRY SUMMARY [2]

Industry: Inorganic Chemicals
Total Number of Phase I Subcategories: 55
Number of Subcategories Studied: 11

Number of Dischargers in Industry:

- Direct: 630
- Indirect: 120
- Zero: 0

II.5.1.2 Subcategory Descriptions

Based on results of toxic pollutant screening and verification sampling and on evaluation of applicable technologies for discharge control and treatment, it has been recommended that effluent limitation guidelines, new source performance standards, and pretreatment standards for new and existing sources be proposed for 11 inorganic chemical manufacturing subcategories. These subcategories, described herein, include [1]:

Aluminum fluoride	Nickel sulfate
Chlor-alkali	Sodium bisulfite
Chrome pigments	Sodium dichromate
Copper sulfate	Sodium hydrosulfite
Hydrofluoric acid	Titanium dioxide
Hydrogen cyanide	

Additionally, 3 of the 11 subcategories may be further subdivided based on process subdivisions as follows:

Subcategory	Process subdivisions
Chlor-alkali	Mercury cell Diaphragm cell
Titanium dioxide	Sulfate Chloride-rutile Chloride-ilmenite
Hydrogen cyanide	Andrussow process Acrylonitrile byproduct

In addition to the 11 subcategories to be discussed in depth, 44 subcategories have been recognized and recommended as candidates for exclusion either under Paragraph 8 of the NRDC consent decree or for other reasons. The 44 additional subcategories are:

Aluminum sulfate	Lithium carbonate
Ammonium chloride	Manganese sulfate
Ammonium hydroxide	Nitric acid
Barium carbonate	Nitric acid (strong)
Borax	Oxygen and nitrogen
Boric acid	Potassium chloride
Bromine	Potassium dichromate
Calcium	Potassium iodide
Calcium carbide	Potassium metal
Calcium carbonate	Potassium permanganate
Carbon dioxide	Sodium bicarbonate
Carbon monoxide	Sodium carbonate
Chromic acid	Sodium fluoride
Cuprous oxide	Sodium hydrosulfide
Ferric chloride	Sodium metal
Ferrous sulfate	Sodium silicate
Fluorine	Sodium thiosulfate
Hydrochloric acid	Stannic oxide
Hydrogen	Sulfur dioxide
Hydrogen peroxide	Sulfuric acid
Iodine	Zinc oxide
Lead monoxide	Zinc sulfate

Table 5-2 (next page) presents subcategory profile data for the 55 subcategories of the inorganic chemicals industry. Table 5-3 presents best practicable control technology (BPT), parameters suggested for each subcategory and lists available data.

II.5.1.2.1 Aluminum Fluoride

Aluminum fluoride is used as a raw material in the production of cryolite (which is used in the production of aluminum), as a metallurgical flux (for welding rod coatings), as a ceramic flux (for glazes and enamels), and as a brazing flux (for aluminum fabrication).

Partially dehydrated alumina hydrate is reacted with hydrofluoric acid gas in the dry process for the manufacture of aluminum fluoride. The product, aluminum fluoride, is formed as a solid and is cooled with noncontact cooling water before being sent for milling and shipping. The gases from the reactor are scrubbed with water to remove unreacted hydrofluoric acid before being vented to the atmosphere.

Wastewater flows emanating from different streams generated from the production of aluminum fluoride are summarized in Table 5-4. Data were generated from prior development documents, industry visits, and 308 questionnaires.

TABLE 5-4. WASTEWATER FLOWS FROM ALUMINUM FLUORIDE MANUFACTURING PLANTS [1]

(m^3/Mg of aluminum fluoride)

Wastewater source	Plant code 605	705	837
Scrubber water	20.0	9.1	3.44
Maintenance, equipment cleaning, and work area washdown	1.61	2.39	1.13
Other (storm water)			7.55

Note: Blanks indicate data not available.

II.5.1.2.2 Chlor-Alkali Industry

Chlorine, hydrogen, and caustic soda (NaOH) or caustic potash (KOH) are produced together by electrolysis of brine. Chlorine is used in the pulp and paper industry and the plastics industry, for water treatment, and as an input in the manufacture of vinyl chloride, chlorinated ethers, and other inorganic and organic chemicals. About two-thirds of the production is for captive use.

TABLE 5-2. INORGANIC CHEMICALS SUBCATEGORY PROFILE DATA SUMMARY [1-3]

Subcategory	Total subcategory production capacity, Mg/yr	Total subcategory production per year, Mg/yr	Total number of plants	308 Data on file: Number of plants on file	Production: Range, Mg/yr	Production: Average, Mg/yr	Production: Median, Mg/yr	Percent of subcategory production	Wastewater, flow range, m^3/d
Aluminum fluoride			7	6	38-45,600	24,300	35,500	143,000[a]	539-2,200
Chlor-alkai									
Diaphragm cell	8,270,000	6,430,000	45	19	14,700-1,500,000	221,000	103,000	66	1,100-7,100
Mercury cell	3,540,000	2,750,000	32	15	19,100-198,000	77,900	70,400	40	4-2,100
Chrome pigments	63,000	64,500	11	4	3,500-8,800	6,300	6,400	30	360-800
Copper sulfate		37,000	18	10	45-9,100	2,020	510	78	0-28
Hydrofluoric acid	363,000	262,000	14	8	7,300-62,000	22,100	15,800	68	0-4,700
Hydrogen cyanide	289,000	166,000	11	3	8,500-64,600	57,800	57,800	82	1,150-7,310
Nickel sulfate			12	6	62-8,250	2,100	1,600	17,700[a]	<1-200
Sodium bisulfite			9	2	4,700-23,600	17,800	16,900	28,300[a]	3-100
Sodium dichromate	140,000	137,000	5	3	20,700-66,800	37,300	24,800	82	455-720
Sodium hydrosulfite	40,300	39,900	2	1	20,400			51	273
Titanium dioxide									
Chloride process	610,000	389,000	8	5	16,900-42,500	28,400	25,600	37	1,140-4,770
Sulfate process	401,000	259,000	5		31,000-74,500	49,000	43,000	95	35,000-125,000
Aluminum sulfate		1,100,000 (1974)[b]	84						
Ammonium chloride			6	3	4,600-13,400			29,800[a]	
Ammonium hydroxide			6		206-9,500			17,000[a]	
Barium carbonate			7	5	158-26,200			48,700[a]	
Borax		91 (1973)[b]							
Boric acid		123,000	3	2	30,200-63,700			77	
Bromine									
Calcium									
Calcium carbide		567,000 (1971)[b]	4						
Calcium carbonate		130,000		3	555-49,800			56	
Carbon dioxide	12,200,000	1,820,000	105	12	1,600-155,000			31	
Carbon monoxide		277,000	5	5	47-63,000			40	
Chromic acid									
Cuprous oxide			0						
Ferric chloride		138,000 (1974)[b]	21						
Ferrous sulfate									
Fluorine									

(continued)

TABLE 5-2 (continued)

Subcategory	Total subcategory production capacity, Mg/yr	Total subcategory production per year, Mg/yr	Total number of plants	308 Data on file: Number of plants on file	Production: Range, Mg/yr	Production: Average, Mg/yr	Production: Median, Mg/yr	Percent of subcategory production	Wastewater, flow range, m^3/d
Hydrochloric acid		2,270,000	83	20				25	
Hydrogen									
Hydrogen peroxide		85,700	7	3	5,560-28,700			66	
Iodine									
Lead monoxide			17						
Lithium carbonate									
Manganese sulfate			0						
Nitric acid	9,180,000	7,170,000	87	11				11	
Nitric acid (strong)				5	5,300-60,200			121,000[a]	
Oxygen and nitrogen	31,200,000		171	9	2,400-378,000			1,470,000[a]	
Potassium chloride									
Potassium dichromate		4,000	1						
Potassium iodide		123,000	9	4	79-634			10	
Potassium metal		100 (1972)[b]							
Potassium permanganate									
Sodium bicarbonate		250,000 (1973)[b]	3						
Sodium carbonate	8,650,000		10	8				2,830,000[a]	
Sodium fluoride		6,460	4						
Sodium hydrosulfide			12	3	3,800-36,500			44,700[a]	
Sodium metal			5	2				300,000[a]	
Sodium silicate	814,000	679,000	30	7	12,400-57,300			37	
Sodium thiosulfate			6	5	4,400-27,000			70,300[a]	
Stannic oxide									
Sulfur dioxide			15	5	27,800-170,000			364,000[a]	
Sulfuric acid	42,100,000	30,500,000	151	47	5,300-47,700			21	
Zinc oxide									
Zinc sulfate									

Note: Blanks indicate data not available.

[a]Production per year (Mg/yr) of 308 data file plants. Total subcategory production rate not available.

[b]Indicates the year data taken.

TABLE 5-3. BPT PARAMETERS FOR INORGANIC CHEMICAL SUBCATEGORIES [1,5]

Subcategory	Pollutant, kg/Mg of Product (mg/L)					
	Aluminum		Barium		Chromium (total)	
	Daily maximum	30-Day average	Daily maximum	30-Day average	Daily maximum	30-Day average
Aluminum fluoride	0.34(20.0)	0.17(10.0)				
Chlor-alkali						
Diaphrahm cell						
Mercury cell						
Chrome pigments					0.10(1.5)	0.034(0.5)
Copper sulfate						
(Recovery process)						
(Pure raw materials process)						
Hydrofluoric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen cyanide (Andrussow process)						
Nickel sulfate						
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.					
(Impure raw materials)						
Sodium bisulfite	Reserved					
Sodium dichromate					0.0088	0.0044
Sodium hydrosulfite	Reserved					
Titanium dioxide						
(Chloride process)						
(Sulfate process)						
Aluminum sulfate	No discharge of process wastewater pollutants to navigable waters except rainwater discharge allowance for total suspended solids.					
Ammonium chloride						
(Anhydrous)	No discharge of process wastewater pollutants to navigable waters.					
(Solvay byproduct)						
Ammonium hydroxide	Reserved					
Barium carbonate	Reserved					
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Boric acid						
(Ore mined)						
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Calcium						
Calcium carbide	Reserved					
Calcium carbonate						
(Milk of lime)						
(Solvay process)						
Carbon dioxide	Reserved					
Carbon monoxide						
Chromic acid	No discharge of process wastewater pollutants to navigable waters.					
Cuprous oxide	Reserved					
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.					
Ferrous sulfate	Reserved					
Fluorine	No discharge of process wastewater pollutants to navigable waters.					
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen peroxide						
(Organic process)						
(Electrolytic process)						
Iodine	No discharge of process wastewater pollutants to navigable waters.					
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.					
Lithium carbonate						
(Spodumene ore)						
(Trona process)	No discharge of process wastewater pollutants to navigable waters.					
Manganese sulfate	Reserved					
Nitric acid	No discharge of process wastewater pollutants to navigable waters.					
Nitric acid (strong)	Reserved					
Oxygen and nitrogen						
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.					
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.					
Potassium iodide			0.009(7.5)	0.003(2.5)		
Potassium metal	No discharge of process wastewater pollutants to navigable waters.					
Potassium permanaganate	Reserved					
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.					
Sodium carbonate						
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.					
Sodium hydrosulfide	Reserved					
Sodium metal	Reserved					
Sodium silicate	Reserved					
Sodium thiosulfate	Reserved					
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.					
Sulfur dioxide	Reserved					
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.					
Zinc oxide	Reserved					
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.					

(continued)

TABLE 5-3 (continued)

Subcategory	Pollutant, kg/Mg of Product (mg/L)					
	Chromium (+6)		Copper		Cyanide	
	Daily maximum	30-Day average	Daily maximum	30-Day average	Daily maximum	30-Day average
Aluminum fluoride						
Chlor-alkali						
Diaphrahm cell						
Mercury cell						
Chrome pigments	0.010(0.2)	0.0034(0.1)			0.010(1.5)	0.0034(0.5)
Copper sulfate						
(Recovery process)			0.003(3.2)	0.001(1.1)		
(Pure raw materials process)			0.006	0.002		
Hydrofluoric acid						
Hydrogen cyanide (Andrussow process)					0.05(1.0)	0.025(0.5)
Nickel sulfate						
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.					
(Impure raw materials)						
Sodium bisulfite	Reserved					
Sodium dichromate	0.009	0.0005				
Sodium hydrosulfite	Reserved					
Titanium dioxide						
(Chloride process)						
(Sulfate process)						
Aluminum sulfate						
Ammonium chloride						
(Anhydrous)	No discharge of process wastewater pollutants to navigable waters.					
(Solvay byproduct)						
Ammonium hydroxide	Reserved					
Barium carbonate	Reserved					
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Boric acid						
(Ore mined)						
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Calcium						
Calcium carbide	Reserved					
Calcium carbonate						
(Milk of lime)						
(Solvay process)						
Carbon dioxide	Reserved					
Carbon monoxide						
Chromic acid	No discharge of process wastewater pollutants to navigable waters.					
Cuprous oxide	Reserved					
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.					
Ferrous sulfate	Reserved					
Fluorine	No discharge of process wastewater pollutants to navigable waters.					
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen peroxide						
(Organic process)						
(Electrolytic process)						
Iodine	No discharge of process wastewater pollutants to navigable waters.					
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.					
Lithium carbonate						
(Spodumene ore)						
(Trona process)	No discharge of process wastewater pollutants to navigable waters.					
Manganese sulfate	Reserved					
Nitric acid	No discharge of process wastewater pollutants to navigable waters.					
Nitric acid (strong)	Reserved					
Oxygen and nitrogen						
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.					
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.					
Potassium iodide						
Potassium metal	No discharge of process wastewater pollutants to navigable waters.					
Potassium permanaganate	Reserved					
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.					
Sodium carbonate						
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.					
Sodium hydrosulfide	Reserved					
Sodium metal	Reserved					
Sodium silicate	Reserved					
Sodium thiosulfate	Reserved					
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.					
Sulfur dioxide	Reserved					
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.					
Zinc oxide	Reserved					
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.					

(continued)

TABLE 5-3 (continued)

Subcategory	Pollutant, kg/Mg of Product (mg/L)					
	Cyanide (A)		Fluoride		Iron	
	Daily maximum	30-Day average	Daily maximum	30-Day average	Daily maximum	30-Day average
Aluminum fluoride			0.68(40.0)	0.34(20.0)		
Chlor-alkali						
Diaphrahm cell						
Mercury cell						
Chrome pigments	0.10(0.2)	0.034(0.10)			0.72(10.8)	0.27(4.0)
Copper sulfate						
(Recovery process)						
(Pure raw materials process)						
Hydrofluoric acid			15(30)			
Hydrogen cyanide (Andrussow process)	0.005(0.1)	0.0025(0.05)				
Nickel sulfate						
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.					
(Impure raw materials)						
Sodium bisulfite	Reserved					
Sodium dichromate						
Sodium hydrosulfite	Reserved					
Titanium dioxide						
(Chloride process)					0.72	0.36
(Sulfate process)					1.7(8.1)	0.84(4.0)
Aluminum sulfate						
Ammonium chloride						
(Anhydrous)	No discharge of process wastewater pollutants to navigable waters.					
(Solvay byproduct)						
Ammonium hydroxide	Reserved					
Barium carbonate	Reserved					
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Boric acid						
(Ore mined)						
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Calcium						
Calcium carbide	Reserved					
Calcium carbonate						
(Milk of lime)						
(Solvay process)						
Carbon dioxide	Reserved					
Carbon monoxide						
Chromic acid	No discharge of process wastewater pollutants to navigable waters.					
Cuprous oxide	Reserved					
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.					
Ferrous sulfate	Reserved					
Fluorine	No discharge of process wastewater pollutants to navigable waters.					
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen peroxide						
(Organic process)						
(Electrolytic process)	0.0004	0.0002				
Iodine	No discharge of process wastewater pollutants to navigable waters.					
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.					
Lithium carbonate						
(Spodumene ore)						
(Trona process)	No discharge of process wastewater pollutants to navigable waters.					
Manganese sulfate	Reserved					
Nitric acid	No discharge of process wastewater pollutants to navigable waters.					
Nitric acid (strong)	Reserved					
Oxygen and nitrogen						
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.					
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.					
Potassium iodide					0.015(12.5)	0.005(4.2)
Potassium metal	No discharge of process wastewater pollutants to navigable waters.					
Potassium permanaganate	Reserved					
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.					
Sodium carbonate						
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.					
Sodium hydrosulfide	Reserved					
Sodium metal	Reserved					
Sodium silicate	Reserved					
Sodium thiosulfate	Reserved					
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.					
Sulfur dioxide	Reserved					
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.					
Zinc oxide	Reserved					
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.					

(continued)

TABLE 5-3 (continued)

Subcategory	Pollutant, kg/Mg of Product (mg/L)					
	Lead		Mercury		Nickel	
	Daily maximum	30-Day average	Daily maximum	30-Day average	Daily maximum	30-Day average
Aluminum fluoride						
Chlor-alkali						
Diaphrahm cell	0.0025(0.005)					
Mercury cell			0.00014(0.00028)			
Chrome pigments	0.42(6.3)	0.14(2.1)				
Copper sulfate						
(Recovery process)					0.006(6.5)	0.002(2.2)
(Pure raw materials process)						
Hydrofluoric acid						
Hydrogen cyanide (Andrussow process)						
Nickel sulfate						
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.					
(Impure raw materials)					0.006(5.1)	0.002(1.7)
Sodium bisulfite	Reserved					
Sodium dichromate						
Sodium hydrosulfite	Reserved					
Titanium dioxide						
(Chloride process)						
(Sulfate process)						
Aluminum sulfate						
Ammonium chloride						
(Anhydrous)	No discharge of process wastewater pollutants to navigable waters.					
(Solvay byproduct)						
Ammonium hydroxide	Reserved					
Barium carbonate	Reserved					
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Boric acid						
(Ore mined)						
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Calcium						
Calcium carbide	Reserved					
Calcium carbonate						
(Milk of lime)						
(Solvay process)						
Carbon dioxide	Reserved					
Carbon monoxide						
Chromic acid	No discharge of process wastewater pollutants to navigable waters.					
Cuprous oxide	Reserved					
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.					
Ferrous sulfate	Reserved					
Fluorine	No discharge of process wastewater pollutants to navigable waters.					
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen peroxide						
(Organic process)						
(Electrolytic process)						
Iodine	No discharge of process wastewater pollutants to navigable waters.					
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.					
Lithium carbonate						
(Spodumene ore)						
(Trona process)	No discharge of process wastewater pollutants to navigable waters.					
Manganese sulfate	Reserved					
Nitric acid	No discharge of process wastewater pollutants to navigable waters.					
Nitric acid (strong)	Reserved					
Oxygen and nitrogen						
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.					
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.					
Potassium iodide						
Potassium metal	No discharge of process wastewater pollutants to navigable waters.					
Potassium permanaganate	Reserved					
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.					
Sodium carbonate						
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.					
Sodium hydrosulfide	Reserved					
Sodium metal	Reserved					
Sodium silicate	Reserved					
Sodium thiosulfate	Reserved					
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.					
Sulfur dioxide	Reserved					
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.					
Zinc oxide	Reserved					
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.					

(continued)

TABLE 5-3 (continued)

Subcategory	Pollutant, kg/Mg of Product (mg/L): Selenium		Sulfide		Zinc	
	Daily maximum	30-Day average	Daily maximum	30-Day average	Daily maximum	30-Day average
Aluminum fluoride						
Chlor-alkali						
Diaphrahm cell						
Mercury cell						
Chrome pigments					0.72(10.8)	0.27(4.0)
Copper sulfate						
(Recovery process)	0.0015(1.6)	0.0005(0.5)				
(Pure raw materials process)						
Hydrofluoric acid						
Hydrogen cyanide (Andrussow process)						
Nickel sulfate						
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.					
(Impure raw materials)						
Sodium bisulfite	Reserved					
Sodium dichromate						
Sodium hydrosulfite	Reserved					
Titanium dioxide						
(Chloride process)						
(Sulfate process)						
Aluminum sulfate						
Ammonium chloride						
(Anhydrous)	No discharge of process wastewater pollutants to navigable waters.					
(Solvay byproduct)						
Ammonium hydroxide	Reserved					
Barium carbonate	Reserved					
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Boric acid						
(Ore mined)						
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Calcium						
Calcium carbide	Reserved					
Calcium carbonate						
(Milk of lime)						
(Solvay process)						
Carbon dioxide	Reserved					
Carbon monoxide						
Chromic acid	No discharge of process wastewater pollutants to navigable waters.					
Cuprous oxide	Reserved					
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.					
Ferrous sulfate	Reserved					
Fluorine	No discharge of process wastewater pollutants to navigable waters.					
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen peroxide						
(Organic process)						
(Electrolytic process)						
Iodine	No discharge of process wastewater pollutants to navigable waters.					
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.					
Lithium carbonate						
(Spodumene ore)						
(Trona process)	No discharge of process wastewater pollutants to navigable waters.					
Manganese sulfate	Reserved					
Nitric acid	No discharge of process wastewater pollutants to navigable waters.					
Nitric acid (strong)	Reserved					
Oxygen and nitrogen						
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.					
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.					
Potassium iodide			0.015(12.5)	0.005(4.2)		
Potassium metal	No discharge of process wastewater pollutants to navigable waters.					
Potassium permanaganate	Reserved					
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.					
Sodium carbonate						
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.					
Sodium hydrosulfide	Reserved					
Sodium metal	Reserved					
Sodium silicate	Reserved					
Sodium thiosulfate	Reserved					
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.					
Sulfur dioxide	Reserved					
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.					
Zinc oxide	Reserved					
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.					

(continued)

TABLE 5-3 (continued)

Subcategory	Pollutant, kg/Mg of Product (mg/L)					
	BOD_5		TOC		TSS	
	Daily maximum	30-Day average	Daily maximum	30-Day average	Daily maximum	30-Day average
Aluminum fluoride					0.86(50.6)	0.43(25.3)
Chlor-alkali						
Diaphrahm cell					0.32(0.64)	
Mercury cell					0.32(0.64)	
Chrome pigments					5.1(76.1)	1.7(25.4)
Copper sulfate						
(Recovery process)					0.069(74.2)	0.023(24.7)
(Pure raw materials process)						
Hydrofluoric acid					25(50)	
Hydrogen cyanide (Andrussow process)	3.6(72.0)	1.8(36.0)			2.4(48.0)	1.2(24.0)
Nickel sulfate						
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.					
(Impure raw materials)					0.096(82.1)	0.032(27.4)
Sodium bisulfite	Reserved					
Sodium dichromate					0.44	0.22
Sodium hydrosulfite	Reserved					
Titanium dioxide						
(Chloride process)					4.6	2.3
(Sulfate process)					21.0(100)	10.5(50.0)
Aluminum sulfate					(50)	(25)
Ammonium chloride						
(Anhydrous)	No discharge of process wastewater pollutants to navigable waters.					
(Solvay byproduct)						
Ammonium hydroxide	Reserved					
Barium carbonate	Reserved					
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Boric acid						
(Ore mined)					0.14	0.07
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Calcium						
Calcium carbide	Reserved					
Calcium carbonate						
(Milk of lime)					0.56(50.0)	0.28(25.0)
(Solvay process)					1.16(49.6)	0.58(24.8)
Carbon dioxide	Reserved					
Carbon monoxide					0.12(19.5)	0.06(9.8)
Chromic acid	No discharge of process wastewater pollutants to navigable waters.					
Cuprous oxide	Reserved					
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.					
Ferrous sulfate	Reserved					
Fluorine	No discharge of process wastewater pollutants to navigable waters.					
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen peroxide						
(Organic process)			0.44	0.22	0.8	0.4
(Electrolytic process)					0.005	0.0025
Iodine	No discharge of process wastewater pollutants to navigable waters.					
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.					
Lithium carbonate						
(Spodumene ore)					2.7	0.9
(Trona process)	No discharge of process wastewater pollutants to navigable waters.					
Manganese sulfate	Reserved					
Nitric acid	No discharge of process wastewater pollutants to navigable waters.					
Nitric acid (strong)	Reserved					
Oxygen and nitrogen						
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.					
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.					
Potassium iodide					0.09(75)	0.03(25)
Potassium metal	No discharge of process wastewater pollutants to navigable waters.					
Potassium permanaganate	Reserved					
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.					
Sodium carbonate					0.20(222)	0.10(111)
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.					
Sodium hydrosulfide	Reserved					
Sodium metal	Reserved				0.46	0.23
Sodium silicate	Reserved				0.01	0.005
Sodium thiosulfate	Reserved					
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.					
Sulfur dioxide	Reserved					
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.					
Zinc oxide	Reserved					
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.					

(continued)

TABLE 5-3 (continued)

Subcategory	Pollutant, kg/Mg of Product (mg/L)					
	NH_3-N		Oil and grease		Arsenic	
	Daily maximum	30-Day average	Daily maximum	30-Day average	Daily maximum	30-Day average
Aluminum fluoride						
Chlor-alkali						
Diaphrahm cell						
Mercury cell						
Chrome pigments						
Copper sulfate						
(Recovery process)						
(Pure raw materials process)						
Hydrofluoric acid						
Hydrogen cyanide (Andrussow process)	0.36(7.2)	0.18(3.6)				
Nickel sulfate						
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.					
(Impure raw materials)						
Sodium bisulfite	Reserved					
Sodium dichromate						
Sodium hydrosulfite	Reserved					
Titanium dioxide						
(Chloride process)						
(Sulfate process)						
Aluminum sulfate						
Ammonium chloride						
(Anhydrous)	No discharge of process wastewater pollutants to navigable waters.					
(Solvay byproduct)	8.8	4.4				
Ammonium hydroxide	Reserved					
Barium carbonate	Reserved					
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Boric acid						
(Ore mined)					0.0028	0.0014
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.					
Calcium						
Calcium carbide	Reserved					
Calcium carbonate						
(Milk of lime)						
(Solvay process)						
Carbon dioxide	Reserved					
Carbon monoxide						
Chromic acid	No discharge of process wastewater pollutants to navigable waters.					
Cuprous oxide	Reserved					
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.					
Ferrous sulfate	Reserved					
Fluorine	No discharge of process wastewater pollutants to navigable waters.					
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen	No discharge of process wastewater pollutants to navigable waters.					
Hydrogen peroxide						
(Organic process)						
(Electrolytic process)						
Iodine	No discharge of process wastewater pollutants to navigable waters.					
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.					
Lithium carbonate						
(Spodumene ore)						
(Trona process)	No discharge of process wastewater pollutants to navigable waters.					
Manganese sulfate	Reserved					
Nitric acid	No discharge of process wastewater pollutants to navigable waters.					
Nitric acid (strong)	Reserved					
Oxygen and nitrogen			0.002(51.3)	0.001(25.6)		
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.					
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.					
Potassium iodide						
Potassium metal	No discharge of process wastewater pollutants to navigable waters.					
Potassium permanaganate	Reserved					
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.					
Sodium carbonate						
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.					
Sodium hydrosulfide	Reserved					
Sodium metal	Reserved					
Sodium silicate	Reserved					
Sodium thiosulfate	Reserved					
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.					
Sulfur dioxide	Reserved					
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.					
Zinc oxide	Reserved					
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.					

(continued)

TABLE 5-3 (continued)

Subcategory	Pollutant, kg/Mg of Product (mg/L) COD Daily maximum	30-Day average	pH
Aluminum fluoride			
Chlor-alkali			
Diaphrahm cell			
Mercury cell			
Chrome pigments			
Copper sulfate			
(Recovery process)			6.0-9.0
(Pure raw materials process)			6.0-9.0
Hydrofluoric acid			
Hydrogen cyanide (Andrussow process)			
Nickel sulfate			
(Pure raw materials)	No discharge of process wastewater pollutants to navigable waters.		
(Impure raw materials)			6.0-9.0
Sodium bisulfite	Reserved		
Sodium dichromate			
Sodium hydrosulfite	Reserved		
Titanium dioxide			
(Chloride process)			
(Sulfate process)			
Aluminum sulfate			6.0-9.0
Ammonium chloride			
(Annydrous)	No discharge of process wastewater pollutants to navigable waters.		
(Solvay byproduct)			6.0-9.0
Ammonium hydroxide	Reserved		
Barium carbonate	Reserved		
Borax	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.		
Boric acid			
(Ore mined)			6.0-9.0
(Trona)	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.		
Bromine	No discharge of process wastewater pollutants except that residual brine and depleted liquor may be returned to original body of water.		
Calcium			
Calcium carbide	Reserved		
Calcium carbonate			
(Milk of lime)			
(Solvay process)			
Carbon dioxide	Reserved		
Carbon monoxide	0.5(81.3)	0.25(40.7)	6.0-9.0
Chromic acid	No discharge of process wastewater pollutants to navigable waters.		
Cuprous oxide	Reserved		
Ferric chloride	No discharge of process wastewater pollutants to navigable waters.		
Ferrous sulfate	Reserved		
Fluorine	No discharge of process wastewater pollutants to navigable waters.		
Hydrochloric acid	No discharge of process wastewater pollutants to navigable waters.		
Hydrogen	No discharge of process wastewater pollutants to navigable waters.		
Hydrogen peroxide			
(Organic process)			6.0-9.0
(Electrolytic process)			6.0-9.0
Iodine	No discharge of process wastewater pollutants to navigable waters.		
Lead monoxide	No discharge of process wastewater pollutants to navigable waters.		
Lithium carbonate			
(Spodumene ore)			6.0-9.0
(Trona process)	No discharge of process wastewater pollutants to navigable waters.		
Manganese sulfate	Reserved		
Nitric acid	No discharge of process wastewater pollutants to navigable waters.		
Nitric acid (strong)	Reserved		
Oxygen and nitrogen			6.0-9.0
Potassium chloride	No discharge of process wastewater pollutants to navigable water except that residual brine and depleted liquor may be returned to the original body of water.		
Potassium dichromate	No discharge of process wastewater pollutants to navigable waters.		
Potassium iodide			6.0-9.0
Potassium metal	No discharge of process wastewater pollutants to navigable waters.		
Potassium permanaganate	Reserved		
Sodium bicarbonate	No discharge of process wastewater pollutants to navigable waters.		
Sodium carbonate			
Sodium fluoride	No discharge of process wastewater pollutants to navigable waters.		
Sodium hydrosulfide	Reserved		
Sodium metal	Reserved		
Sodium silicate	Reserved		
Sodium thiosulfate	Reserved		
Stannic oxide	No discharge of process wastewater pollutants to navigable waters.		
Sulfur dioxide	Reserved		
Sulfuric acid	No discharge of process wastewater pollutants to navigable waters.		
Zinc oxide	Reserved		
Zinc sulfate	No discharge of process wastewater pollutants to navigable waters.		

Note: Blanks indicate data not available.

Two types of cells are currently used for the production of chlorine and caustic: mercury and diaphragm cells. Mercury cells account for approximately 30% of the production while the diaphragm cell accounts for 65%. The Downs cell is another electrolytic process for producing chlorine and sodium (or potassium) from fused salt. However, the amount of chlorine produced by this process is relatively small. Since the predominant method of making chlorine and byproduct caustic is by the use of mercury and diaphragm cells, this study of the chlor-alkali subcategory is restricted to these two processes. In the processes described below, sodium chloride is used as the starting material. The same descriptions hold true, however, when potassium chloride is used, but with one difference--the byproduct in the latter case is caustic potash (KOH) instead of caustic soda (NaOH).

Mercury Cell Process. The sodium chloride (NaCl) solution (brine or salt dissolved in water) is purified before it is sent to the mercury cell for chlorine, caustic, and hydrogen production. This is done by the addition of soda ash (Na_2CO_3) and small amounts of caustic soda until the pH increases to 10 or 11. The calcium and iron present in the brine and trace amounts of other metals are precipitated as hydroxides or carbonates, and the brine is sent to a clarifier for solids separation. The underflow from the clarifier, known as brine mud, is sent to a lagoon or is filtered. The overflow from the clarifier, which is brine, is heated and brought to saturation by the addition of salt recovered from the caustic evaporation. Its pH is then lowered to 3-4 by addition of HCl before it is introduced to the mercury cell.

The mercury cell, in general, consists of two sections: the electrolyzer and the decomposer or denuder. The electrolyzer is an elongated steel trough that is inclined slightly from the horizontal so that the mercury flows in a thin layer at the bottom. This forms the cathode of the cell, and the brine flows concurrently on top of the mercury. Parallel graphite or metal anode plates are suspended from the cover of the cell. Electric current flowing through the cell decomposes the brine, liberating chlorine at the anode and sodium metal at the cathode. The metallic sodium forms an amalgam with mercury:

$$2\ NaCl\ (aq) + Hg \rightleftharpoons Cl_2\ (aq) + 2\ Na\ (Hg)$$

The amalgam from the electrolyzer flows to the denuder. The spent brine (reduced to 22% saturation) is recycled to the brine purification process where it is acidified to pH 3, blown with steam for dechlorination, and saturated by the addition of salt for reuse. In the denuder, the amalgam becomes an anode to a short-circuited iron or graphite cathode. Deionized water added to the denuder reacts with the amalgam to form hydrogen and caustic. The mercury is returned to the electrolyzer. The caustic formed has a concentration of 50% NaOH and is either sent to the storage tank or evaporated (if higher concentrations are needed). The hydrogen gas is cooled by refrigeration to remove water vapor and mercury. The chlorine gas process is similar to that practiced for diaphragm cells.

Diaphragm Cell Process. As in the mercury cell process, the brine is purified by the addition of caustic soda to eliminate or reduce the calcium, magnesium, and iron impurities. The resulting brine mud is similar to that produced from the mercury cell except that it lacks the small amounts of ionic and metallic mercury present in the recycled brine. The final pH of the purified brine solution is adjusted to 6 by the addition of HCl, and the brine is then fed to the diaphragm cells.

The saturated salt solution (26% concentration) is electrolyzed in the diaphragm cell to form chlorine, hydrogen, and sodium hydroxide according to the reaction:

$$2\ NaCl + 2\ H_2O \rightleftharpoons Cl_2 + 2\ NaOH + H_2$$

In one pass through the cell the salt solution is decomposed to approximately half of its original concentration. The diaphragm cell contains a porous asbestos diaphragm separating the anode from the cathode. Chlorine is liberated at the anode, and the hydrogen and caustic are produced at the cathode. In the past, the predominant anode material was graphite with lead used to provide an electrical contact and support. In recent years, however, the majority of graphite anodes have been changed to stabilized metal anodes. The use of metal anodes tends to reduce or eliminate the chlorinated organics and lead impurities in the wastewaters.

The hydrogen from the top of the cathode is cooled to remove water and other impurities, and it is either sold, vented to the atmosphere, or burned to produce steam. The caustic leaving the cathode has a concentration of 11% to 12% NaOH, which may be increased to 50% through multiple-effect evaporation. If the vapor evolved from the last effect of the evaporator is air condensed in direct contact with water using barometric condensors, the amount of wastewater produced may be quite large. During evaporation, salt crystallizes and is removed from all of the evaporators. The concentrated caustic is then settled and stored. The chlorine from the cell is cooled to remove water and other impurities. The condensates are either discharged without treatment or recycled to the brine purifier after steam stripping for chlorine recovery. The chlorine gas, after cooling, is scrubbed with concentrated sulfuric acid to remove water, the acid being used until a constant dilution is reached.

Wastewater Flows. Wastewater flows emanating from different streams generated from the production of chlorine, hydrogen, and caustic soda by mercury-cell manufacturing plants are summarized in Table 5-5. Data were generated from prior development documents, plant visits, and 308 questionnaires.

TABLE 5-5. WASTEWATER FLOWS FROM CHLORINE/CAUSTIC MANUFACTURING PLANTS (MERCURY CELL) [1]

(m^3/Mg of Cl_2)

Wastewater source	Plant code								
	167	299	317	343	385	589	674	747	907
Brine mud	0.67		0.54			0.65	0.87		
Tail gas scrubber	2.25	0.11	0.05		3.39		0.58	0.02	
Mercury-contaminated wastewater			0.53	1.57					0.36

Note: Blanks indicate no data available.

The wastewater flows from chlorine/caustic manufacturing plants using diaphragm cells are summarized in Table 5-6. Data were collected from a prior development document, plant visits, and 308 questionnaires.

TABLE 5-6. WASTEWATER FLOWS FROM CHLORINE/CAUSTIC MANUFACTURING PLANTS (DIAPHRAGM CELL) [1]

(m^3/Mg of Cl_2)

Wastewater source	Plant code					
	261	277	589	736	858	967[a]
Brine mud	0.83	0.02		1.68	0.42	0.28
Cell wash	0.38	0.02	0.05	0.017	0.084	0.18
Tail gas scrubber effluent					0.17	0.29/0.11

Note: Blanks indicate no data available.

[a]Graphite anode plant.

II.5.1.2.3 Chrome Pigments

Chrome pigments are primarily sold in the merchant market; consequently, captive use is minor. They are extensively used in paints, printing ink, floor covering products, and paper, as well as in ceramics, cement, and asphalt roofing.

Chrome pigments (a family of inorganic compounds containing chromium, lead, iron, molybdenum, and zinc) include chrome yellow, chrome orange, molybdate chrome orange, anhydrous and hydrous chromium oxide, zinc yellow and iron blues. At some manufacturing plants, compounds are made in the same facility either simultaneously or sequentially, depending on sales and market requirements.

Chromium Oxide. Chromium oxide consists of two compounds, anhydrous and hydrated chrome oxide (Guignet's green). Anhydrous oxide is prepared by calcination of sodium dichromate with sulfur or carbon. The use of sulfur as the reducing agent eliminates CO_2, CO, and SO_2 emissions, but increases the sulfate raw waste. In the manufacturing process using sulfur, raw materials consisting of sodium dichromate and sulfur are mixed with water and the resultant solution is fed to a kiln. The material is heated, and reacted materials from the kiln are slurried with water, filtered, washed, dried, ground, screened, and packaged. The effluent gases from the kiln containing sulfur dioxide and sulfur trioxide are wet scrubbed before venting to the atmosphere.

Hydrated chromium oxide, also known as chromium hydrate and Guignet's green, is made by reacting sodium dichromate with boric acid. The raw materials are blended in a mixer, heated in an oven, slurried with water, and filtered. The filtered solids are washed with water, dried, ground, screened, and packaged. The filtrate and wash water are treated with sulfuric acid to recover boric acid. A waste stream containing some boric acid and sodium sulfate leaves the boric acid unit.

Chrome Yellow and Chrome Orange. Chrome yellow is one of the most important synthetic pigments. The chrome yellows consist primarily of lead chromate and are made by reacting sodium dichromate, caustic soda, and lead nitrate. Lead chromate is formed as a precipitate during the reaction and is filtered and treated with chemicals to develop the desired pigment properties. The product is then dried, milled, and packaged. The filtrate from the filtration operation is sent to the wastewater treatment facility.

Molybdenum Orange. Molybdenum orange is made by the coprecipitation of lead chromate ($PbCrO_4$) and lead molybdate ($PbMoO_4$). The process consists of dissolving molybdic oxide in aqueous sodium hydroxide and adding sodium chromate. The solution is mixed and reacted with a solution of lead nitrate. The precipitate from the reaction is filtered, washed, dried, milled, and packaged. The filtrate is sent to the treatment facility.

Chrome Green. Chrome greens are a coprecipitate of chrome yellow and iron blues. Iron blues are manufactured by reaction of aqueous solution of iron sulfate and ammonium sulfate with sodium hexacyanoferrate. The precipitate formed is separated and oxidized with sodium chlorate or sodium chromate to form iron blues ($Fe[NH_4][Fe\{CN\}_6]$). Chrome green is produced by mechanically mixing chrome yellow and iron blue pigments in water.

Zinc Yellow. Zinc yellow, also called zinc chromate, is a complex compound of zinc, potassium, and chromium made by the reaction of zinc oxide, hydrochloric acid, sodium dichromate, and potassium chloride. Zinc yellow is formed as a precipitate and is filtered, washed, dried, milled, and packaged for sale.

Wastewater Flows. Process wastewater flows generated from the production of chrome pigments are summarized in Table 5-7. Data were generated from prior development documents, industry visits, and 308 questionnaires.

TABLE 5-7. PROCESS WASTEWATER FLOWS FROM CHROME PIGMENT MANUFACTURING PLANTS [1]

(m^3/Mg of product)

Wastewater source	Plant code			
	002	257	409	894
Chrome yellow and chrome orange	35		44	120
Molybdate chrome orange	31		40	110
Zinc yellow	20		19	
Chrome green				48
Chrome oxide		29		31

Note: Blanks indicate data not available or not applicable.

II.5.1.2.4 Copper Sulfate

Most of the copper sulfate produced is sold in the merchant market, and captive use is very small. Copper sulfate is used in agriculture as an insecticide, an algicide, and as an addition to copper-deficient soils. It is also used in electroplating, in petroleum refining, and as a preservative for wood.

Copper sulfate is produced by reacting copper shot (blister copper) with sulfuric acid, air, and water. Some plants do not start with copper metal but use a waste stream from a copper refinery, which consists of copper, sulfuric acid, and a small amount of nickel.

The resulting copper sulfate solution is either sold or fed to crystallizers producing copper sulfate crystals. These are centrifuged, dried, screened, and then packaged dry for sale.

Wastewater flows emanating from different streams generated from the production of copper sulfate are summarized in Table 5-8. Data were generated from prior development documents, plant visits, and 308 questionnaires.

TABLE 5-8. WASTEWATER FLOWS FROM COPPER SULFATE MANUFACTURING PLANTS [1]

(m^3/Mg of $CuSO_4$)

Wastewater source	Plant 034
$CuSO_4$ waste	2.23
Effluent from lime treatment	2.23
Stream condensate	0.371

II.5.1.2.5 Hydrofluoric Acid

Produced as both anhydrous and aqueous products, hydrofluoric acid (hydrogen fluoride) is used in the manufacture of fluorocarbons, which are used as refrigerating fluids, as plastics for pressurized packing, and as dispersants in aerosol sprays. It is also used in the production of aluminum, in the refining and enriching of uranium fuel, in the pickling of stainless steel, in petroleum alkylation, and for the manufacture of fluoride salts.

With respect to volume of production, hydrofluoric acid (HF) is the most important manufactured compound in the fluorine family. The raw materials used for the manufacture of HF are fluorspar (mainly CaF_2) and sulfuric acid. The reaction between fluorspar and sulfuric acid is endothermic. Reaction kinetics and product yield depend on the purity and fineness of the fluorspar. The sulfuric acid concentration, temperature of the reaction, and the ratio of sulfuric acid to fluorspar are the most important reaction variables.

Hydrogen fluoride generators are primarily externally fired rotary kilns with acid and fluorspar continuously fed through a screw conveyor at the forward end, and calcium sulfate (gypsum) removed from the other end through an air lock. The product also leaves this end, at the top, as a gas. The hydrogen fluoride gas leaving the reactor is cooled in a precooler to condense high boiling compounds, known as drip acid. These condensables consist primarily of fluorosulfonic acid and unreacted sulfuric acid. Most plants return the drip acid to the reactor, and the remaining plants send it to wastewater treatment. The HF gas from the precooler is further cooled and condensed in a cooler/refrigeration unit. The uncondensed gas containing the HF is scrubbed with sulfuric acid and refrigerated to recover the product. The scrubbed acid liquor is returned to the kiln, and residual vent gases are further scrubbed with water to remove HF and other fluoride compounds before they are vented to the atmosphere.

Crude hydrofluoric acid is then distilled to remove the residual impurities, and the concentrate (anhydrous hydrofluoric acid) is stored in tanks. If aqueous hydrofluoric acid is desired, this is then diluted with water to form a 70% HF solution as the final product.

Wastewater flows emanating from different streams generated from the production of hydrofluoric acid are summarized in Table 5-9. Data were generated from prior development documents, 308 questionnaires, and industry visits.

TABLE 5-9. WASTEWATER FLOWS FROM HYDROFLUORIC ACID MANUFACTURING PLANTS [1]

(m^3/Mg of hydrofluoric acid)

Wastewater source	Plant code								
	251	987	753	426	120	722	167	705	837
Gypsum slurry	64.0	-[a]	-[b]	-[a]	-[a]	-[c]	41.6	-[c]	6.5
Drip acid	0.049	-[d]	-[d]	-[d]	-[d]	-[d]	-[d]	0.018	-[d]
Scrubber wastewater	14.4	8.3	2.3	-[b]	0.624	-[c]	40	11.2	1.12
Other	0.53	0.53	8.4	-[b]	5.55	-[b]	5.2	22.5	-[b]

[a]Dry disposal.

[b]Not available.

[c]Total recycle.

[d]Not applicable.

II.5.1.2.6 Hydrogen Cyanide

Over 50% of the hydrogen cyanide manufactured in the United States is produced by the Andrussow process, while about 40% is a byproduct from acrylonitrile manufacture. A major portion of the production is used in the manufacture of methyl methacrylate for Lucite, Plexiglas molding and extrusion powders, and surface coating resins. It is also used as a fumigant for orchards and tree crops.

The hydrogen cyanide subcategory in this study is confined to the Andrussow process, in which air, ammonia, and methane are reacted to produce hydrogen cyanide. The raw materials are reacted at elevated temperatures over a platinum catalyst. In addition to hydrogen cyanide, the reacted gases contain ammonia, nitrogen, carbon monoxide, carbon dioxide, hydrogen, and small amounts of oxygen. The reactor gases are cooled and then scrubbed in one of two processes that are used to remove the unreacted ammonia. In one process the gases are scrubbed with phosphate liquor, the resulting solution is decomposed, and the phosphate solution is recirculated. The recovered ammonia is recycled to the reactor. In the second process sulfuric acid is used to absorb ammonia from the reactor gases.

The hydrogen cyanide is recovered from the ammonia scrubber effluent gases by absorption in cold water, and the waste gases are vented to the atmosphere. The absorbed solution containing hydrogen cyanide, water, and other contaminants is distilled to produce HCN gas of over 99% purity.

The water produced during the initial reaction for the formation of hydrogen cyanide is purged with the distillation bottom stream and is either recycled or discharged to the treatment facility.

Wastewater flows emanating from different streams generated from the production of hydrogen cyanide are summarized in Table 5-10. Data were generated from prior development documents, industry visits, and 308 questionnaires.

TABLE 5-10. WASTEWATER FLOWS FROM HYDROGEN CYANIDE MANUFACTURING PLANTS [1]

(m^3/Mg of hydrogen cyanide)

Wastewater source	Plant code 765	Plant code 782
Recovery and purification		6.3
Pump seal quenches		0.58
Flare stack flushes		0.09
Sample hoods		0.02
NH_3 stripper caustic		0.24
Steam condensate from NH_3 stripper		0.90
Freeze protection		0.06
Washdowns and cleanup		0.25
Boiler blowdown and condensate		1.48
Total	57	9.9

Note: Blanks indicate data not available.

II.5.1.2.7 Nickel Sulfate

The majority of the nickel sulfate produced in the United States is sold in the merchant market. The major use of nickel sulfate is in the metal plating industry, although it is also used in dyeing and printing fabrics and for producing a patina on zinc and brass.

Pure nickel or nickel oxide powder, spent nickel catalysts, and nickel plating solutions or residues may be used to produce nickel sulfate. The nickel sulfate produced when pure raw materials are used is filtered and sold or processed further using a crystallizer to produce a solid nickel sulfate product.

The use of impure raw materials produces a nickel sulfate solution that must be treated in sequence with oxidizers, lime, and sulfides to precipitate impurities which are then removed by filtration. The nickel sulfate solution can be sold or the product may be crystallized, classified, dried, and screened to produce solid nickel sulfate for sale.

Wastewater flows emanating from different streams generated from the production of nickel sulfate are summarized in Table 5-11. Data were generated from prior development documents, plant visits, and 308 questionnaires.

TABLE 5-11. WASTEWATER FLOWS FROM NICKEL SULFATE MANUFACTURING PLANTS [1]

(m^3/Mg of nickel sulfate)

Wastewater source	Plant code		
	369	572	120
Untreated wastewater	0.417		
Treated wastewater	0.417		
Scrubber wastewater		3.15	
$NiSO_4$ wastewater			0.722
All nickel wastes			7.54
Treated effluent			7.54

Note: Blanks indicate data not applicable.

II.5.1.2.8 Sodium Bisulfite

Manufactured in both liquid and powdered form, sodium bisulfite is used in the production of photographic chemicals, organic chemicals, textiles, and in food processing. It is also used in the tanning industry and in the sulfite process for the manufacturing of paper products.

Sodium bisulfite is produced by reacting sodium carbonate (soda ash) with sulfur dioxide and water. This reaction produces a slurry of sodium bisulfite crystals which can be sold, but which is usually processed to form anhydrous sodium metabisulfite. This requires thickening, centrifuging, drying, and packaging operations.

Wastewater flows emanating from different streams generated from the production of sodium bisulfite are summarized in Table 5-12. Data were generated from prior development documents, plant visits, and 308 questionnaires.

TABLE 5-12. WASTEWATER FLOWS FROM SODIUM BISULFITE MANUFACTURING PLANTS [1]

(m^3/Mg of sodium bisulfite)

Wastewater source	Plant code 282	586	987
Untreated waste	2.67		0.102
Treated waste	2.67	188	0.133
MBS sump #1		9.68	
MBS sump #2		9.68	
Amine oxidation pond		2.77	
Zinc sulfate pond effluent		78.5	
Lime treatment influent		110	
Truck washdown		0.134	
SO_2 wastewater		85.9	
No. 1 filter wash			0.051
Floor wash, spills, etc.			0.0123
No. 2 filter wash			0.0386
54-hour aeration			0.133

Note: Blanks indicate data not applicable.

II.5.1.2.9 Sodium Dichromate

Most of the sodium dichromate produced in the United States is used in the chromic acid and pigment industries. It is used for leather tanning and metal treatment, and as a corrosion inhibitor.

The starting materials for the preparation of sodium dichromate are chromite ore, limestone, and soda ash. Their reaction forms sodium chromate, which is reacted with sulfuric acid to produce sodium dichromate.

Chromite ore is a chromium iron oxide containing ferrous chromite ($FeCr_2O_4$ or $FeOCr_2O_3$) as well as small amounts of aluminum, silica, and magnesia. At the plant site, the ore is ground to a fine powder, mixed with soda ash, and calcined in rotary kilns. The reacted product is leached with hot water and filtered. The solid filter cake is dried in rotary kilns. The aluminum present in the thickener overflow is hydrolyzed and removed from the chromate solution as precipitated aluminum hydrate in slurry form. The solution is centrifuged and the centrate is evaporated, to give a concentrated solution of sodium chromate; the latter is reacted with sulfuric acid to give sodium dichromate and sodium sulfate. Sodium sulfate crystallizes as anhydrous sodium sulfate from the boiling solution, and the crystals are removed by filtration. The filtrate is concentrated in multiple-effect evaporators and fed to a water-cooled crystallizer. Sodium dichromate crystallizes out and is centrifuged, dried, and packaged for sale or future use.

Wastewater flows emanating from different streams generated from the production of sodium dichromate are summarized in Table 5-13. Data were generated from prior development documents, 308 questionnaires responses, and industry visits.

TABLE 5-13. WASTEWATER FLOWS FROM SODIUM DICHROMATE MANUFACTURING PLANTS [1]

(m^3/Mg of sodium dichromate)

Wastewater source	Plant code		
	493	376	398
Raw wastewater	4.95		
Residue slurry	2.13		
Mud slurry waste		7.68	
Primary pond effluent		7.68	
Treated effluent	28.9	4.16	
Surface runoff		4.16	
Noncontact cooling water			277[a]

Note: Blanks indicate data not applicable.

[a]2 streams.

II.5.1.2.10 Sodium Hydrosulfite

Most of the sodium hydrosulfite produced in the United States is sold in the merchant market. Sodium hydrosulfite is extensively used in dyeing (cotton) and in the printing industry. It is a powerful reducing agent and is used in the wood pulp bleaching, reducing, and stripping operations of the food, vegetable oil, and soap industries.

In the formate process, sodium hydrosulfite is produced by reacting sodium formate solution, sodium hydroxide solution, and liquid sulfur dioxide in the presence of a recycled stream of methanol solvent. Sodium hydrosulfite precipitates and forms a slurry in the reactor. The coproduct, sodium sulfite is also formed, as are sodium bicarbonate and carbon monoxide gas.

Methyl formate, a minor side product, is produced as the result of a side reaction between sodium formate and methanol. This side reaction product remains in the recycling methanol during the entire process. As a result, some of the methanol must be periodically purged from the recycle system to avoid excessive buildup of this impurity.

The resulting slurry of sodium hydrosulfite in the solution of methanol, methyl formate, and coproducts is sent to a pressurized filter operation which recovers the crystals of sodium hydrosulfite. The crystals are dried in a steam-heated rotary drier, then recovered and packaged. Filtrate and backwash liquors from the filter operation are sent to the solvent recovery system as is the vaporized methanol from the drying operation. Excess heat is avoided in the drying process as sodium hydrosulfite is heat sensitive and tends to decompose to sulfite.

Wastewater flow emanating from plant 672, the only plant sampled, totaled approximately 53 m^3/d (14,000 gal/d). The three streams making up this wastewater production were a coproduct stream producing 0.91 m^3/Mg of product, a raw waste stream yielding 1.87 m^3/Mg of product, and a treated effluent stream producing 4.68 m^3/Mg of product. The higher flow of the treated effluent stream is due to the addition of sanitary waste and dilution water to the aeration basin plus cooling tower and boiler blowdown to the chlorine contact tank. Data were generated by prior development documents, plant visits, and 308 questionnaires.

II.5.1.2.11 Titanium Dioxide

Titanium dioxide (TiO_2) is manufactured by both a chloride and a sulfate process. Ranking within the first 50 chemicals of all United States chemical production, over 50% of this high volume chemical is used in paints, varnishes, and lacquers. Approximately one-third is used in the paper and plastic industries. Other uses are found in ceramics, ink, and rubber manufacturing.

Chloride Process. The chloride process uses rutile or upgraded ilmenite ores as raw material, because the process requires relatively pure materials with a high titanium and low iron content. A beneficiation process, used to upgrade the ilmenite ore, removes a part or all of the iron from the low quality titanium ore. It is assumed that the wastes from the chloride process using beneficiation differ from wastes of the process using pure high grade titanium ore. Therefore, the titanium dioxide subcategory has been further subdivided into three separate categories: sulfate process using ilmenite ore, chloride process using rutile or upgraded titanium ore, and chloride process using ilmenite ore. This section is restricted to the chloride process using rutile ore.

In the chloride process, ore and coke are dried and then reacted with chlorine to form titanium tetrachloride. The titanium tetrachloride is then reacted with oxygen or air to form titanium dioxide and chlorine, the latter being recycled to the process. The reaction generally takes place in a fluidized bed reactor and the product gases leaving the reactor are cooled to remove the impurities, although in some cases purification is accomplished by washing the gases with liquefied titanium dioxide. Residual uncondensed gases are treated to remove acidic materials before being vented to the atmosphere.

The liquefied titanium tetrachloride contains impurities which are removed by distillation. The distillate is the purified titanium tetrachloride and the impurities remain as a residual which becomes waste. The tail gases from the distillation column are scrubbed to remove acidic materials. The titanium tetrachloride product is then reacted with oxygen, as air, to form titanium dioxide and chlorine.

After the oxygenation reaction, the titanium dioxide forms a solid and is separated from the gases. Residual chlorine is refrigerated and liquefied. Tail gases are scrubbed with caustic soda to remove chlorine before being vented to the atmosphere. The titanium dioxide is then sent to the finishing operation where it is vacuum degassed and then treated with alkali, using a minimum amount of water to remove traces of absorbed chlorine and hydrochloric acid. The pigment is then milled, surface treated for end-use application, dried, and packaged for sale.

Wastewater flows emanating from different streams generated from the production of titanium dioxide by the chloride process are summarized in Table 5-14. Data were generated by prior development documents, industry visits, and 308 questionnaires.

TABLE 5-14. WASTEWATER FLOWS FROM TITANIUM DIOXIDE MANUFACTURING PLANTS (CHLORIDE PROCESS) [1]

(m^3/Mg of titanium dioxide)

Wastewater source	Plant code		
	102	172	559
Pit solids and distillation bottom waste			13.9
Settling pond overflow			13.9
TiO_2 scrubber and other product wastewater			90
Inlet to wastewater treatment pond	28.9	35.8	95.7

Note: Blanks indicate data not applicable or not available.

Sulfate Process. Ilmenite ore and slag from iron production generally comprise the raw materials used for preparation of titanium dioxide by the sulfate process. Large amounts of water and sulfuric acid are used in this process, and the majority of plants are colocated with sulfuric acid plants. The preparation of TiO_2 by the sulfate process utilizes three important steps: digestion, precipitation, and calcination.

The ore is dried, ground, and then reacted with sulfuric acid. After the reduction, the product is dissolved in water and clarified with the aid of flocculation agents to remove insoluble impurities such as silicon, zirconium, and unreacted ore. The concentrated solution is diluted with water and heated to form titanium dioxide hydrate which precipitates out. The suspension is filtered and the filtrate (known as strong acid) is separated and either discharged or recycled. Filter residue is slurried with water, and conditioning agents (including potassium, zinc, antimony, calcium compounds, and phosphate salts) are added to control particle size, color, dispersibility, and photochemical stability. This solution is then filtered. Residual acid and iron originally present in the precipitate are removed with the water of hydration by calcination. The resulting TiO_2 pigment is sent to finishing operations, which vary according to the end-product requirement and application. Wet finishing operations may include some, or all, of the following steps: repulping, milling, surface treatment, washing, and drying. Alternative dry finishing operations may include one or more milling steps followed by packaging.

Wastewater flows from the production of titanium dioxide by the sulfate process are summarized in Table 5-15. Data were generated by prior development documents, industry visits, and 308 questionnaires.

TABLE 5-15. WASTEWATER FLOWS FROM TITANIUM DIOXIDE MANUFACTURING PLANTS (SULFATE PROCESS) [1]

(m^3/Mg of titanium dioxide)

Wastewater source	Plant code		
	555	559	605
Strong acid wastewater	8.49	7.4	7.8
Weak acid wastewater	78.2	85	93
Other process wastewater	362		597

Note: Blanks indicate data not available.

II.5.1.2.12 Candidate Subcategories for Paragraph 8 and Other Exclusions

The following paragraphs briefly describe the remaining 44 subcategories, which are candidates for exclusion under Paragraph 8 or for other reasons. No further consideration of these subcategories with respect to wastewater characteristics will be presented in the remainder of this report due to this candidacy and the absence of data.

Aluminum Sulfate. Aluminum sulfate is produced by the reaction of concentrated sulfuric acid with bauxite, clay, and other compounds containing aluminum oxide. The resultant solution is purified to yield a product which can be sold or dehydrated to form crystals. The primary use for aluminum sulfate is as a flocculant in water treatment. Another use is in the papermaking industry where iron-free aluminum sulfate is required for sizing paper.

Due to the small quantity of wastewater discharged by this industry, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Ammonium Chloride. Most ammonium chloride is produced as a byproduct in the manufacture of sodium carbonate (soda ash) by the Solvay process. It is used in the manufacture of dry cell batteries, explosives, dyes, as a washing powder, a soldering flux, a chemical reagent, and a medicinal additive to livestock feed. It is also used in pharmaceutical preparations and freezing mixtures.

No significant concentrations of toxic pollutants were found in the waste during screening of ammonium chloride plant 736. Ammonium was found to be the only pollutant of significance. Since ammonia is not a toxic pollutant, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Ammonium Hydroxide. Ammonium hydroxide is predominantly used as a chemical intermediary and reagent. It is also used in the dyeing and bleaching of fabrics, the production of ammonium salts and aniline dyes, and the extraction of alkaloids from plants.

No plants with a discharge were found in this subcategory. Therefore, this industry has been recommended as a Paragraph 8 exclusion candidate.

Barium Carbonate. Barium carbonate is used in glass manufacturing, as a flux in ceramics and enameling, as an intermediate in the production of barium oxide and hydroxide, and as a coating for photographic paper. It is also used in the synthetic dyestuff industry and for the removal of soluble sulfate in brick manufacturing.

No toxic pollutants were found at significant levels in the waste during screening of barium carbonate plant 360. On the basis of these findings, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Borax. No descriptive information is available in References 1 through 4.

Boric Acid. Boric acid is used in the manufacture of chromic oxide, glazes, enamels, textile fiberglass, and heat resistant glass. It is also used medicinally as a mild antiseptic and in atomic power plants as a nuclear moderator.

This subcategory has only three plants, and the total waste water discharge is not high. Because of the nature of this industry, it has been recommended that this subcategory be further studied.

Bromine. No descriptive information is available in References 1 through 4.

Calcium. No descriptive information is available in References 1 through 4.

Calcium Carbide. Calcium carbide is produced by the reaction of calcium oxide and coke. Calcium carbide is used to produce acetylene by reaction with water. Because the process for calcium carbide production is dry, little wastewater is generated.

This subcategory has limited water effluent from the production plants and has been recommended as an exclusion candidate under Paragraph 8.

Calcium Carbonate. Calcium carbonate is manufactured both in pure and impure form and it is extensively used in many industries. In the pure form, it is used in the rubber, paint, cement, paper, and pharmaceutical industries.

No toxic pollutants were found at significant levels in the raw waste during screening of calcium carbonate plant 883. On the basis of these findings, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Carbon Dioxide. Carbon dioxide is produced in gaseous, liquid, or solid form. A major portion of the production is used captively for the production of urea and for the secondary recovery of oil and natural gas. It is also used for refrigeration, in the food industry, for the carbonation of beverages, in fire extinguishing equipment, and for oil well stimulation.

The only toxic pollutant found at a significant concentration in the raw waste during screening at plant 241 was zinc at a concentration of 910 μg/L. When the data were reviewed with plant personnel, it was discovered that the high zinc level was due to zinc corrosion inhibitors; it was not process related. Therefore, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Carbon Monoxide and Byproduct Hydrogen. In the production of hydrogen by refining natural gas, carbon monoxide is also produced. Carbon monoxide is recovered from several gas sources including, partial combustion of oil or natural gas, coke oven gas, blast furnace gas, water gas, and methane reformer gas.

Carbon monoxide and byproduct hydrogen form the building blocks for other chemicals such as ammonia and methanol. The major use of carbon monoxide is for the manufacture of methanol. It is also used as a gaseous fuel for reducing oxides for special steels, in nickel refining, and in the manufacture of ammonia, acetic acid, and zinc white pigments.

The only pollutants of significance, in terms of waste loads, in this subcategory are chrome and zinc. However, this is the result of the use of corrosion-inhibiting additives in cooling water; it is not process related. Therefore this subcategory has been recommended as a Paragraph 8 exclusion candidate.

Chromic Acid. No descriptive information is available in References 1 through 4.

Cuprous Oxide. Copper oxide is used in the manufacturing of glass, ceramics, marine paints, and photoelectric cells. It is also used in agriculture as a seed fungicide, and as an antiseptic and catalyst.

Only one plant was found to be producing this product at the time of screening. Because this is now a single-plant industry, this subcategory has been recommended for exclusion under Paragraph 8.

Ferric Chloride. Commercial solutions of ferric chloride are produced from iron and steel pickling liquors which contain ferrous chloride and hydrochloric acid. The steel pickling liquors are preheated with steam and then reacted with iron, chlorine, additional hydrochloric acid, and water to produce the desired solution. These solutions are used as copper etchant in photoengraving, in textile dyes, for the chlorination of copper and silver ores, in pharmaceutical production, as an oxidizing agent in chemical synthesis, and for water purification.

This subcategory has been recommended for exclusion under Paragraph 8.

Ferrous Sulfate. No descriptive information is available in References 1 through 4.

Fluorine. No descriptive information is available in References 1 through 4.

Hydrochloric Acid. Most hydrochloric acid is produced as a byproduct in the manufacture of chlorinated organic compounds. It is used in oil well activation, pickling of steel, metal cleaning, monosodium glutamate manufacture, and starch hydrolysis. It is also used as an acid reagent in several chemical manufacturing processes.

On the basis of the low toxic pollutant findings, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Hydrogen. No descriptive information is available in References 1 through 4.

Hydrogen Peroxide. The organic process is the most commonly employed method in the manufacture of hydrogen peroxide. Hydrogen peroxide is used as a bleaching agent in the textile and the pulp and paper industries. It is also used in chemical manufacture (e.g., plasticizers and glycerine) and wastewater treatment, and as a rocket propellant.

During verification sampling of plant 765 it was discovered that the presence of the organics listed in Table 5-16 (Section II.5.2) was not process related; it was caused by a weed killer used at the plant site. Therefore, this subcategory has been recommended for exclusion under Paragraph 8.

Iodine. No descriptive information is available in References 1 through 4.

Lead Monoxide. Lead monoxide is generally produced by the air oxidation of metallic lead, followed by rapid cooling of the product, then milling. Most plants in this subcategory do not use water in the manufacturing process. Its major uses are for noncontact cooling water and dust washdown. Thus, only plants with a significant dust problem will have a significant quantity of wastewater. This subcategory has been recommended for exclusion under Paragraph 8 for this reason.

Lithium Carbonate. No descriptive information is available in References 1 through 4.

Manganese Sulfate. Manganese sulfate is normally sold as a mixture of tetra- and penta-hydrates. It is used in oils for the manufacture of varnishes, in dyeing, and in the manufacture of porcelain. It is also used in the fertilizer industry.

Only one plant in this subcategory was found to be in production at the time of screening. Out of the eight plants contacted, four no longer produced it, two were fertilizer manufacturers, and one manufactured reagent-grade manganese sulfate. Because this is now a single-plant industry, this subcategory has been recommended for exclusion under Paragraph 8.

Nitric Acid. Most of the nitric acid produced is used in the manufacture of ammonium nitrate and other nitrogen fertilizers. On-site captive use is extensively practiced. It is also used in the manufacture of explosives, plastics, and other organic products, and as an acidic and pickling agent.

2,4-Dinitrophenol was found in the raw wastewater during screening at two plants and it is presumed to be from contamination by the organic products manufactured at the plants, not process related. The chromium and zinc found are due to cooling water conditioners present in the blowdown which is mixed with process streams.

It has been recommended that this subcategory be included in the fertilizer industry guidelines.

Nitric Acid (Strong). Strong or concentrated nitric acid is used in the manufacture of organic compounds where nitric acid is required to act as an oxidizing agent rather than as an acid. It is also used in the manufacture of dye intermediates and explosives.

In a followup to the sampling discussed in the section entitled Nitric Acid, it was found that the chromium and zinc are used as corrosion inhibitors in the cooling water, and are not process related. The other values are below significant levels. Verification sampling at plant 623 confirmed this. On the basis of these findings, this subcategory has been recommended for exclusion under Paragraph 8.

Oxygen and Nitrogen. Oxygen, along with nitrogen, is produced from air by distillation of liquefied air. Oxygen is used in the production of steel; in gas welding, medicine, jet fuel, and sewage treatment plants; and in the manufacture of ethylene and acetylene. In rocket propulsion, liquid oxygen is often used as a cryogenic liquid oxidizer in the main stage boosters used for space exploration.

The largest use of nitrogen is in the manufacture of ammonia by the Haber process. It is also used in cryosurgery. As an inert gas, it is used to prevent oxidation by air. In the liquid form, it is used for low temperature refrigeration.

Only one toxic pollutant, copper, was found at a significant level in the raw waste during screening of oxygen and nitrogen plant 993.

Due to the small quantity of wastewater discharged by the industry and the resulting low waste load generated, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Potassium Chloride. No descriptive information is available in References 1 through 4.

Potassium Dichromate. Only one United States plant currently manufactures potassium dichromate. The production process involves the reaction of a sodium dichromate dihydrate solution with potassium chloride. The product is then crystallized by vacuum cooling. Potassium dichromate is used as an oxidizing agent and in brass pickling operations, electroplating, pyrotechnics, explosives, textiles, dyeing, printing, chrome products, and pharmaceuticals, and in many other processes.

This subcategory has been recommended for exclusion under Paragraph 8 on the basis of being a one-plant industry.

Potassium Iodide. Potassium iodide is used in photographic emulsions, animal and poultry feeds, table salts, and analytical chemistry. It also has a number of medical uses.

Due to the small quantity of wastewater discharged by the industry, and the resulting low waste loads generated, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Potassium Metal. For the production of potassium metal, potassium chloride is melted in a gas-fired melt pot and fed to an exchange column. In the column the molten potassium chloride contacts ascending sodium vapors, and sodium chloride and potassium metal are formed. Major uses of potassium metal include manufacture of organo-potassium compounds and production of sodium potassium alloys used in lard modification and nuclear reactor coolant.

Because the industry has only one primary plant, this subcategory has been recommended as a candidate for a Paragraph 8 exclusion.

Potassium Permanganate. No descriptive information is available in References 1 through 4.

Sodium Bicarbonate. Sodium bicarbonate is made by the reaction of sodium carbonate with water and carbon dioxide under pressure and is typically a minor byproduct of soda ash manufacturers. Major uses include food processing, chemical processes, pharmaceuticals, synthetic rubber processes, and leather, paper and textile production.

This subcategory has been recommended for exclusion under Paragraph 8 due to the low quantities of toxic pollutants.

Sodium Carbonate. On-site captive production of sodium carbonate (soda ash) is a dominant practice. Sodium carbonate is used in the manufacture of sodium bicarbonate, ammonium chloride, and calcium chloride. Because of the nature of this industry, it has been recommended that this subcategory be further studied.

Sodium Fluoride. Sodium fluoride is produced by three plants in the United States with each plant using a different process. Sodium fluoride is used to fluoridate water, to heat treat salts, for pickling stainless steel, and as a wood preservative, an adhesive, an insecticide, and an antiseptic.

This subcategory has been recommended for exclusion under Paragraph 8 due to the small number of plants.

Sodium Hydrosulfide. Sodium hydrosulfide is used in the manufacture of sodium sulfide and other chemicals and paper (kraft). It is also used in dehairing of hides and industrial wastewater treatment.

Due to the very small flows and waste loads generated by this industry, this subcategory has been recommended as a Paragraph 8 exclusion candidate.

Sodium Metal. Sodium metal is manufactured with chlorine by electrolysis of fused salt. It is used in the production of tetraethyl lead gasoline additives, sodium cyanide, sodium peroxide, and titanium and zirconium metals. In liquid form, it is used as a nuclear reactor coolant; it is also used as a light, thermally conductive solid in various applications.

No toxic pollutants were found at significant concentrations during screening of sodium metal plant 339. On the basis of these findings, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Sodium Silicate. Sodium silicate is manufactured both in liquid and anhydrous powdered form. It has many industrial uses, such as additives in adhesives, flocculants, and cleaning agents. It is also used in the production of soap and household detergents.

Due to the low waste loads generated by this industry, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Sodium Thiosulfate. Sodium thiosulfate is extensively used in the development of negatives and prints in the photographic industry. It is also used in medicine, in the paper and dyeing industries, and as a bleaching agent for natural products.

No toxic pollutants were found at significant levels in the raw waste during screening of sodium thiosulfate plant 987.

On the basis of these findings, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Stannic Oxide. No descriptive information is available in References 1 through 4.

Sulfur Dioxide. Most sulfur dioxide is produced in the gaseous form, although a small percentage is also produced in liquid form. In the gaseous form, it is predominantly used in on-site manufacture of sulfuric acid. It is also used in the paper and petroleum industries, as well as for fermentation control in the wine industry, for bleaching in the textile and food industries, and in the production of other chemicals.

No toxic pollutants were found at significant levels in the waste during screening of sulfur dioxide plant 363. On the basis of these findings, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Sulfuric Acid. Sulfuric acid is one of the most extensively used of all manufactured chemicals. The major industrial use is in the fertilizer industry, with on-site captive use of the product as a dominant practice. It is also used in the manufacturing of plastics, explosives, detergents, hydrofluoric acid, nuclear fuel, and several other organic and inorganic products.

No toxic pollutants were found at significant concentrations in the raw waste during screening of sulfuric acid plant 363. On the basis of these findings, this subcategory has been recommended as an exclusion candidate under Paragraph 8.

Zinc Oxide. No descriptive information is available in References 1 through 4.

Zinc Sulfate. No descriptive information is available in References 1 through 4.

II.5.2 WASTEWATER CHARACTERIZATION

Wastewaters in the Inorganic Chemicals industry vary considerably between subcategories. Toxic pollutants are generally metals except in cases where organic products are also produced at the same plant. Concentrations and effluent flows range from insignificant to considerable amounts. The following descriptions provide detailed wastewater characterization information for the 11 inorganic subcategories not proposed for exclusion either under Paragraph 8 of the NRDC consent decree or for other reasons. Table 5-16 presents the maximum concentration of each toxic pollutant found in each subcategory within the industry.

II.5.2.1 Aluminum Fluoride Industry

Water Use

Water is used in noncontact cooling of the product, for seals on vacuum pumps, and for scrubbing the reacted gases before they are vented to the atmosphere. Water is also used for leak and spill cleanup and equipment washdown.

Wastewater Sources

Noncontact Cooling Water. Noncontact cooling water is used to cool the product coming out of the reactor. In some cases it is recirculated and the blowdown treated separately from other process contact wastewater or discharged without treatment. The water can be monitored for fluoride and if process contamination occurs it can be diverted to the wastewater treatment facility for fluoride removal.

Floor and Equipment Washings. The quantity and quality of wastewater generated from these operations is variable and depends largely on the housekeeping practices at the individual plants.

Scrubber Wastewater. This is the major source of wastewater requiring treatment before discharge or recycle back to the scrubber. It is contaminated with hydrofluoric acid, aluminum fluoride, and aluminum oxide, and, in some cases, the presence of sulfuric acid and silicotetrafluoride has been detected. These originate as impurities in the hydrofluoric acid used in the process.

Wastewater Characteristics

A summary of daily and unit product raw waste loads found in screening and verification sampling is shown in Table 5-17.

TABLE 5-16. MAXIMUM RAW WASTEWATER CONCENTRATIONS OF TOXIC POLLUTANTS FOUND AT SAMPLED INORGANIC CHEMICAL PLANTS[a] [1] (μg/L)

Toxic pollutant	Aluminum Fluoride		Chlor-Alkali: Mercury cell		Chlor-Alkali: Diaphragm cell, Metal anode		Chlor-Alkali: Diaphragm cell, Graphite anode	Chrome Pigments	
	Screening	Verification (2 plants)	Screening	Verification (5 plants)	Screening	Verification (4 plants)	Verification	Screening	Verification (2 plants)
Metals and inorganics									
Antimony	200	475	<200	950	20	43[b]	1,910	7,700	1,480
Arsenic			<10	400	10	660	680		
Asbestos									
Beryllium									
Cadmium	0.85	33	0.4	787	2	62	46	79	1,250
Chromium	77	1,140	7.7	235	940	18,800	300	55,000	349,000
Copper	120	235	350	1,480	525	16,600	7,450	7,500	4,700
Cyanide								360	8,200
Lead			1	1,900	255	2,000	1,630,000	36,000	69,000
Mercury	2	11	150	27,600	9	347	74		
Nickel	150	285	<100	2,450	54,400	22,100	640	160	740
Selenium	110	97						<10	28
Silver			0.6	1,460	<9	93		7	20
Thallium			<250	650	14		<2		
Zinc			230	34,800	24	4,290	3,200	4,100	273,000
Organics									
Benzene							15		
Carbon tetrachloride							197		
1,2-Dichloroethane							621		
Hexachloroethane							90		
Chloroform							691		
Dichlorobromomethane							309		
Bis(2-ethylhexyl) phthalate							120	<0.1[c]	
Tetrachloroethylene							196		
Phenol								73	
Pentachlorophenol									
Naphthalene									
2,4-Dinitrophenol									
1,1,1-Trichloroethane									

(continued)

TABLE 5-16 (continued)

Toxic pollutant	Copper sulfate Screening	Copper sulfate Verification (1 plant)	Hydrofluoric acid Screening	Hydrofluoric acid Verification (3 plants)	Hydrogen cyanide Screening	Hydrogen cyanide Verification (2 plants)	Nickel sulfate Screening	Nickel sulfate Verification (2 plants)
Metals and inorganics								
Antimony	307	330	70	2,805				
Arsenic	3,500	3,500	10	158				
Asbestos								
Beryllium								
Cadmium	870	870	2	20			9	160
Chromium			73	1,180			1,300	110
Copper	1,850,000	1,850,000	770	595			73,300	355
Cyanide					166	186		
Lead	175	180	5,190	199			55	120
Mercury			2	43			4	10
Nickel	112,000	112,000	150	2,005			175,500	1,115,000
Selenium			25	234			<235	141
Silver								
Thallium			5.5	63	25		21	<3
Zinc	11,000	11,100	8,120	11,313				
Organics								
Benzene								
Carbon tetrachloride								
1,2-Dichloroethane								
Hexachloroethane								
Chloroform								
Dichlorobromomethane								
Bis(2-ethylhexyl) phthalate								
Tetrachloroethylene								
Phenol								
Pentachlorophenol								
Naphthalene								
2,4-Dinitrophenol								
1,1,1-Trichloroethane	244[d]							

(continued)

TABLE 5-16 (continued)

Toxic pollutant	Sodium bisulfate: Screening	Sodium bisulfate: Verification (2 plants)	Sodium dichromate: Screening	Sodium dichromate: Verification (2 plants)	Sodium hydrosulfite: Verification	Titanium dioxide: Chloride: Verification (2 plants)	Titanium dioxide: Sulfate: Screening	Titanium dioxide: Sulfate: Verification (2 plants)
Metals and inorganics								
Antimony	30	650					20	1,400
Arsenic							11	340
Asbestos								
Beryllium								
Cadmium	6	41			43		338	11.7
Chromium	17	3,360	252,000	312,000	9,300	15,200	124,000	30,600
Copper	375	926	35	240	1,450		1,480	1,000
Cyanide					101			
Lead	8	1,050			1,290	5,150	3,730	5,190
Mercury	3	16.7			28			
Nickel	250	455	12,500	1,260	1,660	6,230	6,370	1,300
Selenium			<5	22[b]	34			
Silver	2	<30	<0.5	228[b]	128		64	<15
Thallium							19	41
Zinc	2,480	3,600	544	1,230	27,400	3,110	3,840	16,600
Organics								
Benzene								
Carbon tetrachloride								
1,2-Dichloroethane								
Hexachloroethane								
Chloroform								
Dichlorobromomethane								
Bis(2-ethylhexyl) phthalate								
Tetrachloroethylene								
Phenol					160		20	NA
Pentachlorophenol					373			
Naphthalene								
2,4-Dinitrophenol								
1,1,1-Trichloroethane								

(continued)

TABLE 5-16 (continued)

Toxic pollutant	Boric acid Screening	Carbon dioxide Screening	Carbon monoxide Screening	Hydrochloric acid Screening	Hydrogen peroxide Screening	Nitric acid Screening (2 plants)	Nitric acid Verification (1 plant)	Nitric acid (strong) Screening (2 plants)	Nitric acid (strong) Verification (1 plant)
Metals and inorganics									
Antimony									
Arsenic									
Asbestos									
Beryllium									
Cadmium								<2	<2
Chromium			2,590			110[g]	100[g]	40,000[g]	<50[g]
Copper	340								
Cyanide						<0.04	<0.02	0.02	<0.02
Lead				3.5		29	<10	70	<10
Mercury	1.6		1.2	2.0		0.47	4.5	8.6	1.2
Nickel				5.5		170	85	<5	<50
Selenium									
Silver			1.4			0.5	<15	0.69	<15
Thallium	140								
Zinc	1,190	910	820			120[g]	791[g]	900[g]	115[g]
Organics									
Benzene									
Carbon tetrachloride									
1,2-Dichloroethane									
Hexachloroethane									
Chloroform									
Dichlorobromomethane									
Bis(2-ethylhexyl) phthalate	530								
Tetrachloroethylene									
Phenol					29[f]				
Pentachlorophenol					4,850[f]				
Naphthalene					11[f]				
2,4-Dinitrophenol						215[i]	NA		
1,1,1-Trichloroethane									

(continued)

TABLE 5-16 (continued)

Toxic pollutant	Oxygen and nitrogen Screening	Potassium iodide Screening	Sodium carbonate (Solvay process) Screening	Sodium hydrosulfide Screening	Sodium silicate Screening
Metals and inorganics					
Antimony			430		
Arsenic					
Asbestos					
Beryllium			220		
Cadmium					
Chromium					
Copper	590	1,900			
Cyanide					
Lead			2,700		
Mercury					1.3
Nickel					121
Selenium					
Silver		35	<57		1.3
Thallium		28	200		
Zinc		930[h]	750		
Organics					
Benzene					
Carbon tetrachloride					
1,2-Dichloroethane					
Hexachloroethane					
Chloroform					
Dichlorobromomethane					
Bis(2-ethylhexyl) phthalate					
Tetrachloroethylene					
Phenol				76	
Pentachlorophenol					
Naphthalene				90	
2,4-Dinitrophenol					
1,1,1-Trichloroethane					

[a]No toxic pollutants were found in the following subcategories: ammonium chloride, barium carbonate, calcium carbonate, sodium metal, sodium thiosulfate, sulfur dioxide, and sulfuric acid. Samples were taken but no data were given for the following subcategories: ammonium hydroxide, cuprous oxide, and manganese sulfate. No data were available for the following subcategories: aluminum sulfate, borax, bromine, calcium, calcium carbide, chromic acid, ferric chloride, ferrous sulfate, fluorine, hydrogen, iodine, lead monoxide, lithium carbonate, potassium chloride, potassium dichromate, potassium metal, potassium permanganate, sodium bicarbonate, sodium fluoride, stannic oxide, zinc oxide, and zinc sulfate.

[b]Found at one plant only.

[c]From organic pigment process.

[d]Due to contaminated groundwater.

[e]Includes other cyanide process wastes.

[f]Organics due to organic weed killer - not process related.

[g]Chromium and zinc concentrations due to anticorrosion additives.

[h]Zinc concentration due to water source.

[i]Presumed to be from contamination by the organic products manufactured at the plant - not process related.

Note: Blanks indicate no data available.

TABLE 5-17. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - ALUMINUM FLUORIDE SUBCATEGORY [1]

Pollutant	Raw waste loadings						No. of plants averaged
	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	
Toxic pollutants							
Arsenic	0.071	0.078	0.086	0.0007	0.0016	0.002	3
Cadmium		0.010			0.0002		1
Chromium	0.072	0.16	0.25	0.0016	0.0035	0.0054	2
Copper	0.02	0.16	0.33	0.0002	0.0033	0.0071	3
Nickel	0.025	0.13	0.26	0.00025	0.003	0.0056	3
Mercury	0.0013	0.0041	0.0095	0.000027	0.00005	0.00009	3
Selenium	0.051	0.11	0.17	0.001	0.0015	0.002	2
Conventional pollutants							
TSS	751	2,920	5,510	16.3	53.7		
Fluorine	493	727	986	9.71	11.9		
Aluminum	98.4	220	352	0.97	4.40		

Note: Blanks indicate data not available.

II.5.2.2 Chlor-Alkali Industry

Water Use

The water uses common to both mercury and diaphragm cells include noncontact cooling, cell washings, tail gas scrubbing, equipment maintenance, and area washdown. Noncontact cooling water is used in cooling brine, caustic, chlorine, rectifiers, and compressors. Large amounts of water are also introduced into the process through the salt solution.

One water application unique to the mercury cell process is in the decomposition of mercury-sodium amalgam to form caustic in the denuder. In mercury cell plants, the quantity of water usage was found to range from 7.6 to 204 cubic meters per metric ton of chlorine produced, with noncontact cooling comprising approximately 70% of the total.

In the diaphragm cell process a large quantity of water is used in the barometric condensers if the vapors from the caustic evaporators are contact cooled. For plants practicing contact cooling through barometric condensers, the average amount of water usage is twice that of the mercury cell plant per metric tons of chlorine produced (15 to 492 m^3/Mg). Of the total water usage in diaphragm cell plants, approximately 50% is used for noncontact cooling. In addition, the amount of water used for cleaning diaphragm cells is higher than that required for mercury cells.

Waste Sources

Some of the waste sources produced during the manufacture of chlorine and caustic by diaphragm and mercury cells are similar with the notable exception of the presence of mercury in the wastewaters from mercury cells and asbestos fibers in the wastewater from the diaphragm cell plants. Following are descriptions of the common wastewater streams, followed by descriptions of the individual streams specific to mercury and diaphragm cells.

Common Wastes (Mercury Cell and Diaphragm Cell).

Brine mud - Brine mud is the major portion of the waste solids produced from the two processes. The solids content of the stream varies from 2% to 20% and ranges in volume from 0.04 to 1.5 cubic meters per ton of chlorine produced. The waste is either sent to a pond or filtered. The overflow from the pond (filtrate) is recycled to the process as makeup water for the brine. In the mercury cell process, only 16% of the NaCl solution is decomposed in the cell, and the unconverted brine is recycled to the purification unit after dechlorination. This recycled brine is contaminated with mercury and, therefore, the resulting brine mud contains small amounts of mercury.

Cell room wastes - The major components of this stream include leaks, spills, and cell wash waters. The amount of cell room waste generated per metric ton of chloride is generally higher for diaphragm cell plants, and the wastewater from the washing and rebuilding of the cathode contains asbestos fibers, dissolved chlorine, and brine solution. In mercury cell plants, the cell room wastes contain mercury, dissolved hydrogen, chlorine, and some sodium chloride.

Cell room waste constitutes one of the major streams that has to be treated for mercury. If graphite anodes are used in either the mercury or diaphragm cells, the cell room wastes contain lead and chlorinated organic compounds in addition to the normal pollutants.

Chlorine condensate - Condensation from the cell gas is contaminated with chlorine. At some plants, the condensates are recycled to the process after chlorine recovery. Both contact and noncontact water is used for chlorine cooling and for removal of water vapor, so the amount of wastewater varies from plant to plant. When graphite anodes are used, chlorinated hydrocarbons, lead, and other impurities carried with the chlorine condense in the first-stage cooler. The chlorinated organic compounds that have been detected when graphite anodes are used are: chloroform, methylene chloride, hexachlorobenzene, hexachloroethane, and hexachlorobutadiene.

Spent sulfuric acid - Concentrated sulfuric acid is used to remove the residual water from the Cl_2 gas after the first stage of cooling. In most cases, sulfuric acid is used until a constant concentration of 50% to 70% is reached. The spent acid might contain mercury, asbestos fibers, or chlorinated hydrocarbons (depending on the type of cell) in addition to chlorine. The volume of waste acid is typically of the order of 0.01 cubic meter per metric ton of chlorine.

Tail gas scrubber liquid - The uncondensed chlorine gas from the liquefaction stage, containing some air and other gases, is scrubbed with sodium/calcium hydroxide to form sodium/calcium hypochlorite. When the equipment is purged for maintenance, the "sniff" gas, or tail gas, is absorbed in calcium or sodium hydroxide, producing the corresponding hypochlorites. The amount of tail gas scrubber water varies from 0.04 to 0.58 cubic meter per metric ton of chloride for both diaphragm and mercury cell plants.

Caustic filter washdown - The 50% caustic produced from both mercury and diaphragm cells is treated with chemicals and filtered to remove salt and other impurities. The filters are backwashed periodically as needed; the wastewater volume is variable and usually contains small amounts of mercury or asbestos fibers in addition to the salt.

Process Specific Wastes.

Condenser drainage - In mercury cells, the hydrogen produced is cooled in surface condensers to remove mercury and water that is carried over with the gas. The wastewater is sent either to the wastewater treatment facility or to the mercury recovery facility. After mercury recovery, the water may be discharged to the treatment facility or returned to the denuder after deionization. Information on the volume of this waste stream is not available.

Barometric condenser water - The wastewater specific to the diaphragm cell process is the barometric condenser water. A significant amount of water is used in contact cooling the vapors from the evaporators used to concentrate the caustic. In the mercury cells, the caustic comes out at a concentration of 50% and does not require evaporators unless a caustic of high concentration (e.g., 73%) is required. The barometric condenser wastewater ranges from 89 to 191 cubic meters per metric ton of chlorine. The barometric condenser wastewater is either discharged without treatment or recycled, and a bleed is discharged with or without pH adjustment.

Discharges from the barometric condensers contain some salt and caustic as a result of the carryover from the caustic solution. When graphite anodes are used, the barometric condenser wastewater contains lead.

Sulfate purge wastewater - During the concentration of the caustic by evaporation, sodium chloride precipitates out. The salt is removed and is washed with water to remove sodium sulfate. A portion of wash water is recycled and the rest is purged to waste in order to stop the buildup of sulfates. The stream is one of the major sources of wastewater from chlorine/ caustic plants using diaphragm cells.

A summary of daily and unit product raw waste loads for all plants sampled in the chlor-alkali/mercury cell subcategory is shown in Table 5-18. Similar data for diaphragm cell plants are presented in Table 5-19.

II.5.2.3 Chrome Pigment Industry

Water Use

In the chrome pigment industry water is used for noncontact cooling, for washing the precipitated product, and as boiler feed for steam generation. In some cases water is introduced into the reactor along with the raw materials. In anhydrous and hydrated chrome oxide manufacture, water is used for slurrying of the reaction product and in scrubbing the reactor vent gases.

TABLE 5-18. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING (MERCURY CELL PROCESS [1]

Pollutant	Raw waste loadings						No. of plants averaged
	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	
Toxic pollutants:							
Antimony	0.0059	0.15	0.29	0.00001	0.00045	0.00074	3
Arsenic	0.00045	0.086	0.27	0.000001	0.0003	0.01	5
Cadmium	0.00032	0.0091	0.025	0.0000008	0.00005	0.0002	5
Chromium	0.0014	0.028	0.094	0.000004	0.00009	0.0004	6
Copper	0.029	0.11	0.020	0.0001	0.00033	0.0006	6
Lead	0.034	0.068	0.13	0.000089	0.00032	0.0007	5
Mercury	0.086	2.84	6.71	0.0002	0.016	0.063	6
Nickel	0.018	0.046	0.072	0.00003	0.00026	0.0007	4
Silver	0.00036	0.058	0.22	0.00001	0.00022	0.0008	4
Thallium	0.0027	0.071	0.14	0.00002	0.0003	0.001	4
Zinc	0.11	0.42	1.10	0.0003	0.0023	0.01	6
Conventional pollutants:							
TSS	6.76	307	1,200	0.018	2.19	10.8	

Note: Blanks indicate data not available.

TABLE 5-19. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING (DIAPHRAGM CELL PROCESS) [1]

Pollutant	Raw waste loadings						No. of plants averaged
	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	
Toxic pollutants:							
Arsenic	0.000028	0.0021	0.0033	0.00000015	0.0000056	0.000014	5
Cadmium	0.00034	0.0015	0.0029	0.000001	0.0000033	0.000006	5
Chromium	0.0036	0.58	2.81	0.000015	0.00095	0.0046	5
Copper	0.0037	0.12	0.27	0.000011	0.00041	0.0012	5
Lead	0.00086	0.021	0.064	0.0000037	0.000042	0.000095	5
Nickel	0.013	0.28	0.88	0.00004	0.00064	0.0014	5
Zinc	0.017	0.08	0.17	0.000057	0.00024	0.0007	4
Mercury	0.00018	0.00053	0.00082	0.0000003	0.0000013	0.0000025	3
Selenium	0.00023	0.0016	0.003	0.000003	0.000004	0.000005	2
Antimony		0.00064			0.000003		1
Thallium		0.000045			0.0000002		1
Conventional pollutants:							
TSS	7.39	23.8	53.9	0.026	0.069	0.18	

Note: Blanks indicate data not available.

Waste Sources

Some plants produce different pigment products sequentially in the same process. At a few plants the different pigment products are manufactured concurrently and the wastewaters combined and treated at a single facility. The wastewater sources are similar for all pigment products except that at chrome oxide plants an additional scrubber waste is produced. The quantity of wastewater and the pollutants vary for the different pigment products since the pollutants are dependent on the raw materials used. All the wastewaters generated in the chrome pigments subcategory contain dissolved chromium and pigment particulates.

Additional pollutants that can be present are given below for each major pigment group.

Chrome yellow and chrome orange: The raw wastewaters contain sodium acetate, sodium chloride, sodium nitrate, sodium sulfate, and lead salts.

Chrome oxide: The aqueous process effluent contains sodium sulfate. If boric acid is used in the preparation of hydrated chromic oxide, the wastewater will contain sodium borate and boric acid.

Chrome yellow and chrome orange: Additional pollutants present in the raw wastewater from chrome yellow and chrome orange manufacture include sodium acetate, sodium chloride, sodium nitrate, sodium sulfate, and lead salts.

Molybdenum orange: Process waste effluents from the manufacture of molybdenum orange contain sodium chloride, sodium nitrate, sodium sulfate, chromium hydroxide, lead salts, and silica.

Chrome green: The raw wastewater contains sodium nitrate. If iron blue is manufactured on site as part of the process for chrome green manufacture, the wastewater also contains sodium chloride, ammonium sulfate, ferrous sulfate, sulfuric acid, and iron blue pigment particulates.

Zinc yellow: The raw wastes contain hydrochloric acid, sodium chloride, potassium chloride, and soluble zinc salts.

Because various plants make several chrome pigments sequentially or concurrently, the unit hydraulic load going to the treatment facility will be an average of all the waste loads from the different processes. The raw waste from a complex plant may contain nearly all of the following substances: sodium acetate; sodium chloride; sodium nitrate; sodium sulfate; potassium chloride; lead, iron, and zinc salts; soluble chromium; and pigment particulates.

Wastewater Characteristics

A summary of daily and unit product raw waste loadings for all plants sampled is shown in Table 5-20.

TABLE 5-20. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - CHROME PIGMENTS SUBCATEGORY [1]

Pollutant	Raw waste loadings						No. of plants averaged
	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	
Toxic pollutants							
Antimony	5.90	51.7	98.0	0.14	0.87	1.61	2
Cadmium	0.87	5.44	10.0	0.02	0.16 .	0.09	2
Chromium	698	1,020	1,330	11.5	21.5	30.8	2
Copper	6.08	50.8	95.2	0.14	0.86	1.58	2
Lead	237	347	458	5.46	6.49	7.62	2
Nickel	1.38	1.71	2.03	0.032	0.0325	0.033	2
Zinc	52.2	381	712	0.86	8.63	16.4	2
Cyanide	3.11	24.4	45.8	0.072	0.41	0.75	2
Organics							
Phenols		0.93			0.015		1
Phenolics		8.80			0.14		1
Conventional pollutants							
TSS		3,050			70.4		1

Note: Blanks indicate data not available.

II.5.2.4 Copper Sulfate Industry

Water Use

Water is used in the process as a reaction component which becomes a part of the dry product as its water of crystallization. Water is also used for noncontact cooling, pump seals, and washdowns.

Waste Sources

Noncontact Cooling Water. Noncontact cooling water is used in the crystallizers and constitutes one of the main wastes. This waste is treated before final discharge.

Contact Water. Washdowns, spills, and leaks are sources of contact wastewater, but the flows are relatively small and intermittent, and do not represent a major waste source.

Steam Condensate. A few plants use evaporators, and steam condensate is an additional noncontact waste formed in the process.

Solid Waste. Solid waste is produced by some plants. The copper metal used in the process contains copper sulfides, which are filtered out of the liquor and disposed of in a landfill.

Plants that produce copper sulfate in the liquid form have no contact waste streams from the process. The copper metal, acid, and water are reacted together to form the copper sulfate solution product with no generation of liquid wastes.

Wastewater Characteristics

A summary of daily and unit product raw waste loads for plant 034 is presented in Table 5-21.

TABLE 5-21. SUMMARY OF RAW WASTE LOADINGS FOUND AT COPPER SULFATE PLANT 034 [1]

Pollutant	Raw waste loadings	
	Average, kg/d	Average, kg/Mg
Toxic pollutants		
Antimony	0.014	0.00069
Arsenic	0.16	0.0078
Cadmium	0.039	0.0019
Copper	83.9	4.11
Lead	0.0079	0.00039
Nickel	5.08	0.25
Zinc	0.50	0.024
Conventional pollutants		
TSS	1.78	0.087

II.5.2.5 Hydrofluoric Acid Industry

Water Use

Water is used in hydrofluoric acid production in noncontact cooling, air pollution control, product dilution, seals on pumps and kilns, and for equipment and area washdown. Although noncontact cooling constitutes the major use of water, water is also used, in a majority of cases, in the transport of gypsum as a slurry to the wastewater treatment facility. The water for gypsum transport is provided either by recycling the water from the treatment facility or by using once-through cooling water.

Waste Sources

Drip Acid. Drip acid is formed in the first stage of cooling of the gases emitted from the kiln. The drip acid primarily contains high boiling compounds consisting of complex fluorides and small amounts of hydrofluoric acid, sulfuric acid, and water.

Nine out of eleven plants producing HF recycle the drip acid back to the reactor.

Noncontact Cooling Water. Noncontact cooling water is used for precooling the product gases emitted from the kiln. This stream is relatively unpolluted, and the possibility of product or other process compounds leaking into it is small. In some plants, the cooling water is used to transport the waste gypsum.

Scrubber Wastewater. Scrubber wastewater constitutes the predominant and major source of wastewater in plants which practice dry disposal of gypsum. The water contains fluoride, sulfate, and acidity. The fluoride is present as hydrogen fluoride, silicon tetrafluoride, and hexafluosilicic acid. Scrubber water consequently needs treatment for fluoride before discharge.

Distillation Wastes. Distillation wastes generally contain HF and water. In some cases, vent gases from the distillation column are scrubbed before they are emitted to the atmosphere, resulting in scrubber water.

Gypsum Solids. Additionally, gypsum solids are generated as a byproduct. Seven out of eleven plants producing hydrofluoric acid slurry the gypsum with water and send it to a wastewater treatment facility. Three of the plants transport the gypsum as a dry solid.

Wastewater Characteristics

A summary of daily and unit product raw waste loads for all plants sampled in this subcategory is shown in Table 5-22.

TABLE 5-22. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - HYDROFLUORIC ACID SUBCATEGORY [1]

	Raw waste loadings						
Pollutant	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	No. of plants averaged
Toxic pollutants							
Antimony	0.015	1.63	6.44	0.0003	0.03	0.12	4
Arsenic	0.012	0.46	1.12	0.003	0.0056	0.012	3
Cadmium	0.0036	0.011	0.017	0.0001	0.00027	0.00031	3
Chromium	0.14	1.73	5.49	0.0043	0.024	0.06	4
Copper	0.60	1.42	2.80	0.015	0.028	0.051	4
Lead	0.10	1.74	5.62	0.003	0.046	0.165	4
Mercury	0.0027	0.056	0.20	0.00008	0.00065	0.002	4
Nickel	0.14	3.90	13.0	0.0004	0.051	0.14	4
Selenium	0.016	0.066	0.12	0.0005	0.001	0.002	3
Thallium	0.0054	0.084	0.16	0.00016	0.0021	0.003	2
Zinc	0.49	21.1	72.1	0.014	0.41	1.33	4
Conventional pollutants							
TSS	13,600	133,000	247,000	170	2,710	5,700	
Fluorine	497	2,970	7,890	14.6	45.4	86.9	

Note: Blanks indicate data not available.

II.5.2.6 Hydrogen Cyanide Industry

Water Use

Water is used in noncontact cooling in the absorber, pump seal quenches, flare stack flushes, for washdown and cleanup of tank cars, and for washing equipment and cleaning up leaks and spills.

Waste Sources

The following are the sources of wastewater produced from the manufacture of hydrogen cyanide by the Andrussow process.

Distillation Bottoms. The wastewater contains ammonia, hydrogen cyanide, and small amounts of organic nitriles. The water consists of the water produced by the reaction plus scrubber water used for the absorption of HCN. The absorption water distillation bottoms are either recycled to the ammonia absorber or discharged to the treatment facility. Even if the distillation bottom stream is recycled to the absorber, a portion of it is discharged to stop the buildup of impurities.

Scrubber Streams. If the scrubber liquid is recycled, a portion of it has to be purged to control the accumulation of impurities. The bleed contains the acid used for scrubbing and minor amounts of organic nitriles. The scrubber solution can also be used for the manufacture of other products in which case nothing is discharged from the scrubber operation.

Other Wastewater. This includes leaks and spills, equipment and tank car washings, noncontact cooling water blowdown, and rainfall runoff.

Wastewater Characteristics

A summary of daily and unit product raw waste loads for all plants sampled in this subcategory is presented in Table 5-23.

TABLE 5-23. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - HYDROGEN CYANIDE SUBCATEGORY [1]

	Raw waste loadings						No. of
Pollutant	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	plants averaged
Toxic pollutants							
Total cyanide	173	205	237	0.81	1.20	1.60	2
Free cyanide	106	113	120	0.49	0.65	0.81	2
Conventional pollutants							
TSS	152	383	614	1.02	1.94	2.87	
NH_3-N	3,880	5,790	7,700	26.2	31.1	36.0	
BOD_5	24.5	4,320	8,620	0.16	20.2	40.3	

Note: Blanks indicate data not available.

II.5.2.7 Nickel Sulfate Industry

Water Use

Noncontact cooling water is used for nickel sulfate production in the reactor and in crystallizers. Water is used for direct process contact in the reactor. Small amounts of water are used for maintenance, washdowns, cleanup, etc.

Waste Sources

Noncontact Cooling Water. Noncontact cooling water is the main source of wastewater, but it is usually not treated before discharge.

Contact Water. Direct process contact water constitutes the major portion of treated waste. The water comes from the preliminary preparation of spent plating solutions used in the process. Plants which use impure nickel raw materials generate a filter backwash waste stream with high impurity levels. This stream must be sent through the treatment system.

Washdowns, spills, pump leaks, and maintenance uses account for the remaining wastes produced by nickel sulfate plants.

Wastewater Characteristics

A summary of daily and unit product raw waste loads for all plants sampled is presented in Table 5-24.

TABLE 5-24. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - NICKEL SULFATE SUBCATEGORY [1]

Pollutant	Raw waste loadings: Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	No. of plants averaged
Toxic pollutants							
Cadmium	0.000014	0.0015	0.0045	0.000002	0.00017	0.0005	3
Chromium	0.00023	0.00091	0.0018	0.00001	0.00025	0.0005	2
Copper	0.0011	0.039	0.11	0.0001	0.01	0.03	3
Lead	0.000082	0.0014	0.0028	0.00002	0.0001	0.0003	3
Mercury		0.000027			0.00003		1
Nickel	0.27	10.8	31.5	0.035	1.20	3.45	3
Selenium	0.00027	0.00059	0.00091	0.00003	0.000035	0.00004	2
Thallium		0.000032			0.000009		1
Conventional pollutants							
TSS	0.34	31.2	92.5	0.031		10.1	

Note: Blanks indicate data not available.

II.5.2.8 Sodium Bisulfite Industry

Water Use

Direct process contact water is used to slurry the sodium carbonate for the reaction. Noncontact cooling water is another water use at one plant. Water is also used for pump seals, maintenance, and washdowns.

Waste Sources

Noncontact Cooling Water. Noncontact cooling water from the centrifuge is a source of waste at one plant.

Contact Water. Direct process contact water is the main source of wastewater which must be treated, together with miscellaneous wastes such as water used for maintenance purposes, washdowns, and spill cleanup.

Wastewater Characteristics

A summary of daily and unit product raw waste loadings for all plants sampled in this subcategory is shown in Table 5-25.

TABLE 5-25. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - SODIUM BISULFITE SUBCATEGORY [1]

Pollutant	Raw waste loadings						No. of plants averaged
	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	
Toxic pollutants							
Antimony	0.00045	0.0018	0.0041	0.000007	0.000052	0.00008	2
Cadmium	0.00023	0.0003	0.00041	0.000004	0.00001	0.000017	3
Chromium	0.018	0.54	1.05	0.0003	0.011	0.022	2
Copper	0.005	0.011	0.015	0.00007	0.00046	0.001	2
Lead	0.000091	0.0045	0.0095	0.000007	0.000092	0.0002	3
Mercury	0.000091	0.00021	0.00045	0.000001	0.000006	0.00001	2
Nickel	0.0032	0.0068	0.0091	0.00005	0.00031	0.0007	3
Zinc	0.016	0.18	0.42	0.0002	0.0053	0.0088	3
Conventional pollutants							
TSS	3.20	12.9	25.4	0.21	0.27	0.38	
COD	54.4	117	234	1.33	2.94	4.04	

Note: Blanks indicate data not available.

II.5.2.9 Sodium Dichromate Industry

Water Use

Water is used for noncontact cooling, in leaching, for scrubbing vent gases, and for process steam for heating.

Water Sources

Spent Ore. The unreacted ore is removed from the process as a sludge. The solids contain chromium and other impurities originally present in the ore. The waste is disposed as a solid waste in a landfill or is slurried with water and sent to the treatment facility.

Noncontact Cooling Water and Cooling Tower Breakdown. The noncontact cooling water is either used on a once-through basis and discharged or is recycled and the blowdown discharged to the treatment facility. In addition to dissolved sulfate and chloride, it may contain chromates.

Boiler Blowdown. The steam used for heating is recovered as condensate, while the boiler blowdown is discharged to the treatment facility. It may become contaminated with chromium escaping from the process area and hence should be sent to the wastewater treatment facility for treatment.

The majority of aqueous streams resulting from the manufacture of sodium dichromate are recycled. Streams recycled include condensates from product evaporation and drying; product recovery filtrates; air pollution control scrubber effluents from product drying, leaching, and roasting kilns; filter wash waters; and equipment and process area washdowns. At two plants the wastewater, consisting of boiler and noncontact cooling tower, is used to slurry the spent ore residue to the wastewater treatment facility. At one plant, the only wastewater resulting from process operations is the noncontact cooling water, which is used on a once-through basis.

Wastewater Characteristics

A summary of daily and unit product raw waste loads for all plants sampled in this subcategory is presented in Table 5-26.

TABLE 5-26. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - SODIUM DICHROMATE SUBCATEGORY [1]

	Raw waste loadings						
Pollutant	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	No. of plants averaged
Toxic pollutants							
Chromium	82.1	132	181	0.95	1.17	1.39	2
Hex. chromium	27.5	1,210	3,105	0.466	15.7	43.9	3
Copper	0.0091	0.32	0.92	0.00005	0.0046	0.013	3
Nickel	0.27	4.26	8.98	0.006	0.034	0.049	3
Silver		0.058			0.0009		1
Zinc	0.067	0.22	3.91	0.0009	0.002	0.003	3
Selenium		0.23			0.003		1
Arsenic		0.005			0.00008		1
Conventional pollutants							
TSS	26,600	131,000	236,000	140	2,070	4,000	

Note. Blanks indicate data not available.

II.5.2.10 Sodium Hydrosulfite Industry

Water Use

Water is used in the process as makeup for the reaction solutions and for steam generation in the rotary dryers. Water is also used for noncontact cooling in the reactor gas vent scrubbers and dryers, as well as pump seals and washdowns.

Water Sources

Distillation Column Residue. The strongest process waste is the aqueous residue from the distillation column bottoms (solvent recovery system). This waste contains concentrated reaction coproducts and is purged from the system at a rate of approximately 53 m^3/d (14,000 gal/d). At one plant (672) this waste is sent to a coproduct pond where it is held and either sold to the pulp and paper industry or bled into the treatment system.

Dilute Wastes. The dilute wastes from process are contributed from leaks, spills, washdowns, and tank car washing. At one plant (672) this is collected in a sump and then sent to the biological treatment system.

Blowdown. Cooling tower and boiler blowdown constitutes a noncontaminated wastewater source. This is sent to the final compartment of the chlorine contact tank without treatment for discharge with the combined effluent of the treatment plant.

Scrubber Wastewater. The vent gas scrubbers create a wastewater source which is sent to the methanol recovery distillers for recycle. This waste eventually goes to the coproduct pond with the distilling column bottoms.

Wastewater Characteristics

A summary of daily and unit product raw waste loads for the plant sampled (672) is presented in Table 5-27.

II.5.2.11 Titanium Dioxide Industry

II.5.2.11.1 Chloride Process

Water Use. Water is used in noncontact cooling, for scrubbing tail gases from the purification and oxidation reactor to remove contaminants, and in some cases, in the finishing operation of the product. The total amount of water usage varies from 45.3 m^3/Mg to 383 m^3/Mg of TiO_2 produced. Cooling water constitutes the major use of water and varies from 10.7 m^3/Mg to 280 m^3/Mg of TiO_2 produced.

TABLE 5-27. SUMMARY OF RAW WASTE LOADINGS FOUND AT SODIUM HYDROSULFITE PLANT 672 (FORMATE PROCESS) [1]

Pollutant	Raw waste loadings Average, kg/d	Average, kg/Mg
Toxic pollutants		
Cadmium	0.0041	0.00007
Chromium	0.81	0.14
Copper	0.11	0.0019
Lead	0.041	0.0007
Nickel	0.16	0.0027
Silver	0.0045	0.00008
Zinc	0.63	0.011
Pentachlorophenol	0.04	0.0007
Phenol	0.017	0.0003
Conventional pollutants		
TSS	91.6	1.57
COD	1,690	28.9

Waste Sources.

Wastes from cooling chlorinator gas - These wastes consist of solid particles of unreacted ore, coke, iron, and small amounts of vanadium, zirconium, chromium and other heavy metal chlorides, which are either dissolved in water and sent to the wastewater treatment plant, or disposed in a landfill as solid waste.

Chlorinator process tail gas scrubber waste - The uncondensed gases, after the liquefaction of titanium tetrachloride, are wet scrubbed to remove hydrogen chloride, chlorine, phosgene, and titanium tetrachloride and chlorine in the first stage. In the second stage, they are scrubbed with caustic soda to remove chlorine as hypochlorite.

Distillation bottom wastes - These contain copper, sulfide, and organic complexing agents added during purification in addition to aluminum, silicon, and zirconium chlorides. These are removed as waterborne wastes, and reaction with water converts silicon and anhydrous aluminum chlorides to their respective oxides.

Oxidation tail gas scrubber wastes - The gases from the oxidation unit are cooled by refrigeration to liquefy and recover chlorine. The uncondensed off-gases are scrubbed with water or caustic soda to remove residual chlorine. When caustic soda is used as the scrubbing solution, the resulting solution of sodium hypochlorite is either sold, decomposed, sent to the wastewater treatment facility, or discharged without treatment. The scrubber waste stream also contains titanium dioxide particulates.

Finishing operations waste - The liquid wastes from the finishing operation contain titanium dioxide as a suspended solid and dissolved sodium chloride formed by the neutralization of residual hydrochloric acid with caustic soda.

Wastewater Characteristics. A summary of daily and unit product raw waste loads found in screening and verification sampling is shown in Table 5-28.

TABLE 5-28. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - TITANIUM DIOXIDE SUBCATEGORY (CHLORIDE PROCESS) [1]

Pollutant	Raw waste loadings						No. of plants averaged
	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	
Toxic pollutants							
Chromium	1.76	64.4	127	0.024	0.79	1.55	2
Lead	0.0032	2.0	4.0	0.0004	0.024	0.049	2
Nickel	0.14	2.04	3.93	0.002	0.025	0.048	2
Zinc	0.75	1.47	2.19	0.01	0.019	0.027	2
Conventional pollutants							
TSS	442	4,140	7,830	6.06	51.0	95.9	
Iron	7.57	768	1,530	0.10	9.40	18.7	

II.5.2.11.2 Sulfate Process

Water Use. Water is used in the preparation of titanium dioxide by the sulfate process for noncontact cooling, air emission control, and process reactions. In the process, water is used to leach the soluble sulfate salts from the reaction mass and to convert the titanyl sulfate to titanium dioxide hydrate. Water is also used to wash the titanium dioxide hydrate precipitate free from residual acid and iron. Water is used for air emission control during the drying of ore, on digester units, and for the cleaning of the kiln gases before they are vented to the atmosphere. In the digester unit, water seals are used to maintain a vacuum. Large amounts of water are also used in the finishing operations.

Waste Sources.

Strong acid waste - The concentration of sulfuric acid in strong acid waste varies from 15% to 30% as H_2SO_4. In addition to sulfuric acid, the waste stream contains ferrous sulfate, titania, antimony, and other heavy metal salts. A part of the acid is returned to the process and the rest is sent to the treatment facility.

Weak acid waste - The waste generated from washing the titanium dioxide hydrate precipitate is known as weak acid. The concentration of sulfuric acid in this waste varies from 2% to 4% as H_2SO_4 and contains various impurities, including iron sulfate, titania, antimony, and other heavy metal salts. It also includes, in some cases, the conditioning agents added to the precipitate prior to washing, to control and improve the quality of the final product. The weak acid may also include kiln exhaust gas scrubber waste.

Scrubber wastes - Scrubber wastewater results from the scrubbing of vapors emitted during the drying of the ore, during digestion, and during kiln drying. The amount of wastewater generated depends on the amount of water used and type of emission controls practices. The scrubber water contains titanium dioxide particulates, acid mist, sulfur trioxide, and sulfur dioxide. Of all the waste produced by the titanium dioxide-sulfate process manufacture subcategory, the scrubber wastewater constitutes the major portion.

Wet milling waste - These wastes are generated during wet finishing of the titanium dioxide pigment. Wet milling is used to produce pigment particles of the desired size and surface character and requires steam and water for repulping the pigment. Caustic soda is also used to remove any residual acidity from the titanium dioxide pigment during the finishing operation. The wastewater from wet finishing operations, therefore, contains titania, sodium sulfate, and other agents added to improve or achieve desired properties in the final product.

Digester sludge - After the digestion of the ore in sulfuric acid, the resulting sulfates are dissolved in water and the insoluble impurities are removed in a clarifier or filter. These include silica, alumina, sulfuric acid, and unreacted iron. The quality of this waste varies and depends on the type and quality of ore used. Data on the quantity of this waste indicate that approximately 210 kg/Mg is produced.

Copperas - The recovered ferrous sulfate is marketed or disposed of as a solid waste. The amount of copperas generated is about 950 kg/Mg of TiO_2. The copperas generally contains small amounts of adsorbed sulfuric acid.

Wastewater Characteristics. A summary of daily and unit product raw waste loads found in screening and verification sampling is shown in Table 5-29.

TABLE 5-29. SUMMARY OF RAW WASTE LOADINGS FOUND IN SCREENING AND VERIFICATION SAMPLING - TITANIUM DIOXIDE SUBCATEGORY (SULFATE PROCESS) [1]

	Raw waste loadings						No. of
Pollutant	Minimum, kg/d	Average, kg/d	Maximum, kg/d	Minimum, kg/Mg	Average, kg/Mg	Maximum, kg/Mg	plants averaged
Toxic pollutants							
Antimony	7.66	18.0	28.3	0.08	0.21	0.32	2
Arsenic		1.31			0.014		1
Cadmium	0.091	2.40	6.85	0.0009	0.027	0.078	3
Chromium	132	200	327	1.36	2.11	3.37	3
Copper	8.30	11.6	15.1	0.094	0.12	0.16	3
Lead	3.28	8.56	12.4	0.037	0.089	0.13	3
Nickel	8.30	11.5	14.7	0.086	0.12	0.15	2
Thallium		0.76			0.0078		1
Zinc	53.4	55.3	57.1	0.55	0.57	0.59	2
Organics							
Phenol	0.20				0.002		
Conventional pollutants							
TSS		20,500			211		
Iron		58,500			602		

Note: Blanks indicate data not available.

II.5.3 PLANT SPECIFIC DESCRIPTIONS

The following paragraphs, tables, and figures describe, in as much detail as possible, specific plants for 11 of the inorganic chemical subcategories. Descriptions are limited to plants chosen from the available data because they have the lowest concentrations of toxic pollutants in their final effluent streams and/or are described in sufficient detail in Reference 1.

II.5.3.1 Aluminum Fluoride

Two plants were selected for more detailed description from available data on the aluminum fluoride industry based on the lowest concentration of toxic pollutants in the final effluent stream.

Plant 705

Screening and verification data are provided for plant 705, which produces both hydrofluoric acid and aluminum fluoride. Wastewaters from both processes are mixed and sent to the treatment facility. The combined wastewater is neutralized with lime and sent to a series of settling ponds. Effluent from the last pond is given a final pH adjustment before a portion is discharged and the remainder recycled to the process. Plant 705 does not treat noncontact cooling water.

Figure 5-1 (next page) shows a simplified block diagram of the process including the wastewater treatment facility and sampling locations. Table 5-30 summarizes the flow data of the sample streams and the emission characteristics for important classical pollutant parameters for screening and verification data. Table 5-31 provides toxic pollutant raw waste loads.

TABLE 5-30. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 705 PRODUCING ALUMINUM FLUORIDE [1]

Sampling phase	Wastestream description	Flow, m^3/Mg AlF_3	kg/Mg AlF_3		
			SS	Fluoride	Aluminum
Screening	AlF_3 scrubber	8.9	117	4.67	6.94
	Surface drains[a] cooling tower, blowdown, etc.	17.8	3.5	6.14	0.76
	Treated waste	24	1.98	1.63	0.168
Verification	AlF_3 scrubber	8.9	12.8	12.3	4.08
	Surface drains,[a] cooling tower, blowdown, etc.	17.8	3.57	3.01	0.475
	Treated waste	24	0.048	0.55	0.012

[a]Contribution from both HF and AlF_3 plants.

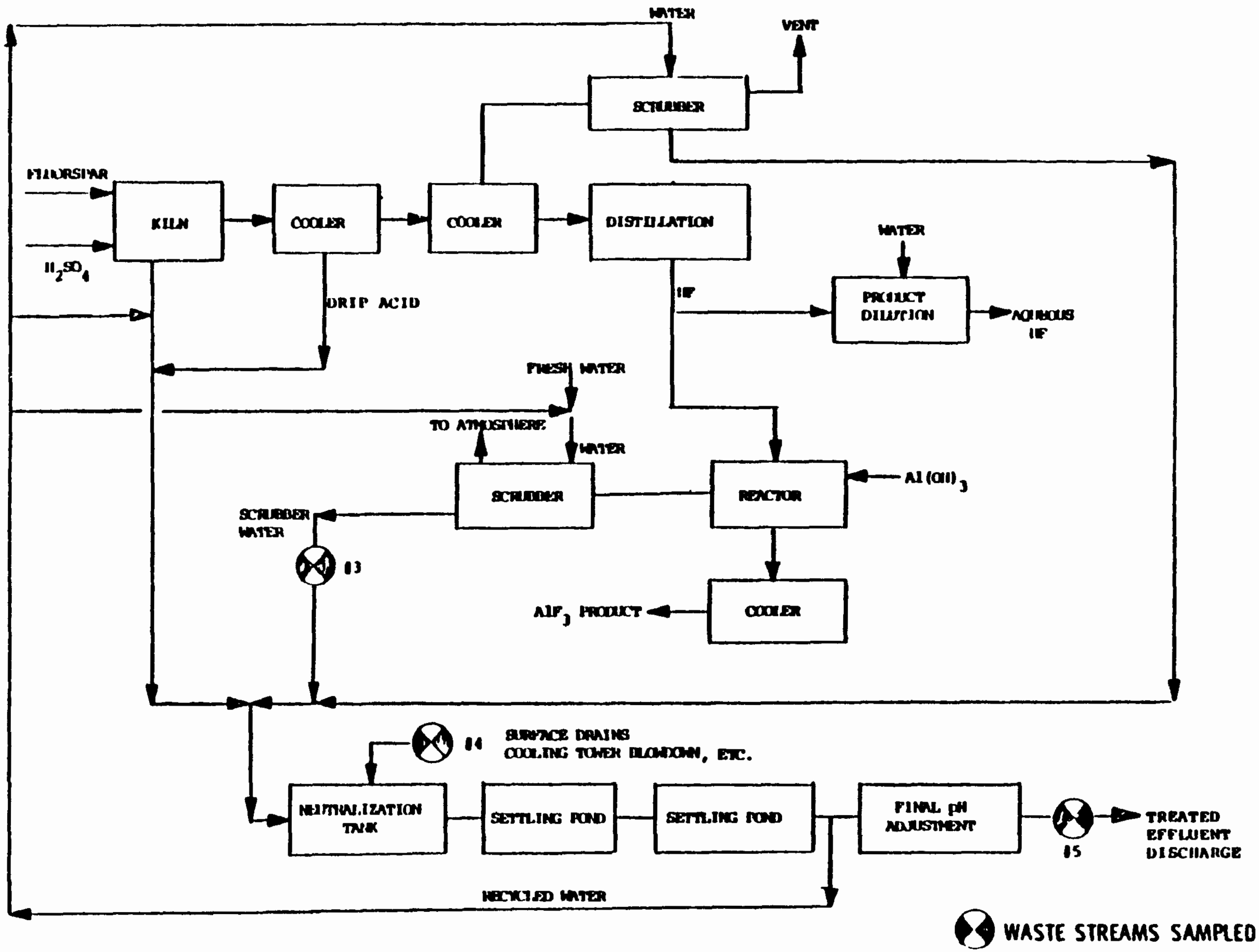


Figure 5-1. General process flow diagram at plant 705 manufacturing aluminum fluoride showing the sampling points [1].

TABLE 5-31. TOXIC POLLUTANT LOADS IN RAW WASTE ALUMINUM FLUORIDE AT PLANT 705 [1] (kg/Mg product)

Pollutant	Screening phase[a]	Verification phase[a]
Arsenic	0.002	0.002
Selenium	0.001	
Chromium	0.0016	0.0054
Copper	0.0027	0.0071
Lead	0.0004	0.001
Mercury	0.000036	0.000027
Nickel	0.003	0.0056
Zinc	0.008	0.0047
Cadmium		0.0002

[a]Screening and verification data shown in table were not completely identified in Reference 1; reported data were assumed by MRC to correspond to the screening and verification phases as noted in the table.

Note: Blanks indicate data not available.

Plant 605

Verification data are provided for plant 605, which produces hydrofluoric acid and aluminum fluoride. Wastewaters from the two processes are combined and sent to gypsum ponds for suspended solids removal. The overflow is treated with an effluent stream from another plant product for pH control and neutralization prior to discharge.

Figure 5-2 is a simplified flow diagram showing the sampling points for plant 605. Table 5-32 summarizes the verification data for the wastestream flows and the emissions of selected classifical pollutants. Table 5-33 presents data for water usage, wastewater flow, and solids generated for plants 705 and 605.

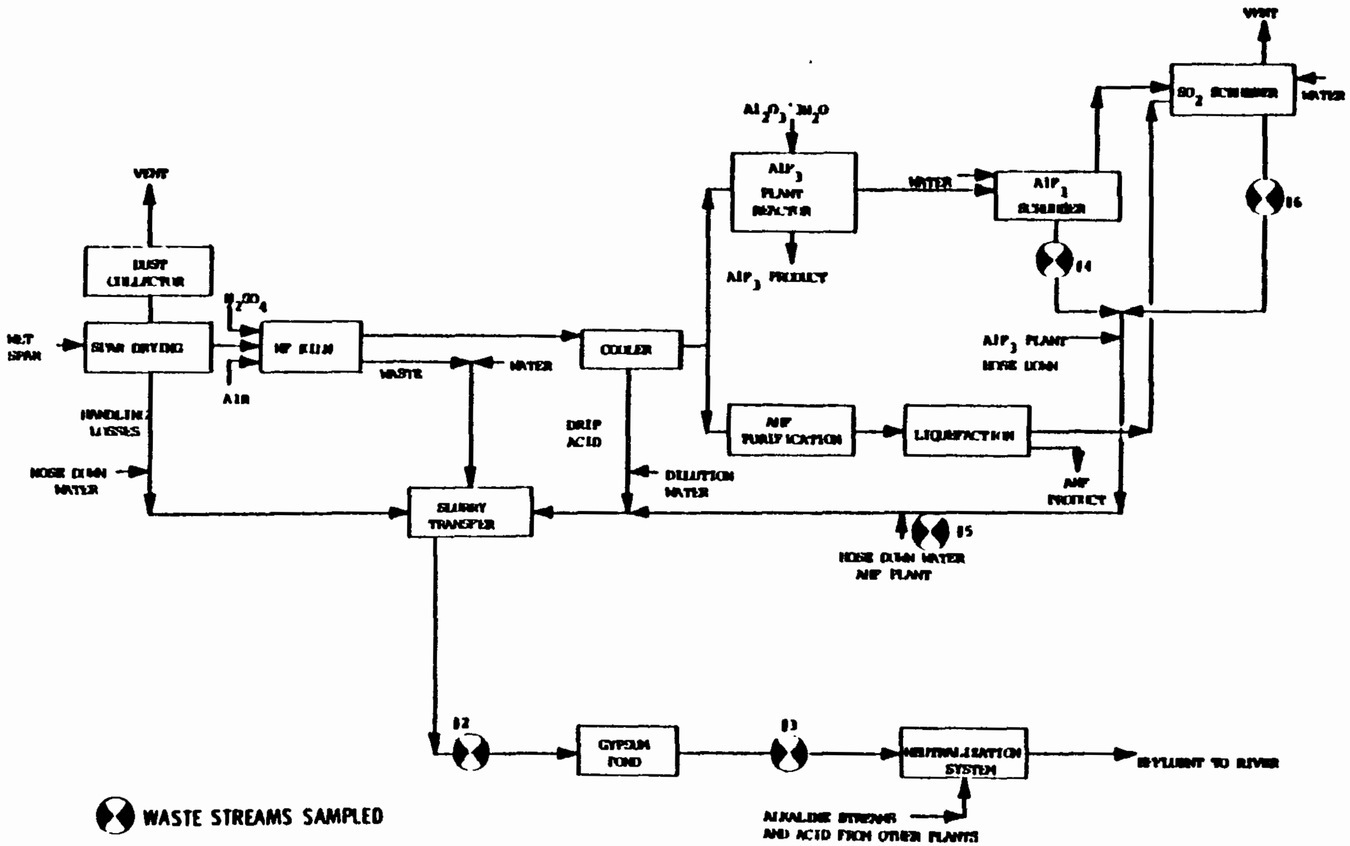


Figure 5-2. General process flow diagram at plant 605 manufacturing aluminum fluoride, showing the sampling points [1].

TABLE 5-32. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 605 PRODUCING ALUMINUM FLUORIDE [1]

Stream	Wastestream description	Flow, m^3/Mg AlF_3	kg/Mg AlF_3	
			SS	Fluoride
4	AlF_3 scrubber water	11.9	14.7	5.53
6	SO_2 scrubber water	12.2	2.6	19.3
2	Gypsum pond influent	24.9		16.4
3	Gypsum pond effluent	24.8	0.232	8.00

TABLE 5-33. WATER USAGE, WASTEWATER FLOW, AND SOLIDS GENERATION FOR ALUMINUM FLUORIDE PLANTS 705 and 506 [1] (m^3/Mg AlF_3)

Description	Plant 705	Plant 605
Water usage		
Noncontact cooling		
Indirect process contact (pumps, seals, leaks, spills)	1.15	
Maintenance (cleaning and work area washdown)	2.4	1.6
Scrubber	9.52	20.0
Wastewater flow		
Scrubber water	9.1	20.0
Maintenance (equipment cleanup and work area washdown)	2.39	1.61
Other		
Solids generated	54	69

Note. Blanks indicate data not available.

II.5.3.2 Chlor-Alkali

II.5.3.2.1 Chlor-Alkali Mercury Cell

Two plants (plants 747 and 317) were selected for detailed description from available data on the chlor-alkali (mercury cell) industry. One other plant (plant 167) is described because of the variety of treatments used in processing the final effluent; however, no final effluent data are available for that plant.

Plant 747. Verification data are provided for plant 747. At that plant, the brine dechlorination system has been converted from barometric condensers to a steam ejector system. The conversion resulted in increased chlorine recovery and reduced contact wastewater. By providing settling and secondary filter facilities, the brine filter backwash has been eliminated. The tail gas scrubber liquid is offered for sale; if not marketed, it is decomposed. The mercury-bearing wastewaters are collected and treated with Na_2S. The reacted solution is filtered, and the filtered solids are retorted for mercury recovery. The filtrate is mixed with the other process wastewaters, and the pH is adjusted before discharge.

The flow diagram of the manufacturing process, including the wastewater treatment facility, is given in Figure 5-3 (next page). Table 5-34 provides the flow data for the sampled streams. The residual chlorine effluent loading at Plant 747, after treatment, ranged from 0.0 to 0.006 kg/Mg. Table 5-35 presents residual mercury loadings, and Table 5-36 shows final effluent loadings of toxic pollutants.

TABLE 5-34. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANTS 747, 317, AND 167 PRODUCING CHLORINE BY USING MERCURY CELLS [1]

Plant	Stream	Wastestream description	Flow, m^3/Mg Cl_2	kg/Mg Cl_2 Lead	SS	Mercury
747	1	Cell waste	0.23	0.000073	0.16	0.0043
	2	Treated waste	0.23	0.000017	0.014	0.000023
	3	Input Cl_2 drying tower	0.15	0.00041		0.0000035
	4	Output Cl_2 drying tower	0.24	0.000014		0.00000072
	5	Dechloro system	0.43	0.0000043	0.0037	0.000015
		Cl_2 condensate	0 0067	0.00000087	0.000027	0.0000018
	7	Tail gas-hypo	0.022	0.000031		0.0000008
31	1	Cell waste	0.29	0.00398	0.013	0.000014
	-	Brine mud filtrate	0.54	0.000063	0.28	0.019
	[illegible]	Tank car wash	0.11	0.000011	0.00198	0.0000036
	4	Collection tank (H_2+3)	0.41	0.028	8.67	0.00056
	5	Treated effluent	0.41	0.000068	0.044	0.000043
	6	Deioniser effluent	0.29	0.0000038	0.0052	0.00000029
	7	Noncontact cooling water	135	0.0014	2.16	0 00014
	8	Final effluent	136	0.0032	2.45	0.00036
67		All chlorine wastes	3.35	0.00024	1.89	0.013
	6	Cell wash	0.0093	0.0000026	0.00057	0.0000067
	7	Brine process water	1.78	0.000018	0.0071	0.000009
	8	Treated chlorine waste	5.58	0.00065	0.013	0 0018
		Brine mud	0 67	0.00696	3.99	.000087

Note Blanks indicate data not available

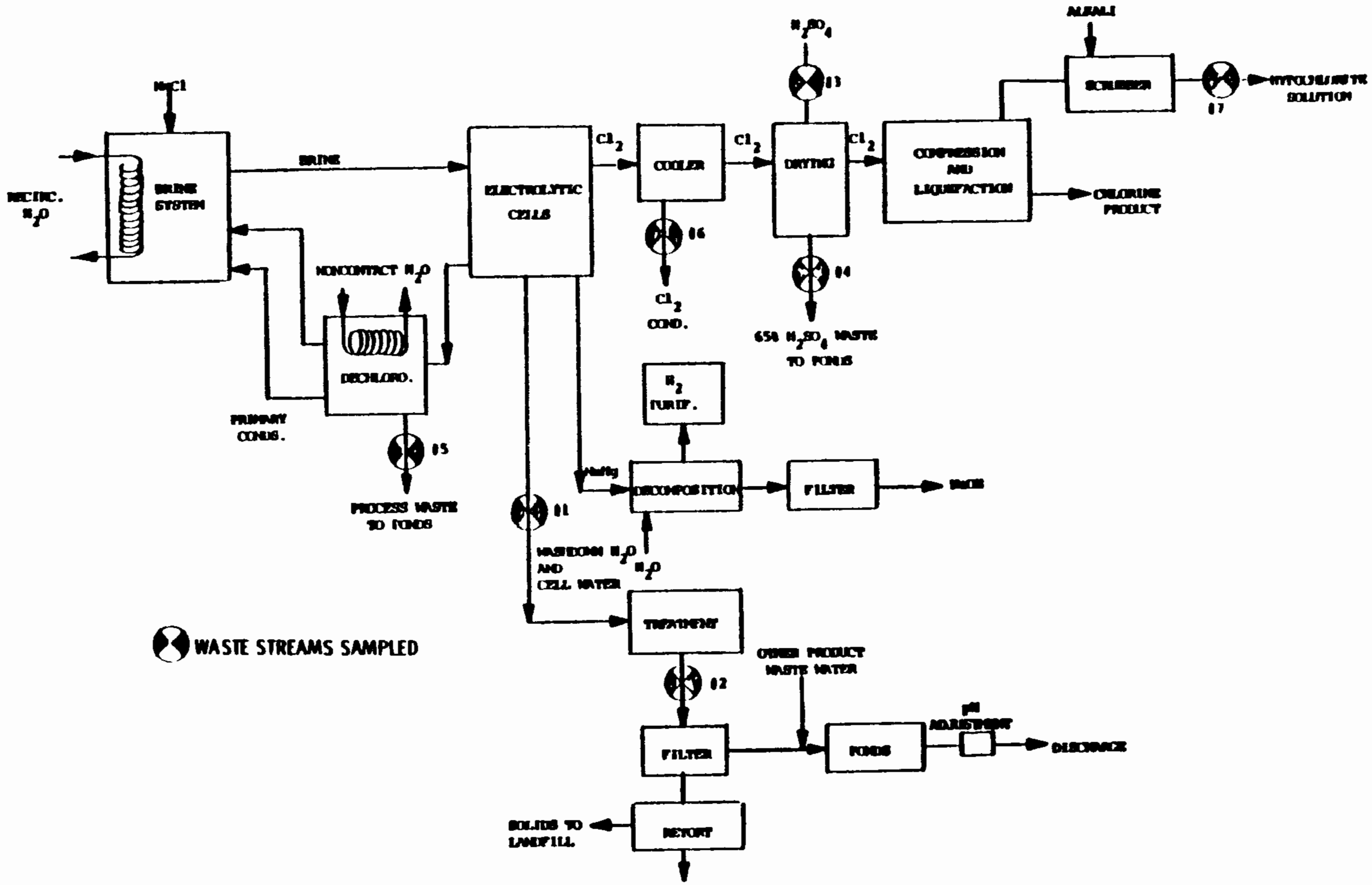


Figure 5-3. General process flow diagram at plant 47, manufacturing chlorine caustic (mercury cell), showing the sampling points [1].

TABLE 5-35. EFFLUENT LOADINGS FROM SELECTED CHLOR-ALKALI PLANTS USING MERCURY CELLS [1]

	Mercury waste load,[a] kg/Mg		
Plant	Average	Maximum daily	Maximum 30-day average
747	0.000055	0.00008	0.000067
747[a]	0.000055	0.000083	0.000065
317[a]	0.000006	0.000048	0.00001

[a]From plant long-term monitoring data.

TABLE 5-36. EFFLUENT TOXIC POLLUTANT LOADS FOLLOWING MERCURY TREATMENT AT CHLORO-ALKALI PLANTS[a,b] [1] (kg/Mg product)

Pollutant	Plant 747	Plant 317
Antimony	<0.059	<0.10
Arsenic	<0.002	<0.008
Cadmium	0.03[c]	<0.001
Chromium	<0.011	<0.02
Copper	<0.006	<0.012
Lead	0.016	0.07
Nickel	<0.011	<0.028
Silver	<0.0035	<0.006
Thallium	<0.01	<0.1
Zinc	<0.006	<0.21

[a]Flow = 0.23 m^3/Mg at Plant 747, and 0.41 m^3 at Plant 317.

[b]Results of 3-day verification sampling.

[c]Indicates effluent load higher than influent load.

Plant 317. Verification data are provided for plant 317. At that plant, the brine purification mud is mixed with spent sulfuric acid and sodium hypochlorite solution. The treatment removes mercury from the mud and transfers it to the solution. The solution is filtered, and the solids are landfilled. The filtrate is mixed with other mercury-contaminated wastewater, which includes the brine purge, cellroom liquid wastes, and plant area washwater. This is then reacted with sodium hydrosulfide to precipitate the mercury as mercury sulfide and then filtered. The solids are sent to a mercury recovery unit; the filtrate is sent to a holding tank. The effluent from the holding tank is mixed with deionizer waste and noncontact cooling water before discharge.

The process flow diagram, given in Figure 5-4 (next page), shows the waste streams sampled. Table 5-34 summarizes the flow data and pollutant emissions for the sampled streams. Table 5-35 presents residual mercury loadings for plant 317; Table 5-36 shows final effluent loadings of toxic pollutants. Table 5-37 provides the unit flow data from the different wastestreams for plants 317 and 167.

TABLE 5-37. WASTE FLOW DATA FOR CHLOR-ALKALI PLANTS USING MERCURY CELLS [1]

Wastestream description	Plant	Flow, $m^3/Mg\ Cl_2$
Brine mud	317	0.54
	167	0.67
Tail gas scrubber	317	0.046
(hypochlorite solution)	167	2.25
Mercury-contaminated	317	0.529
wastewaters	167	

Note. Blanks indicate data not available.

Plant 167. Verification data are provided for plant 167. At that plant, the wastewater streams, consisting of filter backwash, cell-room wash, rainwater runoff, and leaks and spills, are combined and treated for mercury removal. The water is sent to a holding lagoon; the overflow is reduced by reaction with ferrous chloride, which precipitates mercury. The reacted solution is sent to a clarifier. The clarifier underflow is disposed of in a landfill. The overflow is filtered, and the filtrate is passed through activated carbon and an ion exchange column prior to discharge to a lagoon. Effluent from the lagoon, after pH adjustment, is discharged.

Figure 5-5 shows the simplified process flow diagram for plant 167, including the sampling locations. Table 5-34 gives the flow data and pollutant emissions for the sampled streams. Table 5-38 presents toxic pollutant loadings for raw waste from three plants.

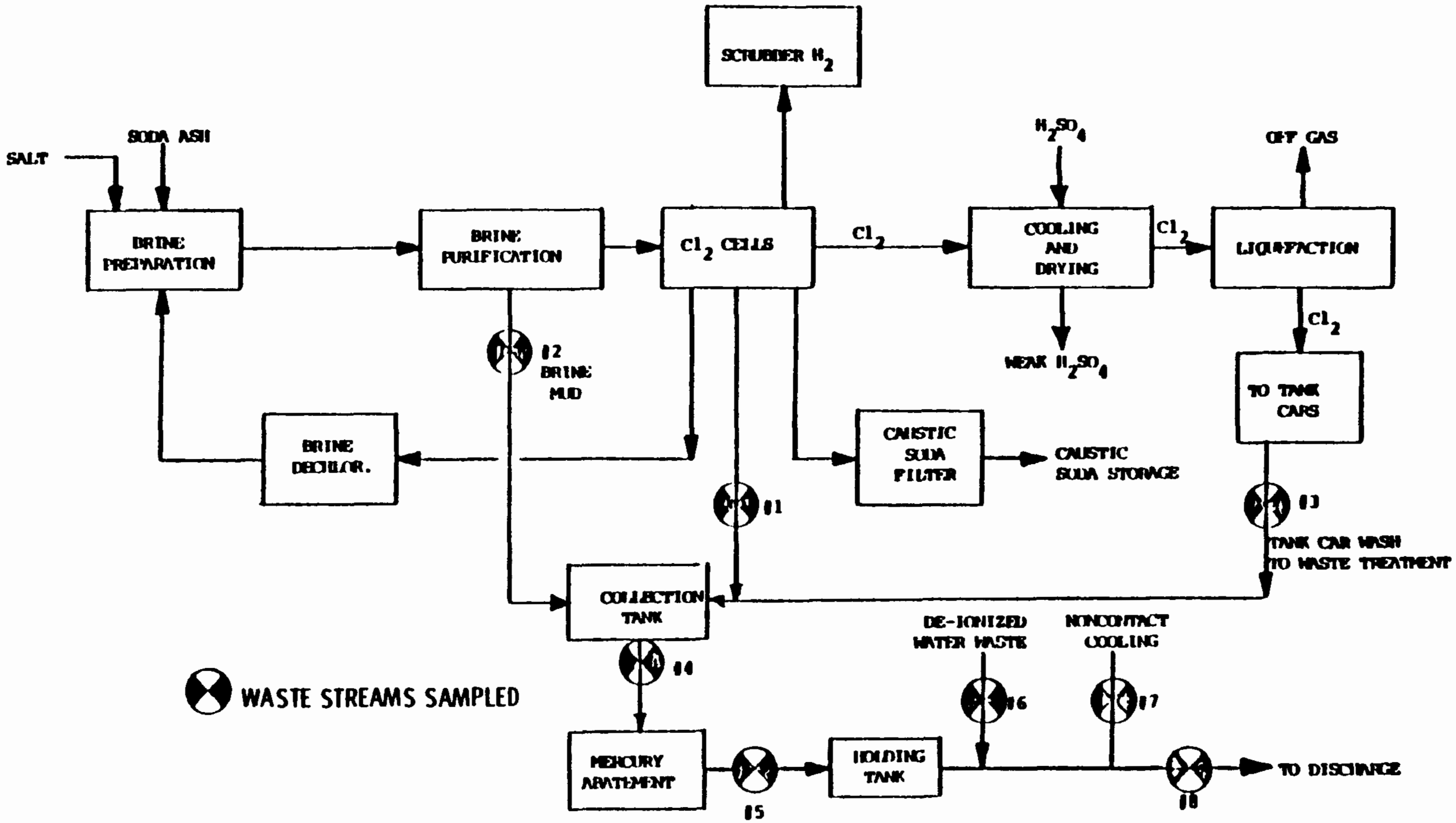


Figure 5-4. General process flow diagram at plant 317, manufacturing chlorine caustic (mercury cell), showing the sampling points [1].

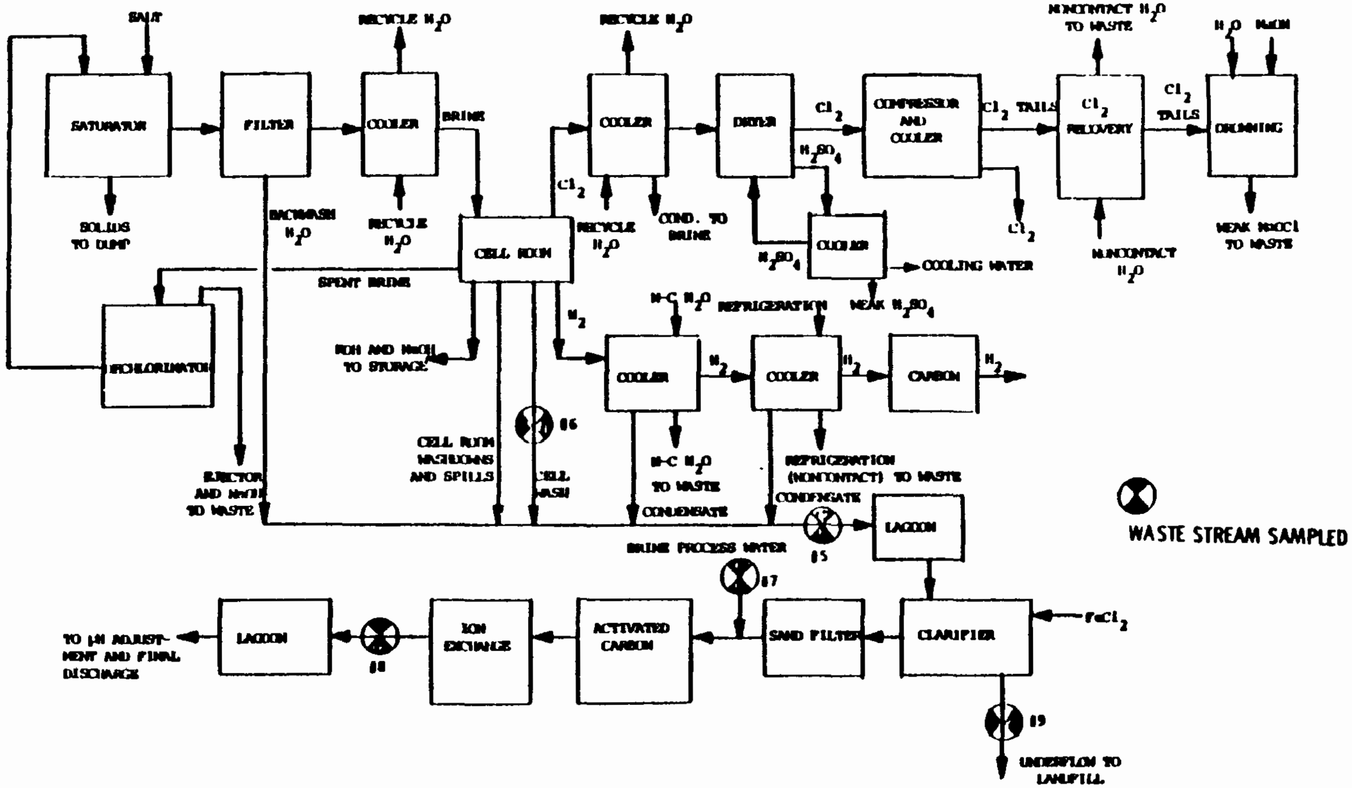


Figure 5-5. General process flow diagram at plant 167, manufacturing chlorine caustic (mercury cell), showing the sampling points [1].

TABLE 5-38. TOXIC POLLUTANT LOADS IN RAW WASTE AT CHLOR-ALKALI PLANTS 747, 317, AND 167 [1]
(kg/Mg product)

Pollutant	Plant 747[a]	Plant 317	Plant 167[a]
Mercury	0.0044	0.063	0.013
Chromium	0.00004	0.000048	0.0004
Thallium		0.00014	0.0001
Arsenic	0.000001	0.0003	0.001
Nickel	0.00003	0.0007	0.0001
Cadmium	0.00001	0.0002	
Copper	0.0002	0.0006	0.0001
Lead	0.0001	0.0007	0.0002
Zinc	0.0005	0.010	0.0006
Antimony	0.00001		
Silver	0.00002	0.00005	

[a]Does not include brine muds.

Note. Blanks indicate data not available.

II.5.3.2.2 Chlor-Alkali Diaphragm Cell

One plant employing a metal anode was selected for detailed description from the available data on the chlor-alkali (metal anode) diaphragm cell industry based on the lowest concentration of toxic pollutants in the final effluent stream.

Plant 736. Verification data are provided for plant 736, which has demisters installed to control the vapors evolved from the last stage of the evaporator during the concentration of caustic. In this treatment, the steam evolved from the concentration of cell liquors passes through metal-wool filters to reduce entrained solids. Cell room washings are sent to a settling chamber, and settled asbestos is sent to a landfill. Other waste waters, consisting of caustic evaporator washings and wastes from salt separation, brine purification operations, and caustic filtration backwash waters, are combined and sent to one of two settling ponds. Skimming devices on the settling ponds remove any oil that separates; the settled solids in the ponds are dredged and diposed of in an abandoned brine well.

Figure 5-6 shows the process flow diagram and sampling points. Table 5-39 provides the pollutant loadings of the streams sampled. Table 5-40 presents the toxic pollutant raw waste load for the plant.

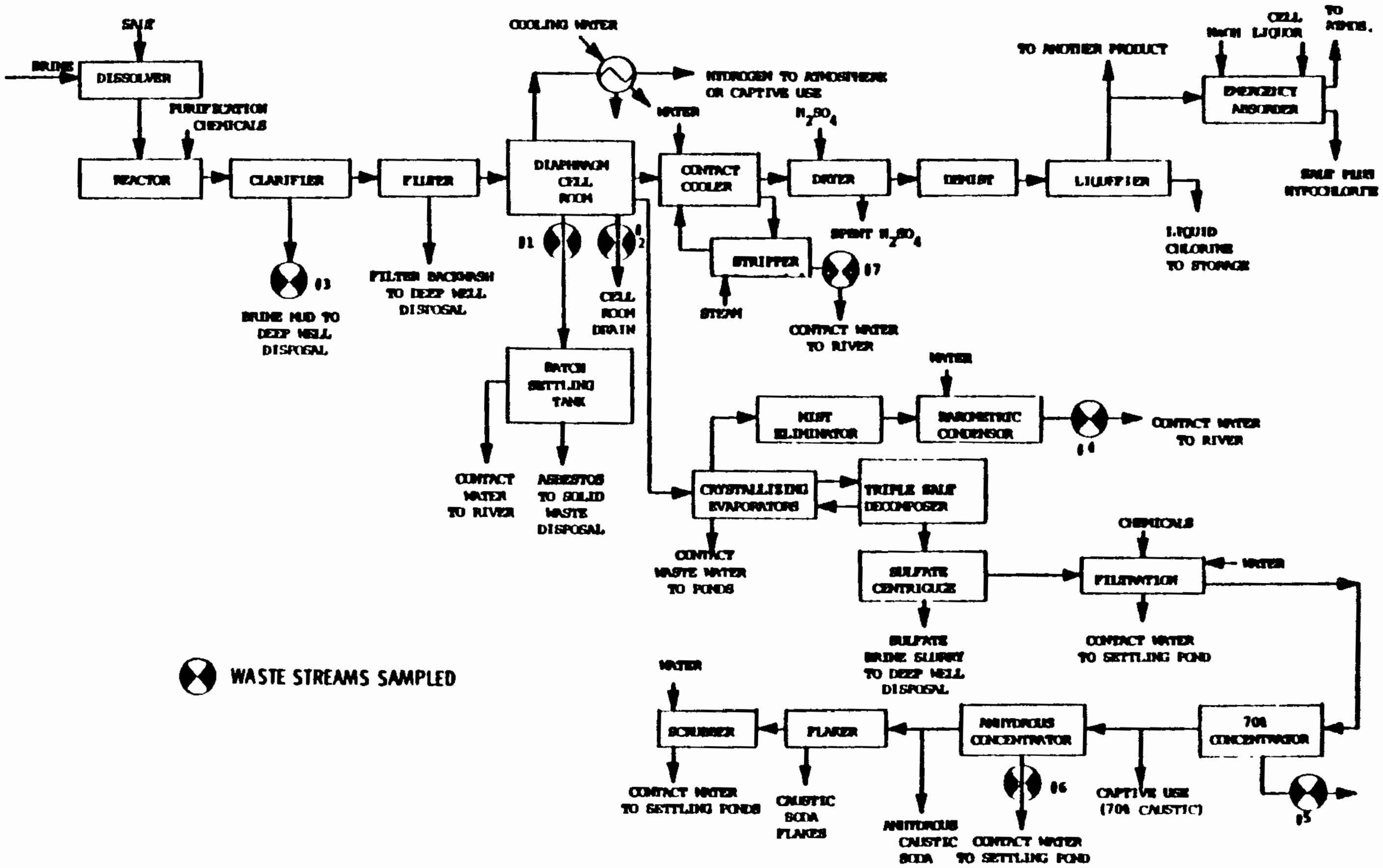


Figure 5-6. General process flow diagram at plant 736, manufacturing chlorine caustic (diaphragm cell), showing the sampling points [1].

TABLE 5-39. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 736 PRODUCING CHLORINE USING METAL ANODE DIAPHRAGM CELLS [1]

Stream	Wastestream description	Flow, m^3/Mg Cl_2	kg/Mg Cl_2 SS	Lead	Asbestos
1	Cell wash	0.652	0.06	0.00000091	
2	Cell room drain	0.0163	0.00462	0.00000275	0.000000085
3	Brine mud	1.63	32.6	0.000031	
4	50% Barometric condenser		(32 mg/L)[a]	(<0.01 mg/L)[a]	(0.0001 mg/L)[a]
5	70% Barometric condenser		(20 mg/L)[a]	(<0.01 mg/L)[a]	(0.001 mg/L)[a]
6	95% Barometric condenser		(90 mg/L)[a]	(0.01 mg/L)[a]	(4×10^{-11} mg/L)[a]
7	Chlorine condenser	0.163	0.00039	0.00000163	

[a]Flow rate of sampled stream is not available; hence pollutant concentration is given in mg/L.

Note. Blanks indicate data not available.

TABLE 5-40. PRIORITY POLLUTANT LOADS IN RAW WASTE AT CHLOR-ALKALI PLANTS 736 and 967[a] [1]

Pollutant	Plant 736	Plant 967[b]
Chromium	0.000044	0.00026
Copper	0.0012	0.0019
Lead	0.0000037	0.273
Mercury	0.0000025	0.000022
Nickel	0.000056	0.00054
Selenium	ND	ND
Thallium	ND	ND
Zinc	0.0007	0.00054
Antimony	0.000003	0.00026
Arsenic	0.000014	0.0028
Cadmium	0.000006	0.000004
Benzene	ND	0.000004
Carbon tetrachloride	ND	0.0003
1,2-Dichloroethane	ND	0.001
Hexachloroethane	ND	0.00014
Chloroform	ND	0.0011
Dichlorobromomethane	ND	0.00046
Hexachlorobutadiene	ND	0.00005
Bis(2-ethylhexyl) phthalate	ND	0.00001
Tetrachloroethylene	ND	0.00046

[a]Does not include brine muds.

[b]Uses graphite anodes

One plant (plant 967) employing a graphite anode was selected for detailed description from the available data on the chlor-alkali (graphite anode) diaphragm cell industry.

Plant 967. Verification data are provided for plant 967. Plant cell washings are sent to an asbestos pond that has a continuous cover of water. Periodically, the settled solids are removed, sealed in drums, and disposed of in a landfill. The overflow from the pond is treated with soda ash to precipitate lead, treated with sulfuric acid to bring the pH down to 6-9, and finally settled.

Table 5-41 shows the wastestreams sampled and waste loadings for plant 967. Figure 5-7 (next page) shows a general process flow diagram, and Table 5-42 shows toxic pollutant removal at the lead treatment facility for the plant. Toxic pollutant raw waste loadings are presented in Table 5-40.

TABLE 5-41. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 967 PRODUCING CHLORINE USING GRAPHITE ANODE DIAPRAGM CELLS [1]

Stream	Wastestream description	Flow, m^3/Mg Cl_2	kg/Mg Cl_2		
			SS	Lead	Asbestos
1	Cell building wastes	0.18	0.187	0.1	0.000075
2	Lead pond effluent	0.55	0.03	0.016	0.0000156
3	Caustic plant effluent	5.38	0.841	0.014	0.00076
4	Brine filter back wash	0.45	5.75	0.0002	0.0000018
5	Cell wash	0.18	0.05	0.0086	0.00066
6	Condensate and spent H_2SO_4	0.79	0.85	0.00073	0.0000098

TABLE 5-42. TOXIC POLLUTANT REMOVAL IN LEAD TREATMENT FACILITY AT CHLOR-ALKALI PLANT 967[a] [1]

Pollutant	Pollutant loads, kg/Mg		Percent removal
	Influent average	Effluent average	
Antimony	0.00078	0.00005	93.6
Arsenic	0.00032	0.00037	-[b]
Chromium	0.00016	0.00005	68.7
Copper	0.0049	0.00003	99.4
Mercury	0.000026	0.00005	-[b]
Nickel	0.00069	<0.00005	>92.8
Zinc	0.0016	<0.0001	>93.8
Lead	0.733	0.029	96.0
Thallium	<0.00004	0.00015	-[b]

[a]Flow - 1.0 m^3/Mg.

[b]Negative removal.

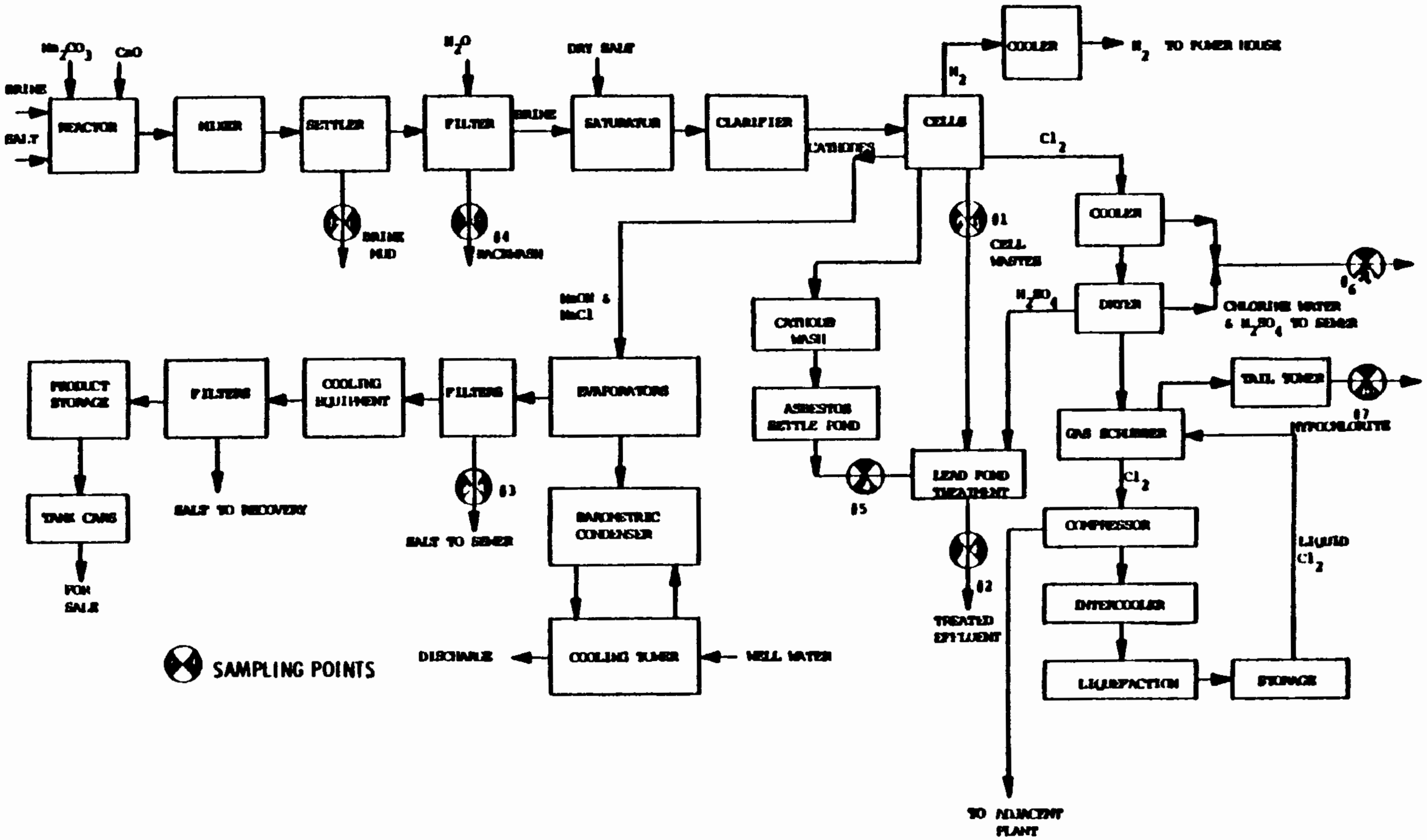


Figure 5-7. General process flow diagram at plant 967, manufacturing chlorine caustic (diaphragm cell), showing the sampling points [1].

Waste flow data from the various sampling points at plants 736 and 967 are contained in Table 5-43. Table 5-44 presents the results of asbestos sampling at the two plants.

TABLE 5-43. WASTE FLOW DATA FOR CHLOR-ALKALI PLANTS USING DIAPHRAGM CELLS [1]

Wastestream description	Flow, $m^3/Mg\ Cl_2$	
	Plant 967	Plant 736
Brine mud	0.277	1.68
Cell wash		0.0168
Tail gas scrubber effluent	0.29; 0.105	

Note: Blanks indicate data not available.

TABLE 5-44. RESULTS OF ASBESTOS SAMPLING AT CHLOR-ALKALI PLANTS USING DIAPHRAGM CELLS [1]

Plant	Wastestream description	Million fibers/liter		
		Total asbestos fibers	Chrisotile	Amphibole
736	Supply	0.7	0.7	0
	Cell wash	20,000,000	20,000,000	0
	Barometric condenser	1.8	0	1.8
	Barometric condenser	5.3	5.3	0
	Barometric condenser	140	140	0
967[a]	Supply	970	970	BDL
	Cell waste	24,000	24,000	800
	Pond effluent	2,400	2,400	BDL
	Caustic wash	7,800	7,800	BDL
	Brine filter backwash	800	620	180
	Cathode wash waste	320,000	320,000	BDL
	Condensate and spent acid	270	180	89
	Neutralizer waste	2,100	2,100	BDL

[a]Uses graphite anode.

II.5.3.3 Chrome Pigments

Two plants were selected for detailed description from the available data on the chrome pigment industry based on the lowest concentration of toxic pollutants in the final effluent stream.

Plant 894

Screening data are provided for plant 894, which produces over 100 products including organic pigments such as copper phthalocyanine. All wastes are combined and treated together. Treatment consists of chromium VI reduction, equalization, and neutralization, followed by clarification and filtration. Sulfur dioxide is added to reduce the hexavalent chromium to the trivalent state at a low pH prior to hydroxide precipitation. The backwash from the sand filters is recycled to the equalization tank. Sludge from the clarifiers is passed through filter presses and then hauled to a landfill, which has a bottom composed of two clay layers with gravel in between to allow the collection of leachate drainage. Water from the sludge is trapped in the gravel layer, then pumped out and returned to the plant for retreatment.

Figure 5-8 (next page) shows the treatment system flow diagram and the sampling points. Table 5-45 provides waste flows and pollutant loadings. Table 5-46 presents influent and effluent verification data as well as monitoring data for the treated effluent.

TABLE 5-45. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANTS PRODUCING CHROME PIGMENTS [1]

Plant	Wastestream description	Flow, m^3/Mg product	kg/Mg product: TSS	Chromium	Iron	Lead	Copper
894 (Verification phase)	Treatment influent	100	78.1	7.93	4.9	1.52	0.356
	Treatment effluent	100	0.393	0.032	0.03	0.011	0.004
	Leachate			0.258	0.39	0.164	0.008
	Sand filter feed	100	1.1	0.060	0.10	0.068	0.0005
002 (Verification phase)	Untreated waste	85.6	59.8	26.2	4.64	13.9	
	Unfiltered treated waste	85.6		11.1	0.128	10.0	
	Filtered treated waste	85.6	82.9	29.9	4.25	14.3	

Note. Blanks indicate no data analyzed.

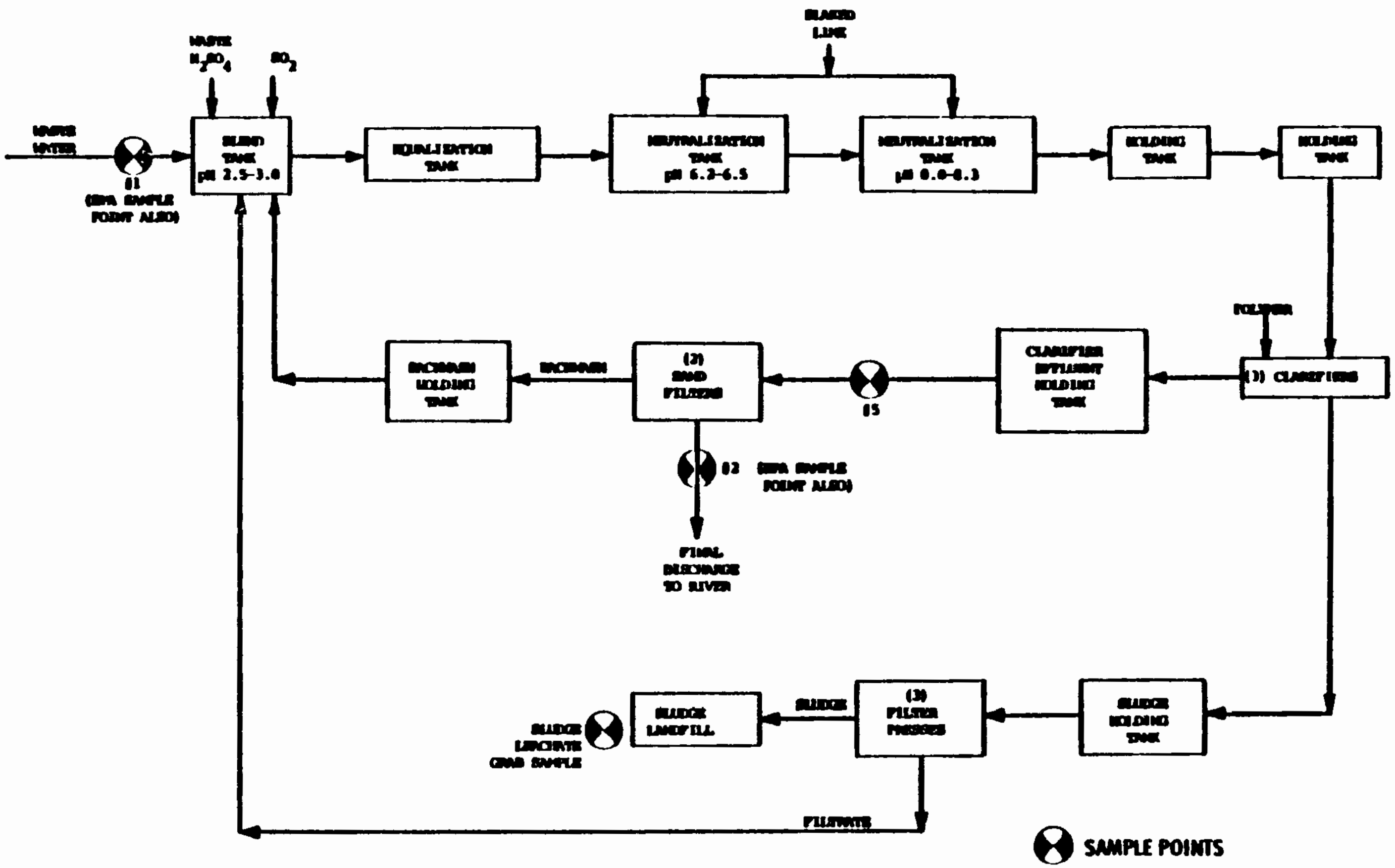


Figure 5-8. General wastewater treatment process flow diagram at plant 894, manufacturing chrome pigment, showing the sampling points [1].

TABLE 5-46. MONITORING AND VERIFICATION SAMPLING OF CHROME PIGMENTS PLANT 894 [1]

Pollutant	Verification sampling[a]			
	Influent		Effluent	
	µg/L	kg/Mg	µg/L	kg/Mg
TSS	780,000	78	3,900	0.39
Chromium	78,000	7.8	320	0.032
Chromium VI	<10	<0.001	<30	<0.003
Iron	49,000	4.9	300	0.03
Lead	15,200	1.52	110	0.011
Zinc	4,200	0.42	58	0.0058
Total cyanide	5,100	0.51	<66	<0.0066
Free cyanide	<940	<0.094	<11	<0.0011
Antimony	740	0.074	300	0.030
Cadmium	900	0.090	8.4	0.00084
Copper	3,560	0.36	40	0.004
Nickel	17	0.0017	<24	<0.0024

Monitoring Data - Treated Effluent

Pollutant	Concentration, µg/L		Waste load
	Av	30-day av	(av), kg/Mg
TSS	11,200	23,500	1.92
Chromium VI	110	300	0.018
Chromium	440	730	0.074
Copper	130	250	0.023
Lead	410	870	0.069
Zinc	44	75	0.0072
Free cyanide	<12	44	0.0019
Total cyanide	120	310	0.019
Arsenic	80	160	0.0125
Cadmium	80	120	0.013
Mercury	<1	1.7	0.00007

[a]Average flow = 153 m^3/Mg.

Plant 002

Verification data are provided for plant 002, which normally produces over 100 products. However, at the time of sampling, zinc chromate was being produced by a continuous production unit. All process contact wastes are treated continuously. The waste is pumped to a treatment tank where sulfur dioxide is added to convert hexavalent chromium to trivalent. The pH is adjusted to 8.5 and the waste is then passed through precoated filters and discharged to a sewer.

Figure 5-9 (next page) shows the waste treatment flow diagram and sampling points. Table 5-45 shows the waste flows and pollutant loadings. At sample point 2, half of the sample was filtered through a glass filter on a Buechner funnel to simulate the filtration process that was bypassed at the time of sampling.

Table 5-47 presents toxic pollutant raw waste loads for both plants. Table 5-48 shows water usage and aqueous process waste effluents.

TABLE 5-47. TOXIC POLLUTANT LOAD IN RAW WASTE AT CHROME PIGMENT PLANTS [1] (kg/Mg product)

Pollutant	Plant 894	Plant 002
Cyanide	0.754	0.072
Chromium	11.5	0.020
Cadmium	0.165	30.8
Copper	1.58	0.140
Lead	7.52	5.46
Zinc	0.855	16.4
Antimony	1.612	0.136
Nickel	0.0334	0.032
Phenols	0.0152	
Phenolics	0.145	

Note: Blanks indicate data not available.

TABLE 5-48. WATER USAGE AND AQUEOUS PROCESS WASTE EFFLUENTS FROM CHROME PIGMENT PLANTS [1] (m^3/Mg product)

	Plant 894				Plant 002		
Description	Chrome yellow and chrome orange	Molybdate chrome orange	Chrome oxide	Chrome green	Chrome yellow and chrome orange	Molybdate chrome orange	Zinc yellow
Water usage							
Noncontact cooling		0	4.7		3.1	5.0	0
Consumed in product boiler feed	3.3	3.5	2.0		1.0	1.3	1.0
Process waste effluent	120	110	31	48	35	31	20

Note. Blanks indicate data not available.

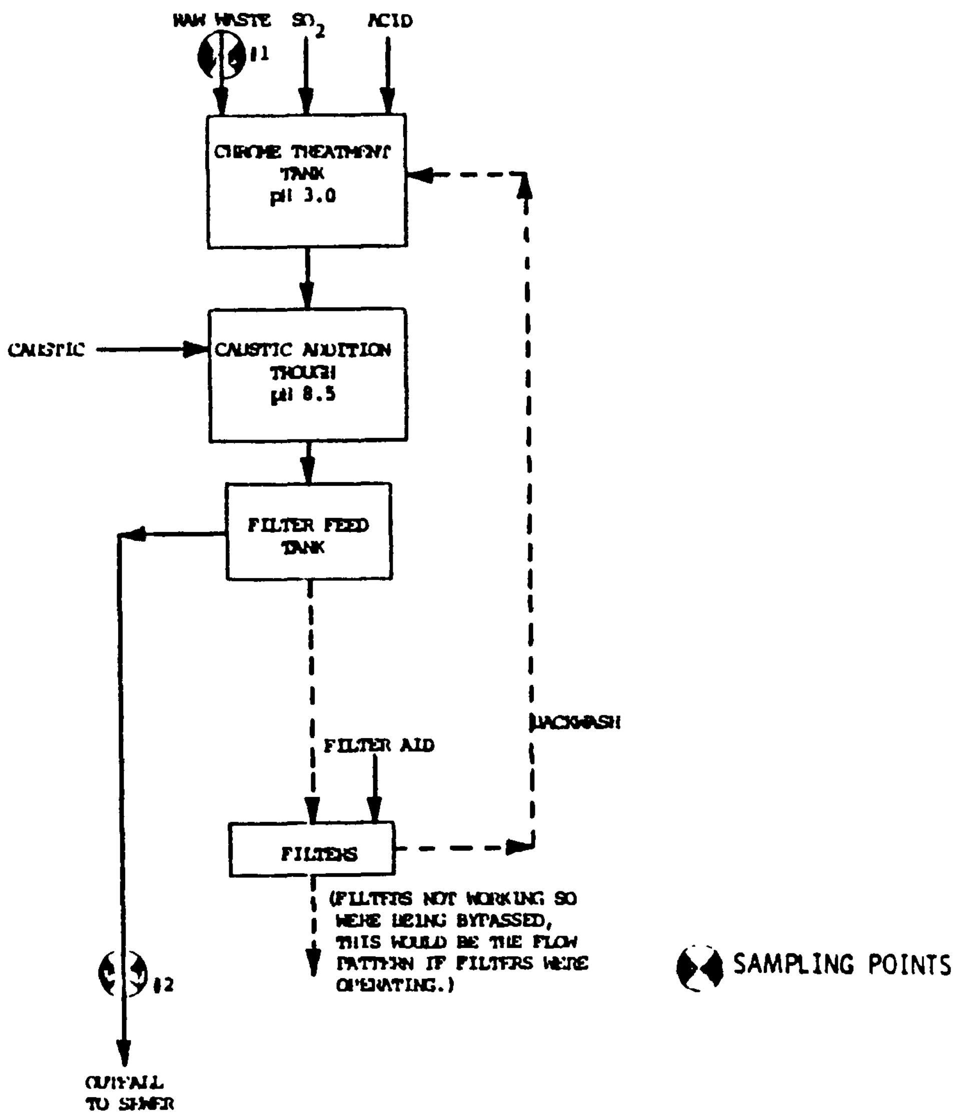


Figure 5-9. General wastewater treatment process flow diagram at plant 002, manufacturing chrome pigment, showing the sampling points [1].

II.5.3.4 Copper Sulfate

One plant was selected for detailed description from the available data on the copper sulfate industry based on the lowest effluent concentration of toxic pollutants in the final effluent stream.

Plant 034

Verification data are provided for plant 034. Waste from the plant drains into a sump from which it is pumped to two neutralization tanks where lime is added. The waste is then passed through a filter press, and filter residue is hauled to a landfill disposal site. The filtrate is mixed with noncontact cooling water and steam condensate in a collection tank. Wastes are then passed through a cloth filter for final polishing and discharged to a sewer.

Figure 5-10 (next page) shows the process flow and sampling points for this plant. Table 5-49 provides data on waste flows and classical pollutant emissions. Table 5-50 presents a summary of the raw waste loadings at this plant, and Table 5-51 gives treated and 30-day monitoring data.

TABLE 5-49. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 034 PRODUCING COPPER SULFATE [1]

Wastestream description	Flow, m^3/Mg product	kg/Mg product			
		TSS	Phenol	Copper	Nickel
$CuSO_4$ waste[a]	2.23	0.0862	0.00004	4.11	0.248
Effluent from lime treatment	2.23	0.0769	0.000027	0.0101	-
Steam condensate	0.371	0.00133	-	0.00167	-

[a]Infiltration of groundwater into the collection sump was suspected at the time of sampling.

TABLE 5-50. SUMMARY OF RAW WASTE LOADINGS FOUND AT COPPER SULFATE PLANT 034 [1]

Pollutant	Loadings	
	Average kg/day	Average kg/Mg
Priority pollutants:		
Antimony	0.014	0.00069
Arsenic	0.16	0.0078
Cadmium	0.039	0.0019
Copper	83.9	4.11
Lead	0.0079	0.00039
Nickel	5.08	0.25
Zinc	0.50	0.024
Conventional pollutants:		
TSS	1.78	0.087

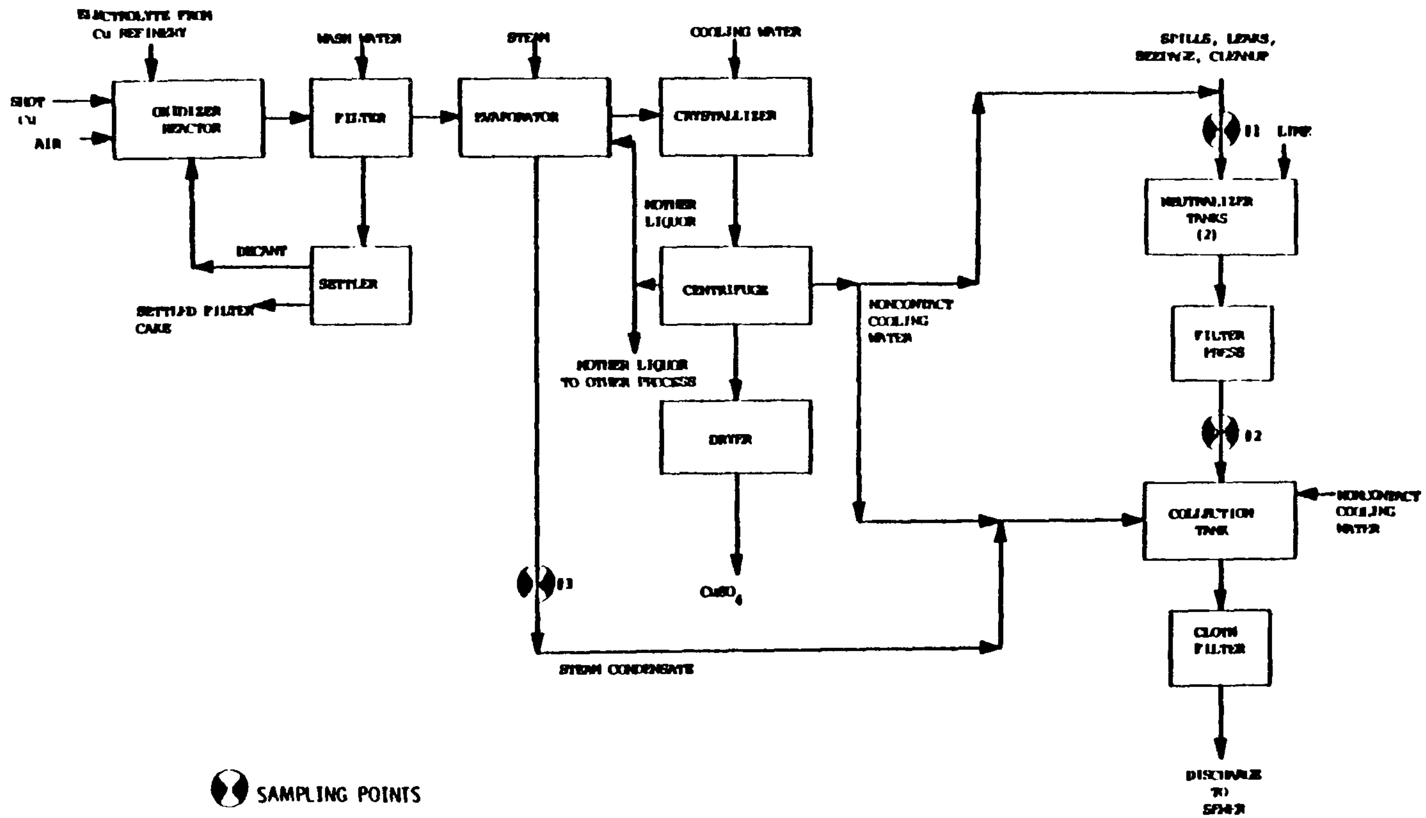


Figure 5-10. General process flow diagram at plant 034, manufacturing copper sulfate, showing the sampling points [1].

TABLE 5-51. VERIFICATION SAMPLING AT COPPER SULFATE PLANT 034 [1]

Pollutant	Raw waste[a] μg/L	Raw waste[a] kg/Mg	Treated effluent[b] μg/L	Treated effluent[b] kg/Mg
	Verification Sampling			
TSS	39,200	0.087	35,000	0.078
Copper	1,850,000	4.1	4,650	0.010
Nickel	112,000	0.248	240	0.0005
Antimony	330	0.0007	36	0.000079
Arsenic	3,500	0.0078	<20	0.000044
Cadmium	870	0.0019	1	0.000002
Chromium	142	0.00038	5	0.00001
Lead	180	0.00039	5	0.00001
Selenium	<11	0.000024	100	0.00022
Zinc	11,100	0.025	16	0.000035

Monitoring Data - Treated Effluent[c]

Pollutant	Concentration, μg/L Av	Concentration, μg/L 30-day avg	Waste load (av), kg/Mg
TSS	26,000	62,400	0.096
Copper	4,300	6,900	0.016
Nickel	340	750	0.0013
Zinc	120	290	0.00044
Arsenic	12	41	0.000044
Selenium	7	43	0.00003

[a]Raw waste flow = 2.23 m^3/Mg.

[b]Before combining with noncontact cooling and steam condensate streams.

[c]Treated effluent flow - 3.7 m^3/Mg.

II.5.3.5 Hydrofluoric Acid

One plant was selected for detailed description from the available data on the hydrofluoric acid industry based on the lowest concentration of toxic pollutants in the final effluent stream. Information on an additional plant is also presented due to the significant amount of available data.

Plant 705

Screening and verification data are provided for plant 705, which produces hydrofluoric acid and aluminum fluoride. The drip acid is sent to the wastewater treatment facility, and the gypsum produced from the reaction is slurried with water and also sent to the treatment facility. Wastewaters from the HF production facility are combined with the aluminum fluoride plant wastewaters. The combined raw wastewater is treated with lime and sent to settling ponds before discharge.

Figure 5-11 (next page) shows the general process and the locations of the sampling points. Table 5-52 provides the screening and verification flow data and TSS and fluoride emissions. Table 5-53 shows pollutant removability data for plant 705.

TABLE 5-52. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS OF PLANTS PRODUCING HYDROFLUORIC ACID [1]

Plant	Stream	Wastestream description	Flow, m^3/Mg HF	kg/Mg HF Fluoride	kg/Mg HF SS
705 (Screening phase)	1	Kiln slurry	26.6	14.6	1,360
	2	Scrubber waste water	10	9.6	0.07
	3	Surface drains cooling tower blowdown	20	6.9	3.92
	4	Treated effluent	23.3	1.58	1.91
705 (Verification phase)	1	Kiln slurry	26.6	3.8	4,730
	2	Scrubber waste water	10	1.52	0.023
	4	Surface drains cooling tower blowdown	20	3.38	4.02
	5	Treated effluent	23.3	0.54	0.04
251 (Verification phase)	5	AHF plant hosedown	1.2	1.9	0.26
	6	SO_2 scrubber waste	14.4	0.31	0.1
	2	Gypsum pond inlet	82.3	54	1,530
	3	Gypsum pond outlet	82.3	26.5	0.8

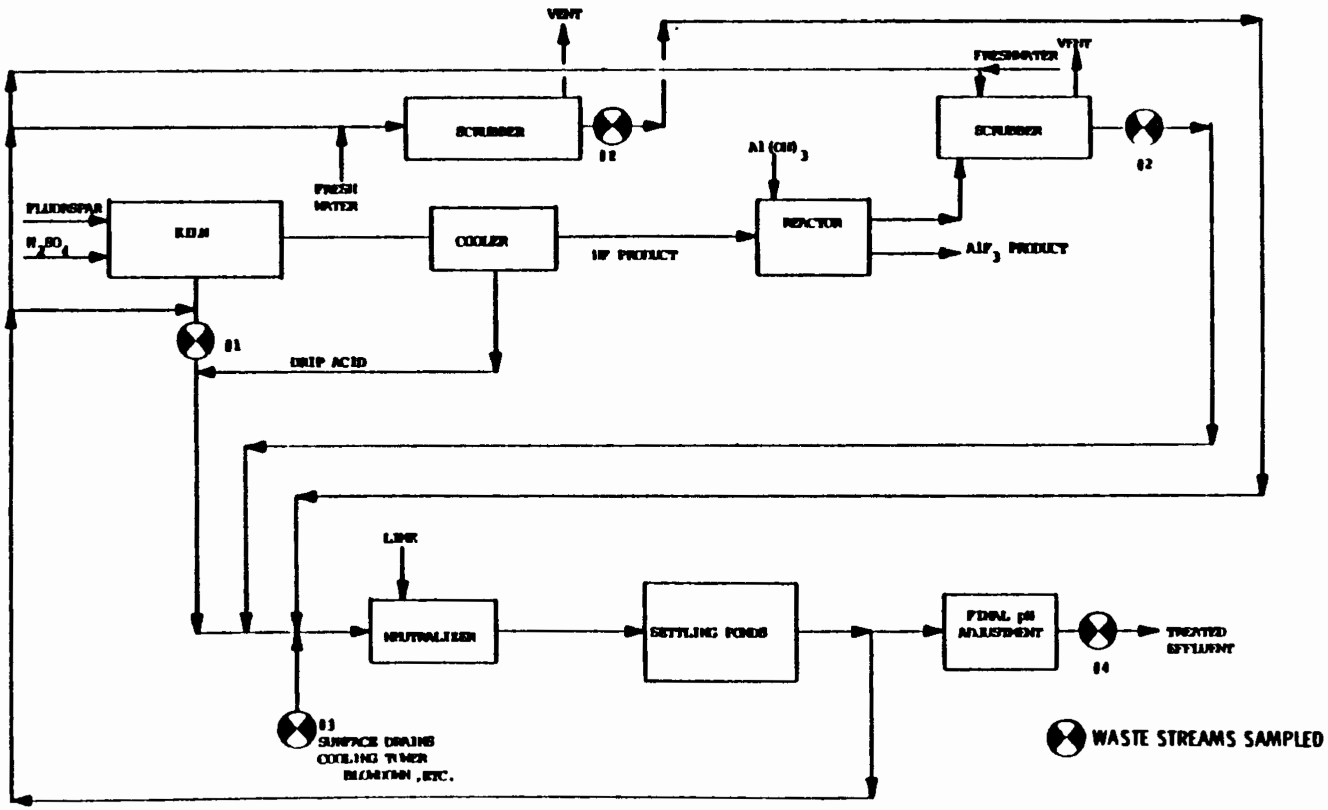


Figure 5-11. General process flow diagram at plant 705, manufacturing hydrofluoric acid, showing the sampling points [1].

TABLE 5-53. TOXIC POLLUTANT REMOVAL AT HYDROFLUORIC ACID PLANT 705[a,b] [1] (kg/Mg)

Pollutant	Influent	Effluent
Antimony	0.00065	0.00012
Arsenic	0.0025	<0.0006
Cadmium	0.0006	0.0001
Chromium	0.024	0.0029
Copper	0.018	0.0012
Lead	0.0031	0.0014
Mercury	0.00036	0.00003
Nickel	0.035	<0.0006
Selenium		0.0003
Thallium	0.00016	0.00007
Zinc	0.015	0.0033

[a]Flow = 62.1 m^3/Mg; value for total raw waste from HF only.

[b]Values are for combined wastes from HF and AlF_3.

Note: Blanks indicate data not available.

Plant 251

Verification data are provided for plant 251, in which the final effluent stream was not sampled. The drip acid at this facility is sent to the waste treatment plant, and the hydrofluoric acid wastewaters are combined with aluminum fluoride plant waste for treatment. In addition to drip acid, the plant wastewater consists of scrubber water, gypsum slurry, and plant area hose down. The treatment consists of gypsum ponds in which the suspended solids are removed. Overflow from the last gypsum pond is neutralized, and the pH is adjusted with wastes from other product lines.

Figure 5-12 provides a block diagram of the process showing the sampling locations. Table 5-52 gives a summary of the waste flow verification data and the concentration and loads of important classical pollutants. Table 5-54 give raw waste toxic pollutant loads for the above two plants. Water usage, wastewater flow, and solids generation data are presented in Table 5-55.

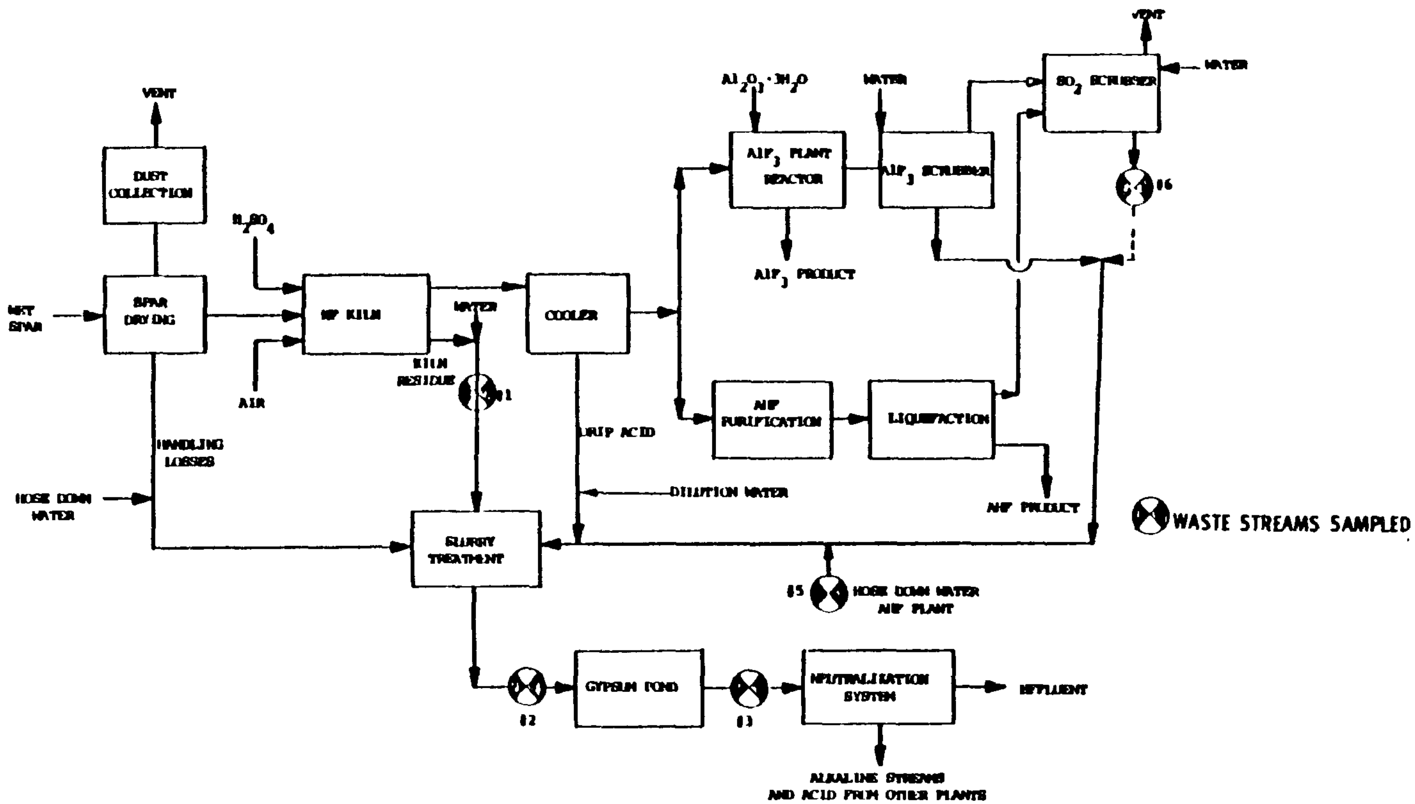


Figure 5-12. General process flow diagram at plant 251, manufacturing hydrofluoric acid, showing the sampling points [1].

TABLE 5-54. TOXIC POLLUTANT LOAD IN RAW WASTE AT HYDROFLUORIC ACID PLANTS [1] (kg/Mg product)

Pollutant	Plant 705	Plant 705	Plant 251
Arsenic	0.003		0.012
Copper	0.027	0.018	0.015
Lead	0.003	0.0075	0.0098
Nickel	0.004	0.032	0.143
Selenium	0.0005		0.0013
Zinc	0.269	0.014	0.031
Cadmium	0.0001	0.0004	
Chromium	0.0043	0.018	0.06
Mercury	0.00008	0.0004	0.002
Antimony	0.0016	0.0004	0.0003
Thallium			

Note: Blanks indicate data not available.

TABLE 5-55. WATER USAGE, WASTEWATER FLOW, AND SOLIDS GENERATION FOR HYDROFLUORIC ACID PLANT 251 AND PLANT 7-5 [1] (m^3/Mg HF)

Description	Plant 705	Plant 251
Water usage		
Noncontact cooling	30	154
Gypsum slurry transport	30	0
Maintenance, equipment, and area washdown	16.9	
Air pollution control	11.2	7.9
Wastewater flow		
Gypsum slurry	Total recycle	64.0
Drip acid	0.018	0.049
Scrubber wastewater	11.2	14.4
Other	22.5	0.53
Solids generation		
Gypsum solids going to treatment facility	3,300	1,530
Total solids produced	3,380	1,650
Kiln residue produced	-[a]	4.0[a]
Total wastewater influent to treatment facility	58.2	82.4

[a]Residue is slurried with water.
Note: Blanks indicate data not available.

II.5.3.6 Hydrogen Cyanide

Two plants were selected for detailed description from the available data on the hydrogen cyanide industry based on the lowest concentration of toxic pollutants in the final effluent stream.

Plant 765

Screening and verification data are provided for plant 765. The combined wastes for the plant consist of distillation bottoms, ammonia recovery purge liquor, tank car washings, leaks, spills, and equipment cleanout, purge from the noncontact cooling water system, and stormwater runoff. These combined wastes are commingled with the other cyanide production wastewaters and sent to the alkaline chlorination treatment facility, which consists of a trench, where the pH is adjusted to 10 with dilute caustic, followed by two ponds. Sodium hypochlorite is added at the pond inlets. The effluents from the ponds are discharged to a third pond where sufficient chlorine and caustic are added to reach the required effluent quality; namely, an oxidizable free-cyanide residual of 0.1 ppm and a residual chlorine of about 15 to 20 ppm. The third pond is operated in a continuous-flow mode and is baffled to control circulation. Agitation is provided in the flow channel, and the outlet is equipped with a control device to stop the flow when the effluent cyanide concentration exceeds the desired level.

Figure 5-13 (next page) is a flow diagram of the treatment process indicating the sampling locations used during the screening program. Table 5-56 provides the flow and pollutant data for the sampled streams. A comparison of the raw and treated effluent data in the table indicates that the plant achieves a cyanide reduction of 99%. Table 5-57 gives treated effluent and daily monitoring data for plant 765.

TABLE 5-56. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 765 PRODUCING HYDROGEN CYANIDE [1]

Wastestream description	Flow, m^3/Mg HCN	kg/Mg HCN SS	kg/Mg HCN Ammonia nitrogen	Cyanide
Raw HCN waste	57	1.08	27.2	0.82
Influent to the pond[a]	57[a]	55.8[b]	11.1[b]	0.388[b]
Treated effluent from the final pond	57[b,c]	1.9[b]	7.05[b]	<0.000114[b]

[a]Stream is a commingled wastewater; flow given is the amount contributed by the HCN process.

[b]Pollutant load was calculated by apportioning the mass emitted between the two wastestreams on the basis of measured flows; this is clearly a very approximate process, and the results must be used with caution.

[c]Addition or loss of water from rainfall, addition of chemicals, and evaporation has not been estimated.

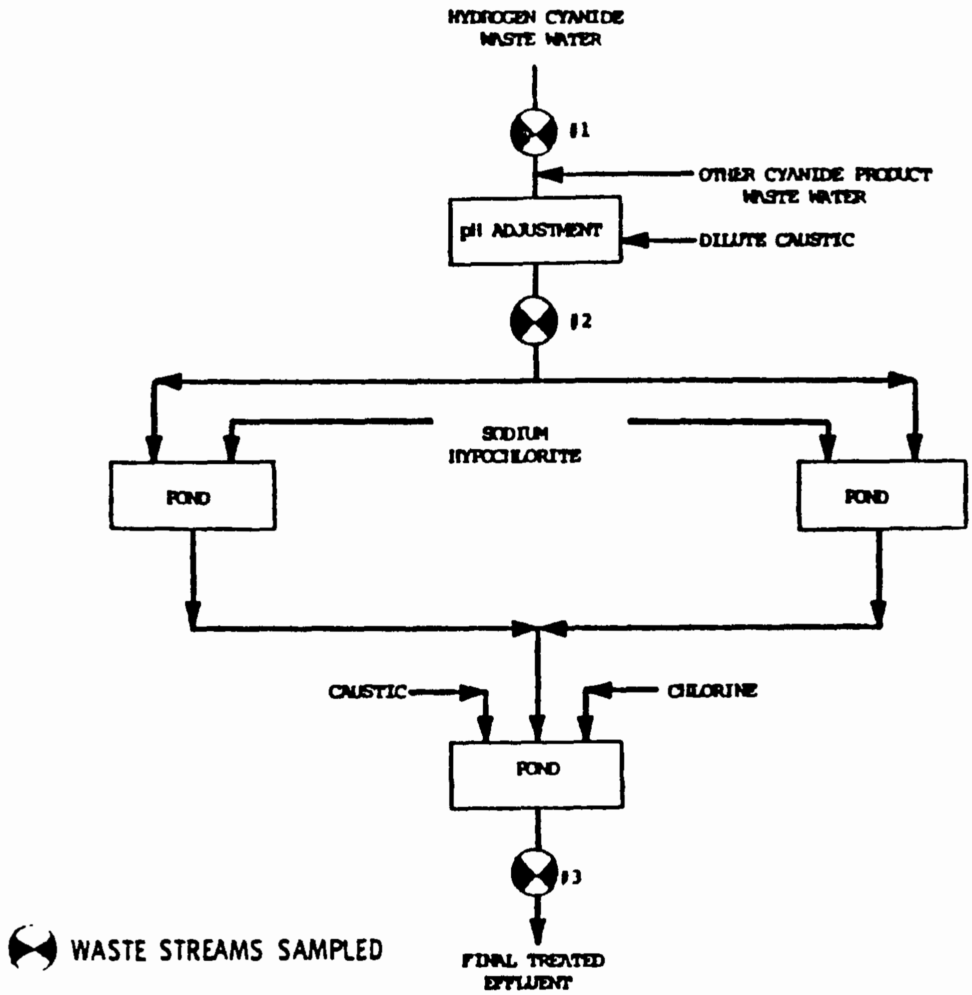


Figure 5-13. General wastewater treatment process flow diagram at plant 765, manufacturing hydrogen cyanide, showing the sampling points [1].

TABLE 5-57. VERIFICATION SAMPLING AT HYDROGEN CYANIDE PLANT 765 [1]

Verification sampling[a]

Pollutant	Influent mg/L	Influent kg/Mg	Effluent quality, mg/L
TSS[b]	71	6.52	19
Total cyanide	28.4	2.61	<0.0026
Free cyanide	6.81	0.626	<0.002
BOD	6.3	0.580	<33
Ammonia	194	17.8	124

Monitoring Data - Treated Effluent[c]

Parameter	Concentration, mg/L			Waste load, kg/Mg		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Total cyanide	0.78	3.8	9.2	0.039	0.192	0.46
Oxidizable cyanide	0.01	0.2	3.27	0.0005	0.01	0.16
Ammonia nitrogen (NH_3-N)	3.86	72	204	0.193	3.63	10.2
COD	54.2	320	904	2.71	15.9	45.2
TOC	15.7	166	512	0.78	8.3	25.6
TSS	5.0	35	267	0.25	1.75	13.4

[a]Flow = 57 m^3/Mg.

[b]Average for 2 days only.

[c]Results of a 28-day comprehensive test.

Plant 782

Verification data are provided for plant 782, which combines the plant wastewater with other production wastewater and treats the combined flow in a complex biological treatment system. A part of the commingled wastewater is sent to an ammonia stripper from which the aqueous effluent is mixed with the rest of the wastewater and sent to the treatment facility. The primary treatment facility consists of oil skimmers, grit removal, and pH adjustment. Effluent from the primary treatment goes through an API separator and into an aerated lagoon. Effluent from the lagoon is flocculated and sent to a clarifier. Overflow from the clarifier is sent to a final settling basin before discharge. Surface drainage from the hydrogen cyanide and other process areas is collected separately. It is treated chemically and passed through a trickling filter from which a portion of the

A general flow diagram of the treatment process including the streams sampled is shown in Figure 5-14 (next page). Table 5-58 provides the flow data and concentrations of the important pollutants. Because of the intermixing of the various product wastewaters, unit pollution loads are uncertain and not given. The total wastewater generated from HCN manufacture and the amount going to the treatment facility was verified during the plant visit and was confirmed in the 308 Questionnaire response provided by the industry. Based on that flow and the concentrations determined by analysis, the raw waste load is that shown below:

	Flow, m^3/Mg	Total cyanide, kg/Mg HCN	Ammonia nitrogen, kg/Mg HCN	TSS, kg/Mg HCN
Effluent from combined plant waste treatment	9.9	0.02	0.05	0.74

The load values assigned to the HCN process were estimated by proportioning the total loads in relation to the respective flow rates. The result is, therefore, approximate and must be used with caution. In calculating the pollutant loads, the loss or gain of water to the treatment system due to factors such as evaporation, loss through filtered solids, precipitation, and the water introduced by treatment chemicals, has been neglected.

TABLE 5-58. FLOW AND POLLUTANT CONCENTRATION DATA OF OF THE SAMPLED WASTESTREAMS FOR PLANT 782 PRODUCING HYDROGEN CYANIDE [1]

			mg/L		
Stream	Wastestream description	Flow, m^3/day	Total cyanide	Ammonia nitrogen	TSS
1	Distillation bottom purge	11.3	70	887	24
2	Ammonia stripper influent	1,140	167	410	76
3	Ammonia stripper effluent	1,140	51.3	41	162
4	Influent to primary treatment facility	5,560	31	1,380	110
5	Final treated effluent		2.2	5.16	74.3

Note. Blanks indicate data not available.

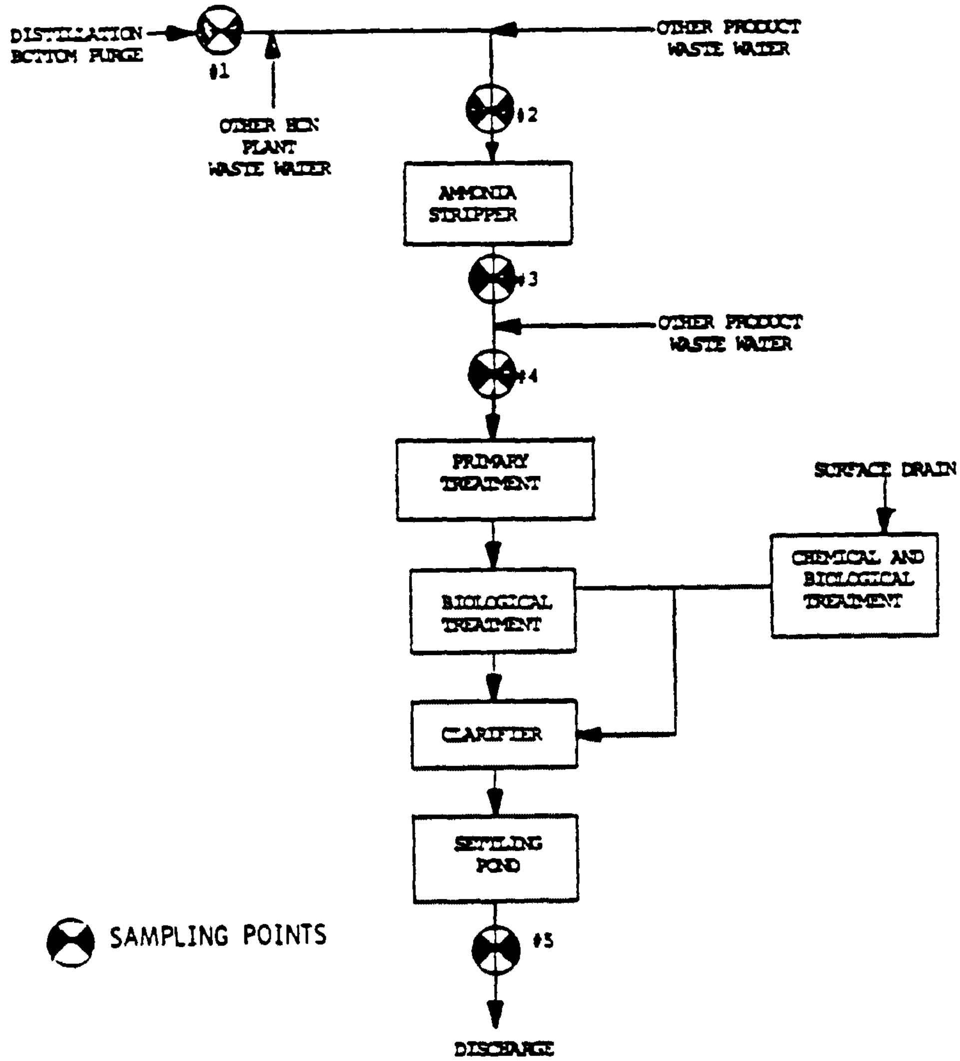


Figure 5-14. General wastewater treatment process flow diagram at plant 782, manufacturing hydrogen cyanide, showing the sampling points [1].

The final concentrations of cyanide and ammonia in the treated effluent shown in Table 5-58 indicate that the treatment system is efficient in the removal of these pollutants with cyanide destruction exceeding 99 percent. Table 5-59 gives treated effluent and daily monitoring data for plant 782.

TABLE 5-59. VERIFICATION SAMPLING AT HYDROGEN CYANIDE PLANT 782 [1]

Verification sampling[a]

Pollutant	Influent mg/L	Influent kg/Mg	Effluent quality, mg/L
TSS	110	2.87	74
Total cyanide	31	0.808	2.2
Free cyanide	19.0	0.495	1.73
BOD	1,550	40.3	376
Ammonia	1,380	36.0	5.04

Daily Monitoring Data - Treated Effluent

Parameter	Concentration, mg/L			Waste load, kg/Mg		
	Minimum	Average	Maximum	Minimum	Average	Maximum
BOD	9.0	39.7	125	0.041	2.38	10.2
Oxidizable cyanide	0.021	0.112	0.18	0.0014	0.0072	0.013
Total cyanide	0.38	2.33	8.83	0.0025	0.14	1.0
Ammonia	2.0	27.1	281	0.023	1.7	24.1
TSS	5.0	103	585	0.0088	6.5	50.6

[a]Flow = 6.25 m^3/Mg.

Water usage and wastewater flow data are presented in Table 5-60 for plants 765 and 782. The large variation in flow is the result of plant 765 not recycling the water used to absorb the hydrogen cyanide from the reactor gases. This procedure is used because the plant is located where sufficient cold water is readily available at low cost, and once-through use is cost effective. Table 5-61 gives toxic pollutant raw waste loads for the plants.

TABLE 5-60. WATER USAGE AND WASTEWATER FLOW DATA FOR HYDROGEN CYANIDE PLANTS 765 AND 782 [1] (m^3/Mg)

Description	Plant 765	Plant 782
Water usage		
Noncontact cooling	29.5	18.93
Total consumption	58.3	8
Wastewater flow	57	9.9

TABLE 5-61. TOXIC POLLUTANT LOADS IN RAW WASTE AT HYDROGEN CYANIDE PLANTS [1] (kg/Mg product)

Pollutant	Plant 765	Plant 782[a]	Plant 765[a]
Total cyanide	5.9	0.808	1.6
Free cyanide		0.49	0.807
Thallium	0.0014		

[a]Verification data.
Note: Blanks indicate data not available.

II.5.3.7 Nickel Sulfate

Two plants were selected for detailed description from the available data on the nickel sulfate industry based on the lowest concentration of toxic pollutants in the effluent stream.

Plant 120

Verification data are provided for plant 120. Treatment of process wastes at the plant consists of pH adjustment to precipitate nickel and other trace metals, followed by sand filtration. The wastes are mixed with other plant wastes and discharged through a single outfall. Solid wastes from the plant are disposed of or used as landfill.

Figure 5-15 provides the general process flow diagram. Figure 5-16 presents the wastewater treatment process flow diagram including sampling points. Table 5-62 gives flow and concentration data for the sampled wastestreams. Table 5-63 presents the treated effluent and daily monitoring data for plant 120.

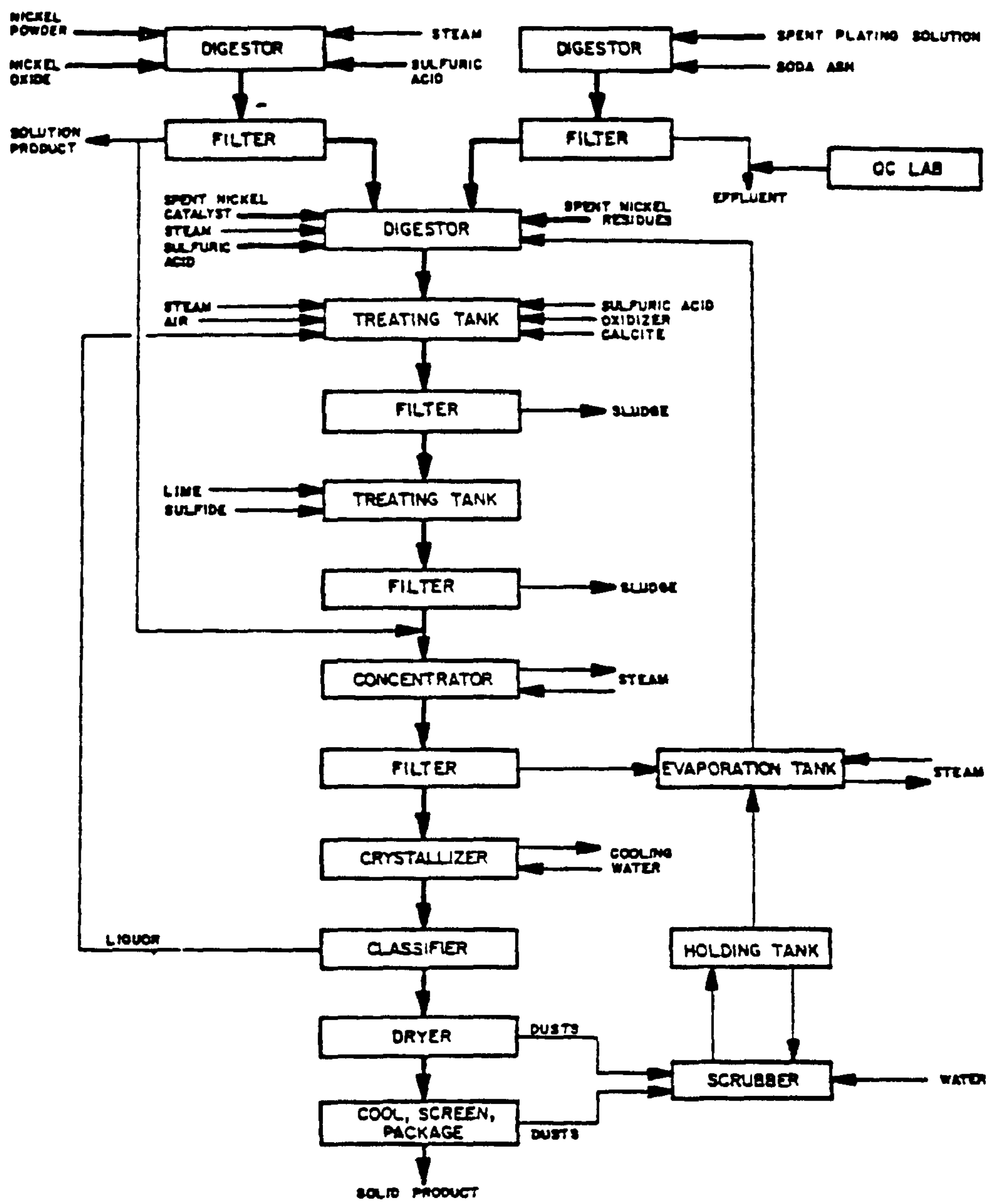


Figure 5-15. General process flow diagram of plant 120, manufacturing nickel sulfate [1].

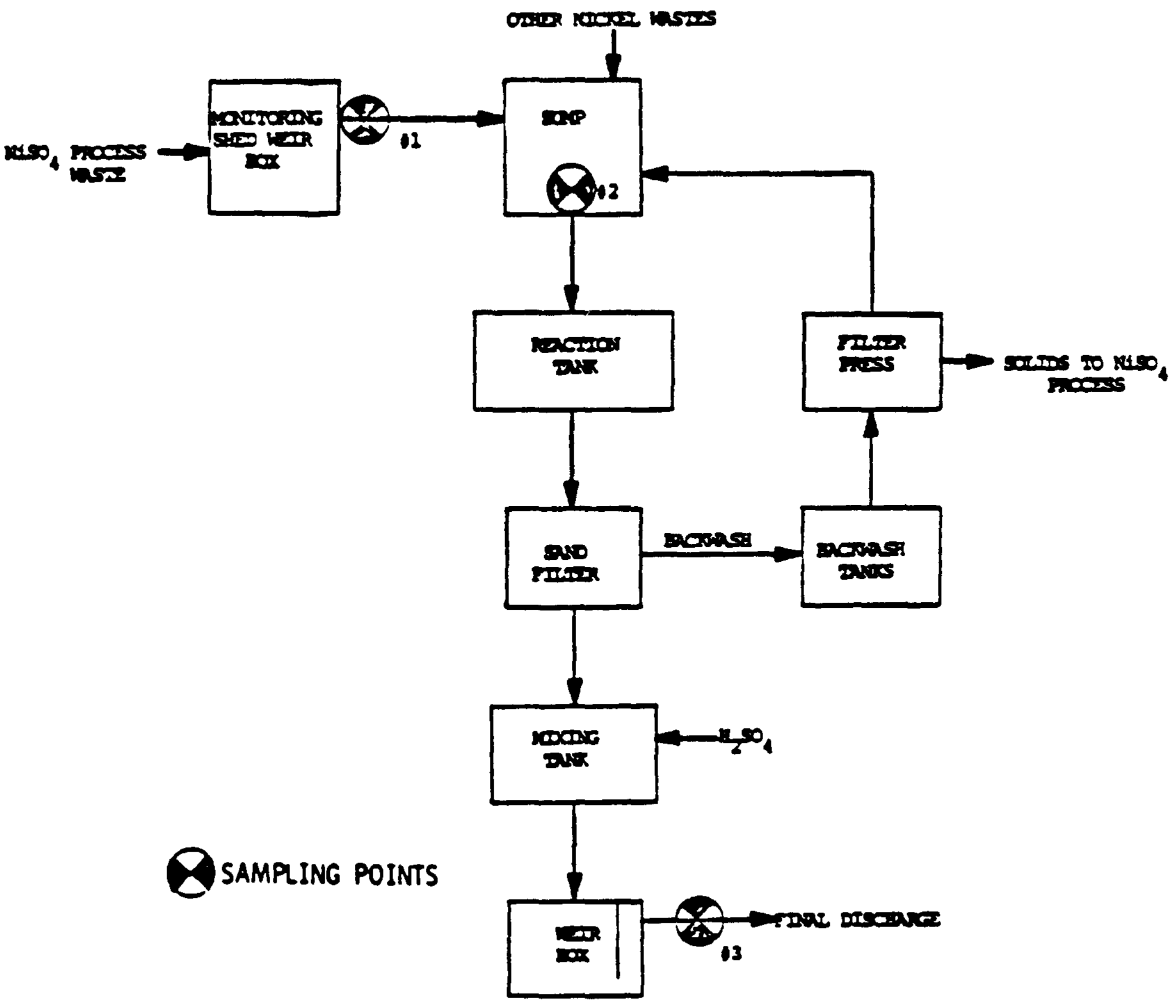


Figure 5-16. General wastewater treatment process flow diagram at plant 120, manufacturing nickel sulfate, showing the sampling points [1].

TABLE 5-62. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANTS PRODUCING NICKEL SULFATE [1]

Plant	Wastestream description	Flow, m^3/Mg product	kg/Mg product: TSS	kg/Mg product: Nickel	kg/Mg product: Copper	kg/Mg product: Lead
120	$NiSO_4$ waste	0.722	0.031	0.0355	0.00015	0.00004
	All nickel wastes	7.54	0.521	0.094		
	Treated effluent	7.54	0.032	0.0015	0.0002	
369	Untreated waste	0.417		0.073	0.031	0.0005
	Treated waste	0.417		0.00058	0.0075	0.0002

Note. Blanks indicate data not available.

TABLE 5-63. WASTE CHARACTERISTICS OF NICKEL SULFATE PLANT 120 [1]

Verification sampling[a]

Pollutant	Raw waste, μg/L: Average	Raw waste, μg/L: Maximum	Raw waste, kg/Mg: Average	Raw waste, kg/Mg: Maximum	Treated effluent quality, μg/L: Average	Treated effluent quality, μg/L: Maximum
TSS	43,000	64,000	0.842	1.25	4,330	8,000
Nickel	49,200	75,800	0.962	1.48	200	340

Effluent Monitoring - Daily Data

Pollutant	Concentration, μg/L: Minimum	Concentration, μg/L: Average	Concentration, μg/L: Maximum	Waste load, kg/Mg: Minimum	Waste load, kg/Mg: Average	Waste load, kg/Mg: Maximum
Nickel	80	1,830	8,330	0.043	0.35	1.89

[a]Flow = 0.72 m^3/Mg.

Plant 369

Screening data are provided for plant 369. Treatment at this plant consists of adjusting the pH to between 9 and 10 to precipitate metal hydroxides, which are removed by settling prior to final discharge. Table 5-62 gives flow and concentration data for the sampled waste streams. No flow diagram is available for plant 369.

Table 5-64 presents raw waste load data for plants 120 and 369. Table 5-65 presents water usage information for the two plants.

TABLE 5-64. TOXIC POLLUTANT LOADS IN RAW WASTE AT NICKEL SULFATE PLANTS [1]
(kg/Mg product)

Pollutant	Plant 369	Plant 120
Nickel	0.073	0.035
Copper	0.030	0.0002
Chromium	0.0005	0.00001
Lead	0.00002	0.00006
Zinc	0.00011	0.00004
Mercury		
Cadmium	0.000004	0.000002
Selenium		0.00004
Thallium	0.000009	

Note: Blanks indicate data not available.

TABLE 5-65. WATER USAGE FOR NICKEL SULFATE PLANTS 120 AND 369 [1]
(m^3/Mg)

Description	Plant 120[a]	Plant 369
Noncontact cooling	13.6	0.417
Direct process contact	4.01	0.783
Miscellaneous (main, pump seals, etc.)	0	0.094

[a]Includes uses for other process.

II.5.3.8 Sodium Bisulfite

Two plants were selected for detailed description from the available verification data on the sodium bisulfite industry based on the lowest concentration of toxic pollutants in the effluent stream.

Plant 987

The filter wash is the main process waste at plant 987. This waste is neutralized with 50% caustic soda to a pH of 9 to 10 in an oxidation tank while mechanically agitating to convert the bisulfite waste to sulfite. The sulfite is then oxidized to sulfate with air. The treated waste, including solids, is discharged to a river after a 17-hour retention period.

Figure 5-17 (next page) provides a process flow diagram of plant 987 including sampling points. Table 5-66 provides flow and pollutant concentration data on the sampling points.

TABLE 5-66. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANTS PRODUCING SODIUM BISULFITE [1]

Plant	Wastestream description	Flow, m^3/Mg product	kg/Mg product TSS	COD	Zinc	Copper
987	Filter wash 1	0.051	0.113	1.42	0.000071	0.000018
	Floor wash, spills, etc.	0.0123	0.0457	0.299	0.000044	0.0000111
	Filter wash 2	0.0386	0.0052	0.908	0.000039	0.0000357
	Treatment influent (1+2+3)	0.102	0.315	3.46	0.00024	0.000075
	54-hour aeration	0.133	0.375	1.19	0.00024	0.000075
	Treated effluent	0.133	0.0031	1.02	0.000000799	0.000036
586	MBS sump 1	9.68	0.191	1.12	0.0067	0.011
	MBS sump 2	9.68	0.051	0.455	0.0025	0.00031
	Amine oxidation pond	2.77	2.43	2.33	0.0031	0.00028
	$ZnSO_4$ pond effluent	78.5	11.8	0.759	1.38	0.0022
	Lime treatment influent	110	10.8	28.6		0.0040
	Truck washdown	0.134	0.0117	0.0975	0.00517	0.00000269
	SO_2 wastes	85.9	1.97	52.5		
	Final treated effluent	188	4.27	21.7		

Note: Blanks indicate data not available.

Plant 586

The sodium bisulfite wastes at plant 586 are combined with process wastes from an amine plant, a zinc sulfate plant, and truck wash waste. Lime is added to the wastes, which are then passed through an aeration tank with an 8-hour retention time. Treated waste goes through primary and secondary settling before final discharge.

Figure 5-18 (page II.5.3-44) is a general flow diagram of plant 586 showing the sampling point locations. Table 5-66 provides flow and pollutant concentration data for the sampled streams. Table 5-67 gives final treated effluent concentrations for TSS, COD and zinc.

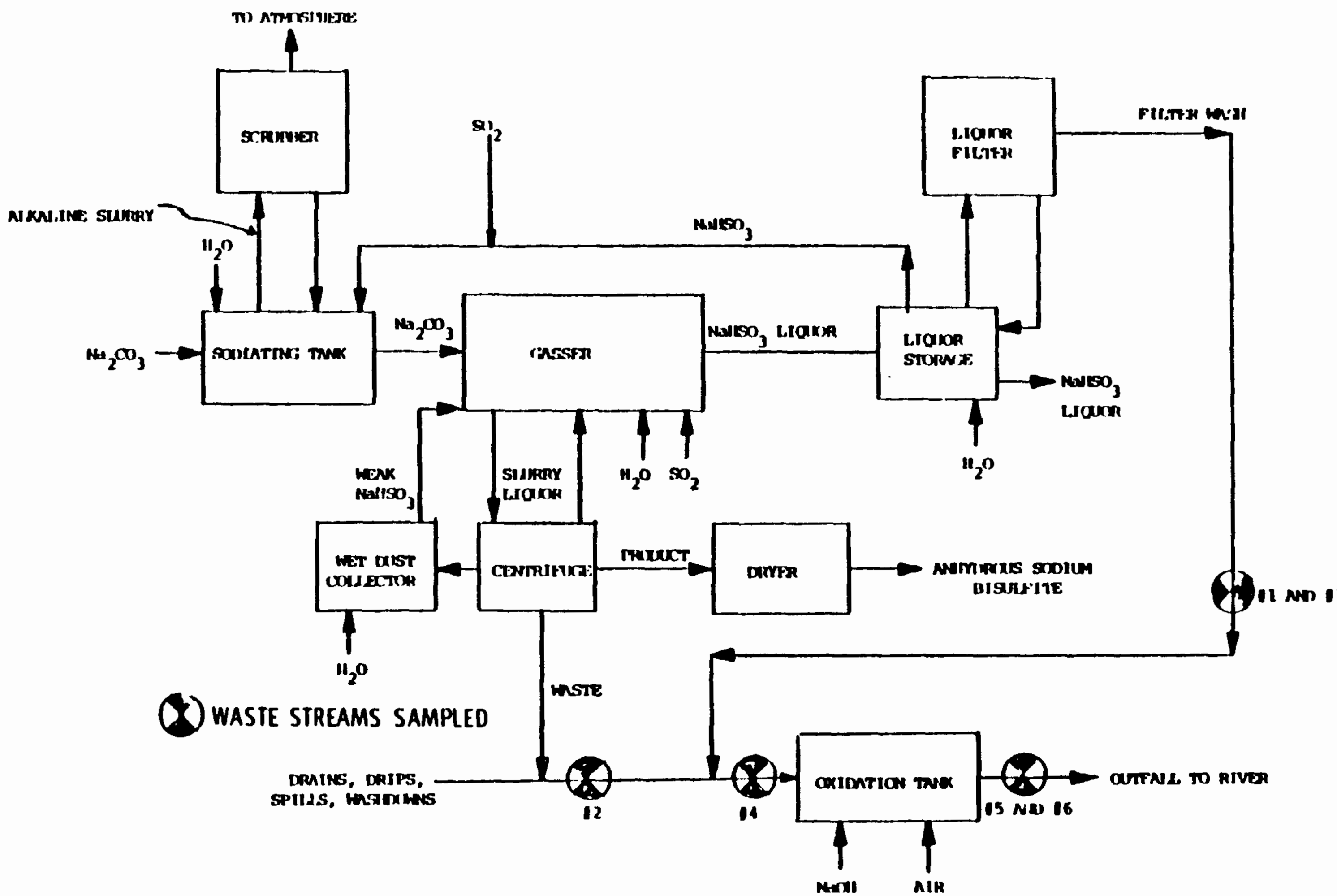


Figure 5-17. General process flow diagram at plant 987, manufacturing sodium bisulfite, showing the sampling points [1].

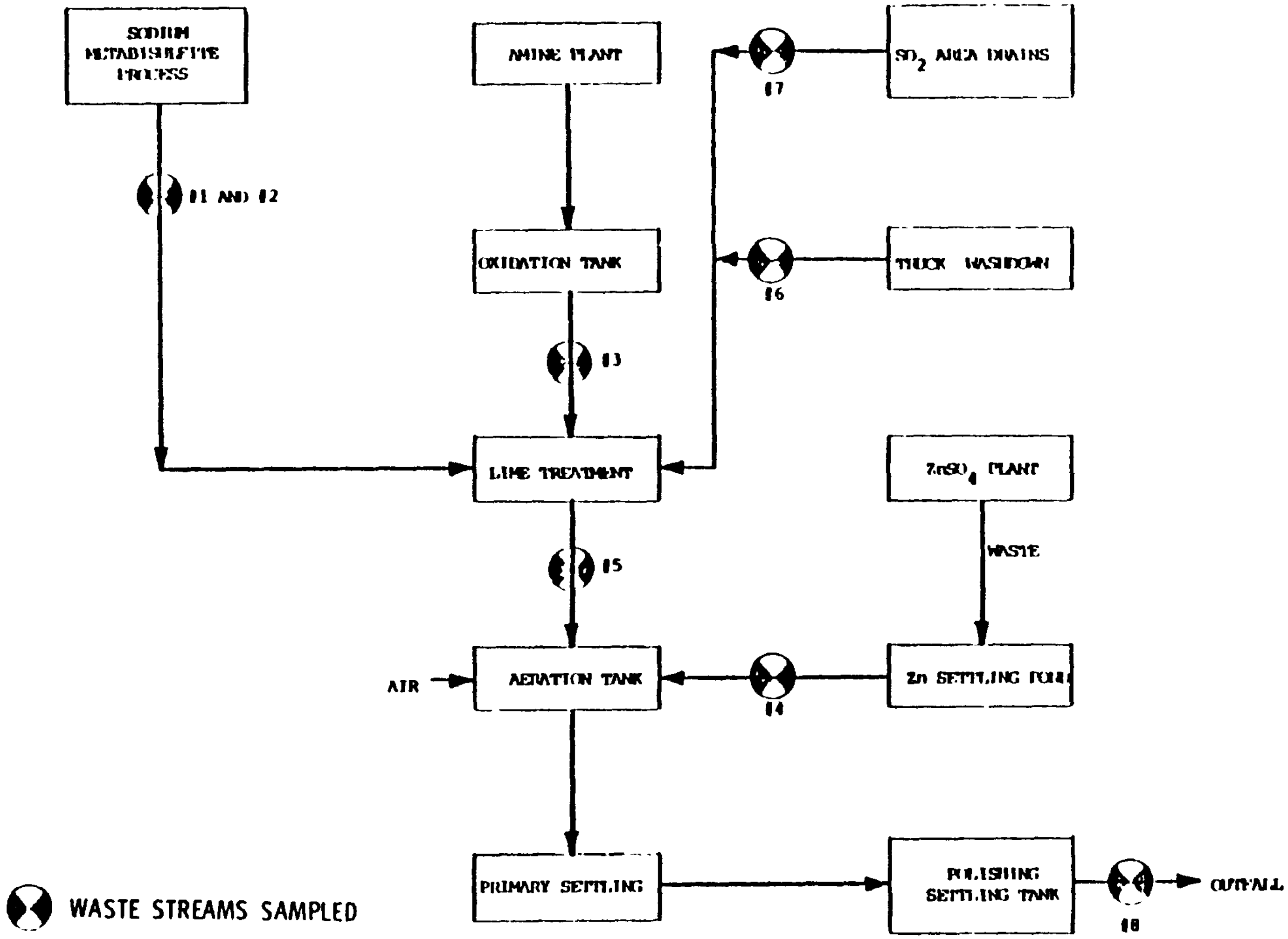


Figure 5-18. General flow diagram at plant 586, manufacturing sodium bisulfite, showing the sampling points [1].

TABLE 5-67. TREATMENT PRACTICES AND VERIFICATION SAMPLING AT SODIUM BISULFITE PLANT 586 [1]

Treatment[a]	Treated effluent						
	TSS		COD		Zinc		Flow,
	mg/L	kg/Mg	mg/L	kg/Mg	μg/L	kg/Mg	m^3/Mg
Lime pH adjustment aeration, and settling	22.7	0.386	115	1.96	59	0.001	17

[a]Combined treatment with other process wastes.
Note: Blanks indicate data not available.

Table 5-68 provides water usage data for plants 586 and 987. Table 5-69 gives raw waste toxic pollutant loads for the selected plants.

TABLE 5-68. WATER USAGE AT SODIUM BISULFITE PLANTS [1] (m^3/Mg)

Description	Plant 986
Direct contact process	1.15
Noncontact cooling	0
Maintenance, washdowns, etc.	0.397

TABLE 5-69. TOXIC POLLUTANT LOADS IN RAW WASTE AT SODIUM BILSULFITE PLANTS [1] (kg/Mg product)

Pollutant	Plant 987[a]	Plant 586[a]
Copper	0.00007	0.0002
Zinc	0.0002	0.0088
Cadmium	0.000004	0.00001
Chromium	0.0003	0.022
Lead	0.00007	0.0002
Mercury	0.000001	0.00001
Nickel	0.00005	0.00017
Antimony	0.000007	0.00008

[a]Verification data.

II.5.3.9 Sodium Dichromate

Two plants were selected for detailed description from the available data on the sodium dichromate industry based on the lowest concentration of toxic pollutants in the final effluent stream. Screening data are provided for plant 493, and verification data are given for plant 376.

Plant 493

At plant 493, the wastewater going to the treatment facility includes the boiler and cooling tower blowdown and a small volume of effluent from a scrubber on a by-product sodium sulfate operation. The total waste includes the spent ore residue, which is also sent to the treatment facility. At the treatment facility, the alkaline wastewaters are reacted with imported acidic industrial waste at an elevated temperature in a reactor. The chromium is precipitated during the reaction. The reacted waste is sent to clarifiers via holding tanks. In the clarifiers, large quantities of water are used to wash the precipitated solids in a countercurrent fashion. The final clarifier overflow, which is the the treated effluent, is filtered and discharged, and the clarifier underflow is disposed of in a quarry.

Figure 5-19 (next page) provides a block diagram of the treatment process and indicates the streams sampled. Table 5-70 gives the flow data and pollutant emissions of the streams sampled. Treated effluent data are given in Table 5-71 and Table 5-72.

TABLE 5-70. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANTS PRODUCING SODIUM DICHROMATE [1]

Plant	Stream	Wastestream description	Flow, m^3/Mg product	kg/Mg product TSS	kg/Mg product Hexavalent chromium	kg/Mg product Chromium
493 (Screening phase)	1	Raw wastewater	4.95	183	3.5	1.25
	2	Treated effluent	28.9	0.018	0.00004	0.022
	3	Residue slurry	2.13	185	0.0004	3.93
376 (Verification phase)	1	Mud slurry waste	7.68	3,990	0.407	1.04
	2	Primary pond effluent	7.68	0.591		0.808
	3	Surface runoff	4.16	0.621	0.057	0.55
	4	Effluent	4.16	7.94		0.77

Note. Blanks indicate no data available.

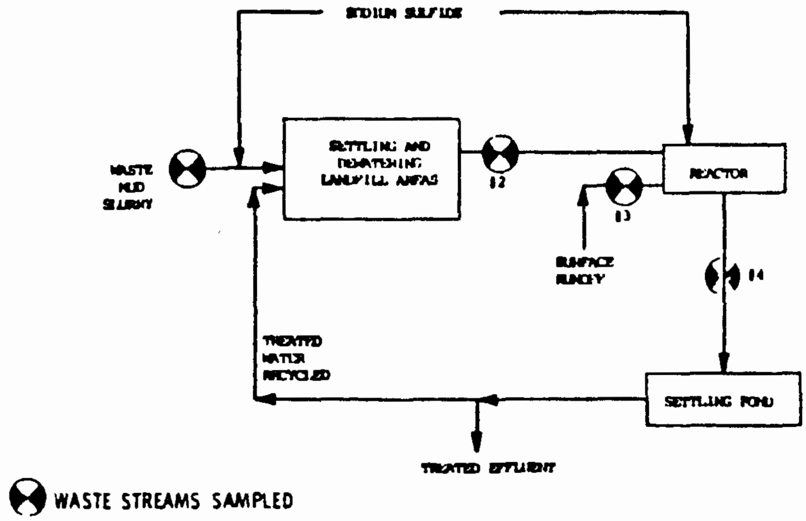


Figure 5-20. General wastewater treatment process flow diagram at plant 376, manufacturing sodium chromate, showing the sampling points [1].

TABLE 5-73. TOXIC POLLUTANT RAW WASTE LOADS AT SODIUM DICHROMATE PLANTS [1] (kg/Mg product)

Pollutant	Plant 493[a]	Plant 376
Chromium	0.95	1.39
Copper	0.00005	0.0008
Lead		0.0002
Nickel	0.047	0.006
Zinc	0.002	0.003
Selenium		
Arsenic		0.0008

[a]Screening data.
Note: Blanks indicate no data available.

TABLE 5-74. WATER USAGE IN SODIUM DICHROMATE SUBCATEGORY [1] (m^3/Mg)

Description	Water usage	
	Plant 376	Plant 493
Noncontact cooling	11.4	5.7
Direct process contact		2.85
Indirect process contact (pumps, seals, leaks and spills)		0.2
Maintenance (e.g., cleaning and work area washdown)		0.2
Air pollution control		1.0
Noncontact ancillary uses		3.12

Note: Blanks indicate data not available.

II.5.3.10 Sodium Hydrosulfite

One plant was selected for detailed description from data available on the sodium hydrosulfite industry based on the lowest concentration of toxic pollutants in the final effluent stream.

Plant 672

Screening data are provided for plant 672; two different streams at the plant were analyzed. Because of the nature of the two wastestreams, each one is handled differently. The dilute waste is first sent to a holding pond, where the flow is equalized and the waste is mechanically aerated. This pond also contains approximately 5.7 m^3/d (1,500 gpd) of waste from a sodium bisulfite process. The pH of the pond effluent is adjusted with sulfuric acid, and the effluent is then sent to an aeration basin. A nitrogen-phosphate fertilizer and urea are added as nutrients. Approximately 13 m^3/d (3,500 gal/d) of sanitary waste and up to 98 m^3/d (25,900 gal/d) of clean dilution water are also added to the aeration basin. This basin formerly had mechanical aerators, but now has air diffusers that allow better temperature control for biological oxidation. Effluent from aeration goes to a clarifier. Approximately 53 m^3/d (14,000 gal/d) of the settled sludge is returned to the aeration basin and 9 m^3/d (2,400 gal/d) is sent to drying piles on site. More dilution water is added to the clarifier when needed for TDS control. Overflow from the clarifier goes to a chlorine contact tank because of the sanitary waste. Blowdown water from the cooling tower and boilers is added to the final chamber of the chlorine contact tank. Effluent from this unit is sent to a final polishing pond for settling and equalization before discharge.

The coproduct waste from the distilling column bottoms is sent to a lined coproduct pond at a rate of 53 m^3/d (14,000 gal/d) and held for one of two possible disposal methods. When there is a market for the coproducts, the waste is concentrated and sold to the pulp and paper industry. When this is not possible and the pond reaches near capacity, the waste is bled into the treatment system described above through the dilute waste holding pond.

A general flow diagram of the biological treatment system is included in Figure 5-21 (next page). Table 5-75 shows the individual wastestreams, the total combined input to the treatment system, the treated effluent quality, and the efficiency of the system.

TABLE 5-75. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 672[a] PRODUCING SODIUM HYDROSULFITE[b] [1]

Stream	Wastestream description	Flow, m^3/Mg	COD mg/L	COD kg/Mg	TSS mg/L	TSS kg/Mg	Zinc µg/L	Zinc kg/Mg
1	Coproduct	0.91	77,922	70.9	61	0.056	24,000	0.022
2	Dilute waste	1.87	14,628	27.4	263	0.49	770	0.0014
3	Raw influent	1.87	15,487	29.0	843	1.58	5,850	0.011
4	Treated effluent	4.68[c]	740	3.46	25	0.12	122	0.00057
Percent removal				95.2		97.0		97.9

[a]Only dilute wastewater being treated at sampling time.

[b]All values are an average of 3 days of sampling.

[c]Higher flow due to the addition of sanitary waste and dilution water to the aeration basin plus cooling tower and boiler blowdown to the chlorine contact tank.

Table 5-76 presents final treated effluent concentrations and loadings; raw waste pollutant loadings are presented in Table 5-77.

TABLE 5-76. SCREENING RESULTS FROM SODIUM HYDROSULFITE PLANT 672[a] [1]

Pollutant	Raw waste influent µg/L	Raw waste influent kg/Mg	Treated effluent µg/L	Treated effluent kg/Mg
COD	15,500,000	29.0	740,000	3.46
TSS	840,000	1.58	25,000	0.12
Zinc	5,800	0.011	120	0.00057
Chromium	7,400	0.014	<43	<0.0002
Copper	1,000	0.0019	28	0.00013
Lead	830	0.0015	70	0.00013
Nickel	1,400	0.0027	160	0.00075
Cadmium	37	0.000069	29	0.00014
Phenol	150	0.0003	<10	<0.00005
Pentachlorophenol	370	0.0007	<10	<0.00005

[a]Flow of raw waste influent = 1.87 m^3/Mg; flow of treated effluent = 4.68 m^3/Mg. The higher flow in the treated effluent is due to the addition of sanitary wastes and dilution water to the aeration basin, plus cooling tower and boiler blowdown to the chlorine contact tank.

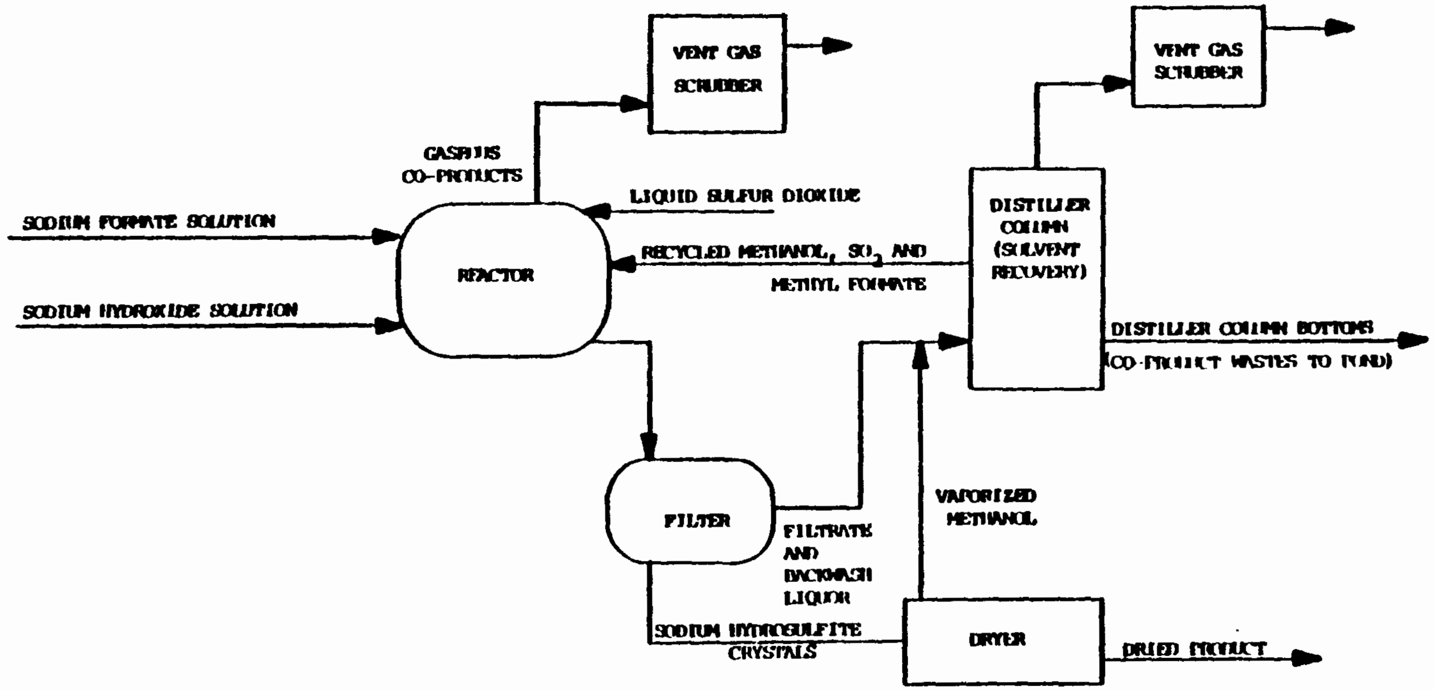


Figure 5-21. General process flow diagram at plant 672, manufacturing sodium hydrosulfite [1].

TABLE 5-77. SUMMARY OF RAW WASTE LOADINGS FOUND AT A SODIUM HYDROSULFITE PLANT (FORMATE PROCESS) 672 [1]

Pollutant	Loadings Average kg/day	Average kg/Mg
Priority		
Cadmium	0.0041	0.00007
Chromium	0.81	0.14
Copper	0.11	0.0019
Lead	0.041	0.0007
Nickel	0.16	0.0027
Silver	0.0045	0.00008
Zinc	0.63	0.011
Pentachlorophenol	0.04	0.0007
Phenol	0.017	0.0003
Conventional		
TSS	91.6	1.57
COD	1,690	28.9

II.5.2.11 Titanium Dioxide

II.5.3.11.1 Chloride Process

Two plants were selected for detailed description from the available data on the titanium dioxide chloride process industry based on the lowest concentration of toxic pollutants in the final effluent stream.

Plant 559

Screening and verification data are provided for plant 559 which uses the conventional chloride process to produce titanium dioxide. The solids, hereinafter called pit solids and consisting mainly of unreacted ore, coke, iron, and trace metal chlorides, including $TiCl_4$, separated from the first stage cooling of the chlorinated gases, are slurried with water and sent to the wastewater treatment facility. The wastewater from the chloride process is mixed with other product wastewater and treated in combination. A flow diagram of the treatment facility, including the sampling locations, is shown in Figure 5-22. Slurried pit solids and the distillation column bottom residue are sent to a large settling pond where they are mixed with the other process wastewater. Overflow from the settling pond is neutralized with ground calcium carbonate in a reactor. The scrubber and other wastewater from the chloride process is mixed with other product

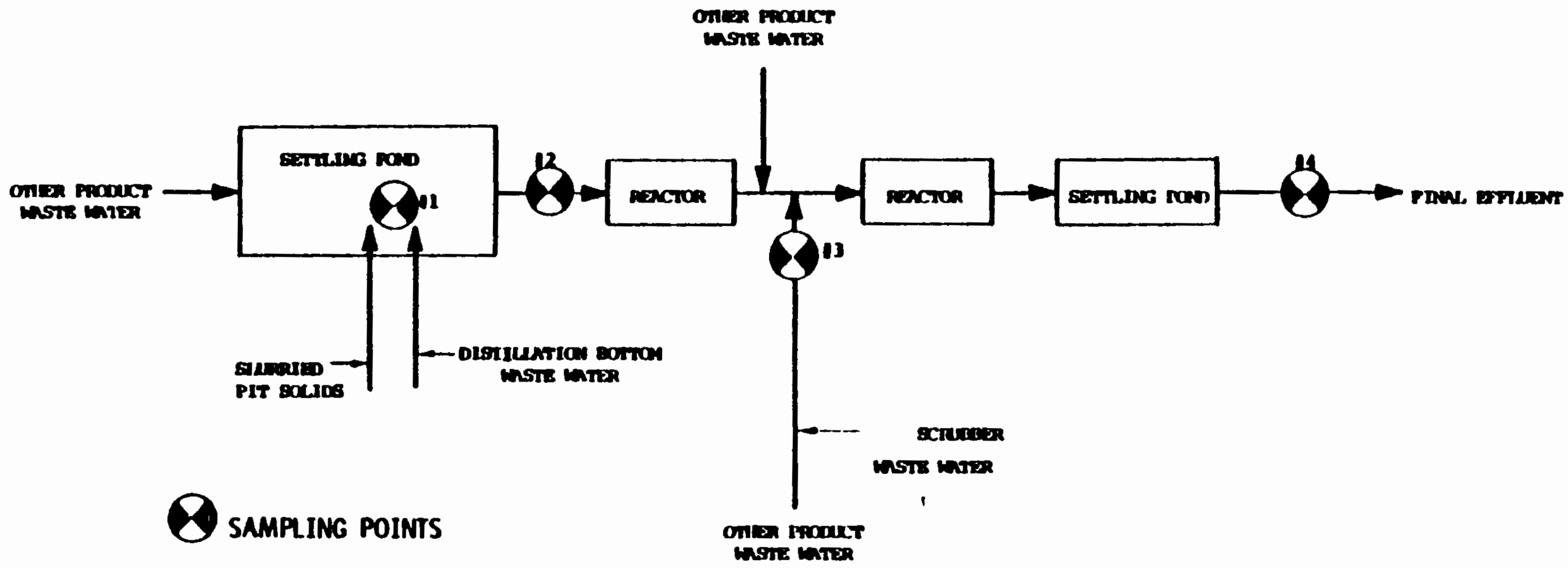


Figure 5-22. General flow diagram at plant 559, manufacturing titanium dioxide (chlorine process), showing the sampling points [1].

wastewater and combined with the settling pond effluent. The combined solutions are neutralized with lime in a second reactor and then sent to a settling pond before discharge. Because the chloride process wastewaters are mixed with other product wastewater prior to treatment, the sampling results represent the total input mixture rather than only the TiO_2 process raw wastes. Problems were encountered during the sampling of the pit solids and distillation bottoms. The pipes carrying the wastes from the process discharged at the bottom of the settling pond, and it was not possible to take the samples right at the outlet of the pipe. The combined sample of the two streams was taken at the surface of the discharge. It is probable that some solids settled before the stream reached the surface.

Table 5-78 provides the waste flows and pollutant loadings for the streams sampled at plant 559. Treated effluent pollutant concentrations are given in Table 5-79.

TABLE 5-78. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 559 PRODUCING TITANIUM DIOXIDE USING THE CHLORIDE PROCESS [1]

Stream	Wastestream description	Flow, m^3/Mg TiO_2	kg/Mg TiO_2		
			SS	Iron	Chromium
1	Pit solids and distillation bottom waste	13.9[a]	95.7	18.7	1.55
2	Settling pond overflow	13.9[a]	0.22	>18.7[a,b]	0.36[a]
3	TiO_2 (Cl process) scrubber and other product wastewater	90	28.2[a]	38.7[a]	0.0096[a]
4	Final effluent	104[a]	2.3[a]	0.45[a]	0.0026[a]

[a]Pollutant load was calculated by apportioning the mass emitted between the two wastestreams on the basis of measured flows; this is clearly a very approximate process and results must be used with caution.

[b]Effluent value is higher than influent because of the introduction of other product wastewater in the pond contributing to higher load.

TABLE 5-79. RAW WASTE AND TREATED EFFLUENT QUALITY AT TITANIUM DIOXIDE PLANT USING CHLORIDE PROCESS [1]

Verification sampling

Pollutant	Plant 172[c] Raw waste, kg/Mg	Plant 172[c] Treated effluent µg/L	Plant 172[c] Treated effluent kg/Mg	Plant 559[a,b] Raw waste, kg/Mg	Plant 559[a,b] Treated effluent, µg/L
TSS	6.06	6,670	0.245	95.9	23,000
Iron	0.104	327	0.012	18.7	4,400
Chromium	0.024	17	0.00062	1.55	25
Lead	0.00004	<2.3	<0.000084	0.049	<2.3
Nickel	0.002	<10	<0.00037	0.048	5
Zinc	0.010	90	0.0033	0.027	61.7

Monitoring Data - Plant 172 Treated Effluent

Pollutant (average)	µg/L	kg/day	kg/Mg
TSS	3,140	8.34	0.114
Chromium	4	0.013	0.00018
Copper	10	0.027	0.00037
Zinc	12	0.028	0.00038

[a] Loads in effluent not included because it includes other process wastes.

[b] Average raw waste flow = 13.9 m^3/Mg.

[c] Average flow of treated effluent = 35.9 m^3/Mg.

Plant 172

Screening and verification data are provided for the chloride process wastewater in plant 172. The wastewater from the process, mainly the scrubber water, is collected in trenches and sent to a central reactor basin. Other discharges, including a part of the total rain runoff, are also collected in ditches and sent to the reactor basin. In the reactor basin, sodium hyroxide is used for neutralization, and the resulting effluent is mixed with the remaining rainwater runoff and sent to the first of two retention basins arranged in series. Overflow from the second retention is adjusted for pH using sulfuric acid before discharge.

A simplified diagram of the treatment system including the sampling points is shown in Figure 5-23. Table 5-80 provides the

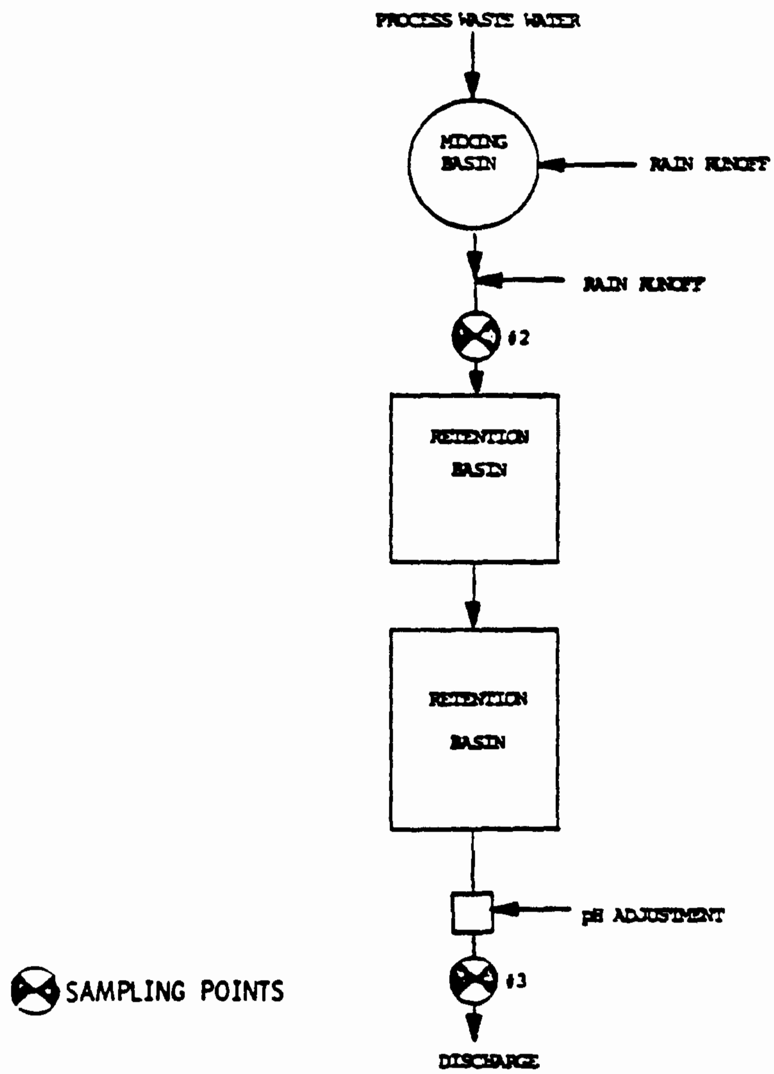


Figure 5-23. General flow diagram at plant 172, manufacturing titanium dioxide (chloride process) showing the sampling points [1].

TABLE 5-80. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 172 PRODUCING TITANIUM DIOXIDE USING CHLORIDE PROCESS [1]

Stream	Wastestream description	Flow, m^3/Mg TiO_2	pH	kg/Mg TiO_2				
				TSS	Zinc	Chromium	Iron	Nickel
2	Inlet to wastewater treatment pond	35.8	7.9	7.97	0.0096	0.0223	0.107	<0.0008
3	Wastewater treatment effluent	35.8	7.6	0.238	0.003	0.0006	0.011	<0.00036

waste flow and pollutant loadings for the streams sampled. Table 5-79 presents treated effluent and monitoring data, and Table 5-81 presents water usage.

TABLE 5-81. WATER USAGE AT TITANIUM DIOXIDE PLANT 172 USING CHLORIDE PROCESS [1] (m^3/Mg TiO_2)

Description	Water usage
Noncontact cooling	10.7
Direct process contact	15.3
Indirect process contact	0.72
Maintenance, equipment cleaning and work area washdown	0.52
Air pollution control	7.14
Noncontact ancillary uses	10.4
Sanitary and potable water	0.31
Total	45.3

Table 5-82 gives the raw wastewater toxic pollutant loadings for exemplary plant 559.

TABLE 5-82. TOXIC POLLUTANT LOADS IN RAW WASTE AT TITANIUM DIOXIDE PLANT 559 USING THE CHLORIDE PROCESS [1] (kg/Mg product)

Pollutant	Raw waste load
Chromium	1.55
Lead	0.049
Nickel	0.048
Zinc	0.027

II.5.3.11.2 Sulfate Process

One plant was selected for detailed description from the available data on the titanium dioxide-sulfate process industry based on the lowest concentration of toxic pollutants in the final effluent stream.

Plant 559

Verification and screening data are provided for plant 559 which uses the sulfate process to produce titanium dioxide. At this plant, the strong acid is sent to a lined holding pond for equalization. Effluent from the pond is neutralized with ground calcium carbonate in a reactor; a sufficient amount is added to raise the pH to a level such that calcium sulfate, but not ferrous hydroxide, is precipitated. The CO_2 formed during the reaction is vented to the atmosphere, and the calcium sulfate slurry goes to a clarifier. Underflow from the clarifier is filtered to produce pure gypsum crystals at a concentration of 70 to 80%.

The weak acid is sent to a settling pond, where it is combined with a small quantity of other wastes. Effluent from the weak acid pond is mixed with the calcium sulfate clarifier overflow and neutralized with ground calcium carbonate in a three-stage reactor. Pebble and slaked lime are also added to raise the pH and precipitate more calcium sulfate. Air is also introduced to convert the ferrous iron to ferric. Effluent from the reactor goes to another clarifier, and the clarifier underflow is filtered to concentrate the solids to 70%. Overflow from the second clarifier is mixed with the other process wastewaters, which include the scrubber finishing, and cooling wastewaters. The combined water is neutralized with slaked lime before it is sent to a final settling pond, the effluent from which is discharged.

Figure 5-24 (next page) represents the flow diagram of the treatment process and shows the sampling locations for both screening and verification. Table 5-83 provides the flow data for the waste streams and Table 5-84 presents pollutant data for the effluent; Table 5-85 presents daily monitoring data of the effluent. Table 5-86 presents raw waste toxic pollutant loading for both sampling phases.

TABLE 5-83. FLOW AND POLLUTANT CONCENTRATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANT 559 PRODUCING TITANIUM DIOXIDE USING THE SULFATE PROCESS [1]

Stream	Wastestream description	Flow, m^3/Mg TiO_2	kg/Mg TiO_2 SS	kg/Mg TiO_2 Iron	kg/Mg TiO_2 Chromium
4	Weak acid pond overflow	107	1.75[a]	305[a]	2.81[a]
3	Strong acid pond overflow	9.7	1.94	87.6	0.18
5	Scrubber and other product wastewater	583	183[a]	83.6[a]	0.062[a]
6	Final treatment effluent	700[a,b]	16.1	3.08	0.017

[a]Pollutant load was calculated by multiplying the flow contributed by the sulfate process stream times the concentration of pollutant. Pollutant load = (total stream flow) x (fraction contributed by sulfate process waste) x (stream pollutant concentrated).

[b]While calculating the unit flow, the contributions to the treatment process from precipitation, the water in the treatment chemicals, and the losses from evaporation and from solids leaving the process have not been considered.

TABLE 5-84. VERIFICATION RESULTS OF RAW WASTE AND TREATED EFFLUENT FOR TITANIUM DIOXIDE PLANT 559[a] [1]

Pollutant	Raw waste, kg/Mg Average	Raw waste, kg/Mg Maximum	Treated effluent µg/L Average	Treated effluent µg/L Maximum	Treated effluent kg/Mg Average
TSS	310	330	23,000	38,000	19.5
Total iron	670	770	4,400	7,900	3.7
Antimony			<15	<15	0.01
Arsenic	0.015	0.020	<10	<10	<0.008
Cadmium	0.008	0.001	0.1	0.2	0.0001
Chromium	5.0	5.6	25	30	0.02
Copper	0.13	0.14	<5	<5	<0.004
Lead	0.16	0.17	2	3	0.002
Nickel	0.19	0.22	<5	<5	0.004
Thallium	0.004	0.008	<5	<5	0.002
Zinc	0.72	0.76	61	65	0.05

[a]Flow = 616 m^3/Mg; includes cooling water and a small part of chloride process waste.

Note: Blanks indicate data not available.

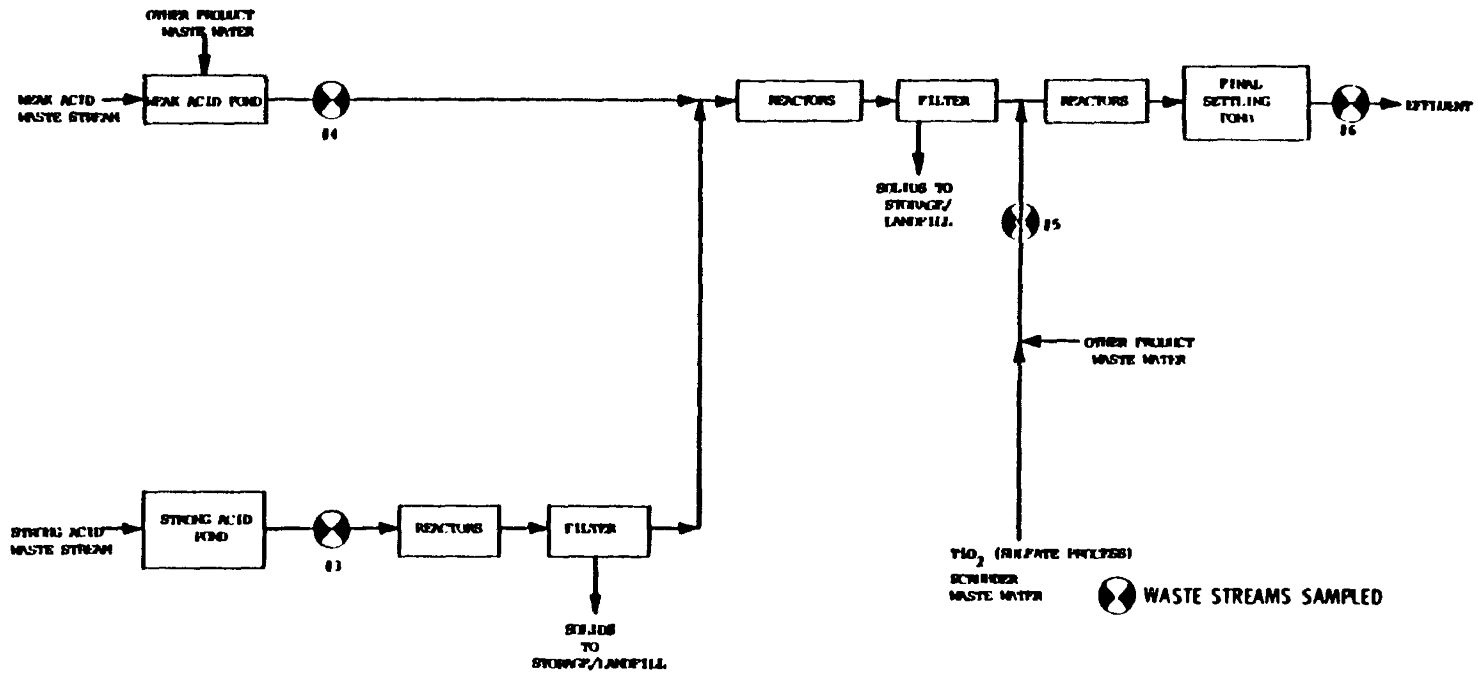


Figure 5-24. General flow diagram at plant 559, manufacturing titanium dioxide (sulfate process), showing the sampling points [1].

TABLE 5-85. SUMMARY OF DAILY EFFLUENT MONITORING DATA FOR COMBINED WASTEWATER TREATMENT DISCHARGE AT TITANIUM DIOXIDE PLANT 559 USING SULFATE PROCESS [1]

Parameter	Concentration, μg/L			Waste load kg/Mg	lbs/1,000 lbs	
	Minimum	Average	Maximum	Minimum	Average	Maximum
Chromium	10	21	119	0.00049	0.0014	0.0045
Cadmium	1	9	20	0.00004	0.00062	0.0012
Total iron	400	3,250	19,100	0.29	2.14	12.99
Dissolved iron	80	279	4,980	0.04	0.194	4.0
Lead	2	17	50	0.00008	0.0012	0.003
Nickel	10	29	80	0.00057	0.0019	0.0046
Zinc	10	27	300	0.00049	0.0019	0.022
TSS		35,800			23.9	

Note. Blanks indicate data not available.

TABLE 5-86. TOXIC POLLUTANT RAW WASTE LOADS AT TITANIUM DIOXIDE PLANT 559 USING THE SULFATE PROCESS [1] (kg/Mg)

Pollutant	Screening[a] phase	Verification[a] phase
Cadmium	0.0009	0.003
Chromium	3.37	1.36
Copper	0.118	0.155
Arsenic	0.0135	
Lead	0.103	0.128
Nickel	0.151	0.086
Zinc	0.55	0.589
Antimony	0.08	
Phenol		0.002
Thallium	0.0078	

[a]Screening and verification data shown in table were not completely identified in Reference 1; reported data were assumed by MRC to correspond to screening and verification phases as noted in table.

Note: Blanks indicate not detected in measurable quantities.

II.5.4 POLLUTANT REMOVABILITY

The inorganic chemicals industry discharges a variety of toxic pollutants into plant wastewater streams due to the large number of products manufactured by the different subcategories of this industry. Each subcategory has specific major pollutants, and in some subcategories a specific treatment method is used to control pollutant discharge. Generally, these major pollutants are toxic metals. Table 5-87 (next page) lists the toxic metals and the treatment methods normally used to reduce their concentrations. The treated waste concentrations and removal efficiencies are assumed to represent the best performance characteristics obtainable under the specified operating conditions. The operating conditions are assigned as optimal conditions.

II.5.4.1 Aluminum Fluoride Industry

The toxic pollutants found in actual aluminum fluoride plant wastewaters include copper, arsenic, chromium, and selenium. In the case of selenium, it is apparent that the source was largely the raw water supply. Therefore, selenium is not regarded as a process related pollutant, but its control in the treated effluent may be required.

Copper and chromium trace impurities may be present in the hydrofluoric acid used to react with bauxite to form aluminum fluoride. Arsenic may originate as an impurity in the bauxite ore. Waste treatment processes should be designed to control fluoride, copper, arsenic, and chromium.

Toxic pollutants are generally reduced in the wastewater from this industry by neutralization and settling. Lime, soda ash, and alum are the common chemicals used to precipitate the pollutants. Fluoride is also precipitated as calcium fluoride using this technology.

No effluent data are available at this time.

Potential treatment technologies include the exchange of copper and chromium for hydrogen or sodium ions by ion exchange from clarified solutions. Copper and chromium at low levels may also be controlled by xanthate precipitation, although the process is not widely used. Sulfide precipitation will reduce copper to very low levels but does not control chromium or arsenic. A combination of lime and ferric sulfate coagulation is probably the most effective proposed method for reducing arsenic concentrations.

TABLE 5-87. WASTEWATER TREATMENT OPTIONS AND PERFORMANCE DATA SUMMARY FOR TOXIC METALS [1]

	Antimony				Arsenic			
	Concentration, μg/L		Percent		Concentration, μg/L		Percent	
Treatment technology	Initial	Final	removal	pH	Initial	Final	removal	pH
Activated alumina					400-1,000[a]	<400	96-99+	6.8
Activated carbon					400-1,000[b]	<4,000	63-97	3.1-3.6
Activated carbon (granular)								
Activated carbon (pulverized, Pittsburgh type RC)								
Activated carbon/alum								
Alum								
Alum/filter	600	200	62	6.4				
Bisulfite reduction								
Caustic soda/filter								
Chlorine precipitation (alkaline chlorination in presence of cyanide)								
Ferric chloride					300	50	98	
Ferric chloride/filter	500	200	65	6.2				
Ferric sulfate					5,000	500	90	6.0
Ferric sulfate/filter								
Ferrite coprecipitation								
Ferrite coprecipitation/filter								
Ferrous sulfate/filter								
Ferrous sulfide (Sulfex)								
Lime					5,000,[c] 5,000[d]	1,000,[c] 1,400[d]	80,[c] 72[d]	10.0,[c] 11.5[d]
Lime softening					200	30	85	
Lime/ferric chloride/filter					3,000	50	98	10.3
Lime/filter	600	400	28	11.5				
Lime/sulfide								
Reduction/lime								
Sodium carbonate/filter								
Sodium hydroxide								
Sodium hydroxide/filter								
Sulfide								
Sulfide precipitation								
Sulfide/filter						50		6-7
Sulfur dioxide reduction								

(continued)

TABLE 5-87 (continued)

Treatment technology	Beryllium: Concentration, µg/L Initial	Beryllium: Concentration, µg/L Final	Beryllium: Percent removal	Beryllium: pH	Cadmium: Concentration, µg/L Initial	Cadmium: Concentration, µg/L Final	Cadmium: Percent removal	Cadmium: pH
Activated alumina								
Activated carbon								
Activated carbon (granular)								
Activated carbon (pulverized, Pittsburgh type RC)								
Activated carbon/alum								
Alum								
Alum/filter								
Bisulfite reduction								
Caustic soda/filter								
Chlorine precipitation (alkaline chlorination in presence of cyanide)								
Ferric chloride								
Ferric chloride/filter								
Ferric sulfate								
Ferric sulfate/filter								
Ferrite coprecipitation								
Ferrite coprecipitation/filter					240,000	8	>99	Neutral
Ferrous sulfate/filter								
Ferrous sulfide (Sulfex)					4,000	10	>99	8.5-9.0
Lime								
Lime softening					440-1,000	8	92-98	5-6.5
Lime/ferric chloride/filter								
Lime/filter	100	6	99.4	11.5	5,000,[c] 5,000[d]	250,[c] 100[d]	95,[c] 98[d]	10.0,[c] 11,5[d]
Lime/sulfide					300-1,000	6	>98	8.5-11.3
Reduction/lime								
Sodium carbonate/filter								
Sodium hydroxide								
Sodium hydroxide/filter								
Sulfide								
Sulfide precipitation								
Sulfide/filter								
Sulfur dioxide reduction								

(continued)

TABLE 5-87 (continued)

Treatment technology	Copper: Concentration, µg/L Initial	Copper: Concentration, µg/L Final	Copper: Percent removal	Copper: pH
Activated alumina				
Activated carbon				
Activated carbon (granular)				
Activated carbon (pulverized, Pittsburgh type RC)				
Activated carbon/alum				
Alum	3,000	200	93	6.5-7.0
Alum/filter				
Bisulfite reduction				
Caustic soda/filter				
Chlorine precipitation (alkaline chlorination in presence of cyanide)				
Ferric chloride				
Ferric chloride/filter				
Ferric sulfate				
Ferric sulfate/filter	5,000	300	95	6.0
Ferrite coprecipitation				
Ferrite coprecipitation/filter		10	>99	
Ferrous sulfate/filter				
Ferrous sulfide (Sulfex)	3,200, 4,000	20, 10	99, >99	8.5-9.0
Lime	1,000-2,000, 3,000	1,000-2,000, 200	90, 93	>8.5, 9.5
Lime softening				
Lime/ferric chloride/filter				
Lime/filter	3,200, 5,000,[c] 5,000[d]	70,400,[c] 500[d]	98, 92,[c] 91[d]	8.5-9.0, 10,[c] 11,5[d]
Lime/sulfide	50,000-130,000	<500		5.0-6.5
Reduction/lime				
Sodium carbonate/filter				
Sodium hydroxide				
Sodium hydroxide/filter				
Sulfide				
Sulfide precipitation				
Sulfide/filter				
Sulfur dioxide reduction				

(continued)

TABLE 5-87 (continued)

Treatment technology	Chromium III: Concentration, µg/L: Initial	Chromium III: Concentration, µg/L: Final	Chromium III: Percent removal	Chromium III: pH	Chromium VI: Concentration, µg/L: Initial	Chromium VI: Concentration, µg/L: Final	Chromium VI: Percent removal	Chromium VI: pH
Activated alumina								
Activated carbon								
Activated carbon (granular)					3,000	500	98	6.0
Activated carbon (pulverized, Pittsburgh type RC)					10,000, 10,000	1,500, 400	85, 96	3.0, 2.0
Activated carbon/alum								
Alum								
Alum/filter								
Bisulfite reduction						50-1,000		
Caustic soda/filter								
Chlorine precipitation (alkaline chlorination in presence of cyanide)								
Ferric chloride								
Ferric chloride/filter								
Ferric sulfate			>98	6.5-9.3				
Ferric sulfate/filter	5,000	50	99					
Ferrite coprecipitation					500	BDL		
Ferrite coprecipitation/filter	10,000	<10						
Ferrous sulfate/filter								
Ferrous sulfide (Sulfex)								
Lime	15,000, 3,200	100, <100		9.5				
Lime softening		150	>98	10.6-11.3				
Lime/ferric chloride/filter								
Lime/filter	5,000,[c], 5,000[d]	100,[c] 100,[d] 50	98,[c] 98[d]	10,[c] 11.5,[d] 7-9				
Lime/sulfide								
Reduction/lime	140,000,[e] 1,300,000[e]	1,000,[f] 60[f]		7-8				
Sodium carbonate/filter								
Sodium hydroxide								
Sodium hydroxide/filter								
Sulfide								
Sulfide precipitation								
Sulfide/filter								
Sulfur dioxide reduction						50-1,000		

(continued)

TABLE 5-87 (continued)

	Lead			
	Concentration, µg/L		Percent	
Treatment technology	Initial	Final	removal	pH
Activated alumina				
Activated carbon				
Activated carbon (granular)				
Activated carbon (pulverized, Pittsburgh type RC)				
Activated carbon/alum				
Alum				
Alum/filter				
Bisulfite reduction				
Caustic soda/filter				
Chlorine precipitation (alkaline chlorination in presence of cyanide)				
Ferric chloride				
Ferric chloride/filter				
Ferric sulfate				
Ferric sulfate/filter				
Ferrite coprecipitation				
Ferrite coprecipitation/filter	475,000	10	99.9	
Ferrous sulfate/filter	5,000	75	98.5	6.0
Ferrous sulfide (Sulfex)	189,000	100	99.9	8.5-9.0
Lime				
Lime softening				
Lime/ferric chloride/filter				
Lime/filter	189,000, 5,000,[c] 5,000[d]	100, 75,[c] 100[d]	99.9, 98.5,[c] 98.0[d]	8.5-9.0, 10,[c] 11.5[d]
Lime/sulfide				
Reduction/lime				
Sodium carbonate/filter	1,260,000, 5,000	600, 10-30	>99, >99	10.1, 9.0-9.5
Sodium hydroxide				
Sodium hydroxide/filter	1,700,000	600	>99	10.5
Sulfide				
Sulfide precipitation				
Sulfide/filter				
Sulfur dioxide reduction				

(continued)

TABLE 5-87 (continued)

Treatment technology	Mercury II Concentration, µg/L Initial	Final	Percent removal	pH
Activated alumina				
Activated carbon	10-50, 60-90	<0.5-60		
Activated carbon (granular)				
Activated carbon (pulverized, Pittsburgh type RC)				
Activated carbon/alum	20-30	9		
Alum				
Alum/filter				
Bisulfite reduction				
Caustic soda/filter				
Chlorine precipitation (alkaline chlorination in presence of cyanide)				
Ferric chloride				
Ferric chloride/filter				
Ferric sulfate				
Ferric sulfate/filter				
Ferrite coprecipitation	6,000-7,400	1-5	99.9	
Ferrite coprecipitation/filter				
Ferrous sulfate/filter				
Ferrous sulfide (Sulfex)				
Lime				
Lime softening				
Lime/ferric chloride/filter				
Lime/filter				
Lime/sulfide				
Reduction/lime				
Sodium carbonate/filter				
Sodium hydroxide				
Sodium hydroxide/filter				
Sulfide	300-50,000, 10,000	10-120, 1,800	-,[g], 96.4	10.0
Sulfide precipitation				
Sulfide/filter	16,000, 36,000, 300-6,000	40, 60, 10-125	99, 99.8, 87-99.2	5.5, 4.0, 5.8-8.0
Sulfur dioxide reduction				

(continued)

TABLE 5-87 (continued)

Treatment technology	Nickel				Silver			
	Concentration, μg/L		Percent		Concentration, μg/L		Percent	
	Initial	Final	removal	pH	Initial	Final	removal	pH
Activated alumina								
Activated carbon								
Activated carbon (granular)								
Activated carbon (pulverized, Pittsburgh type RC)								
Activated carbon/alum								
Alum								
Alum/filter								
Bisulfite reduction								
Caustic soda/filter		300		11.0				
Chlorine precipitation (alkaline chlorination in presence of cyanide)					105,000-250,000	1,000-3,500	>97	
Ferric chloride								
Ferric chloride/filter					500	40	98.2	6.2
Ferric sulfate					150	30-40	72-83	6-9
Ferric sulfate/filter								
Ferrite coprecipitation								
Ferrite coprecipitation/filter								
Ferrous sulfate/filter								
Ferrous sulfide (Sulfex)	75,000	<50	99.9	8.5-9.0				
Lime	75,000	1,500	98	8.5-9.0				
Lime softening					150	10-30	80-93	9.0-11.5
Lime/ferric chloride/filter								
Lime/filter	5,000,[c] 5,000[d]	300,[c] 150[d]	94,[c] 97[d]	10.0,[c] 11.5[d]				
Lime/sulfide								
Reduction/lime								
Sodium carbonate/filter								
Sodium hydroxide					54,000	15,000	72	9.0
Sodium hydroxide/filter								
Sulfide								
Sulfide precipitation							very high	5-11
Sulfide/filter								
Sulfur dioxide reduction								

(continued)

TABLE 5-87 (continued)

Treatment technology	Selenium Concentration, μg/L Initial	Selenium Concentration, μg/L Final	Selenium Percent removal	Selenium pH	Thallium Concentration, μg/L Initial	Thallium Concentration, μg/L Final	Thallium Percent removal	Thallium pH
Activated alumina								
Activated carbon								
Activated carbon (granular)								
Activated carbon (pulverized, Pittsburgh type RC)								
Activated carbon/alum								
Alum								
Alum/filter	500	260	48	6.4	600	400	31	6.4
Bisulfite reduction								
Caustic soda/filter								
Chlorine precipitation (alkaline chlorination in presence of cyanide)								
Ferric chloride								
Ferric chloride/filter	100, 50	30, 10	75-80	6.2, 6.2	600	400	30	6.2
Ferric sulfate	100, 100	20, 30	82, 75	5.5, 7.0				
Ferric sulfate/filter								
Ferrite coprecipitation								
Ferrite coprecipitation/filter								
Ferrous sulfate/filter								
Ferrous sulfide (Sulfex)								
Lime								
Lime softening								
Lime/ferric chloride/filter								
Lime/filter	500, 60	300-40	35, 38	11.5, 11.5	500	200	60	11.5
Lime/sulfide								
Reduction/lime								
Sodium carbonate/filter								
Sodium hydroxide								
Sodium hydroxide/filter								
Sulfide								
Sulfide precipitation								
Sulfide/filter								
Sulfur dioxide reduction								

(continued)

TABLE 5-87 (continued)

Treatment technology	Zinc: Concentration, μg/L, Initial	Zinc: Concentration, μg/L, Final	Zinc: Percent removal	Zinc: pH
Activated alumina				
Activated carbon				
Activated carbon (granular)				
Activated carbon (pulverized, Pittsburgh type RC)				
Activated carbon/alum				
Alum				
Alum/filter				
Bisulfite reduction				
Caustic soda/filter				
Chlorine precipitation (alkaline chlorination in presence of cyanide)				
Ferric chloride				
Ferric chloride/filter				
Ferric sulfate				
Ferric sulfate/filter				
Ferrite coprecipitation	18,000	20	>99	
Ferrite coprecipitation/filter				
Ferrous sulfate/filter				
Ferrous sulfide (Sulfex)	3,600	10-20	>99	8.5-9.0
Lime				
Lime softening				
Lime/ferric chloride/filter				
Lime/filter	3,600, 16,000, 5,000,[c] 5,000[d]	250, 20-230, 800,[c] 1,200[d]	93, -, 84,[c] 77[d]	8.5-9.0, -, 10.0,[c] 11.5[d]
Lime/sulfide				
Reduction/lime				
Sodium carbonate/filter				
Sodium hydroxide	33,000	1,000	97	9.0
Sodium hydroxide/filter				
Sulfide	42,000	1,200	97	
Sulfide precipitation				
Sulfide/filter				
Sulfur dioxide reduction				

[a] Activated alumina (2 g/L).

[b] Activated carbon (3 mg/L).

[c] Lime (260 mg/L).

[d] Lime (600 mg/L).

[e] Concentration as chromium VI.

[f] Concentration as chromium III.

[g] Percent removal unavailable due to form of data.

Note: Blanks indicate no data available.
Multiple tests are reported, if available, with values separated by commas.

II.5.4.2 Chlor-Alkali Industry

Mercury Cells

Existing chlorine plants using mercury cells are already controlling mercury in their wastewaters in response to current regulations which call for a discharge of less than 0.00014 kg/Mg of product as a 30-day average. Potential candidates for further control are the common heavy metals: chromium, nickel, zinc, copper, lead, and antimony, as well as arsenic, thallium, and asbestos, most of which respond to the sulfide process for mercury precipitation. Some of these metals represent corrosion products from reaction between chlorine and the plant materials of construction.

With the phasing out of graphite anodes, chlorinated organics are not common constituents of mercury cell wastewaters, although some may originate by the contact of chlorine with rubber linings and other organic structural components. Traces of certain toxic organics were found but none in significant concentrations.

Air pollutant emissions, generally called tail gas emissions, are a result of noncondensable gas emissions and often have high chlorine concentrations. These emissions are normally scrubbed with caustic soda or lime solution to produce hypochlorite which may be sold, decomposed to chloride, sent to the water treatment plant, or discharged without treatment. Other scrubbing processes often used include steam and vacuum stripping, and chlorine absorption columns.

There are many water treatment practices used to reduce the pollutant concentrations in chlor-alkali wastewater. Most of the toxic pollutants can be essentially removed by sulfide precipitation followed by settling or filtration. However, chromium and asbestos are not affected by such treatment. Alkaline precipitation controls all of the heavy metals with varying degrees of removability at a given pH. Mercury levels are generally controlled by mercury sulfide precipitation as a result of treatment with hydrochloric acid and sodium bisulfide. Other technologies currently being practiced on a limited scale include ferrous chloride reduction, activated carbon absorption, ion exchange, and chemical treatment with sodium bisulfite, sodium hydrosulfide, sodium sulfide, and sodium borohydride.

Tables 5-88 and 5-89 show the effluent loadings for treated effluent emanating from mercury cell chlor-alkali manufacturing facilities.

TABLE 5-88. EFFLUENT LOADINGS FROM SELECTED CHLOR-ALKALI MERCURY CELL PLANTS [1] (kg/Mg)

Plant	Mercury waste load		
	Average	Maximum daily	Maximum 30-day average
343	0.000025	0.00094	0.00029
907	0.00002	0.00026	0.00003
898	0.00006	0.0025	0.00043
195	0.00004	0.00073	0.00015
106	0.000065	0.00022	0.000096
747	0.000055	0.00008	0.000067
589	0.000055	0.00086	0.00049
299	0.00004	0.00019	0.000056
747[a]	0.000055	0.000083	0.000065
317[a]	0.000006	0.000048	0.00001
195[a]	0.000022	0.00066	0.0001
324[a]	0.00086	0.0022	0.0018

[a]From plant long-term monitoring data.

TABLE 5-89. EFFLUENT TOXIC POLLUTANT LOADS FOLLOWING MERCURY TREATMENT[a] [1] (kg/Mg)

Flow, m³/Mg: 0.23, plant 747; 2.8, plant 106; 0.41, plant 317; 1.5, plant 299

Pollutant	Plant			
	747	106	317	299
Antimony	<0.059	1.6	<0.10	0.22
Arsenic	<0.002	<0.015	<0.008	0.092
Cadmium	0.03[b]	<0.039	<0.01	0.11
Chromium	<0.011	<0.028	<0.02	0.09
Copper	<0.006	0.15	<0.012	0.055
Lead	0.016	1.05[b]	0.07	<0.074
Nickel	<0.011	0.40	<0.028	<0.074
Silver	<0.0035	0.72	<0.006	0.022
Thallium	<0.01	0.71	<0.1	0.3
Zinc	<0.006	<0.23	0.21	0.15

[a]Results of 3-day verification sampling.

[b]Effluent load higher than influent load.

Diaphragm Cells

Existing regulations in diaphragm cell-graphite anode chlorine plants call for lead discharge to be less than 0.0025 kg/Mg as a 30-day average. Other toxic pollutants to be controlled include asbestos, antimony, arsenic, chromium, copper, nickel, and chlorinated organics.

The use of graphite anodes, in either mercury cell or diaphragm cell plants, results in the generation of a variety of simple chlorinated hydrocarbons as a result of the attack of the product chlorine on the anodes. These organic pollutants are sometimes produced by the reaction of the chlorine with process exposed rubber.

Toxic heavy metals are normally controlled by sulfide or carbonate precipitation. Asbestos is trapped in a chemical flocculant or may be settled or filtered to remove the toxic fibers. Chlorinated organics are normally controlled by a reboiler on the chlorine purifier or by a vacuum stripper. Carbon absorption and steam stripping are also used for this purpose.

Alternate metal removal methods include ion exchange and xanthate precipitation. Hydrocarbons may be removed by waste incineration. Membrane separation for metal control has not proven to be a viable alternative.

Table 5-90 gives a subcategory profile of treatment processes used at reported plants for the diaphragm cell subdivision of the chlor-alkali industry. Table 5-91 shows the lead wasteload and the removal efficiency of a lead treatment facility associated with graphite anode-diaphragm cell plant 967.

TABLE 5-90. EFFLUENT LOADINGS - CHLOR-ALKALI DIAPHRAGM CELL PLANTS [1] (kg/Mg)

	Lead waste load		Suspended solids waste load	
Plant	Average	Maximum	Average	Maximum
589[a]	0.002	0.030		
738[a]	0.001	0.015		
261[a]	0.0025	0.019		
014[a]	0.006	-	2.81	-
967	0.0085	0.024		

[a]Plant uses metal anodes.

TABLE 5-91. TOXIC POLLUTANT REMOVAL AT LEAD TREATMENT FACILITY, PLANT 967 [1]

Flow: 1.0 m^3/Mg

Pollutant	Pollutant load, kg/Mg: Influent average	Pollutant load, kg/Mg: Effluent average	Removal, percent
Antimony	0.00078	0.00005	93.6
Arsenic	0.00032	0.00037	-[a]
Chromium	0.00016	0.00005	68.7
Copper	0.0049	0.00003	99.4
Mercury	0.000026	0.00005	-[a]
Nickel	0.00069	<0.00005	>92.8
Zinc	0.0016	<0.0001	>93.8
Lead	0.733	0.029	96.0
Thallium	<0.00004	0.00015	-[a]

[a]Negative removal.

II.5.4.3 Chrome Pigments Industry

The toxic pollutants found within the chrome pigments industry in significant amounts are the heavy metals often found in chromium ore, including chromium, antimony, copper, cadmium, nickel, lead, and zinc. In some raw wastes, ferro- and ferricyanide are found, presumably from metal complexing steps in the ore processing and the manufacture of iron blues. These complex cyanides may pass through the treatment processes and could slowly revert to simple cyanide ions.

All of the common heavy metals (except hexavalent chromium) found in chrome pigment wastes are normally treated by alkaline precipitation with substances such as lime or caustic soda, although the optimum pH may differ from each metal. Reaction with sulfide compounds such as sodium bisulfide precipitates the same metals, but in a less pH-dependent manner and, with the exception of chromium, to lower concentrations. Chromium in its hexavalent form is reduced to its trivalent form by SO_2 reduction and then precipitated as chromium hydroxide at a pH above 10. Ion exchange, biological oxidation, filtration, and settling are other treatment methods used for pollutant reduction within this industry.

Table 5-92 shows treated effluent verification data for plant 894 of this subcategory.

TABLE 5-92. VERIFICATION SAMPLING OF CHROME PIGMENTS PLANT 894 [1]

Average flow: 153 m^3/Mg

Pollutant	Influent µg/L	Influent kg/Mg	Effluent µg/L	Effluent kg/Mg	Percent removal
TSS	780,000	119	3,900	0.60	99.5
Chromium	78,000	11.9	320	0.05	99.6
Chromium VI	<10	<0.0015	<30	0.005	-[a]
Iron	49,000	7.5	300	0.046	99.4
Lead	15,200	2.3	110	0.017	99.3
Zinc	4,200	0.64	58	0.009	98.6
Cyanide	5,100	0.78	<66	0.010	98.7
Cyanide (free)	<940	0.14	<11	<0.0017	98.8
Antimony	740	0.11	300	0.046	59.5
Cadmium	900	0.14	8.4	0.0013	99.1
Copper	3,560	0.54	40	0.006	98.9
Nickel	17	0.003	<24	<0.0037	-[a]

[a]Negative removal.

II.5.4.4 Copper Sulfate Industry

The toxic pollutants found in copper sulfate plant wastewaters are closely related to the purity of the copper and acid sources. The heavy metals (cadmium, nickel, and zinc) which were found during field sampling may originate as trace impurities in copper scrap. Arsenic was found at one plant in wastewater containing floor washings and infiltrated groundwater. A possible source of arsenic, and other copper ore trace metals, is the use of sulfuric acid made from sulfur dioxide produced in the roasting of copper sulfide ore. In any event, it appears that copper, arsenic, cadmium, nickel, and zinc are typical toxic pollutants encountered in copper sulfate wastewaters.

Copper, nickel, cadmium, and zinc can be separated from solution by alkaline precipitation at pH values from 7.2 (copper) to 9.7 (cadmium). Arsenic levels are also reduced by this treatment at high pH levels. Other technologies currently employed include aeration, clarification, gravity separation, centrifugation, and filtration.

Metal removal from plant wastewaters could also be accomplished by sulfide precipitation, ion exchange from clarified solutions, or the xanthate process. Arsenic removal can also be achieved by the addition of ferric chloride during alkaline or sulfide precipitation.

Table 5-93 shows verification data for the raw waste, treated effluent, and removal efficiencies for plant 034.

TABLE 5-93. VERIFICATION SAMPLING OF COPPER SULFATE PLANT 034 [1]

Flow: 2.23 m^3/Mg

Pollutant	Raw waste		Treated effluent[a]		Percent removal
	μg/L	kg/Mg	μg/L	kg/Mg	
TSS	39,200	0.087	35,000	0.078	10.7
Copper	1,850,000	4.1	4,650	0.010	99.7
Nickel	112,000	0.248	240	0.0005	99.8
Antimony	330	0.0007	36	0.000079	89.1
Arsenic	3,500	0.0078	<20	0.000044	>99.4
Cadmium	870	0.0019	1	0.000002	99.9
Chromium	142	0.00038	5	0.00001	96.5
Lead	180	0.00039	5	0.00001	97.2
Selenium	<11	0.000024	100	0.00022	-[b]
Zinc	11,100	0.025	16	0.000035	99.8

[a]Before combining with noncontact cooling and steam condensate streams.

[b]Negative removal.

II.5.4.5 Hydrofluoric Acid Industry

Toxic pollutants in raw wastewaters and slurries typical of the hydrogen fluoride industry include the heavy metals zinc, lead, nickel, mercury, chromium, arsenic, copper, and selenium, which are often found as impurities in fluorspar. Raw wastewaters from plants practicing dry disposal of kiln wastes may include some of the heavy metals in scrubber and area washdown wastes, but in considerably smaller amounts, since the spent ore is hauled as a solid waste and bypasses the wastewater treatment facilities. Although a fluoro-sulfonate complex is found in hydrofluoric acid wastes containing drip acid, organic compounds are not anticipated in wastewaters from this industry.

Raw wastewater from this industry is presently being treated by alkaline precipitation, settling, filtration, clarification, and complete recycle of wastewater.

Treatment methods currently under study or feasible due to other industry applications include sulfide precipitation, xanthate process, and ion exchange from clarified solutions. Sulfide precipitation from cleared solutions will control zinc, lead, nickel, copper, and, to a lesser extent, antimony.

Tables 5-94 and 5-95 present treated effluent and waste influent-treated effluent comparisons for several hydrofluoric acid manufacturing plants.

TABLE 5-94. TOXIC POLLUTANT REMOVAL AT HYDROFLUORIC ACID PLANTS[a] [1]
(kg/Mg)

Flow,[b] m^3/Mg: 62.1, plant 705; 127, plant 167

Pollutant	Plant 705		Plant 167	
	Influent	Effluent	Influent	Effluent
Antimony	0.00065	0.00012	0.0058	<0.026[c]
Arsenic	0.0025	<0.0006	0.019	<0.003
Cadmium	0.0006	0.0001	-	<0.0003
Chromium	0.024	0.0029	0.060	0.032
Copper	0.018	0.0012	0.015	0.010
Lead	0.0031	0.0014	0.011	0.0047
Mercury	0.00036	0.00003	0.0034	<0.00015
Nickel	0.035	<0.0006	0.14	0.077
Selenium	-	0.0003	0.008	0.011[c]
Thallium	0.00016	0.00007	-	0.0010
Zinc	0.015	0.0033	0.031	0.023

[a]Values are for combined wastes from HF and AlF_3.
[b]Values are for total raw waste from HF only.
[c]Negative removal.

TABLE 5-95. SUMMARY OF EFFLUENT QUALITY ATTAINED AND VARIABILITY OBSERVED AT FOUR REPRESENTATIVE HYDROFLUORIC ACID PLANTS [1]

Parameter	Treated waste load			Flow, m^3/Mg (gal/short ton)
	pH	Fluoride, kg/Mg	TSS, kg/Mg	
Plant 664				
Daily average	6.8	0.10	0.29	5.6 (1,340)
Daily maximum	2.9 - 7.7	0.34	1.1	16 (3,760)
Monthly average	6.8	0.10	0.27	5.6 (1,340)
Monthly maximum	5.0 - 7.5	0.16	0.63	10.5 (2,500)
Plant 753				
Daily average		0.72	0.38	
Daily maximum		2.0		
Monthly average		0.64		11 (2,650)
Monthly maximum		0.76		
Plant 722				
Daily average	9.0	0.81	0.54	10.2 (2,450)
Daily maximum	2.8 - 12.2	2.6	1.2	24 (5,760)
Monthly average				
Monthly maximum				
Plant 705				
Daily average				
Daily maximum				
Monthly average		0.49	0.84	26.8 (6,430)
Monthly maximum		0.8	1.53	139 (33,400)

Note: Blanks indicate no data available.

II.5.4.6 Hydrogen Cyanide Industry

The only toxic pollutant found during field sampling within the hydrogen cyanide industry was cyanide, both oxidizable and in the form of metallic complexes such as ferro- and ferricyanides. Ammonia, which is present as a nonconventional pollutant, exerts a demand for the chlorine used to oxidize cyanide and should be removed by steam stripping.

Cyanide is decomposed readily by oxidation at high pH levels, forming cyanate as an intermediate product. Further decomposition into carbon dioxide and nitrogen is possible with complete oxidation. Alkaline chlorination is widely used in the electroplating industry to break down metallic cyanide complexes. Although oxidation agents such as hydrogen peroxide might be used, their operating costs are generally not favorable. If ammonia is present, it increases the cost of chlorination since it also reacts with the chlorine. If ammonia is not to be controlled, ozonation may prove to be a more cost effective oxidant.

Due to excess chlorine usage, the discharge from cyanide destruction is high in chlorine, and dechlorination is generally needed. Biological treatments such as aeration and trickling filtration are used to reduce the chlorine concentration in the raw wastewater. Other technologies often used include sodium hypochlorite treatment, API separators, and caustic adjustment.

Ozonation to oxidize the chlorine in the wastewater is currently under study for use as a treatment method within this industry. Sulfur dioxide is also a potential treatment technology.

Table 5-96 shows raw waste and treated effluent verification data and removal efficiencies for plants 765 and 782.

TABLE 5-96. VERIFICATION SAMPLING OF HYDROGEN CYANIDE PLANTS [1]

Flow, m^3/Mg: 57, plant 765; 6.25, plant 782

Plant code	Pollutant	Influent mg/L	Influent kg/Mg	Effluent, mg/L	Percent removal
765	TSS[a]	71	6.52	19	73.2
	Cyanide (total)	28.4	2.61	<0.0026	>99.9
	Cyanide (free)	6.81	0.626	<0.002	>99.9
	BOD	6.3	0.580	<33	-[b]
	Ammonia	194	17.8	124	36.1
782	TSS	110	2.87	74	32.7
	Cyanide (total)	31	0.808	2.2	92.9
	Cyanide (free)	19.0	0.495	1.73	90.9
	BOD	1,550	40.3	376	75.7
	Ammonia	1,380	36.0	5.04	99.6

[a]Average for 2 days only.

[b]Negative removal.

II.5.4.7 Nickel Sulfate Industry

The toxic pollutants present in a specific process operation depend upon the sources and nature of the raw materials being used, which presumably could vary from time to time. If impure raw materials include spent plating solutions, most of the heavy metals will be rejected from the process as sludges by the purification of the plating solutions prior to nickel sulfate production. The sludge produced may be handled as a solid or slurry waste, with the former being safely landfilled and the latter being treated and settled in treatment facilities. The only significant toxic pollutant found in the sampling program was nickel.

Alkaline precipitation will remove nickel and most other heavy metals from solution, allowing them to be settled and filtered in successive steps. Nickel and the common heavy metals, except chromium, can also be precipitated as metallic sulfide, for later separation by settling and filtration.

Table 5-97 shows raw waste and treated effluent characteristics and removal efficiency for plant 120.

TABLE 5-97. VERIFICATION SAMPLING OF WASTE CHARACTERISTICS AND TREATED EFFLUENT QUALITY OF NICKEL, SULFATE PLANT 120 [1]

Flow: 0.72 m^3/Mg

	Raw waste				Treated effluent quality, μg/L		
	μg/L		kg/Mg				Percent
Pollutant	Average	Maximum	Average	Maximum	Average	Maximum	removal[a]
TSS	43,000	64,000	0.842	1.25	4,330	8,000	89.9
Nickel	49,200	75,800	0.96	1.48	200	340	99.6

[a] Based on raw waste and treated effluent average values.

II.5.4.8 Sodium Bisulfite Industry

Toxic pollutants should not normally be present in wastes originating solely from the manufacture of sodium bisulfite from sodium carbonate and sulfur dioxide. However, it is reported that some sources of sodium carbonate contain zinc and other trace metals in measurable amounts. Dissolved zinc was found in some sodium bisulfite wastewaters during the sampling program. It may be assumed that zinc enters the wastestream by corrosion of galvanized metals from coproduct operations, or from non-process zinc compounds used by the industry.

Raw wastewater from this industry is generally treated by alkaline precipitation to remove the toxic metal pollutants. Lime, sodium carbonate, and caustic soda are normally used for this treatment, which is usually followed by a settling basin. Sodium hypochlorite may also be used as a treatment chemical.

Three other treatment methods may also be feasible for this industry: sulfide precipitation, which readily precipitates zinc from solution; ion exchange from clarified solutions; and the xanthate process.

Table 5-98 shows treated effluent verification data for plants 282 and 586.

TABLE 5-98. TREATMENT PRACTICES AND VERIFICATION SAMPLING AT SODIUM BISULFITE PLANTS [1]

Flow, m^3/Mg: 2.67, plant 282; 17, plant 586

		Treated effluent					
		TSS		COD		Zinc	
Plant	Treatment	mg/L	kg/Mg	mg/L	kg/Mg	μg/L	kg/Mg
282	Caustic neutralization, sodium hypochlorite oxidation	159	0.424	979	2.61	2,540	0.0068
586[a]	Lime pH adjustment, aeration, and settling	22.7		115		59	

[a]Combined treatment with other process wastes.

Note: Blanks indicate data not available.

II.5.4.9 Sodium Dichromate Industry

Toxic pollutants found within the sodium dichromate industry in significant amounts are the primary pollutant, hexavalent chromium, and the common heavy metals often present as impurities in the chromium ore, notably zinc and nickel. By controlling chromium, the incidental removal of other trace heavy metals will also be achieved.

Alkaline precipitation and reaction with sulfite are two methods used to separate nickel and zinc from solution. Hexavalent chromium must be reduced to its trivalent form by reacting with sodium bisulfide before it can be precipitated by alkaline substances. Clarification, filtration, and settling are also used as control technologies.

Although ion exchange or xanthates can remove metals from clarified solutions, they are inappropriate for treating raw waste slurries from this industry.

Table 5-99 shows chromium and suspended solids effluent waste loadings and a brief description of the waste treatment practices. Table 5-100 shows verification toxic pollutant data for treated effluent from plants 398 and 493.

TABLE 5-99. EFFLUENT CONTROL AND TREATMENT PRACTICES AND ACHIEVEMENTS AT SODIUM DICHROMATE PLANTS [1]

			Effluent waste load, kg/Mg					
			Chromium		Chromium VI		TSS	
Plant	Control and Treatment practice	pH	Average	Maximum	Average	Maximum	Average	Maximum
398	Once-through cooling water, dispose of ore residue as solid, no treatment of cooling water discharge.	6.6 t0 8.5			0.0079	0.034		
493	Recirculate cooling water, slurry ore residue, treat all wastes with pickle liquor, counter-current solids wash, clarify and filter effluent.	6.3 to 8.3	0.00038	0.0049		0.00018	0.1	0.3
376	Recirculate cooling water, slurry or residue, treat all wastewater with sodium sulfide, remove solids in settling ponds.		0.00058	0.0017		0.00058	0.047	0.69

TABLE 5-100. VERIFICATION SAMPLING OF SODIUM DICHROMATE PLANTS [1]

Flow, m^3/Mg: 584, plant 398; 3.8, plant 493

Pollutant	Plant 398[a] treated effluent, kg/Mg	Plant 493 Raw waste, kg/Mg	Plant 493 Treated effluent µg/L	Plant 493 Treated effluent kg/Mg
TSS	2.05	140	2,000	0.0075
Chromium VI	43.9	2.64	4	0.000016
Chromium	-[b]	0.95	2,500	0.0094
Nickel	0.049	0.047	90	0.00034
Zinc	0.0009	0.002	110	0.00041
Copper	0.013	0.00005	16	0.00006

[a]No treatment, only cooling water outfalls.

[b]Less than supply water of 495 µg/L.

II.5.4.10 Sodium Hydrosulfite Industry

Although sodium hydrosulfite is being manufactured by both the zinc process and the formate process, the trend is away from the zinc process for environmental reasons. This discussion concerns only the formate process, using a sodium formate feedstock from a source which appears to contain significant heavy metal impurities (chromium, zinc, nickel, lead, and copper), as well as trace amounts of cyanide. A predominant characteristic of sodium hydrosulfite wastes is their high chemical oxygen demand resulting from various forms of sulfite, from methyl formate, and from residual methanol after a solvent recovery process. Low levels of phenolic compounds are also found in the raw wastes.

The significant heavy metals appear largely in a coproduct wastestream which is often sold for use in the pulp and paper industry. When no market exists, these wastes are bled into the product wastes.

Practical technologies for controlling COD include various forms of mechanical and biological oxidation. For the relatively simple chemical oxidation of sulfite to sulfate, intimate contact with atmospheric oxygen is effective, using submerged air diffusers, induced air in a circulating system, or mechanical surface aeration. For biochemical oxidation of resistant organics such as formates, phenols, chlorinated hydrocarbons, and methanol, trickling filtration, rotating biological discs, or variations of the activated sludge process can provide intimate contact between organic pollutants and the microbiological organisms which use them as food.

Technologies for controlling heavy metals include alkaline precipitation, which is effective for the common heavy metals, and sulfide treatment, which precipitates nickel, zinc, and copper, but does not control chromium without a subsequent pH increase.

In this subcategory an exception is made to the assumed exclusion of sanitary sewage from the wastestream. To utilize the nutrients and bacteria present in sewage as support for a biological oxidation system to control organics and COD, the plant sanitary wastes are included in the biological treatment.

Vent scrubber water containing methanol is also treated by the above processes.

Table 5-101 shows concentrations, loadings, and the removal efficiency for conventional and toxic pollutants for plant 672.

TABLE 5-101. SCREENING RESULTS FROM SODIUM HYDROSULFITE PLANT 672 [1]

Flow, m^3/Mg: 1.87, influent; 4.68, effluent[a]

Pollutant	Raw waste influent µg/L	Raw waste influent kg/Mg	Treated effluent µg/L	Treated effluent kg/Mg	Percent removal
COD	15,500,000	29.0	740,000	3.46	95.2
TSS	840,000	1.58	25,000	0.12	97.0
Zinc	5,800	0.011	120	0.00057	97.9
Chromium	7,400	0.014	<43	<0.0002	>99.4
Copper	1,000	0.0019	28	0.00013	97.2
Lead	830	0.0015	70	0.00013	91.6
Nickel	1,400	0.0027	160	0.00075	88.6
Cadmium	37	0.000069	29	0.00014	11.7
Phenol	150	0.0003	<10	<0.00005	>93.4
Pentachlorophenol	37	0.0007	<10	<0.00005	>97.3

[a]Higher flow due to the addition of sanitary wastes and dilution water to the aeration basin, plus cooling tower and boiler blowdown to the chlorine contact tank.

II.5.4.11 Titanium Dioxide Industry

Toxic pollutants to be controlled in this industry are the common heavy metals found in the ore (i.e., chromium, lead, nickel, and zinc). Although coke and certain proprietary organic complexing agents are used in the chloride process, the amount of chlorinated organic toxic pollutants produced is insignificant and pollutants are found in all ores, nor are they found in all plants utilizing the same process.

Alkaline substances and sulfide compounds are used to control the heavy metals by precipitation as metallic hydroxides, carbonates, or sulfides. Lime neutralization also reduces the concentration of arsenic in the wastewater, although the removal mechanism is not known. Dissolved air flotation, settling, filtration, and centrifuging are a few of the physical methods used for pollutant control.

Among potential treatment technologies, ion exchange can remove metals from clarified solutions, but it is seldom specific enough to remove only the trace metals and is not effective in solutions saturated with calcium. Lime treatment combined with ferric iron may be the most effective means of controlling arsenic concentrations.

Table 5-102 and Table 5-103 show verification effluent data for the chloride process and sulfate process, respectively.

TABLE 5-102. FLOW AND POLLUTANT CONCENTRATION VERIFICATION DATA OF THE SAMPLED WASTESTREAMS FOR PLANTS PRODUCING TITANIUM DIOXIDE (CHLORIDE PROCESSES) [1]

Average flow, m^3/Mg: 35.9, plant 172; 13.9, plant 559

	Plant 172			Plant 559[a]	
	Raw waste,	Treated effluent		Raw waste,	Treated effluent,
Pollutant	kg/Mg	µg/L	kg/Mg	kg/Mg	µg/L
TSS	6.06	6,670	0.245	95.9	23,000
Iron	0.104	327	0.012	18.7	4,400
Chromium	0.024	17	0.00062	1.55	25
Lead	0.00004	<2.3	<0.000084	0.049	<2.3
Nickel	0.002	<10	<0.00037	0.048	5
Zinc	0.010	90	0.0033	0.027	61.7

[a] Loads in effluent not included because it includes other process water.

TABLE 5-103. SUMMARY OF DAILY EFFLUENT MONITORING VERIFICATION DATA FOR COMBINED WASTE WATER TREATMENT DISCHARGE AT TITANIUM DIOXIDE PLANT 559 (SULFATE PROCESS) [1]

Flow: 616 m^3/Mg[a]

	Raw waste, kg/Mg		Treated effluent		
			µg/L		Average,
Pollutant	Average	Maximum	Average	Maximum	kg/Mg
TSS	310	330	23,000	38,000	19.5
Total, iron	670	770	4,400	7,900	3.7
Antimony			<15	<15	<0.01
Arsenic	0.015	0.020	<10	<10	<0.008
Cadmium	0.008	0.001	0.1	0.2	0.0001
Chromium	5.0	5.6	25	30	0.02
Copper	0.13	0.14	<5	<5	<0.004
Lead	0.16	0.17	2	3	0.002
Nickel	0.19	0.22	<5	<5	0.004
Thallium	0.004	0.008	<5	<5	0.002
Zinc	0.72	0.76	61	65	0.05

[a] Includes cooling water and a small part of chloride process waste.

Note: Blanks indicate no data available.

II.5.5 REFERENCES

1. Draft Development Document for Inorganic Chemicals Manufacturing Point Source Category - BATEA, NSPS, and Pretreatment Standards (draft contractor's report). Contract 68-01-4492, U.S. Environmental Protection Agency, Effluent Guidelines Division, Washington, D.C., April 1979.

2. NRDC Consent Decree Industry Summary - Inorganic Chemicals Industry.

3. Supplement for Pretreatment to the Development Document for the Inorganic Chemicals Manufacturing Point Source Category. EPA-440/1-77/087A, U.S. Environmental Protection Agency, Washington, D.C., July 1977.

4. Development Document for Effluent Limitations Guidelines and NSPS for the Major Inorganic Products Point Source Category. EPA-440/1-74-007-a, U.S. Environmental Protection Agency, Washington, D.C., March 1974.

5. Environmental Protection Agency Effluent Guidelines and Standards for Inorganic Chemicals (40CFR415; 39FR9612, March 12, 1974; amended as shown in Code of Federal Regulations, Vol. 40, revised as of July 1, 1976; 41FR51599 and 51601, November 23, 1976; 42FR17443, April 1, 1977, 42FR10681, February 23, 1977; 42FR37294, July 20, 1977).

II.6 IRON AND STEEL MANUFACTURING

II.6.1 INDUSTRY DESCRIPTION [1-9]

II.6.1.1 General Description

The Iron and Steel Manufacturing Industry encompasses all operations under SIC codes 3312, 3315, 3316, and 3317. Within these classifications are establishments involved in the production of iron, steel, and those ferrous products which do not require machining (rolling and drawing are not considered machining operations for these classifications). It also includes ancillary processes necessary to the primary functions of the plants. Therefore, coke production, scale removal, pickling, and alkaline cleaning are all included in this industry. Excluded are those operations engaged in the manufacture of iron and steel castings, which are classified under group 332 of the SIC code.

There are 1,863 plants in this industry, but far fewer plant sites. Because of the interrelationships of these plants, there are frequently a large number of plants on a single site with the product of one plant serving as the feedstock for another through a series of operations that produce one or more final products (usually several). Depending on the subcategory, about 40% to 80% of the plants in this industry are located in Pennsylvania and Ohio. Approximately 75% to 85% of all plants are located in the states of Pennsylvania, Ohio, West Virginia, Kentucky, Indiana, Illinois, Michigan and Wisconsin. These plants are grouped around the coal and iron mining regions, where shipping distance of the needed raw materials is short and shipment is inexpensive. The remaining plants tend to be found in coastal portation costs also tend to be moderate (especially Alabama, California, Texas, and Georgia). Furthermore, all the states mentioned have sizable contiguous bodies of water available for use. There are a few plants in the arid region of the Southwest, but they must necessarily be among the portion of the industry with low or zero discharge rates.

Discharge rates in the industry vary from 0 to over 384 m^3/Mg (23,000 gal/ton) with a mean discharge of 30.5 m^3/Mg (1,827 gal/ton). Additional industry data are found in Table 6-1.

TABLE 6-1. INDUSTRY SUMMARY [10]

Industry: Iron and Steel Manufacturing
Total Number of Subcategories: 25
Number of Subcategories Studied: 24

Number of Dischargers in Industry:

- Direct: 1,405
- Indirect: 238
- Zero: 220

II.6.1.2 Subcategory Descriptions [1-10]

The following paragraphs briefly describe the 24 subcategories of this industry that were studied. Process descriptions, number of facilities, subdivisions, production capacity and wastewater discharge flow rates are included in this general description. The wire pickling and coating subcategory is not described in this section due to a lack of information. However, some categories address related subjects and may be referred to if information is needed.

Table 6-2 presents best practicable control technology pollutant data for each subcategory within this industry.

Cokemaking [2]

The production of metallurgical coke is an essential part of the iron and steel industry, since coke is one of the basic raw materials necessary for the operation of ironmaking blast furnaces. Cokemaking has been divided into the byproduct recovery cokemaking subcategory and the beehive cokemaking subcategory. Of the two traditional processes for the manufacture of coke, byproduct recovery has virtually eclipsed beehive oven in commercial application. Less than 1% of the metallurgical coke produced in 1977 was made in beehive ovens (four small plants in three states). The remaining 99% of coke production comes from coke plants practicing varying degrees of byproduct recovery (61 locations, some with 2 or 3 plants per location, in 17 different states).

Byproduct Recovery Coke. The byproduct recovery process, as the name implies, places emphasis not only on the production of high-quality coke for use as blast furnace or foundry fuels and carbon sources, but also provides a means for recovery of valuable byproducts of the distillation reaction. Air is deliberately excluded from the coking chambers, while heat for the distillation process is supplied from external combustion of fuel gases in flues located within dividing walls separating adjacent ovens.

TABLE 6-2. BPT LIMITATIONS FOR IRON AND STEEL MANUFACTURING[a] [11]

	Pollutant parameter						
Subcategory[b]	Oil and grease, kg/Mg	TSS, kg/Mg	Ammonia, kg/Mg	Cyanide, kg/Mg	Phenol, kg/Mg	Dissolved iron, kg/Mg	Zinc, kg/Mg
Byproduct coke	0.0327/0 0109	0.1095/0.0365	0 2736/0.0912	0 0657/0.0219	0.0045/0.0015		
Beehive coke[c]							
Sintering	0.0063/0.0021	0.0312/0.0104					
Blast furnace (iron)		0.0780/0 0260	0.1953/0.0651	0.0234/0 0078	0.0063/0 0021		
Blast furnace (ferromanganese)		0.3129/0.1043	1 5636/0.5212	0.4689/0.1563	0 0624/0.0208		
Basic oxygen furnace (semiwet air pollution control)[c]							
Basic oxygen furnace (wet air pollution control)		0.0312/0.0104					
Open hearth furnace		0.0312/0.0104					
Electric arc furnace (semiwet air pollution control)[c]							
Electric arc furnace (wet air pollution control)		0.0312/0.0104					
Vacuum degassing		0.0156/0.0052					
Continuous casting and pressure slab molding	0.0234/0.0078	0.0780/0.0260					
Hot forming-primary	0.0684/0.0288	0.1113/0.0371					
Hot forming-section	0.3285/0.1095	0.7260/0.2420					
Hot forming-flat	0.5004/0.1668	0.5004/0.1668					
Pipe and tube	0.1254/0.0418	0.4254/0.1418					
Pickling-sulfuric acid, batch and continuous	0.00312/0.00104	0.0156/0.0052				0.00033/0.00011	
Pickling-hydrochloric acid, batch and continuous	0.0039/0.0013	0.0189/0.0063				0.00039/0.00013	
Cold rolling	0.00312/0.00104	0.0078/0.0026				0.00030/0.00011	
Hot coating-galvanizing	0.1125/0.0375	0.3750/0.1250					0.0375/0.0125
Hot coating-terne	0.1125/0.0375	0.3750/0.1250					
Combination acid pickling (batch and continuous)	0.1251/0.0417	0.3129/0.1043				0.0126/0.0042	
Scale removal (kolene and hydride		0.1563/0.0521		0.0015/0.0005		0.0063/0.0021	
Wire pickling and coating	0.1251/0.0417	0.3129/0.1043		0.0030/0.0010		0.0126/0.0042	
Continuous alkaline cleaning		0.0156/0.0052				0.0006/0.0002	

(continued)

TABLE 6-2 (continued)

Subcategory[b]	Pollutant parameter: Dissolved chromium, kg/Mg	Hexavalent chromium, kg/Mg	Lead, kg/Mg	Tin, kg/Mg	Fluorine, kg/Mg	Dissolved nickel kg/Mg	Dissolved copper, kg/Mg	pH
Byproduct coke								6 to 9
Beehive coke[c]								
Sintering								6 to 9
Blast furnace (iron)								6 to 9
Blast furnace (ferromanganese)								6 to 9
Basic oxygen furnace (semiwet air pollution control)[c]								
Basic oxygen furnace (wet air pollution control)								6 to 9
Open hearth furnace								6 to 9
Electric arc furnace (semiwet air pollution control)[c]								
Electric arc furnace (wet air pollution control)								6 to 9
Vacuum degassing								6 to 9
Continuous casting and pressure slab molding								6 to 9
Hot forming-primary								6 to 9
Hot forming-section								6 to 9
Hot forming-flat								6 to 9
Pipe and tube								6 to 9
Pickling-sulfuric acid, batch and continuous								6 to 9
Pickling-hydrochloric acid, batch and continuous								6 to 9
Cold rolling								6 to 9
Hot coating-galvanizing	0.0225/0.0075	0.00015/0.00005						6 to 9
Hot coating-terne			0.00375/0.00125	0.0375/0.0125				6 to 9
Combination acid pickling (batch and continuous)	0.0063/0.0021				0.1878/0.0626	0.0030/0.0010		6 to 9
Scale removal (kolene and hydride	0.0030/0.0010	0.0003/0.0001						6 to 9
Wire pickling and coating	0.0063/0.0021				0.1878/0.0626	0.0030/0.0010	0.0030/0.0010	6 to 9
Continuous alkaline cleaning	0.0003/0.0001					0 00015/0.00005		6 to 9

Note: Blanks indicate no data available.

[a]Values are daily maximum/30-day average limitations.

[b]Although not a subcategory, miscellaneous runoffs from casting and slagging have the following BPT limitation: there shall be no discharge of process wastewater pollutants from casting and slagging to navigable waters (but the limitation does not apply to any operation in Mahoning Valley).

[c]There shall be no discharge of process wastewater pollutants to navigable waters

Volatile components are recovered and processed in a variety of ways to produce tars, light oils, phenolates, ammonium compounds, naphthalene, and other materials, including coke oven gas. A complete list of coal chemicals produced by byproducts coke plants appears in Table 6-3.

TABLE 6-3. COAL CHEMICALS PRODUCED BY U.S. BYPRODUCTS RECOVERY COKEMAKING PLANTS [2]

Crude coal tar
Crude light oils
Ammonium sulfate
Sodium phenolate or sodium carbolate
Toluene, all grades
Xylene, all grades
Intermediate light oils
Naphthalene, solidifying at <74°C
Naphthalene, solidifying at between 74°C and 79°C
Benzene, specification grades
Benzene, all other industrial grades
Solvent naphtha, all grades
Pitch-of-tar, soft (S.P. <43.3°C)
Pitch-of-tar, hard (S.P. >71.1°C)
Creosote oils, straight distillate
Creosote oils, in coal tar solutions
Enriched ammonia liquor (high NH_3 content)
Crude chemical oil (tar acid oils)
Mono- and diammonium phosphate
Phenol, industrial grades
Phenol, all other grades
Cresols
Cresylic acid
Picolines
Anhydrous ammonia
Elemental sulfur

Production capacities of the 59 byproduct recovery cokemaking plants range from 520 Mg/d (580 tons/d) to 21,000 Mg/d (23,000 tons/d), with a total annual capacity of 69,000,000 Mg (77,000,000 tons). The average raw wastewater flow for the byproduct recovery cokemaking subcategory is 0.38 m^3/Mg (92 gal/ton) of product.

Beehive Coke. The beehive process utilizes ovens in which carefully controlled quantities of air are admitted to the coking chambers so that the volatile products which distill from the coal are immediately burned, thus generating additional heat for further coking of the coal. No attempt is made to recover gases or other byproducts of this distillation process. The average raw wastewater flow for the beehive cokemaking subcategory is 1.5 m^3/Mg (370 gal/ton) of product.

This subcategory has been recommended as a Paragraph 8 exclusion under the NRDC Consent Decree.

<u>Sintering</u> [3]

The 35 sintering steel mills in the United States have an annual production capacity of 48,000,000 Mg (53,000,000 tons). Fourteen of these mills operate dry dust collecting systems and do not discharge wastewater; therefore they are not included in the data base for this report. Production capacity at the 21 wet sintering mills ranges from a minimum of 450 Mg/d (500 tons/d) to a maximum of 11,000 Mg/d (12,000 tons/d).

Sintering is an agglomeration process in which iron-bearing material, generally fines from various sources, is taken and mixed with finely divided fuel such as coke breeze. The mixture is placed on a traveling grate, the bed of raw feed mix is ignited on the surface, and, as the mixture moves along on the traveling grate, air is pulled down through the mixture (wind boxes) to enhance combustion and to sinter the fine ore particles into lumps. The combusted sinter drops off the traveling grate at the end of the machine and is then cooled, crushed, and screened before the proper size sinter is sent to the blast furnace. Improper size sinter is returned to the head of the sinter process.

Wastewater flow rates for this subcategory range from 0.11 m^3/Mg (26 gal/ton) to 39 m^3/Mg (9,300 gal/ton). Process water varies from 0.50 m^3/Mg (120 gal/ton) to 39 m^3/Mg (9,300 gal/ton).

<u>Blast Furnaces</u> [3]

Blast furnace operations produce both pig iron and ferromanganese iron. Therefore, there are two blast furnace subcategories, blast furnace-iron and blast furnace-ferromanganese. Only one furnace was found producing ferromanganese on a regular basis. The following description of blast furnace operations applies to both pig iron and ferromanganese furnaces, with the exception that ferromanganese ore is used in the latter.

Blast furnaces are large, cylindrical steel structures approximately 100 feet high. Iron is produced by combusting a mixture of iron ore, coke, and limestone which is fed periodically through the top of the furnace. Combustion is promoted by blowing heated air into the lower part of the furnace. As the raw materials melt and decrease in volume, the entire mass of the charge descends. Additional raw materials are added to keep the mass within the furnace at a constant level.

Cleaning of top gases produced in the furnace can be accomplished using a variety of wet or dry processes. One method uses one wet scrubber (primary), a second type uses two wet scrubbers (primary and secondary), and a third uses one wet scrubber and one dry air pollution control device.

There are 55 plants with blast furnace operations in the United States, most having more than one blast furnace, for a total of 174 blast furnaces. The annual capacity of the 55 plants is 109,000,000 Mg (120,000,000 tons). Productions range from 720 Mg/d (800 tons/d) to 20,000 Mg/d (22,000 tons/d).

<u>Basic Oxygen Furnaces</u> [4]

Basic oxygen furnace (BOF) steelmaking operations are divided into two subcategories: basic oxygen furnace-semiwet air pollution control, and basic oxygen furnace-wet air pollution control. The latter is further subdivided into open combustion and suppressed combustion.

All BOF furnace methods use pure oxygen to refine the hot metal (iron) and other metallics into steel by oxidizing and removing the elements present such as silicon, phosphorus, etc.

The basic oxygen furnace top blown steelmaking process is a method of producing steel in a pearshaped, refractory-lined, open-mouth furnace with a mixture of hot metal, scrap, and fluxes. Pure oxygen is injected at supersonic velocities through a water-cooled copper-tipped steel lance for approximately 25 minutes. As this process is exothermic, (heat generating), a definite percentage of steel scrap can be melted without use of external fuel. The general ratio is about 70% hot metal and 30% scrap.

The waste products from the basic oxygen process are heat, airborne fluxes, slag, carbon monoxide and dioxide gases, and oxides of iron (FeO, Fe_2O_3, Fe_3O_4) emitted as submicrometer dust.

The basic oxygen furnace is always equipped with some type of gas-cleaning system for containing and cooling the huge amounts of hot gases and collecting the submicrometer particulates produced. Water is always used to quench the offgases to temperatures where the gas-cleaning equipment can effectively handle them. Two main process types of gas-cleaning systems are used for the basic oxygen furnace, precipitators and venturi scrubbers, although a bag filter type installation is presently being installed for a BOF specialty steel producer.

There are 10 semiwet BOF steelmaking operations in the United States producing approximately 19,000,000 Mg (21,000,000 tons) annually; there are 13 wet-open combustion plants producing nearly 44,000,000 Mg (48,000,000 tons) annually; and there are 6 wet-suppressed combustion plants producing 15,000,000 Mg

(16,000,000 tons) annually. In 1976, the basic oxygen process accounted for about 63% of steel production.

Open Hearth Furnace [4]

The open hearth subcategory is subdivided into plants using semi-wet air pollution control methods (APCM) and wet APCMs. There are five open hearth facilities in the United States with only one facility using a semiwet APCM. Production capacity at these five plants ranges from 3,500 Mg/d (3,800 tons/d) to 9,100 Mg/d (11,000 tons/d).

The open hearth furnace steelmaking process is an old method of steel production. A shallow rectangular refractory basin or hearth enclosed by refractory-lined walls and roof is used. The front wall has water-cooled doors for charging raw materials. These raw materials may be all scrap, but the most common charge is a 50-50 mixture of hot metal and scrap steel. A tap hole is provided to drain the molten metal from the furnace.

Open hearth furnaces are normally equipped with some type of gas-cleaning system for cooling and scrubbing the hot gases emitted from the furnace. Dry, semiwet, and wet APCMs may be used. Semiwet systems generally consist of a spark box or spray chamber that cools the gas by water spray to approximately 280°C (550°F). The wet scrubber systems quench the gases emanating from the furnace by evaporation. If waste heat boiler tubes are used less heat is required to be removed. Scrubbers may be independently mounted or manifolded into a central system. Effluent from these process is discharged for treatment.

The applied flow rate is 5 m^3/Mg (1,200 gal/ton) at the semiwet APCM facility; it ranges from 3.4 m^3/Mg (900 gal/ton) to 16.7 m^3/Mg (4,400 gal/ton) at the wet APCM plants. The discharge flow rate is 0.26 m^3/Mg (69 gal/ton) at the semiwet APCM facility, and it ranges from 0.40 m^3/Mg (105 gal/ton) to 2.2 m^3/Mg (580 gal/ton) at the wet APCM plants.

Electric Arc Furnaces [5]

The electric arc furnace (EAF) steelmaking process is a method of producing high-quality and alloy steels in refractory-lined cylindrical furnaces utilizing a cold steel scrap charge and fluxes. The heat for melting the scrap charge, fluxes, etc., is furnished by passing an electric current (arcing) through the scrap or steel bath by means of three triangularly spaced cylindrical carbon electrodes inserted through the furnace roof.

Electric arc furnace steelmaking operations are divided into two subcategories by the type of air pollution control system used: electric arc furnace-semiwet APCM, and electric arc furnace-wet APCM. These air pollution control methods have been briefly described in previous subcategories. The majority of electric arc furnace operations in the United States are dry operations with no discharge and are therefore not considered a subcategory. There are four semiwet electric arc furnace plants in the United States with an annual production capacity of 3,800,000 Mg (4,200,000 tons). The eight wet electric arc furnace plants have an annual production capacity of 4,700,000 Mg (5,100,000 tons). There is one specialty steel wet electric arc furnace operation which has an annual production capacity of 830,000 Mg (910,000 tons).

Applied flow rates for process wastewater for semiwet electric arc furnace plants range from 1.13 m^3/Mg (270 gal/ton) to 2.67 m^3/Mg (640 gal/ton). For wet electric arc furnace plants the range is 3.46 m^3/Mg (830 gal/ton) to 14.6 m^3/Mg (3,500 gal/ton). The discharge flow ranges from 0 m^3/Mg (0 gal/ton) to 1.13 m^3/Mg (270 gal/ton) for semiwet operations and from 0 m^3/Mg (0 gal/ton) to 14.6 m^3/Mg (3,500 gal/ton) for wet operations.

Vacuum Degassing [5]

The vacuum degassing subcategory is subdivided into specialty steel and carbon steel vacuum degassers. There are a total of 35 vacuum degassers in the United States, with 7 producing carbon steel and the remainder producing specialty steels. Annual production capacity of the carbon steel facilities is approximately 6,100,000 Mg (6,700,000 tons); for specialty steels it is 6,900,000 Mg (7,700,000 tons).

The vacuum degassing operation serves as an intermediary step in steelmaking. After the hot metal has been refined to steel in BOF, EAF, or open hearth furnaces, the heat of steel is transferred to the vacuum degasser for further refining. Degassing is performed only if steel order specifications require it.

Vacuum degassing is the process whereby molten steel is subjected to low pressures in order to eliminate gases absorbed by the steel that may reduce its quality. Gases such as hydrogen, oxygen, and nitrogen can impact detrimental qualities to the finished product if not removed from the steel while it is in its molten state. Hydrogen, in particular, can cause flaking and embrittlement of steel. Oxygen and nitrogen when in combination with other elements can remain in the steel as weakening impurities.

Hydrogen and oxygen are removed from the molten steel by decreasing the partial pressure of each above the molten bath. Oxygen is removed as carbon monoxide or by complexing with strong deoxidizers such as aluminum, titanium, or silicon. After degassing the steel is sent to final product processing. Vacuum degassing is used primarly for specialty steels. Only 7 of the 35 degassing plants refine more carbon steel than specialty steel.

Continuous Casting [5]

Continuous casting plants in the United States are identified as carbon steel or specialty steel casters. There are 54 continuous casting facilities in the United States with a total annual production of 24,849,000 Mg (27,392,000 tons) of cast steel. Five of these plants are specialty steel facilities and the remainder produce carbon steel.

In the continuous casting process the hot molten steel is poured from the ladle into a refractory-lined tundish that maintains a constant head of molten metal. This constant head is essential to a controlled rate, and in multiple-strand operations it distributes the molten metal to the casting networks. The molten metal is poured into oscillating water-cooled copper molds where partial solidification occurs. These molds oscillate to prevent the steel from sticking to them. As the metal solidifies, the product is removed continuously to a series of cooling zones. The rough product is then sent to finishing.

Flow rates for applied process water in this subcategory vary from 0.09 m^3/Mg (22 gal/ton) to 67 m^3/Mg (16,000 gal/ton) and average 19.6 m^3/Mg (4,700 gal/ton). Discharge flow rates range from 0 m^3/Mg (0 gal/ton) to 23 m^3/Mg (5,300 gal/ton) and average 1.7 m^3/Mg (400 gal/ton).

Hot Forming-Primary [6]

The hot forming-primary mill is the first step toward making a finished product from steel ingots. Primary mills produce either blooms, slabs, or billets. Blooming mills can be coupled with billet mills so that the semifinished bloom can immediately be rolled in the billet mill while it is still hot. There are, however, many variations of primary mills depending upon the plants' needs.

The hot forming-primary subcategory is subdivided into carbon steel and specialty steels. The 86 hot forming-primary carbon steel mills in the United States have an annual production capacity of 192,000,000 Mg (212,000,000 tons). The 14 hot forming-primary specialty mills have an annual production capacity 12,400,000 Mg (13,700,000 tons).

Typical primary mill operations begin when an ingot buggy transfers a heated ingot from the soaking pits where the ingot is maintained at approximately 1200°C, to an ingot-receiving table which, in turn, delivers the ingot to the mill-approach tables. The latter tables transport the ingot to the front table or roller table in preparation for rolling.

Depending upon the type of primary mill, (reversing, tandem, etc.), the hot ingot is passed between the mill rollers and reduced in cross-sectional size. After the ingot is rolled to the desired size, the end of the bloom, slab, or billet is cut off or "cropped." The crop shear removes a sufficient length of stock to meet chemical and metallurgical specifications.

Blooms from the primary mill are processed into rails and joint bars, structural and other sections, and billets. Billets are further processed into tube rounds, bar and rod, wire, and special products.

Average flow rates of the eight sampled carbon primary mills are 2.8 m^3/Mg (670 gal/ton) applied flow and 1.4 m^3/Mg (320 gal/ton) discharge flow. Average flow rates at the nine sampled specialty steel mills are 12 m^3/Mg (2,800 gal/ton) applied flow and 7.0 m^3/Mg (1,700 gal/ton) discharge flow.

Hot Forming-Section [6]

Section rolling mills take the semifinished product from blooming mills and hot roll either an intermediate finished product called a billet (which is further reduced in other finishing mills) or roll the bloom directly to a finished product. Most billets are rolled directly from the blooming mill without reheating furnaces, but some steel plants do provide furnaces between the blooming and billet mills.

The intermediate and finished products from a section mill include rails, joint bars, I-beams, channels, angles, wide flanged beams, H-beams, sheet piling, and billets (which are further processed into tube rounds, bar and rod, wire, and numerous special sections).

The hot forming-section steel mills are of two types: carbon steel and specialty steel mills. The 235 hot forming-section carbon steel mills in the United States have an annual production capacity of 130,000,000 Mg (140,000,000 tons), and the 37 special steel section mills have an annual production capcity of 15,000,000 Mg (16,000,000 tons). Daily production at hot forming-section steel mills ranges from 8.1 Mg (9 tons) to 9,700 Mg (11,000 tons). Average applied and discharge flow rates for the hot forming-section mills sampled are 19 m^3/Mg (4,500 gal/ton) applied flow and 6.9 m^3/Mg (1,660 gal/ton) discharge flow.

Hot Forming-Flat [6]

The hot forming-flat subcategory is subdivided into plate mills and hot strip and sheet mills. In the United States there are a total of 68 facilities in this subcategory. The 26 plate mills annually produce 2.2 x 10^7 Mg. The 42 flat-hot strip and sheet mills annually produce 9.4 x 10^7 Mg. Some mills are capable of producing both types of product.

The basic operation of a plate mill is the reduction of a heated slab to the weight and dimensional limitations defining plates (more than 8 inches wide and at least 0.23 inch thick or over 48 inches wide and 0.18 inch thick). This is accomplished by heating the slab descaling, rolling, leveling or flattening, cooling, and shearing to desired size.

Hot strip mills are often continuous. These mills use slabs that are reheated to rolling temperature by reheating furnaces. The basic operation of a hot strip mill is the reduction of slabs to flat strip steel in thicknesses of 0.04 inch to 1.25 inches, widths of 24 inches to 96 inches and lengths up to 2,000 feet. The product may be sold as produced, further processed in cold reduction mills, or used for plated or coated products.

<u>Pipe and Tube</u> [7]

The pipe and tube subcategory is subdivided into hot forming and cold forming operations. In the United States there are 55 hot forming pipe and tube mills (with an annual production capacity of 17,000,000 Mg [19,000,000 tons]) and 108 cold forming pipe and tube mills (with an annual production capacity of 8,794,000 Mg [9,696,000 tons]).

Within the pipe and tube subcategory, the processes employed and the equipment used vary between hot forming and cold forming operations. The basic differences between the two arise in the process water usage rates and the wastewater characteristics.

A hot forming pipe and tube mill takes hot steel and processes it into products such as seamless pipe and tube. Relatively high water rates are required for the various contact and noncontact cooling systems. On the other hand, the cold forming process takes a cold semifinished product and manufactures cold drawn or welded pipe and tube. Water requirements are lower and the presence of soluble oil distinguishes the wastewater.

Daily production capacity of the hot forming pipe and tube mills ranges from 44 Mg (48 tons) to 3,100 Mg (3,400 tons). Daily production capacity of the cold forming pipe and tube mills ranges from 0.73 Mg (0.8 tons) to 3,100 Mg (3,400 tons). Average applied flow rate for all 55 hot forming pipe and tube mills is 25.8 m^3/Mg (6,200 gal/ton) and the average discharge rate is 17.7 m^3/Mg (4,250 gal/ton). The average applied flow rate for the 108 cold forming pipe and tube mills is 11 m^3/Mg (2,700 gal/ton) and the average discharge rate is 7.1 m^3/Mg (1,700 gal/ton).

<u>Sulfuric Acid Pickling</u> [8]

The sulfuric acid pickling subcategory is subdivided into continuous pickling and batch pickling, each further subdivided into carbon steel and specialty steel. The 44 continuous sulfuric acid pickling operations in the United States have an estimated annual production capacity of 14,500,000 Mg (16,000,000 tons); the 105 batch sulfuric acid operations have an estimated annual production capacity of 8,200,000 Mg (19,000,000 tons).

Annual production at batch H_2SO_4 pickling-carbon steel mills ranges from 180 Mg (200 tons) to 840,000 Mg (920,000 tons). At batch H_2SO_4 pickling-specialty steel mills the range is 3,800 Mg (4,200 tons) to 280,000 Mg (300,000 tons); at continuous H_2SO_4 pickling-carbon steel mills it is 1,000 Mg (1,100 tons) to 2,500,000 Mg (2,800,000 tons); and at continuous H_2SO_4 pickling-specialty steel mills it is 17,200 Mg (19,000 tons) to 261,000 Mg (288,000 tons).

The traditional method of scale removal is "pickling," the chemical removal of surface oxides from metal by immersion in a heated solution. Carbon steel pickling is almost universally accomplished in either hydrochloric or sulfuric acid, and stainless is pickled in hydrofluoric or nitric acid. Acid type used, bath temperature, use of inhibitors, and source of agitation depend on the type of material to be pickled.

Various organic chemicals are used in pickling to inhibit acid attachment on the base metal, while permitting preferential attachment to the oxider. Wetting agents are used to improve the effective contact of the acid solution with the metal surface. Pickling may be done on a batch or a continuous basis depending on the product being pickled. A rinse step normally follows the operation to reduce acid carryover.

The major wastewater flows arise from rinsing and fume-scrubbing operations. Rinse water flows are somewhat dependent on product requirements and process line configuration. As process lines become more complex, an occasional opportunity arises to reduce flows via recirculation of a portion of the rinse water. For example, final rinse water can be reused for initial spray rinsing and for makeup to fume scrubber, thus reducing the total process wastewater.

Discharge flow rates of wastewater vary throughout this subcategory. Continuous pickling generaly discharges slightly more water than does batch pickling. Continuous processes consisting of rinses, fume hood scrubbers, acid recovery systems, and spent pickle liquor condensates release averages of 2.3, 0.42, 0.32, and 0.086 m^3/Mg of product, respectively. Batch processes use the same general processes and release 2.0, 0.55, 0.012, and 0.075 m^3/Mg of product, respectively.

Hydrochloric Acid Pickling [8]

The hydrochloric acid pickling subcategory includes continuous strip pickling and batch pickling operations. There are 43 hydrochloric acid pickling steel mills with an annual production capacity of 23,000,000 Mg. Pickling is accomplished by one of two general processes dependent upon the type of material to be pickled. Pickling lines for hot-rolled strip operate continuously on long coils. The steel passes through the pickler countercurrently to the flow of the acid solution. Most pickling operations are followed by several rinsing steps which remove the excess acid and oxides that may cling to the surface. The water for the rinse can be reused in subsequent rinsing operations.

Continuous operations have several wastewater sources including acid regeneration, neutral rinse, and specialty, carbon steel, and wire product rinses. Average flow from the various continuous operations are:

Acid regeneration	1.0 m^3/Mg
Neutral rinse	1.7 m^3/Mg
Specialty steel pickling	2.7 m^3/Mg
Carbon steel pickling	1.8 m^3/Mg
Wire pickling	6.8 m^3/Mg

Batch operations normally use much more water. Average flows for this pickling process are:

Neutral rinse	5.5 m^3/Mg
Carbon steel pickling	3.8 m^3/Mg
Wire pickling	7.9 m^3/Mg

Cold Rolling [7]

Cold rolling is an operation in which unheated metal is passed through a pair of rolls to reduce its thickness, generally by a relatively small amount; to produced a smooth, dense surface; and/or to develop controlled mechanical properties in the metal.

A typical modern cold rolling shop would contain a continuous pickling operation (sulfuric or hydrochloric acid) for the removal of scale and rust from the hot rolled breakdown coil. Oil applied to the strip as it leaves the pickler prevents rusting and acts as a lubricant in the cold rolling mill. The coil is then fed into a continuous cold rolling reducing mill that can contain up to six rolling stands in series.

During rolling the steel becomes quite hard and unsuitable for most uses. As a result, the strip must usually undergo an annealing operation to return its ductility and to effect other required changes in mechanical properties. This is done in either a batch or continuous annealing operation.

The cold rolling subcategory is divided into three subsections: recirculating mills, direct application mills, and combination mills. There are 170 recirculating cold rolling mills in the United States with an annual production capacity of 27,000,000 Mg (30,000,000 tons). The 79 direct application cold rolling mills have an annual production capacity of 17,000,000 Mg (19,000,000 tons). Annual production capacity at the 20 combination cold rolling mills is 13,000,000 Mg (15,000,000 tons).

Hot Coating [9]

Hot coating operations are divided into two subcategories, hot coating-galvanizing and hot coating-terne plating. Hot coating processes in the iron and steel industry involve the immersion of clean steel into baths of molten metal for the purpose of attaching a thin layer of this metal onto the steel surfaces. Such coatings serve to provide certain desired qualities, such as resistance to corrosion, safety from contamination, or a decorative bright appearance. Finished products retain the strength of steel while gaining the improved surface quality of the coated metal for a fraction of the cost of products made entirely of that metal alone.

The principal metallic coating operations practiced in the iron and steel industry can be divided into two major classes; hot coating and cold coating. Zinc, terne, and aluminum coatings are most often applied hot, while tin and chromium are usually applied electrolytically from plating solutions maintained at 20°C to 90°C (68-194°F), not actually "cold," but relatively so when compared with molten metal temperatures encountered in the hot dip processes. This cold coating process is not considered within this industry description due to its inclusion in the electroplating industry.

Continuous hot dip-galvanizing is the most common method used for hot coating steel with zinc. The process starts with annealed and tempered strip which receives a light muriatic acid (HCl) pickle and rinse, then proceeds directly through a layer of fluxing agent to the molten zinc bath. The coated strip is dried and recoiled, or cut to size for shipment.

Terne (from a French word meaning "dull") is an inexpensive, corrosion-resistant, hot dip coating consisting of tin and lead in a ratio typically near five or six parts lead to one part tin.

A major portion of all terne-coated material is used in the auto industry to manufacture gas tanks, with lesser amounts going into the production of automotive mufflers, oil pans, air cleaners, and radiator parts.

The third major metallic coating applied using the hot dip technique is aluminum. Products made of aluminum-finished steel include bright and matte finished sheets and strip used as building materials in marine, industrial, or other environments where high degrees of resistance to corrosion are required.

There are 94 hot coating plants in the United States, of which 68 responded to basic DCP's. The annual production capacity of those 68 plants (representing 173 production lines) is 7,700,000 Mg (8,500,000 tons).

Daily production at the nine sampled hot coating-galvanizing plants ranges from 5 Mg/d (6 tons/d) to 1,585 Mg/d (1,750 tons/d). At the three sampled hot coating-terne plating plants daily production ranges from 475 Mg/d (525 tons/d) to 510 Mg/d (560 tons/d).

Combination Acid Pickling [8]

Pickling is the process of chemically removing oxides and scale from the surface of a metal by the action of water solutions of inorganic acids. While pickling is only one of several methods of removing surface oxides, it is widely used in the manufacture of various steel products because of its comparatively low operating costs and ease of operation. Considerable variation in the types of pickling solutions, operations, and equipment is found in the industry.

In combination acid pickling, a minimum of two different acid solutions act on the product being processed. These two acids can be in different tanks or can be mixed together, as is done in some cases with nitric and hydrofluoric acids. Depending on the type of material to be pickled, combination acid pickling (CAP) is carried out by one of two general processes, the subdivisions of this subcategory: CAP-batch type and CAP-continuous type.

Batch Type Pickling. Large, open tanks of a wide range of sizes are used for batch type pickling, principally for rods, bars, billets, sheet, strip, wire and tubing. The tanks, generally rubber lined and brick sheathed, hold a large volume of heated acid solution. After reaching a certain iron buildup due to scale removal, the acid solution is considered spent and dumped as a batch.

Continuous Pickling. Continuous pickling is done on a small number of steel products, including, strip, sheet, and wire. In this process, there are at least two acid tanks, each usually divided into 4 or 5 compartments. The fresh acid solution is added to the last tank section and cascades through the tank to an overflow located in the first section. Acid flow is opposite to the direction of product travel.

After pickling, the product is rinsed before moving on to the next sequence in the process. The rinse step may vary from a one-step dunk to more sophisticated multistage rinsing.

In the United States there are 57 plants with 152 combination acid pickling mills. Of these mills, 78 are batch type and 74 are continuous type operations. The annual production capacity of the 78 batch type operations is 3,000,000 Mg (2,700,000 tons); that of the 74 continuous type operations is 3,100,000 Mg (3,400,000 tons).

Wastewater discharge at combination acid facilities varies with the process type used. Batch type processes discharge 2.1 m^3 of water per Mg of product (500 gal/ton) while continuous type processes discharge nearly 11 m^3 of water per Mg of product (2,500 gal/ton). Other sources of wastewater include fume hood scrubber water (6.3 m^3/Mg [1,500 gal/ton]) and spent pickle liquor (0.063 m^3/Mg [15 gal/ton]).

Scale Removal, Kolene and Hydride [9]

The scale removal subcategory is subdivided into kolene scale removal and hydride scale removal. Kolene scale removal operations are further subdivided into continuous and batch type operations. In the United States there are 11 continuous type kolene scale removal mills, which have an annual production capacity of 120,000 Mg (130,000 tons). There are 10 batch type kolene scale removal mills with an annual production capacity of 260,000 Mg (280,000 tons). The eight hydride scale removal mills in the United States have an annual production capacity of 92,000 Mg (100,000 tons).

The kolene process utilizes highly oxidizing salt baths at 370°C to 480°C (700-900°F), which react far more aggressively with scale than with the base metal. This results in a smoother surface than is obtainable with acid pickling.

Sodium hydride descaling depends on the strong reducing properties of a 1.5% to 2% by weight concentration of sodium hydride in a fused caustic soda bath at 370°C (700°F). Most scale-forming oxides are reduced to the base metal; oxides of metals that form acid radicals are partially reduced. Hydride and kolene descaling operations are operated only as an integral part of the pickling process.

The average discharge flow rates for kolene scale removal mills are 6.20 m^3/Mg (1,500 gal/ton) for batch type operations and 1.8 m^3/Mg (420 gal/ton) for continuous type operations. The average discharge flow rate for hydride scale removal mills is 2.6 m^3/Mg (610 gal/ton).

Continuous Alkaline Cleaning [9]

Alkaline cleaners are used where mineral and animal fats and oils must be removed. Mere dipping in solutions of various compositions, concentrations, and temperatures is often satisfactory. The use of electrolytic cleaning may be advisable for large-scale production, or where this method yields a cleaner product. Caustic soda, soda ash, alkaline silicates, and phosphates are common alkaline cleaning agents. Sometimes the addition of wetting agents to the cleaning bath will facilitate cleaning.

Alkaline cleaning may be carried out by two different methods. Continuous cleaning is used at 70% of the mills that responded to questionnaires, and the balance use batch cleaning. Continuous cleaning mills use approximately 1.8 m^3 of water per Mg of product (434 gal/ton) to clean sheet, strip, or wire. Batch cleaning transfers the product from the wash to the rinse manually and uses approximately 1.3 m^3 of water per Mg of product (307 gal/ton).

Alkaline cleaning lines are usually operated as a part of a larger, more complex line such as an annealing, galvanizing, or pickling line. Water flow rates range from 0.002 m^3/Mg (0.059 gal/ton) of product to 1.25 m^3/Mg (300 gal/ton) of product. Products from this process vary considerably, ranging from sheet and strip to chain link fence.

II.6.2 WASTEWATER CHARACTERIZATION [1-9]

The following paragraphs and tables describe the wastewater generated from each subcategory. These descriptions normally include a general statement on the potential sources of wastewater, average wastewater flow, and the common pollutants found in the wastewater. Tables present median, maximum, and average conventional and toxic pollutant concentrations for the raw and treated wastewater when sufficient data are available. The tables were generated from the sampling data found in the reference documents. Also reported is the average percent removal determined by the reduction in the average treated effluent concentration compared with the average raw wastewater concentration.

II.6.2.1 Subcategory 1 - Byproduct Cokemaking [2]

Raw waste loads from byproduct cokemaking operations differ widely based on the type of coal used, variations in recovery processes, water use system configurations, oven carbonizing temperatures, and duration of the cycle. The major liquid wastes generated during cokemaking and byproduct recovery operations include excess ammonia liquor, final cooler wastewater, light oil recovery wastes from the benzol plant, barometric condenser wastes, desulfurizer wastes, and contaminated waters from air pollution emission scrubbers. Some additional wastewater may result from coke wharf drainage, quench pump overflows, and coal pile runoff. Table 6-4 shows the ranges of volumes for these sources.

TABLE 6-4. WASTEWATER FLOWS FROM SOURCES IN THE BYPRODUCT COKEMAKING SUBCATEGORY [2]

Wastewater stream	Average, m^3/Mg
Excess ammonia liquor	0.17
Final cooler wastewater	0.14
Benzol plant wastes	0.25
Barometric condenser	0.16
Desulfurizer	0.081
Air pollution emission scrubbers	1.7
Steam condensates	0.040
Miscellaneous wastes	0.15

Conventional pollutants often found in the raw wastewater include significant concentrations of total suspended solids, ammonia, sulfide, and oil and grease. Subcategory data are presented in Table 6-5. Toxic pollutants found in the wastewater generally consist of metals, phenols, and aromatics. Table 6-6 lists information on these pollutants.

TABLE 6-5. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANT FOR THE BYPRODUCT RECOVERY COKEMAKING SUBCATEGORY [2]

	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a]			Number detected	Concentration, mg/L[a]			
Parameter		Median	Maximum	Average		Median	Maximum	Average	
Ammonia	7	2,400	8,300	2,900	9	220	4,900	900	69
Thiocyanate	7	593	1,250	530	9	29	1,050	29	95
Oil and grease	7	83	180	140	8	11	40	16	90
Phenol	7	630	1,700	740	7	5.1	220	26	96
Sulfide	7	440	1,800	630	8	91	1,800	320	49
TSS	7	59	97	67	8	41	540	120	-[b]
pH	7	8.6	9.7	8.3	9	8.5	11.8	8.9	

[a]Except pH values, given in pH units.

[b]Negative removal.

TABLE 6-6. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE BYPRODUCT RECOVERY COKEMAKING SUBCATEGORY [2]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, μg/L			Number detected	Concentration, μg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Antimony	3	33	335	120	3	41	130	60	50
Arsenic	3	660	170,000	57,000	2	210	400	210	99
Cyanide	7	26,000	190,000	47,000	5	2,500	22,000	8,800	81
Selenium	4	410	2,600	860	3	640	650	430	50
Silver	6	25	670	130	4	17	25	17	87
Zinc	5	130	470	200	3	130	220	110	45
Nitrogen compounds									
Acrylonitrile	5	2,700	4,700	2,700	2	1,600	3,000	1,600	40
Phenols									
2,4-Dimethylphenol	3	5,000	84,000	23,000	0				
2-Nitrophenol	2	770	1,500	770	1	<5			99
Pentachlorophenol	1	395			1	49			88
Phenol	7	120,000	670,000	240,000	5	48	53,000	11,000	95
2,4,6-Trichlorophenol	1	400			0				
p-Chloro-*m*-cresol	2	2,200	4,300	2,200	2	33	64	33	94
4,6-Dinitro-*o*-cresol	2	530	970	530	1	<5			99
Aromatics									
Benzene	7	27,000	86,000	29,000	5	260	140,000	30,000	-[a]
2,4-Dinitrotoluene	1	1,900			1	510			78
2,6-Dinitrotoluene	1	240			1	140			42
Ethylbenzene	5	300	640	340	4	27	6,600	1,700	-[a]
Toluene	5	5,700	17,000	6,700	5	73	11,000	2,600	61
Polycyclic aromatics									
Acenaphthylene	7	3,200	6,400	3,000	5	7	1,600	330	89
Benzo(a)anthracene	3	150	1,200	490	3	5	260	88	82
Benzo(a)pyrene	4	360	1,100	480	3	13	13	9	98
Chrysene	5	320	1,500	550	0				
Fluoranthene	7	950	3,100	1,200	5	8	500	110	91
Fluorene	7	370	2,500	700	5	10	190	47	87
Naphthalene	7	27,500	39,000	25,000	4	700	5,900	1,800	95
Pyrene	6	760	2,600	910	5	8	280	64	
Halogenated aliphatics									
Chloroform	5	120	1,400	400	3	200	280	180	55
1,1-Dichloroethylene	2		3	3				0	
Pesticides and metabolites									
Isophorone	2	2,000	4,000	2,000	1	170			92

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

II.6.2.2 Subcategory 2 - Beehive Cokemaking [2]

This subcategory provides sufficient oxygen to burn volatile by-products during the cokemaking process. As a result of this complete burning and the lack of byproduct recovery, relatively simple wastewater is generated, solely from the quenching operation. Total suspended solids is the only pollutant requiring control in this subcategory. Table 6-7 shows conventional pollutant data for the beehive cokemaking process.

TABLE 6-7. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE BEEHIVE COKEMAKING SUBCATEGORY [2]

	Raw wastewater				Treated effluent				
	Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]			Percent
Parameter	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
Ammonia	3	0	0.33	0.11	3	0	0.24	0.08	27
Cyanide, total	3	0	0.002	0.0007	3	0	0.004	0.001	-[b]
Oil and grease	3	<5	<5	<5	3	0	<5	<1.6	68
Phenol	3	0	0.011	0.004	3	0	0.014	0.005	-[b]
TSS	3	170	720	310	3	0	36	12	96
pH	3	7.3	7.3	7.2	1			7.1	

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

Effluent flow rates range from 0 to 2.04 m^3/Mg. Total recycle is often used because of the low pollutant loadings.

II.6.2.3 Subcategory 3 - Sintering [3]

Process wastewaters emanating from the sintering subcategory exhibit common quality characteristics. Suspended solids, oil and grease, sulfide, and fluoride are normally present in some concentrations. However, the quantities of these regulated parameters exhibit considerable variability depending on the number of sources generating wastewater. Tables 6-8 and 6-9 present conventional and toxic pollutant data for this subcategory.

TABLE 6-8. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR SINTERING SUBCATEGORY [3]

Average raw wastewater flow. 2 0 m^3/Mg (485 gal/ton)
Average treated effluent flow 0.55 m^3/Mg (132 gal/ton)

	Raw wastewater				Treated effluent				
	Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]			Percent
Parameter	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
Fluoride	4	4.7	18 0	6 9	4	20	180	55	-[b]
TSS	5	4,300	20,000	6,000	4	420	15,000	3,900	36
Oil and grease	5	200	500	240	3	180	1,100	430	-[b]
Sulfide	5	5.8	190	52	4	4.1	11	5.0	91
pH	5	11.4	12.7	10.4	4	8.9	12.8	9.4	

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-9. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR SINTERING SUBCATEGORY [3]

Toxic pollutant	Raw wastewater: Number detected	Raw wastewater: Concentration, µg/L Median	Maximum	Average	Treated effluent: Number detected	Treated effluent: Concentration, µg/L Median	Maximum	Average	Average percent removal
Metals and inorganics									
Cadmium	2	690	1,300	690	2	420	770	420	39
Chromium	3	98	620	250	2	50	90	50	80
Copper	3	520	600	400	3	270	550	410	-[a]
Cyanide	4	260	15,000	3,900	3	160	1,100	430	89
Lead	2	5,600	5,900	5,600	3	800	5,500	3,200	43
Nickel	2	110	200	110	2	74	130	70	36
Silver	2	12	13	12	2	10	10	10	17
Zinc	3	940	8,700	3,400	3	940	5,000	1,900	44
Phthalates									
Butyl benzyl phthalate	3	85	290	130	3	580	990	520	-[a]
Di-n-butyl phthalate	3	120	250	130	3	170	420	200	-[a]
Di-n-octyl phthalate	3	20	370	130	3	350	490	280	-[a]
Phenols									
2,4-Dinitrophenol	1	14			1	140			-[a]
Phenol	3	56	1,000	380	3	630	990	370	2
Polycyclic aromatics									
Benzo(a)anthracene	2	260	516	260	3	150	260	140	46
Benzo(a)pyrene	2	220	430	220	3	190	240	140	36
Chrysene	2	160	320	160	3	53	410	160	-
Fluoranthene	2	130	254	130	3	310	860	390	-[a]
Pyrene	3	7	320	110	3	300	1,100	470	-[a]

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentrations.

Wastewater is generated from several areas. Sinter machine and pretreatment areas produce an average wastewater flow of 6.06 m^3/Mg of product (1,442 gal/ton). If a large discharger is eliminated from the data set, the average flow reduces to 1.34 m^3/Mg (319 gal/ton). The final product treatment area produces an average wastewater flow of 2.03 m^3/Mg of product (4999 gal/ton). Other areas generating smaller quantities of wastewater include storage areas, sinter cooling, and crushing/screening operations.

II.6.2.4 Subcategories 4 and 5 - Blast Furnace-Iron and Ferromanganese [3]

Blast furnace process wastewater is water which comes into intimate contact with the process or its products, thus becoming contaminated with various pollutants associated with the process. This wastewater may be a combination of several wastestreams, but it is primarily associated with the scrubber wash water from the wet scrubbing of blast furnace top gases. Other miscellaneous waters may include floor drains, drip legs, and dekishing operations.

Top gases contain large amounts of particulates, carbon dioxide, carbon monoxide, and organic substances. Large particulates are removed by dry processing, and the gas is then wet scrubbed to remove other contaminants. Thus, the wastewater entering the treatment system contains quantities of suspended solids and organic substances. Wastewater flow entering treatment ranges from 2.52 m^3/Mg product to 37.7 m^3/Mg. Treated discharge ranges from 0 m^3/Mg (water recycle) to 27.9 m^3/Mg.

Tables 6-10, 6-11, and 6-12 present conventional and toxic pollutant data on a subcategory basis. Data come from sampled plants. No toxic pollutant data are available for the ferromanganese subcategory.

TABLE 6-10. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR BLAST FURNACE-IRON SUBCATEGORY [3]

	Raw wastewater				Treated effluent				
		Concentration, mg/L[a]				Concentration, mg/L[a]			
Parameter	Number detected	Median	Maximum	Average	Number detected	Median	Maximum	Average	Average percent removal
Ammonia-N	4	39	64	40	4	30	45	30	75
Cyanide	4	6.2	85	24	4	0.66	33	8.6	64
Fluoride	4	13	160	48	4	12	147	44	8
Phenol	4	2.8	5.4	2.8	4	2.4	6.7	2.9	-[b]
TSS	4	1,600	7,100	2,700	4	54	168	78	97
Sulfide	4	7	68	21	3	0.4	0.5	0.4	98
pH	4	9.7	10.2	9.1	4	9.8	10.9	9.5	

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-11. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOUND IN BLAST FURNACE-IRON SUBCATEGORY [3]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, µg/L			Number detected	Concentration, µg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Antimony	1	37			1	15			59
Arsenic	1	46			1	6			87
Cadmium	4	100	200	100	3	10	11	10	90
Chromium	4	300	630	330	3	23	54	29	91
Copper	4	240	1,200	420	4	28	170	60	85
Lead	2	21,000	43,000	18,000	4	81	3,100	830	95
Nickel	3	230	1,200	480	3	60	94	54	89
Selenium	1	63			1	4			94
Silver	3	57	73	47	3	10	26	14	-
Zinc	4	25,000	90,000	36,000	3	1,200	32,000	8,500	76
Phthalates									
Bis(2-ethylhexyl) phthalate	4	100	3,200	860	4	320	11,000	2,900	-[a]
Butyl benzyl phthalate	4	95	340	130	4	8	350	94	28
Di-n-butyl phthalate	4	320	9,800	2,600	4	94	190	73	98
Diethyl phthalate	2	10	16	10	2	86	170	86	-[a]
Dimethyl phthalate	1	47			3	3	120	30	36
Di-n-octyl phthalate	4	82	12,000	3,000	3	36	86	32	99
Phenols									
2,4-Dichlorophenol	1	240			2	30	44	30	88
2,4-Dimethylphenol	3	3	53	18	2	83	163	83	-[a]
Phenol	3	640	2,800	1,200	4	590	1,800	770	38
Aromatics									
Hexachlorobenzene	1	103			0				>99
Polycyclic aromatics									
Benzo(a)pyrene	3	7	9,500	3,200	2	5	8	5	99
Chrysene	3	15	310	110	3	7	74	28	75
Fluoranthene	3	82	11,000	3,600	4	15	230	65	98
Fluorene	2	15	21	15	4	8	29	12	20
Naphthalene	3	14	19	14	3	3	15	5	64
Pyrene	3	53	10,000	3,400	3	12	41	20	99
Halogenated aliphatics									
Chloroform	4	12	48	20	4	31	54	34	-[a]

Note: Blanks indicate no data available
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration

TABLE 6-12. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE BLAST FURNACE-FERROMANGANESE SUBCATEGORY [3]

Parameter	Raw wastewater		Treated effluent		Percent removal
	Number detected	Concentration, mg/L[a]	Number detected	Concentration, mg/L[a]	
Ammonia-N	1	710	1	680	4
Cyanide	1	690	1	710	-[b]
Manganese	1	500	1	53	89
Phenol	1	64	1	6.3	3
Sulfide	1	130			
TSS	1	4,200	1	410	90
pH	1	8.8 - 11.1	1	8.8 - 11.1	

Note: Blanks indicate no data available.

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw concentration.

II.6.2.5 Subcategories 6 and 7 - Basic Oxygen Furnace-Semiwet and -Wet Air Pollution Control [4]

Wastewater results from the steelmaking process when wet gas collection systems are used on furnaces. Spray water cooling and quenching or the use of wet washers result in wastewaters containing particulates from the gas stream. The basic oxygen furnace has four main water systems:

1. Oxygen lance cooling water system,
2. Furnace trunnion ring and nose cone cooling water system,
3. Hood cooling water system, and
4. Fume collection scrubber and gas cooling system.

The first three can be either "once-through" systems or closed recirculating systems. Fume collection systems can vary from a completely dry precipitator to a semiwet precipitator to a wet, high energy venturi scrubber. Water use and characterization varies with each system. The raw wastewater flow rate as determined by EPA field sampling varies from plant to plant, depending on the gas-cleaning system used. The flow rates are presented in Table 6-13.

TABLE 6-13. DISCHARGE FLOW RATES FOR BASIC OXYGEN FURNACE PLANTS SAMPLED [4]

Gas treatment	Plant code	Discharge flow	
		m^3/Mg	gal/ton
Semiwet	0432A	0	0
	0396D	0.12	29
Wet-open combustion	0112A	1.83	440
	0584F	0.27	65
	0020B	2.7	640
	0856B	2.0	470
	0868A	0.54	130
	0112D	0.42	100
Wet-suppressed combustion	0060	0.31	75
	0384A	0.33	80
	0856N	0.37	89
	0684F	0.04	10

The raw effluent discharges from the semiwet, wet-open and wet-suppressed combustion gas-cleaning systems are similar in waste characterization of the regulated parameters of suspended solids, fluoride, and pH. However, the quantity of solids may vary depending on the gas-cleaning system installed. Semiwet systems discharge less solids than wet systems, and open combustion systems discharge more than suppressed systems. Fluoride concentrations vary with the amount of raw material, fluorspar, which is used as a fluxing compound. BOF raw and effluent waste loads for semiwet, wet-open combustion, and wet-suppressed combustion are shown in Table 6-14.

TABLE 6-14. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE BASIC OXYGEN FURNACE SUBCATEGORIES [4]

Average flow, m^3/Mg	Raw wastewater	Treated effluent
Semiwet	0.98	3.7
Wet-open combustion	3.0	1.3
Wet-suppressed combustion	4.1	0.24

Subcategory		Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a] Median	Maximum	Average	Treated effluent: Number detected	Treated effluent: Concentration, mg/L[a] Median	Maximum	Average	Average percent removal
Semiwet APCM	TSS	2	420	330	300	1	125	81	81	75
	Fluoride	1		3.1		1		3.8	3.8	-[b]
	pH	2	11.8	11.5	11.5	2	11.9	11.6	11.6	
Wet-open combustion	TSS	4	7,800	3,500	4,000	6	1,200	50	340	92
	Fluoride	1		8.5		2	9	6.7	6.7	21
	pH	4	11.7	9.8	9.8	6	11.9	10.1	10	
Wet-suppressed combustion	TSS	3	1,500	380	840	3	55	47	38	95
	pH	3	11.3	9.4	10	3	10	8.8	8.9	

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

A total of 68 different toxic pollutants were detected at the nine wet-open and wet-suppressed combustion basic oxygen furnace plants sampled. Semiwet plants were not sampled because these technologies are recommended by BPT and BAT limitations as zero discharges. The toxic pollutant data for raw waste loads and gross treated effluent wastewater are shown in Table 6-15.

II.6.2.6 Subcategory 8 - Open Hearth Furnace [4]

The open hearth furnace process has two separate water systems. The furnace cooling system normally includes a checker reversal valve system and is generally limited to cooling the furnace doors and the valve system. Because it is usually a once-through system, the only parameter of concern is temperature.

The fume collection water system conditions the flue gas from the furnace for final release. Pollutants captured by this system are dependent on the type of fuel used in the furnace, and the system's wastewater may contain nitrous and sulfur oxides. The aqueous discharge from the high venturi scrubbers are scrubbing waters from primary quenching operations. Wet and semiwet air pollution control methods divide the open hearth furnace subcategory into two subdivisions. The raw effluent discharges from the semiwet and wet gas-cleaning systems are similar in

TABLE 6-15. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE BASIC OXYGEN FURNACE-WET SUBCATEGORY [4]

	Wet-open combustion								
	Raw wastewater				Treated effluent				Average percent removal
	Number	Concentration, µg/L			Number	Concentration, µg/L			
Toxic pollutant	detected	Median	Maximum	Average	detected	Median	Maximum	Average	
Metals and inorganics									
Antimony	1	17		0.01					
Arsenic	2	60	70	60	2	12	17	12	80
Cadmium	3	174	260	150	3	10	488	170	-[a]
Chromium	3	360	17,000	5,800	4	540	30,100	7,800	-[a]
Copper	4	825	1,200	600	4	217	476	230	62
Lead	4	370	12,000	3,300	4	455	942	517	84
Mercury	3	33	34	16.8	4	0.05	0.30	0.15	99
Nickel	3	47	675	244	4	530	2,020	773	-[a]
Selenium	2	16	28	16	2	20	31	20	-[a]
Silver	2	27	43	27	2	175	339	175	-[a]
Thallium	2	11	15	11	2	70	80	70	-[a]
Zinc	4	3,400	48,500	14,300	4	706	2,140	970	93
Phthalates									
Bis(2-ethylhexyl) phthalate	2		120	60	4	72	317	118	-[a]
Aromatics									
Benzene	2	1.5	3	1.5					
Polycyclic aromatics									
Chrysene	2	13	23	13					
Fluoranthene	1	34							
Pyrene	1	32							
Halogenated aliphatics									
Chloroform					4	56	122	62	-[a]

(continued)

TABLE 6-15 (continued)

Toxic pollutant	Wet-suppressed combustion								Average percent removal
	Raw wastewater				Treated effluent				
	Number detected	Concentration, µg/L			Number detected	Concentration, µg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Antimony	1	4							
Arsenic	1			0.01					
Cadmium	2	62	91	62	2	9	10	9	85
Chromium		603	1,050	603	3	12	13	11.6	98
Copper	3	63	310	3	2	10	100	60	-
Cyanide	1	1							
Lead	3	700	27,000	13,850	2	645	822	645	95
Mercury	1	0.2							
Nickel	2	174	327	174	3	10	691	237	-[a]
Selenium	1	3							
Silver	2	12	19	12	2	12.5	15	12.5	4.2
Zinc	1	8.3			3	227	281	203	-[a]
Phthalates									
Bis(2-ethylhexyl) phthalate	2	447	868	447	3	29	298	112	75
Butyl benzyl phthalate	1	9							
Di-n-butyl phthalate	2		11	7	2	10	10	10	-[a]
Phenols									
Phenol	1	8							
Aromatics									
Toluene	2	2	3	2					
Polycyclic aromatics									
Pyrene	1	5							

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

waste characterization as regards the regulated parameter of suspended solids, fluoride, pH, etc. However, the quantity of solids is variable according to the gas-cleaning systems installed. Semiwet gas-cleaning systems discharge less solids than wet systems. Fluoride concentrations are variable depending on fluorspan usage. Wastewater characterization for conventional pollutants for sampled wet system open hearth plants is presented in Table 6-16. Toxic pollutant data are found later in the plant specific section of this subcategory, because only one semiwet and one wet air pollution control plant have been sampled. See Tables 6-70 and 6-71.

TABLE 6-16. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE OPEN HEARTH FURNACE SUBCATEGORY, WET APCM SUBDIVISION [4]

Average raw wastewater flow: 2.2 m^3/Mg (510 gal/ton)
Average treated effluent flow: 1.5 m^3/Mg (360 gal/ton)

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a]	Treated effluent: Number detected	Treated effluent: Concentration, mg/L[a]	Percent removal
TSS	1	1,500	1	15	99
Fluoride	1	100	1	27	63
Nitrate	1	640	1	450	30
pH	1	6.7	1	9.1	

[a]Except pH values, given in pH units.
[b]Treated effluent concentration exceeds raw concentration.

II.6.2.7 Subcategories 9 and 10 - Electric Arc Furnace-Semiwet and -Wet Air Pollution Control [5]

The electric arc furnace (EAF) subcategory has two main plant water systems. A once-through cooling system that maintains the door and electrode rings generates heated water that may be recirculated or released. Pollutant levels in this stream are small. A fume collection cooling scrubbing system may be a dry, semiwet, or wet system. Dry systems do not produce any aqueous discharges. The semiwet system employs a spark box or spray chamber to condition the hot gases for a precipitator or baghouse. Aqueous discharges from such systems are generally treated with other, similar wastes. The wet high energy venturi scrubber systems extract gases from the furnace and condition and cool them. The discharge is similar to that of a basic oxygen furnace.

The raw effluent discharges from semiwet and wet gas-cleaning systems are similar in waste characterization of the regulated parameter of suspended solids, fluoride, zinc, and pH. However, the quantity of solids is variable according to the gas-cleaning systems installed. Semiwet gas-cleaning systems discharge less solids than wet systems. pH is generally in the range of 7.0 to 9.0 for all gas-cleaning systems. Fluoride concentrations are variable, but this is due to the amount of raw material, fluorspan (a fluxing compound), rather than the type of gas-cleaning system used. Zinc concentrations are likewise variable; they are highly dependent upon the amount of galvanized scrap charged to the furnace.

Only one plant (059B) was sampled for toxic pollutants in the electric arc furnace-semiwet subcategory. Data for this plant are presented in the plant specific section in Tables 6-74 and 6-75.

Conventional pollutant data for the semiwet subcategory are presented in Table 6-17.

TABLE 6-17. WASTEWATER CHARACTERIZATION FOR CONVENTIONAL POLLUTANTS FOR ELECTRIC ARC FURNACE-SEMIWET SUBCATEGORY [5]

Average raw wastewater flow: 0.4 m^3/Mg (975 gal/ton)
Average treated effluent flow: 0 m^3/Mg (0 gal/ton)

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a]	Treated effluent: Number detected	Treated effluent: Concentration, mg/L[a]	Percent removal
TSS	1	2,200	1	530	76
Fluoride	1	30	1	28	7
pH	1	7.8	1	6.7	

Note: Blanks indicate no data available.
[a]Except pH values, given in pH units.

Conventional pollutants are characterized in Table 6-18 for wet operations. Wastewater characterization of toxic pollutants for the electric arc furnace-wet subcategory is presented in Table 6-19.

TABLE 6-18. WASTEWATER CHARACTERIZATION FOR CONVENTIONAL POLLUTANTS FOR ELECTRIC ARC FURNACE-WET SUBCATEGORY [5]

Average raw wastewater flow: 2.4 m^3/Mg (578 gal/ton)
Average treated effluent flow: 1.3 m^3/Mg (309 gal/ton)

Parameter	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a] Median	Maximum	Average	Number detected	Concentration, mg/L[a] Median	Maximum	Average	
TSS	3	2,800	6,300	3,400	3	38	86	44	99
Fluoride	2	39	49	39	2	30	34	30	
pH	3	7.1	9.0	7.9	3	7.6	7.8	7.6	

[a]Except pH values, given in pH units.

TABLE 6-19. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR ELECTRIC ARC FURNACE-WET SUBCATEGORY [5]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, µg/L			Number detected	Concentration, µg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Antimony	1	670			1	10			99
Arsenic	1	120			1	11			91
Cadmium	1	3,300			1	1,500			55
Chromium	1	4,300			1	550			87
Copper	1	1,300			1	80			94
Lead	1	9			1	1,500			-[a]
Nickel	1	43			1	10			77
Silver	1	63			1	10			84
Zinc	3	100,000	190,000	97,000	2	29,000	38,000	29,000	70
Phthalates									
Bis(2-ethylhexyl) phthalate	3	160	170	110	3	110	330	150	-[a]
Butyl benzyl phthalate	3	57	150	70	2	51	95	51	27
Di-n-butyl phthalate	3	17	65	30	3	11	21	12	60
Phenols									
4-Nitrophenol	2	19	31	19	0				>99
Pentachlorophenol	2	22	40	22	1	14			36
Aromatics									
Benzene	3	10	25	14	3	12	28	15	-[a]
Polycyclic aromatics									
Fluoranthene	2	30	58	30	2	7	10	7	77
Pyrene	2	28	53	28	2	72	150	72	-[a]

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

II.6.2.8 Subcategory 11 - Vacuum Degassing [5]

The effluent discharges from the vacuum degassing process are characteristically low in concentrations of the following regulated parameters: suspended solids, lead, manganese, nitrate, zinc, and pH. Typical concentrations of these parameters in degasser effluent waters are:

Suspended solids	30 mg/L
Lead	1 mg/L
Manganese	10 mg/L
Nitrate	25 mg/L
Zinc	5 mg/L
pH	6.0 - 9.0

The appearance of lead, manganese, and zinc in degasser effluents is due to the use of these metals in specialty steels. The gases emitted from the molten steel contain these constituents, which come into contact with barometric condenser cooling water during degassing. Nitrates occur in the effluent as a result of the reaction of nitrogen gas with oxygen in the high-temperature environment. Nitrogen gas is used to blanket the molten steel bath to enhance degassing, and it is therefore available for conversion to nitrate form. Wastewater characterization data for conventional and toxic pollutants emitted from sampled carbon steel vacuum degassing plants are presented in Tables 6-20 and 6-21. Refer to Tables 6-79 and 6-80 of the plant specific section for wastewater characterization for toxic pollutants for the sampled specialty steel vacuum degassing plant.

TABLE 6-20. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE VACUUM DEGASSING SUBCATEGORY [5]

Average raw wastewater flow: 1.3 m^3/Mg (303 gal/ton)
Average treated effluent flow: 1.2 m^3/Mg (280 gal/ton)

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a] Median	Maximum	Average	Treated effluent: Number detected	Treated effluent: Concentration, mg/L[a] Median	Maximum	Average	Average percent removal
TSS	4	30	81	47	3	29	39	28	40
Nitrate	3	2.8	27	10	2	14	27	14	-[b]
Manganese	3	4.0	9.0	5.0	3	0.27	9	3.1	38
pH	2	8.1	8.6	7.9	3	7.9	7.9	7.0	

[a]Except pH values, given in pH units.

[b]Average treated effluent concentration exceeds average raw wastewater concentration.

TABLE 6-21. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE VACUUM DEGASSING SUBCATEGORY, CARBON STEEL SUBDIVISION [7]

Toxic pollutant	Raw wastewater: Number detected	Raw wastewater: Concentration, µg/L Median	Maximum	Average	Treated effluent: Number detected	Treated effluent: Concentration, µg/L Median	Maximum	Average	Average percent removal
Metals and inorganics									
Chromium	3	130	3,000	1,100	3	26	3,000	1,000	10
Copper	3	90	440	190	3	210	440	230	-[a]
Lead	3	300	2,000	830	3	90	2,000	720	13
Nickel	2	32	40	32	2	22	30	22	31
Zinc	3	2,000	30,000	10,800	3	330	30,000	10,000	8
Phthalates									
Butyl benzyl phthalate	2	34	57	34	2	28	53	28	18
Di-n-butyl phthalate	2	31	43	31	2	260	500	260	-[a]

Note: Blanks indicate no data available.

[a]Treated effluent concentration exceeds raw waste water concentration.

II.6.2.9 Subcategory 12 - Continuous Casting [5]

The continuous casting steelmaking process produces mill scale and oils and greases from the secondary spray cooling process. Withdrawal and guide rolls guide the cast product through the solidification stage. Since the cast product is hot, the surface oxidizes and the resulting scale washes out with the spray cooling water. Additional mill scale flakes off when the cast product discharges onto caster runout tables. Caster equipment employs hydraulic and lubrication systems which add oils and greases to the wastewater. A typical analysis of the regulated parameters is as follows:

Suspended solids	50 mg/L
Oil and grease	25 mg/L
pH	6-9

The appearance of heavy metal constituents, such as chromium, lead, and zinc, in caster wastewaters is due to the use of these metals in steelmaking and alloying. Concentrations of heavy metals in the wastewater, however, are generally low and have little impact upon the treatment of caster wastes. Also, relatively few organic pollutants are found in wastewater samples.

Wastewater characterization for conventional pollutants for sampled continuous casting carbon steel plants is presented in Table 6-22. Major toxic pollutants for this subcategory are listed in Table 6-23.

II.6.2.10 Subcategory 13 - Hot Forming-Primary [6]

The hot forming process produces scale and oil and grease as the waste products from the primary rolling mill operation. As the hot ingot is being rolled in the mill stands, the steel surface oxidizes and is continuously scaling and chipping off. These scale particles range in size, with approximately 6% being less than 100 mesh, and consist primarily of iron oxides. Oils are found in rolling mill wastewaters as a result of oil spills, line breaks, and excessive dripping of lubricants as well as wash down oils. Another wastestream that contributes to the pollutant loading is the emission gas scrubber, which collects particulates and other pollutants. The raw effluent discharges from the primary carbon and specialty rolling mills have similar waste characterization for the regulated parameters of suspended solids, oil and grease, and pH. However, the quantities of solids vary between carbon and specialty rolling mills. The carbon rolling operation results in higher scale quantities, and specialty scale is much finer. Applied water rates are generally higher for specialty steel rolling mills.

TABLE 6-22. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE CONTINUOUS SUBCATEGORY [5]

Average raw wastewater flow: 12 m^3/Mg (2,852 gal/ton)
Average treated effluent flow: 0.28 m^3/Mg (67.5 gal/ton)

	Raw wastewater				Treated effluent				
	Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]			Average percent
Parameter	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
TSS	4	25	48	26	4	15	37	15	-[b]
Oil and grease	4	22	39	23	4	2	35	15	35
pH	4	7.4	8.3	7.2	4	7.8	9.4	8.0	

[a]Except pH values, given in pH units.
[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-23. WASTEWATER CHARACTERIZATION FOR TOXIC POLLUTANTS FOR CONTINUOUS CASTING SUBCATEGORY [5]

	Raw wastewater				Treated effluent				Average
	Number	Concentration, µg/L			Number	Concentration, µg/L			percent
Toxic pollutant	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
Metals and inorganics									
Copper	4	54	160	72	4	120	210	120	75
Nickel	4	11	100	32	3	27	90	47	-[a]
Selenium	3	10	220	80	3	8	10	8	90
Zinc	4	250	740	360	4	290	970	430	-[a]
Phenols									
p-Chloro-*m*-cresol	3	16	110	45	2	7	11	7	84
Phthalates									
Di-n-butyl phthalate	3	12	84	34	3	45	50	43	-[a]
Di-n-octyl phthalate	4	19	180	57	3	11	710	180	-[a]
Aromatics									
Toluene	4	7	26	12	4	6	10	6	50

[a]Treated effluent concentration exceeds raw wastewater concentration.

The appearance of heavy metal constituents such as chromium, lead, and zinc in hot forming wastewaters is due to the use of these metals in steelmaking and alloying. Concentrations of heavy metals in the wastewater, however, are generally low and have little impact upon the treatment of the wastewater. Also, relatively few organic toxic pollutants were detected in the water of plants sampled.

Wastewater characterization data for conventional pollutant parameters for sampled hot forming-primary mills are presented in Table 6-24. Toxic pollutant concentrations for all sampled hot forming-primary (carbon and specialty) steel mills are presented in Table 6-25.

TABLE 6-24. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HOT FORMING-PRIMARY SUBCATEGORY [6]

Average raw wastewater flow: 2.8 m^3/Mg (678 gal/ton)
Average treated effluent flow: 1.3 m^3/Mg (323 gal/ton)

Parameter	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a] Median	Maximum	Average	Number detected	Concentration, mg/L[a] Median	Maximum	Average	
TSS	5	54	240	87	5	2	18	6	93
Oil and grease	5	35	170	60	5	10	12	9	85
pH	9	7.9	8.9	7.9	8	7.8	8.1	7.6	

[a]Except pH values, given in pH units.

II.6.2.11 Subcategory 14 - Hot Forming-Section [6]

The hot forming process produces scale and oil and grease as the waste products from the section rolling mill operation. Wastewater sources and loadings are very similar to those of the hot forming-primary subcategory and include scale pit effluent, rolling mill wastewater, oil spill wastes, high pressure water sprays, and wet precipitation or scrubber for cleaning gaseous emissions. Rolling mill wastewaters generally contain 100 to 200 mg/L of suspended solids and 50 to 100 mg/L of oil and grease. The pH of these wastewaters rarely deviates from the 6.0 to 9.0 range. The appearance of heavy metal constitutuents such as chromium, lead, and zinc in hot forming wastewaters is due to the use of these metals in steelmaking and alloying. Concentrations of heavy metals in the wastewaters, however, are generally low and have little impact upon treatment of the wastewater. Also, relatively few organic toxic pollutants were detected in the waters of the plants sampled. Conventional pollutant concentrations for hot forming-sections mills are presented in Table 6-26. Toxic pollutant concentrations for hot forming-section mills are presented in Table 6-27.

II.6.2.12 Subcategory 15 - Hot Forming-Flat [6]

The raw effluent discharges from plate mills in the hot forming-flat subcategory are similar in character to the wastewaters of other hot forming mills. Plate mill wastewaters generally contain 100 to 200 mg/L of suspended solids and 50 to 100 mg/L of oil and grease. The pH range of these wastewaters rarely deviates from the 6.0 to 9.0 range. Wastewater sources are also similar to those of the previously described hot forming subcategories. Major sources include rolling mill wastewater, oil and grease spills, and wet scrubbing of gaseous emissions. Wastewater characterization for flat plate mills is presented

TABLE 6-25. WASTEWATER CHARACTERIZATION FOR TOXIC POLLUTANTS FOR HOT FORMING-PRIMARY SUBCATEGORY [6]

Toxic pollutant	Raw wastewater: Number detected	Raw wastewater: Concentration, µg/L: Median	Maximum	Average	Treated effluent: Number detected	Treated effluent: Concentration, µg/L: Median	Maximum	Average	Average percent removal
Metals and inorganics									
Cadmium	5	<10	<10	<10					
Chromium	5	50	130	80	5	40	130	62	22
Copper	5	300	970	440	5	40	760	180	59
Cyanide	2	2	2	2					
Lead	5	300	810	330	5	50	320	10	97
Nickel	5	220	570	310	5	20	480	120	61
Silver	5	20	20	20					
Zinc	5	100	140	90	5	30	100	48	47
Phthalates									
Bis(2-ethylhexyl) phthalate	3	18	149	71					
Di-n-butyl phthalate	2	6	10	6					
Di-n-octyl phthalate	3	7	7	6					
Halogenated aliphatics									
Chloroform	6	<10	13	<10					
Methylene chloride	2	2	2	2					
Trichloroethylene	3	100	270	63					

Note: Blanks indicate no data available.

TABLE 6-26. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HOT FORMING-SECTION SUBCATEGORY, [6]

Average raw wastewater flow: 18 m^3/Mg (4,400 gal/ton)
Average treated effluent flow: 3 m^3/Mg (720 gal/ton)

	Raw wastewater				Treated effluent				
	Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]			Average percent
Parameter	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
TSS	10	44	260	66	10	10	87	26	60
Oil and grease	10	32	250	47	10	9	30	11	77
pH	10	7.6	8.1	7.6	10	7.8	9.5	7.9	

[a]Except pH values, given in pH units.

TABLE 6-27. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE HOT FORMING-SECTION SUBCATEGORY [6]

	Raw wastewater				Treated effluent				Average
	Number	Concentration, µg/L			Number	Concentration, µg/L			percent
Toxic pollutant	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
Metals and inorganics									
Cadmium	1	10							
Chromium	10	30	240	67	10	36	130	59	12
Copper	10	60	600	70	10	38	760	130	-[a]
Lead	10	50	790	140	9	50	320	85	39
Nickel	10	55	830	230	9	22	490	170	26
Zinc	10	80	1,230	270	10	47	2,200	280	-[a]
Phthalates									
Bis(2-ethylhexyl) phthalate	5	150	1,300	190					
Butyl benzyl phthalate	1	14							
Dimethyl phthalate	3	5	11	7					
Phenols									
2,4-Dinitrophenol	3	13	19	12					
Polycyclic aromatics									
Naphthalene	3	10	10	7					
Pyrene	2		5	5					
Halogenated aliphatics									
Methylene chloride	4	160	190	44					

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

in Tables 6-28 and 6-29. Tables 6-30 and 6-31 present conventional and toxic wastewater characteristics for the hot forming-flat hot strip and sheet mills.

TABLE 6-28. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HOT FORMING-FLAT SUBCATEGORY, PLATE MILL SUBDIVISION [6]

Average raw wastewater flow: 10 m^3/Mg (2,500 gal/ton)
Average treated effluent flow: 5.0 m^3/Mg (1,200 gal/ton)

Parameter	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a] Median	Maximum	Average	Number detected	Concentration, mg/L[a] Median	Maximum	Average	
TSS	7	35	110	49	7	1	7	2.5	45
Oil and grease	7	18	72	30		10	13	10	59
pH	7	7.7	8.9	7.8	10	7.4	7.9	7.5	

[a]Except pH values, given in pH units.

II.6.2.13 Subcategory 16 - Pipe and Tube [6, 7]

Wastewater results from the hot forming operation because of the large amount of direct contact cooling and descaling waters required between the hot steel and the piercing, plug, and reeler mill equipment. Seamless pipe and tube operations and butt weld mills emit wastewater from the cleaning of the dies and the rolling operations respectively. Roll cooling sprays used in butt welded pipe mills are generally once-through water systems where the scale- and oil-bearing waters are discharged to scale pits. Seamless tube mills have similar roll cooling wastewaters, plus a once-through spray quench water system. The cold forming process produces wastewater as a result of continuous flushing of rolls and welders with soluble oil coolant solutions. The raw effluent discharges from pipe and tube mills are similar in character to other hot forming mill wastewaters. Pipe and tube mill wastewaters generally contain 100 to 200 mg/L of suspended solids and 50 to 100 mg/L of oil and grease. The pH of these wastewaters rarely deviates from the 6.0 to 9.0 range. Oils are found in hot mill wastewaters as a result of oil spills, line breakers, and excessive dripping of lubricants; appreciable quantities of spent oils and greases are added when equipment is washed down. The appearance of heavy metal constituents such as chromium, lead, and zinc in hot forming wastewaters is due to the use of these metals in steelmaking and alloying. Concentrations of heavy metals in the wastewater, however, are generally low and have little impact upon treatment of the wastewater. The scale formed in the cold worked mills is primarily a very fine ferric oxide (Fe_2O_3) which occurs as a result of surface oxidation of the steel.

TABLE 6-29. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE HOT FORMING-FLAT SUBCATEGORY, PLATE MILL SUBDIVISION [6]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, µg/L			Number detected	Concentration, µg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Chromium	7	40	120	50	7	640	1,000	460	-[a]
Copper	7	210	330	190	7	40	50	40	79
Lead	7	60	470	140	7	50	50	46	67
Nickel	7	150	980	270	7	40	40	34	87
Zinc	7	90	110	80	7	30	70	34	57
Phthalates									
Bis(2-ethylhexyl) phthalate	6	430	820	350					
Di-n-butyl phthalate	1	32							
Phenols									
2,4-Dimethylphenol	2		14	9					
Pentachlorophenol	2		12	8					
Halogenated aliphatics									
Methylene chloride	3	14	120	44	1			<0.01	-

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-30. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HOT FORMING-FLAT SUBCATEGORY, HOT STRIP AND SHEET MILL SUBDIVISION [6]

Average raw wastewater flow: 22 m^3/Mg (5,300 gal/ton)
Average treated effluent flow: 22 m^3/Mg (5,300 gal/ton)

Parameter	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a] Median	Maximum	Average	Number detected	Concentration, mg/L[a] Median	Maximum	Average	
TSS	2	52	57	52	2	21	38	21	60
Oil and grease	2	8	10	8	2	3	4	3	67
pH	2	7.8	8.1	7.8	2	7.8	7.9	7.8	

[a]Except pH values, given in pH units.

Water soluble and emulsified oils, which are essential to the operation of the cold forming mill, are found in appreciable quantities in the wastewater. Suspended solids concentrations are generally in the range of 100 to 200 mg/L. The pH is sometimes slightly acidic, but it is generally in the range of 6.0 to 9.0.

As is true for hot forming operations, wastewaters are generally low in heavy metals and organic toxic pollutants.

Wastewater characterization for conventional and toxic pollutants for two sampled hot forming pipe and tube mills is presented in Tables 6-32 and 6-33. Heavy metal toxic pollutants originate in the raw materials used in steel making. These metals find their way into the process wastewaters when the product scale contaminates the wastewater. Copper was the only toxic metal found in the data reviewed. No toxic organics were detected at levels greater than 10 µg/L and are not reported due to this. Refer to Table 6-96 in the plant specific section for wastewater characterization for conventional pollutants for the sampled cold forming pipe and tube plant.

II.6.2.14 Subcategory 17 - Sulfuric Acid Pickling [8]

There are three main sources of wastewater in sulfuric acid pickling operations: spent pickle liquor (acid concentrates), rinse waters, and acid vapors and mists. Typical spent sulfuric pickle liquor averages about 8% free acid and 8% dissolved iron. On this basis, each ton of steel pickled (at 1% loss) would generate about 25 gal of spent pickle liquor.

After pickling, the material is subjected to a water rinse to remove the acid/iron solution from the surface. Typical rinse water flow rates range from 1 to 50 L/S (15 to 80 gal/min).

TABLE 6-31. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE HOT FORMING-FLAT SUBCATEGORY, HOT STRIP AND SHEET MILL SUBDIVISION [11]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, µg/L			Number detected	Concentration, µg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Chromium	2	86	170	86	2	88	174	88	-[a]
Copper	2	35	45	35	2	16	31	16	54
Lead	1	50			1	50			0
Nickel	1	20			1	20			0
Zinc	2	112	200	112	2	105	206	105	6
Phthalates									
Bis(2-ethylhexyl) phthalate	1	279							
Di-n-butyl phthalate	2		23	12					
Phenols									
2,4-Dinitrophenol	1	28							
Halogenated aliphatics									
Chloroform	1	18							

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-32. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE PIPE AND TUBE SUBCATEGORY, HOT FORMING SUBDIVISION [6]

Average raw wastewater flow: 31 m^3/Mg (7,500 gal/ton)
Average treated effluent flow: 34 m^3/Mg (8,100 gal/ton)

	Raw wastewater				Treated effluent				
	Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]			Average percent
Parameter	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
TSS	2	51	66	51	4	20	38	20	61
Oil and grease	2	6.5	7.9	6.5	4	4	4	4	38
pH	2	7.6	7.8	7.6	4	7.6	7.8	7.6	

[a]Except pH values, given in pH units.

TABLE 6-33. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE PIPE AND TUBE SUBCATEGORY, HOT FORMING SUBDIVISION [6]

	Raw wastewater				Treated effluent				Average
	Number	Concentration, µg/L			Number	Concentration, µg/L			percent
Toxic pollutant	detected	Median	Maximum	Average	detected	Median	Maximum	Average	removal
Metals and inorganics									
Beryllium	1	10							
Cadmium	1	<10							
Chromium	2	140	240	140	2	37	43	37	74
Copper	2	73	80	73	2	26	31	26	64
Lead	2	430	800	430	1	50			88
Nickel	2	300	500	300	1	20			93
Zinc	2	160	250	160	1	120	210	120	25

Note. Blanks indicate no data available.

Many pickling facilities are equipped to include a scrubbing device which uses water to collect the acid mist. Others use condensing "demisters" to trap acid vapors for return to the pickling tanks. Most large continuous H_2SO_4 picklers utilize wet scrubber systems with recycle of frame scrubber wastewaters. Efficient operations achieve less than 3% blowdown from their scrubbers.

Another source of acid vapors and mists is the absorber vent scrubber associated with an acid recovery mist. Other recovery units tend to use demister type or dry vent controls for preventing pollution from this source. In most cases condensates are returned to the pickling tank.

Wastewater characterization for conventional pollutants is presented in Table 6-34 for sulfuric acid batch pickling operations and in Table 6-35 for sulfuric acid continuous pickling operations. Toxic pollutant data for batch pickling operations are presented in Table 6-36. Two continuous pickling operations were sampled for toxic pollutants, and data for both plants (094 and 097) are presented in Tables 6-97 and Table 6-98 in the plant specific section.

TABLE 6-34. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE SULFURIC ACID PICKLING SUBCATEGORY, BATCH SUBDIVISION [8]

Average raw wastewater flow: rinse water - 0.68 m^3/Mg (271 gal/ton)

	Gross raw wastewater				Gross process effluent			
	Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]		
Parameter	detected	Median	Maximum	Average	detected	Median	Maximum	Average
TSS	5	32	360	180		0.6	1.3	0.7
Oil and grease	5	18	48	24	4	8.8	11	4.9
pH	5	1.8	6.9	3.3		8.4	9.0	8.3

Note: Blanks indicate no data available.
[a]Except pH values, given in pH units.

TABLE 6-35. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE SULFURIC ACID PICKLING SUBCATEGORY, CONTINUOUS SUBDIVISION [8]

Average raw wastewater flow: spent concentrate - 0.083 m^3/Mg (19.8 gal/ton)
rinse water - 0.69 m^3/Mg (164 gal/ton)
fume hood scrubber - 0 037 m^3/Mg (8.9 gal/ton)

	Spent concentrate				Rinse water				Fume hood scrubber			
	Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]			Number	Concentration, mg/L[a]		
Parameter	detected	Median	Maximum	Average	detected	Median	Maximum	Average	detected	Median	Maximum	Average
TSS	7	200	17,000	2,600	13	38	500	192	3	7.5	200	69
Oil and grease	6	10	46	18	3	14	33	19	3	2.5	9	4.5
pH	7	<1			2	4	5.7	4	3	1.7	1.9	1.7

Note: Blanks indicate no data available.
[a]Except pH values, given in pH units

TABLE 6-36. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE SULFURIC ACID PICKLING SUBCATEGORY, BATCH SUBDIVISION [8]

Toxic pollutant	Spent concentrate Concentration, µg/L				Rinse water Concentration, µg/L			
	Number detected	Median	Maximum	Average	Number detected	Median	Maximum	Average
Metals and inorganics								
Arsenic	1	170			3	<10	173	64
Cadmium	2	270	280	270	3	<10	302	107
Hexavalent chromium	2	4						
Chromium, Total	2	232,000	260,000	232,000	3	50	2,000	680
Copper	2	3,600	4,700	3,600	3	140	2,400	860
Cyanide	2	13	17	13	2	11	11	11
Lead	2	800	1,600	800	3	40	1,000	360
Nickel	2	25,000	27,000	25,000	3	60	13,800	4,600
Silver	2	51	600	51				
Zinc	2	74,000	133,000	74,000	3	90	1,800	640
Phenols								
2,4,6-Trichlorophenol	1	41						
Aromatics								
Benzene					1	<10		
Toluene	1	<10						
Polycyclic aromatics								
Acenaphthylene				5				1
Naphthalene					1	<10		
Pyrene					2	<10	<10	<10
Halogenated aliphatics								
Chloroform	1	20			2	<10	<10	<10
Methylene chloride	2	33	52	33	3	43	165	73
Trichloroethylene	1	<10						

Toxic pollutant	Treated wastewater Concentration, µg/L			
	Number detected	Median	Maximum	Average
Aromatics				
Benzene	2	<10	<10	<10
Polycyclic aromatics				
Fluoranthene	1	<10		
Naphthalene	2	<10	<10	<10
Halogenated aliphatics				
Chloroform	5	20	25	22
Methylene chloride	5	154	230	140

Note: Blanks indicate no data available.

II.6.2.15 Subcategory 18 - Hydrochloric Acid Pickling [8]

The process wastewater generated during pickling operations include spent acid concentrations, rinse water, fume hood scrubber wastewater, and absorber vent scrubber wastewater. A typical discharge flow rate for an acid concentrate is 0.084 m^3/Mg (20 gal/ton). The spent pickling solution may contain free acid, ferrous salts, and relatively small amounts of other metal sulfates, chlorides, lubricants, inhibitors, and hydrocarbons. Rinse water is used to flush the pickled metal and thus appears as dilute spent liquor. Continuous facilities use 6 to 65 L/S (100 to 1,000 gpm) and batch facilities use 1.5 to 20 L/S (25 to 300 gpm). Fume hood scrubbers and absorber vent scrubbers collect acid mists to prevent air contamination; as a result their discharges must be treated to neutralize the captured acid.

Most chemical characteristics show significant variation, reflecting pickling line configuration and applied flows. Note that the major constituents of the wastewater are dissolved iron and suspended solids. The concentrations of other constituents are generally less than 1 mg/L except in the concentrates where chromium, copper, nickel, and zinc concentrations were generally greater than 10 mg/L. Tables 6-37 through 6-40 present conventional and metal concentrations for raw wastewater and gross treated effluent for continuous line acid concentrates, rinse water, fume hood scrubbers, and absorber vent scrubbers. Table 6-41 presents toxic pollutant concentration data for the continuous line raw wastewater. Additional data on the hydrochloric acid pickling subcategory appear in the plant specific section. Also found in the plant specific section is information on batch-type hydrochloric acid pickling.

TABLE 6-37. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS AND METALS FOR THE HYDROCHLORIC ACID PICKLING SUBCATEGORY, CONTINUOUS SUBDIVISION (CONCENTRATES) [8]

Average raw waste flow: 0.08 m^3/Mg (19.5 gal/ton)
Average gross effluent flow: 0.17 m^3/Mg (41.4 gal/ton)

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a] Median	Maximum	Average	Gross effluent: Number detected	Gross effluent: Concentration, mg/L[a] Median	Maximum	Average	Average percent removal
TSS	6	97	320	120	1			36	30
Oil and grease	1			5.1	1			<1	80
pH	3	<1	<1	<1	1			8.4	
Antimony	2		3.7	1.9					
Arsenic	2		0.4	0.21					
Cadmium	2		0.31	0.3					
Total chromium	3	8.7	18	9.4					
Copper	3	11	28	14					
Lead	1			2.1					
Nickel	3	13	13	9.5					
Zinc	3	4.2	4.6	3.8					

Note: Blanks indicate no data available.
[a]Except pH values, given in pH units.

TABLE 6-38. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS AND TOXIC METALS FOR THE HYDROCHLORIC ACID PICKLING SUBCATEGORY, CONTINUOUS SUBDIVISION (RINSES) [8]

Average raw waste flow: 0.5 m^3/Mg (120 gal/ton)
Average gross effluent flow: 0.64 m^3/Mg (152 gal/ton)

Parameter	Raw wastewater				Gross effluent				Average percent removal
	Number detected	Concentration, mg/L[a] Median	Maximum	Average	Number detected	Concentration, mg/L[a] Median	Maximum	Average	
TSS	9	15	210	34	5	2	36	12	65
Oil and grease	6	28	150	40	5	1	6	3.5	91
pH	11	1.6	4.2	2.4	5		9.0	8.0	
Antimony	2		0.19	0.19					
Arsenic	2		0.24	0.23	2		0.044	0.031	86
Cadmium	1			0.01	2			0.011	-[b]
Total chromium	3	0.57	0.79	0.57	1			0.22	61
Copper	5	0.67	1.6	0.72	2		0.25	0.14	81
Lead	2		0.43	0.29	1			0.032	89
Nickel	4	0.73	1.3	0.78	2		0.44	0.25	68
Zinc	5	0.38	1.4	0.49	2		0.066	0.045	91

Note: Blanks indicate no data available.

[a]Except pH values, given in pH units.

[b]Gross effluent concentration exceeds raw waste concentration.

TABLE 6-39. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS AND TOXIC METALS FOR THE HYDROCHLORIC ACID PICKLING SUBCATEGORY, CONTINUOUS SUBDIVISION (FUME HOOD SCRUBBERS) [8]

Average raw waste flow: 0.11 m^3/Mg (25 gal/ton)
Average gross effluent flow: 0.078 m^3/Mg (18.6 gal/ton)

Parameter	Raw wastewater				Gross effluent				Average percent removal
	Number detected	Concentration, mg/L[a] Median	Maximum	Average	Number detected	Concentration, mg/L[a] Median	Maximum	Average	
TSS	4	7.5	2,100	530	2		11	7.0	98
Oil and grease	4	29	330	95	2		1.9	1.4	99
pH	6	1.4	3.3	1.6	2		9.0	8.0	
Antimony	2	0.10	0.11	0.10					
Arsenic	2	0.055	0.07	0.055	2	0.008	0.013	0.008	99
Cadmium				-[b]	1	0.011			
Total chromium	3	0.15	0.24	0.16	1	0.075			53
Copper	4	0.19	0.76	0.31	2	0.17	0.28	0.17	55
Lead	1	0.35			1	0.025			93
Nickel	3	0.1	0.2	0.13	2	0.13	0.19	0.13	23
Zinc	4	0.13	1.5	0.45	1	0.027			94

Note: Blanks indicate no data available.

[a]Except pH values, given in pH units.

[b]Detected but not quantified.

TABLE 6-40. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS AND TOXIC METALS FOR THE HYDROCHLORIC ACID PICKLING SUBCATEGORY, CONTINUOUS SUBDIVISION (ABSORBER VENT SCRUBBERS) [8]

Average raw waste flow: 0.86 m^3/Mg (205 gal/ton)
Average gross effluent flow: 0.71 m^3/Mg (170 gal/ton)

Parameter	Raw wastewater				Gross effluent				Average percent removal
	Number detected	Concentration, mg/L[a]			Number detected	Concentration, mg/L[a]			
		Median	Maximum	Average		Median	Maximum	Average	
TSS	6	85	150	80	1	9.7			
Oil and grease	2		2.2	2.0	1	0.47			75
pH	6	5.6	7.1	4.2					
Antimony	1			0.21					
Arsenic	1			0.017	1	0.002		0.002	-[c]
Cadmium				-[c]	1	0.011			
Total chromium	1			0.98		-[b]		-[b]	
Copper	2		1.3	0.87	1	0.024			98
Lead	1			0.1		-[b]		-[b]	
Nickel	2		0.79	0.72	1	0.059			92
Zinc	2		1.1	0.9		-[b]		-[b]	

Note: Blanks indicate no data available.

[a]Except pH values, given in pH units.

[b]Detected but not quantified.

[c]Gross effluent concentration exceeds raw waste concentration.

II.6.2.16 Subcategory 19 - Cold Rolling [7]

The major water use on cold rolling mills is for cooling the rolls and the material being rolled. This is accomplished by using a flooded lubrication system to supply both lubrication and cooling. A water-oil emulsion is sprayed directly on the material and rolls as the material enters the rolls. Each stand has its own sprayer and, where recycle is used, its own recycle system.

The water used in cold rolling mill must be of fairly good quality, free of suspended matter. High quality rolling oils are added to form the emulsion. Recirculating mills recircle the oil emulsion. The material being rolled is clean and free from rust, and because no scale is generated during the rolling, oil and temperature are the basic pollutants in the discharge when the emulsion is not recirculated.

Direct application mills constantly add fresh rolling solutions on a once-through basis. Normally these plants install treatment systems to recover the oils for potential reuse. This process is normally used only when a high quality product is desired.

A third type of cold rolling mill is a combination mill which combines the recirculation and direct application of the rolling emulsion. The discharge rate at such a mill is substantially less than that at a direct application mill due to the partial recirculation. Wastewater characterization for conventional pollutants for the three subdivisions of the

TABLE 6-41. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE THE HYDROCHLORIC ACID PICKLING SUBCATEGORY, CONTINUOUS SUBDIVISION [14]

	Absorber vent scrubber raw wastewater			Fume hood scrubber raw wastewater				Rinse wastewater			
		Concentration, µg/L			Concentration, µg/L				Concentration, µg/L		
Toxic pollutant	Number detected	Maximum	Average	Number detected	Median	Maximum	Average	Number detected	Median	Maximum	Average
Metals and inorganics											
Antimony	1	<210		2	175	200	170	3	<100	190	110
Arsenic	1	<23		3	66	75	50	3	233	290	190
Beryllium	1	<20		1	<20			1	<20		-[a]
Cadmium	1	<20		4	<12	<200	59	6	<15	<200	45
Chromium	2	<200	<140	3	150	<330	190	6	390	840	300
Copper	2	1,600	850	4	120	390	180	5	690	1,500	770
Cyanide	2	18	10	4	6	12	6	6	8	75	20
Lead	1	<600		3	<100	<600	260	6	260	6,200	1,250
Mercury	1	32		1	2						
Nickel	2	790	420	3	150	<500	230	6	690	1,300	700
Selenium	1	<35		3	<10	<10	7	3	<10	200	70
Silver	1	<250		4	<20	<250	75	6	21	<250	58
Thallium	1	<70		1	<50						
Zinc	2	1,300	670	4	87	270	120	6	380	1,500	520
Phenols											
Pentachlorophenol					26	43	26				
Aromatics											
Benzene									12	14	12
Chlorobenzene				1	26						
Polycyclic aromatics											
Fluoranthene								6	<10	65	19
Pyrene								6	<10	75	22
Halogenated aliphatics											
Chlorodibromomethane				1	13						
Chloroform	1	26		4	<10	16	12	5	<10	37	16
1,1-Dichloroethylene				1	12						
1,2-*Trans*-dichloroethylene	1	23									
Methylene chloride	2	1,100	550	3	<10	82	34	6	11	3,600	690
Tetrachloroethylene	1	14						3	22	40	24
Trichloroethylene								2	37	65	37

(continued)

TABLE 6-41 (continued)

Toxic pollutant	Spent pickle liquor Concentration, µg/L Number detected	Median	Maximum	Average	Discharge wastewater Concentration, µg/L Number detected	Median	Maximum	Average
Metals and inorganics								
Antimony	2	2,100	4,100	2,100	2	100	190	100
Arsenic	2	35	45	35	3	230	260	170
Beryllium					1	<20		
Cadmium	4	140	280	150	5	<20	240	96
Chromium	5	8,700	37,000	13,000	5	440	2,300	770
Copper	5	11,000	22,000	11,000	5	680	900	620
Cyanide	5	8	11	8	5	14	74	23
Lead	4	1,700	1,500,000	390,000	5	420	33,000	7,000
Mercury					1	<2		
Nickel	5	13,000	22,000	10,000	5	640	860	540
Selenium	4	<10	170	50	4	6	20	9
Silver	4	290	390	250	5	23	250	70
Thallium	1	180			1	<50		
Zinc	5	4,200	61,000	15,000	5	600	290,000	58,000
Aromatics								
Benzene					2	12	14	12
Polycyclic aromatics								
Fluoranthene	5	<10	65	21	5	<10	56	20
Pyrene	4	<10	75	26	5	<10	65	22
Halogenated aliphatics								
Chloroform	5	<10	100	28	5	<10	36	15
Methylene chloride	5	14	3,500	720	5	15	3,600	740
Tetrachloroethylene	3	31	40	27	2	29	37	29
Trichloroethylene					2	50	90	50

Note: Blanks indicate no data available.

[a]Detected but not quantified.

cold rolling subcategory is presented in Table 6-42 through Table 6-44. Wastewater characterization for the cold rolling subcategory for toxic pollutants is presented in Table 6-45.

TABLE 6-42. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE COLD ROLLING SUBCATEGORY, RECIRCULATING MILL SUBDIVISION [7]

Average raw waste flow: 27.7 m^3/Mg (6,602 gal/ton)
Average gross effluent flow: 0.2 m^3/Mg (50.3 gal/ton)

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a] Median	Maximum	Average	Gross effluent: Number detected	Gross effluent: Concentration, mg/L[a] Median	Maximum	Average	Average percent removal
TSS	3	2,200	5,000	2,600	2	110	200	110	96
Oil and grease	3	37,000	82,000	40,000	2	71	140	71	99
pH	3	6.5	6.7	6.3	8	6.1	8.2	6.1	

[a]Except pH values, given in pH units.

TABLE 6-43. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE COLD ROLLING SUBCATEGORY, DIRECT APPLICATION MILL SUBDIVISION [7]

Average raw waste flow: 2.7 m^3/Mg (659 gal/ton)
Average gross effluent flow: 2.7 m^3/Mg (659 gal/ton)

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a] Median	Maximum	Average	Gross effluent: Number detected	Gross effluent: Concentration, mg/L[a] Median	Maximum	Average	Average percent removal
TSS	1	290			1	300			-[b]
Oil and grease	1	1,900			1	1,400			26
pH	1	7.2			1	3.3			

Note: Blanks indicate no data available.
[a]Except pH values, given in pH units.
[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-44. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE COLD ROLLING SUBCATEGORY, COMBINATION MILL SUBDIVISION [7]

Average raw waste flow: 1.4 m^3/Mg (339 gal/ton)
Average gross effluent flow: 1.4 m^3/Mg (339 gal/ton)

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a] Median	Maximum	Average	Gross effluent: Number detected	Gross effluent: Concentration, mg/L[a] Median	Maximum	Average	Average percent removal
TSS	2	630	990	630	2	11	16	11	98
Oil and grease	3	1,000	1,400	1,000	2	5	6	5	99
pH	3	6.2	7.1	6.2	2	7.9	8.2	7.9	

Note: Blanks indicate no data available.
[a]Except pH values, given in pH units.

TABLE 6-45. WASTEWATER CHARACTERIZATION OF POLLUTANTS FOR COLD ROLLING SUBCATEGORY [7]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, µg/L			Number detected	Concentration, µg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Antimony	1	580			2	200	300	200	66
Cadmium	2	45	45	45	1	20			56
Chromium	2	380	6,500	2,300	3	600	1,170	600	74
Copper	3	2,260	7,450	3,470	2	43	65	43	99
Cyanide	2	23	34	23					
Lead	3	1,550	2,500	1,420	2	70	90	70	95
Nickel	2	740	1,250	740	1	35			95
Zinc	3	680	1,750	870					
Phenols									
2-Chlorophenol	2	17,760	35,500	17,760					
2,4-Dimethylphenol	2	12,530	25,000	12,530					
2-Nitrophenol	2	35,030	70,000	35,030	1	21			>99
Pentachlorophenol	1	43							
Phenol	2	160		250	3	288	536	288	-[a]
4,6-Dinitro-*o*-cresol	1	94							
Aromatics									
Ethylbenzene	1	390			1	10			98
Toluene	2	87	110	87	1	60			31
Halogenated aliphatics									
Carbon tetrachloride	1	110							
Chloroform	3	80	540	210	2	34	43	34	83
1,1,2,2-Tetrachloroethane	1			0.005					
Tetrachloroethylene	2	815	1,150	815	1	16			98
1,1,1-Trichloroethane	2	217	415	217					
Pesticides and metabolites									
Xylene	1	4,300							

Note: Blanks indicate no data available.

[a]Treated effluent concentration exceeds raw wastewater concentration.

II.6.2.17 Subcategories 20 and 21 - Hot Coating-Galvanizing and -Terne Plating [9]

The major wastewater flows generated during hot coating operations in the iron and steel industry fall into several distinct groupings such as:

1. Continuously running dilute wastewater from rinsing and scrubbing operations following alkaline or acid cleaning steps, rinses following chemical treatment or surface passivation steps and final product rinses after hot dripping. These waters carry suspended and dissolved matter, chlorides, sulfates, phosphates, silicates, oily matter, and varying amounts of dissolved metals (iron, zinc, chromium, lead, tin, aluminum, cadmium) depending on which coating metal is used.

2. More concentrated intermittent discharges, including spent alkaline and acid cleaning solutions, fluxes, chemical treatment solutions, and regenerant solutions from in-line ion exchange systems. These discharges contain higher concentrations of the parameters listed above as being present in rinse water.

3. Terne scrubber wastewaters, produced by continuously scrubbing vapors and mists collected from the coating liner cleaning and coating steps. Scrubbers may be once-through a recirculating, and the wastewaters from scrubbing can be used as process rinses, since only volatile components are scrubbed out of the air. Less than one-third of the hot coating lines have wet fume scrubbers.

4. Noncontact cooling waters, used to control temperatures of the furnaces and molten metal bath pots associated with coating operations. Except for an increase in temperature, these waters do not pick up any pollutants during their passage through the coating lines; thus, they require no treatment if they are kept separate from contaminated process waters.

Wastewater characterization of conventional and toxic pollutants for the nine sampled plants in the hot coating-galvinizing subcategory is presented in Tables 6-46 and 6-47. Wastewater characterization of conventional pollutants for three plants sampled in the hot coating-terne plating subcategory is presented in Table 6-48. Toxic pollutant data on the terne plating subcategory are currently limited to one plant and may be found in the plant specific section of this report.

TABLE 6-46. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HOT COATING-GALVANIZING SUBCATEGORY [9]

Raw wastewater flow: 4.3 m^3/Mg (1,025 gal/ton)
Treated effluent flow: 4.3 m^3/Mg (1,026 gal/ton)

Parameter	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a]			Number detected	Concentration, mg/L[a]			
		Median	Maximum	Average		Median	Maximum	Average	
Hexavalent chromium	8	0.005	7	0.88	5	0.006	0.077	0.020	77
Oil and grease	10	20	210	45	6	6	11	6	87
TSS	10	84	330	100	6	9	43	17	83
pH	10	6.1	11.2	5.8	6	8.1	9.0	8.2	

[a]Except pH values, given in pH units.

II.6.2.18 Subcategory 22 - Combination Acid Pickling [8]

The wastewater from continuous acid pickling operations can originate from three sources depending on the wastewater disposal practices at the mill and the type of equipment installed. The first source of wastewater is the rinse tank(s) used to rinse the acid solution from the product after it is pickled. This wastewater source has the highest flow and contains solids, oils and greases, and dissolved metals, and it normally has a very low pH.

If fume hood scrubbers are installed, wastewater characteristics similar to those found in the rinse waters are generated. Fume hood scrubbers represent the second source of wastewater from continuous and pickling operations. The flow rates through the scrubbers vary considerably throughout this subcategory, but the discharge flow rate from this source can be reduced to below 0.42 m^3/Mg (100 gal/ton) of steel processed if recycle is practiced.

The third source of wastewater from continuous acid pickling operations is the spent pickle liquor bath, which has lower flow rates but higher contamination levels than the other two sources. Because of the small volume and high pollutant levels in this source, the waste is handled off site in more than 60% of the mills. Typical levels in the three sources are summarized in Table 6-49.

Wastewater characterization data for pickle rinse water for the combination acid pickling-batch type is shown in Tables 6-50 and 6-51. Wastewater characterization data of conventional pollutants for pickle rinse water in the combination acid pickling-continuous type is shown in Table 6-52. No toxic pollutant data are currently available for the continuous combination acid process.

TABLE 6-47. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE HOT COATING-GALVANIZING SUBCATEGORY [9]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, μg/L			Number detected	Concentration, μg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Antimony	1	3			1	3			-
Arsenic	3	14	40	21	3	10	10	9	51
Beryllium	1	<20				<20		<0.02	-
Cadmium	6	20	200	45	6	20	20	17	62
Chromium	6	15	10,200	2,113	6	35	200	77	96
Copper	6	90	2,500	487	6	30	170	52	90
Cyanide	6	12	19	12	6	10	21	9.8	18
Lead	6	310	25,000	4,390	6	145	600	270	94
Selenium	3	10	10	8.4	3	10	12	11	-[b]
Silver	6	20	2,500	65	6	20	250	70	-[b]
Thallium	1	50			1	50			-
Zinc	6	9,100	88,900	26,760	6	130	770	1,390	95
Phenols									
2-Chlorophenol	2	7	10	7	2	4	5	4	43
2,4-Dichlorophenol	3	5	5	5	1	10			-[a]
2,4-Dinitrophenol	1	5			1	5			-
2-Nitrophenol				ND	2	5	5	5	-[b]
Pentachlorophenol	3	5	22	10	3	5	5	4	60
Phenol	1	5			2	8	10	8	-[b]
2,4,6-Trichlorophenol	2	8	10	8	1	5			38
4,6-Dinitro-*o*-cresol				ND	2	10	20	10	-[b]
Aromatics									
Benzene	3	5	11	11	4	6	10	7	36
1,3-Dichlorobenzene	1	144						ND	>99
Toluene	2	8	10	8	3	10	10	8	-[b]
Polycyclic aromatics									
Acenaphthene	1	5			5	5	5	5	-
Acenaphthylene	1	10			5	5	10	7	30
Anthracene	1	5			1	7			-[b]
Benzo(a)anthracene				ND	1	5			-[b]
Benzo(a)pyrene				ND	4	5	10	6	-[b]
Chrysene					1	5			-[b]
Fluoranthene	4	7	24	11	6	9	10	7	36
Fluorene	3	5	10	10	4	5	10	6	14
Naphthalene				ND	2	10	10	10	-[b]
Phenanthrene	1	5			1	7			-[b]
Pyrene	5	5	21	12	5	7	10	7	42
2-Chloronaphthalene					2	4	5	4	-[b]
Halogenated aliphatics									
Chloroform	6	13	106	37	6	12	48	18	51
Dichlorobromomethane	1	10						ND	>99
1,2-*Trans*-dichloroethylene	1	5						ND	>99
Methylene chloride	5	16	12	134	5	13	230	60	-[b]
Tetrachloroethylene	5	10	17	10	2	8	8	8	20
1,1,1-Trichloroethane	2	39	67	39	2	19	32	19	51
Trichloroethylene	1	46			2	7	10	7	85

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a] Indicates water quality of central treatment effluent.

[b] Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-48. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HOT COATING-TERNE PLATING SUBCATEGORY [9]

Average raw waste flow: 5.2 m^3/Mg (1,239 lb/ton)
Average gross effluent flow: 5.2 m^3/Mg (1,239 lb/ton)

Parameter	Raw wastewater				Gross effluent				Average percent removal
	Number detected	Concentration, mg/L[a]			Number detected	Concentration, mg/L[a]			
		Median	Maximum	Average		Median	Maximum	Average	
Oil and grease	1	4			1	4			-
TSS	1	11			1	11			-
pH	1	6.5			1	6.5			

Note: Dashes indicate negligible removal.
[a]Except pH values, given in pH units.

TABLE 6-49. TYPICAL CONTAMINANT LEVELS IN THE THREE WASTEWATER SOURCES IN COMBINATION ACID PICKLING OPERATIONS [8]

Flow/parameter	Pickle rinse water, batch type	Pickle rinse water, continuous type	Fume hood scrubber water	Spent pickle liquor
Flow				
- normal, m^3/Mg	2.1	10.5	6.3	0.063
- after recycle, m^3/Mg			0.42	
Parameter concentration, mg/L[a]				
TSS	1,300	200	50	150
Oil and grease	12.5	3.3	5	2.0
Dissolved iron	300	80	190	20,000
Fluoride[b]	230	75	2,000	5,000
Dissolved chromium	75	20	40	3,500
Dissolved nickel	45	15	20	4,800
Nitrates[c]	150			5,000
Copper	1.7	0.21		180
pH	2.5	4.0	2.5	1.2

Note: Blanks indicate data not available.
[a]Except pH values, given in pH units.
[b]Fluorides are present in significant quantities only when hydrofluoric acids are used in the combination acid pickling process.
[c]Nitrates are present in significant quantities only when nitric acids are used in the combination acid pickling process.

TABLE 6-50. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE COMBINATION ACID PICKLING SUBCATEGORY, BATCH-TYPE SUBDIVISION [8]

Average raw waste flow. 1.2 m^3/Mg
Average gross effluent flow: 1.2 m^3/Mg

Parameter	Raw wastewater				Gross effluent				Average percent removal
	Number detected	Concentration, mg/L[a]			Number detected	Concentration, mg/L[a]			
		Median	Maximum	Average		Median	Maximum	Average	
TSS	4	80	460	124	4	40	530	159	
Oil and grease	4	6	10.5	7.1	4	6.8	24	11	
Fluoride	3	37	52	38	3	19	95	41	
pH	4	3.1	9	4.5	4	9 9	11.9	9.9	

Note: Blanks indicate no data available.
[a]Except pH values, given in pH units.
[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-51. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE COMBINATION ACID-BATCH-TYPE SUBDIVISION [8]

Raw wastewater flow: 5.2 m^3/Mg (1,239 lb/ton)
Treated effluent flow: 5.2 m^3/Mg (1,239 lb/ton)

Parameter	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a]			Number detected	Concentration, mg/L[a]			
		Median	Maximum	Average		Median	Maximum	Average	
Total iron	3	19	110	45	3	19	110	46	-[b]
Total lead	3	<0.06	0.2	0.1	3	<0.06	0.25	0.12	-[b]
Oil and grease	3	3	10	4.3	3	4.3	13	7.1	-[b]
TSS	3	11	48	22	3	11	51	24	-[b]
Total tin	3	<2	<2	<2	3	<2	<2	<2	-
pH	3	3.6 - 5.2	5.2 - 6.1	4.5	3	3.6 - 5.2	5.2 - 6.1	4.5	-

Note: Dashes indicate negligible removal.

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-52. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR COMBINATION ACID PICKLING-CONTINUOUS-TYPE SUBDIVISION [8]

Average raw wastewater flow: 6.6 m^3/Mg
Average treated effluent flow: 6.64 m^3/Mg

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[a] Median	Maximum	Average	Treated effluent: Number detected	Treated effluent: Concentration, mg/L[a] Median	Maximum	Average	Percent removal
TSS	1	14			1	8			43
Oil and grease	1	6.3			1	4.3			32
Fluoride	1	180			1	9.5			94
Nitrate	1	0.35							
pH	1	7.5			1	7.9			

Note: Blanks indicate data not available.
[a]Except pH values, given in pH units.

II.6.2.19 Subcategory 23 - Scale Removal [9]

The major source of wastewater in the kolene operation is the discharge from the quench water tank and/or the rinse steps that follow the scale removal operation. The wastewaters generated in these steps contain significant levels of solids, and total and hexavalent chromium, and they are at elevated pH and temperature levels. The quality of the rinse water may vary greatly depending on the age of the salt solution in the kolene bath and the amount of carry-over into the rinse tanks. Wastewater characterization data of conventional and toxic pollutants for kolene scale removal mills is represented in Tables 6-53 and 6-54, respectively.

TABLE 6-53. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR KOLENE SCALE REMOVAL SUBDIVISION[a] [9]

Average raw wastewater flow: 1.31 m^3/Mg
Average treated effluent flow: 1.31 m^3/Mg

Parameter	Raw wastewater: Number detected	Raw wastewater: Concentration, mg/L[b] Median	Maximum	Average	Treated effluent: Number detected	Treated effluent: Concentration, mg/L[b] Median	Maximum	Average	Percent removal
TSS	4	440	1,200	340	4	71	190	88	74
Hexavalent chromium	3	120	260	160	3	1	80	27	83
pH	4	12.5	13	12.4	4	8.5	11.7	10.8	

Note: Blanks indicate data not available.
[a] includes batch and cintinuous processes.
[b]Except pH values, given in pH units.

TABLE 6-54. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR KOLENE SCALE REMOVAL SUBDIVISION [9]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, μg/L			Number detected	Concentration, μg/L			
		Median	Maximum	Average		Median	Maximum	Average	
Metals and inorganics									
Antimony	3	100	450	190	1	203			-[a]
Cadmium	2	80	140	80	1	20			75
Total chromium	3	365,000	367,000	278,000	3	15,000	102,000	39,060	85
Copper	3	133	4,750	1,645	3	50	61	53.7	98
Nickel	3	835	37,500	13,034	3	835	1,350	820	94
Selenium	1	27							
Zinc	3	80	179	93	3	34	40	31.3	66
Halogenated aliphatics									
Chloroform	1	41			1	141			-[a]

Note: Blanks indicate data not available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

Because different salt solutions are used in the hydride scale removal process, the flow and wastewater characteristics from that process are significantly different than those from the kolene operations. The flow rate averages approximately 2.52 m^3/Mg (600 gal/ton) of product. Generally, the same pollutants are found, but in different quantities, in the waste streams from both processes. In addition, cyanide is sometimes generated in the hydride process but not in the kolene process. Wastewater characterization data for conventional and toxic pollutants for the hydride process are presented in Tables 6-55 and 6-56, respectively.

TABLE 6-55. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HYDRIDE SCALE REMOVAL SUBDIVISION [9]

Average raw waste flow: 5.3 m^3/Mg
Average gross effluent flow: 5.3 m^3/Mg

Parameter	Raw wastewater				Gross effluent				Percent removal
	Number detected	Concentration, mg/L[a]			Number detected	Concentration, mg/L[a]			
		Median	Maximum	Average		Median	Maximum	Average	
TSS	2	440	490	440	2	43	69	43	91
Dissolved iron	2	18	37	18	2	0.53	0.83	0.53	97
pH	3	11.9	12.4	11.9	3	7.9	8.2	7.9	

Note: Blanks indicate no data available.

[a]Except pH values, given in pH units.

TABLE 6-56. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR HYDRIDE SCALE REMOVAL SUBDIVISION [9]

	Raw wastewater				Treated effluent				
		Concentration, μg/L				Concentration, μg/L			Average
Toxic pollutant	Number detected	Median	Maximum	Average	Number detected	Median	Maximum	Average	percent removal
Metals and inorganics									
Antimony	2	475	750	475	1	250			47
Cadmium	1	12			1	10			
Chromium	2	8,400	15,300	8,400	2	24,000	47,800	24,000	-[a]
Copper	2	593	670	593	2	50	50	50	35
Cyanide	0				2	203	369	203	-[a]
Lead	2	675	1,100	675	2	50	50	50	93
Nickel	2	4,510	8,700	4,510	2	780	1,350	780	83
Selenium	1	35			0				
Silver	1	115			2	20	20	20	82
Zinc	2	138	75	138	2	32.5	40	32.5	76

Note: Blanks indicate data not available.

[a]Treated effluent concentration exceeds raw wastewater concentration.

II.6.2.20 Subcategory 24-Continuous Alkaline Cleaning [9]

In the alkaline cleaning process, wastewaters are generated in the cleaning solution tanks and in the subsequent rinsing steps. The first potential source, the bath itself, contains a caustic solution that usually has a high level of sodium compounds and other constituents, depending on the type of solutions being used. Some mills have demonstrated the ability to reuse the same cleaning solution continuously, and they add fresh solution only to make up for evaporation losses. However, due to the buildup of contamination in the baths, most mills discharge the contents of the bath on a weekly or monthly basis, or as soon as the cleaning ability of the solution is impaired by the buildup of dissolved solids and oils.

Depending on the type of cleaning solutions used, the constituents in the wastewater from this process may vary considerably. The usual pollutant materials present in the waste streams from the process are suspended and dissolved solids, oils and greases that are sometimes in emulsions, and lesser amounts of dissolved metals. These pollutants are generated by the mills using the standard cleaning solution prepared with a caustic such as sodium hydroxide. However, some mills use solutions containing phosphates or permanganates that may contribute additional pollutants to the waste stream. Because of the nutrient potential of the phosphates, in some forms, the impact of this parameter on receiving bodies may be significant.

Because most alkaline cleaning baths are used to process a large amount of product, contamination can build up in the tank to extremely high levels. Average levels of pollutants found in alkaline cleaning baths are shown below:

Parameter	Typical value
Alkalinity	1,000 mg/L
Iron (total)	100 mg/L
Oil and grease	1,500 mg/L
pH	12-13
TDS	25,000 mg/L
TSS	1,000 mg/L
Temperature	70°F - 200°F

The rinse step(s) following the cleaning operation represent the second source of wastes from the alkaline cleaning process. After immersion of the product into the cleaning bath, rinsing is required to remove residual cleaning solution from the product and to cool the product if the cleaning bath was heated. Rinsing is usually performed in drip tanks or spray chambers, using either one tank or several depending on the degree of rinsing required. Although some mills use standing (or bath) rinse tanks (i.e., no continuous flow through the tanks), many mills use rinse tanks that have continuous water feed and overflows. This is done to keep the rinse water relatively free from contamination and at a low temperature, so that the product may be cooled if necessary. The quality of the wastewater being discharged from the rinse tanks can vary considerably depending on such factors as the type of rinsing used (i.e., whether rinsing is done on a batch or flow-through basis), the age of the solution in the cleaning tanks, and the amounts of cleaning solution carried over from the cleaning step.

Tables 6-57 and 6-58 present conventional and toxic pollutant data, respectively, for the alkaline cleaning subcategory.

TABLE 6-57. WASTEWATER CHARACTERIZATION OF CLASSICAL POLLUTANTS FOR THE ALKALINE CLEANING SUBCATEGORY[a] [9]

Average raw waste flow: 1.49 m^3/Mg
Average gross effluent flow: 1.49 m^3/Mg

Parameter	Raw wastewater				Gross effluent				Average percent removal
	Number detected	Concentration, mg/L[b]			Number detected	Concentration, mg/L[b]			
		Median	Maximum	Average		Median	Maximum	Average	
TSS	3	11	17	7.2	3	16	92	36	-[c]
Oil and grease	3	9	21	13	3	4	4.5	4.1	68
Dissolved iron	3	0.34	0.70	0.38	3	0.83	18	6.3	-[c]
pH	3	9	10.8	9.2	3	7.5	7.6	7.1	

[a]Includes batch and continuous cleaning.

[b]Except pH values, given in pH units.

[c]Effluent concentration exceeds raw wastewater concentration.

TABLE 6-58. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOUND IN THE CONTINUOUS ALKALINE CLEANING SUBCATEGORY [9]

Toxic pollutant	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, µg/L Median	Maximum	Average	Number detected	Concentration, µg/L Median	Maximum	Average	
Metals and inorganics									
Nickel	2	20	35	20	2	4,175	7,000	4,175	-[a]
Phenols									
Phenol	1	24							
Aromatics									
2,6-Dinitrotoluene	1	47							
Fluoranthene	1	24							
Pyrene	1	32							
Halogenated aliphatics									
Chloroform	2	48.5	52	48.5	3	64.5	65	64.5	-[a]
Tetrachloroethylene	2	37	49	37	1	52			-[a]

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

II. 6.3 PLANT SPECIFIC DESCRIPTION [2-9]

The following paragraphs describe conventional and toxic pollutant data, and treatment methods at selected plants within each subcategory of the iron and steel industry. Plants were selected on the basis of completeness of sampling data and description of control methods. Only conventional data are presented for some subcategories due to the lack of toxic pollutant analyses. One plant was selected for presentation for each subcategory and subdivision. Selection was based on the availability of data and description of the treatment method used. Additional plant specific data are available in the draft contractor reports (See references).

II.6.3.1 Subcategory 1 - Byproduct Coke [2]

Plant 009

This plant uses a physical/chemical treatment system. Excess ammonia liquor from two coke plants is mixed and then passed through a gas flotation unit, a mixed media filtration unit, an activated carbon adsorption unit, and free and fixed ammonia strippers. Benzol plant wastewaters for both plants are mixed and passed through the gas flotation, mixed media filtration, and activated carbon adsorption units prior to disposal in coke quenching. Table 6-59 and Table 6-60 present plant specific conventional and toxic pollutant data, respectively, for Plant 009 in the byproduct coke subcategory.

TABLE 6-59. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR THE BYPRODUCT COKE SUBCATEGORY (PLANT 009) [2]

Raw wastewater flow: 0.20 m^3/Mg (47 gal/ton)
Treated effluent flow: 0.40 m^3/Mg (97 gal/ton)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
Ammonia	8,300	220	97
Oil and grease	83	9	89
Total phenols	1,700	1	99
Sulfide	980	550	
TSS	97	31	68
pH	8.6	9	

[a]Except pH values, given in pH units.

II.6.3.2 Subcategory 2 - Beehive Coke [2]

Plant E

Coke quench runoffs from this plant are treated in simple settling ponds with no provision for recycle. Table 6-61 presents conventional pollutant data for this plant.

II.6.3.3 Subcategory 3 - Sintering [3]

Plant 019

Sinter plant wastewaters are treated by mixing them with lime to aid floc formation. The floc is settled in a Lamella thickener. Overflow is mixed with makeup water and recycled to scrubbers. Underflow is discharged to a blast furnace clarifier for further treatment.

Table 6-62 and Table 6-63 present plant specific conventional and toxic pollutant data, respectively, for Plant 019 in the sintering subcategory.

II. 6.3.4 Subcategory 4 - Blast Furnace-Iron [3]

Plant 028

Blast furnace gas cleaning system wastewaters are treated by aeration, neutralization with lime, chlorination, coagulation

TABLE 6-60. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR THE BYPRODUCT COKE SUBCATEGORY (PLANT 009) [2]

Average raw wastewater flow: 1.49 m^3/Mg
Average treated effluent flow: 1.49 m^3/Mg

Parameter	Raw wastewater				Treated effluent				Average percent removal
	Number detected	Concentration, mg/L[a] Median	Maximum	Average	Number detected	Concentration, mg/L[a] Median	Maximum	Average	
TSS	4	18	550	150	4	54	130	60	60
Oil and grease	3	5	21	10	4	4	5	3.6	64
Dissolved iron	3	0.10	0.30	14	4	9.4	24	11	21
pH	4	8.3	12	10	4	6.9	7.5	6.9	

[a]Except pH values, given in pH units.

TABLE 6-61. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT E, BEEHIVE COKE SUBCATEGORY [2]

Raw wastewater flow: 2.05 m^3/Mg
Treated effluent flow: 2.05 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Concentration, mg/L[a] Treated effluent	Percent removal
Ammonia	0.33	0.24	27
Oil and grease	<5	<5	-
Total phenols	0.011	0.014	-[b]
Sulfide	<0.02	<0.02	-
TSS	170	36	78
pH	7.3	7.1	

Note: Dashes indicate negligible removal.

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-62. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 019, SINTERING SUBCATEGORY [3]

Raw wastewater flow: 1.25 m^3/Mg
Treated effluent flow: 0.11 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Concentration, mg/L[a] Treated effluent	Percent removal
TSS	810	15,000	-[b]
Oil and grease	210	1,100	-[b]
pH	5.9	8.6	
Total phenols	2,200	2,100	5

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-63. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT, 019 FOR THE SINTERING SUBCATEGORY [3]

Toxic pollutant	Concentration, µg/L		Percent removal
	Raw wastewater	Treated effluent	
Metals and inorganics			
Cadmium	1,300	770	41
Chromium	20	10	50
Copper	600	270	55
Cyanide	260	160	38
Lead	5,300	800	85
Nickel	200	130	35
Silver	13	10	23
Zinc	8,700	5,000	43
Phthalates			
Butyl benzyl phthalate	85	990	-[a]
Di-n-butyl phthalate	124	420	-[a]
Di-n-octyl phthalate	20	490	-[a]
Phenols			
Phenol	1,000	990	1
2,4-Dinitrophenol	ND	ND	-
Polycylic aromatic hydrocarbons			
Benz(a)anthracene	ND	260	-[a]
Benzo(a)pyrene	ND	190	-[a]
Chrysene	ND	53	-[a]
Fluoranthene	ND	860	-[a]
Pyrene	7	1,100	-[a]

Note: Blanks indicate no data available
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

with polymer, thickening, cooling and recycle. A portion of the recycle water is blown down and discharged to a municipal sanitary sewer.

Tables 6-64 and 6-65 present plant specific classical and toxic pollutant data, respectively, for Plant 028 in the iron blast furnace subcategory.

TABLE 6-64. PLANT SPECIFIC CLASSICAL POLLUTANT DATA FOR PLANT 028, IRON BLAST FURNACE SUBCATEGORY [3]

Raw wastewater flow: 9.5 m^3/Mg (2,300)
Treated effluent flow: 0.78 m^3/Mg (190)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
Ammonia-N	25	16	36
Fluoride	9	7.9	14
Total phenols	2.5	2.0	80
TSS	1,600	44	97
Sulfide	2.5	0.5	80
pH	10.2	8.8	

[a]Except pH values, given in pH units.

II.6.3.5 Subcategory 5 - Blast Furnace-Ferromanganese [3]

Plant 025

Venturi scrubber wastewaters at this plant are treated via thickening and complete recycle to the scrubbers. Gas cooler wastewaters are treated in a similar manner. As a result, this plant achieves zero discharge.

Tables 6-66 and 6-67 presents plant specific classical and toxic pollutant data, respectively, for Plant 025 in the ferromanganese blast furnace subcategory.

II. 6.3.6 Subcategory 6 - Basic Oxygen Furnace - Semiwet Air Pollution Control [4]

Plant U

Table 6-68 presents plant specific conventional pollutant data for Plant U in the basic oxygen furnace-semiwet air pollution control subcategory.

TABLE 6-65. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 028, THE IRON BLAST FURNACE SUBCATEGORY [3]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Cadmium	150	10	93
Chromium	630	9	99
Copper	1,200	30	98
Lead	23,000	83	99
Nickel	1,200	60	95
Silver	73	5	93
Zinc	30,000	330	99
Phthalates			
Bis(2-ethylhexyl) phthalate	3,200	11,000	-[a]
Butyl benzyl phthalate	340	9	97
Di-n-butyl phthalate	540	180	67
Diethyl phthalate	ND	ND	-
Dimethyl phthalate	ND	3	-[a]
Di-n-octyl phthalate	130	90	31
Phenols			
2,4-Dichlorophenol	240	44	82
2,4-Dimethylphenol	3	ND	>99
Phenol	250	560	-[a]
Aromatics			
Hexachlorobenzene	ND	ND	-
Polycylic aromatic			
Benzo(a)pyrene	ND	190	-[a]
Fluoranthene	ND	23	-[a]
Flourene	ND	10	-[a]
Chrysene	ND	ND	-
Naphthalene	8	15	-[a]
Pyrene	ND	12	-[a]
Halogenated aliphatics			
Chloroform	10	32	-[a]

Note: Blanks indicate no data available
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-66. PLANT SPECIFIC CLASSICAL POLLUTANT DATA FOR PLANT 025, FERROMANGANESE BLAST FURNACE SUBCATEGORY [3]

Raw wastewater flow: 48.1 m^3/Mg (11,500 gal/ton)
Treated effluent flow: 48.3 m^3/Mg (11,600 gal/ton)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
Ammonia-N	710	680	4
Manganese	500	53	89
Total phenols	6.5	6.3	3
Sulfide	130		
TSS	4,200	410	90
pH	11.3		

Note: Blanks indicate no data available.

[a]Except pH values, given in pH units.

TABLE 6-67. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 025, FERROMANGANESE BLAST FURNACE SUBCATEGORY [3]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Cyanide	690,000	710,000	-[a]
Zinc	30,000	26,000	13
Aromatics			
Benzene	21	10	52
Toluene	17	4	76
Polycylic aromatic			
Napthalene	39	24	38
Halogenated aliphatics			
Chloroform	160	140	13
Tetrachloroethylene	64	9	86

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-68. PLANT SPECIFIC POLLUTANT DATA FOR PLANT U, BASIC OXYGEN FURNACE - SEMIWET AIR POLLUTION CONTROL SUBCATEGORY [4]

Raw wastewater flow: 3.0 m^3/Mg (730 gal/ton)
Treated effluent flow: 3.0 m^3/Mg (730 gal/ton)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	420	38	91
Fluoride	3.1	3.8	-[b]
pH	11.8	11.9	
Copper	0.03		
Lead	1.0	1.0	-
Mercury	0.001	0.0027	-[b]
Zinc	1.1	1.6	-[b]

Note: Blanks indicate data not available.
Dashes indicate negligible removal.

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

This plant utilizes chemical coagulation, thickening, and recycle of all wastewaters generated by its gas cleaning system. Thirteen percent of the recycle is reused for slag processing. System equipment is comprised of thickener and vacuum filters for solids dewatering.

II. 6.3.7 Subcategory 7 - Basic Oxygen Furnace- Wet Air Pollution Control [4]

Open Combustion

Plant 036. This plant uses primary solids separation (cyclones and classifiers). Classifier overflow is discharged to a thickener. Thickener overflow is recycled with 53% blowdown. Makeup water is added to the recycle. Blowdown is discharged to sewers. Thickener underflow is discharged to centrifuges for final dewatering.

Suppressed Combustion

Plant 032. This plant uses primary solids separation (hydroclones and classifiers). Overflow from primary solids separation is discharged to thickeners. Thickener overflow is recycled after pH adjustment with 6.1% blowdown. Blowdown is discharged to a clarifier, and this overflow is discharged to a central wastewater treatment system. Thickener and clarifier underflows are discharged to settling lagoons. The BOF system has a secondary ventilation scrubber system that also discharges effluents to the thickeners.

Table 6-69 and Table 6-70 present plant specific conventional and toxic pollutant data, respectively, for both Plant 036 and Plant 032 in the open combustion and suppressed combustion subdivisions of the basic oxygen furnace - wet air pollution control subcategory.

TABLE 6-69. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANTS 036 and 032, BASIC OXYGEN FURNACE - WET AIR POLLUTION CONTROL SUBCATEGORY, OPEN COMBUSTION AND SUPPRESSED COMBUSTION SUBDIVISIONS [4]

	Plant 036 (Open combustion)	Plant 032 (Suppressed combustion)
Raw wastewater flow, m^3/Mg:	1.91	6.16
Treated effluent flow, m^3/Mg:	1.02	0.41

	Plant 036			Plant 032		
	Concentration, mg/L[a]			Concentration, mg/L[a]		
Parameter	Raw wastewater	Treated effluent	Percent removal	Raw wastewater	Treated effluent	Percent removal
TSS	7,100	1,200	82	1,500	55	96
pH	11.3	12		9.2	8.8	

[a]Except pH values, given in pH values.

II.6.3.8 Subcategory 8 - Open Hearth Furnace [4]

Semiwet Air Pollution Control

Plant 043. The gas cleaning system used at this plant is a semiwet unit whereby gases are temperature conditioned for precipitation cleaning. Each furnace has its own spray chamber and is manifolded to a central precipitator gas cleaning system. A common water treatment system services all of the spray chambers.

The water treatment system consists of a thickener for sedimentation. Thickener overflow is recycled with a 0.3% blowdown

TABLE 6-70. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR (PLANTS 036 AND 032), THE BASIC OXYGEN FURNACE - WET AIR POLLUTION CONTROL SUBCATEGORY, THE OPEN COMBUSTION AND SUPPRESSED COMBUSTION SUBDIVISIONS [4]

Toxic Pollutants	Plant 036 (Open combustion)			Plant 032 (Suppressed combustion)		
	Concentration, mg/L			Concentration, mg/L		
	Raw wastewater	Treated effluent	Percent removal	Raw wastewater	Treated effluent	Percent removal
Metals and inorganics						
Cadmium	170	10	94	98	8	92
Chromium	370	40	43	1,100	13	99
Copper	330	360	-[a]	320	9	97
Lead	370	160	57	27,000	470	98
Mercury	34	0.1	99			
Nickel	47	10	79	340	10	97
Silver	43	340	-[a]	30	15	50
Zinc	2,000	710	65	8,400	230	97
Phthalates						
Bis(2-ethylhexyl) phthalate	10	110	-[a]	60	29	52
Di-n-butyl phthalate				7	10	-[a]
Halogenated aliphatics						
Chloroform	53	120	-[a]		0.04	

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

discharged to a final polishing lagoon. Thickener underflow is conveyed to a settling lagoon. The dry precipitation dust is slurried and evacuated from precipitation hoppers by pneumatic conveyors with water jet ejectors. The effluent is discharged to another thickener. The thickener overflow is recycled to the water jet ejectors, and the underflow is discharged to the same settling lagoons as are the spark box effluents.

Table 6-71 and Table 6-72 present plant specific conventional and toxic pollutant data, respectively, for Plant 043 in the semiwet air pollution control subdivision of the open hearth furnace subcategory.

Wet Air Pollution Control

Plant 042. This plant uses a manifolded, wet hydroscrubber, gas cleaning system by which all furnaces are exhausted through a common ductwork to three gas cleaning systems. Three central ducters of hydroscrubbers serve as the gas cleaning

TABLE 6-71. PLANT SPECIFIC CLASSICAL POLLUTANT DATA PLANT 043, OPEN HEARTH FURNACE SUBCATEGORY, SEMIWET AIR POLLUTION CONTROL SUBDIVISION [4]

Raw wastewater flow: 4.9 m^3/Mg (1,160 gal/ton)
Treated effluent flow: 0.02 m^3/Mg (3.7 gal/ton)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	510	30	94
Fluoride	260	32	88
Nitrate	10	9.1	9
pH	2.7	10.8	

[a]Except pH values, given in pH units.

TABLE 6-72. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 043, THE OPEN HEARTH FURNACE SUBCATEGORY, THE SEMIWET AIR POLLUTION CONTROL SUBDIVISION [4]

Toxic pollutant	Concentration, μg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Chromium	80	10	78
Copper	83	13	84
Cyanide	39	6	85
Nickel	53	9	83
Zinc	600	40	93
Phthalates			
Di-n-butyl phthalate	21	10	52

Note: Blanks indicate data not available.
Dashes indicate negligible removal.

system, with each cluster capable of serving a number of furnaces through the manifolded ductwork. The hydroscrubber uses steam or air and a water jet ejector to pump and clean open hearth off gases. Waste heat boilers furnish the steam.

The joint water treatment system serves both the electric arc furnace shop and the open hearth shop. The effluent discharge waters are neutralized, flocculated with polymers, and then discharged to clarifiers for sedimentation. Clarifier overflow is recycled with a 71% blowdown that is discharged to final polishing lagoons. Clarifier underflow is dewatered in vacuum filters.

Table 6-73 presents plant specific classical pollutant data for Plant 042 in the wet air pollution control subdivision of the open hearth furnace subcategory.

TABLE 6-73. PLANT SPECIFIC POLLUTANT DATA FOR PLANT 042, OPEN HEARTH FURNACE SUBCATEGORY, WET AIR POLLUTION CONTROL SUBDIVISION [4]

Raw wastewater flow: 2.1 m^3/Mg (510 gal/ton)
Treated effluent flow: 1.5 m^3/Mg (360 gal/ton)

	Concentration, mg/L[a]		
Parameter	Raw wastewater	Treated effluent	Percent removal
TSS	1,500	15	99
Fluoride	100	27	73
Nitrate	640	450	30
pH	6.7	9.1	
Zinc	390	4	99

[a]Except pH values, given in pH units.

II.6.3.9 Subcategory 9 - Electric Arc Furnace Semiwet Air Pollution Control [5]

Plant 059B The treatment system at this plant consists of a clarifier for sedimentation. Clarifier overflow is discharged, and the underflow is dewatered using vacuum filters. Table 6-74 and Table 6-75 present plant specific conventional and toxic pollutant data, respectively, for Plant 059B in the electric arc furnace - toxic pollutant data, respectively, for Plant 059B in the electric arc furnace - semiwet air pollution control subcategory.

II.6.3.10 Subcategory 10 - Electric Arc Furnace-Wet Air Pollution Control [5]

Plant 052

Plant 052 uses neutralization, flocculation, and clarification to treat the wastewaters from the electric arc furnace (EAF) shop. The water treatment system also treats open-hearth shop wastewaters. The wastewaters from the steam hydroscrubber systems of the EAF and open-hearth shops discharge to a pump station and are pumped to a flocculation and neutralization tank which is followed by a clarifier. Thirty percent of the clarifier overflow is recycled to the gas cleaning system. Vacuum filters dewater the clarifier underflow. Blowdown is discharged to mill settling ponds.

Tables 6-76 and 6-77 present conventional and toxic pollutant data for plant 052 in this subcategory.

II.6.3.11 Subcategory 11 - Vacuum Degassing [5]

Carbon Steel

Plant 062. This plant utilizes a combination treatment system for its vacuum degasser and continuous caster. Vacuum degasser wastewater is discharged to a hot well from which a sidestream is treated through a belt filter. The filter effluent and the remaining degasser wastewater is then discharged to a main hot well. From the hot well, the combined degasser and caster wastewaters are treated through a scale pit, sand filters, and cooling tower. A recycle is taken from the cooling tower back to the degasser. This system has zero discharge since the plant recirculates its water through a 7.6×10^4 m^3 (20 M gal) reservoir.

Tables 6-78 and 6-79 present conventional and toxic pollutant data for carbon steel vacuum degasser plant 065.

Specialty Steel

Plant 068. Vacuum degasser wastewater discharges to a hot well and is then treated via the mill central treatment facility. Treatment includes deep bed filters and clarifiers. A recycle is taken from the central treatment facility to the vacuum degasser.

Tables 6-80 and 6-81 present conventional and toxic pollutant data for specialty steel vacuum degasser plant 068.

TABLE 6-74. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 059B, ELECTRIC ARC FURNACE - SEMIWET AIR POLLUTION CONTROL SUBCATEGORY [5]

Raw wastewater flow: 0.33 m^3/Mg
Treated effluent flow: 0.33 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater[b]	Treated effluent
TSS		120
Fluoride		64
pH		8.1

[a]Except pH values, given in pH units.

[b]A representative raw wastewater sample could not be obtained.

TABLE 6-75. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 059B, ELECTRIC ARC FURNACE - SEMIWET AIR POLLUTION CONTROL SUBCATEGORY [5]

Toxic pollutant	Concentration, µg/L Raw wastewater[a]	Treated effluent
Metals and inorganics		
Cyanide (EPA)		3
Zinc		450
Phthalates		
Bis(2-ethylhexyl) phthalate		31
Butyl benzyl phthalate		21
Di-n-butyl phthalate		7
Diethyl phthalate		51
Dimethyl phthalate		ND
Di-n-octyl phthalate		57
Phenols		
Phenol		ND
Halogenated aliphatics		
Chloroform		66
1,2-*trans*-Dichloroethane		14

Note: Blanks indicate data not available.

[a]A raw wastewater sample could not be obtained.

TABLE 6-76. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 052, ELECTRIC ARC FURNACE-WET SUBCATEGORY [5]

Raw wastewater flow: 4.96 m^3/Mg
Treated effluent flow: 3.5 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	890	7	99
Fluoride	30	27	10
pH	9.0	7.8	

[a]Except pH values, given in pH units.

TABLE 6-77. PLANT SPECIFIC DATA FOR PLANT 052, THE ELECTRIC ARC FURNACE-WET AIR POLLUTION CONTROL SUBCATEGORY [5]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Zinc	2,000		
Phthalates			
Bis(2-ethylhexyl) phthalate	160	330	-[a]
Butyl benzyl phthalate	7	95	-[a]
Di-n-butyl phthalate	7	11	35
Phenols			
4-Nitrophenol	ND	ND	-
Pentachlorophenol	ND	ND	-
Aromatics			
Benzene	7	5	29
Polycyclic aromatic hydrocarbons			
Fluoranthene	ND	ND	-
Pyrene	ND	ND	-

Note: Blanks indicate data not available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-78. PLANT SPECIFIC POLLUTANT DATA FOR PLANT 062, VACUUM DEGASSER SUBCATEGORY, CARBON STEEL SUBDIVISION [5]

Raw wastewater flow: 0.73 m^3/Mg (175 gal/ton)
Treated effluent flow: 0.66 m^3/Mg (159 gal/ton)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	30	16	47
Nitrate	2.8		
Manganese	2.0	0.27	87
pH	8.6	7.9	

[a]Except pH values, given in pH units.

TABLE 6-79. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 062, VACUUM DEGASSER SUBCATEGORY, THE CARBON STEEL SUBDIVISION [5]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Chromium	130	26	80
Copper	90	207	-[a]
Lead	300	60	80
Nickel	23	13	43
Zinc	2,000	330	84
Phthalates			
Butyl benzyl phthalate	57	3	95
Di-n-butyl phthalate	43	7	84

Note: Blanks indicate data not available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-80. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 068, VACUUM DEGASSER SUBCATEGORY, SPECIALTY STEEL SUBDIVISION [5]

Raw wastewater flow: 2.8 m^3/Mg
Treated effluent flow: 2.8 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	81	39	52
Nitrate	0.7	0.7	-
Manganese	4,000	0.13	99
pH	8.1	7.9	

Note: Dashes indicate negligible removal.

[a]Except pH values, given in pH units.

TABLE 6-81. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 068, VACUUM DEGASSER SUBCATEGORY, THE SPECIALTY STEEL SUBDIVISION [5]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Chromium	50	19	62
Copper	47	23	51
Lead	200	90	55
Nickel	40	30	75
Zinc	500	300	40
Phthalates			
Butyl benzyl phthalate	ND	53	-[a]
Di-n-butyl phthalate	ND	500	-[a]

Note: Blanks indicate data not available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

II.6.3.12 Subcategory 12 - Continuous Casting [5]

Carbon Steel

Plant AF. The continuous caster at this plant is on a combination treatment system with a vacuum degasser. The treatment consists of a scale pit, high-flow-rate pressure filters, a cooling tower, and a recycle pump system. Blowdown is less than 2%.

Table 6-82 presents pollutant data for plant AF.

TABLE 6-82. PLANT SPECIFIC POLLUTANT DATA FOR PLANT AF, CONTINUOUS CASTING SUBCATEGORY, CARBON STEEL SUBDIVISION [5]

Raw wastewater flow: 6.2 m^3/Mg (1,500 gal/ton)
Treated effluent flow: 3.9 m^3/Mg (930 gal/ton)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	89	22	80
Oil and grease	3	<0.5	98
pH	6.6	6.8	
Copper	37	0.25	99
Zinc	2.6	1.6	38

[a]Except pH values, given in pH units.

II.6.3.13 Subcategory 13 - Hot Forming-Primary [6]

Carbon Steel

Plant 083. The wastewater treatment system at plant 083 serves several hot forming mills and steelmaking facilities (BOF, electric arc furnace, etc.). The hot forming mills include primary, section, and plate rolling mills, (blooming mill, structural mill, plate mill, and rod mill). The blooming mill wastewaters are discharged to a main pump station after passing through primary scale pits with oil collection equipment. The rod mill has its own treatment equipment and discharges only a blowdown to the central treatment system. Other mill wastewaters discharge to the main pump station as well. The combined waste stream is then treated by flocculating clarifiers and is recycled through a cooling tower to the mills. Tables 6-83 and 6-84 present conventional and toxic pollutant data for this plant.

TABLE 6-83. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 083 (53 IN.), HOT FORMING-PRIMARY SUBCATEGORY, CARBON SUBDIVISION [6]

Raw wastewater flow: 1.3 m^3/Mg
Treated effluent flow: 0.05 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	240	9	96
Oil and grease	35	10	71
pH	7.1	7.6	

[a]Except pH values, given in pH units.

TABLE 6-84. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 083 (53 IN.) FOR HOT FORMING-PRIMARY SUBCATEGORY, CARBON STEEL SUBDIVISION [6]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Chromium	120	130	-[a]
Copper	530	40	92
Lead	70	50	29
Nickel	9	20	-[a]
Zinc	100	70	30

Note: Blanks indicate no data available
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

Specialty Steel

Plant 082. The wastewater treatment system at plant 082 serves a combination of hot forming mills consisting of primary and flat rolling mills (two slab mills, two plate mills) for carbon and specialty steel production. The wastewaters from the specialty, primary, and flat rolling mills are discharged to the waste treatment plant main collection sump after passing through primary and combination secondary scale pits. The wastewaters from the main collection sump are discharged to settling basins which, in turn, discharge to filters. Filtered water is then discharged to the river. No recycle is employed.

Tables 6-85 and 6-86 present conventional and toxic pollutant data for this plant.

TABLE 6-85. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 082 (140 IN) HOT FORMING-PRIMARY-SPECIALTY STEEL [6]

Raw wastewater flow: 0.71 m^3/Mg (170 gal/ton)
Treated effluent flow: 0.71 m^3/Mg (170 gal/ton)

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	83	1	99
Oil and grease	75	12	84
pH	7.8	7.5	

[a]Except pH values, given in pH units.

TABLE 6-86. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 082 (140 IN), FOR HOT FORMING-PRIMARY SUBCATEGORY, SPECIALTY STEEL SUBDIVISION [6]

Toxic pollutant	Concentration, μg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Chromium	50	30	40
Copper	190	40	79
Lead	400	50	88
Nickel	570	50	91
Zinc	80	30	63

II.6.3.14 Subcategory 14 - Hot Forming-Section [6]

Carbon Steel

Plant 088. Bar mill wastewaters at plant 088 are first treated by two sets of scale pits. One set receives wastewaters from the hot saws, shears, stands, pull rods and bar rotators and then recycles them to the process. The second set of pits accepts bar mill stands effluent and skip cooling water. A partial recycle is taken from the scale pits back to the process. The remainder of the scale pit effluent is sent to a mix tank and then to a clarifier. Clarifier overflow is recycled to the bar mill. Three percent of the overflow is blowdown to the sewer. Clarifier underflow is discharged to an underflow pond.

Tables 6-87 and 6-88 present conventional and toxic pollutant data for hot forming-section-carbon steel plant 088.

TABLE 6-87. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 088 (14 IN. BAR MILL), HOT FORMING-SECTION SUBCATEGORY, CARBON SUBDIVISION [6]

Raw wastewater flow: 29 m^3/Mg
Treated effluent flow: 0.58 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Concentration, mg/L[a] Treated effluent	Percent removal
TSS	80	87	-[b]
Oil and grease	68	15	79
pH	7.5	7.5	

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

Specialty Steel

Plant 081. The wastewater treatment system for plant 081 serves a combination of hot forming mills consisting of primary and section rolling. The wastewaters are discharged to a Lamella separator after passing through primary scale pits. The overflow from the Lamella is recycled to the primary and section rolling mills. A 7.1% blowdown from the Lamella is discharged to a central wastewater treatment system which also treats the wastewater from combination acid pickling, alkaline cleaning, kolene

TABLE 6-88. PLANT SPECIFIC TOX POLLUTANT DATA FOR PLANT 088, (14 IN. BAR MILL) FOR THE HOT FORMING-SECTION SUBCATEGORY, CARBON STEEL SUBDIVISION [6]

Toxic pollutant	Concentration, μg/L		Percent removal
	Raw wastewater	Treated effluent	
Metals and inorganics			
Chromium	30	120	-[a]
Copper	75	270	-[a]
Lead	66	95	-[a]
Nickel	180	470	-[a]
Zinc	1,200	2,200	-[a]

Note: Blanks indicate no data available
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

and hydride descaling, continuous alkaline cleaning, and one-section rolling mill. Makeup water is added to the Lamella separator and section mills as required.

Tables 6-89 and 6-90 present conventional and toxic pollutant data for hot forming-section-specialty steel plant 081.

TABLE 6-89. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 081 (NO. 4 HOT MILL), HOT FORMING-SECTION SUBCATEGORY, SPECIALTY STEEL SUBDIVISION [6]

Raw wastewater flow: 34 m^3/Mg (8,200 gal/ton)
Treated effluent flow: 1.4 m^3/Mg (340 gal/ton)

Parameter	Concentration, mg/L[a]		Percent removal
	Raw wastewater	Treated effluent	
TSS	84	23	73
Oil and grease	250	8	97
pH	7.3	7.9	

[a]Except pH values, given in pH units.

TABLE 6-90. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 081 (NO. 4 HOT MILL), HOT FORMING-SECTION SUBCATEGORY, SPECIALTY STEEL SUBDIVISION [6]

Toxic pollutant	Concentration, μg/L		Percent removal
	Raw wastewater	Treated effluent	
Metals and inorganics			
Chromium	90	70	22
Copper	130	75	42
Lead	50	50	-
Nickel	830	490	41
Zinc	85	45	47

Note: Blanks indicate no data available
Dashes indicate negligible removal.

II.6.3.15 Subcategory 15 - Hot Forming-Flat [6]

Plate Mills

Plant 082. Wastewaters from the 3.56 m (140-inch) mill go to primary scale pits and then to a combined secondary scale pit. Overflow from the secondary scale pits is discharged to three common settling basins set in parallel. The effluent from the settling basin is then passed through media filters. Filtered water is then discharged to a receiving stream. Filter backwash is taken to a backwash settling basin which discharges to the three parallel settling basins.

Tables 6-91 and 6-92 present conventional and toxic pollutant data for plant 082 of this subdivision.

Hot Strip and Sheet Mills

Plant 087. Plant 087 is a central treatment system serving a merchant mill, butt weld pipe mill, blooming mill, hot scarfer and a 1.12 m (44-inch) hot strip mill. Wastewaters from the various sources pass first through their individual scale pits equipped with baffler and oil removal equipment and are then pumped to clarifiers. Coagulant aids are added at the clarifier inlet to assist in settling. Clarifier overflow is discharged to a receiving stream as the underflow is processed by vacuum filters.

Table 6-93 presents conventional and toxic pollutant data for plant 087 of this subdivision.

TABLE 6-91. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 082 (140 IN. MILL), HOT FORMING-FLAT SUBCATEGORY, PLATE MILL SUBDIVISION [6]

Raw wastewater flow: 0.50 m^3/Mg
Treated effluent flow: 0.50 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	67	1	99
Oil and grease	46	10	78
pH	8.9	7.4	

[a]Except pH values, given in pH units.

TABLE 6-92. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 082 (140 IN. MILL) HOT FORMING-FLAT SUBCATEGORY, PLATE MILL SUBDIVISION [6]

Toxic pollutant	Concentration, µg/L Raw wastewater	Effluent[a]	Percent removal
Metals and inorganics			
Chromium	60	1,000	-[b]
Copper	160	40	75
Lead	260	40	
Nickel	37	40	-[b]
Zinc	80	30	63

Note: Blanks indicate no data available
Dashes indicate negligible removal.

[a]Effluent from primary scale pit.

[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-93. PLANT SPECIFIC POLLUTANT DATA FOR PLANT 087 (44 IN. HOT STRIP), HOT FORMING-FLAT SUBCATEGORY, HOT STRIP AND SHEET SUBDIVISION [6]

Raw wastewater flow: 20.1 m^3/Mg
Treated effluent flow: 20.1 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	57	38	33
Oil and grease	6	4	33
pH	7.6	7.6	
Chromium	170	170	-
Copper	45	35	22
Zinc	200	210	-[b]

Note: Blanks indicate not determined.
Dashes indicate negligible removal.

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

II.6.3.16 Subcategory 16 - Pipe and Tube [6, 7]

Hot Forming

Weld Mill (Plant 087). This mill practices once-through treatment and utilizes a primary scale pit that discharges to a central clarification water treatment facility. The primary scale pit overflow waters are mixed with other wastewater from a merchant mill, hot strip mill, and blooming mill hot scarfer before treatment in the clarifier. Lime and polymer are added as coagulant aids. Clarifier overflow is discharged to a receiving stream, while the clarifier underflow is dewater through vacuum filters.

Table 6-94 presents conventional and toxic pollutant data respectively, for plant 087.

TABLE 6-94. PLANT SPECIFIC POLLUTANT DATA FOR PLANT 087 (WELD MILL), TUBE AND PIPE SUBCATEGORY, HOT FORMING SUBDIVISION [6]

Raw wastewater flow: 34 m^3/Mg
Treated effluent flow: 34 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	66	38	42
Oil and grease	5	4	20
pH	7.4	7.5	
Chromium	240	43	82
Copper	65	31	52
Lead	800		
Nickel	500		
Zinc	250	21	92

[a]Except pH values, given in pH units.

Cold Forming

Plant HH-2. Tubing mill wastewaters discharge to a settling and cooling basin which receives wastes from other mill operations such as open hearths and rolling mills. Overflow from this settling basin flows to a similar basin and then to oil-skimming facilities. The effluent is then pumped to a large main reservoir from which all of the water is recycled. However, if the reservoir is full, the treated effluent, after oil skimming, is discharged to a receiving stream.

Table 6-95 presents conventional pollutant data for cold-forming plant HH-2. No toxic pollutant data are currently available for this subdivision.

II.6.3.17 Subcategory 17 - Sulfuric Acid Pickling [8]

Continuous Pickling

Plant 094. Spent concentrates from this plant are hauled off-site. Rinses are combined with all other finishing mill wastewaters, equalized, skimmed, treated with lime and polymers, and clarified with thickening and centrifugation of underflows. These treated effluents are discharged.

TABLE 6-95. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT HH-2, PIPE AND TUBE SUBCATEGORY, COLD FORMING SUBDIVISION [7]

Raw wastewater flow: 24.2 m^3/Mg
Treated effluent flow: 0 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	23	4.3	81
Oil and grease	63	2	33
pH	5.8	6.2	

Note: Blanks indicate no data available.

[a]Except pH values, given in pH units.

Tables 6-96 and 6-97 present conventional and toxic pollutant data for continuous sulfuric acid pickling plant 094.

TABLE 6-96. PLANT SPECIFIC CLASSICAL POLLUTANT DATA FOR PLANT 094, SULFURIC ACID PICKLING SUBCATEGORY, CONTINUOUS PICKLING SUBDIVISION [8]

Rinsewater flow: 1.5 m^3/Mg
Carbon treated wastewater: 1.5 m^3/Mg

Pollutant	Concentration, mg/L[a] Rinsewater	Carbon-treated wastewater	Percent removal
TSS	38	6	84
Oil and grease	9	6	33
Dissolved iron	40	0.05	99
pH	5.7	7.8	

[a]Except pH values, given in pH units.

<u>Batch Pickling</u>

<u>Plant 092</u>. Treatment at this facility includes contract hauling of major portions of the spent concentrates, blending

TABLE 6-97. PLANT SPECIFIC TOXIC POLLUTANTS FOR PLANT 094, FOUND IN THE SULFURIC ACID PICKLING SUBCATEGORY, CONTINUOUS PICKLING SUBDIVISION [8]

	Concentration, μg/L		
Toxic pollutant	Sheet pickling	Strip pickling	Treated wastewater
Metals and inorganics			
Arsenic	<10	<10	<10
Cadmium	<10	<10	<10
Chromium	<10	50	20
Copper	55	140	<10
Cyanide	11	11	8
Lead	40	<10	<10
Nickel	60	11	40
Silver	<10	<10	<10
Zinc	40	90	70
Phthalates			
Bis(2-ethylhexyl) phthalate	<10	<10	62
Butyl benzyl phthalate	ND	<10	ND
Di-n-butyl phthalate	<10	<10	<10
Diethyl phthalate	ND	34	<10
Dimethyl phthalate	ND	<10	<10
Aromatics			
Benzene	<10	ND	<10
Polycyclic aromatics			
Acenaphthylene	ND	<10	<10
Fluoranthene	ND	ND	<10
Naphthalene	ND	<10	<10
Pyrene	<10	<10	10
Halogenated aliphatics			
Chloroform	<10	<10	19
Methylene chloride	170	<10	230

Note: Blanks indicate no data available.

and equalization of some concentrates and all rinses, and treatment via a central facility, which includes chromium reduction, neutralization with lime, coagulation with polymer, sedimentation with a clarifier, thickening and vacuum filtration of underflows, and oil skimming.

Tables 6-98 and 6-99 present conventional and toxic pollutant data for batch-type sulfuric acid pickling plant 092.

TABLE 6-98. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 092, SULFURIC ACID PICKLING SUBCATEGORY, BATCH PICKLING SUBDIVISION [8]

Concentrate flow: 0.061 m^3/Mg
Rinsewater flow: 1.4 m^3/Mg

	Concentration, mg/L[a]		
Pollutant	Spent concentrate	Rinsewater	Rinse process effluent
TSS	310	360	29
Oil and grease	17	43	9
pH	<1	6.9	8.3
Dissolved iron	39,000	52	0.45

[a]Except pH values, given in pH units.

II.6.3.18 Subcategory 18 - Hydrochloric Acid Pickling [8]

Continuous Strip Pickling

Plant 091. This plant pickles wire in a continuous mode. Spent pickle liquor and rinses are neutralized with lime, oxidized, clarified, and filtered through pressure sand filters prior to discharge to a receiving stream. Clarifier sludge is dewatered by vacuum filtration prior to disposal.

Tables 6-100 and 6-101 present conbentional and toxic pollutant data respectively, for this plant.

Batch Pickling

Plant U-2. The waste pickle liquors and rinse waters from the batch pickling operations are neutralized in a batch treatment tank by sodium carbonate prior to sanitary sewer discharge.

Table 6-102 presents conventional pollutant data for the above batch hydrochloric acid pickling plant.

II.6.3.19 Subcategory 19 - Cold Rolling [7]

Recirculating Mills

Plant 101. The cold mill wastes at this plant originate at twelve different cold mill operations. All wastes are collected in a holding tank and are treated in an ultrafiltration

TABLE 6-99. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT, 092, FOUND IN THE SULFURIC ACID PICKLING SUBCATEGORY, BATCH SUBDIVISION [8]

Toxic pollutant	Concentration, µg/L Raw rinse wastewater	Concentration, µg/L Process effluent	Percent removal
Metals and inorganics			
Arsenic	39	10	74
Cadmium	4,000	10	99
Chromium	16,300	360	99
Copper	740	40	95
Cyanide	38	39	-[a]
Lead	ND	<10	-[a]
Nickel	1,400	330	76
Silver	ND	<10	-[a]
Zinc	3,900	12	99
Phthalates			
Bis(2-ethylhexyl) phthalate	1,100	26	97
Butyl benzyl phthalate	<10	ND	99
Di-n-butyl phthalate	54	ND	99
Diethyl phthalate	ND	ND	-
Dimethyl phthalate	ND	ND	-
Phenols			
2,4-Dichlorophenol	ND	ND	
2,4-Dinitrophenol	26	ND	99
2-Nitrophenol	ND	ND	-
4-Nitrophenol	39	ND	99
Phenol	ND	ND	
2,4,6-Trichlorophenol	11	ND	99
p-Chloro-m-cresol	ND	ND	-
4,6-Dinitro-o-cresol	ND	ND	-
Polycyclic aromatics			
Acenapthene	ND	ND	-
Acenaphthylene	ND	ND	-
Benzo(a)pyrene	ND	ND	-
Chrysene	ND	ND	-
Fluoranthene	ND	ND	-
Fluorene	ND	ND	-
Pyrene	ND	ND	-
Halogenated aliphatics			
Chloroform	ND	10	-[a]
Dichlorobromomethane	<10	ND	99
Methylene chloride	27	11	59
Tetrachloroethylene	ND	ND	-
Trichloroethylene	ND	ND	-

[a]Process effluent concentration exceeds rinse water concentration.

TABLE 6-100. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 091, HYDROCHLORIC ACID PICKLING SUBCATEGORY, CONTINUOUS WIRE PICKLING SUBDIVISION [8]

	Concentrate	Rinses
Raw wastewater flow, m^3/Mg:	0.076	1.3
Treated effluent flow, m^3/Mg:	0.076	1.3

	Concentrate			Rinses		
	Concentration, mg/L[a]			Concentration, mg/L[a]		
Parameter	Raw wastewater	Effluent	Percent removal	Raw wastewater	Effluent	Percent removal
Dissolved iron	56,000	21,000	63	-[b]	0.3	-[c]
TSS	2,900	9.8	>99	24,000	0.83	>99
Oil and grease	1	1.7	-[d]	-[b]	0.51	-[c]
pH	<1	8.3-8.5	NA		8.3-8.5	

[a]Except pH values, given in pH values.

[b]Blanking results in negative concentration.

[c]Unable to perform calculation

[d]Gross effluent exceeds raw waste concentrate.

TABLE 6-101. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 091, THE HYDROCHLORIC ACID PICKLING SUBCATEGORY, CONTINUOUS STRIP PICKLING SUBDIVISION [8]

	Concentration, µg/L		
Toxic pollutant	Concentrate	Rinse	Discharge
Metals and inorganics			
Cadmium	280	30	20
Chromium	37,000	1,700	40
Copper	22,000	610	30
Cyanide	8	58	21
Lead	1,600,000	24,000	190
Nickel	22,000	610	30
Zinc	61,000	290,000	130
Phenols			
2,4-Dichlorophenol	5	5	10
4,6-Dinitrophenol	5	ND	ND
2,4-Dimethylphenol	5	5	ND
Pentachlorophenol	5	ND	5
Phenol	ND	10	ND
2,4,6-Trichlorophenol	5	ND	ND
4,6-Dinitro-o-cresol	ND	70	ND
Aromatics			
Benzene	ND	ND	5
Polycyclic aromatics			
Acenaphthene	5	5	5
Acenaphthylene	5	5	5
Anthracene	ND	5	ND
Benzo(a)pyrene	5	5	10
Chrysene	5	5	ND
Fluoranthene	10	11	10
Fluorene	ND	5	ND
Naphthalene	ND	5	ND
Phenanthrene	ND	5	ND
Pyrene	5	12	10
Halogenated aliphatics			
Chloroform	10	8	5
Methylene chloride	10	15	21
Tetrachloroethylene	5	8	ND
Trichloroethylene	ND	65	10

Note: Blanks indicate no data available.

TABLE 6-102. PLANT SPECIFIC POLLUTANT DATA FOR PLANT U-2, HYDROCHLORIC ACID PICKLING SUBCATEGORY, BATCH PICKLING SUBDIVISION [8]

	Concentrate	Rinses
Raw wastewater flow, m^3/Mg:	0.027	0.39
Treated effluent flow, m^3/Mg:		0.39

Parameter	Concentrate[b] Concentration, mg/L[a] Raw wastewater	Rinses Concentration, mg/L[a] Raw wastewater	Rinses Concentration, mg/L[a] Treated effluent[b]	Percent removal
Dissolved iron	77,000	190	0.5	99
TSS	400	0	390	-[c]
Oil and grease		3	5	-[c]
pH	<1	1.8	8.5	

Note: Blanks indicates data not available.
[a]Except pH values, given in pH units.
[b]Effluent is contractor hauled.
[c]Effluent concentration exceeds raw influent concentration.

unit on a batch basis. The discharge from this treatment goes to a POTW. There is no other discharge from this plant.

Tables 6-103 and 6-104 present conventional and toxic pollutant data for the raw and treated wastewater stream at this plant.

TABLE 6-103. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 101, COLD ROLLING SUBCATEGORY, RECIRCULATING MILL SUBDIVISION [7]

Raw wastewater flow: 0.078 m^3/Mg
Treated effluent flow: 0.078 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Concentration, mg/L[a] Treated effluent	Percent removal
TSS	2,200	200	91
Oil and grease	82,000	140	99
Dissolved iron	34	810	-[b]
pH	6.5	4.1	

[a]Except pH values, given in pH units.
[b]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-104. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 101, COLD ROLLING SUBCATEGORY, RECIRCULATING MILL SUBDIVISION [7]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Antimony	150	300	-[a]
Cadmium	45	20	56
Chromium	6,500	1,200	66
Copper	7,500	65	99
Cyanide	11	<10	>10
Lead	1,600	90	94
Zinc	1,800		
Phthalates			
Bis(2-ethylhexyl) phthalate		<10	
Butyl benzyl phthalate		ND	
Di-n-butyl phthalate		<10	
Di-n-octyl phthalate		<10	
Diethyl phthalate		23	
Dimethyl phthalate		22	
Phenols			
2-Chlorophenol	36,000	ND	>99
2,4-Dimethylphenol	25,000	ND	>99
2-Nitrophenol	70,000	210	>99
Pentachlorophenol	ND	<10	-[a]
Phenol	540	540	-
4,6-Dinitro-o-cresol	ND	ND	-
Aromatics			
Ethylbenzene	390	10	97
Toluene	110	60	45
Halogenated aliphatics			
Carbon tetrachloride	110	ND	>99
Chloroform	80	43	46
Methyl chloride		<10	
Tetrachloroethylene	1,200	16	>99
1,1,1-Trichloroethane	420	<10	>99

Note: Dashes indicate negligible removal.
Blanks indicate no data available.

[a]Treated effluent concentration exceeds raw wastewater concentration.

Direct Application Mills

Plant 105. This mill uses waste oil handling tanks and oil skimming. Discharge from this process goes to central treatment lagoons where additional oil and solids are removed.

Tables 6-105 and 6-106 present pollutant data for this facility.

TABLE 6-105. PLANT SPECIFIC POLLUTANT DATA FOR PLANT 105, COLD ROLLING SUBCATEGORY, DIRECT APPLICATION MILL SUBDIVISION [7]

Raw wastewater flow: 0.49 m^3/Mg
Treated effluent flow: 0.49 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	290	300	-[b]
Oil and grease	1,900	1,400	26
pH	7.2	3.3	
Dissolved iron	23	170	-[b]

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

Combination Mills

Plant YY-Z. This facility uses primary settling, oil skimming, chemical treatment, and final settling in a clarifier. Other wastes are combined with cold mill wastes before being treated in a central treatment system.

Conventional pollutant data are given in Table 6-107. No toxic pollutant data are currently available on these mills.

II.6.3.20 Subcategory 20 - Hot Coating - Galvanizing [16]

Plant 111. In this plant wiper waters are collected and recycled via hot rolling mills, with a small continuous bleed-off to the treatment system. Pickling rinses and spent HCl concentrations are combined with wastes from nail and fence galvanizing, treated with lime, aerated, clarified and pressure-sand filtered prior to discharge.

TABLE 6-106. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 105, THE COLD ROLLING SUBCATEGORY DIRECT APPLICATION MILL SUBDIVISION [7]

Toxic pollutant	Concentration, µg/L		Percent removal
	Raw wastewater	Treated effluent	
Metals and inorganics			
Antimony	16	290	-[a]
Arsenic	30	31	-[a]
Cadmium	140	200	-[a]
Chromium	170	240	-[a]
Copper	240	450	-[a]
Cyanide	15	13	13
Lead	420	600	-[a]
Nickel	350	500	-[a]
Selenium	26	76	-[a]
Silver	180	250	-[a]
Zinc	200	680	-[a]
Phenols			
Phenols	53	54	-[a]
Aromatics			
1,2-Dichlorobenzene	11	ND	>99
1,3-Dichlorobenzene	17	ND	>99
Halogenated aliphatics			
Carbon tetrachloride	33	43	-[a]
Chloroform	39	67	-[a]
1,1-Dichloroethane	14	93	-[a]
Tetrachloroethylene	82	71	13
1,1,1-Trichloroethane	140	190	-[a]

Note: Blanks indicate no data available.

[a]Treated effluent concentration exceeds raw wastewater concentration.

Treatment influent and effluent pollutant concentrations are given in Tables 6-108 and 6-109.

II.6.3.21 Subcategory 21 - Hot Coating-Terne Plating [9]

Plant 113

Wastewaters from this continuous terne plating line are currently discharged without treatment. A combined chemical treatment plant is currently under construction.

TABLE 6-107. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT YY-2, COLD ROLLING SUBCATEGORY, COMBINATION MILL SUBDIVISION [7]

Raw wastewater flow: 0.58 m^3/Mg
Treated effluent flow: 0.58 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	260	16	94
Oil and grease	620	6	99
pH	7.1	8.2	

[a]Except pH values, given in pH units.

TABLE 6-108. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 111, HOT COATING-GALVANIZING SUBCATEGORY [9]

Raw wastewater flow: 5.9 m^3/Mg
Treated effluent flow: 5.9 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
Oil and grease	20	4	80
pH	7.4	8.4	
TSS	67	11	84
Hexavalent chromium	0.002	0.006	-[b]

[a]Except pH values, given in pH units.
[b]Effluent concentration exceeds raw wastewater concentration.

Raw wastewater concentrations are given in Table 6-110 and 6-111.

TABLE 6-109. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 111, HOT COATING-GALVANIZING SUBCATEGORY [9]

Toxic pollutant	Concentration, µg/L Raw wastewater	Concentration, µg/L Treated effluent	Percent removal
Metals and inorganics			
Chromium	140	40	71
Copper	60	30	50
Cyanide	7	21	-[a]
Lead	200	180	10
Nickel	30	20	33
Silver	<20	20	-
Zinc	3,200	120	96
Phthalates			
Bis(2-ethylhexyl) phthalate	86	130	-[a]
Butyl benzyl phthalate	ND	ND	-
Di-n-butyl phthalate	ND	18	-[a]
Di-n-octyl phthalate	ND	ND	-
Diethyl phthalate	5	10	-[a]
Dimethyl phthalate	5	5	-
Phenols			
Pentachlorophenol	ND	5	-[a]
Aromatics			
Benzene	ND	5	-[a]
1,3-Dichlorobenzene	ND	ND	-
Polycyclic aromatics			
Fluoranthene	ND	10	-[a]
Halogenated aliphatics			
Chloroform	15	5	67
Methylene chloride	120	21	83
Tetrachloroethylene	13	ND	>99
1,1,1-Trichloroethane	67	ND	>99
Trichloroethylene	46	10	78

Note: Blanks indicate no data available.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-110. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 113, HOT COATING-TERNE PLATING SUBCATEGORY [9]

Raw wastewater flow: 4.2 m^3/Mg
Treated effluent flow: 4.2 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
Oil and grease	0	4	-[b]
pH	6.5	6.5	
TSS	11	11	0
Hexavalent chromium		0.002	

[a]Except pH values, given in pH units.

[b]Treated effluent concentration exceeds raw wastewater concentration.

II.6.3.22 Subcategory 22 - Combination Acid Pickling [8]

Batch Type

Plant 122-2. The pickling wastes from this plant are combined with wastes from approximately 20 other sources and then undergo equalization and neutralization, flocculation with polymers, and clarification with oil skimming. Sludge formed in the treatment process is dewatered in mechanical centrifuges. The discharge from this system goes to a receiving stream.

Tables 6-112 and 6-113 present conventional and toxic pollutant data for this facility.

Plant I. Plant I utilizes lime neutralization of spent pickling solutions, mixing with acid rinses, and sedimentation in a lagoon to treat wastewater generated by the strip pickling process.

Conventional data for this plant are given in Table 6-114. No toxic pollutant data were available for this plant.

TABLE 6-111. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 113, HOT COATING-TERN PLATING SUBCATEGORY [9]

Toxic pollutant	Concentration, µg/L		Percent removal
	Raw wastewater	Treated effluent	
Metals and inorganics			
Antimony	<6		
Arsenic	<2	8	-[a]
Beryllium	<8		
Cadmium	<80		
Chromium	2,700	2,700	-
Copper	40	40	-
Cyanide	3	3	-
Lead	670	670	-
Mercury	0.7	0.1	85
Nickel	230	590	-
Selenium	2		
Silver	25	25	-
Thallium	50		
Zinc	93	93	-
Phenols			
2,4-Dichlorophenol	3		
Pentachlorophenol	7		
Phenol	11		
2,4,6-Trichlorophenol	3		
p-Chloro-m-cresol	3		
Aromatics			
Benzene	7		
2,4-Dinitrotoluene	0.003		
2,6-Dinitrotoluene	3		
Ethylbenzene	3		
Toluene	7		
Polycyclic aromatics			
Acenaphthene	3		
Anthracene	7		
Benzo(a)pyrene	3		
Benzo(b)fluoranthene	3		
Benzo(k)fluoranthene	3		
Chrysene	7		
Fluoranthene	7		
Fluorene	3		
Phenanthrene	7		
Pyrene	7		

(continued)

TABLE 6-111 (continued)

Toxic pollutant	Concentration, μg/L Raw wastewater	Treated effluent	Percent removal
Halogenated aliphatics			
Chloroform	53		
1,1-Dichloroethylene	3		
1,2-*Trans*-dichloroethylene	9		
Methylene chloride	830		
Tetrachloroethylene	14		
1,1,1-Trichloroethane	3		
Pesticides and metabolites			
Isophorone	3		

Note: Blanks indicate no data available.

[a]No organic sampling conducted.

[b]Concentration level needs further evaluation.

TABLE 6-112. PLANT SPECIFIC POLLUTANT DATA FOR PLANT 122-2, COMBINATION ACID PICKLING SUBCATEGORY, BATCH-TYPE SUBDIVISION [8]

Raw wastewater flow: 0.84 m^3/Mg
Treated effluent flow: 1.30 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	460	17	96
Dissolved iron	360	0.83	99
Oil and grease	7	4.5	35
Fluoride	37	19	49
pH	9	7.6	

[a]Except pH values, given in pH units.

TABLE 6-113. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 122-2, COMBINATION ACID PICKLING SUBCATEGORY, BATCH-TYPE SUBDIVISION [8]

Toxic pollutant	Concentration, µg/L		Percent removal
	Raw wastewater	Treated effluent	
Metals and inorganics			
Arsenic	10	ND	>99
Chromium	60,000	180	99
Copper	1,700	50	97
Cyanide	71	35	51
Lead	600	50	92
Nickel	37,000	1,400	96
Zinc	300	40	87
Halogenated aliphatics			
Chloroform	20	<10	50
Tetrachloroethylene	24	ND	>99

Note: Blanks indicate no data available.

TABLE 6-114. PLANT SPECIFIC POLLUTANT DATA FOR PLANT I, COMBINATION ACID PICKLING SUBCATEGORY, CONTINUOUS TYPE SUBDIVISION [8]

Raw wastewater flow: 7.6 m^3/Mg
Treated effluent flow: 7.6 m^3/Mg

Parameter	Concentration, mg/L[a]		Percent removal
	Raw wastewater	Treated effluent	
TSS	560	130	76
Fluoride	33	9.1	72
Nitrate	26	32	-[b]
Oil and grease	0.7	1.5	-[b]
Dissolved iron	62	24	61
pH	6.5	6.2	
Copper	0.15	ND	>99
Chromium	17.1	1.8	89
Nickel	6.0	5.2	13
Zinc	0.75	0.24	68

[a]Except pH values, given in pH units.

[b]Effluent concentration exceeds raw wastewater concentration.

II.6.3.23 Subcategory 23 - Scale Removal [9]

Kolene Scale Removal

Plant 131. Treatment at this plant consists of chromium reduction, neutralization with lime and other wastes, settling in a classifier, and final settling in a polishing lagoon. Sludges generated are dewatered by vacuum filters.

Tables 6-115 and 6-116 give raw and treated wastewater pollutant concentrations.

TABLE 6-115. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 131, SCALE REMOVAL SUBCATEGORY, KOLENE SCALE REMOVAL SUBDIVISION [9]

Raw wastewater flow: 0.75 m^3/Mg
Treated effluent flow: 0.75 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Process effluent	Percent removal
TSS	120	50	58
Hexavalent chromium	120	1	99
pH	12.6	9.4	

[a]Except pH values, given in pH units.

Hydride Scale Removal

Plant 132. This facility treats its wastewater by neutralization, flocculation with polymers, and clarification with oil skimming. The sludges are dewatered in cyclones.

Tables 6-117 and 6-118 present pollutant concentrations at this facility.

II.6.3.24 Subcategory 24 - Continuous Alkaline Cleaning [9]

Mill 156

This mill utilizes a complex central treatment system. The wastes from the alkaline cleaning line comprising less than 1% of the total flow to the central treatment system. The alkaline cleaning solutions and rinses are combined with wastes from other sources and then undergo equilization, neutralization, and

TABLE 6-116. PLANT SPECIFIC TOXIC POLLUTANT DATA FOR PLANT 131, THE SCALE REMOVAL SUBCATEGORY, KOLENE SCALE REMOVAL SUBDIVISION [9]

Toxic pollutant	Concentration, µg/L Raw wastewater	Treated effluent	Percent removal
Metals and inorganics			
Antimony	21	200	-[a]
Arsenic	30	<10	67
Cadmium	140	20	85
Chromium	370,000	15,000	96
Copper	130	61	53
Nickel	770	280	63
Selenium	27	ND	>99
Thallium	65	50	23
Zinc	180	34	81
Halogenated aliphatics			
Chloroform	ND	140	-[a]

[a]Treated effluent concentration exceeds raw wastewater concentration.

TABLE 6-117. PLANT SPECIFIC CONVENTIONAL POLLUTANT DATA FOR PLANT 132, SCALE REMOVAL SUBCATEGORY, HYDRIDE SCALE REMOVAL SUBDIVISION [9]

Raw wastewater flow: 0.24 m^3/Mg
Treated effluent flow: 0.24 m^3/Mg

Parameter	Concentration, mg/L[a] Raw wastewater	Treated effluent	Percent removal
TSS	490	17	>99
Dissolved iron	0.45	0.83	-[b]
pH	12.4	7.6	

[a]Except pH values, given in pH units.
[b]Effluent concentration exceeds raw wastewater concentration.

TABLE 6-118. PLANT SPECIFIC TOXIC METAL CONCENTRATION DATA FOR PLANT 132, THE SCALE REMOVAL SUBCATEGORY, HYDRIDE SCALE REMOVAL SUBDIVISION [9]

Toxic pollutant	Concentration, µg/L Raw wastewater	Concentration, µg/L Treated effluent	Percent removal
Metals and inorganics			
Cadmium	<10	<10	-
Chromium	15,000	180	99
Copper	670	50	93
Cyanide	ND	35	-[a]
Lead	25	50	-[a]
Nickel	8,700	1,400	84
Silver	20	20	-
Zinc	75	40	47

Note: Blanks indicate not sampled.
Dashes indicate negligible removal.

[a]Treated effluent concentration exceeds raw wastewater concentration.

primary clarification in a thickener. From the clarifier the wastes enter a high-density-sludge (HDS) unit where the solids and metals are settled out. The overflow from the HDS unit is then filtered. The filtrate is discharged to a final polishing lagoon where additional settling and temperature equalization is carried out prior to discharge to a receiving stream.

Pollutant concentrations for the raw and treated wastewater are presented in Table 6-119.

II.6.4 Pollutant Removability [1-9]

The iron and steel industry generates a wide variety of wastewaters from its subcategories. Pollutant concentrations and waste loads differ significantly not only within the industry but also within subcategories, creating problems in the selection of the treatment technology to be used. Central treatment facilities often combine waste streams from several subcategories, increasing the selection dilemma. This stream combining is a direct result of many subcategories being represented on a single plant site.

Wastewater from this industry is generally low in organic concentrations due to the limited use of organic materials. Concentrations of these organics are generally less than 0.1 mg/L and are often less than 0.01 mg/L. Only the byproduct recovery cokemaking subcategory has concentrations that are usually

TABLE 6-119. PLANT SPECIFIC POLLUTANT DATA FOR PLANT 156, CONTINUOUS ALKALINE CLEANING SUBCATEGORY [9]

Raw wastewater flow: 0.28 m^3/Mg
Treated effluent flow: 0.28 m^3/Mg

Parameter	Concentration, mg/L[a] Raw waste	Effluent waste
TSS	11	1
Oil and grease	9.0	4.0
Dissolved iron	0.34	0.045
pH	7.7	7.5
Chromium	0.055	0.03
Lead	0.075	0.075
Zinc	0.30	0.13
Pentachlorophenol	0.029	

[a]Except pH values, given in pH units.

greater than this. This is the direct result of the recovery of the organic byproducts. Biological treatment methods are often used to reduce these toxic organic concentrations.

Metal concentrations in this industry vary considerably. Individual subcategories may release significant concentrations of particular metals used within their processes. An example of this is the hot coating subcategories, which may release large concentrations of lead, chromium, and zinc. Metal cocentrations are generally reduced by settling, chemical addition, neutralization, or filtration.

Treatment technologies used in the iron and steel industry vary between subcategories. However, several methods are more prevalent than others. Scale pits and settling ponds are used in 17 of the subcategories. This treatment is used at most facilities because of the high concentration of solids normally present in the wastewater. Clarification and sludge thickening are also used to reduce the solids concentration and volume. Chemical addition is used both as a pH adjustment and as a flocculant aid. Common chemicals used include lime, polymers, alum, and ferric sufate. Dissolved metals may be precipitated with this treatment method, reducing the metal concentration in the final effluent.

Filtration is also a common treatment method that may be used as a solids removal mechanism or as a sludge thickening process. Several filtration methods are currently in use including pressure, sand, deep bed, and vacuum filters.

Recycling of treated water is a very common practice in this industry. Twenty-three of twenty-four subcategories studied used this technology to reduce effluent volume and control cost. Nine subcategories have facilities practicing 100% recycle, and several other subcategories recycle over 80% of their fume scrubber and rinsewater streams. Wastewater is generally treated in some manner before recycling.

Generally, more than one technology is used at each facility. Settling is normally a preliminary step to another treatment method and may also be present more than once in a treatment scheme. Chemical addition and filtration treatments are often used in conjunction with other treatment technologies.

Table 6-120 presents treatment technologies currently used in this industry, by subcategory. The data are based on available information from 308 questionnaires and from plant sampling visits in each subcategory.

Removal efficiency data may be found in the wastewater characterization section (II.6.2) and in the plant specific section (II.6.3) of this industry description.

TABLE 6-120. TREATMENT TECHNOLOGIES CURRENTLY IN USE IN THE IRON AND STEEL INDUSTRY [1-9]

Treatment technology	Subcategory number																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Settling, scale pit, or lagoon	X	X	X			X					X	X	X	X	X	X	X	X	X	X	X	X	X	
Clarifier	X		X	X			X	X	X	X	X	X	X	X	X	X	X					X		X
Thickener		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X		X
Centrifuge																						X		X
Settling cone													X	X								X		X
Chemical addition - lime	X		X	X				X			X	X	X	X	X	X	X	X	X	X	X	X	X	
- polymer			X			X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
- ferric sulfate												X	X	X	X	X								
- alum													X	X	X		X		X					
- sulfur dioxide																							X	
- chromium reduction																				X	X		X	
-alkaline chlorination	X		X	X																			X	
pH adjustment	X			X													X	X	X	X	X	X	X	X
Gas flotation	X																X		X					
Filtration												X	X	X	X	X	X		X					
Filtration - pressure			X	X								X	X	X	X	X							X	
- sand											X	X		X		X							X	
- mixed media	X														X				X					X
- flat bed												X												
- deep bed			X									X	X											
- carbon[a]			X	X																				
- vacuum	X		X			X	X						X	X	X	X	X	X		X	X	X	X	X
Ultrafiltration																			X				X	
Activated carbon column	X																		X				X	
Oil skimming			X									X	X	X	X	X	X		X	X	X	X	X	X
API separators																X								
Lamella separator							X					X	X											
Aeration	X																X	X	X	X	X	X		
Activated sludge	X																							
Biological oxidation	X																							
Free still	X																							
Fixed still	X																							
Deep well injection	X																	X						
Cooling tower				X								X	X	X	X	X	X							
Partial recycle	X			X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X
Complete recycle		X	X		X			X	X			X	X	X		X								
Contractor hauled												X	X	X	X		X	X	X			X		

[a]In development stage.

II.7 LEATHER TANNING AND FINISHING INDUSTRY

II.7.1 INDUSTRY DESCRIPTION

II.7.1.1 General Description [1]

The leather tanning and finishing industry in the United States is included within the U.S. Department of Commerce, Bureau of Census Standard Industrial Classification (SIC) Code 3100, Leather and Leather Products. The part of the industry discussed in this report is identified as SIC 3111, Leather Tanning and Finishing.

Leather tanning is a general term encompassing the numerous processing steps included in converting animal skins or hides into leather. There are three primary hide or skin types used to manufacture leather, namely, cattle hides, sheepskins, and pigskins. Other skins utilized in smaller quantities include goatskin, horse hide, deerskin, and elkskin.

There are approximately 188 tanneries producing leather products in the United States. These tanneries are located in four general regions: the New England states, the Mid-Atlantic states, the Midwest, and the Pacific Coast. Of these, about 75% are privately owned.

Table 7-1 summarizes pertinent information regarding the total number of subcategories, the number of subcategories studied by the Effluent Guidelines Division, and the number and type of dischargers in the leather tanning and finishing industry.

TABLE 7-1. INDUSTRY SUMMARY [1, 2]

Industry: Leather Tanning and Finishing
Total Number of Subcategories: 9
Number of Subcategories Studied: 7

Number of Dischargers in Industry:

- Direct: 18
- Indirect: 170
- Zero: 1

Best practicable technology (BPT) limitations for the seven categories are listed in Table 7-2.

TABLE 7-2. BPT LIMITATIONS FOR THE LEATHER TANNING AND FINISHING INDUSTRY [1] (kg/Mg)

Subcategory	Daily maximum	30-day average	Daily maximum	30-day average	
	BOD_5		TSS		
Hair pulp/chrome tan/retan-wet finish	7.0	3.5	11.2	5.6	
Hair save/chrome tan/retan-wet finish	8.2	4.1	13.4	6.7	
Hair save/nonchrome tan/retan-wet finish	6.0	3.0	9.6	4.8	
Retan-wet finish	2.6	1.3	4.2	2.1	
No beamhouse	5.0	2.5	8.0	4.0	
Through-the-blue	4.0	2.0	6.6	3.3	
Shearling	20.8	10.4	33.6	16.8	
	Total chromium		Oil and grease		pH[a]
Hair pulp/chrome tan/retan-wet finish	0.24	0.12	2.0	1.0	6.0 - 9.0
Hair save/chrome tan/retan-wet finish	0.28	0.14	2.2	1.1	6.0 - 9.0
Hair save/nonchrome tan/retan-wet finish	0.20	0.10	1.7	0.83	6.0 - 9.0
Retan-wet finish	0.086	0.043	0.70	0.35	6.0 - 9.0
No beamhouse	0.17	0.083	1.4	0.69	6.0 - 9.0
Through-the-blue	0.14	0.07	1.1	0.56	6.0 - 9.0
Shearling	0.70	0.35	5.8	2.9	6.0 - 9.0

[a]In pH units.

II.7.1.2 Subcategory Description

The primary criteria for subcategorizing the leather tanning and finishing industry are (1) the type or condition of animal hide processed, (2) the method of hair removal, (3) the type of tanning agent used, and (4) the extent of finishing performed. Also taken into consideration are plant size, age, location, wastewater characteristics, and water usage.

The seven subcategories that were derived, based on the above criteria, are defined as follows:

1. <u>Hair pulp/chrome tan/retan-wet finish</u> - facilities that primarily process raw or cured cattle or cattle-like hides into finished leather by chemically dissolving the hair (hair pulp); tanning with chrome; and retanning and wet finishing.

2. <u>Hair save/chrome tan/retan-wet finish</u> - facilities that primarily process raw or cured cattle or cattle-like hides into finished leather by chemically loosening and mechanically removing the hair; tanning with chrome; and retanning and wet finishing.

3. Hair save/nonchrome tan/retan-wet finish - facilities that process raw or cured cattle or cattle-like hides into finished leather by chemically loosening and mechanically removing the hair; tanning, primarily with vegetable tannins, alum, syntans, oils, or other chemicals; and retanning and wet finishing.

4. Retan-wet finish - facilities that process previously unhaired and tanned hides or splits into finished leather through retanning and wet finishing processes including coloring, fat-liquoring, and mechanical conditioning.

5. No beamhouse - facilities that process previously unhaired and pickled cattle hides, sheepskins or pigskins into finished leather by tanning with chrome or other agents, followed by retanning and wet finishing.

6. Through-the-blue - facilities that process raw or cured cattle or cattle-like hides into the blue-tanned state only, by chemically dissolving or loosening the hair and tanning with chrome, with no retanning or wet finishing.

7. Shearling - facilities that process raw or cured sheep or sheep-like skins into finished leather by retaining the hair on the skin; tanning with chrome or other agents; and retanning and wet finishing.

The following paragraphs discuss the subcategory processes in detail.

Hair Pulp/Chrome Tan/Retan-Wet Finish

Tanneries in this subcategory primarily process brine-cured or green salted cattle hides into finished leather. Various amounts of water are used in performing the three wet processing operations, namely, beamhouse, tanyard, and retan-wet finish. Water use for individual subprocesses typically employed is described in the following paragraphs.

Soak and Wash. The purpose of this operation is to remove salt, restore the moisture content of the hides, and remove any foreign material such as dirt and manure. Brine-cured hides are soaked and washed simply to remove salt, while green salted hides require the removal of manure and dirt as well as salt. The quantity of manure and dirt varies with the season of the year and the origin of the hide. Industry data estimate the wastewater volume from this subprocess to be about 20% of the total wastewater flow.

Fleshing. Fleshing follows the soak and wash operation if this was not done previously. Fleshings are isolated as a solid waste and, when handled properly, do not make a significant contribution to the total waste loads of a cattle hide tannery.

Unhairing. Pulping to remove hair involves the addition of lime and sharpeners (e.g., sodium sulfhydrate) in relatively high concentrations. The process dissolves the proteinaceous hair enough to dissipate it in the unhairing solution. As reported by various tanneries, this segment of beamhouse operations generates between 20 and 38% of the total tannery flow, an average of 32% for those facilities reporting such information.

Bating and Pickling. The bating subprocess delimes, reduces swelling, peptizes the fibers, and removes protein degradation products. Major chemical additions are ammonium sulfate to reduce pH to an acceptable level and enzyme to condition the protein matter.

Following the bating process, hides are prepared for tanning by pickling. Pickling solutions contain primarily sulfuric acid and salt, although small amounts of wetting agent and biocide are sometimes added. Since protein degradation products, lime, and other waste material are removed through bating, the quantities of BOD_5, suspended solids, and nitrogen are relatively low. Principal waste constituents are the acid and salt. Bate and pickle wastewater volumes, reported as a combined total by several tanneries, range from 9 to 50% of the plant flow and average 26% for the combined process flow.

Tanning. Chrome tanning employs a chromium sulfate or a chrome tanning solution as the tanning agent. Other chemical additives include sodium formate and soda ash. The chromium must be in the trivalent form and must be dissolved in an acidic medium to accomplish desired results.

For those plants reporting data, the median and average flows associated with the tanning process were found to be 4.4 and 6.6% of total plant water use.

Retanning, Coloring and Fatliquoring. The chrome-tanned hides normally remain in the same drums for these three subprocesses. Retanning increases the penetration of tanning solution into the hides after splitting and uses either chrome, vegetable, or synthetic tanning agents. Because retanning uses lower concentrations of chemicals, the wastewater strength is not high and does not represent a significant portion of the total waste flow.

The most variable process in the tannery is coloring. There are hundreds of different kinds of dyes, both synthetic and vegetable based. Synthetic dyes are the most widely used in the industry and usually require the addition of acid to facilitate dye up-take in the leather. The fatliquoring operation can be performed either before or after coloring. Ultimate use of the leather product dictates the type and amount of oil required for this subprocess.

Drying by the pasting method requires a small amount of water, first to prepare the mixture and then to wash it off. Even though the volume is very small, pollutants associated with the starch can be present in relatively high concentrations. Several tanneries report the reuse of paste mixtures, which minimizes the amount of material entering the waste stream.

Process effluent from wet finishing (retan, color, and fatliquoring) is considered high-volume, low-strength wastewater, compared to the waste streams associated with beamhouse and tanyard operations. Because wet finishing imparts color to the process water, recycling is not normally practiced. The wastewater volumes from the combined subprocesses, reported as a percentage of total tannery flow, are highly variable, ranging from 12 to 30%.

Finishing. Because leather finishing operations are basically dry, they contribute the lowest wastewater flow of any tannery process. There is some wet processing, such as wetting the hides to facilitate handling in the staking or tacking operations, but most leather finishers do not have a contaminated discharge resulting from their processing activities.

Hair Save/Chrome Tan/Retan-Wet Finish

In the hair save unhairing operation, the hair is loosened for subsequent machine removal. The depilatory chemicals utilized are the same as those characteristic of hair pulping, but are present in lower concentrations.

The second step in the hair save operation is machine removal of hair from the hide. Removed hairs require washing only if they are to be baled and sold; otherwise they are handled as solid wastes.

The average water consumption of hair save operations is approximately 20% greater than for hair pulp tanneries. The higher water use is associated with machine removal and washing of the hair.

Hair Save/Nonchrome Tan/Retan-Wet Finish

The principal difference between this subcategory and the previous one is the tanning operation. Cattle hides leaving the beamhouse are bated and pickled in a similar manner but are tanned with such agents as alum, zirconium, and other metal salts, as well as syntans, gluteraldehyde, and formaldehyde. Vegetable tannings accomplish the major portion of nonchrome tanning.

Spent solutions from the vegetable tanning process are quite different from chrome solutions. The reaction rate of vegetable tannings with the hides is much slower than that associated with chrome. Because of the longer contact time, the process normally proceeds in vats with some type of gentle agitation. Process solution conservation is prevalent due to the cost of these tanning agents.

Retan-Wet Finish

These tanneries receive previously tanned hides or splits for retanning and finishing. Either chrome, vegetable, or synthetic tanning agents can be used for retanning. Wastewater sources for the wet finishing steps are coloring, fatliquoring, and drying. Without the beamhouse and tanyard operations, flow and waste loads per unit of production decrease. The average flow for a retan-wet finish facility is less than one-half of the volume characteristic of tanneries with beamhouse and tanyard processes.

No Beamhouse

These tanneries primarily include plants that tan unhaired pigskins and pickled sheepskins. They may also receive pickled and unhaired cattle hides, which are subjected to tanyard and retan-wet finish processes.

Unhaired, pickled sheepskins require fleshing if this has not previously been done. Previously fleshed skins usually require refleshing after tanning. Pigskins are not subjected to this operation.

Grease removal is necessary for both sheepskins and pigskins and follows the soak and wash step. Utilizing the same drums, degreasing proceeds by one of two methods: (1) hot water with detergent, or (2) solvent addition. In either case, the grease is separated and recovered as a by-product having some commercial value. For pigskins, the total amount of grease removed from the skin can approach 10% of the skin weight. The quantity entering the waste stream is usually a small part of the total. In solvent degreasing, the solvent is recovered for reuse. BOD_5, COD, and suspended solids are other constituents in waste streams generated by this operation.

Prior to tanning pigskins, the tanneries must remove the embedded portion of the hair from the skins. The pickling step follows to prepare the skins for tanning.

Sheepskins and pigskins may be tanned with chrome or vegetable tannins, although the majority of tanneries utilize the chrome tanning method. The conventional practice is to tan pigskins completely, thus eliminating the need for a retan operation. Tanned sheepskins are retanned in a manner similar to cattle hides. The wet finishing operations for both types of skins are equivalent to those previously described.

Elimination of the beamhouse results in lower average flow and waste loads per unit of production than is typical; however, the no-beamhouse segment generates higher flows and waste loads than tanneries which only retan and wet finish.

Through-the blue

Facilities in this segment process raw or cured cattle hides through the blue-tanned state only. The remaining steps to produce finished leather are performed by other tanneries.

Unhairing of the hides may use either the hair pulp or the hair save method. Hair pulping results in the higher waste loads, while hair save uses more water. Following bating and pickling, the unhaired hides are chrome tanned to the blue stage.

Average wastewater flows for through-the-blue tanneries are lower than those for no-beamhouse tanneries, but greater than for facilities that only retan and wet finish.

Shearling

Tanneries in this subcategory process raw or cured sheepskins into finished leather with the hair (wool) intact. The major processing operations include tanyard and retan-wet finish.

Prior to the tanning operation, the skins are soaked and washed to cleanse them of foreign matter. This step requires a substantial amount of water for shearlings. The shearling hides are fleshed after washing. Degreasing follows, using either of the two methods described in the no-beamhouse subcategory; however, grease recovery is not normally practiced by shearling tanneries.

Unlike unhaired sheepskins, shearling hides are pickled in the manner characteristic of cattle hide processing, i.e., prior to tanning. They do not, however, require liming and bating. Tanning may be accomplished with chrome or vegetable tannins, although the chrome method is generally preferred. The retanning and wet finishing steps for shearlings follow.

Because shearling hides are processed with the hair intact, average water consumption is more than four times the volume per unit of production observed for the no-beamhouse process, which essentially employs the same processing steps.

II.7.1.3 Wastewater Flow Characterization

The volume of water utilized in the leather tanning and finishing industry fluctuates. Processing techniques within each subcategory of the industry may differ from tannery to tannery. Most tanneries have combined processes that fall under several different subcategories, and all process wastewater is generally discharged to a common sewer. Wastewater flows are tabulated in Table 7-3.

TABLE 7-3. SUMMARY OF SUBCATEGORY FLOWS [1]

Subcategory	Total number of plants reporting flow	Average flow, L/kg	Total number operating below average flow
Hair pulp/chrome tan/retan-wet finish	31	38	16
Hair save/chrome tan/retan-wet finish	12	46	6
Hair save/nonchrome tan/retan-wet finish	16	33	8
Retan-wet finish	8	14	4
No beamhouse	14	28	7
Through-the-blue	2	23	1
Shearling	3	116	2

II.7.2 WASTEWATER CHARACTERIZATION [1]

Water is used extensively in the leather tanning and finishing industry. Some of its purposes for use are listed below:

(1) for soaking and washing unprocessed hides.
(2) as a medium which allows chemicals to react with hides/skins.
(3) as a carrier for dyes and pigments which impart the desired color to the final product.
(4) for cleaning processing areas and equipment.

II.7.2.1 Hair Pulp/Chrome Tan/Retan-Wet Finish

The primary constituents of the soak and wash waste stream are BOD_5, COD, suspended solids, and dissolved solids. For a cattle hide tannery with this operation preceding hair pulping and chrome tanning, typical ranges for BOD_5 and suspended solids range from 7 to 22 and 8 to 43 kg/Mg of hide (lb/1,000 lb of hide), respectively. Because the incoming hides are generally either brine-cured or green-salted, the salt must be removed in preparation for unhairing. This removal results in relatively high total solids values, ranging from 143 to 267 kg/Mg of hide (lb/1,000 lb of hide).

The liming and unhairing process is one of the principal contributors to the plant effluent. Spent unhairing liquors contain very high concentrations of proteinaceous organic matter, dissolved and suspended inorganic solids, and sulfides (mostly in the dissolved form) in a highly alkaline solution. Most sulfides found in tannery wastewater come from spent unhairing liquors, although some potentially significant amounts, depending upon the specific processes and formulations, carry over into spent tanning and retanning liquors. The BOD_5 content of the waste from this operation may range from 53 to 67 kg/Mg of cattle hide processes. Concurrently, the estimated total nitrogen levels range from 11 to 15 kg/Mg (lb/1,000 lb) of raw material.

In the bating of unhaired hides, lime reacts with ammonium sulfate to produce calcium sulfate, which enters the plant effluent. The total nitrogen content of the waste stream varies from 5 to 8 kg/Mg of hide, with ammonia constituting two-thirds. The pickling step which follows generates relatively low levels of pollutant including BOD_5, suspended solids, and nitrogen.

The chrome-tanning operation generates signficant wastes because it is the major source of chromium in the total plant effluent; however, the organic content of the spent tanning solution, including BOD_5 and suspended solids, is generally low.

The wet finishing operations, which include retanning, coloring and fatliquoring, generate high-volume, low-strength wastewaters compared to the effluents from beamhouse and tanyard processes. The temperature of the retan, color, and fatliquor waste streams is high, typically exceeding 37.7°C (100°F). Use of high temperatures in retanning ensures maximum chromium uptake, thereby reducing its discharge to the total waste stream.

Since this subcategory represents the largest portion of the leather tanning industry, considerable data are available for characterizing its wastewaters, particularly for classical parameters. Table 7-4 summarizes the classical parameters which were employed to characterize the raw loads associated with this industry segment. The values for the selected wastewater constituents represent subcategory averages. Table 7-5 summarizes the toxic pollutant present. Constituents are characterize by pollutant type, times found, and concentration.

TABLE 7-4. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HAIR PULP/CHROME TAN/ RETAN-WET FINISH SUBCATEGORY [1]

Pollutant	Number of data points	Concentration, mg/L: Range of individual data points	Concentration, mg/L: Mean
BOD_5	205	210 - 4,300	1,600
COD	170	180 - 27,000	4,600
TSS	210	25 - 36,000	2,400
TKN	58	90.0 - 630	330
Total phenols	15	0.140 - 110	1.0
Sulfides	170	0.800 - 200	64
Oil and grease	75	15 - 10,000	400
Total chromium	180	3.00 - 350	76
Ammonia	168	17.0 - 380	100

II.7.2.2 Hair Save/Chrome Tan/Retan-Wet Finish

The principal difference between this subcategory and the previous one is the method of removing hair from cattle hides. Although water use is greater for machine removal and washing of hair, the waste loads associated with the hair save process are substantially less than those for hair pulp operations. The proteinaceous hair does not dissolve totally in the unhairing solution for the hair save process. This results in a lower BOD_5 content in the waste stream, ranging from 17 to 58 kg/Mg of raw material. The total nitrogen and sulfide content also decrease correspondingly. The remaining tannery operations essentially are the same as for subcategory one, thereby contributing similar waste loads.

Tables 7-6 and 7-7 summarize the raw wastewater characteristics for this subcategory in terms of classical parameters and toxic pollutants. Classical pollutants have been normalized based on production and are presented as subcategory averages.

II.7.2.3 Hair Pulp/Nonchrome Tan/Retan-Wet Finish

The tanning of cattle hides by nonchrome methods distinguishes this segment from the previous one. The most significant difference between the raw waste loads of the two subcategories occurs in the total chromium content. The use of nonchrome tanning agents reduces the average chromium level. The small amount of chromium present in the effluent from nonchrome tanneries, generally originates in the retanning operations which may require chromium salts.

TABLE 7-5. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE HAIR PULP/CHROME TAN/RETAN-WET FINISH SUBCATEGORY [1]

Toxic pollutants	Number of samples	Number detected	Concentration, µg/L Range	Mean
Metals and inorganics				
Chromium	3	3	43,000 - 180,000	80,000
Copper	3	3	50 - 380	173
Cyanide	2	2	20 - 60	40
Lead	3	3	1,100 - 2,400	1,700
Nickel	3	3	20 - 60	40
Zinc	3	3	200 - 580	430
Ethers				
Bis(2-chloroisopropyl) ether	3			ND
Phthalates				
Bis(2-ethylhexyl) phthalate	3	1		51
Butyl benzyl phthalate	3			ND
Di-n-butyl phthalate	3			ND
Diethyl phthalate	3			ND
Dimethyl phthalate	3	1		120
Nitrogen compounds				
Benzidine	3	1		27
3,3'-Dichlorobenzidine	3			ND
1,2-Diphenylhydrazine	3			ND
N-nitrosodiphenylamine	3			ND
Phenols				
2,4-Dichlorophenol	3			ND
2,4-Dimethylphenol	3	1		Present
Pentachlorophenol	3			ND
Phenol	3	3	3,000 - 4,000	3,700
2,4,6-Trichlorophenol	3	2	880 - 5,900	3,400
Aromatics				
Benzene	3	3	10 - 20	15
Chlorobenzene	3			ND
1,2-Dichlorobenzene	3	1		260
1,3-Dichlorobenzene	3			ND
1,4-Dichlorobenzene	3	1		54
Ethylbenzene	3	2	88	88
Hexachlorobenzene	3			ND
Nitrobenzene	3	1		430
Toluene	3	3	150 - 400	280
1,2,4-Trichlorobenzene	3			ND
Polycyclic aromatic hydrocarbons				
Acenaphthene	3	1		32
Acenaphthylene	3	1		16
Chrysene	3			ND
Fluoranthene	3			ND
Fluorene	3			ND
Naphthalene	3	2	24 - 67	46
Phenanthrene/anthracene	3	1		94
Pyrene	3			ND
Halogenated aliphatics				
Chlorodibromomethane	3			ND
Chloroform	3	1		20
Dichlorobromomethane	3	3	10	10
1,1-Dichloroethane	3	1		20
1,2-Dichloroethane	3			ND
1,2-*Trans*-dichloroethylene	3	1		30
1,1,2,2-Tetrachloroethane	3	1		10
1,1,1-Trichloroethane	3	1		Present
1,1,2-Trichloroethane	3	1		10
Trichlorofluoromethane	3			ND
Pesticides and metabolites				
Chlordane	3			ND
Isophorone	3			ND

Note: ND = not detected.

TABLE 7-6. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE HAIR SAVE/CHROME TAN/ RETAN-WET FINISH SUBCATEGORY [1]

Pollutant	Number of data points	Concentration, mg/L	
		Range of individual data points	Mean
BOD	101	140 - 2,800	980
COD	30	700 - 5,700	2,600
TSS	82	94.0 - 8,600	1,900
TKN	56	63 0 - 3,600	140
Total phenols	24	0 440 - 6.80	2.2
Sulfides	70	0.030 - 300	20
Oil and grease	30	49.0 - 620	240
Total chromium	56	0 006 - 390	31
Ammonia	31	0 400 - 660	90

TABLE 7-7. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE HAIR SAVE/CHROME TAN/RETAN-WET FINISH SUBCATEGORY [1]

Toxic pollutants	Number of samples	Number detected	Concentration, µg/L	
			Range	Mean
Metals and inorganics				
Chromium	2	2	31,000 - 150,000	90,500
Cyanide	2	2	20 - 50	35
Lead	2	2	100 - 1,300	700
Nickel	2	2	5 - 40	22
Zinc	2	2	240 - 400	315
Ethers				
Bis(2-chloroisopropyl) ether	2			ND
Phthalates				
Bis(2-ethylhexyl) phthalate	2	1		32
Butyl benzyl phthalate	2			ND
Di-n-butyl phthalate	2			ND
Diethyl phthalate	2			ND
Dimethyl phthalate	2			ND
Nitrogen compounds				
Benzidine	2			ND
3,3'-Dichlorobenzidine	2			ND
1,2-Diphenylhydrazine	2			ND
N-nitrosodiphenylamine	2			ND
Phenols				
2,4-Dichlorophenol	2	1		114
2,4-Dimethylphenol	2			ND
Pentachlorophenol	2	1		6,200
Phenol	2	2	252 - 5,500	2,900
2,4,6-Trichlorophenol	2	1		4,800
Aromatics				
Benzene	2	1		10
Chlorobenzene	2	1		10
1,2-Dichlorobenzene	2			ND
1,3-Dichlorobenzene	2			ND
1,4-Dichlorobenzene	2			ND
Ethylbenzene	2	1		150
Hexachlorobenzene	2			ND
Nitrobenzene	2			ND
Toluene	2	2	10 - 150	80
1,2,4-Trichlorobenzene	2			ND
Polycyclic aromatic hydrocarbons				
Acenaphthene	2			ND
Acenaphthylene	2			ND
Chrysene	2			ND
Fluoranthene	2	1		2
Fluorene	2			ND
Naphthalene	2	1		49
Phenanthrene/anthracene	2	1		56
Pyrene	2	1		1
Halogenated aliphatics				
Chloroform	2	2	10 - 41	26
Dichlorobromomethane	2			ND
1,1-Dichloroethane	2			ND
1,2-Dichloroethane	2			ND
1,1,2,2-Tetrachloroethane	2			ND
1,1,1-Trichloroethane	2	1		10
1,1,2-Trichloroethane	2			ND
Trichlorofluoromethane	2			ND
Pesticides and metabolites				
Chlordane	2			ND
Isophorone	2			ND

Note: ND = not detected.

Lesser variations occur for the classical parameters, such as BOD_5 and suspended solids. Table 7-8 presents these values along with the waste loads for chromium and phenols. Table 7-9 summarizes the presence of other toxic pollutants and their respective levels for hair pulp/nonchrome tan/retan-wet finish tanneries.

TABLE 7-8. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE NONCHROME TAN/RETAN-WET FINISH SUBCATEGORY [1]

		Concentration, mg/L	
Pollutant	Number of data points	Range of individual data points	Mean
BOD_5	48	1.00 - 7,800	1,200
COD	40	1,100 - 75,000	5,100
TSS	55	28.0 - 8,200	1,700
TKN	21	130 - 1,200	200
Total phenols	16	0.280 - 100	1.2
Sulfides	29	0.100 - 330	68
Oil and grease	32	2.00 - 1,300	340
Total chromium	30	0.250 - 110	11
Ammonia	20	23 - 680	90

Tables 7-10 and 7-11 characterize the tannery wastewaters for conventional and toxic pollutants, respectively.

II.7.2.4 Retan-Wet Finish

The tanneries in this industry segment limit their operations to retan and wet finish hides or splits that have been unhaired and tanned. The absence of the beamhouse process results in lower organic and sulfide loadings for this subcategory.

II.7.2.5 No Beamhouse

These tanneries consist only of tanyard and retan-wet finish operations with no beamhouse. Since unhairing operations are absent from these tanneries, the raw waste loads, including BOD_5, suspended solids and sulfide, are lower. Tanyard operations increase conventional pollutant levels beyond those typical for strictly retan-wet finish facilities. Tables 7-12 and 7-13 present the average values for conventional and toxic pollutants in no-beamhouse tanneries.

II.7.2.6 Through-the-Blue

Hair removal and chrome tanning of cattle hides are the basic operations of the through-the-blue tanneries. Relatively high organic loads, as well as the nitrogen and sulfide contents, reflect beamhouse operations; total chromium levels result from

TABLE 7-9. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE NONCHROME TAN/RETAN-WET FINISH SUBCATEGORY [1]

Toxic pollutants	Number of samples	Number detected	Concentration, μg/L Range	Mean
Metals and inorganics				
Chromium	4	4	430 - 10,000	5,100
Copper	4	4	100 - 740	380
Cyanide	3	2	60 - 100	80
Lead	4	4	100 - 200	140
Nickel	4	4	40 - 95	61
Zinc	4	4	300 - 700	490
Ethers				
Bis(2-chloroisopropyl) ether	4			ND
Phthalates				
Bis(2-ethylhexyl) phthalate	4			ND
Butyl benzyl phthalate	4			ND
Di-n-butyl phthalate	4	1		Present
Diethyl phthalate	4	1		Present
Dimethyl phthalate	4			ND
Nitrogen compounds				
Benzidine	4			ND
3,3'-Dichlorobenzidine	4			ND
1,2-Diphenylhydrazine	4			ND
N-nitrosodiphenylamine	4			ND
Phenols				
2,4-Dichlorophenol	4			ND
2,4-Dimethylphenol	4			ND
Pentachlorophenol	4	2	10 - 2,900	1,500
Phenol	4	4	51 - 25,000	9,000
Aromatics				
Benzene	4	3	10 - 10	10
Chlorobenzene	4			ND
1,2-Dichlorobenzene	4	3	49 - 200	126
1,3-Dichlorobenzene	4			ND
1,4-Dichlorobenzene	4	3	19 - 20	20
Ethylbenzene	4	3	10 - 120	58
Hexachlorobenzene	4			ND
Nitrobenzene	4			ND
Toluene	4	4	10 - 15	12
1,2,4-Trichlorobenzene	4			ND
Polycyclic aromatic hydrocarbons				
Acenaphthene	4			ND
Acenaphthylene	4			ND
Chrysene	4			ND
Fluoranthene	4			ND
Fluorene	4			ND
Naphthalene	4	3	6 - 59	32
Phenanthrene/anthracene	4	1		8
Pyrene	4			ND
Halogenated aliphatics				
Chloroform	4	1		24
Dichlorobromomethane	4	1		10
1,1-Dichloroethane	4			ND
1,2-Dichloroethane	4			ND
1,2-*Trans*-dichloroethylene	4			ND
1,1,2,2-Tetrachloroethane	4	1		10
Tetrachloroethylene	4	1		23
1,1,1-Trichloroethane	4			ND
1,1,2-Trichloroethane	4			ND
Trichloroethylene	4			ND
Trichlorofluoromethane	4			ND
Pesticides and metabolites				
α-BHC } β-BHC }	4			ND
Chlordane	4			ND
Isophorone	4			ND

Note: ND = not detected.

TABLE 7-10. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE RETAN-WET FINISH SUBCATEGORY [1]

		Concentration, mg/L	
Pollutant	Number of data points	Range of individual data points	Mean
BOD_5	30	200 - 1,600	780
COD	9	1,200 - 4,800	3,100
TKN	9	110 - 480	210
Total phenols	8	0.230 - 17.0	3.9
Sulfides	7	0.160 - 2.40	1.1
Oil and grease	29	58 - 850	270
Total chromium	24	1.60 - 380	53
Ammonia	9	58.0 - 160	110

TABLE 7-11. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE RETAN-WET FINISH SUBCATEGORY [1]

			Concentration, μg/L	
Toxic pollutants	Number of samples	Number detected	Range	Mean
Metals and inorganics				
Chromium	3	3	16,000 - 130,000	89,000
Copper	3	3	160 - 330	250
Cyanide	2	1		30
Lead	3	3	100 - 3,500	1,300
Nickel	3	3	6 - 100	45
Zinc	3	3	150 - 280	198
Ethers				
Bis(2-chloroisopropyl) ether	3			ND
Phthalates				
Bis(2-ethylhexyl) phthalate	3			ND
Butyl benzyl phthalate	3			ND
Di-n-butyl phthalate	3	1		Present
Diethyl phthalate	3	1		Present
Dimethyl phthalate	3			ND
Nitrogen compounds				
Benzidine	3			ND
3,3'-Dichlorobenzidine	3			ND
1,2-Diphenylhydrazine	3			ND
N-nitrosodiphenylamine	3	1		250
Phenols				
2,4-Dichlorophenol	3			ND
2,4-Dimethylphenol	3			ND
Pentachlorophenol	3			ND
Phenol	3	2	3,200	3,200
2,4,6-Trichlorophenol	3	2	570	570
Aromatics				
Benzene	3	2		10
Chlorobenzene	3			ND
1,2-Dichlorobenzene	3			ND
1,3-Dichlorobenzene	3			ND
1,4-Dichlorobenzene	3			ND
Ethylbenzene	3	3	10 - 150	80
Hexachlorobenzene	3			ND
Nitrobenzene	3			ND
Toluene	3	3	10 - 11	10
1,2,4-Trichlorobenzene	3			ND
Polycyclic aromatic hydrocarbons				
Acenaphthene	3	1		Present
Acenaphthylene	3			ND
Chrysene	3			ND
Fluoranthene	3			ND
Fluorene	3			ND
Naphthalene	3	1		Present
Phenanthrene/anthracene	3	2	110 - 140	120
Pyrene	3			ND
Halogenated aliphatics				
Chloroform	3	2	10 - 10	10
Dichlorobromomethane	3			ND
1,1-Dichloroethane	3			ND
1,2-Dichloroethane	3			ND
1,2-*Trans*-dichloroethylene	3			ND
1,1,2,2-Tetrachloroethane	3			ND
Tetrachloroethylene	3			ND
1,1,1-Trichloroethane	3			ND
1,1,2-Trichloroethane	3			ND
Trichloroethylene	3			ND
Trichlorofluoromethane	3			ND
Pesticides and metabolites				
α-BHC } β-BHC	3			ND
Chlordane	3			ND
Isophorone	3			ND
TCDD	3	1		ND

Note: ND = not detected.

TABLE 7-12. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE NO BEAMHOUSE SUBCATEGORY [1]

Pollutant	Number of data points	Concentration, mg/L Range of individual data points	 Mean
BOD_5	130	20 - 20,000	1,000
COD	64	140 - 38,000	1,700
TSS	124	120 - 37,000	632
TKN	12	22.0 - 160	168
Total phenols	20	0.112 - 9.90	1.2
Sulfides	13	0.090 - 6.40	3.2
Oil and grease	32	85.0 - 1,200	340
Total chromium	66	2.80 - 1,900	68
Ammonia	22	6.20 - 99.0	36

TABLE 7-13. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE NO BEAMHOUSE SUBCATEGORY [1]

Toxic pollutants	Number of samples	Number detected	Concentration, μg/L Range	 Mean
Metals and inorganics				
Chromium	3	3	16,000 - 170,000	74,000
Copper	3	3	140 - 260	190
Cyanide	3			ND
Lead	3	3	60 - 1,600	790
Nickel	3	3	6 - 30	15
Zinc	3	3	96 - 2,600	1,000
Ethers				
Bis(2-chloroisopropyl) ether	3			ND
Phthalates				
Bis(2-ethylhexyl) phthalate	3			ND
Butyl benzyl phthalate	3			ND
Di-n-butyl phthalate	3			ND
Diethyl phthalate	3			ND
Dimethyl phthalate	3			ND
Nitrogen compounds				
Benzidine	3			ND
3,3'-Dichlorobenzidine	3			ND
1,2-Diphenylhydrazine	3			ND
N-nitrosodiphenylamine	3			ND
Phenols				
2,4-Dichlorophenol	3			ND
2,4-Dimethylphenol	3			ND
Penatchlorophenol	3	2	3,400 - 3,700	3,600
Phenol	3	1		6,200
2,4,6-Trichlorophenol	3	3	2,400 - 4,200	3,300
Aromatics				
Benzene	3	2	10 - 150	80
Chlorobenzne	3			ND
1,2-Dichlorobenzene	3	1		36
1,3-Dichlorobenzene	3			ND
1,4-Dichlorobenzene	3	1		13
Ethylbenzene	3	2	10 - 150	80
Hexachlorobenzene	3			ND
Nitrobenzene	3			ND
Toluene	3	2	10 - 150	80
1,2,4-Trichlorobenzene	3			ND
Polycyclic aromatic hydrocarbons				
Acenaphthene	3			ND
Acenaphthylene	3			ND
Chrysene	3			ND
Fluoranthene	3			ND
Fluorene	3			ND
Naphthalene	3	2	5 - 49	27
Phenanthrene/anthracene	3	2	111 - 130	120
Pyrene	3			ND
Halogenated aliphatics				
Chloroform	3	3	2 - 18	10
Dichlorobromomethane	3	1		10
1,1-Dichloroethane	3			ND
1,2-Dichloroethane	3			ND
1,2-*Trans*-dichloroethylene	3			ND
1,1,2,2-Tetrachloroethane	3			ND
Tetrachloroethylene	3	1		40
1,1,1-Trichloroethane	3			ND
1,1,2-Trichloroethane	3			ND
Trichloroethylene	3	1		10
Trichlorofluoromethane	3			ND
Pesticides and metabolites				
α-BHC } β-BHC	3			ND
Chlordane	3			ND
Isophorone	3			ND

Note ND = not detected

chrome tanning procedures. Average raw waste loads for the major parameters are presented in Table 7-14. Table 7-15 identifies the toxic pollutants and their respective concentrations.

TABLE 7-14. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE THROUGH-THE-BLUE SUBCATEGORY [1]

Pollutant	Number of data points	Concentration, mg/L Range of individual data points	Mean
BOD_5	8	1,300 - 11,000	2,500
COD	5	10,500 - 33,000	6,400
TSS	8	1,200 - 14,000	3,900
TKN	5	960 - 1,800	-[a]
Total phenols	1	9.60	-[a]
Sulfides	4	137 - 680	118
Oil and grease	9	67.0 - 6,200	560
Total chromium	4	230 - 400	100
Ammonia	4	400 - 610	-[a]

[a]Mean reported in reference was outside range of data.

II.7.2.7 Shearling

Tanneries in this subcategory tan and wet finish sheepskins with wool intact. Subprocessing operations eliminate the need for a beamhouse; however, the amount of foreign matter which must be removed from the wool creates higher organic waste loads than those of no-beamhouse tanneries. The absence of grease recovery during the degreasing step is responsible for the higher oil and grease loads. Chrome tanning is prevalent for shearling processing and results in significant levels of total chromium in the untreated wastewater. Tables 7-16 and 7-17 summarize the conventional and toxic pollutants found at shearling tanneries.

II.7.3 PLANT SPECIFIC DESCRIPTION [1]

Tables 7-18 through 7-27 present toxic pollutant and conventional pollutant data for leather tanning and finishing process plants. The data presented are based on information from six plants in five subcategories. An end-of-pipe treatment system was used for each tannery. The treatment system used by each site is listed on each table. No additional information is currently available on an individual plant basis.

II.7.4 POLLUTANT REMOVABILITY

II.7.4.1 Industry Application

The leather tanning and finishing industry utilizes two general systems to minimize the quantity of pollutants discharged by tanneries. They are (1) in-plant process control and (2) end-of-pipe effluent treatment systems. End-of-pipe treatment approaches include preliminary treatment and primary treatment,

TABLE 7-15 WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE THROUGH-THE-BLUE SUBCATEGORY [1]

Toxic pollutants	Number of samples	Number detected	Concentration, µg/L Range	Mean
Metals and inorganics				
Chromium	1	1		550,000
Copper	1	1		100
Lead	1	1		28
Nickel	1	1		160
Zinc	1	1		980
Ethers				
Bis(2-chloroisopropyl) ether	1			ND
Phthalates				
Bis(2-ethylhexyl) phthalate	1			ND
Butyl benzyl phthalate	1			ND
Di-n-butyl phthalate	1			ND
Diethyl phthalate	1			ND
Dimethyl phthalate	1			ND
Nitrogen compounds				
Benzidine	1			ND
3,3'-Dichlorobenzidine	1			ND
1,2-Diphenylhydrazine	1			ND
N-nitrosodiphenylamine	1			ND
Phenols				
2,4-Dichlorophenol	1			ND
2,4-Dimethylphenol	1	1		Present
Pentachlorophenol	1			ND
Phenol	1	1		Present
2,4,6-Trichlorophenol	1	1		Present
Aromatics				
Benzene	1			ND
Chlorobenzene	1			ND
1,2-Dichlorobenzene	1	1		ND
1,3-Dichlorobenzene	1			Present
1,4-Dichlorobenzene	1	1		Present
Ethylbenzene	1	1		Present
Hexachlorobenzene	1			ND
Nitrobenzene	1			ND
Toluene	1	1		Present
1,2,4-Trichlorobenzene	1			ND
Polycyclic aromatic hydrocarbons				
Acenaphthene	1			ND
Acenaphthylene	1	1		Present
Chrysene	1			ND
Fluoranthene	1			ND
Fluorene	1	1		Present
Naphthalene	1	1		Present
Phenanthrene/anthracene	1	1		Present
Pyrene	1			ND
Halogenated aliphatics				
Chloroform	1	1		Present
Dichlorobromomethane	1			ND
1,1-Dichloroethane	1			ND
1,2-Dichloroethane	1			ND
1,2-*Trans*-dichloroethylene	1			ND
1,1,2,2-Tetrachloroethane	1			ND
Tetrachloroethylene	1			ND
1,1,1-Trichloroethane	1	1		Present
1,1,2-Trichloroethane	1			ND
Trichloroethylene	1			ND
Trichlorofluoromethane	1			ND
Pesticides and metabolites				
α-BHC β-BHC	1			ND
Chlordane	1			Present
Isophorone	1			ND

Note: ND = not detected.

TABLE 7-16. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE SHEARLING SUBCATEGORY [1]

Pollutant	Number of data points	Concentration, mg/L	
		Range of individual data points	Mean
BOD_5	24	100 - 3,900	350
COD	19	370 - 31,500	900
TSS	25	120 - 7,600	390
TKN	7	39.0 - 750	53
Sulfides	10	0.080 - 68.0	0.2
Oil and grease	12	56.0 - 1,200	150
Total chromium	16	0.020 - 140	13
Ammonia	7	8.70 - 35.0	13

TABLE 7-17. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOR THE SHEARLING SUBCATEGORY [1]

Toxic pollutants	Number of samples	Number detected	Concentration, μg/L	
			Range	Mean
Metals and inorganics				
Chromium	2	2	2,000 - 53,000	36,500
Copper	2	2	35 - 120	78
Cyanide	2	2	10	10
Lead	2	2		75
Nickel	2	2	20 - 27	24
Zinc	2	2	190 - 500	340
Ethers				
Bis(2-chloroisopropyl) ether	2			ND
Phthalates				
Bis(2-ethylhexyl) phthalate	2	1		93
Butyl benzyl phthalate	2			ND
Di-n-butyl phthalate	2			ND
Diethyl phthalate	2			ND
Dimethyl phthalate	2			ND
Nitrogen compounds				
Benzidine	2			ND
3,3'-Dichlorobenzidine	2			ND
1,2-Diphenylhydrazine	2			ND
N-nitrosodiphenylamine	2			ND
Phenols				
2,4-Dichlorophenol	2			ND
2,4-Dimethylphenol	2			ND
Pentachlorophenol	2	1		400
Phenol	2	1		91
2,4,6-Trichlorophenol	2			ND
Aromatics				
Benzene	2	2	5 - 10	8
Chlorobenzene	2			ND
1,2-Dichlorobenzene	2	1		61
1,3-Dichlorobenzene	2			ND
1,4-Dichlorobenzene	2	2	19 - 20	20
Ethylbenzene	2			ND
Hexachlorobenzene	2			ND
Nitrobenzene	2			ND
Toluene	2	2	9 - 10	10
1,2,4-Trichlorobenzene	2			ND
Polycyclic aromatic hydrocarbons				
Acenaphthene	2			ND
Acenaphthylene	2			ND
Chrysene	2			ND
Fluoranthene	2			ND
Fluorene	2			ND
Naphthalene	2	2		26
Phenanthrene/anthracene	2	1		36
Pyrene	2			ND
Halogenated aliphatics				
Chloroform	2	2	12 - 20	16
Dichlorobromomethane	2			ND
1,1-Dichloroethane	2			ND
1,2-Dichloroethane	2			ND
1,2-*Trans*-dichloroethylene	2			ND
1,1,2,2-Tetrachloroethane	2	1		18
Tetrachloroethylene	2			ND
1,1,1-Trichloroethane	2			ND
1,1,2-Trichloroethane	2			ND
Trichloroethylene	2			ND
Trichlorofluoromethane	2			ND
Pesticides and metabolites				
α-BHC, β-BHC	2			ND
Chlordane	2			ND
Isophorone	2			ND

Note: ND = not detected.

TABLE 7-18. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE HAIR PULP/CHROME TAN/RETAN-WET FINISH SUBCATEGORY FOR PLANT 47 [1]

Treatment type: Activated sludge

Pollutant	Concentration, mg/L[a] Influent	Effluent	Percent removal
BOD_5	1,500	49	97
COD	6,000	560	91
TSS	6,400	230	96
TKN	750	280	63
Sulfides	19	17	9
Oil and grease	250	35	86
pH	8.6	7.6	
Ammonia	440	240	46

[a]Except pH, given in pH units.

TABLE 7-19. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE HAIR SAVE/NONCHROME TAN/RETAN-WET FINISH SUBCATEGORY FOR PLANT 47 [1]

Treatment type: Activated sludge

Pollutant	Concentration, µg/L Influent	Effluent	Percent removal
Metals and inorganics			
Chromium	6,400	170	97
Copper	200	25	88
Cyanide	100	400	-[a]
Lead	100	50	50
Nickel	60	30	50
Zinc	460	59	87
Phthalates			
Bis(2-ethylhexyl) phthalate	ND	26	-[a]
Phenols			
Pentachlorophenol	2,900	200	93
Phenol	850	ND	>99
2,4,6-Trichlorophenol	1,700	38	98
Aromatics			
Benzene	<10	<10	-[b]
1,2-Dichlorobenzene	49	ND	>99
1,4-Dichlorobenzene	19	ND	>99
Ethylbenzene	43	<10	98
Toluene	<10	<10	-[b]
Polycyclic aromatic hydrocarbons			
Naphthalene	19	ND	>99
Phenanthrene/anthracene	7.6	ND	>99
Halogenated aliphatics			
Chloroform	ND	ND	-[b]
1,1,2,2-Tetrachloroethane	<10	ND	>99
Pesticides and metabolites			
α-BHC } β-BHC	ND	ND	-[b]

Note: ND = not detected.

[a]Negative removal.

[b]Negligible removal.

TABLE 7-20. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE HAIR SAVE/CHROME TAN/RETAN-WET FINISH SUBCATEGORY FOR PLANTS 248 and 320 [1]

Treatment type: Extended aeration, activated sludge

Pollutant	Concentration, mg/L[a] Influent	Effluent	Percent removal
	Plant 248		
BOD_5	1,200	920	26
COD	2,600	1,800	31
TSS	1,100	560	49
TKN	250	190	26
Sulfides	50	30	40
Oil and grease	170	91	47
pH	11.0	10.5	
Ammonia	98	60	39
	Plant 320		
BOD_5	2,000	300	86
COD	4,000	890	87
TSS	2,250	130	94
TKN	290	160	43
Sulfides	16	6	63
Oil and grease	550	17	97
pH	8.4	7.6	
Ammonia	150	123	18

[a]Except pH, given in pH units.

TABLE 7-21. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE HAIR SAVE/CHROME TAN/RETAN-WET FINISH SUBCATEGORY FOR PLANTS 248 and 320 [1]

Treatment type Extended aeration, activated sludge

Pollutant	Plant 248 Concentration, μg/L Influent	Effluent	Percent removal	Plant 320 Concentration, μg/L Influent	Effluent	Percent removal
Metals and inorganics						
Chromium	31,000	20,000	35	170,000	1,700	99
Copper	57	37	35	220	8	96
Cyanide	20	40	-[a]	50	40	20
Lead	100	30	70	3,100	60	98
Nickel	5	34	-[a]	75	30	60
Zinc	230	140	39	2,100	170	92
Phthalates						
Bis(2-ethylhexyl) phthalate	ND	ND	-[a]	32	6	83
Phenols						
Pentachlorophenol	9,500	3,100	67	ND	12	-[a]
Phenol	480	435	9	5,500	1,400	75
2 4 6-Trichlorophenol	10,500	4,300	59	ND	12	-[a]
Aromatics						
Benzene	ND	ND	-[b]	<10	<10	-[b]
1,2-Dichlorobenzene	215	69	68	ND	<10	-[a]
1,4-Dichlorobenzene	99	21	79	ND	<10	-[a]
Ethylbenzene	ND	ND	-[b]	>100	<10	99
Toluene	<10	<10	-[b]	>100	<10	99
Polycyclic aromatic hydrocarbons						
Naphthalene	49	15	69	ND	2 3	-[a]
Phenanthrene/anthracene	56	<10	98	2 9	1 4	52
Halogenated aliphatics						
Bromoform	41	<10	98	<10	ND	>99
1,1,2,2-Tetrachloroethane	ND	ND	-[b]	ND	ND	-[b]
Pesticides and metabolites						
α-BHC / β-BHC	ND	ND	-[b]	ND	ND	-[b]

Note ND = not detected

[a]Negative removal

[b]Negligible removal

TABLE 7-22. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE SHEARLING SUBCATEGORY FOR PLANT 253 [1]

Treatment type: Activated sludge

Pollutant	Concentration, mg/L[a] Influent	Effluent	Percent removal
BOD_5	1,000	27	97
COD	2,400	490	79
TSS	770	110	86
TKN	49	27	45
Sulfides	0.16	0.13	17
Oil and grease	410	25	94
pH	5.2	7.7	
Ammonia	11	17	-[b]

[a]Except pH, given in pH units.

[b]Negative removal.

TABLE 7-23. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE SHEARLING SUBCATEGORY FOR PLANT 253 [1]

Treatment type: Activated sludge

Pollutant	Concentration, μg/L Influent	Effluent	Percent removal
Metals and inorganics			
Chromium	53,000	2,200	96
Copper	120	7	94
Cyanide	10	<10	>0
Lead	80	30	63
Nickel	27	19	30
Zinc	500	68	86
Phthalates			
Bis(2-ethylhexyl) phthalate	93	34	63
Phenols			
Pentachlorophenol	400	130	68
Phenol	91	ND	>99
2,4,6-Trichlorophenol	ND	ND	ND
Aromatics			
Benzene	5	ND	>99
1,2-Dichlorobenzene	ND	ND	-[a]
1,4-Dichlorobenzene	20	ND	>99
Ethylbenzene	ND	ND	-[a]
Toluene	9	ND	>99
Polycyclic aromatic hydrocarbons			
Naphthalene	35	ND	>99
Phenanthrene/anthracene	36	6	83
Halogenated aliphatics			
Chloroform	12	10	16
1,1,2,2-Tetrachloroethane	18	ND	>99
Pesticides and metabolites			
α-BHC } β-BHC }	ND	ND	-[a]

Note: ND = not detected.

[a]Negligible removal.

TABLE 7-24. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE HAIR PULP/CHROME TAN/RETAN-WET FINISH SUBCATEGORY FOR PLANT 184 [1]

Treatment type: Aerated lagoons

Pollutant	Concentration, mg/L[a] Influent	Effluent	Percent removal
BOD_5	1,900	20	99
COD	5,500	220	96
TSS	2,900	160	95
TKN	500	100	79
Sulfides	200	0.4	99
Oil and grease	720	17	98
pH	8.4	6.8	
Ammonia	260	64	76

[a]Except pH, given in pH units.

TABLE 7-25. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE HAIR PULP/CHROME TAN/RETAN-WET FINISH SUBCATEGORY FOR PLANT 184 [1]

Treatment type: Aerated lagoon

Pollutant	Concentration, µg/L Influent	Effluent	Percent removal
Metals and inorganics			
Chromium	160,000	1,100	99
Copper	50	5	90
Cyanide	60	150	-[a]
Lead	1,100	80	93
Nickel	60	30	50
Zinc	500	49	90
Phthalates			
Bis(2-ethylhexyl) phthalate	51	2	96
Phenols			
Pentachlorophenol	ND	ND	-[a]
Phenol	4,400	ND	>99
2,4,6-Trichlorophenol	880	ND	>99
Aromatics			
Benzene	<10	<10	-[a]
1,2-Dichlorobenzene	260	ND	>99
1,4-Dichlorobenzene	54	ND	>99
Ethylbenzene	88	ND	>99
Toluene	>100	<10	99
Polycyclic aromatic hydrocarbons			
Naphthalene	24	ND	>99
Phenanthrene/anthracene	ND	ND	-[a]
Halogenated aliphatics			
Chloroform	ND	ND	-[a]
1,1,2,2-Tetrachloroethane	ND	ND	-[a]
Pesticides and metabolites			
α-BHC, β-BHC	ND	ND	-[a]

Note: ND = not detected.

[a]Negligible removal.

TABLE 7-26. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE RETAN-WET SUBCATEGORY FOR PLANT 247 [1]

Treatment type: Physical/chemical

Pollutant	Concentration, mg/L[a] Influent	Effluent	Percent removal
BOD_5	620	6.7	99
COD	1,900	28	99
TSS	520	7.7	98
TKN	180	4.4	98
Sulfides	0.5	0.3	40
Oil and grease	180	15	91
pH	4.3	4.4	-
Ammonia	110	1.5	99

[a]Except pH, given in pH units.

TABLE 7-27. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE RETAN-WET FINISH SUBCATEGORY FOR PLANT 247 [1]

Treatment type: Physical/chemical

Pollutant	Concentration, µg/L Influent	Effluent	Percent removal
Metals and inorganics			
Chromium	16,000	<20	>99
Copper	260	<8	97
Cyanide	<10	<10	-[a]
Lead	300	8	97
Nickel	6	4	33
Zinc	150	61	61
Phthalates			
Bis(2-ethylhexyl) phthalate	ND	ND	-[a]
Phenols			
Pentachlorophenol	ND	ND	-[a]
Phenol	3,200	60	98
2,4,6-Trichlorophenol	570	<10	99
Aromatics			
Benzene	<10	<10	-[a]
1,2-Dichlorobenzene	ND	ND	-[a]
1,4-Dichlorobenzene	ND	ND	-[a]
Ethylbenzene	>100	12	92
Toluene	11	<10	99
Polycyclic aromatic hydrocarbons			
Naphthalene	ND	8.5	-[a]
Phenanthrene/anthracene	130	7.3	95
Halogenated aliphatics			
Chloroform	<10	<10	-[a]
1,1,2,2-Tetrachloroethane	ND	ND	-[a]
Pesticides and metabolites			
α-BHC } β-BHC }	ND	ND	-[a]

Note: ND = not detected.

[a]Negligible removal.

secondary treatment, and advanced waste treatment. Preliminary treatment includes in-plant controls, preliminary treatment of segregated streams, and primary treatment of combined streams by coagulation-sedimentation. Secondary treatment is intended for use to remove biodegradable organic material. Advanced waste treatment includes technologies that remove certain pollutants and produce an effluent of high clarity and extremely low content of conventional, nonconventional, and toxic pollutants.

Current treatment employed in the tanning industry ranges from no treatment to several types of secondary treatment. Twelve percent of the industry dischargers have no pretreatment; yet, all the direct dischargers have at least primary treatment and some form of secondary treatment. Eighteen plants discharge their wastewaters directly to surface waters. One-hundred and seventy indirect dischargers discharge to municipal treatment plants.

II.7.4.2 Treatment Methods

In-Plant Control

Process Changes. Process changes are difficult to make because of the numerous tanning methods employed. Substitution of effluents from one process for make-up water in another is generally feasible at some points within a tannery. Before tanneries can make this change, however, they must establish the quantity and pollutant content of water required for each operation.

Substitution of Process Ingredients. Chemical ingredients of low pollution potential can often be substituted for problem pollutants. A number of process chemical substitution opportunities exist.

Water Conservation and Reuse. Conscientious use of water helps to reduce both the volume of wastes and the amount of water used. One plant in the industry currently employs a comprehensive water conservation program. Through implementation of this program, the total use of water has decreased nearly 50%.

Water may also be conserved by reusing it in another process. The water, however, must be filtered or treated. Batch washing reduces water consumption by approximately one-fifth.

Automatic Monitoring Devices. Automatic monitoring equipment for detecting abnormal levels of selected constituents guards against the failure of established precautionary measures. In addition to indicating loss of materials, automatic sensing devices also can operate recovery equipment.

Recovery and Reuse of Process Chemicals. The most efficient method of eliminating pollutants from tannery wastes and of reducing the volume of effluent is through reuse of water and chemical agents and through recovery of materials that are normally used. Four plants in the industry are currently using this approach. These facilities use recycle systems to reduce the amounts of tanning liquor discharged into the waste streams.

Preliminary Treatment

Screening. The principal function of screening is to remove objectionable material that has a potential for damaging plant equipment and clogging pumps or sewers. Much of the screening employed in this industry has been ineffective due to poorly operated screens, or screens with openings that are too large, or both.

Carbonation of Beamhouse Waste Stream. Carbonation is effective in the treatment of alkaline wastes. Four tanneries in the United States have operated flue gas or carbon dioxide carbonation systems. Carbonation is attractive for tannery pre-treatment facilities. The effectiveness of flue gas carbonation of beamhouse waste streams is optimal when the pH is lowered to the isoelectric point. The introduction of only flue gas can limit the degree of treatment possible.

Secondary Treatment

Activated Sludge Systems. The activated sludge process is one of the most controllable and flexible of all secondary treatment systems. It is applicable to almost all treatment situations and plays a very important role in this industry for treatment of toxic pollutants. With proper design and operation, high organic removals are possible. Designs based on solids retention time (SRT) afford optimum residence time for solids with minimal hydraulic retention. However, pilot studies are required to establish appropriate design parameters defining the relative rate of biological growth and decay with a given wastewater.

Activated sludge systems, including various modifications, have been and can be effective in organic reductions to low BOD_5 concentrations even under low temperature conditions. Removals of suspended solids prior to final effluent discharge and maintenance of a large quantity of active biomass in the aeration basin, especially during winter months to compensate for lower rates of organism activity, appear to depend on conservative design and diligent operation of the final clarifier.

Physical-Chemical Processes

Chappel Process. The Chappel process is a patented physical-chemical process for treating wastewater streams. The basis for this process is the assumption that all waste streams contain components that flocculate or settle in the proper environment.

Activated Carbon. The use of activated carbon in treating industrial wastewaters has been generally successful depending on the application, the soundness of engineering, the degree of proper operation and maintenance, and the performance criteria established for the system. A relatively new application of powdered activated carbon (PAC) is being tested and evaluated in combined carbon-biological systems because of the ability of activated carbon to improve the performance of biological systems. This concept is now undergoing extensive testing, using powdered carbon material in activated sludge systems. The carbon is metered into the system with the influent at a concentration normally less than 100 mg/L. It is recirculated and purged along with the biological solids at a rate that maintain an equilibrium concentration of 1,000 to 2,000 mg/L. Since the powdered carbon is added directly to the activated sludge process, this eliminates the need for carbon-adsorption beds or columns.

Other treatment technologies may also be in current use in the leather tanning and finishing industry.

II.7.5 REFERENCES

1. Development Document for Proposed Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Leather Tanning and Finishing Point Source Category. U.S. Environmental Protection Agency, Effluent Guidelines Division, Washington, D.C., July 1979.

2. Effluent Guidelines and Standards for Leather Tanning and Finishing. U.S. Environmental Protection Agency, 40 CFR 425; 39FR 12958, April 9, 1974.

3. NRDC Consent Decree Industry Summary. Leather Tanning and Finishing Industry.

II.8.3 COIL COATING

II.8.3.1 Industry Description

II.8.3.1.1 General Description [1]

The coil coating industry consists of approximately 70 plants processing approximately 4 billion square meters of painted coil each year. Facilities vary in size and corporate structure, ranging from independent shops to captive operations. Independent shops obtain untreated coil, conversion coating chemicals, and paints, and produce a wide variety of coated coil. Typically, the annual production at these plants is low compared to that from the captive coating operations. The captive coil coating operation is usually an integral part of a large corporation engaged in many other kinds of metal production and finishing.

The coil coating sequence, regardless of basis material or conversion coating process used, consists of three functional steps: cleaning, conversion coating, and painting. Basically, there are three types of cleaning operations used in coil coating, and they can be used alone or in combinations. These are: mild alkaline cleaning, strong alkaline cleaning, and acid cleaning. There are four basic types of conversion coating operations, and the use of one precludes the use of the others on the same coil. These are: chromating, phosphating, use of complex oxides, and no-rinse conversion coating. Some of these conversion coating operations are designed for use on specific basis materials. The painting operation is performed by roll coating and is independent of the basis material and conversion coating. Some specialized coatings are supplied without conversion-coating the basis material. For example, Zincrometal is a specialized coating consisting of two coats of special paints that do not require conversion coating. In this process, coils are cleaned and dryed, and then receive two coats of the special paints.

The selection of basis material, conversion coating, and paint formulation is an art based upon experience. The variables that are typically involved in the selection are appearance, color, gloss, corrosion resistance, abrasion resistance, process line capability, availability of raw materials, customer preference, and cost. Some basis materials inherently work better with certain conversion coatings, and some conversion coatings work better with certain paint formulations. On the whole, however, the choice of which combination to use on a basis material is limited only by plant and customer preferences.

The following subsections describe the coil coating processes in more detail.

Cleaning. Coil coating requires that the basis material be clean. A thoroughly clean coil assures efficient conversion coating and a resulting uniform surface for painting. The soils, oils, and oxide coatings found on a typical coil originate from rolling mill operations and storage conditions prior to coil coating. Such substances can stop the conversion coating reaction, cause a coating void on part of the basis material, and cause the production of a nonuniform coating. Cleaning operations must chemically and physically remove these interfering substances without degrading the surface of the basis material. Excessive cleaning can roughen a basically smooth surface to a point where a paint film will not provide optimum protective properties.

Aluminum and galvanized steel are prone to develop an oxide coating that acts as a barrier to chemical conversion coatings. However, these oxide films are easier to remove than rust and therefore require a less vigorous cleaning process. A mild alkaline cleaner is usually applied with power spray equipment to remove the oxide coating and other interfering substances. The cleaning solutions normally used consist of combinations of sodium carbonates, phosphates, silicates, and hydroxides. These compounds give the solution its alkaline character and emulsify the removed soils. Soap and detergents may be added to the solution to lower the surface and interfacial tension. A good cleaning solution also rinses easily. Solutions may be made stronger with the addition of more sodium hydroxide.

Steel, unless adequately protected with a film of oil subsequent to rolling mill operations, has a tendency to form surface rust rather quickly. This rust on the surface of the metal prevents proper conversion coating. A traditional method of removing rust is an acid applied by power spray equipment. The spraying action cleans both by physical impingement and the etching action of the acid. The power spray action is followed by a brush scrub which further removes soil loosened by the acid. The brush scrub is followed by a strong alkaline spray wash which removes all traces of the acid and neutralizes the surface.

A spray rinse follows the alkaline cleaning step. Spray rinsing is conducive to the fast line speeds which make coil coating an economical coating procedure. The spray rinse physically removes alkaline cleaning residues and soil by both the physical impingement of the water and the diluting action of the water. The rinse water is usually maintained at approximately 66°C (150°F) to keep the coil warm for the subsequent conversion coating reactions and to help the rinsing action. The rinsing action prevents contamination of the conversion coating bath with cleaning residues which are dragged out on the strip and that could be subsequently deposited in the conversion coating solutions. The rinsing step also keeps the surface of the metal wet and active, which permits faster conversion coating film formation.

The no-rinse conversion coating and the Zincrometal processes require a coil that is clean, warm, and dry. For these processes, a squeegee roll and forced air drying are used to assure a clean, dry coil following alkaline cleaning and rinsing.

Conversion Coatings. The basic objective of the conversion coating process is to provide a corrosion-resistant film that is integrally bonded chemically and physically to the base metal and that provides a smooth and chemically inert surface for subsequent application of a variety of paint films. The conversion coating processes effectively render the surface of the basis material electrically neutral and immune to galvanic corrosion. Conversion coating on basis material coils does not involve the use of applied electric current to coat the basis material. The coating mechanisms are chemical reactions that occur between solution and basis material.

Four types of conversion coatings are normally used in coil coating:

- Chromate conversion coatings
- Phosphate conversion coating
- Complex oxides conversion coatings
- No-rinse conversion coatings

Chromate conversion coatings, phosphate conversion coatings, and complex oxide conversion coatings are applied in basically the same manner. No-rinse conversion coatings are roll applied and use quite different chemical solutions than phosphating, chromating, or complex oxides solutions. However, the dried film is used as basis for paint application similar to phosphating, chromating, and complex oxide conversion coatings films.

Chromate conversion coatings can be applied to both aluminum and galvanized surfaces but are generally applied only to aluminum surfaces. These coatings produce an amorphous layer of chromium chromate complexes and aluminum ions. The coatings offer unusually good corrosion-inhibiting properties but are not as abrasion resistant as phosphate coatings. Scratched or abraded films retain a great deal of protective value because the hexavalent chromium content of the film is slowly leached by moisture, providing a self-healing effect. Under limited applications, these coatings can serve as the finished surface without being painted. If further finishing is required, it is necessary to select an organic finishing system that has good adhesive properties. Chromate conversion coatings are extremely smooth, electrically neutral, and quite resistant to chemical attack.
to chemical attack.

Chromate conversion coatings for aluminum are carried out in acidic solutions. These solutions usually contain one chromium salt, such as sodium chromate, or chromic acid and a strong oxidizing agent such as hydrofluoric acid or nitric acid. The final film usually contains both products and reactants and water of hydration. Chromate films are formed by the chemical reaction of hexavalent chromium with a metal surface in the presence of "accelerators", such as cyanides, acetates, formates, sulfate, chlorides, fluorides, nitrates, phosphates, and sulfamates.

Chromate conversion coating requires that the basis material be alkaline-cleaned and spray-rinsed with warm water. The cleaning and rinsing assures a clean, warm, wet surface on which the conversion coating process takes place. Once the film is formed, it is rinsed with water followed by a chromic acid sealing rinse. This latter rinse seals the free pore area of the coating by forming a chromium chromate gel. Also, the sealing rinse more thoroughly removes precipitated deposits that may have been formed by hard water in previous operations. The coil is then subjected to a forced air drying step to assure a uniformly dry surface for the following painting operation.

Phosphate conversion coatings provide a highly crystalline, electrically neutral bond between a base metal and paint film. The most widespread use of phosphate coatings is to prolong the useful life of paint finishes. Phosphate coatings are primarily used on steel and galvanized surfaces but also can be applied to aluminum. Basically, there are three types of phosphate coatings: iron, zinc, and manganese. Manganese coatings are not used in coil coating operations because they are relatively slow in forming and, as such, are not amenable to the high production speeds of coil coaters.

The remaining two phosphate coatings are applied by spraying or immersing the coil, with the major difference between them being the weight and thickness of the dried coating. Iron phosphate coatings are the thinnest and lightest and generally the cheapest. Iron phosphate solutions are applied chiefly as a base for paint films. Spray application of iron phosphating solutions is most commonly used. The coating weights range from 0.22 to 0.86 g/m^2.

Zinc phosphate coatings are quite versatile and can be used as a base for paint or oil, as an aid to cold forming, to increase wear resistance, and to provide rustproofing. Zinc phosphate coatings can be applied by spray or immersion with applied coating weights ranging from 1.08 to 10.8 g/m^2 for spray coating and from 1.61 to 43.1 g/m^2 for immersion coating.

Phosphate coatings are formed in the metal surface, incorporating metal ions dissolved from the surface. This creates a coating that is integrally bonded to the base metal. In this respect, phosphate coatings differ from electrodeposited coatings, which are superimposed on the metal. Most metal phosphates are insoluble in water but soluble in mineral acids. Phosphating solutions consist of metal phosphates dissolved in carefully balanced solutions of phosphoric acid. As long as the acid concentration of the bath remains above a critical point, the metal ions remain in solution. Accelerators speed up film formation and prevent the polarization effect of hydrogen on the surface of the metal. Accelerators commonly used include nitrites, nitrates, chlorates, and peroxides. Cobalt and nickel nitrite accelerators are the most widely used and develop a coarse crystalline structure. The peroxides are relatively unstable and difficult to control, while chlorate accelerators generate a fine sludge that may cause dusty or powdery deposits.

After phosphating, the coil is passed through a recirculating hot water spray rinse. The rinsing action removes excess acid and unreacted products, thereby stopping the conversion coating reaction. Insufficient rinsing could cause blistering under the subsequent paint film from the galvanic action of the residual acid and metal salts.

The basis material is then passed through an acid sealing rinse comprised of up to 0.1% by volume of phosphoric acid, chromic acid, and various metallic conditioning agents, notably zinc. This solution seals the free pore area of the coating by forming a chromium chromate gel. Also, this acidic sealing rinse more thoroughly removes precipitated deposits formed by hard water in the previous rinses. Modified chromic acid rinses have found extensive use in the industry. These rinses are prepared by reducing chromic acid with an organic reductant to form a mixture of trivalent chromium and hexavalent chromium in the form of a complex chromium chromate.

Complex oxide conversion coatings can be applied to aluminum and galvanized surfaces but are generally applied to only galvanized surfaces. The nature of the film and the chemical and physical reactions of its formation are a function and a reinforcement of the naturally occurring protective oxide coating that is found on galvanized surfaces. The physical properties of the complex oxide conversion coating film are comparable to those of chromate conversion coating films and phosphate conversion coating films.

Complex oxide film is formed in a basic solution while the films described earlier are formed in an acidic solution. Complex oxide conversion coating reactions do not contain either hexavalent or trivalent chromium ions. However, the sealing rinse contains much greater quantities of hexavalent and trivalent chromium ions than do the sealing rinses associated with phosphate conversion coatings and chromate conversion coatings.

Recent developments in chromate conversion coating solutions have resulted in a solution that can be applied to cold rolled steel, galavanized steel, or aluminum without the need for any rinsing after the coating has formed on the basis material. The basis material must first be alkaline cleaned, thoroughly rinsed, and forced-air dried prior to conversion coating. The conversion coating solution is applied with a roll mechanism used in roll coating paint. Once the solution is roll coated onto the basis material, the coil is forced-air dried at approximately 66°C. The no-rinse solutions are formulated in such a way that once a film is formed and dried, there are no residual or detrimental products left on the coating that could interfere with normal coil coating paint formulations.

Although no-rinse conversion coatings currently represent a small proportion of the conversion coating techniques that are used, they offer several advantages, including fewer process steps in a physically smaller process line, higher line speeds, application of a very uniform thickness by roll coating rather than spray or dip coating, and reduction of waste treatment requirements because of the reduced use of chromium compounds. Disadvantages include roll coating mechanism wear possibly reducing quality, the closer coordination of entire line that is needed, difficulty in adaptation, and the hazardous organic acids content of the no-rinse conversion coating chemicals.

Painting. Roll coating of paint is the final process in a coil coating line. Roll coating is an economical method to paint large areas of metal with a variety of finishes and produces a uniform and high quality coating. The reverse roll procedure for coils is used by the coil coating industry, and allows both sides of the coil to be painted simultaneously.

The paint formulations used in the coil coating industry have high pigmentation levels (providing hiding power), adhesion, and flexibility. Most coatings of this type are thermosetting and are based on vinyl, acrylic, and epoxy functional aromatic polyethers, and some reactive monomer or other resin with reactive functions, such as melamine formaldehyde resins. Also, a variety of copolymers of butadiene with styrene or maleic anhydride are used in coating formulations. These coatings are cured by oxidation mechanisms during baking similar to those that harden drying oils.

After paint application, all coils are cured in an oven. Curing temperatures depend upon basis material, conversion coating, paint formulation, and line speed. Typical temperatures range from about 93°C to a maximum of about 371°C. Upon leaving the oven, the coils are quenched with water to induce rapid cooling prior to rewinding.

The quench is necessary for all basis materials, conversion coatings, and paint formulations. A coil that is rewound when too warm will develop internal and external stresses, causing a possible degradation of the appearance of the paint film and of the forming properties of the coil. The volume of water used in the quench often has the largest flow rate of all of the coil-coating processes. However, the water is often circulated to a cooling tower for heat dissipation and reuse.

The finished coils are used in a variety of industries. The building products industry utilizes prefinished coils to fabricate exterior siding, window and door frames, storm windows and storm gutters, and various other trim and accessory building products. The food and beverage industries utilize various types of coils and finishes to safely and economically package and ship a wide variety of food and beverage products. Until recently, the automotive and appliance industries have made limited use of prefinished coils. These industries have relied on post assembly finishing of their products. Recently, the automotive industry has begun using a cold rolled steel coil coated on one side with a finish called Zincrometal. This coating is applied to the under surfaces of the exterior automobile sheet metal to protect them from corrosion. The appliance industry uses prefinished coils in constructing certain models of refrigerator exteriors to provide a finished product that minimizes the costly and labor-intensive painting operation after forming.

Coil coating operations are located throughout the country, usually in well established industrial centers. Compared to some other industries, coil coating operations are not physically large. Coil coating operations use large quantities of water and are often a significant contributor to municipal waste treatment systems or surface waters. In addition, the curing ovens from coil coating operations are a source of air pollution in the form of reactive hydrocarbons.

Table 8.3-1 presents an industry summary of the coil coating industry.

TABLE 8.3-1. INDUSTRY SUMMARY [1, 2]

Industry: Coil Coating
Total number of subcategories: 3
Number of subcategories studied: 3

Number of Dischargers in industry:

- Direct: 36
- Indirect: 54
- Zero dischargers: 0

II.8.3.1.2 Subcategory Description

The primary purpose of subcategorization is to establish groupings within the coil coating industry such that each group has a uniform set of effluent limitations. While subcategorization is based on wastewater characteristics, a review of the other subcategorization factors reveals that the basis material used and the processes performed on these basis materials are the principal factors affecting the wastewater characteristics of plants in the coil coating industry. The coil coating industry is therefore divided into the following three subcategories:

Coil Coating on steel
Coil coating on zinc coated steel (galvanized)
Coil coating on aluminum or aluminized steel

The following subsections describe the above subcategories.

Subcategory 1 - Coil Coating on Steel. The coil coating on steel subcategory consists of approximately 31 plants, of which eight facilities coat steel alone. The remaining plants coat a combination of steel coils and coil from the other subcategories. Approximately 470 x 10^6 m^2 of coated steel are produced each year. Operations used at these facilities include acid cleaning, strong alkaline cleaning, phosphating, no-rinse conversion coating, roll coating, and Zincrometal coating. Table 8.3-2 presents water usage data for the general operations at steel coating facilities.

TABLE 8.3-2. SUMMARY OF WATER USAGE RATES FOR THE COIL COATING INDUSTRY BY SUBCATEGORY [1]

Operation	Number of points	Water use, L/m^2 Range	Mean	Median
		steel		
Cleaning	9	0.30 - 7.3	2.3	1.5
Conversion coating	8	0.041 - 0.76	0.43	0.41
Painting[a]	20	0.29 - 5.1	2.1	2.1
All operations	13	0.37 - 13	4.5	4.7
		galvanized		
Cleaning	10	0.17 - 4.4	1.1	0.83
Conversion coating	10	0.025 - 0.84	0.40	0.50
All operations	12	0.65 - 8.4	3.7	2.0
		aluminum		
Cleaning	12	0.21 - 2.0	0.97	0.97
Conversion coating	12	0.18 - 1.8	0.56	0.47
All operations	15	0.39 - 6.3	2.9	2.4

[a]Painting water usage listed under steel is for all basis materials.

Subcategory 2 - Coil Coating on Zinc Coated Steel (Galvanized). The coil coating on galvanized steel subcategory consists of 15 plants with an annual production of approximately 600 x 10^6 m^2. Only three facilities produce coated galvanized steel alone. Five plants also coat steel coils, and seven facilities coat steel and aluminum along with galvanized steel. Operations used at the galvanized coating facilities include mild alkaline cleaning, phosphating, chromating, complex oxide treatment, no-rinse conversion coating, roll coating, and Zincrometal coating. Table 8.3-2 above also presents water usage data for the general operations at galvanized coating facilities.

Subcategory 3 - Coil Coating on Aluminum. This subcategory consists of 32 facilities producing 470 x 10^6 m^2 of product annually. Fifteen facilities coat only aluminum coils, eleven coat steel coils with the aluminum, and seven coat all three types of basis metal. The aluminum coating facilities use mild alkaline cleaning, phosphating, chromating, complex oxide treatment, no-rinse conversion coating, and roll coating. Table 8.3-2 above also gives water usage information for the general processes in this industry.

II.8.3.2 Wastewater Characterization [1]

Water is used in virtually all coil coating operations. It provides the mechanism for removing undesirable compounds from the basis material, is the medium for the chemical reactions that occur on the basis material, and cools the basis material following baking. Water is the medium that permits the high degree of automation associated with coil coating and the high quality of the finished product. The nature of coil coating operations, the large amount basis material processed, and the quantity and type of chemicals used produces a large volume of wastewater that requires treatment before discharge.

Wastewater generation occurs for each basis material (steel, galvanized and aluminum) and for each functional operation (cleaning, conversion coating, and painting). The wastewater generated by the three functional operations may (1) flow directly to a municipal sewage treatment system or surface water, (2) flow directly to an on-site waste treatment system and then to a municipal sewage treatment system or surface water, (3) be reused directly or following intermediate treatment, or (4) undergo a combination of the above processes.

Coil coating operations that produce wastewater are characterized by the pollutant constituents associated with respective basis materials. The constituents in the raw wastewaters include ions of the basis material, oil and grease found on the basis material, components of the cleaning and conversion coating solutions, and the paints and solvents used in roll coating the basis materials. The following tables present wastewater characterization data for each subcategory. These data are the result of verification sampling at a number of plants in each subcategory. Screening samples were generally first analyzed to determine what compounds should be analyzed. The pollutants that have been chosen were found in a concentration greater than 0.010 mg/L.

Tables 8.3-3 through 8.3-10 present raw wastewater characterization data for each general process in each subcategory and for the wastewater in each subcategory when combined into a single representative stream as a whole. Table 8.3-11 presents raw wastewater flow data for each subcategory.

TABLE 8.3-3. CONVENTIONAL AND NONTOXIC POLLUTANT CONCENTRATIONS FOR THE RAW WASTEWATER IN THE COIL COATING INDUSTRY, BY SUBCATEGORY [1]

Pollutant	Number of points	Number detected	Concentration, mg/L: Range	Mean	Median
			steel		
Conventional					
TSS	13	13	17 - 2,900	490	150
TDS	6	6	700 - 15,000	5,700	1,700
Total phosphorus	8	8	5.8 - 120	52	43
Total phenols	12	12	<0.010 - 0.21	0.047	0.020
Oil and grease	12	12	2.1 - 1,400	510	340
Nontoxic inorganic					
Aluminum	13	12	0.020 - 1.9	0.66	0.61
Barium	2	1	0.53	0.53	0.53
Boron	2	1	0.25	0.25	0.25
Calcium	2	2	16 - 70	43	43
Cobalt	2	1	0.31	0.31	0.31
Iron	13	13	0.78 - 21	10	10
Magnesium	2	2	4.4 - 21	13	13
Manganese	13	13	0.25 - 1.3	0.60	0.53
Molybdenum	2	2	<0.010 - 0.066	0.038	0.038
Sodium	2	2	310 - 500	400	400
Strontium	1	1	0.33	0.33	0.33
Tin	2	1	0.33	0.33	0.33
Titanium	2	1	0.042	0.042	0.042
Vanadium	2	1	0.031	0.031	0.031
Yttrium	2	1	0.021	0.021	0.021
Fluorides					
			galvanized		
Conventional					
TSS	12	12	35 - 570	190	110
TDS	3	3	170 - 1,600	740	430
Total phosphorus	5	5	8.7 - 56	26	15
Total phenols	11	9	<0.010 - 0.071	0.026	<0.010
Oil and grease	12	12	2.3 - 870	200	53
Nontoxic inorganic					
Aluminum	12	11	0.29 - 5.3	2.2	1.7
Barium					
Boron					
Calcium					
Cobalt					
Iron	11	11	0.40 - 17	4.6	2.8
Magnesium					
Manganese	12	12	<0.010 - 0.81	0.17	0.12
Molybdenum					
Sodium					
Strontium					
Tin					
Titanium					
Vanadium					
Yttrium					
Fluorides	12	12*	0.21 - 9.4	3.7	2.1
			aluminum		
Conventional					
TSS	15	15	3.4 - 880	240	85
TDS	3	3	910 - 1,300	1,100	1,100
Total phosphorus	5	5	1.7 - 12	6.7	7.0
Total phenols	15	11	<0.010 - 0.071	0.028	0.026
Oil and grease	15	14	1.3 - 730	130	58
Nontoxic inorganic					
Aluminum	15	15	4.3 - 680	190	110
Barium					
Boron	15	15	9.0	9.0	9.0
Calcium					
Cobalt					
Iron	15	15	0.18 - 10	3.6	3.4
Magnesium	1	1	20	20	20
Manganese					
Molybdenum	1	1	0.050	0.050	0.050
Sodium	1	1	170	170	170
Strontium					
Tin	1	1	0.060	0.060	0.060
Titanium					
Vanadium					
Yttrium					
Fluorides	15	15	2.4 - 240	67	21

Note: Blanks indicate no data available.

TABLE 8.3-4. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATER FOR THE COIL COATING INDUSTRY, BY SUBCATEGORY [1]

Toxic pollutant	steel: Number of points	steel: Number detected	steel: Concentration, µg/L Range	steel: Mean	steel: Median	galvanized: Number of points	galvanized: Number detected	galvanized: Concentration, µg/L Range	galvanized: Mean	galvanized: Median	aluminum: Number of points	aluminum: Number detected	aluminum: Concentration, µg/L Range	aluminum: Mean	aluminum: Median
Metals and inorganics															
Antimony	1	1		3,000	3,000										
Arsenic	2	1	75	75											
Cadmium	13	7	<10 - 39	<10	<10	12	8	<10 - 200	55	45	15		<10	<10	<10
Chromium	13	13	40 - 330,000	62,000	6,400	11	11	49 - 130,000	46 000	58,000	15	15	1,800 27,000	71,000	43,000
Copper	13	13	11 - 140	52	51	12	12	<10 - 60	21	<10	15	13	<10 - 480	80	43
Cyanide	12	7	<10 - 55	21	12	12	7	<10 - 160	89	82	15	12	<10 - 18,000	4,800	570
Lead	13	10	11 - 1,500	300	140	12	12	<10 - 2,100	680	420	15	8	54 - 200	120	120
Mercury	2	2	<10	10											
Nickel	13	9	<10 - 2,100	620	390	12	6	<10 - 3,200	760	400					
Silver	2	1	20	20											
Zinc	13	13	1,500 - 340,000	40,000	7,600	12	12	2,300 - 150,000	51,000	25,000	15	15	12 - 15,000	2,200	200
Phthalates															
Bis(2-ethylhexyl) phthalate	12	11	<10 - 620	98	35	11	11	<10 - 1,100	250	180	14	13	<10	<10	<10
Butyl benzyl phthalate	12	2	<10 - 300	150	150	11	4	<10 - 32	<10	<10	14	2	<10	<10	<10
Di-n-butyl phthalate	12	10	<10	<10	<10	11	8	<10 - 160	29	<10	14	6	<10 - 12	<10	<10
Diethyl phthalate	12	10	<10 - 600	140	56	11	11	<10 - 390	85	48	14	11	<10 - 200	79	55
Dimethyl phthalate						11	1	<10 - 390	<10	<10	14	4	<10 - 14	<10	<10
Di-n-octyl phthalate	12	4	<10 - 180	59	29	11	1	<10	<10	<10	14	3	<10	<10	<10
Phenols															
2,4-Dimethylphenol	5	1	21	21	21	2	0								
Phenol	5	1	16	16	16	4	0								
Aromatics															
Benzene	1	1		<10	<10						2	1	<10	<10	
Ethylbenzene	1	1		<10	<10										
Toluene	5	1	<10	<10	<10	4	0				5	1	<10	<10	<10
Polycyclic aromatic hydrocarbons															
Acenaphthylene	12	1	<10	<10	<10	11	1	<10	<10	<10					
Anthracene	12	11	<10 - 1,400	340	64	11	6	<10 - 250	49	<10	14	4	<10	<10	<10
Benz(a)anthracene	12	5	<10 - 160	69	56	11	6	<10 - 25	<10	<10					
Benzo(a)pyrene	12	1	<10	<10	<10	11	2	<10	<10	<10			<10	<10	<10
Benzo(b)fluoranthene	12	1	35	35	35	11	1	<10	<10	<10	14	4	<10	<10	<10
Benzo(ghi)perylene						11	0				14	1	<10	<10	<10
Benzo(k)fluoranthene	12	1	35	35	35	11	1	<10	<10	<10	14	1	<10	<10	<10
Chrysene	12	5	<10 - 160	59	23	11	6	<10 - 25	<10	<10	14	1			
Dibenz(ah)anthracene						11	0								
Fluoranthene	12	6	<10 - 130	45	40	11	4	<10	<10	<10			<10	<10	<10
Fluorene	12	4	<10 - 300	90	30	11	6	<10 - 78	24	<10	14	1	<10	<10	<10
Indeno(1,2,3-cd)pyrene						11	0				14	1			
Naphthalene	12	6	<10 - 25	<10	<10	11	4	<10 - 35	<10	<10			<10	<10	<10
Phenanthrene	12	11	<10 - 1,400	340	64	11	6	<10 - 71	18	<10	14	6	<10	<10	<10
Pyrene	12	4	<10 - 50	21	16	11	4	<10	<10	<10	14	4			
Halogenated aliphatics															
1,1-Dichloroethane	7	1	18	18	18	3	0								
1,1-Dichloroethylene						9	3	<10 240	85	15					
1,2-*Trans*-dichloroethylene						9	4	<10 - 82	25	<10					
Methylene chloride	1	1		<10	<10						1	1		<10	<10
Tetrachloroethylene	1	1		<10	10						1	1		<10	<10
1,1,1-Trichloroethane	8	6	<10	<10	<10	11	6	<10 - 1,300	260						
Trichloroethylene	8	6	<10	<10	<10	11	5	<10 - 1,300	310	<10	1	1			
Pesticides and metabolites															
Isophorone	12	3	600	600	600	11	3	<10 - 93	35	<10				<10	<10

Note: Blanks indicate no data available.

TABLE 8.3-5. CONVENTIONAL AND NONTOXIC INORGANIC POLLUTANT CONCENTRATIONS IN THE RAW WASTEWATER FOR CLEANING OPERATIONS IN THE COIL COATING INDUSTRY, BY SUBCATEGORY [1]

Pollutant	Number of points	Number detected	Concentration, mg/L[a] Range	Mean	Median
			steel		
Conventional					
TSS	9	9	52 - 440	220	260
TDS	4	4	1,100 - 17,000	9,200	9,300
Total phosphorus	7	7	11 - 78	46	42
Total phenols	8	5	0.019 - 0.27	0.11	0.020
Oil and grease	9	9	9.8 - 1,700	520	260
Minimum pH	9	9	6.8 - 10.9	8.7	8.5
Maximum pH	9	9	7.4 - 11.9	10.0	10.6
Fluorides	9	9	0.18 - 3.4	1.3	0.98
Nontoxic inorganic					
Aluminum	9	7	0.27 - 0.85	0.45	0.34
Iron	9	9	0.93 - 80	25	5.2
Manganese	9	9	0.26 - 1.7	0.80	0.63
			galvanized		
Conventional					
TSS	10	10	19 - 630	250	160
TDS	1	1	200	200	200
Total phosphorus	9	9	9.4 - 56	33	33
Total phenols	9	7	0.010 - 0.079	0.037	0.021
Oil and grease	10	10	10 - 970	260	110
Minimum pH	10	10	2.2 - 9.4	6.4	7.6
Maximum pH	10	10	7.4 - 11.9	10.2	10.6
Fluorides	10	10	0.16 - 16	2.5	1.1
Nontoxic inorganic					
Aluminum	10	9	0.41 - 4.9	2.4	1.3
Iron	10	10	0.19 - 18	4.8	1.0
Manganese	10	9	0.012 - 0.73	0.19	0.16
			aluminum		
Conventional					
TSS	12	12	6 - 970	180	49
Total phosphorus	9	6	0.69 - 100	63	90
Total phenols	12	11	0.010 - 0.16	0.047	0.020
Oil and grease	12	9	1.0 - 2,800	530	75
Minimum pH	12	12	7.1 - 11.0	9.4	10.0
Maximum pH	12	12	8.4 - 11.9	10.6	11.2
Fluorides	12	9	0.43 - 9.5	2.0	0.8
Nontoxic inorganic					
Aluminum	12	12	8.6 - 940	400	250
Iron	12	12	0.077 - 0.69	0.35	0.28
Manganese	12	9	0.021 - 15	5.0	1.3

Note: Blanks indicate no data available.

[a]Except pH, which is given in pH units.

TABLE 8.3-6. CONCENTRATONS OF TOXIC POLLUTANTS FOUND IN THE RAW WASTEWATER FOR CLEANING OPERATIONS IN THE COIL COATING INDUSTRY, BY SUBCATEGORY [1]

	steel					galvanized					aluminum				
Toxic pollutants	Number of points	Number detected	Concentration, µg/L Range	Mean	Median	Number of points	Number detected	Concentration, µg/L Range	Mean	Median	Number of points	Number detected	Concentration, µg/L Range	Mean	Median
Metals and inorganics															
Cadmium	9	2	3 - 6	4	4	10	2	6 - 120	45	40	12	3	3 - 21	9	3
Chromium	9	8	28 - 620	240	180	10	9	59 - 610	310	270	12	9	28 - 6,000	1,300	180
Copper	9	9	21 - 180	70	59	10	9	9 - 57	30	20	12	9	9 - 210	84	75
Cyanide	8	5	9 - 120	44	24	10	4	12 - 43	22	17	12	9	5 - 260	40	10
Lead	9	3	180 - 1,100	540	460	10	9	180 - 2,600	1,600	2,000	12	5	60 - 220	140	170
Nickel	9	5	3 - 210	69	39	10	1	150	150	150					
Zinc	9	9	220 - 42,000	10,000	3,200	10	10	690 - 120,000	63,000	85,000	12	10	13 - 14,000	1,600	210
Phthalates															
Bis(2-ethylhexyl) phthalate	9	7	5 - 150	45	20	10	9	14 - 340	120	74	12	10	1 - 450	130	15
Butyl benzyl phthalate	9	1	360	360	360	10	1	13	13	13	12	2	5 - 12	8	8
Di-n-butyl phthalate	9	5	5 - 30	12	5	10	7	2 - 170	44	25					
Diethyl phthalate	9	6	5 - 210	72	32	10	8	5 - 420	140	86	12	7	20 - 450	170	80
Dimethyl phthalate											12	2	2 - 5	3	3
Di-n-octyl phthalate	9	3	5	5	5	10	1	5	5	5					
Polycyclic aromatic hydrocarbons															
Acenaphthylene	9	1	5	5	5										
Anthracene	9	7	2 - 280	69	10	10	3	10 - 250	93	20	12	2	5	5	5
Benz(a)anthracene	9	2	1 - 30	16	16	10	4	5 - 27	15	14					
Benzo(a)pyrene											12	3	1 - 2	2	2
Chrysene	9	2	1 - 30	16	16	10	4	5 - 27	15	14					
Fluoranthene	9	1	68	68	68	10	3	5	5	5					
Fluorene	9	1	1	1	1	10	4	5 - 85	35	26	12	1	5	5	5
Naphthalene	9	2	5 - 20	12	12	10	2	5 - 38	21	21	12	3	2 - 5	3	2
Phenanthrene	9	7	2 - 280	69	10	10	3	10 - 47	26	20	12	2	5	5	5
Pyrene						10	3	5	5	5					
Halogenated aliphatics															
1,1,1-Trichloroethane	6	5	2 - 4	3	2	10	4	1 - 6	4	4					
Trichloroethylene	6	4	1 - 22	7	3	10	2	1 - 2	1	1					
Pesticides and metabolites															
Isophorone	9	1	18	18	18	10	1	47	47	47					

Note: Blanks indicate no data available.

TABLE 8.3-7. CONVENTIONAL AND NONTOXIC INORGANIC POLLUTANT CONCENTRATIONS IN THE RAW WASTEWATER FOR THE CONVERSION COATING OPERATION IN THE COIL COATING INDUSTRY, BY SUBCATEGORY [1]

Pollutant	Number of points	Number detected	Concentration, mg/l[a] Range	Mean	Median
			steel		
Conventional					
TSS	8	8	27 - 250	130	130
TDS	3	3	3,300 - 3,500	3,400	3,400
Total phosphorus	6	6	9.7 - 71	41	43
Total phenols	7	4	0.001 - 0.23	0.067	0.018
Oil and grease	7	6	2 - 18	7.6	6.6
Minimum pH	8	8	3.3 - 11.4	5.8	4.3
Maximum pH	8	8	5.1 - 11.5	7.7	7.5
Fluorides	8	8	1.1 - 74	31	27
Nontoxic inorganic					
Aluminum	8	5	0.20 - 10.6	3.0	1.2
Iron	8	8	3.3 - 77	19	9.2
Manganese	8	8	0.11 - 1.5	0.61	0.49
			galvanized		
Conventional					
TSS	10	10	68 - 450	250	190
TDS	1	1	2,500	2,500	2,500
Total phosphorus	7	7	3.8 - 66	33	25
Total phenols	10	7	0.005 - 0.067	0.021	0.020
Oil and grease	10		1.3 - 110	19	11
Minimum pH	10	10	2.4 - 11.1	4.5	3.4
Maximum pH	10	10	3.3 - 12.0	8.2	8.6
Fluorides	10	10	1.5 - 71	16	11
Nontoxic inorganic					
Aluminum	10	9	1.3 - 10.6	3.6	2.3
Iron	10	10	0.84 - 21	6.6	5.1
Manganese	10	10	0.035 - 1.3	0.25	0.12
			aluminum		
Conventional					
TSS	12	12	4.2 - 1,200	160	55
Total phosphorus	2	2	13 - 16	15	15
Total phenols	12	8	0.004 - 0.14	0.029	0.011
Oil and grease	12	9	0.20 - 60	9.4	2.0
Minimum pH	12	12	1.6 - 5.4	3.0	2.5
Maximum pH	12	12	3.7 - 6.7	5.2	5.1
Fluorides	12	12	18 - 510	210	31
Nontoxic inorganic					
Aluminum	12	12	11 - 410	160	110
Iron	12	12	0.83 - 87	21	7.8
Manganese	12	12	0.049 - 12	1.4	0.34

Note: Blanks indicate no data available.

[a]Except pH, which is given in pH units.

TABLE 8.3-8. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE RAW WASTEWATER OF CONVERSION COATING OPERATIONS IN THE COIL COATING INDUSTRY, BY SUBCATEGORY [1]

Toxic pollutant	Number of points	Number detected	Concentration, µg/L Range	Mean	Median	Number of points	Number detected	Concentration, µg/L Range	Mean	Median	Number of points	Number detected	Concentration, µg/L Range	Mean	Median
	steel					galvanized					aluminum				
Metals and inorganics															
Cadmium	8	3	1 - 73	27	6	10	5	8 - 110	42	10	12	3	3 - 19	10	8
Chromium	8	8	280 - 920,000	320,000	71,000	10	10	3,400 - 790,000	290,000	120,000	12	12	15,000 - 970,000	270,000	120,000
Copper	8	6	29 - 160	54	32	10	8	4 - 140	31	18	12	10	11 - 980	190	52
Cyanide	7	1	92	92	92	10	5	120 - 470	290	200	12	9	17 - 7,500	3,200	2,600
Lead	8	3	10 - 3,600	1,400	480	10	10	5 - 1,300	560	500	12	2	170 - 400	290	290
Nickel	8	4	120 - 19,000	3,100	6,800	10	6	33 - 31,000	7,600	4,400	12	4	18 - 260	120	110
Zinc	8	8	530 - 140,000	54,000	51,000	10	10	33,000 - 710,000	220,000	75,000	12	12	16 - 43,000	8,800	540
Phthalates															
Bis(2-ethylhexyl) phthalate	7	5	5 - 110	31	14	10	9	10 - 1,200	240	43	12	9	2 - 300	52	20
Butyl benzyl phthalate						10	3	5	5	5					
Di-n-butyl phthalate	7	3	4 - 14	8	5	10	3	5 - 20	10	5	12	2	5	5	5
Diethyl phthalate	7	6	10 - 180	120	130	10	9	15 - 300	86	51	12	9	2 - 200	76	50
Dimethyl phthalate											12	1	110	110	110
Di-n-octyl phthalate	7	1	760	760	760						12	1	2	2	2
Polycyclic aromatic hydrocarbons															
Acenaphthylene	7	1	5	5	5	10	1	3	3	3					
Anthracene	7	3	5	5	5	10	3	5 - 290	99	5					
Benz(a)anthracene						10	1	5	5	5	12	4	2 - 5	4	4
Benzo(a)pyrene											12	2	2 - 3	2	2
Chrysene						10	1	5	5	5					
Fluoranthene	7	1	5	5	5	10	1	23	23	23					
Fluorene	7	2	5	5	5	10	1	5	5	5					
Naphthalene	7	4	5	5	5	10	5	5 - 15	7	5	12	3	2 - 5	4	5
Phenanthrene	7	3	5	5	5	10	3	5 - 290	99	5	12	4	2 - 5	4	4
Pyrene						10	1	11	11	11					
Halogenated aliphatics															
1,1-Dichloroethane	7	1	77	77	77	10	4	16 - 140	52	52					
1,1-Dichloroethylene						10	1	2	2	2					
1,2-*Trans*-dichloroethylene						10	2	1 - 15	8	8					
1,1,1-Trichloroethane	8	3	0.1 - 43	15	1										
Trichloroethylene	8	3	1 - 88	35	14	10	2	29 - 110	71	71					
Pesticides and metabolites															
Isophorone						10	1	516	516	516					

Note: Blanks indicate no data available.

TABLE 8.3-9. CONVENTIONAL AND NONTOXIC INORGANIC POLLUTANT CONCENTRATIONS IN THE RAW WASTEWATER FOR PAINTING OPERATIONS FOR THE COIL COATING INDUSTRY [1]

	Total industry				
	Number	Number	Concentration, mg/L[a]		
Pollutant	of points	detected	Range	Mean	Median
Conventional					
TSS	20	18	0.010 - 24	6.9	5.0
TDS	3	3	99 - 1,100	440	130
Total phosphorus	18	11	0.25 - 15	3.2	0.78
Total phenols	20	15	0.003 - 0.040	0.016	0.015
Oil and grease	20	15	1.0 - 26	7.1	5.0
Minimum pH	20	20	4.9 - 8.0	6.8	6.8
Maximum pH	20	20	7.2 - 9.0	7.9	7.7
Fluorides	20	20	0.15 - 11	1.6	0.85
Nontoxic inorganic					
Aluminum	20	8	0.46 - 1.4	0.96	1.0
Iron	20	20	0.018 - 1.6	0.37	0.14
Manganese	20	15	0.002 - 0.78	0.18	0.021

[a]Except pH, which is given in pH units.

TABLE 8.3-10. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE RAW WASTEWATER FOR PAINTING OPERATIONS IN THE COIL COATING INDUSTRY [1]

Toxic pollutant	Total industry				
	Number of points	Number detected	Concentration, µg/L		
			Range	Mean	Median
Metals and inorganics					
Cadmium	20	37	8 - 270	97	14
Chromium	20	15	4 - 440	57	13
Copper	20	7	4 - 17	8	6
Cyanide	20	17	5 - 200	39	21
Lead	20	2	32 - 64	48	48
Nickel	20	11	190	190	190
Zinc	20	20	14 - 5,000	610	150
Phthalates					
Bis(2-ethylhexyl) phthalate	18	14	3 - 880	94	17
Butyl benzyl phthalate	18	2	5 - 15	10	10
Di-n-butyl phthalate	18	16	2 - 20	6	5
Diethyl phthalate	18	15	10 - 330	78	50
Dimethyl phthalate	18	2	2 - 4	3	3
Di-n-octyl phthalate	18	1	5	5	5
Polycyclic aromatic hydrocarbons					
Anthracene	16	2	5	5	5
Benzo(a)pyrene	18	1	5	5	5
Benzo(b)fluoranthene	18	1	5	5	5
Benzo(ghi)perylene	18	1	5	5	5
Benzo(k)fluoranthene	18	1	5	5	5
Fluoranthene	18	1	5	5	5
Naphthalene	18	3	2 - 5	4	5
Phenanthrene	18	2	5	5	5
Halogenated aliphatics					
1,1-Dichloroethylene	6	1	36	36	36
1,2-*Trans*-dichloroethylene	6	1	43	43	43
1,1,1-Trichloroethane	9	4	1 - 3,100	900	250
Trichloroethylene	9	5	0.1 - 3,100	730	5

Note: Blanks indicate no data available.

TABLE 8.3-11. WASTEWATER FLOW FOR THE COIL COATING INDUSTRY [1]

Operation	Number of points	m^3/day Range	Mean	Median
		steel		
Cleaning	9	7.7 - 650	170	130
Conversion coating	8	14 - 75	38	44
All operations	13	9 - 890	440	500
		galvanized		
Cleaning	10	15 - 330	105	98
Conversion coating	10	1.8 - 75	36	45
		aluminum		
Cleaning	12	11 - 160	83	85
Conversion coating	12	15 - 60	39	45
		total industry		
Painting	20	36 - 1,100	320	250

Wastewaters from the coil coating on steel subcategory generally have higher levels of phosphorus than that from the other subcategories because of the use of concentrated phosphate alkaline cleaners. Oil and grease in this subcategory are also found in larger concentrations than the other basis materials wastewater because of the increased raw material protection needed to inhibit rust. This can often cause an increase in the number of hydrocarbons found in this wastewater. Suspended solids may be greater because of the adhering dirts in the oil.

Coil coating on galvanized steel generally produces significant suspended solids concentrations in wastewater. Another pollutant problem is the high concentration of dissolved zinc and iron in the wastewater as a result of the dissolved metals from the cleaning operation. Significant concentrations of hexavalent chromium are generally expected in all three subcategory wastewaters.

Wastewaters from the coil coating on aluminum subcategory contain higher levels of cyanide and fluorides than the other subcategories as a result of chromating solutions containing cyanide ions and hydrofluoric acid. Aluminum wastewater is also more acidic and contains more dissolved aluminum. This is due to the acidic nature of the chromating solutions that dissolve more aluminum than the phosphating solutions.

Painting wastewater generally consists of quench water. Wastewater from this operation is generally less toxic than wastewater from the other general operations; normally only the following pollutants are expected to exceed 0.010 mg/L: oil and grease, fluorides, TSS, iron, zinc, bis(2-ethylhexyl) phthalate, and diethyl phthalate.

II.8.3.3 Plant Specific Information

A limited amount of individual plant specific data for the coil coating industry is available. Data available in the reference documents on the influent and effluent streams from the sedimentation treatment system for the plants discussed in the following subsections are summarized in Table 8.3-12. These data are assumed to be screening data because of the lack of definition in the reference document. All three subcategories are represented by these facilities.

II.8.3.3.1 Plant 11055

This site uses the chromating and phosphating processes to coat cold rolled steel, galvanized steel, and aluminum. The data presented is the analysis of the clarifier influent and effluent at the site.

II.8.3.3.2 Plant 15436

This facility coats only aluminum basis material by a chromating process. Approximately 1.6×10^7 m^2 of aluminum material is cleaned and coated and 2.6×10^7 m^2 is painted. The plant uses water at 0.48 L/m^2 of product. Treatment consists of clarification followed by discharge to surface waters.

II.8.3.3.3 Plant 36058

This plant produces coil-coated metal from all three subcategories. Chromating and phosphating processes are used to clean and coat 2.0×10^4 m^2 of aluminum, 4.7×10^6 m^2 of galvanized steel, and 1.9×10^7 m^2 of steel. Water usage at the site is approximately 19.5 L/m^2 for each subcategory. Treatment consists of clarification, chemical reduction, pH adjustment, and skimming prior to surface discharge, although the treatment sequence is not indicated.

II.8.3.3.4 Plant 01057

This aluminum coil coating facility uses a chromating process. Treatment consists of lagooning and sedimentation.

TABLE 8.3-12. PLANT SPECIFIC INFORMATION ON COIL COATING PLANTS USING SEDIMENTATION [1]

Parameter	Concentration: Raw	Concentration: Treated	Percent removal
	Plant 11055		
Oil and grease, mg/L	210	6.4	97
TSS, mg/L	1,100	31	97
Aluminum, µg/L	1,900	ND	>99
Chromium, total, µg/L	35,000	180	>99
Copper, µg/L	6	15	-[a]
Iron, µg/L	15,000	ND	>99
Lead, µg/L	1,500	110	93
Nickel, µg/L	150	120	20
Zinc, µg/L	340,000	500	>99
	Plant 15436		
Oil and grease, mg/L	170	2.000	99
TSS, mg/L	710	52	93
Aluminum, µg/L	130,000	11,000	92
Chromium, total µg/L	50,000	2,800	94
Copper, µg/L	14	17	-[a]
Iron, µg/L	5,000	900	82
Lead, µg/L	150	40	73
Nickel, µg/L	ND	ND	
Zinc, µg/L	120	210	-[a]
	Plant 36058		
Oil and grease, mg/L	710	ND	>99
TSS, mg/L	250	120	52
Aluminum, µg/L	71,000	130	82
Chromium, total, µg/L	95	120	-[a]
Copper, µg/L	110	15	77
Iron, µg/L	14,000	2,400	83
Lead, µg/L	130	ND	>99
Nickel, µg/L	ND	ND	
Zinc, µg/L	7,600	720	96
	Plant 01057		
Oil and grease, mg/L	3.8	3.6	5
TSS, mg/L	7.1	2.7	62
Aluminum, µg/L	4,300	3,300	23
Chromium, total, µg/L	1,800	3	>99
Copper, µg/L	ND	ND	
Iron, µg/L	250	130	48
Lead, µg/L	ND	ND	
Nickel, µg/L	ND	ND	
Zinc, µg/L	210	34	84

Note: ND means not detected.
[a]Negative removal.

II.8.3.4 Pollutant Removability [1]

This section describes the treatment techniques currently in use to recover or remove wastewater pollutants normally found at coil coating facilities. The treatment processes can be divided into six categories: recovery techniques, oil removal, dissolved inorganics removal, cyanide destruction, trace organics removal, and solids removal.

Recovery of process chemicals in coil coating plants is applicable to chromating baths and sealing rinses. Recovery techniques currently in use include ion exchange and election-chemical chromium regeneration.

Other possible recovery processes that are not currently in use include evaporation and insoluble starch xanthate. Ion exchange columns are used at four facilities within the coil coating industry. The wastewater stream is filtered to remove solids and then flows through a column of ion exchange resin which retains copper, iron, and trivalent chromium. The stream then passes through an anion exchanger which retains hexavalent chromium. Several columns may be necessary to achieve the desired levels. By regenerating the exchange resin the life expectancy of the column is extended. In some regeneration procedures, hexavalent chromium is removed by conversion to sodium dichromate with sodium hydroxide. The sodium dichromate is then passed through a cation exchanger which converts it to chromic acid for reuse. The cation exchanger can be regenerated with sulfuric acid.

Electrochemical chromium regeneration oxidizes trivalent chromium to hexavalent chromium by electro oxidation. This system can be used with the wastewater or the drag-out sludge from a settling basin. One coil coating operation presently uses this technique for chromic acid regeneration. This system offers relatively low energy consumption, operation at normal bath temperatures, elimination of metallic sludges, and regeneration of chromic acid.

Oils occuring in wastewaters from the coil coating industry generally come from cutting fluids, lubricants, and preservative coatings used in metal fabrication operations. Oil skimming is the only current method used in this industry to remove this oil. Oil flotation has been suggested for this industry to achieve low oil concentrations or to remove emulsified oils but is not in current practice.

Oil skimming as a pretreatment method is effective in removing naturally floating waste material. It can also improve the performance of subsequent downstream treatments. Many coil coating plants employ this treatment process.

The dissolved inorganic pollutants for the coil coating category are hexavalent chromium, chromium (total), copper, lead, nickel, zinc, cadmium, iron, and phosphorus. Removal of these inorganics is often a major step toward detoxifying wastewater. Chromium reduction, which can be carried out chemically or electrochemically, is frequently a preliminary step. The next major step in the classic treatment system is chemical precipitation, which is often accomplished by the addition of lime, sodium sulfide, sodium hydroxide, sodium carbonate, or ammonia. These additives result in the precipitation of metal hydroxides.

Cyanide destruction in coil coating facilities is necessary to reduce the cyanide concentration in wastewater from the plating and cleaning baths. Cyanide is generally destroyed by oxidation. Alkaline chlorination is the standard technique used in the coil coating industry, but oxidation by ozone, hydrogen peroxide, or electrochemically have been suggested for use. These alternate techniques, however, have not been demonstrated at this time.

Plant sampling data show that organic compounds tend to be removed in standard wastewater treatment equipment. Oil separation not only removes oil but also removes organics that are more soluble in the oil than in water. Clarification also removes organic solids by adsorption on inorganic solids. Carbon adsorption to remove organics has been demonstrated in the electroplating industry but is not presently used in the coil coating industry.

Sedimentation by means of clarification is the most common technique used for the removal of precipitates. The major advantage of sedimentation is the simplicity of the process. Sedimentation is used in 55 coil coating plants in various forms, including ponds, lagoons, slant tube clarifiers, and Lamella clarifiers.

Granular bed filters are used in 10 coil coating plants to remove residual solids from the clarifier effluent. Chemicals may be added upstream to enhance the solids removal. Pressure filtration is also used in this industry to reduce the solids concentration in clarifier effluent and to remove excess water from the clarifier sludge. Other sludge dewatering technologies used include vacuum filtration, centrifugation, and sludge bed drying.

Table 8.3-12, presented in section II.8.3.3 of this report, gives the available pollutant removability data.

II.8.3.5 References

1. Development Document for Effluent Limitations Guidelines and Standards for the Coil Coating Point Source Category. EPA 440/1-79/071a, U.S. Environmental Protection Agency, Effluent Guidelines Division, Washington, DC, August 1979.

2. NRDC Consent Decree Industry Summary - Coil Coating Industry.

II.8.6 FOUNDRIES

II.8.6.1 Industry Description

II.8.6.1.1 General Description [1]

The foundry industry comprises facilities that pour or inject molten metal into a mold to produce intricate metal shapes that cannot be readily formed by other methods.

The foundry industry in the United States employs over 400,000 workers in 4,400 foundries that produce over 17,230 Mg (19 million tons) of product annually. This production includes cast pieces made of iron, steel, aluminum, brass, and copper, as well as other metals. Included in this industry are Standard Industrial Classification (SIC) Codes 3321, 3322, 3324, 3325, 3361, 3362, and 3369.

The basic foundry process is essentially the same regardless of the method of melting, molding, or finishing. A raw material charge is melted in a furnace, from which the molten metal is withdrawn as needed. The mold for the product is a sand cast or a set of metal die blocks which are locked together to make a complete cavity. The molten metal is ladled into the mold, and then the mold is cooled until the metal solidifies into the desired shape. The rough product is further processed by removing excess metal, quenching, cleaning and chemical treatment.

Table 8.6-1 presents industry summary data for the foundry industry including the number of subcategories and the number and type of wastewater dischargers.

TABLE 8.6-1. INDUSTRY SUMMARY [2]

Industry: Foundries
Total number of subcategories: 9
Number of subcategories studied: 6
Number of dischargers in industry:

- Direct: 1,050
- Indirect: 498
- Zero: 450

No BPT limitations are currently listed for this industry by the EPA in the available references.

II.8.6.1.2 Subcategory Description [1]

The foundry industry includes a number of foundry types as well as processes within these foundry types. Plants are capable of casting one or more metals on a site and each site may utilize one or more processes that can generate wastewater.

The following subcategories have been selected to describe the foundry industry based on the type of metal cast, the type of process, plant size, geographical location, age, wastewater characteristics and treatability, process water usage, and method of effluent disposal.

(1) Iron and steel foundries

(2) Aluminum casting

(3) Zinc casting

(4) Copper casting

(5) Magnesium casting

(6) Lead casting

(7) Tin casting

(8) Titanium casting

(9) Nickel casting

Iron and Steel Foundries. Iron is the world's most widely used metal. When alloyed with carbon, it has a wide range of useful engineering properties. Four general classes of iron are produced in foundries: gray, ductile, malleable, and steel. The same general processes are used with all four classes of metal in the production of products ranging from cooking utensils and pipe fittings to steel railroad car wheels.

Aluminum Casting. Aluminum is a light metal with good tensile strength. It is easily cast, extruded, or pressed, and it weighs half as much as a similar product made from steel. Establishments that are engaged in producing castings and die castings of aluminum and its alloys produce household and hospital utensils, and machinery castings.

Zinc Casting. Zinc, with a lower melting point than most metals, is generally die cast, making its process different from other foundry subcategories. Because it is not as strong as most metals, it is usually alloyed with metals such as copper, aluminum, or magnesium. Common products from this subcategory are zinc castings.

Copper Casting. Copper is second only to aluminum in importance among the nonferrous metals. It is often alloyed with tin, lead, and zinc to produce brass and bronze. Copper castings are produced by several methods which include centrifugal molds, green sand molds, and die casting. Products include bushings and bearings, propellers, and other cast products.

Magnesium Casting. Most magnesium is generally cast in sand molds. This is to prevent metal-mold reactions, which may occur because of the reactive nature of molten magnesium. Inhibitors such as sulfur, boric acid, or ammonium fluorosilicate are often mixed with the sand to prevent these reactions.

Lead Casting. Lead foundries produce lead castings such as lead wheel balancing weights and sash balances, as well as white metal castings.

Other Subcategories. The remaining three subcategories, Tin Casting, Titanium Casting, and Nickel Casting, have been recommended for Paragraph 8 exclusion under the NRDC Consent Decree. This recommendation is based on the low number of plants and low production by these subcategories.

II.8.6.1.3 Subcategory Operations

Several of the above subcategories may be divided into separate operation types. These operations are presented below with a brief description of each.

Aluminum Casting. The aluminum foundry industry can be subdivided into five operations which represent different processes within the foundry. These include investment casting, melting furnace scrubbers, casting quench operations, die casting operations, and die lube operations. Investment (also known as precision or lost wax) casting operations use molds that are produced by surrounding an expendable pattern with a ceramic slurry that hardens at room temperature. The pattern, normally a wax, is then melted or burned out of the hard mold. These molds provide very close tolerances. After the molten metal is poured into the mold and solidifies, the mold is broken away. Thus, a new mold is needed for each casting. Process wastewaters include those resulting from mold backup, hydroblast (of castings), and dust collection (used in conjunction with hydroblasting and the handling of the investment material and castings).

A second operation inherent to the aluminum foundry industry involves the use of wet scrubbers to remove noxious materials from melting furnace gases. The wastewater sources resulting from this process are either the discharges from wastewater scrubber equipment packages or the discharge from treatment systems separate from the scrubber system.

The third operation type, cast quenching, is practiced more frequently in nonferrous than in ferrous foundries. Ordinarily, it is used to promote the rapid cooling and solidification of casting material or to produce certain metal grain structures that are obtainable only through sudden thermal changes. In these cases, the casting is quenched in a water bath which may be plain water or may contain an additive to promote some special condition. The only wastewaters considered in association with this operation are those which are discharged from the casting quench tanks.

Theoretically, the fourth operation type, die casting, does not produce a process wastewater. However, in most die casting operations major sources of wastewater include contact mold cooling water, die surface cooling sprays, casting machine hydraulic systems using water, and leakage from various noncontact cooling systems which are subsequently contaminated by dirt, oil, and grease.

Die lube operations involve the application of lubricants to die casting molds to prevent the casting from sticking to the die. The lubricants used are dependent on the temperature of the metal, the operating temperature of the die, and the alloy to be cast. The lubricants, generally organic compounds, may enter the waste stream through leaks in mold machinery.

Copper and Copper Alloy Casting. The copper and copper alloy foundry industry can be subdivided into three operation types which represent various processes within the plant: dust collection, mold cooling and casting quench, and continuous casting. Mold cooling is commonly used in casting operations which employ permanent molds. In such an operation, it is often necessary to force cool the mold with water which subsequently becomes contaminated with materials picked up from the mold surface.

Continuous casting is used in operations where a slab or billet is "worked" to produce a final product. Such slabs are continuously cast by pouring molten metal into a water-cooled mold at a controlled rate and withdrawing a solid piece from the bottom of the mold. This piece is then cut into lengths for further processing. Wastewaters result from the cooling of the molds and castings used in and produced from continuous casting equipment.

Dust collection and casting quench operations are similar to those used in aluminum foundries.

Ferrous Foundries. Ferrous (iron and steel) foundries have five operations that can produce wastewater in some form. These include dust collection, melting furnace scrubber, slag quenching, casting quench and mold cooling, and sand washing operations. Slag quenching is commonly used to rapidly cool and fragmentize slag (a mixture of nonmetallic fluxes introduced with the "charge" to remove impurities from the molten metal) to an easily handled bulk material. The quench water is a waste product that must be handled.

The reclamation and reuse of sand is a major operation in foundries which use sand as a molding media. In this operation, water is used to "wash" impurities, primarily "spent" binders and sand, from the casting sand prior to its reuse in the molding operations. The sand and binders become "spent" as a result of the heat present in the casting process. Additionally, sand can be "washed" using a number of dry and thermal methods. These latter methods have the advantage of not producing a wastewater stream.

Dust collection, melting furnace scrubber, casting quench and mold cooling operations are similar to those described for aluminum and copper/copper alloy foundries.

Magnesium Casting. Magnesium foundries generate wastewater in grinding scrubber and dust collection operations. Because of the violent reaction of fine magnesium particles with air, wet scrubbers are used to control the dust from the grinding operations.

Zinc Casting. Zinc foundry operations include casting quench operations and melting furnace scrubber operations similar to those described above.

II.8.6.1.4 Wastewater Flow Characterization [1]

Table 8.6-2 presents wastewater flow characterization for the foundry industry by subcategory. Also presented in this table is the degree of process water recycle, and the number of plants surveyed with central wastewater treatment facilities for all of the processes at that plant. The discharge flow represents all processes within the subcategory.

II.8.6.2 Wastewater Characterization [1]

Each type of operation in the foundry industry can produce different types of pollutants in the wastewater stream. Also because each subcategory operation often involves different processes, subcategory pollutant concentrations may vary. The character of wastewater for each subcategory is given in Tables 8.6-3 through 8.6-12. Operations within each subcategory have been combined to give an overall view of the subcategory. More detailed information on each operation is provided in the section of this report dealing with each specific plant.

TABLE 8.6-2. WASTEWATER FLOW CHARACTERIZATION BY SUBCATEGORY [1]

Subcategory	Respondents, no. of plants	Discharge flow, m³/d			Amount of recycle, %	Central treatment facilities, no. of plants	Operation treatment facility, no. of plants
		Range	Average	Median			
Iron and steel foundries	283				0 - 100	82	178
Aluminum casting	30	0.15 - 2.0 x 10^3	170	7.3	0 - 100	7	18
Zinc casting	14	10.3 - 280	99	11.4	0 - 100	6	8
Copper casting	21	1.2 - 6.7 x 10^3	1,800	420	0 - 100	7	14
Magnesium casting	2	0.01 - 3.2	1.6	1.6	0 - 100	0	2
Lead casting	0						

Note: Blanks indicate no information currently available.

TABLE 8.6-3. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR THE IRON AND STEEL FOUNDRIES [1]

Pollutant	Number of times		Concentration, mg/L[a]		
	Sampled	Detected	Maximum	Average	Median
TSS	23	23	8,900	2,700	1,100
Total phenols	20	19	31	2.9	0.59
Sulfides	9	9	10	2.1	1.0
Oil and grease	18	16	200	29	10
pH	21	21	11	7.7	7.5

[a]Except pH values, which are given in pH units.

TABLE 8.6-4. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR ALUMINUM CASTING [1]

Pollutant	Number of times		Concentration, mg/L[a]		
	Sampled	Detected	Maximum	Average	Median
TSS	8	8	1,700	540	100
Total phenols	4	4	66	17	0.07
Oil and grease	8	8	8,500	1,200	20
pH	8	8	8.6	7.3	7.2

[a]Except pH values, which are given in pH units.

TABLE 8.6-5. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR ZINC CASTING [1]

Pollutant	Number of times		Concentration, mg/L[a]		
	Sampled	Detected	Maximum	Average	Median
TSS	3	3	3,800	1,300	92
Total phenols	3	3	1.4	0.52	0.11
Oil and grease	3	3	17,000	5,700	70
pH	3	3	7.4	6.8	7.4

[a]Except pH values, which are given in pH units.

TABLE 8.6-6. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR COPPER CASTING [1]

Pollutant	Number of times		Concentration, mg/L[a]		
	Sampled	Detected	Maximum	Average	Median
TSS	2	2	610	230	230
Oil and grease	3	2	38	23	30
pH	3	3	8.3	7.7	7.8

[a]Except pH values, which are given in pH units.

TABLE 8.6-7. WASTEWATER CHARACTERIZATION OF CONVENTIONAL POLLUTANTS FOR MAGNESIUM CASTING [1]

Pollutant	Number of times		Concentration, mg/L[a]		
	Sampled	Detected	Maximum	Average	Median
TSS	1	1			8.3
Total phenols	1	1			1.1
Oil and grease	1	1			6
pH	2	2	9.8	8.7	8.7

[a]Except pH values, which are given in pH units.

TABLE 8.6-8. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOUND IN IRON AND STEEL FOUNDRIES [1]

Toxic pollutant	Number of times Sampled	Number of times Detected	Range, µg/L	Median, µg/L
Metals and inorganics				
Antimony	8	5	ND - 900	50
Arsenic	8	4	ND - 160	2
Beryllium	16	9	ND - BDL	BDL
Cadmium	10	3	ND - 740	ND
Chromium	10	8	ND - 700	35
Copper	17	15	ND - 4,400	300
Cyanide	22	12	ND - 370	6
Lead	17	14	ND - 140,000	320
Mercury	21	13	ND - 3.6	0.1
Nickel	17	13	ND - 910	40
Selenium	10	1	ND - BDL	ND
Silver	4	2	ND - 30	ND[a]
Thallium	4	2	ND - BDL	ND[a]
Zinc	17	11	ND - 170,000	590
Ethers				
Bis(2-chloroethyl) ether	3	1	ND - BDL	ND
Bis(2-chloroethoxy)methane	3	2	ND - 20	BDL
Phthalates				
Bis(2-ethylhexyl) phthalate	10	7	ND - 1,200	5.5
Butyl benzyl phthalate	8	6	ND - 200	16
Di-n-butyl phthalate	10	6	ND - 200	6[a]
Diethyl phthalate	9	5	ND - 39	1
Dimethyl phthalate	9	4	ND - 2,200	ND
Di-n-octyl phthalate	2	2	BDL - 41	41[a]
Nitrogen compounds				
Benzidine	1	0		ND
N-nitrosodiphenylamine	6	5	ND - 1,400	12
N-nitroso-di-n-propylamine	1	1		BDL

(continued)

TABLE 8.6-8 (continued).

Toxic pollutant	Number of times Sampled	Number of times Detected	Range, µg/L	Median, µg/L
Phenols				
2-Chlorophenol	7	4	ND - 200	BDL
2,4-Dichlorophenol	7	5	ND - 2,200	20
2,4-Dimethylphenol	9	6	ND - 1,100	11
2-Nitrophenol	6	4	ND - 40	10[a]
4-Nitrophenol	4	3	ND - 40	13[a]
Pentachlorophenol	6	4	ND - 130	21[a]
Phenol	9	6	ND - 20,000	100
2,4,6-Trichlorophenol	7	3	ND - 80	ND
p-Chloro-*m*-cresol	6	4	ND 170	BDL
4,6-Dinitro-*o*-cresol	6	4	ND - 38	14[a]
Aromatics				
Benzene	10	5	ND - 100	ND[a]
Chlorobenzene	2	2	BDL	BDL
2,4-Dinitrotoluene	3	3	BDL - <50	<7
2,6-Dinitrotoluene	4	4	BDL - <50	<7[a]
Ethylbenzene	5	4	ND - BDL	BDL
Hexachlorobenzene	1	1		BDL
Nitrobenzene	2	2	<3 - <280	<140
Toluene	8	5	ND - 40	1[a]
1,2,4-Trichlorobenzene	3	2	ND - 7	BDL
Polycyclic aromatic hydrocarbons				
Acenaphthene	9	6	ND - 36	BDL
Acenaphthylene	9	6	ND - 40	BDL
Anthracene	9	7	ND - <410	<3
Benz(a)anthracene	7	5	ND - 21	9
Benzo(a)pyrene	4	4	BDL - <30	BDL
Benzo(b)fluoranthene	3	3	BDL - <36	6
Benzo(k)fluoranthene	2	2	BDL - 6	6[a]
Chrysene	9	4	ND - 21	ND
Fluoranthene	10	7	ND - <390	1[a]
Fluorene	8	6	ND - <620	44
Naphthalene	10	5	ND - 93	ND[a]
Phenanthrene	9	7	ND - <410	<3
Pyrene	10	6	ND - <1,100	6[a]

(continued)

TABLE 8.6-8 (continued).

Toxic pollutant	Number of times Sampled	Number of times Detected	Range, μg/L	Median, μg/L
Polychlorinated biphenyls and related compounds				
Aroclor 1016, 1232 1248, 1260	10	4	ND - 270	ND
Aroclor 1221, 1254, 1424	10	3	ND - 330	ND
Halogenated aliphatics				
Carbon tetrachloride	8	6	ND - 20	BDL
Cloroform	10	3	ND - 80	ND
Dichlorobromomethane	3	1	ND - 37	ND
1,2-Trans-dichloroethylene	1	1		<11
Methylene chloride	10	6	ND - 470	BDL
Tetrachloroethylene	10	4	ND - 370	ND
1,1,1-Trichloroethane	10	6	ND - 60	BDL
1,1,2-Trichloroethane	3	2	ND - 20	BDL
Trichloroethylene	7	3	ND - 180	ND
Pesticides and metabolites				
Aldrin	6	3	ND - BDL	ND[a]
α-BHC	7	0		ND
β-BHC	7	2	ND - 30	ND
δ-BHC	8	1	ND - 20	ND
γ-BHC	6	3	ND - 20	ND[a]
Chlordane	5	0		ND
4,4'-DDE	5	2	ND - 20	ND
4,4'-DDD	5	1	ND - BDL	ND
4,4'-DDT	9	3	ND - 20	ND
Dieldrin	7	6	ND - 20	BDL
α-Endosulfan	5	4	ND - BDL	BDL
β-Endosulfan	5	2	ND - BDL	ND
Endosulfan sulfate	4	2	ND - BDL	ND[a]
Endrin	5	4	ND - 9	BDL
Endrin aldehyde	5	2	ND - 20	ND
Heptachlor	7	2	ND - 20	ND
Heptachlor epoxide	6	0		ND
Isophorone	6	1	ND - BDL	ND

[a]Determination of median concentration involved averaging of given value and BDL.

TABLE 8.6-9. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOUND IN ALUMINUM CASTING FOUNDRIES [1]

Toxic pollutant	Number of times Sampled	Number of times Detected	Range, μg/L	Median, μg/L
Metals and inorganics				
Chromium	8	4	ND - <100	ND[a]
Copper	1	1		450
Cyanide	9	7	ND - 14	5
Lead	9	4	ND - 2,000	50
Mercury	9	5	ND - 0.9	BDL
Nickel	9	4	ND - 300	ND
Selenium	9	2	ND - <40	ND
Zinc	9	9	90 - 8,800	810
Ethers				
Bis(2-chloroethyl) ether	1	1		9
Phthalates				
Bis(2-ethylhexyl) phthalate	9	7	ND - 820,000	680
Butyl benzyl phthalate	3	3	BDL - 690	BDL
Di-n-butyl phthalate	9	9	BDL - 5,400	74
Diethyl phthalate	7	6	ND - 730	91
Dimethyl phthalate	4	3	ND - 35	29[a]
Di-n-octyl phthalate	3	3	BDL - 4	BDL
Nitrogen compounds				
N-nitroso-di-n-propylamine	2	2	34 - 210	120
Phenols				
2-Chlorophenol	3	3	BDL - 53	53
2,4-Dichlorophenol	7	7	BDL - 5,700	22
2,4-Dimethylphenol	7	7	BDL - 91	41
2-Nitrophenol	5	5	BDL - 330	29
Pentachlorophenol	3	3	BDL - 1,600	BDL
Phenol	6	5	ND - 26,000	570
2,4,6-Trichlorophenol	8	7	ND - 380	250
4,6-Dinitrophenol	4	2	ND - 140	ND[a]
p-Chloro-m-cresol	6	5	ND - 280	71
4,6-Dinitro-o-cresol	5	5	BDL - 70	61

(continued)

TABLE 8.6-9 (continued)

Toxic pollutant	Number of times Sampled	Number of times Detected	Range, µg/L	Median, µg/L
Aromatics				
Benzene	9	9	BDL - 84	BDL
Chlorobenzene	1	1		250
Ethylbenzene	4	3	ND - 78	BDL
Toluene	8	7	ND - 540	BDL
Polycyclic aromatic hydrocarbons				
Acenaphthene	5	3	ND - 200	BDL
Acenaphthylene	7	3	ND - 47	ND
Anthracene	4	4	BDL - <470	<10[a]
Benz(a)anthracene	3	2	ND - <13,000	<13,000
Benzo(a)pyrene	4	3	ND - 53	37[a]
Chrysene	4	3	ND - 43,000	6,900
Fluoranthene	7	6	ND - 320	2
Fluorene	7	5	ND - 800	BDL
Naphthalene	5	4	ND - 160	11
Phenanthrene	4	4	BDL - <470	<10[a]
Pyrene	7	7	BDL - 250	BDL
Polychlorinated biphenyls and related compounds				
Aroclor 1016, 1232, 1248, 1260	8	8	BDL - 830	12
Aroclor 1221, 1254, 1424	8	8	BDL - 1,400	5
Halogenated aliphatics				
Bromoform	1	1		BDL
Carbon tetrachloride	6	6	BDL - 480	BDL
Chlorodibromomethane	1	1		BDL
Chloroform	9	5	ND - 450	4
Dichlorobromomethane	6	4	ND - 2	BDL
1,1-Dichloroethane	1	1		55
1,2-Dichloroethane	3	3	BDL - 170	5

(continued)

TABLE 8.6-9 (continued)

Toxic pollutant	Number of times Sampled	Detected	Range, μg/L	Median, μg/L
Halogenated aliphatics (continued)				
1,2-*Trans*-dichloroethylene	2	0		ND
Methylene chloride	9	4	ND - 2,400	ND
1,1,2,2-Tetrachloroethane	2	2	BDL - 18	18[a]
Tetrachloroethylene	8	3	ND - 160	ND
1,1,1-Trichloroethane	3	2	ND - 16,000	140
1,1,2-Trichloroethane	1	1		BDL
Trichloroethylene	8	7	ND - 280	BDL
Pesticides and metabolites				
Aldrin	2	2	BDL	BDL
α-BHC	7	6	ND - 26	BDL
β-BHC	5	4	ND - 70	BDL
δ-BHC	8	8	BDL - 2	BDL
γ-BHC	2	2	BDL	BDL
Chlordane	5	4	ND - 38	BDL
4,4'-DDE	6	5	ND - 10	10[a]
4,4'-DDD	2	2	BDL	BDL
4,4'-DDT	8	7	ND - BDL	BDL
Dieldrin	3	3	BDL	BDL
α-Endosulfan	3	3	BDL	BDL
β-Endosulfan	3	2	ND - BDL	BDL
Endosulfan sulfate	2	2	BDL	BDL
Endrin	3	2	ND - BDL	BDL
Endrin aldehyde	2	2	BDL	BDL
Heptachlor	4	3	ND - BDL	BDL
Heptachlor epoxide	2	1	ND - BDL	ND[a]

[a]Determination of median concentration involved averaging of given value and BDL.

TABLE 8.6-10. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOUND IN ZINC CASTING [1]

Toxic pollutant	Number of times Samples	Number of times Detected	Range, μg/L	Median, μg/L
Metals and inorganics				
Chromium	3	3	<10	<10
Copper	3	1	ND-150	ND
Cyanide	4	3	ND-19	9
Lead	4	4	<10	<10
Mercury	3	2	ND-0.3	0.3
Nickel	3	2	ND-3	ND
Selenium	3	0		ND
Zinc	4	4	3,700-350,000	41,000
Phthalates				
Bis(2-ethylhexyl) phthalate	4	4	67-5,500	2,100
Butyl benzyl phthalate	3	3	<10-80	<10
Di-n-butyl phthalate	4	4	<10-217	14
Diethyl phthalate	3	2	ND-110	<10
Dimethyl phthalate	2	2	<10-80	45
Di-n-octyl phthalate	1	1		2,800
Phenols				
2-Chlorophenol	2	2	19-210	120
2,4-Dichlorophenol	3	3	<10-1,300	25
2,4-Dimethylphenol	4	4	32-12,000	75
4-Nitrophenol	1	1		1,600
4,6-Dinitrophenol	2	2	<10-900	460
Pentachlorophenol	1	1		<10
Phenol	4	4	<10-30,000	260
2,4,6-Trichlorophenol	3	3	51-1,400	65
p-Chloro-m-cresol	3	3	14-73	30
Aromatics				
Benzene	2	2	<10-150	80
Toluene	2	2	<10-27	19
2,4-Dinitrotoluene	1	1		<37
2,6-Dinitrotoluene	1	1		<37
Ethylbenzene	1	1		<10
Nitrobenzene	1	1		60
1,2,4-Trichlorobenzene	1	1		1,000
Polyacrylic aromatic hydrocarbons				
Acenaphthene	3	2	ND-37	<10
Acenaphthlyene	2	2	<10-43	27
Benzo(a)anthracene	1	1		<10
Chrysene	1	1		<10

TABLE 8.6-10 (continued).

Toxic pollutant	Number of times: Samples	Number of times: Detected	Range, µg/L	Median, µg/L
Polyacrylic aromatic hydrocarbons (continued)				
Anthracene	1	1		<86
Fluorene	2	2	<10-46	28
Phenanthrene	1	1		<86
Fluoranthene	3	3	<10-14	12
Naphthalene	4	4	<10-3,300	30
Pyrene	3	3	<10	<10
Polychlorinated biphenyls and related compounds				
Aroclor 1016, 1232, 1248, 1260	3	3	<5-54	<5
Aroclor 1221, 1254, 1424	3	3	<5-43	<5
Halogenated aliphatics				
Carbon tetrachloride	2	2	<10-29	15
Chloroform	4	2	ND-57	<5
1,2-Trans-dichloroethylene	1	1		43
Methylene chloride	4	2	ND-290	6
Tetrachloroethylene	3	1	ND-132	ND
1,1,1-Trichloroethane	1	1		144
Trichloroethylene	2	2	<10-230	120
Bromoform	1	1		<10
Dichlorobromomethane	1	1		<10
Pesticides and metabolites				
Aldrin	1	1		<5
α-BHC	2	2	<5	<5
β-BHC	1	1		
δ-BHC	4	4	<5	<5
γ-BHC	1	1		
Chlordane	2	2	<5	<5
4,4'-DDE	4	4	<5	<5
4,4'-DDD	2	2	<5	<5
4,4'-DDT	4	4	<5	<5
α-Endosulfan	2	2	<5	<5
β-Endosulfan	2	2	<5	<5
Endosulfan sulfate	1	1		<5
Endrin	1	1		<5
Endrin aldehyde	2	2	<5	<5
Heptachlor	1	1		<5
Heptachlor epoxide	2	2	<5	<5

TABLE 8.6-11. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOUND IN MAGNESIUM CASTING [1]

Toxic Pollutant	Number of times Sampled	Number of times Detected	Range (ug/L)	Median (ug/L)
Metals and inorganics				
Copper	2	2	20-60	40
Cyanide	2	0		ND
Lead	2	2	30-80	55
Mercury	2	0		ND
Selenium	2	0		ND
Zinc	2	1	ND-1,200	600
Phthalates				
Bis(2-ethylhexyl) phthalate				
Butyl benzyl phthalate	2	0		ND
Di-n-butyl phthalate	2	1	ND-10	5
Diethyl phthalate	2	1	ND-40	20
Dimethyl phthalate	2	0		ND
Phenols				
2-Chlorophenol	1	0		ND
2-Nitrophenol	1	1		BDL
Pentachlorophenol	1	1		11
Phenol	1	1		6
2,4-Dimethylphenol	1	0		ND
Aromatics				
Benzene	1	1		BDL
1,2-Dichlorobenzene	1	1		BDL
1,3-Dichlorobenzene	1	1		BDL
1,4-Dichlorobenzene	1	1		BDL
Hexachlorobenzene	1	1		BDL
Toluene	1	1		18
Polycyclic aromatic hydrocarbons				
Acenaphthene	1	1		11
Acenaphthylene	2	1	ND-32	16
Anthracene	2	2	BDL-<30	<30[a]
Benz(a)anthracene	2	0		ND
Benzo(a)pyrene	2	0		ND
Chrysene	2	1	ND-10	5
Fluoranthene	2	0		ND
Fluorene	2	2	BDL-3	3[a]
Naphthalene	1	1		BDL
Phenanthrene	2	2	BDL-<30	<30[a]
Pyrene	2	2	BDL-<7	<7[a]
Polychlorinated biphenyls and related compounds				
Aroclor 1016, 1232, 1248, 1260	2	2	BDL	BDL
Aroclor 1221, 1254, 1424	1	1		BDL
Halogenated aliphatics				
Chloroform	2	0		ND
Dichlorobromomethane	1	0		ND
Hexachloroethane	1	1		BDL
Methylene chloride	2	1	ND-44	22
Tetrachloroethylene	2	0		ND
Pesticides and metabolites				
α-BHC	1	1		BDL
γ-BHC	1	1		BDL
4,4'-DDD	1	1		BDL
4,4'-DDT	2	2	BDL	BDL
Dieldrin	1	1		BDL
α-Endosulfan	1	1		BDL
Endrin aldehyde	2	2	BDL	BDL
Heptachlor epoxide	1	0		ND

[a]Determination of median concentration involved averaging of given value and BDL.

TABLE 8.6-12. WASTEWATER CHARACTERIZATION OF TOXIC POLLUTANTS FOUND IN COPPER AND COPPER ALLOY CASTING [1]

Toxic pollutant	Number of times Samples	Number of times Detected	Range, μg/L	Median, μg/L
Metals and inorganics				
Cadmium	3	2	ND-100	100
Chromium	1	0		ND
Copper	3	2	ND-110,000	350
Cyanide	3	1	ND-490	ND
Lead	3	2	ND-28,000	70
Mercury	3	1	ND-0.1	ND
Nickel	3	1	ND-720	ND
Selenium	3	0		ND
Zinc	3	3	2,000-130,000	2,700
Phthalates				
Bis(2-ethylhexyl) phthalate	3	1	ND-11	ND
Butyl benzyl phthalate	3	2	ND-180	6
Di-n-butyl phthalate	3	1	ND-1	ND
Diethyl phthalate	2	2	BDL-6	6[a]
Dimethyl phthalate	2	2	15-38	27
Di-n-octyl phthalate	2	2	BDL	BDL
Nitrogen compounds				
1,2-Diphenylhydrazine	1	1		BDL
Phenols				
2,4-Dimethylphenol	2	2	BDL-36	36[a]
2-Nitrophenol	1	1		BDL
4-Nitrophenol	1	1		BDL
Pentachlorophenol	2	2	11-17	14
Phenol	2	2	BDL-25	25[a]
2,4,6-Trichlorophenol	1	1		BDL
p-Chloro-m-cresol	1	1		BDL
4,6-Dinitrophenol	2	1	ND-BDL	ND[a]
4,6-Dinitro-o-cresol	1	1		BDL
Aromatics				
Benzene	2	1	ND-BDL	ND[a]
2,6-Dinitrotoluene	1	1		4
Toluene	2	1	ND-BDL	ND[a]
Polycyclic aromatic hydrocarbons				
Acenaphthene	2	2	BDL-5	5[a]
Acenaphthylene	3	2	ND-6	BDL
Anthracene	1	1		<21
Benz(a)anthracene	1	1		<29
Benzo(a)pyrene	2	2	BDL-6	6[a]

TABLE 8.6-12 (continued).

Toxic pollutant	Number of times: Samples	Number of times: Detected	Range, µg/L	Median, µg/L
Polycyclic aromatic hydrocarbons (continued)				
Benzo(k)fluoranthene	1	1		<7
Benzo(b)fluoranthene	1	1		<7
Chrysene	2	2	BDL-57	57[a]
Fluoranthene	3	2	ND-4	BDL
Fluorene	2	2	BDL	BDL
Naphthalene	1	1		11
Phenanthrene	1	1		<21
Pyrene	3	3	BDL-12	6
Polychlorinated biphenyls and related compounds				
Aroclor 1016, 1232, 1248, 1260	3	0		ND
Aroclor 1221, 1254, 1424	3	0		ND
Halogenated aliphatics				
Bromoform	1	1		BDL
Carbon tetrachloride	1	1		11
Chloroform	3	0		ND
Hexachlorocyclopentadiene	1	1		BDL
Methylene chloride	3	0		ND
Tetrachloroethylene	2	1	ND-80	40
Trichloroethylene	1	1		56
1,1,1-Trichloroethane	1	1		37
Pesticides and metabolites				
Aldrin	2	1	ND-BDL	ND[a]
α-BHC	3	0		ND
β-BHC	3	1	ND-BDL	ND
δ-BHC	3	2	ND-BDL	BDL
γ-BHC	2	1	ND-BDL	ND[a]
Chlordane	2	1	ND-BDL	ND[a]
4,4'-DDE	3	3	BDL	BDL
4,4'-DDT	2	0		ND
Dieldrin	1	0		ND
Endosulfan sulfate	3	1	ND-BDL	ND
Endrin aldehyde	2	2	BDL-4	4[a]
Heptachlor	3	1	ND-BDL	ND
Heptachlor epoxide	2	2	BDL	BDL
Isophorone	1	1		BDL

[a]Determination of median concentration involved averaging of given value and BDL.

II.8.6.3 Plant Specific Descriptions [1]

The following plants have been selected to present plant-specific information on each subcategory and, when possible, each process within the subcategory. Plants were selected on the basis of the completeness of the available information. A brief description is given of each plant, its treatment system, and the toxic and conventional pollutants emitted.

II.8.6.3.1 Iron and Steel Foundries

Plant 291C. This large foundry has a separate treatment system for melting scrubbing waters. This consists of chemical additions, clarification, and vacuum filtration of the settled materials. Clarifier overflow is recycled with makeup from non-contact cooling water.

Dust collection scrubber water, slag quench water, and sand washing wastewaters are settled and recycled with makeup from noncontact cooling water. Excess water is discharged to a Publicly Owned Treatment Works (POTW).

Plant 417A. This plant employs a heat-treated casting quench operation involving the complete recycle of all process wastewaters. The treatment system utilizes a settling channel, from which solids are removed infrequently, and a cooling tower to provide for quench water cooling.

Tables 8.6-13 and 8.6-14 present plant-specific information for each process within the iron and steel foundry industry.

II.8.6.3.2 Aluminum Foundries

Plant 4704. Wastewaters from mold backup, hydroblast casting cleaning, and dust collection are co-treated. Polymer is added to aid settling in a Lamella inclined-plate separator. The Lamella unit sludge is filtered through a paper filter, and the filtrate is returned to the head of the treatment system. The treated effluent is discharged to the river.

Plant 715C. This plant provides for the complete recycle of all die lubricating operation solutions. The die lubrication solutions are collected both by gravity drains connected to a holding tank and by drip pans beneath each casting machine. Wheeled tanks are used to collect and transport the die lubricant solutions collected in these pans to the die lubricant storage tanks.

A skimmer located on the holding tank provides for tramp oil removal. The die lubricant solutions are pumped from the holding tank, through a cyclonic separator, and then to a storage tank

TABLE 8.6-13. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE IRON AND STEEL SUBCATEGORY, PLANT 291C AND PLANT 417A [1]

	Plant 291C												Plant 417A		
	Melting furnace scrubber operations			Dust collectors			Slag quenching operations			Sand washing operations			Casting quench operations		
	Concentration, mg/L[a]		Percent	Concentration, mg/L[a]		Percent	Concentration, mg/L[a]		Percent	Concentration, mg/L[a]		Percent	Concentration, mg/L[a]		Percent
Flow/pollutant	Raw	Treated	removal	Raw	Treated	removal	Raw	Treated	removal	Raw	Treated	removal	Raw	Treated	removal
Flow, m^3/Mg	2.1	2.1		0.40	0.40		0.42	0.42		0.84	1.05		21	21	
Pollutant															
TSS	1,100	71	94	410	41	90				630	170	73	90	62	31
Total phenols	3	12	-[b]		0.23		2.1	1.7	19	0.01	0.022	-[b]			
Sulfides				1	0.2	80	10	2	80						
Oil and grease	70	21	70	3	2.7	10	200	39	81		4		ND	9	-[b]
pH	6.9	6.9		7.2	7.3					7.0	6.2		8.6	8.6	

Note: Blanks indicate no information available.

[a]Except flow, which is given in m^3/Mg, and pH values, which are given in pH units.

[b]Negative removal.

TABLE 8.6-14. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE IRON AND STEEL SUBCATEGORY, PLANT 291C AND PLANT 417A [1]

	Plant 291C												Plant 417A		
	Melting furnace scrubber operations			Dust collectors			Slag quenching operations			Sand washing operations			Casting quench operations		
	Concentration, µg/L		Percent	Concentration, µg/L		Percent	Concentration, µg/L		Percent	Concentration, µg/L		Percent	Concentrations, µg/L		Percent
Toxic pollutant	Raw	Treated	removal	Raw	Treated	removal	Raw	Treated	removal	Raw	Treated	removal	Raw	Treated	removal
Metals and inorganics															
Antimony	800	400	50	70	BDL	-[a]				300	BDL	-[a]	ND	BDL	-[a]
Arsenic	160	30	81	ND	BDL	-[a]				3	BDL	-[a]	ND	BDL	-[a]
Beryllium	ND	BDL	-[a]	ND	BDL	-[a]				ND	BDL	-[a]	ND	BDL	-[a]
Cadmium	740	840	-[b]	ND	BDL	-[a]	200	BDL	-[a]	ND	BDL	-[a]	ND	BDL	-[a]
Chromium	430	BDL	-[a]	7	BDL	-[a]	700	BDL	-[a]	ND	BDL	-[a]	ND	BDL	-[a]
Copper	3,400	220	94	90	BDL	-[a]	350	BDL	-[a]	ND	70	-[b]	20	50	-[b]
Cyanide	47	180	-[b]	7	74	-[b]	ND	ND	-[a]	5	25	-[b]	3	2	33
Lead	100,000	8,500	92	30	10	67	6,100	590	90	100	80	20	ND	60	-[b]
Mercury	1.1	1.1	-[c]	ND	1	-[b]	2.1	2	5	0.1	1.3	-[b]	ND	0.8	-[b]
Nickel	110	130	-[b]	ND	20	-[b]	40	39	2	BDL	BDL	-[a]	ND	BDL	-[a]
Selenium	ND	BDL	-[a]	ND	BDL	-[a]	ND	BDL	-[a]	ND	BDL	-[a]	ND	BDL	-[a]
Silver	30	BDL	-[a]										ND	BDL	-[a]
Thallium	BDL	BDL	-[a]										ND	BDL	-[a]
Zinc	150,000	190,000	-[b]	ND	370	-[b]	25,000	8,000	68	ND	12,000	-[b]	ND	140	-[b]
Ethers															
Bis(2-chloroethyl) ether	ND	8	-[b]												
Bis(2-chloroisopropyl) ether		3	-[a]												
Phthalates															
Bis(2-ethylhexyl) phthalates	90	84	7	9	2	70	1,200	90	93	5	11	-[b]	ND	27	-[b]
Butyl benzyl phthalate	74	41	45	ND	BDL	-[a]	20	27	-[b]		BDL				
Di-n-butyl phthalate	ND	190	-[b]	ND	8	-[b]	110	70	36	ND	BDL	-[a]	BDL	BDL	-[a]
Diethyl phthalate	ND	30	-[b]	3	BDL	-[a]	39	20	99	ND	BDL	-[a]	ND	BDL	-[a]
Dimethyl phthalate	660	320	52	ND	44	-[b]	ND		-[a]	ND	10	-[b]			
Di-n-octyl phthalate		73	-[a]	BDL											
Nitrogen compounds															
Acrylonitrile		23	-[a]												
Benzidine	ND	BDL	-[a]												
1,2-Diphenylhydrazine	ND	BDL	-[a]				1,400	180	87						
N-nitrosodiphenylamine	ND	190	-[b]												
Phenols															
2-Chlorophenol	ND	85	-[b]	ND	BDL	-[a]	20	40	-[b]	ND	BDL	-[a]		BDL	
2,4-Dichlorophenol	39	40	-[b]	ND	BDL	-[a]	20	ND	>99		BDL		BDL	BDL	-[a]
2,4-Dimethylphenol	ND	400	-[b]	ND	BDL	-[a]	60	40	33	BDL	BDL	-[a]	BDL	ND	-[a]
2-Nitrophenol	ND	30	-[b]	ND	BDL	-[a]	40	40	-[c]	BDL					
4-Nitrophenol	40	20	50												
Pentachlorophenol	130	140	-[b]	ND	12	-[b]	21	27	-[b]	BDL	BDL	-[a]			
Phenol	80	2,600	-[b]	ND	3	-[b]	100	88	17	ND	BDL	-[a]			
2,4,6-Trichlorophenol	ND	72	-[b]	ND	2	-[b]	80	51	36	ND	BDL	-[a]	BDL	BDL	-[a]
p-Chloro-*m*-cresol	ND	63	-[b]	ND		-[a]	120		-[a]	BDL					
4,6-Dinitro-*o*-cresol	ND	88	-[b]	ND	7	-[b]	20	40	-[b]	BDL	BDL	-[a]			

(continued)

TABLE 8.6-14 (continued)

	Plant 291C													Plant 417A		
	Melting furnace scrubber operations			Dust collectors			Slag quenching operations			Sand washing operations				Casting quench operations		
	Concentration, µg/L		Percent removal	Concentration, µg/L		Percent removal	Concentration, µg/L		Percent removal	Concentration, µg/L		Percent removal		Concentrations, µg/L		Percent removal
Toxic pollutant	Raw	Treated		Raw	Treated		Raw	Treated		Raw	Treated			Raw	Treated	
Aromatics																
Benzene	16	17	–[b]	ND	BDL	–[a]	100	60	40	BDL				ND	BDL	–[a]
Chlorobenzene	BDL															
2,4-Dinitrotoluene		300		<7												
2,6-Dinitrotoluene		300		<7												
Ethylbenzene	BDL	BDL	–[a]													
Hexachlorobenzene	BDL															
Nitrobenzene	<280	BDL	–[a]	<3							BDL					
Toluene	3	BDL	–[a]	ND	BDL	–[a]	40	40	–[c]							
1,2,4-Trichlorobenzene	ND	570	–[b]	7												
Polycyclic aromatic hydrocarbons																
Acenaphthene	ND	BDL	–[a]	ND	10	–[b]	20	27	–[b]	ND	BDL	–[a]				
Acenaphthylene	ND	16	–[b]	ND	10	–[b]	40	57	–[b]	ND	BDL	–[a]				
Anthracene	78	32	59	3	51	–[b]	ND			ND	<4	–[b]				
Benz(a)anthracene	9	BDL	–[a]	ND	BDL	–[a]	20	60	–[b]		BDL			BDL		
Benzo(a)pyrene				BDL											BDL	
Chrysene	4	BDL	–[a]	ND	13	–[b]	ND			ND	BDL	–[a]		ND	BDL	–[a]
Fluoranthrene	390	97	75	ND	6	–[b]	51	72	–[b]	ND	BDL	–[a]		ND	BDL	–[a]
Fluorene	620	9	99	ND	5	–[b]	53	68	–[b]							
Naphthalene	ND	270	–[a]	ND	BDL	–[a]	20	20	–[c]	ND	BDL	–[a]		ND	BDL	–[a]
Phenanthrene	78	32	53	3	51	–[b]	ND			ND	<4	–[b]				
Pyrene	1,100	47	96	ND	19	–[b]	ND			ND	BDL	–a		ND	BDL	–[a]
Polychlorinated biphenyls and related compounds																
Arochlor 1016, 1232, 1248, 1260	270	46	83	BDL	BDL	–[a]	20	20	–[c]	ND	BDL	–[a]		ND	BDL	–[a]
Aroclor 1221, 1254, 1424	330	55	83	ND	BDL	–[a]	20	20	–[c]	ND	BDL	–[a]		ND	BDL	–[a]
Halogenated aliphatics														BDL	BDL	–[a]
Carbon tetrachloride	ND	BDL	–[a]				20		–[c]	<20				ND	BDL	–[a]
Chloroform	ND	26	–[a]	ND	18	–[b]	80	210	–[b]	ND	BDL	–[a]				
Dichlorobromomethane							37	23	38					BDL		
1,2-Dichloroethane		BDL														

(continued)

TABLE 8.6-14 (continued)

Toxic pollutant	Plant 291C: Melting furnace scrubber operations, Concentration, µg/L Raw	Treated	Percent removal	Plant 291C: Dust collectors, Concentration, µg/L Raw	Treated	Percent removal	Plant 291C: Slag quenching operations, Concentration, µg/L Raw	Treated	Percent removal	Plant 291C: Sand washing operations, Concentration, µg/L Raw	Treated	Percent removal	Plant 417A: Casting quench operations, Concentrations, µg/L Raw	Treated	Percent removal
Halogenated aliphatics (continued)															
Methylene chloride	20	36	[b]	ND	5	[b]	470	230	51	ND	10	[b]	ND	BDL	[a]
Tetrachloroethylene	ND	45	[b]	ND	1	[b]	370	72	81	BDL			ND	BDL	[a]
1,1,1-Trichloroethane	ND	9	[b]	ND	BDL	[a]	60	40	33	ND	BDL	[a]	BDL	BDL	[b]
1,1,2-Trichloroethane	ND	BDL	[a]				20								
Trichloroethylene	ND	30	[b]				180	20	89				ND	BDL	[a]
Pesticides and metabolites															
Aldrin	BDL	BDL	[a]	BDL	BDL	[a]	ND	BDL	[a]					BDL	
α-BHC										ND	BDL	[a]	ND	BDL	[a]
β-BHC	ND	8	[b]	BDL			20			ND	BDL	[a]	ND	BDL	[a]
δ-BHC	BDL	BDL	[a]	ND	BDL	[a]	20	20	[c]	ND	BDL	[a]			
γ-BHC	BDL	BDL	[a]	ND	BDL	[a]	20	20	[c]	ND	BDL	[a]	ND	BDL	[a]
Chlordane										ND	BDL	[a]	ND	BDL	[a]
4,4'-DDE	ND	BDL	[a]	BDL			20			ND	BDL	[a]		BDL	
4,4'-DDD										BDL					
4,4'-DDT	BDL	BDL	[b]	ND	BDL	[a]	20	20	[c]	ND	BDL	[a]	ND	BDL	[a]
Dieldrin		BDL					20			ND	BDL	[a]			
α-Endosulfan	BDL												ND	BDL	[a]
β-Endosulfan	ND	BDL	[b]							ND	BDL	[a]		BDL	
Endosulfan sulfate				BDL						BDL			ND	BDL	[a]
Endrin										BDL					
Endrin aldehyde	9	BDL	[a]	ND	BDL	[a]	20	20	[c]	ND	BDL	[a]			
Heptachlor				BDL			20			ND	BDL	[a]	ND	BDL	[a]
Heptachlor epoxide				ND						ND	BDL	[a]	ND	BDL	[a]
Isophorone	ND	BDL	[a]										ND	BDL	[a]

Note: Blanks indicate no information currently available.

[a]Indeterminate removal.

[b]Negative removal.

[c]Indicates negligible removal.

for reuse. A paper filter is used to remove solids from the cyclone concentrate; the filtrate goes into the storage tanks. The die lubricants collected in the pans are filtered using a paper filter prior to discharge to the storage tanks. In the storage tanks the solutions are "freshened" with makeup water or new lubricants as needed. The wheeled tanks mentioned above are then used to transport the die lubricants back to the machines. An extensive maintenance program is followed to minimize leakage of various fluids at the die casting machines which would result in contamination of the die lubricant solutions.

Plant 574C. Aluminum and zinc die casting waters are co-treated. After collection in a receiving tank where oil is skimmed, they are batch treated by emulsion breaking, flocculation, and settling before discharge. The released oil is returned to the receiving tank for skimming, and the settled wastes are vacuum filtered and dried before being landfilled. Filtrate water is returned to the receiving tank.

Tables 8.6-15 and 8.6-16 present plant-specific information on conventional and toxic pollutants for the above facilities.

II.8.6.3.3 Copper Foundries

Plant 6809. Mold cooling and casting wastewaters are recycled through a cooling tower in this system; a portion of the process wastewater flow is "blowndown" for treatment with other nonfoundry wastewaters. The mold cooling and casting quench system blowdown represents 3% of the combined wastewater flow. These combined wastewaters are settled and skimmed in a lagoon and are then discharged.

Plant 9979. This plant is a continuous casting operation producing both copper and aluminum products. This 100% recycle operation uses a cooling tower to reduce the wastewater system heat load.

Plant 9094. This plant has requested confidentiality. No treatment technology description is available.

Tables 8.6-17 and 8.6-18 present conventional and toxic pollutant data for the above copper foundry facilities.

II.8.6.3.4 Magnesium Foundries

Plant 8146. This foundry uses dust collectors and magnesium grinding scrubbers from which the wastewater flow is discharged untreated. No treatment description or treated wastewater concentrations are available. Tables 8.6-19 and 8.6-20 present conventional and toxic pollutant data for this facility.

TABLE 8.6-15. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE ALUMINUM CASTING SUBCATEGORY, PLANT 4704, PLANT 574C, AND PLANT 715C [1]

Flow/pollutant	Plant 4704 Investment casting operations Concentration, mg/L[a] Raw	Treated	Percent removal	Plant 574C Die casting operations Concentration, mg/L[a] Raw	Treated	Percent removal	Plant 715C Die lube operations Concentration, mg/L[a] Raw	Treated	Percent removal
Flow, m^3/Mg	21	21		5.5	5.5				
Pollutant									
TSS	930	83	91	530	9.9	98	1,700	1,600	6
Total phenols							66	64	3
Sulfides							3.3	<0.2	94
Oil and grease	18	10	44	20	12	40	8,500	9,900	_[b]
pH	7	7.1		7.2	9.1		6.9	7.1	

Note: Blanks indicate no information currently available.

[a]Except pH values, which are given in pH units.

[b]Negative removal.

TABLE 8.6-16. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE ALUMINUM CASTING SUBCATEGORY, PLANT 4704, PLANT 574C, AND PLANT 715C [1]

Toxic pollutant	Plant 4704 Investment casting operations: Concentration, µg/L Raw	Plant 4704: Concentration, µg/L Treated	Plant 4704: Percent removal	Plant 574C Die casting operations: Concentration, µg/L Raw	Plant 574C: Concentration, µg/L Treated	Plant 574C: Percent removal	Plant 715C Die lube operations: Concentration, µg/L Raw	Plant 715C: Concentration, µg/L Treated	Plant 715C: Percent removal
Polychlorinated biphenyls and related compounds									
Aroclor 1016, 1232, 1248, 1260	10	BDL	50				570	480	16
Aroclor 1221, 1254 1424	3	BDL	–[b]				810	650	20
Halogenated aliphatics									
Carbon tetrachloride	26	10	62	BDL	BDL	–[b]	480	55	89
Chloroform	ND	20	–[a]	4	7	–[a]	450	500	–[a]
Dichlorobromomethane	BDL								
1,1-Dichloroethane							55		
1,2-Dichloroethane	5	BDL	–[b]						
1,2-*Trans*-dichloroethylene	ND			ND	BDL	–[b]			
Methylene chloride	40	34	15	2	39	–[a]	2,400	2,500	–[a]
1,1,2,2-Tetrachloroethane	BDL							18	
Tetrachloroethylene	10	94	–[a]	ND	30	–[a]	160	210	–[a]
1,1,1-Trichloroethane	140	46	67	ND	51	–[a]	16,000	2,200	83
1,1,2-Trichloroethane	BDL	BDL	–[b]					7	
Trichloroethylene	69	78	–[a]	ND	21	–[a]	280	140	50
Pesticides and metabolites									
Aldrin							BDL	BDL	–[b]
α-BHC	ND						26	6	77
β-BHC	ND	BDL	–[b]	BDL			70	55	21
δ-BHC							BDL	BDL	–[b]
γ-BHC	BDL	BDL	–[b]	BDL	BDL	–[b]	7	<5	29
Chlordane	ND	BDL	–[b]	BDL			38	24	37
4,4'-DDE	ND	BDL	–[b]	BDL			BDL	BDL	–[b]
4,4'-DDD									
4,4'-DDT	ND	BDL	–[b]	BDL	BDL	–[b]	BDL	BDL	–[b]
Dieldrin	BDL						BDL	BDL	–[b]
α-Endosulfan	BDL						BDL	BDL	–[b]
β-Endosulfan	ND	BDL	–[b]	BDL					
Endosulfan sulfate	BDL								
Endrin	ND			BDL					
Heptachlor	ND	BDL	–[b]	BDL	BDL	–[b]			
Heptachlor epoxide	ND	BDL	–[b]						

Note: Blanks indicate no information currently available.

[a]Negative removal.

[b]Indeterminate removal.

TABLE 8.6-16 (continued)

Toxic pollutant	Plant 4704 Investment casting operations Concentration, µg/L Raw	Treated	Percent removal	Plant 574C Die casting operations Concentration, µg/L Raw	Treated	Percent removal	Plant 715C Die lube operations Concentration, µg/L Raw	Treated	Percent removal
Metals and inorganics									
Chromium	20	30	-[a]	<100	<150	-[a]	BDL	BDL	-[b]
Copper	450	83	82						
Cyanide	ND	7	-[a]	5	23	-[a]	8	10	-[a]
Lead	50	BDL	60	200	150	25	2,000	2,100	-[a]
Mercury	0.2	BDL	-[b]	BDL	BDL	-[b]	BDL	BDL	-[b]
Nickel	5	BDL	-[b]	<90	<40	56	BDL	BDL	-[b]
Selenium	ND	BDL	-[b]	<40	BDL	50	BDL	BDL	-[b]
Zinc	490	100	80	1,300	40	97	1,600	1,500	6
Ethers									
Bis(2-chloroethyl) ether				9		-[b]			
Phthalates									
Bis(2-ethylhexyl) phthalate	ND	12	-[a]	5,500	32	96	820,000	16,000	98
Butyl benzyl phthalate	BDL	BDL	-[b]	690	BDL	97			
Di-n-butyl phthalate	6	BDL	-[b]	74	1	99	5,400	9,300	-[a]
Diethyl phthalate	BDL			730	BDL	97	600	10,500	-[a]
Dimethyl phthalate	ND	13	-[a]	BDL			29		
Di-n-octyl phthalate	4								
Nitrogen compounds									
N-nitroso-di-n-propylamine				34			207		
Phenols									
2,4-Dichlorophenol	BDL			BDL	BDL	-[b]	5,700		
2,4-Dimethylphenol	5	BDL	-[b]	41	BDL	50			
2-Nitrophenol	BDL								
Pentachlorophenol	BDL	BDL	-[b]				1,600		
Phenol				16	BDL	-[b]	26,000	34,000	-[a]
2,4,6-Trichlorophenol	ND						350	69	80
p-Chloro-*m*-cresol	ND	BDL	-[b]	110	62	44			
4,6-Dinitro-*o*-cresol	BDL								
Aromatics									
Benzene	BDL	BDL	-[b]	BDL	BDL	-[b]	84	50	40
Chlorobenzene							250	470	-[a]
Ethylbenzene		BDL			ND				
Toluene	BDL	BDL	-[b]	ND	BDL	-[b]	540	180	67
Polycyclic aromatic hydrocarbons									
Acenaphthene	ND			200	BDL	90	18		
Acenaphthylene	2	BDL	-[b]					500	
Anthracene	BDL			<10	BDL	-[b]	470	3,200	-[a]
Benz(a)anthracene				ND	BDL	-[b]		7,300	
Benzo(a)pyrene	ND	BDL	-[b]	53	BDL	62			
Chrysene	ND	10	-[a]	780	10	99			
Fluoranthrene	ND	12	-[a]	370	BDL	96		93	
Fluorene	BDL	BDL	-[b]	800	BDL	98	32	10,000	-[a]
Naphthalene	ND	BDL	-[b]	160	3	98			
Phenanthrene	BDL			<10	BDL	-[b]	470	3,200	-[a]
Pyrene	24	BDL	17	80	BDL	75		3,200	

(continued)

TABLE 8.6-17. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE COPPER FOUNDRIES SUBCATEGORY PLANT 9979, PLANT 6809, AND PLANT 9094 [1]

Flow/pollutant	Plant 9979 Continuous casting operations: Concentration, mg/L[a] Raw	Plant 9979: Concentration, mg/L[a] Treated	Plant 9979: Percent removal	Plant 6809 Molding cooling and casting quench operations: Concentration, mg/L[a] Raw	Plant 6809: Concentration, mg/L[a] Treated	Plant 6809: Percent removal	Plant 9094 Dust collection systems: Concentration, mg/L[a] Raw	Plant 9094: Concentration, mg/L[a] Treated	Plant 9094: Percent removal
Flow, m^3/Mg	8.8	8.8		0.76	0.76				
Pollutant									
TSS	18	11	39	52	20	62	610	2	>99
Total phenols							2.1	0.01	>99
Oil and grease	ND	11	-[b]	30	6.2	79	8	0.4	95
pH	7.8	7.9		8.3	7.9		7.1	7.7	

Note: Blanks indicate no information currently available.

[a] Except flow, which is given in m^3/Mg and pH values, which is given in pH units.

[b] Negative removal.

TABLE 8.6-18. CONCENTRTIONS OF TOXIC POLLUTANTS FOUND IN THE COPPER FOUNDRIES SUBCATEGORY, PLANT 9979, PLANT 6809, AND PLANT 9094 [1]

	Plant 9979 Continuous casting operations			Plant 6809 Molding cooling and casting quench operations			Plant 9094 Dust collection systems		
	Concentration, μg/L		Percent	Concentration, μg/L		Percent	Concentration, μg/L		Percent
Toxic pollutant	Raw	Treated	removal	Raw	Treated	removal	Raw	Treated	removal
Metals and inorganics									
Cadmium	ND	10	[a]	100	40	60	100	BDL	[b]
Chromium							ND	BDL	[b]
Copper	ND	2,400	[a]	350	110	69	110,000	160	>99
Cyanide	ND	1	[a]	ND	2	[a]	49	1	98
Lead	70	130	[a]	ND	BDL	[b]	28,000	81	>99
Mercury	ND	BDL	[b]	0.3	0.9	[a]	ND	0.5	[a]
Nickel	ND	BDL	[b]	ND	60	[a]	720	BDL	[b]
Selenium	ND	BDL	[b]	ND	BDL	[b]	ND	BDL	[b]
Zinc	2,700	4,400	[a]	2,000	1,400	30	130,000	450	>99
Phthalates									
Bis(2-ethylhexyl) phthalate	ND	320	[a]	BDL	170	[a]	11	17	[a]
Butyl benzyl phthalate	6			20	20	[c]	180	BDL	[b]
Di-n-butyl phthalate	ND	30	[a]	ND	19	[a]	1	11	[a]
Diethyl phthalate				BDL	14	[a]	6	BDL	[b]
Dimethyl phthalate				15	93	[b]	38	11	71
Di-n-octyl phthalate				BDL			BDL		
Nitrogen compounds									
Benzidine							BDL		
1,2-Diphenylhydrazine							BDL		
Phenols									
2,4-Dimethylphenol	BDL						36		
2-Nitrophenol							BDL		
4-Nitrophenol							BDL	6	[a]
Pentachlorophenol	17						11		
Phenol	BDL						25	BDL	[b]
2,4,6-Trichlorophenol							BDL		
p-Chloro-*m*-cresol							BDL	BDL	[b]
4,6-Dinitro-*o*-cresol	BDL								
Aromatics									
Benzene				ND	BDL	[b]	BDL		
2,6-Dinitrotoluene							4		
Toluene		BDL		ND			BDL		
Polycyclic aromatic hydrocarbons									
Acenaphthene		BDL		BDL			5	BDL	[b]
Acenaphthylene	ND	BDL	[b]	BDL	19	[a]	6	BDL	[b]
Anthracene							<21	BDL	[b]
Benz(a)anthracene							<29		
Benzo(a)pyrene		BDL		BDL	BDL	[b]	6	BDL	[b]
Benzo(b)fluoranthene							<7		
Benzo(k)fluoranthene							<7		
Chrysene				BDL	19	[a]	57	BDL	[b]
Fluoranthrene	ND	BDL	[b]	BDL	BDL	[b]	4	BDL	[b]
Fluorene		BDL		BDL			BDL	BDL	[b]
Naphthalene							11		
Phenanthrene							<21	BDL	[b]
Pyrene		BDL		BDL	BDL	[b]	6	12	[a]

(continued)

TABLE 8.6-18 (continued)

Toxic pollutant	Plant 9979 Continuous casting operations Concentration, µg/L Raw	Plant 9979 Concentration, µg/L Treated	Plant 9979 Percent removal	Plant 6809 Molding cooling and casting quench operations Concentration, µg/L Raw	Plant 6809 Concentration, µg/L Treated	Plant 6809 Percent removal	Plant 9094 Dust collection systems Concentration, µg/L Raw	Plant 9094 Concentration, µg/L Treated	Plant 9094 Percent removal
Polychlorinated biphenyls and related compounds									
Aroclor 1016, 1232, 1248, 1260	ND	BDL	[b]	ND			ND	BDL	[b]
Aroclor 1221, 1254 1424	ND	BDL	[b]	ND			ND	BDL	[b]
Halogenated aliphatics									
Bromoform				BDL					
Carbon tetrachloride				11					
Chloroform	ND	BDL	[b]	ND	230	[a]	ND	BDL	[b]
Hexachlorocyclopentadiene							BDL		
Methylene chloride	ND	15	[a]	ND	30	[a]	ND	BDL	[b]
1,1,2,2-Tetrachloroethane		BDL							
Tetrachloroethylene		BDL		80	93	[a]	ND	BDL	[b]
1,1,1-Trichloroethane				37	44	[a]			
Trichloroethylene				50	56	[a]			
Pesticides and metabolites									
Aldrin	BDL						ND	BDL	[b]
α-BHC	ND	BDL	[b]	ND			ND	BDL	[b]
β-BHC	ND	BDL	[b]	ND			ND	BDL	[b]
δ-BHC	BDL						ND	BDL	[b]
γ-BHC	BDL			BDL			ND	BDL	[b]
Chlordane	ND	BDL	[b]	BDL					
4,4'-DDE	<5			BDL			BDL		
4,4'-DDT	ND	BDL	[b]	ND					
Dieldrin		BDL					ND	BDL	[b]
β-Endosulfan		BDL							
Endosulfan sulfate	ND	BDL	[b]	BDL			ND		
Endrin aldehyde				BDL			4		
Heptachlor	ND	BDL	[b]	BDL			ND	BDL	[b]
Heptachlor epoxide		BDL		BDL			BDL		
Isophorone				BDL	BDL	[b]			

Note: Blanks indicate no information currently available.

[a]Negative removal.

[b]Indeterminate removal.

[c]Indicates negligible removal.

TABLE 8.6-19. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND N THE MAGNESIUM FOUNDRIES SUBCATEGORY, PLANT 8146 [1]

Pollutant	Grinding scrubber operations — Concentration, mg/L[a]		Dust collection systems — Concentration, mg/L[a]	
	Raw	Treated[b]	Raw	Treated[b]
TSS			8.3	
Oil and grease			6	
pH	9.8		7.6	

Note: Blanks indicate no information currently available.

[a]Except pH, which is given in pH units.

[b]No treatment at this facility.

TABLE 8.6-20. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE MAGNESIUM FOUNDRIES SUBCATEGORY, PLANT 8146 [1]

	Grinding scrubber operations Concentration, μg/L		Dust collection systems Concentration, μg/L	
Toxic pollutant	Raw	Treated[a]	Raw	Treated[a]
Metals and inorganics				
Copper	60		20	
Cyanide	ND		ND	
Lead	80		30	
Mercury	ND		ND	
Nickel			ND	
Selenium	ND			
Zinc	1,200		ND	
Phthalates				
Bis(2-ethylhexyl) phthalate	51		14	
Butyl benzyl phthalate	ND		ND	
Di-n-butyl phthalate	ND		10	
Diethyl phthalate	ND		40	
Dimethyl phthalate	ND		ND	
Phenols				
2-Chlorophenol			ND	
2,4-Dimethylphenol			ND	
2-Nitrophenol			<20	
Pentachlorophenol			11	
Phenol			6	
Aromatics				
Benzene			BDL	
1,2-Dichlorobenzene	BDL			
Hexachlorobenzene	BDL			
Toluene			18	
Polycyclic aromatic hydrocarbons				
Acenaphthene			11	
Acenaphthylene	ND		32	
Anthracene	BDL		<30	
Benz(a)anthracene	ND		ND	
Benzo(a)pyrene	ND		ND	
Chrysene	ND		10	
Fluoranthrene	ND		ND	
Fluorene	BDL		3	
Naphthalene			BDL	
Phenanthrene	BDL		<30	
Pyrene	BDL		7	
Polychlorinated biphenyls and related compounds				
Aroclor 1016, 1232, 1248, 1260	BDL			
Aroclor 1221, 1254 1424	BDL			
Halogenated aliphatics				
Chloroform	ND		ND	
Dichlorobromomethane	ND			
Hexachloroethane	BDL			
Methylene chloride	44		ND	
Tetrachloroethylene	ND		ND	
Pesticides and metabolites				
α-BHC	BDL			
γ-BHC			BDL	
4,4'-DDE	BDL			
4,4'-DDT	BDL		BDL	
Dieldrin	BDL			
Endrin aldehyde	BDL		BDL	
Heptachlor epoxide	ND			

Note: Blanks indicate no information currently available.

[a]No treatment at this facility.

II.8.6.3.5 Zinc Foundries

Plant 436-E. Zinc die casting quench wastes, aluminum die casting quench wastes, cutting and machining collants, and impregnating wastes are co-treated in a batch-type system. The zinc casting quench waste is actually the effluent from a system that recycles the quench tank contents through a settling and skimming operation and back to the quench tanks. The zinc casting quench wastes represent approximately 25% of the total treatment volume. After undergoing a sulfuric acid-and-alum emulsion break, neutralization, flocculation, and solids separation, the treated effluent is discharged to a land-locked swamp.

Plant 462-G. This plant has requested confidentiality. No treatment technology description is available. However, raw and treated data are presented.

Tables 8.6-21 and 8.6-22 present conventional and toxic pollutant data for the two zinc foundries described.

II.8.6.3.6 Lead Foundries

There are no plant-specific data in the available source documents concerning the lead foundry subcategory.

II.8.6.4 Pollutant Removability [1]

Two conventional pollutants represent the major wastewater pollutant concerns in the foundry industry. Suspended solids are present in high concentrations in nearly every wastewater source emanating from the foundry processes. Oil and grease are also present in many of these sources. Primary treatment technologies are generally used to reduce the amounts of these pollutants emitted. Metals may also be present in the wastewater streams and can be removed by chemical precipitation.

The most common treatment method used to reduce the high solids content in the wastewater is sedimentation. Wastewaters from foundry processes are treated by lagooning, clarification with chemical addition, cyclone separation, dragout chambers, and Lamella inclined-plate separators.

Chemicals used for clarification include polymers, lime and alum. Sulfuric acid and alum are also used as emulsion breakers. Settled sludges are dewatered by filtration or other techniques and are generally hauled away by waste disposal contractors. Ultrafiltration is used at a few plants to trap high molecular weight organics prior to discharge to a POTW.

TABLE 8.6-21. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE ZINC FOUNDRIES SUBCATEGORY, PLANT 462G AND PLANT 436E [1]

	Plant 462G						Plant 436E		
	Melting furnace scrubbers			Casting quench operations			Casting quench operations		
	Concentration, mg/L[a]			Concentration, mg/L[a]			Concentration, mg/L[a]		
Pollutant	Raw	Treated	Percent removal	Raw	Treated	Percent removal	Raw	Treated	Percent removal
TSS	430	310	28	40	32	20	92	8.0	91
Total phenols	91	14	85	0.048	0.009	81	0.11	0.38	-[b]
Oil and grease	760	860	-[b]	22	29	-[b]	70	4.2	94
pH	4.7			7.4			5.7	9.1	

Note: Blanks indicate no information currently available.

[a]Except pH values, which are given in pH units.

[b]Negative removal.

TABLE 8.6-22. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE ZINC FOUNDRIES SUBCATEGORY, PLANT 462G AND PLANT 436E [1]

	Plant 462G						Plant 436E		
	Melting furnace scrubbers			Casting quench operations			Casting quench operations		
	Concentration, μg/L			Concentration, μg/L			Concentration, μg/L		
Toxic pollutant	Raw	Treated	Percent removal	Raw	Treated	Percent removal	Raw	Treated	Percent removal
Metals and inorganics									
Chromium	BDL			BDL	BDL	-[a]	BDL	BDL	-[a]
Copper	ND	5.7	-[b]	ND	79	-[b]	150	50	67
Cyanide	8	7.3	9	9	79	-[b]	ND	4	-[b]
Lead	BDL	BDL	-[a]	BDL	BDL	-[a]	BDL	BDL	-[a]
Mercury	0.3	0.5	-[b]	0.3	0.8	-[b]	ND	0.3	-[b]
Nickel	ND	BDL	-[b]	ND	BDL	-[a]	30	120	-[b]
Selenium	ND	9.9	-[b]	ND	9.5	-[b]	ND	BDL	-[a]
Zinc	19,000	11,000	42	3,700	2,300	38	350,000	36,000	90
Phthalates									
Bis(2-ethylhexyl) phthalate	5,500	5,500	-[c]	170	180	-[b]	47	15	68
Butyl benzyl phthalate	80	49	39	<10	<10	-[c]	<10		-[c]
Di-n-butyl phthalate	<10	70	-[b]	17	110	-[b]	<10	<10	-[b]
Diethyl phthalate	110	180	-[b]	<10	<10	-[c]	ND	29	
Dimethyl phthalate	80	130	-[b]	<10	<10	-[c]			
Phenols									
2-Chlorophenol							19		
2,4-Dichlorophenol	1,300	220	77	<10	<10	-[c]	25		
2,4-Dimethylphenol	12,000	490	96	42	<10	76	110		
4-Nitrophenol							1,600		
Pentachlorophenol				<10					
Phenol	30,000	2,300	92	53	<10	81	<10	230	-[b]
2,4,6-Trichlorophenol	1,400	600	57	65	27	58	51		
p-Chloro-m-cresol							14		
Aromatics									
Benzene	<10	<10	-[c]						
2,4-Dinitrotoluene	<37	<17	54						
2,6-Dinitrotoluene	<37	<17	54						
Ethylbenzene	<10								
Nitrobenzene	60								
Toluene	<10	<10							
1,2,4 Trichlorobenzene	1,000		-[c]						
Polycyclic aromatic hydrocarbons									
Acenaphthene	37	39	-[b]	<10	<10	-[c]	ND		
Acenaphthylene	43	<10	77				<10		
Anthracene	<86							<10	
Benz(a)anthracene	<10								
Chrysene	<10								
Fluoranthene	12	26	-[b]	14	33	-[b]	<10		
Fluorene	46						<10		
Naphthalene	3,300	<10	>99	<10	<10	-[c]	<10		
Phenanthrene	<86							<10	
Pyrene	<10	17	-[b]	<10	20	-[b]	<10		

(continued)

TABLE 8.6-22 (continued)

Toxic pollutant	Plant 462G: Melting furnace scrubbers — Concentration, µg/L: Raw	Treated	Percent removal	Plant 462G: Casting quench operations — Concentration, µg/L: Raw	Treated	Percent removal	Plant 436E: Casting quench operations — Concentration, µg/L: Raw	Treated	Percent removal
Polychlorinated biphenyls and related compounds									
Aroclor 1016, 1232, 1248, 1260	<5			<5					
Aroclor 1221, 1254 1424	<5			<5	<5	-[c]			
Halogenated aliphatics									
Carbon tetrachloride	<20								
Chloroform	ND	<10	-[b]	ND	<10	-[b]	<10		
Methylene chloride	ND	<10	-[b]	ND	<10	-[b]	11	800	-[b]
Tetrachloroethylene	ND	<10	-[b]	ND	31	-[b]			
Trichloroethylene	<10	<10	-[c]						
Pesticides and metabolites									
Aldrin				<5					
α-BHC				<5					
β-BHC				<5	<5	-[c]			
δ-BHC				<5					
γ-BHC	<5	<5	-[c]	<5	<5	-[c]	<5		
Chlordane							<5	<5	-[c]
4,4'-DDE	<5	<5	-[c]	<5			<5	<5	-[c]
4,4'-DDD	<5	<5	-[c]				<5	<5	-[c]
4,4'-DDT	<5	<5	-[c]	<5			<5		
α-Endosulfan							<5		
β-Endosulfan							<5	<5	-[c]
Endrin							<5		
Endrin aldehyde	<5						<5		
Heptachlor				<5	<5	-[c]			
Heptachlor epoxide				<5					

Note: Blanks indicate no information currently available.

[a]Indeterminate removal.

[b]Negative removal.

[c]Indicates negligible removal.

Oil skimming is also used at foundry facilities to remove the oil and grease that results from housekeeping and from machinery leaks.

Another common control method used extensively in the foundry industry is the recycling of wastewater. Most processes have facilities that recycle 100% of the wastewater and can be classified as zero dischargers. Processes can also recycle less than 100% of the wastewater; these normally treat the non-recycled wastewater before discharge.

Tables 8.6-13 through 8.6-20 (Sections II.8.6.3.1 through II.8.6.3.5) present pollutant removability data for each foundry subcategory. This information is the result of a screening program. No data are currently available concerning the treatability of wastewater emanating from the magnesium or lead foundry subcategories.

II.8.6.5 REFERENCES

1. Foundry Industry (Contractor's Draft Report). Contract 68-01-4379, U.S. Environmental Protection Agency, Washington, D.C., May 1979.

2. NRDC Consent Decree Industry Summary - Foundries.

II.8.10 PORCELAIN ENAMELING

II.8.10.1 Industry Description

II.8.10.1.1 General Description [1, 2]

The porcelain enameling industry consists of approximately 130 plants enameling approximately 200 million square meters of steel, iron, aluminum, and copper each year (each coat of multiple coats is considered in this total). Porcelain enameling is the application of glass-like coatings to the metals mentioned above. The purpose of the coating is to improve resistance to chemicals, abrasion, and water, and to improve thermal stability, electrical resistance, and appearance. The coating applied to the metal, called a "slip," is composed of one of many combinations of frits (glassy raw materials), clays, coloring oxides, water, and special additives such as suspending agents. These vitreous inorganic coatings are applied to the metal by a variety of methods such as spraying, drying, and flow coating and are bonded to the metal at temperatures over 500°C.

Several processes are used in the porcelain enameling industry regardless of the metal being coated. These processes, discussed below, include preparation of the enamel slip, surface preparation of the base material, and enamel application and firing to fuse the coating to the metal.

Enamel Slip Preparation. The preparation of the enamel slip includes ball milling the frit and raw materials to the appropriate consistency. Frit is the glassy raw material that makes up the backbone of porcelain enameling. Most frit is manufactured outside the operation but some plants do include captive operations. Other raw materials, such as clay, gums, or opacifiers, are mixed into the frit by the ball mill, which then releases this mixture to the coating operation.

Base Material Surface Preparation. In order for the porcelain enamel to form a good bond with the workpiece, the base metal to be coated must be properly prepared. Depending on the type of metal being finished, one or more preparation processes are performed. Solvent cleaning removes oil, greases, and fingerprints from the metal by exposing it to nonflammable solvents such as trichloroethylene or 1,1,2-trichloroethane at their boiling points. This process may also be combined with water to provide a two-phase cleaning system for solvent-soluble and water-soluble contaminants.

Alkaline cleaning removes oils and soils from the workpieces by the detergent nature of the solution. Soaking, spraying, and electrolytic alkaline cleaning are the common methods used, with the electrolytic process providing the cleanest surface. If aluminum is the metal being coated, a stronger alkaline solution is often used as a mild etch that removes the surface oxides.

Acid treatment is used to remove rust, scale, and oxides from the base and may be carried out in the form of acid cleaning, pickling, or etching. Each option involves a slightly stronger acid solution. Generally, sulfuric acid is used for this treatment, although other acids may be employed.

Nickel deposition is a common step when enameling steel in order to improve the bonding of the enamel to the metal. Nickel is normally deposited after the part has been acid treated and rinsed. Neutralization normally follows acid pickling and nickel deposition to remove the last traces of acid left on the metal. Chromate cleaning and grit blasting may also be used to prepare the base metal prior to the coating process. When used, grit blasting is normally the sole preparation step because it cleans the metal and roughens the surface, providing a good base for bonding.

Enamel Application and Firing. Once the workpiece has undergone the proper base metal preparation and the enamel slip has been prepared, the next step is the actual application of the porcelain enamel. Included among the application methods are air spraying, electrostatic spraying, dip coating, flow coating, powder coating, and silk screening. After each coating is applied the part is fired in a furnace to achieve a fusion between the enamel coating and the base metal or substrate.

Air spraying is the most widely used method for enamel application. In this process the enamel is atomized and propelled by air onto the base metal to form an enamel coating. Overspraying is a common problem with this technique since the atomized particles may not adhere to the part. Spray booths to collect this oversprayed enamel are necessary. A modification of this technique is the electrostatic spray coating method where the atomized particles are charged at 70,000 to 100,000 volts and directed toward the grounded part. This charge increases the adhering efficiency but does not eliminate the need for the spray booth collectors. Other advantages such as edging and the coating of both sides at once are also seen.

Dip coating consists simply of dipping the workpiece in an enamel bath and allowing it to drain. Flow coating floods the piece with enamel and then recycles the unused, recovered enamel. Powder coating is the dusting of a red hot cast iron workpiece with porcelain enamel in the form of a dry powder. The glass powder melts as it strikes the hot surface. Silk screening is used to apply a decorative pattern on a porcelain enameled piece.

Porcelain enameling plants are located primarily in the states of Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, Kentucky, and Tennessee. Seventy-seven percent of the facilities discharge to POTW's, 21% to streams or rivers, and 2% to both. Approximately 10% of the plants recycle, with an average recycle of 9.6 m^3/hr, which represents 46% of the average process water usage rate of 20.8 m^3/hr. Average plant production is approximately 1.5 x 10^6 m^2/yr.

Table 8.10-1 presents an industry summary of the number of subcategories and the number and type of dischargers for this industry.

TABLE 8.10-1. INDUSTRY SUMMARY [2]

Industry: Porcelain Enameling

Total Number of Subcategories: 4

Number of Subcategories Studied: 4

Number of Dischargers in Industry:
- Direct: 30
- Indirect: 100
- Zero: 0

II.8.10.1.2 <u>Subcategory Descriptions</u> [1]

The porcelain enameling industry consists of four subcategories, porcelain enameling on: steel, iron, aluminum, and copper. This subcategorization was chosen on the basis of the base metals used. Other possible subcategories (dependent on wastewater characterization, manufacturing processes, products, water use, etc.) were considered, but all were found to be directly related to the base metal used. In addition to the four subcategories selected, steel and aluminum base metals may be further divided into two segments, sheet and strip, to account for the significant water saving potential of continuous operations relative to individual sheet processing. However, because only two porcelain enameling facilities treat strip, no separate division is necessary at this time.

In general, only 10% of the porcelain enameling facilities enamel more than one type of base metal. Over 70% of the plants enamel solely on steel, 10% on aluminum, and 8% on iron. Less than 1% of the plants enamel copper, strip steel, or strip aluminum separately.

<u>Subcategory 1 - Porcelain Enameling on Steel</u>. Steel is by far the most widely used base metal for porcelain enameling with

an average yearly production usage of 1.9 x 10^8 m^2 (2.1 x 10^9 ft^2) for 1976. This figure represents the area of enamel applied. For multiple coats, the area for each coat is considered. Among the products which use porcelain enameled steel are the following: cooking and heating equipment such as ranges, home laundry equipment (washers and dryers), refrigerators, freezers, dishwashers, water heaters, process vessels, architectural panels, plumbing fixtures, and various appliance parts.

Several processes are used when enameling on steel. The parts to be coated are first alkaline cleaned and rinsed to remove soils. An acid treatment step and rinse follow in which sulfuric acid, ferric sulfate in conjunction with sulfuric acid, or muriatic acid are used for oxide removal. A nickel deposition step and rinse ensues, followed by a neutralization operation which removes any remaining traces of acid.

Following surface preparation and drying, the part is ready for the enamel application. Steel parts are either sprayed, dipped, or flow coated. The enamel slip can be applied in a single coating operation (referred to as direct-on), or a ground coat and a cover coat may be applied separately. For the direct-on process, corners and edges are usually reinforced (precoated) to ensure coverage. For either case, each coat is fired at a temperature of approximately 820°C (1,500°F). Total thickness of sheet steel enamels involving a ground coat and cover coat is in the range of 0.13 to 0.20 mm (5 to 9 mils).

When the direct-on process is utilized, surface preparation requirements are more critical to ensure effective enamel adhesion. The acid etch is often deeper and the nickel deposition is always thicker. Typically, the nickel coating is 0.10 to 0.20 g/ft^2 for direct-on coating as compared to 0.03 to 0.07 g/ft^2 for two-coat applications. A few porcelain enamelers prefer to omit the nickel deposition step. While the nickel enhances the enamel bonding, product quality requirements may not require nickel deposition. The omission of the nickel step necessitates the utilization of a heavy acid etch to ensure a clean, properly conditioned surface for enamel bonding.

<u>Subcategory 2 - Porcelain Enameling on Cast Iron</u>. Cast iron is porcelain enameled primarily for plumbing fixtures for the sanitary products industry. It is also used for cookware and for various appliance parts such as grates for gas ranges. The average yearly production for 1976 is estimated at 1.0 x 10^7 m^2 (1.1 x 10^8 ft^2). This figure represents the areas of enamel applied. For multiple coats, the area for each coat is considered.

The porcelain enameling of cast iron is a process in which water is not generally used for metal preparation but is sometimes used for coating application. The casting to be coated is blasted with sand or a combination of grit and sand to produce a smooth, velvety surface. The parts are then brushed off and any rough edges are removed by grinding.

The ground coat is then applied by spraying, dipping, or flow coating. If only one coat is required, a heavy ground coat is applied. If there is to be a ground coat and a top coat, a thin layer of enamel is used for the ground coat. The ground coat is then fired. The firing period is longer than for sheet steel because of the greater mass of the enameled body, and firing temperature is reduced to avoid excessive baking. When the cast is removed from the furnace and still red hot, the top coat is applied by powder coating. The enamel in powder form is dusted on the hot part and fuses to the surface. Total thickness of dry process coatings is approximately 0.50 mm (20 mils).

Subcategory 3 - Porcelain Enameling on Aluminum. Porcelain enameling on aluminum finds use in the cookware and housewares industry. It is also used for panels and signs. The estimated yearly production for 1976 is 4.7 x 10^6 m^2 (5.0 x 10^7 ft^2). This figure represents the area of enamel applied. For multiple coats, the area for each coat is considered.

Although all aluminum parts can be coated in a similar fashion, the surface preparation can vary from company to company. The choice of surface preparation methodology is based upon the alloy type of the base metal and the cleanliness requirements involved. Pure aluminum requires only a cleaning step. A heat treatable alloy may require a pickling step in addition to cleaning. Porcelain enameling on a high magnesium alloy could necessitate a chromate cleaning process. This chromate coating retards the oxidation of the magnesium in this high strength alloy.

Nearly all aluminum parts are first treated in an alkaline solution. In some cases this is only a cleaner for removing grease and soils; sometimes it is a mild etchant to remove a layer of metal and its oxides. Frequently, this is all the surface preparation that is necessary. Any further preparation steps are to remove residual oxides (example: chemical deoxidizing with nitric acid) or to impart a thin protective layer on the metal (alkaline chromate treatment). The users of such processes were limited in the plants studied [1].

Aluminum does not require a ground coat. Enamel is generally applied by spraying, with firing accomplished by heating to 450°C to 550°C (850°F to 1,040°F) for 2 to 10 minutes.

Subcategory 4 - Porcelain Enameling on Copper. Porcelain enameling on copper represents a very small part of the porcelain enameling category. It is not practiced by many firms and the ones involved with it do it on a small scale. Enameled copper is used mostly for ornamental purposes, such as jewelry, decorative ware, and metal sculpture.

Since it is essential to remove all the oil and grease on the copper before coating, the part is first alkaline cleaned, degreased, or annealed. After cleaning, the part is then typically pickled for oxide removal.

The enamel application involves two processes: a ground coat or backing coat, and a cover coat to prevent the copper base from being taken into solution with the enamel and causing discoloration. This ground coat is applied by either spraying or dipping. The cover coat can be applied by powder coating or with silk screening to achieve patterns.

Other Subdivisions - In addition to the above subcategories, porcelain enameling on continuous strip is a subdivision within this industry. However, because there are only two plants in the United States producing this product, a separate subcategory is not necessary. These plants start with coils of steel, aluminum, or aluminized steel, porcelain enamel them, and either recoil them for sale to metal fabricators or shear them into pieces for use as architectural panels or chalkboards. The estimated production for 1976 is 2.0×10^6 m^2 (2.2×10^7 ft^2). This figure represents the area of enamel applied. For multiple coats, the area for each coat is considered.

The surface preparation operations for strip are dependent upon whether the basis material is steel or aluminum. The surface preparation steps for steel strip are minimal in comparison to porcelain enameling on steel sheets since precleaned strip steel is used. Steel strip is nickel immersion plated prior to the enameling step. Surface preparation for aluminum involves only cleaning. The enamel for either basis material is applied by means of spray guns which are aimed at the surface of the moving strip. Two coats are normally applied, the strip being fired after each coat.

II.8.10.2 Wastewater Characterization [1]

This section presents water uses and discharges, and waste constituents emanating from the porcelain enameling category. Published literature, data collection portfolio (dcp) responses, and sampling data have been used to obtain the relevant information. The majority of the waste constituent data result from a sampling program in which plants were sampled downstream of the porcelain enameling process but prior to any treatment for a 3-day sampling period.

Table 8.10-2 presents wastewater flow data on a subcategory and stream basis for the porcelain enameling industry.

TABLE 8.10-2. WASTEWATER FLOWS FROM THE PORCELAIN ENAMELING INDUSTRY [1]

Stream	Number of points	Wastewater flow, m^3/day Range	Median	Mean
P/E on steel				
Alkaline cleaning	15	9.4 - 120	30	45
Acid treatment	15	5.7 - 44	20	20
Nickel deposition	9	19 - 30	24	23
Neutralization	5	1.0 - 15	15	11
Coating	15	1.9 - 300	4.0	70
Total raw waste	15	20 - 410	180	150
P/E on iron				
Coating	7	0.64 - 7.2	1.2	2.9
P/E on aluminum				
Alkaline cleaning	8	19 - 220	170	130
Coating	8	4.8 - 55	30	29
Total raw waste	8	68 - 220	200	160
P/E on copper				
Acid pickling	2	7.3		7.3
Coating	3	0.64 - 1.3	0.64	0.85
Total raw waste	3	1.3 - 7.9	7.9	5.7

Note: Blanks indicate insufficient data available.

Subcategory 1 - Porcelain Enameling on Steel. Wastewater from porcelain enameling on steel is generated by base metal surface preparation, enamel application, ball milling, and related operations. The constituents in the wastewater include the base material being coated (iron), as well as the components of the surface treatment solutions and enamels being applied.

Water rinses are used in surface preparation operations such as acid pickling, alkaline cleaning, and nickel deposition to remove any process solution film left from the previous bath. A water rinse may also follow the neutralization step. Another common water use is in the ball milling process, which uses water as the vehicle for the enamel ingredients, as a cooling medium, and for cleaning up the equipment. Coating application processes normally employ wet spray booths to capture oversprayed enamel particles. Water wash spray booths use a water curtain into which the enamel particles are blown and captured.

The major sources of waste generated by this subcategory are the process solutions used in basis material preparation, the base metal being coated, and the enamel being prepared. Alkaline cleaning solution varies with the type of soil being removed. Wastewaters from this operation contain constituents of the cleaning solution as well as oil and greases. Wastewater also contain iron but in lesser concentrations than those from the acid pickling process. Alkaline cleaning wastes enter the waste-stream in three ways: during the rinse step, from the cleaning bath overflow, and in the batch dump of the spent alkaline bath.

Acid treatment is typically sulfuric acid with lesser amounts of hydrochloric, phosphoric, and nitric acids being used. Acid solutions develop a high metallic content due to the dissolution of the steel itself during the pickling operation. As a result, the baths are frequently dumped, putting large amounts of iron into the wastestream. Also present in significant concentrations are phosphorus and manganese. The stream has a low pH as well.

Nickel deposition can place large amounts of nickel and iron into the wastestream by batch dumping and dragout. The neutralization step eases the pH burden and adds little additional loading of any pollutant.

The introduction of enamel into the wastestream results in an increase in the concentration of metals, but these metals (antimony, titanium, zirconium, tin, cobalt, and manganese) are in solid form while the metals generated by surface preparation are normally in dissolved form. These solid metals increase the suspended solids concentration of the stream. Other metals that may be found in the enamel preparation and application wastestream in significant amounts include aluminum, copper, iron, lead, nickel, and zinc. Table 8.10-3 presents pollutant sampling data for the processes used in the porcelain enameling on steel industry. The not detected values have been excluded from the calculation of the ranges, medians, and averages throughout this section.

Subcategory 2 - Porcelain Enameling on Iron

There are two different types of cast iron porcelain enameling: wet process and dry process. The dry process uses no water and does not produce wastewater. Wet process enameling of cast iron employs water for ball milling and enamel application. These processes are very similar to the ones described for the steel subcategory. Surface preparation involves sand or grit blasting and uses water only in an air scrubber operation. Ball milling uses water as a vehicle for the enamel slip ingredients, as cooling water, and for equipment cleanup. Coating application uses water as a trap for the excess enamel particles during the spray step. Wastewater constituents in significant concentrations in the streams emanating from this subcategory include suspended solids, aluminum, iron, copper, lead, manganese, nickel, titanium, zinc, and cobalt. All of these metals are the result of the enamel carryover via spray booth blowdown or ball mill washdown.

Table 8.10-4 presents wastewater characterization data for the streams in this subcategory.

TABLE 8.10-3. WASTEWATER CHARACTERIZATION OF THE PORCELAIN ENAMELING ON STEEL SUBCATEGORY [1]

Pollutant	Number of samples	Number not detected	Range, mg/L[a]	Median, mg/L[a]	Average mg/L[a]	Number of samples	Number not detected	Range, mg/L[a]	Median, mg/L[a]	Average, mg/L[a]
	Alkaline cleaning					Acid treatment				
Conventional parameters										
TSS	14	0	6 2 - 650	44	147	13	0	1 9 - 140	10	18
Total phosphorus	13	1	1 1 - 27	7 1	4 3	6	0	7 1 - 12	8 9	9 4
Total phenols	13	1	0.006 - 0 69	0 018	0 081	9	4	0 015 - 0 043	0 027	0.028
Oil and grease	5	0	12 - 63	16	32	4	0	2 - 17	4 2	6 8
pH	14	0	2 -11	8.35	7 6	14	0	2 - 3 4	2 3	2.4
Fluorides	15	0	0.26 - 1.8	0 94	0.91	15	0	0 14 - 1 1	0 72	0 61
Toxic pollutants										
Metals and inorganics										
Antimony	15	15			0	15	15			0
Arsenic	15	15			0	15	15			0
Beryllium	15	15			0	15	15			0
Cadmium	15	12	0.005 - 0.084	0 018	0.036	15	15			0
Chromium	14	10	0.004 - 0.01	0.006	0.006	15	0	0.011 - 3.1	0.32	0 79
Copper	15	2	0.002 - 0.22	0 071	0.040	15	0	0.006 - 0.38	0.064	0 092
Cyanide	5	5			0	8	4			0
Lead	15	15			0	15	11	0.05 - 0.1	0 072	0.074
Nickel	13	9	0.014 - 0.063	0.021	0.030	15	3	0.60 - 11	2.4	4.2
Selenium	15	14		0.003	0.003	15	15			0
Zinc	14	2	0.013 - 0.81	0.029	0.10	15	0	0.017 - 0.25	0 091	0 11
Organics										
Toluene	3	3			0	3	3			0
1,2-Dichlorobenzene										
Chloroform										
Dichlorobromomethane										
1,1,2,2-Tetrachloroethane										
Tetrachloroethylene										
Nontoxic inorganics										
Aluminum	15	3	0.081 - 0.92	0.15	0.23	15	5	0.054 - 0.52	0.22	0.23
Iron	12	0	0.10 - 8.3	1.6	2.9	15	0	180 - 10,000	1,300	2,600
Manganese	13	3	0.066 - 0.36	0.16	0.19	15	0	0.57 - 53	3 4	11
Titanium	15	15			0	15	15			0
Cobalt	15	14		0.001	0.001	15	0	0.017 - 0.38	0.036	0.121
	Nickel deposition					Neutralization				
Conventional parameters										
TSS	7	0	2 - 77	4	20	3	0	8.0 - 9.0	9 0	8.7
Total phosphorus	6	0	1.1 - 8.3	4.4	4.5	4	1	0.04 - 7 5	0.38	2.6
Total phenols	6	1	0.008 - 0.042	0.029	0.028	3	0	0.004 - 0 024	0 004	0 011
Oil and grease	4	0	1 - 18	4.9	7 2	3	0	3 - 3.8	3 3	3.4
pH	8	0	2.0 - 6.2	2.7	3.3	4	0	8.4 - 9.0	9 0	8.9
Fluorides	9	0	0.27 - 0.80	0 50	0.51	4	0	0.32 - 1.1	0 42	0.55
Toxic pollutants										
Metals and inorganics										
Antimony	9	9			0	4	4			0
Arsenic	9	9			0	4	4			0
Beryllium	9	9			0	4	4			0
Cadmium	9	9			0	4	4			0
Chromium	9	0	0 019 - 0 13	0 044	0 060	4	2	0.012 - 0.032		0.022
Copper	9	0	0 008 - 0 079	0 019	0 032	4	3		0 014	0 014
Cyanide	4	4			0	3	3			0
Lead	9	9			0	4	4			0
Nickel	9	0	2 9 - 280	8 7	73	4	0	0.075 - 9 4	0 17	2 5
Selenium	9	9			0	4	4			0
Zinc	9	0	0 036 - 0 27	0 073	0 10	4	0	0 011 - 0 025	0 012	0 015

(continued)

TABLE 8.10-3 (continued)

Pollutant	Number of samples	Number not detected	Range mg/L[a]	Median mg/L[a]	Average mg/L[a]	Number of samples	Number not detected	Range, mg/L[a]	Median mg/L[a]	Average mg/L[a]
	Nickel deposition					Neutralization				
Toxic pollutants										
Organics										
Toluene										
1,2-Dichlorobenzene						4	4			
Chloroform										
Dichlorobromomethane										
1 1 2 2-Tetrachloroethane										
Tetrachloroethylene										
Nontoxic inorganics										
Aluminum	9	6	0 19 - 0 33	0 28	0 27	4	3		0 34	0 34
Iron	9	0	57 - 1,100	170	400	4	0	1 8 - 44	3 5	13
Manganese	9	0	0 27 - 7 6	1 4	2 8	4	0	0 24 - 0 25	0 032	0 085
Titanium	9	9			0	4	4			0
Cobalt	9	0	0.010 - 0 37	0 049	0 12	4	4			0
	Coating					Total raw waste				
Conventional parameters										
TSS	15	0	360 - 320,000	14,000	40,000	12	0	66 - 16,000	1,700	3,600
Total phosphorus	13	0	0 49 - 9.8	1.5	2 8	6	0	3.8 - 13	6.1	6.9
Total phenols	15	5	0 010 - 0 028	0 017	0 018	12	1	0 006 - 0 29	0 019	0 049
Oil and grease	9	0	2 - 98	12	27	4	0	3.8 - 38	34	27
pH	15	0	7 - 12.5	8 6	8 8	12	0	2 - 12 5	5 8	6 1
Fluorides	15	0	15 - 115	46	50	14	0	1.3 - 30	7 7	11
Toxic pollutants										
Metals and inorganics										
Antimony	15	7	1.6 - 1,000	3.9	130	14	7	0.098 - 22	2 7	5.9
Arsenic	15	10	0 25 - 3.5	0.42	1 5	14	9	0.005 - 2.5	0.056	0 96
Beryllium	15	10	0.035 - 0.12	0.059	0.065	14	9	0.001 - 0 008	0 005	0 005
Cadmium	15	6	0 097 - 9 6	0 76	2 5	14	3	0.0 - 0.59	0.032	0 088
Chromium	15	0	0 005 - 37	0.21	2.8	13	0	0.022 - 0 84	0.075	0 18
Copper	15	0	0.26 - 55	3 0	7.2	14	0	0.034 - 2.2	0.40	0 59
Cyanide	9	8	0.055	0 055	0 055	4	4			0
Lead	15	2	0.18 - 11	2 3	3 3	14	1	0 004 - 0.69	0.19	0 26
Nickel	15	0	1 8 - 360	22	44	12	0	1.4 - 32	6 9	11
Selenium	15	5	0.12 - 17	0 79	4.0	14	4	0.001 - 13	0 042	2.6
Zinc	15	0	1 1 - 1,300	58	170	13	0	0.078 - 45	6 8	14
Organics										
Toluene	30	3			0	2	2			0
1,2-Dichlorobenzene	3	3			0					
Chloroform	3	3			0					
Dichlorobromomethane	3	3			0					
1,1,2,2-Tetrachloroethane	3	3			0					
Tetrachloroethylene	3	3			0					
Nontoxic inorganics										
Aluminum	15	0	5 2 - 1,500	100	230	14	0	0.45 - 210	18	33
Iron	15	0	2 6 - 620	24	77	11	0	53 - 670	160	300
Manganese	15	0	1 8 - 400	29	79	12	0	0 53 - 61	6 4	12
Titanium	15	0	5 8 - 1,600	100	310	14	0	0 17 - 1,200	14	110
Cobalt	15	0	0 31 - 350	13	52	14	0	0 19 - 9 2	2 4	3 5

Note Blanks, when not associated with a number of samples indicate no data available

[a]Except pH values, given in pH units

TABLE 8.10-4. WASTEWATER CHARACTERIZATION OF THE PORCELAIN ENAMELING ON CAST IRON SUBCATEGORY [1]

	Coating				
Pollutant	Number of samples	Number not detected	Range, mg/L[a]	Median, mg/L[a]	Average, mg/L[a]
Conventional parameters					
TSS	7	0	6,600 - 81,000	19,000	27,000
Total phosphorus	7	1	0.49 - 2.1	0.93	1.1
Total phenols	6	0	0.008 - 0.038	0.017	0.020
Oil and grease	3	0	1.0 - 9.5	3.7	4.7
pH	7	0	7.9 - 11.4	9.4	9.4
Fluorides	7	0	2.0 - 115	23	41
Toxic pollutants					
Metals and inorganics					
Antimony	7	6		6.0	6.0
Arsenic	7	4	1.9 - 2.8	2.4	2.4
Beryllium	7	3	0.002 - 0.12	0.036	0.049
Cadmium	7	3	0.014 - 9.6	0.59	2.7
Chromium	7	0	0.0 - 1.1	0.21	0.43
Copper	7	0	0.001 - 8.8	0.42	2.6
Cyanide	3	2		0.009	0.009
Lead	7	0	0.49 - 880	7.6	170
Mercury	1	0		0.001	0.001
Nickel	7	3	0.25 - 67	33	33
Selenium	7	0	0.43 - 160	9.3	29
Silver	1	1			0
Thallium	1	1			0
Zinc	7	1	0.68 - 650	9.0	127
Nontoxic inorganics					
Aluminum	7	0	0.38 - 1,200	240	340
Barium	1	1			0
Boron	1	0		0.157	0.157
Iron	6	1	18 - 150	38	56
Magnesium	1	0		3.1	3.1
Manganese	7	0	0.003 - 65	2.2	15
Molybdenum	1	0		0.037	0.037
Tin	1	0		0.033	0.033
Titanium	7	3	0.022 - 100	37	44
Gold	1	1			0
Sodium	1	1			0
Calcium	1	1			0
Cobalt	7	0	0.044 - 95	8.9	24

Note: Blanks indicate insufficient data available.

[a]Except pH values, given in pH units.

Subcategory 3 - Porcelain Enameling on Aluminum

Wastewaters from this subcategory come from surface preparation, enamel application, ball milling, and related operations. Constituents of this wastewater include aluminum and components of the surface preparation solutions and the enamels being applied.

Water is used in this subcategory as solution makeup and for rinsing in the surface preparation process, as the vehicle for the coating in the application process (normally done by spray coating), and for cooling and cleanup in the ball milling operation.

The surface preparation process contributes pollutants to the wastewater by the continuous overflow of the cleaning bath (if a continuous process), by the batch dumping of spent solutions, and by the rinsing steps directly following the process. Generally, significant quantities of dirt and grease are removed during this cleaning process. Also entering the wastestream is a considerable amount of aluminum. When an alkaline cleaning process is used the wastewater contains significant concentrations of suspended solids, phosphorus, and aluminum. Acids used to deoxidize the surface normally remove a larger amount of aluminum than alkaline treatments and therefore increase the dissolved aluminum concentration. The enamel preparation and application steps contribute significant amounts of suspended solids and metals, particularly cadmium, lead, titanium, zinc, aluminum, barium, iron, selenium, and antimony due to use of these metals in the enamel itself. There are also high levels of fluorides and phosphorus.

Table 8.10-5 presents conventional and toxic pollutant concentrations for the porcelain enameling on aluminum subcategory.

Subcategory 4 - Porcelain Enameling on Copper

Wastewater from this subcategory is generated as in the previous subcategories; by surface preparation, enamel application, ball milling, and related operations. Wastewater constituents generally consist of copper and the components used to form the enamel.

Water is used to rinse the workpieces after various operations, as a constituent of the enamel slip, in spray booths, and in cleaning, cooling and air scrubbing. Pollutants such as dirt and greases enter the wastestream from the surface preparation and rinsing steps. Acid pickling adds dissolved copper to the wastestream. Enamel preparation and application may add high concentrations of aluminum, titanium, manganese, nickel, zinc, and cobalt, as well as fluorides, antimony, copper, lead, and iron.

Table 8.10-6 gives conventional and toxic pollutant concentrations for the porcelain enameling on copper subcategory on a stream basis.

TABLE 8.10-5. WASTEWATER CHARACTERIZATION OF THE PORCELAIN ENAMELING ON ALUMINUM SUBCATEGORY [1]

Pollutant	Number of samples	Number not detected	Range, mg/L[a]	Median, mg/L[a]	Average, mg/L[a]
			Alkaline cleaning		
Conventional parameters					
TSS	8	0	1.0 - 180	17	40
Total phosphorus	8	0	0.41 - 24	9.4	8.5
Total phenols	8	1	0.005 - 0.016	0.007	0.008
Oil and grease	8	4	3 - 11	6.7	6.9
pH	8	0	6.3 - 10.4	8.8	8.7
Fluorides	8	0	0.72 - 0.98	0.91	0.88
Toxic pollutants					
Metals and inorganics					
Antimony	8	8			0
Arsenic	8	8			0
Beryllium	8	8			0
Cadmium	8	7		0.003	0.003
Chromium	8	6	0.007 - 0.018		0.012
Copper	8	6	0.021 - 0.056		0.038
Cyanide	8	6	0.015 - 0.18		0.095
Lead	8	6	0.040 - 4.3		2.2
Nickel	8	8			0
Selenium	8	8			0
Zinc	8	1	0.019 - 0.54	0.17	0.21
Organics					
Bis(2-ethylhexyl) phthalate	8	8			0
Di-n-octyl phthalate	8	8			0
Toluene	3	3			0
Nontoxic inorganics					
Aluminum	8	1	0.68 - 26	4.5	6.6
Barium	8	8			0
Iron	8	0	0.013 - 0.33	0.059	0.097
Manganese	8	5	0.019 - 0.18	0.14	0.11
Titanium	8	8			0
Cobalt	8	8			0
			Coating		
Conventional parameters					
TSS	8	0	55 - 650	320	330
Total phosphorus	8	0	0.38 - 65	1.3	9.8
Total phenols	8	3	0.005 - 0.018	0.008	0.010
Oil and grease	8	5	2.3 - 4.7	3.3	3.4
pH	8	0	7.0 - 10	9.0	8.9
Fluorides	8	0	0.92 - 1.9	0.94	1.2
Toxic pollutants					
Metals and inorganics					
Antimony	8	6	0.21 - 0.36		0.29
Arsenic	8	8			0
Beryllium	8	8			0
Cadmium	8	1	0.29 - 54	5.0	11
Chromium	8	0	0.008 - 0.039	0.027	0.024
Copper	8	2	0.005 - 0.18	0.030	0.057
Cyanide	8	7		0.002	0.002
Lead	8	0	3.5 - 38	9.1	15
Nickel	8	8			0
Selenium	8	4	0.53 - 7.1	0.65	2.2
Zinc	8	0	0.15 - 2.0	0.66	0.74

(continued)

TABLE 8.10-5 (continued)

Pollutant	Number of samples	Number not detected	Range, mg/L[a]	Median, mg/L[a]	Average, mg/L[a]
			Coating		
Toxic pollutants (continued)					
Organics					
Bis(2-ethylhexyl) phthalate	8	8			0
Di-n-octyl phthalate	8	8			0
Toluene	3	3			0
Nontoxic inorganics					
Aluminum	8	0	0.25 - 2.1	0.36	0.62
Barium	8	0	0.11 - 1.4	0.36	0.59
Iron	8	0	0.11 - 0.94	0.19	0.33
Manganese	8	6	0.003 - 0.011		0.007
Titanium	8	0	3.1 - 30	6.0	10
Cobalt	8	7		0.029	0.029
			Total raw waste		
Conventional parameters					
TSS	8	0	12 - 190	93	105
Total phosphorus	8	0	0.88 - 24	9.5	9.3
Total phenols	8	0	0.0 - 0.015	0.007	0.007
Oil and grease	8	3	1.7 - 11	4.5	5.8
pH	8	0	6.3 - 10.4	8.8	8.7
Fluorides	8	0	0.74 - 0.98	0.92	0.89
Toxic pollutants					
Metals and inorganics					
Antimony	8	6	0.15 - 0.26		0.21
Arsenic	8	8			0
Beryllium	8	8			0
Cadmium	8	1	0.007 - 5.2	2.3	2.2
Chromium	8	0	0.001 - 0.013	0.006	0.006
Copper	8	2	0.0 - 0.13	0.046	0.048
Cyanide	8	6	0.005 - 0.14		0.073
Lead	8	0	0.15 - 12	3.1	3.9
Nickel	8	8			0
Selenium	8	4	0.11 - 0.63	0.44	0.40
Zinc	8	0	0.12 - 0.53	0.33	0.30
Organics					
Bis(2-ethylhexyl) phthalate	8	8			0
Di-n-octyl phthalate	8	8			0
Toluene	3	3			0
Nontoxic inorganics					
Aluminum	8	0	0.077 - 10	2.7	3.8
Barium	8	0	0.010 - 0.24	0.039	0.10
Iron	8	0	0.017 - 0.71	0.17	0.24
Manganese	8	3	0.002 - 0.13	0.018	0.046
Titanium	8	0	0.093 - 6.1	2.1	2.6
Cobalt	8	1	0.006	0.006	0.006

Note: Blanks indicate insufficient data available.

[a]Except pH values, given in pH units.

TABLE 8.10-6. WASTEWATER CHARACTERIZATION OF THE PORCELAIN ENAMELING ON COPPER SUBCATEGORY [1]

Pollutant	Number of samples	Number not detected	Range, mg/L[a]	Median, mg/L[a]	Average, mg/L[a]
			Acid pickling		
Conventional parameters					
TSS	2	0	14 - 24		19
Total phosphorus	2	1		0.52	0.52
Total phenols	2	1		0.006	0.006
Oil and grease	1	0		200	200
pH	2	0	6.2 - 6.6		6.45
Fluorides	2	0	0.11 - 0.12		0.12
Toxic pollutants					
Metals and inorganics					
Antimony	2	2			0
Arsenic	2	2			0
Beryllium	2	2			0
Cadmium	2	2			0
Chromium	2	0	0.008 - 0.009		0.008
Copper	2	0	9.7 - 12		11
Cyanide	2	2			0
Lead	2	2			0
Nickel	2	2			0
Selenium	2	2			0
Zinc	2	0	0.049 - 0.22		0.13
Organics					
1,2-Dichlorobenzene					
Toluene	2	2			0
Chloroform	2	2			0
Dichlorobromomethane	2	2			0
1,1,2,2-Tetrachloroethane	2	2			0
Tetrachloroethylene	2	2			0
Nontoxic inorganics					
Aluminum	2	0	0.050 - 0.17		0.11
Iron	2	0	0.15 - 51		26
Manganese	2	0	0.010 - 0.019		0.014
Titanium	2	2			0
Cobalt	2	2			0
			Coating		
Conventional parameters					
TSS	3	0	14,000 - 94,000	31,000	46,000
Total phosphorus	1	0		1.0	1.0
Total phenols	3	3			0
Oil and grease	3	0	2.0 - 98	10	37
pH	3	0	7.6 - 10.1	8.7	8.8
Fluorides	3	0	46 - 66	56	56
Toxic pollutants					
Metals and inorganics					
Antimony	3	0	1.6 - 3.5	2.4	2.5
Arsenic	3	2		0.42	0.42
Beryllium	3	1	0.035 - 0.059		0.047
Cadmium	3	0	0.097 - 0.26	0.22	0.19
Chromium	3	0	0.20 - 0.63	0.30	0.38
Copper	3	0	4.7 - 7.1	5.9	5.9
Cyanide	3	2		0.055	0.055
Lead	3	0	2.3 - 4.8	4.8	4.0
Nickel	3	0	38 - 49	40	42
Selenium	3	0	0.51 - 0.81	0.77	0.70
Zinc	3	0	58 - 200	82	110

(continued)

TABLE 8.10-6 (continued)

Pollutant	Number of samples	Number not detected	Range, mg/L[a]	Median, mg/L[a]	Average, mg/L[a]
			Coating		
Toxic pollutants (continued)					
Organics					
1,2-Dichlorobenzene	1	1			0
Toluene	3	3			0
Chloroform	3	0	0.00	0.00	0.00
Dichlorobromomethane	3	1	0.00		0.00
1,1,2,2-Tetrachloroethane	3	1	0.00		0.00
Tetrachloroethylene	3	1			0
Nontoxic inorganics					
Aluminum	3	0	100 - 200	180	160
Iron	3	0	15 - 29	16	20
Manganese	3	0	64 - 120	85	89
Titanium	3	0	120 - 560	220	300
Cobalt	3	0	48 - 64	51	54
			Total raw waste		
Conventional parameters					
TSS	3	0	1,100 - 94,000	2,500	33,000
Total phosphorus	1	0		0.080	0.080
Total phenols	3	2		0.006	0.006
Oil and grease	2	0	2 - 190		95
pH	3	0	6.2 - 10.1	8.1	7.8
Fluorides	3	0	3.8 - 56	5.4	22
Toxic pollutants					
Metals and inorganics					
Antimony	3	0	0.13 - 2.4	0.28	0.92
Arsenic	3	2		0.42	0.42
Beryllium	3	1	0.005 - 0.035		0.020
Cadmium	3	0	0.008 - 0.22	0.021	0.083
Chromium	3	0	0.023 - 0.63	0.032	0.23
Copper	3	0	7.1 - 12	9.3	9.3
Cyanide	3	2		0.004	0.004
Lead	3	0	0.19 - 4.8	0.38	1.8
Nickel	3	0	3.1 - 49	3.2	18
Selenium	3	0	0.041 - 0.81	0.062	0.30
Zinc	3	0	4.8 - 200	6.6	69
Organics					
1,2-Dichlorobenzene					
Toluene	3	3			0
Chloroform	3	0	0.00	0.00	0.00
Dichlorobromomethane	3	0	0.00	0.00	0.00
1,1,2,2-Tetrachloroethane	2	0	0.00		0.00
Tetrachloroethylene	3	1	0.00		0.00
Nontoxic inorganics					
Aluminum	3	0	8.1 - 200	15	73
Iron	3	0	1.4 - 48	29	26
Manganese	3	0	5.2 - 120	6.9	43
Titanium	3	0	9.7 - 560	18	190
Cobalt	3	0	3.9 - 64	4.1	24

Note: Blanks, when not associated with a number of samples, indicate no data avilable.

[a]Except pH values, given in pH units.

II.8.10.3 Plant Specific Description [1]

Only a limited amount of information is available on specific plants within this industry. This section describes the treatment practice and wastewater composition at five plants: three that enamel on steel, one on aluminum, and one on strip steel. The major treatment operation employed is a settling technique. Treatment operations are not necessarily listed in this narrative in the same order that they are used at the plants. Wastewater composition data were obtained from verification sampling.

Porcelain Enameling on Steel

Plant 33617. This facility produces approximately 1.56 x 10^7 m^2/yr of porcelain enameled steel and uses 0.009 m^3 of water/m^2 of product for this production. Average process water flow rate is 23 m^3 of water/hr. The mixed wastestream (combined with other process wastes) is treated by several treatment methods including settling, pH adjustment by lime and/or acid, equalization, inorganic coagulation, clarification, sedimentation lagooning, ultrafiltration, and contract removal of the oil sludge. Discharged water is released to a surface stream.

Plant 40063. This plant produces 370 m^2/hr of porcelain enameled steel and uses 0.031 m^3 of water/m^2 of product in the process. Average process water flow rate is 11.7 m^3 of water/hr. The treatment facility treats only the process wastewater and consists of equalization, pH adjustment with lime, polyelectrolyte coagulation, clarification, vacuum filtration, and sludge landfill. Discharge is to a surface waterway.

Plant 47033. This plant produces 1.4 x 10^6 m^2/yr of porcelain enameled steel and minor amounts of other products. Process water used per square meter of product is 0.06 m^3, and the flow rate is 44.7 m^3/hr. The unmixed wastestream is discharged to a municipal treatment works after undergoing equalization, settling, pH adjustment with caustic, and contract removal of the sludge.

Table 8.10-7 gives the water use for each process in the production of porcelain enameled steel for the above plants. Pollutant concentrations for the raw and treated effluents are presented in Table 8.10-8.

Porcelain Enameling on Aluminum

Plant 33077. This facility produces 4.5 m^2/yr of porcelain enameled aluminum and uses 0.11 m^3 of process water/m^2 of product. The mixed wastewater stream is treated by equalization, settling, pH adjustment with lime and/or acid, polyelectrolyte coagulation, clarification, and contractor removal of the resulting sludge prior to discharge to a surface stream. Water use for

TABLE 8.10-7. WATER USE IN THE PORCELAIN ENAMELING ON STEEL SUBCATEGORY [1] (m^3 of water/m^2 product)

Process	Plant identification		
	33617	40063	47033
Alkaline cleaning	0.00094	0.0032	0.103
Acid treatment	0.00014	0.0026	0.0376
Nickel deposition	0.00033	0.0027	0.0208
Neutralization	0.00011	0.0016	0.0056
Ball milling	0.00004	0.0173	0.00102
Coating	0.00066	0.0112	-[a]

[a]Use of dip coating and spray coating in a dry booth.

TABLE 8.10-8. CONCENTRATIONS OF POLLUTANTS FOUND IN PORCELAIN ENAMELING ON STEEL FACILITIES[a] [1]

Pollutant	Raw wastewater, mg/L	Treated effluent, mg/L	Percent removal	Raw wastewater, mg/L	Treated effluent, mg/L	Percent removal	Raw wastewater, mg/L	Treated effluent, mg/L	Percent removal
	Plant 33617			Plant 40063			Plant 47033		
Conventional parameters									
TSS	1,660	16	99	3,600	13	99+	190	90	53
Total phosphorus	14	1.5	89	12	1.0	92	3.4	2.2	35
Toxic pollutants									
Metals and inorganics									
Antimony	ND	ND		10	ND	100	31	3.3	89
Arsenic	0.062	ND	100	6.9	ND	100	ND	ND	
Cadmium	0.005	ND	100	ND	ND		0.35	0.12	66
Chromium	0.570	ND	100	ND	ND		0.028	0.019	32
Copper	0.560	0.009	98	0.63	0.003	99+	0.15	0.031	79
Lead	0.28	ND	100	ND	ND		ND	ND	
Nickel	10.80	1.04	90	5.5	ND	100	1.0	0.77	23
Selenium	ND	ND		30	ND	100	ND	ND	
Zinc	2.78	0.032	99	16	0.044	99+	1.4	0.23	84
Nontoxic inorganics									
Aluminum	24	ND	100	28	0.35	99	4.9	0.55	89
Cobalt	4.1	0.08	98	4.7	ND	100	2.1	0.26	88
Iron	150	0.85	99	110	0.57	99	29	9.7	67
Manganese	6.0	0.35	94	210	0.012	99+	3.3	0.43	87
Titanium	2.0	ND	100	125	ND	100	3.3	0.22	93

Note: Blanks indicate insufficient data available.

[a]Treatment involves sedimentation.

this production consists of 0.14, 0.014, and 0.014 m^3 of water/m^2 of product for surface preparation, ball milling, and coating, respectively. Table 8.10-9 presents pollutant concentrations for the raw and treated effluents.

Porcelain Enameling on Strip Steel

Plant 36077. This plant produces 9.7 x 10^5 m^2/yr of strip steel and uses 0.006 m^3 of process water/m^2 of product. The unmixed wastewater stream is settled before discharging to a surface stream. Amounts of water used for the production process are 0.0021, 0.0021, and 0.0018 m^3/m^2 for ball milling, coating application, and cooling, respectively. Rinse from the nickel deposition step is recycled. Table 8.10-9 presents pollutant concentrations for the raw and treated wastewater at this plant.

TABLE 8.10-9. CONCENTRATIONS OF POLLUTANTS FOUND IN PORCELAIN ENAMELING ON ALUMINUM AND STRIP STEEL[a] [1]

Pollutant	Raw wastewater, mg/L	Treated effluent, mg/L	Percent removal	Raw wastewater, mg/L	Treated effluent, mg/L	Percent removal
	Aluminum plant 33077			Strip steel plant 36077		
Conventional parameters						
TSS	66	5	92	22,000	340	98
Total phosphorus	80	3.6	96			
Toxic pollutants						
Metals and inorganics						
Antimony	ND	ND		17	ND	100
Arsenic	ND	ND		ND	ND	
Cadmium	20	0.9	96	8.0	2.0	75
Chromium	0.06	0.006	90	ND	ND	
Copper	0.020	ND	100	3.0	0.20	93
Lead	30	0.5	98	40	3.0	93
Nickel	ND	ND		30	1.0	97
Selenium	3.8	0.084	98	0.72	ND	100
Zinc	0.70	0.070	90	400	5.0	99
Nontoxic inorganics						
Aluminum	1.0	0.20	80	200	10	95
Cobalt				30	0.3	99
Iron	0.30	ND	100	20	2.0	90
Manganese	0.008	ND	100	5.0	0.3	94
Titanium	20	0.4	98	100	10	90

Note: Blanks indicate insufficient data available.

[a]Treatment involves sedimentation.

II.8.10.4 Pollutant Removability [1]

Treatment technologies used in the porcelain enameling industry are generally chosen to remove the major wastewater components: suspended solids and toxic metals. Table 8.10-10 presents a summary of the treatment and disposal techniques used by this industry. Usually more than one treatment method is used at each facility.

Some type of settling technique is used in a large portion of the plants, with a settling tank the most common technique. pH adjustment by chemical addition is another common treatment that is used to neutralize the alkaline or acid wastes. Coagulants are sometimes used to aid settling. Once the settling nears

TABLE 8.10-10. TREATMENT METHODS IN CURRENT USE IN THE PORCELAIN ENAMELING INDUSTRY [1]

Treatment method	Number of plants using the method, by subcategory				Total plants
	Steel	Iron	Aluminum	Copper	
Skimming	2				2
Settling tank	35	8	6	1	50
Clarifier	16		2		18
Sedimentation lagoon	11				11
Tube/plate settler	3				3
Equalization	24	2	2		28
pH adjustment-lime	15	1	2		18
pH adjustment-caustic	7				7
pH adjustment-acid	6		1		7
pH adjustment-carbonate	1		1		2
pH adjustment-final	6				6
Coagulant-polyelectrolyte	10	1	1		12
Coagulant-inorganic	3	1			4
Chromium reduction	2		1		3
Emulsion breaking	1				1
Chlorination	1				1
Ultrafiltration	2				2
Pressure filtration	5				5
Vacuum filtration	5				5
Filtration	3				3
Aeration	2				2
Trickling filter	1	1			2
Centrifugation sludge	1				1
Material recovery	1	2			3
Air pollution control	1				1
Process reuse-oil	1				1
Contract removal-oil	7				7
Contract removal-sludge	8		1		9
Landfill-oil	2		1		3
Landfill-sludge	17	2			19
Sludge drying bed	3	1			4
Sludge thickening	1				1

completion, filtration techniques are used to concentrate the sludge, which is then landfilled or contractor hauled. Oils may be treated in a similar manner. Table 8.10-11 presents data collection portfolio (dcp) effluent characterization data from the plants within this industry. Tables 8.10-8 and 8.10-9 in the plant specific section give raw wastewater concentrations, treated effluent concentrations, and percent removal of the pollutants.

Brief descriptions of the common treatment practices and the water reuse and recycle techniques follow.

Equalization/Neutralization

Raw waste waters are commonly collected in equalization basins to even out the flow and the pollutant contaminant load. This permits uniform and controlled operation of subsequent treatment facilities.

TABLE 8.10-11. EFFLUENT CHARACTERIZATION FOR THE PORCELAIN ENAMELING INDUSTRY[a] [1]

Pollutant	P/E on steel: Number of samples	P/E on steel: Range, mg/L[b]	P/E on steel: Median, mg/L[b]	P/E on steel: Average, mg/L[b]	P/E on iron: Number of samples	P/E on iron: Range, mg/L[b]	P/E on iron: Median, mg/L[b]	P/E on iron: Average, mg/L[b]	P/E on aluminum: Number of samples	P/E on aluminum: Range, mg/L[b]	P/E on aluminum: Median, mg/L[b]	P/E on aluminum: Average, mg/L[b]
Conventional parameters												
TSS	37	1 - 1,400	96	390	15	9.8 - 1,100	40	210	5	20 - 390	230	200
Total phosphorus	15	0.13 - 2,100	7.3	150	2	0.12 - 5.4		2.8	3	9.2 - 16	14	13
Oil and grease	26	0.4 - 250	7.1	24	13	0.4 - 58	5.2	17	4	1 - 44	7.5	15
pH	10	4.9 - 8.7	7.0	7.2	6	4.8 - 7.0	7.0	6.4	0			
Toxic pollutants												
Metals and inorganics												
Antimony	3	0.001 - 0.014	0.001	0.005	0				0			
Arsenic	4	0.001 - 0.15	0.024	0.050	0				0			
Cadmium	17	0 - 0.75	0.008	0.060	0				2	0.13 - 0.53		0.33
Chromium	31	0.01 - 124	0.15	4.4	8	0.01 - 124	0.015	16	4	0.01 - 1.45	0.37	0.60
Chromium, hexavalent	5	0 - 0.044	0.005	0.017	0				0			
Copper	27	0 - 6.7	0.09	0.40	7	0.03 - 0.10	0.08	1.02	4	0.01 - 0.10	0.06	0.060
Lead	29	0 - 18	0.20	1.2	8	0.06 - 0.48	0.25	0.24	4	0.13 - 3.6	0.36	1.4
Nickel	39	0.02 - 900	0.50	26	9	0.12 - 22	1.6	4.1	4	0.01 - 0.36	0.13	0.16
Selenium	2	0.001 - 0.020										
Zinc	38	0 - 6.9	0.20	0.94	7	0.15 - 2.3	0.20	0.50	2	0.43 - 0.77		0.60
Nontoxic inorganics												
Iron	32	0.17 - 200	9.3	23	8	0.17 - 150	1.7	37	0			

Pollutant	P/E on copper: Number of samples	P/E on copper: Range, mg/L[b]	P/E on copper: Median, mg/L[b]	P/E on copper: Average, mg/L[b]	P/E industry: Number of samples	P/E industry: Range, mg/L[b]	P/E industry: Median, mg/L[b]	P/E industry: Average, mg/L[b]
Conventional parameters								
TSS	0				49	1 - 1,400	124	370
Total phosphorus	1		0.125	0.125	20	0.12 - 2,100	8.3	110
Oil and grease	0				36	0.4 - 250	8.0	22
pH	0				16	4.8 - 8.7	7.0	6.9
Toxic pollutants								
Metals and inorganics								
Antimony	0				3	0.001 - 0.014	0.001	0.005
Arsenic	0				4	0.001 - 0.15	0	0.050
Cadmium	1		0.010	0.010	19	0 - 0.75	0.009	0.09
Chromium	0				36	0.01 - 124	0.15	3.9
Chromium, hexavalent	0				5	0 - 0.044	0.005	0.017
Copper	1		0.010	0.010	31	0 - 6.7	0.08	
Lead	1		0.010	0.010	34	0 - 18.4	0.17	1.1
Nickel	1		1.0	1.0	45	0.01 - 900	0.71	22.6
Selenium					2	0.001 - 0.020		0.01
Zinc	1		0.010	0.010	41	0 - 6.9	0.20	0.91
Nontoxic inorganics								
Iron	1		14	14	33	0.013 - 200	6.5	23

Note: Blanks indicate insufficient data available.

[a] Based on historical data from the plant dcp responses.

[b] Except pH values, given in pH units.

Wastes in this industry generally require pH adjustment which can be performed in mixed equalization basins or in separate neutralization reactor basins following equalization.

Sedimentation/Settling

Sedimentation by means of clarification or simple settling is the most common technique for removal of precipitates. It is often preceded by chemical precipitation, which converts dissolved pollutants to solid form, and by coagulation, which enhances settling by coagulating suspended solids into larger, faster settling particles. Sedimentation preceded by chemical addition is often referred to as clarification. Simple sedimentation normally requires a long retention time to adequately reduce the solids content. When clarification is used retention times are reduced and removal efficiency is increased. A properly operated sedimentation system is capable of efficient removal of suspended solids, metal hydroxides, and other wastewater impurities.

Chemical Addition/Precipitation

Chemical precipitation is used in porcelain enameling to precipitate dissolved metals and phosphates. Chemical precipitation can be utilized to permit removal of metal ions such as iron, lead, tin, copper, zinc, cadmium, aluminum, mercury, manganese, cobalt, antimony, arsenic, beryllium, molybdenum, and trivalent chromium. Removal efficiency can approach 100% for the reduction of heavy metal ions. Porcelain enameling plants commonly use lime, caustic, and carbonate for chemical precipitation and pH adjustment.

Granular Bed Filtration

Granular bed filters are used in procelain enameling wastewater treatment to remove residual solids from clarifier effluent. Filtration polishes the effluent and reduces suspended solids and insoluable precipitated metals to very low levels. Fine sand and coal are media commonly utilized in granular bed filtration. The filter is backwashed after becoming loaded with solids, and the backwash is returned to the treatment plant influent for removal of solids in the clarification step.

Sludge Concentration and Dewatering

Sludges from clarifiers can be thickened in gravity thickeners or mechanically thickened by centrifuges. Thickened sludges can be further dewatered on one of a number of dewatering operations including vacuum filters, pressure filters, and belt filter presses. Dewatered sludges are disposed generally to landfills which must be properly constructed to conform with provisions of the Resource Conservation and Recovery Act and regulations governing disposal of hazardous wastes.

In-Plant Technology

Many facilities in this industry use in-plant technology to reduce or eliminate the waste load requiring end-of-pipe treatment and thereby improve the quality of the effluent discharge and reduce treatment costs. In-plant technology involves water reuse, process material conservation, reclamation of waste enamel, process modifications, material substitutions, improved rinse techniques, and good housekeeping practices.

Water reuse is practiced at several plants in this industry. Water that may be reused for such purposes as rinse water, makeup water, and cleanup water includes air conditioning water, acid treatment rinse water, and noncontact cooling water. Reuse of acid rinse water in alkaline rinses has been demonstrated at many electroplating plants.

Process material conservation is practiced by the recovery, reuse, or purification of the materials used in the processes. In the nickel deposition process the nickel solution is filtered to reduce its iron content, giving a longer life to the solution. Because the bath is dumped less often, the pollutant load is reduced.

The use of dry spray booths can also reduce the wastewater volume from the plant as well as increasing excess enamel recovery and reuse. Overspray is captured on filter screens and then swept up and reused in the enamel slip. Several plants use this and other, similar processes to recover the enamel raw material.

Process modifications, material substitutions, improve rinsing techniques, and good housekeeping procedures may also significantly reduce the amount and loading of the wastewater released.

II.8.10.5 References

1. Development Document for Effluent Limitations Guidelines and Standards for the Porcelain Enameling Point Source Category. EPA-440/1-79/072a, U.S. Environmental Protection Agency, Washington, D.C., August 1979.

2. NRDC Consent Decree Industry Summary - Porcelain Enameling Industry.

II.9.2 EXPLOSIVES MANUFACTURE

II.9.2.1 Industry Description [1]

II.9.2.1.1 General Description

The Explosives Manufacture point source category is covered by Standard Industrial Classification (SIC) Code 2892. This category includes the following operations:

(1) Manufacturing operations that produce

- (a) explosives
- (b) blasting agents
- (c) solid propellants
- (d) pyrotechnics
- (e) initiating explosive compounds.

(2) Packaging or assembling operations in which the products listed above are converted into end-use products. These operations include the loading, assembling, and packing of ammunition and military ordnance.

(3) Operations used to demilitarize or dispose of obsolete, off-grade, contaminated, or unsafe explosives and propellants.

The Explosives Manufacturing Industry may generally be divided into the commercial (private) sector and the military sector. On a production basis the military sector, consisting of 24 plants, has operations that are for the most part distinctly different from those used by the commercial sector, which consists of 280 plants. Operations common to both apply in only a few areas.

The major products manufactured by the commercial sector of the industry are blasting agents and dynamites. Other products manufactured in limited quantities include double-base propellants, nitroglycerin, nitroglycerin/ethylene glycol dinitrate mixtures, special grained ammonium nitrate for use in dynamites, pyrotechnics, and initiating explosives.

Production processes consist primarily of mixing, blending, and loading, assembling, and packing (LAP) operations.

The military sector manufactures explosives and propellants at separate installations. The products are then shipped to munitions loading plants for assembly into finished items. Munitions loading plants are designated LAP operations.

Most military explosives manufacturing facilities are government owned, contractor operated. Of the 24 plants, only 10 Army Ammunition Plants (AAP) were scheduled to operate in 1978, and the level of production ranges from 10% to 70% of total plant capacity. The common explosives produced by the military include trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX), cyclotetramethylenetetranitramine (HMX), nitrocelluose, and nitroglycerin. Nitroguanidine is often used by the military but is normally purchased from commercial sources. Pyrotechnics supplemental to those manufactured by the military are also purchased from commercial sources.

Water usage is minimal in the explosives industry, the major uses being equipment and facility cleanup and safety. Reuse is limited, however, due to the possibility of introduction of foreign materials that could sensitize an explosion in the processing equipment.

In 1977, over 1,686 Gg (3.7 billion pounds) of industrial explosives, blasting agents, and unprocessed explosive-grade ammonium nitrate were sold for consumption in the United States. Approximately 85% of this total was processed blasting agents and unprocessed ammonium nitrate.

Table 9.2.1 summarizes information pertinent to the commercial sector of the explosives manufacture point source category in terms of the number of subcategories and the number and type of dischargers in the industry [2]. Only the commercial sector of the Explosives Manufacturing Industry is discussed herein, because the military sector operates a limited number of plants, produces very few products in the primary subcategory for consideration, and products are manufactured for use within the military.

TABLE 9.2-1. INDUSTRY SUMMARY [2]

Industry: Explosives Manufacture
Total Number of Subcategories: 5
Number of Subcategories Studied by Effluent Guidelines Division: 1

Number of Dischargers in Industry:

- Direct: 180
- Indirect: 0
- Zero: 100

Best practicable control technology parameters are not currently available for the five subcategories as defined in Section II.9.2.1.2. BPT regulations previously published in the Federal Register are [3]:

Manufacture of explosives:

	1-day maximum	30-day average
COD, kg/Mg	7.77	2.50
BOD_5, kg/Mg	0.72	0.24
TSS, kg/Mg	0.25	0.084
pH	6-9	

LAP operations:

	1-day maximum	30-day average
Oil and grease, kg/Mg	0.11	0.035
TSS, kg/Mg	0.26	0.088
pH	6-9	

II.9.2.1.2 Subcategory Descriptions [1]

Five subcategories, based on the variety of production processes, product types, and wastewater characteristics, have been selected for the explosives industry. Factors such as plant location, size, age, solid-waste generation, air pollution control technology, and energy consumption do not have a significant impact on waste characteristics; they therefore are not included in the subcategorization criteria. The five subcategories are:

- Subcategory 1 - Manufacture of Explosives
- Subcategory 2 - Manufacture of Propellants
- Subcategory 3 - LAP of Explosives
- Subcategory 4 - Manufacture and LAP of Initiating Compounds
- Subcategory 5 - Formulation and Packaging of Blasting Agents, Dynamite, and Pyrotechnics

The annual production estimate for the Explosives Manufacture Industry is presented in Table 9.2-2. Also presented is the precentage of total industry production contributed by each subcategory in 1977. As indicated by the table, 95.3% of the total industry output is represented by Subcategory 5, Formulation and Packing of Blasting Agents, Dynamite and Pyrotechnics. Due to the dominance of this subcategory in the industry, this report primarily addresses the Formulation and Packaging of Blasting Agents, Dynamite, and Pyrotechnics in terms of wastewater characteristics. Since this subcategory does not include military explosives products, only data regarding the commercial sector are reported.

Subcategory 1 - Manufacture of Explosives. The manufacture of explosives includes operations that produce explosive compounds by the mixed acid nitration of organic material. Raw materials used in this process include nitric acid or ammonium nitrate as the nitrate source and either sulfuric or acetic acid as a dehydrating agent. Examples of the organic molecules used are glycerin, ethylene glycol, toluene, resorcinol, hexamine, and

TABLE 9.2-2. ESTIMATE OF ANNUAL INDUSTRY PRODUCTION BY SUBCATEGORY[a] [1]

Subcategory	Subcategory title	Production[b], Gg	Percent of total industry output
1	Manufacture of Explosives	23	2
2	Manufacture of Propellants	10	1
3	Load, Assemble, and Pack (LAP) Explosives	16	1.4
4	Manufacture and LAP of Initiating Compounds	4	0.3
5	Formulation and Packaging of Blasting Agents, Dyanmite, and Pyrotechnics	1,090	95.3
		1,143	100.0

[a]Based on 1977 industry production.

[b]Production excludes explosive-grade ammonium nitrate.

cellulose. Upon nitration, these organic molecules form, in the order presented above, the following products: trinitroglycerin (TNG) and dinitroglycerin (DNG), ethylene glycol dinitrate (EGDN), trinitrotoluene (TNT), and dinitrotoluene (DNT), trinitroresorcinol (TNR), cyclotrimethylenetrinitramine (RDX), and nitrocellulose (NC). Nitration may be accomplished on either a batch or a continuous basis. Initiating compounds, dynamite, and black powder are not included in the subcategory due to differences in process and wastewater characteristics.

Production in this subcategory creates relatively large volumes of wastewater from neutralization and washing of the final product. Wastewaters are generally low in suspended solids, contain soluble nitrate and sulfate salts, and have organic concentrations that are proportional to the solubility of the products and byproducts.

Subcategory 2 - Manufacture of Propellants. This subcategory includes the manufacture of nitrocellulose-based propellants and gas generators. Propellants are similar to explosive products in that they are mixtures of oxidant and fuel held together in a polymeric matrix. They differ in the rate at which the reaction proceeds. Explosives detonate in a chain reaction that occurs extremely rapidly while propellants simply burn, evolving large volumes of gas in a definite and controllable manner. The most commonly produced commercial propellants are called smokeless powders and are designated as either single-base, double-base, or triple-base propellants. Single-base propellants are basically nitrocellulose, double-base propellants are chiefly nitrocellulose, and nitroglycerin, and triple-base propellants primarily contain nitrocellulose, nitroglycerin, and nitroguanidine. These propellants find principal use as the propelling charge in munitions, but they are also used in gas generators and rocket propulsion. Another type of propellant is the composite propellant, an intimate mixture of a fuel, usually aluminum powder, and an oxidizer, usually ammonium perchlorate, held together by a polymeric binder. Composite propellants are used principally for rocket propulsion.

Relatively large volumes of wastewater are generated as the result of water used to transport propellant between unit operations, to remove solvents from the final product, to cool and lubricate in the cutting and machining of the final product, and to clean and wash down process equipment. The presence of organic solvents often makes organic loading higher than in Subcategory 1, and the suspended solids present are generally propellant fines from the cutting and machining operations.

Subcategory 3 - LAP of Explosives. This subcategory includes facilities that obtain the necessary explosives and propellants from outside sources, then mix and pack these materials into a final product. Included in the commercial sector of this subcategory are the loading and assembly of small- to intermediate-caliber ammunition, and the manufacturers of explosive devices. The military sector of this subcategory produces large-caliber shells, bombs, grenades, and other munitions that are filled with blends of TNT and other ingredients. Propellants and small explosive devices are usually loaded dry, while explosives are normally melted down in kettles and molded as liquids. The small volumes of wastewater produced reflect the characteristics of the materials being handled and generally result from plant cleanup operations.

Subcategory 4 - Manufacture and LAP of Initiating Compounds. This subcategory includes plants that manufacture "sensitive" explosive compounds, such as trinitroresorcinol, nitromannite, isosorbide dinitrate, tetryl, tetracene, lead azide, lead styphnate, and mercury fulminate. Initiating compounds, which are produced by the mixed acid nitration of organics, are extremely sensitive materials that can be made to explode by the application of heat or a slight shock. They are very dangerous to handle and are used in comparatively small quantities to initiate the detonation of larger quantities of less sensitive explosives. Plant facilities often include a LAP operation on site to reduce the bulk shipping of these hazardous compounds. Final products include primers, detonators, detonating cords, percussion caps, and electric blasting caps. The LAP operation differs from Subcategory 3 by the small amounts of explosives used.

Wastewater from this subcategory is generated by neutralization and purification of the compounds, safety practices, and plant and equipment cleanup. Wastewater volume is generally higher per unit production than in other subcategories due to safety procedures. Pollutant loads result from the production processes and from chemical treatment of catch basins and sumps to desensitize released initiating compounds.

Subcategory 5 - Formulation and Packaging of Blasting Agents, Dynamite, and Pyrotechnics. Subcategory 5 includes operations that manufacture blasting agents, dynamite, black powder, and pyrotechnics. Processes that produce pyrophoric materials, which ignite spontaneously if not covered with water, are excluded because of the liberal use of water necessary to prevent spontaneous ignition.

Blasting agents--Blasting agents include ANFO and slurries (water gels). ANFO (ammonium nitrate/fuel oil) blasting agent compositions, also known as nitrocarbonitrates, are easily prepared and inexpensive, and they dominate the explosives market today. They are generally used in mining operations, with the major portion produced being used for bulk loading into dry bore holes. If water is present, the ANFO compositions may be placed in water-resistant containers and used.

The raw materials used to manufacture ANFO mixtures include fuel oil, explosive-grade ammonium nitrate (AN), aluminum granules, ferrophosphorus, and dinitrotoluene. The AN used is normally produced under special prilling conditions that give the prills high porosity for better absorption of the oil. Small amounts of anticaking agents are also used.

Fuel oil is received in bulk and is stored in large tanks. When needed it is pumped to the use site. The AN is received in bulk railroad hopper cars and may be transferred to a storage area or used from the hopper car. The remaining ingredients are normally received in bags or steel drums.

ANFO may be produced by dry mechanical mixing, injection of the fuel oil into the AN as it is transferred to the packaging area, or injection of the fuel oil into the AN as it is transferred into the bore hole at the use site. Packaging, when used, consists of cylindrical plastic tubes, plastic-lined bags, or metal cannisters.

Approximately 75 plants produce ANFO. Their wastewater is limited to periodic cleanup of the plant area and rainfall runoff from the unloading areas. Dry cleanup is used when possible, but AN is very hydroscopic and tends to become pasty and hard to clean in humid conditions. Heated floors are sometimes used to reduce hydroscopic effects and thereby aid in the cleanup process.

Slurries (water gels) are water-resistant, high energy blasting agents used for wet bore holes and applications requiring greater energy than that supplied by ANFO. Slurry products usually require a high explosive primer for detonation. Slurry formulation is an art and can produce a desired energy release as well as the desired explosive properties. Sensitivity relies on the type and characteristics of the raw materials used and the method of mixing. Water resistance and gel consistency are achieved by addition of cross-linking soluble gums. There are approximately 21 slurry manufacturing plants in the United States.

Raw materials are received in the same way as at ANFO plants, with sodium nitrate, aluminum granules, and organic liquid extenders also being received in bulk.

Slurries may be prepared on site or at the plant. For packaged slurries the entire formulation is prepared by premixing the liquid ingredients into a paste, then adding the solids and packaging the product. On-site production may be carried out in two ways. In one method the slurry is prepared as above but the gum crosslink agent is not added until the slurry is pumped into the bore hole. In the second method the paste is prepared, all the dry ingredients are added at the use site, and the mixture is pumped into the bore hole.

Wastewater from slurry production comes from automatic packaging machinery, periodic equipment cleanup, dust control scrubbers, and rainfall runoff.

Dynamites--Seven plants produce high explosive dynamite compositions that are used in underground mines and for blasting small-diameter bore holes. Dynamite consists of nitroglycerin or ethylene glycol dinitrate, porous filler material, and oxidizing salts such as AN. The grained AN used in dynamite is produced by controlled evaporation of high concentration AN solutions followed by crystallization in open-top agitated vessels (kettles).

Production occurs in three general steps. First, all ingredients except the nitroglycerin or ethylene glycol dinitrate are mixed in batch blenders in a building known as a dope house. The dope mixes are then transferred to the mix house where the nitroglycerin or ethylene glycol dinitrate is added in batch blenders. The mix is then sent to the packaging house and loaded into cardboard tubes by wooden tamping machines.

Plant and equipment cleanup and dust control wet scrubbers are the major sources of wastewater.

Pyrotechnics--The 45 commercial pyrotechnic plants in the United States are divided into 2 general types. The fireworks industry consists of 13 major and 25 minor plants. The flare industry, which produces illuminating flares, distress flares, and smoke generators, consists of seven plants.

Fireworks consist primarily of black powder and metal salts, which produce the colors. The mixture is held together by a water soluble binder such as sugar or gum. The ingredients are combined in dry batches and water is added. The wet mixture is then molded and air dried. Black powder is also used for the fuse and propelling charge of the assembled device. Flares are produced similarly but may use an organic binder instead of a water soluble one. If so, an organic solvent may be necessary to clean the equipment. Fireworks production equipment is generally dry cleaned with brushes.

Ammonium Nitrate (AN). Explosive-grade ammonium nitrate plants, although they do not fall directly under this SIC code, are related to the industries of Subcategory 5 because of the extensive use of AN as a raw material in their products. Approximately 16% of all the AN produced in the United States in 1976 was used in explosives products. Ammonium nitrate is produced by several processes including the Stengel, prilling, and graining processes. The general procedure is evaporation of the water from a solution of AN by a physical process.

Wastewater from the production of AN generally is limited to plant housekeeping, air pollution control, and fugitive discharges, although some wastewater may result from the evaporation steps in the process. AN is the major pollutant in the wastewater, which allows the wastewater to be recycled, if not too contaminated, or sold as dilute fertilizer solution.

Table 9.2-3 presents a list of the common ingredients for the products described above.

II.9.2.2 Wastewater Characterization [1]

The general nature of the wastewater sources within the explosives industry results in a wide variance of wastewater volumes. The volume of wastewater generated depends on operating methods, equipment type and condition, housekeeping practices, safety practices, product mix, and package type. Table 9.2-4 presents wastewater flowrate data for each type of production in Subcategory 5.

Wastewater does not originate from direct contact within the process with the ingredients used to produce the products; therefore, only cleanup operations normally have the potential to contribute pollutants to the wastewater stream. The materials that may possibly enter the wastewater stream include the ingredients of each type of explosive found in Table 9.2-3. Ammonium nitrate, which is used extensively in this industry, is generally found in all wastewater from Subcategory 5 facilities and contributes to the TKN, NH_3-N, NO_3-N, and TDS levels. Inorganic

TABLE 9.2-3. COMMON EXPLOSIVE INGREDIENTS

Product	Ingredients
Dynamite	Nitroglycerin, barium sulfate, ammonium nitrate, ammonium chloride, sodium nitrate, sodium chloride, calcium carbonate, calcium stearate, sulfur, nitrocellulose, phenolic resin or glass beads, bagasse, sawdust or wood flour, coal, cornmeal and cornstarch, inorganic salts, grain and seed hulls and flour
Black powder	Charcoal, sulfur, potassium nitrate
Ammonium nitrate/fuel oil mixtures	Ammonium nitrate, ferrophosphorus, calcium silicate, dinitrotoluene, fuel oil, aluminum, coal, mineral oil
Slurries (water gels)	Ammonium nitrate, sodium nitrate, guar gum, water, crosslinking agents for gum, ethylene glycol, aluminum granules, flakes, or powders, glass microspheres, fuel oil, smokeless powder, trinitrotoluene, carbon fuel, organic amines, ferrophosphorus, silicon
Propellants	Nitrocellulose, plasticizers, density modifiers, burning rate modifiers, nitroglycerin, nitroguanidine, aluminum powder, oxidizers (e.g., ammonium perchlorate), polymeric binders
Pyrotechnics	Black powder, potassium nitrate, copper salts, barium nitrate, strontium nitrate, strontium carbonate, aluminum metal, magnesium metal, potassium chlorate, potassium perchlorate, antimony sulfide, red phosphorus, ammonium perchlorate, boron, manganese oxide, lead oxide, copper oxide, sugar, linseed oil
Initiating compounds	Pentaerythritol tetranitrate (PETN),2,4,6-trinitroresorcinol (styphnic acid), nitromannite (HNM), isosorbide dinitrate, trinitrophenylmethylnitramine (tetryl), tetracene, lead azide, lead styphnate, mercury fulminate

TABLE 9.2-4. SUMMARY OF WASTEWATER FLOWRATE DATA FOR SUBCATEGORY 5 [1]

	Wastewater volume					
	m^3/d (gal/d)			m^3/Mg of product (gal/lb)		
Product type	Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum
ANFO	0.3 (79.3)	0	3.8 (1,004)	0.009 (0.001)	0	0.04 (0.005)
Slurry	5.2 (1,374)	0	31 (8,190)	0.20 (0.024)	0	0.81 (0.097)
Dynamite	72 (19,022)	0	348 (91,942)	0.11 (0.013)	0	2.8 (0.336)
Pyrotechnics	-[b]	0	0.76 (201)	-[b]	0	0.13 (0.016)

[a] Average is based on plants reporting data only.

[b] Average value is not presented since only a fraction of pyrotechnics plants generate wastewater.

salts and metals are used in most Subcategory 5 product types and contribute to TDS, TSS, and nitrate levels, and to heavy metal concentrations. Small concentrations of organic materials may also be found in some industry wastewaters.

Tables 9.2-5 and 9.2-6 summarize the available verification data on toxic pollutants and on conventional and classical pollutants, respectively, for the Explosives Manufacture Industry. Since most plants have several production processes on site, the data have been collated into these processes representing wastewater production processes rather than an average plant.

II.9.2.3 Plant Specific Description [1]

Based on the products manufactured and the quantity of information available, the four plants described below were selected for presentation of plant specific data. Final treated effluent data are not currently available for any of these sampled plants.

- Plant 03 - Plant 03 produces ANFO products, slurry products, and explosive-grade ammonium nitrate. Raw wastewater from the plant is sent to an evaporative/percolative pond where the water is lagooned. The lagoon has no effluent reported.

- Plant 27 - Plant 27 produces only ANFO products. Raw wastewater is collected in a clay-lined pond, then periodically applied to vegetation-covered land adjacent to the plant.

- Plant 30 - Plant 30 produces dynamite, ANFO products, and NCN products. Treatment consists of an evaporative/percolative pond that has no reported effluent.

- Plant 63 - Plant 63 produces solely pyrotechnic products. Very little wastewater is produced. An evaporative/percolative pond is used to hold the wastewater produced by the process. No effluent flow was reported.

Table 9.2-7 presents toxic and conventional pollutant concentration data for the selected plants. Data are from the verification sampling phase except as noted. Each plant is divided into product lines and is usually presented as an entire plant. Treated effluent data were not available. Pollutant loading data for each plant subdivision are presented in Table 9.2-8.

II.9.2.4 Pollutant Removability [1]

Treatment practices are limited in number in the explosives industry due to the small volumes of wastewater produced and the typical characteristics of the wastewaters from the plants. Effluent data are very limited, since most plants do not recognize any effluent discharge from plant property. No plant specific treatment data are available at this time.

TABLE 9.2-5. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATER FROM THE FORMULATION AND PACKAGING OF BLASTING AGENTS, DYNAMITE, AND PYROTECHNICS [1]

	ANFO					Slurry					Dynamite				
	Number of times		Concentration, μg/L			Number of times		Concentration, μg/L			Number of times		Concentration, μg/L		
Toxic pollutant	Analyzed	Detected	Av	Med	Max	Analyzed	Detected	Av	Med	Max	Analyzed	Detected	Av	Med	Max
Metals and inorganics															
Antimony	2	0			ND	1	1	350	350	350					
Copper	2	2	470	470	940	1	1	10	10	10					
Cyanide	1	1	14	14	14	2	2	1,300	1,300	2,600	1	1	10	10	10
Lead	4	2	30	5	110	2	2	50	50	80	1	1	10	10	10
Nickel	1	1	100	100	100										
Silver	2	0			ND										
Zinc	4	3	730	730	1,400	2	2	510	510	980	1	1	1,400	1,400	1,400
Phthalates															
Bis(2-ethylhexyl) phthalate															
Di-n-octyl phthalate															
Phenol															
Phenol	2	2[a]	68	68	70						1	1	20	20	20
Pesticides and metabolites															
Isophorone						1	0			ND					

	Ammonium nitrate					Pyrotechnics				
Toxic pollutant	Analyzed	Detected	Av	Med	Max	Analyzed	Detected	Av	Med	Max
Metals and inorganics										
Antimony	1	0			ND	1	0			ND
Copper	1	1	30	30	30	1	1	37	37	37
Cyanide						1	1	150	150	150
Lead	2	1	10	10	20	1	1			ND
Nickel						1	0			ND
Silver	1	1	2	2	2					
Zinc	2	2	70	70	116	1	1	45	45	45
Phthalates										
Bis(2-ethylhexyl) phthalate						1	1	72	72	72
Di-n-octyl phthalate						1	0			ND
Phenol										
Phenol						1	1	15	15	15
Pesticides and metabolites										
Isophorone										

NOTE: Blanks indicate not analyzed or not reported.

[a]Both below minimum detection.

TABLE 9.2-6. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN RAW WASTEWATER FROM THE FORMULATION AND PACKAGING OF BLASTING AGENTS, DYNAMITE, AND PYROTECHNICS [1]

Pollutant	ANFO: Number of times Analyzed	ANFO: Number of times Detected	ANFO: Concentration, mg/L Av	ANFO: Concentration, mg/L Med	ANFO: Concentration, mg/L Max	Slurry: Number of times Analyzed	Slurry: Number of times Detected	Slurry: Concentration, mg/L Av	Slurry: Concentration, mg/L Med	Slurry: Concentration, mg/L Max
BOD_5	1	1	3,120	3,120	3,120	2	2	6,060	6,060	9,870
COD	1	1	2,760	2,760	2,760	3	3	5,880	4,020	13,600
TSS	1	1	1,130	1,130	1,130	3	3	935	820	1,980
TKN	1	1	13,500	13,500	13,500	3	3	4,690	5,770	8,240
Oil and grease	1	1	1,300	1,300	1,300					
TDS	1	1	80,100	80,100	80,100	3	3	18,900	18,000	38,000
NH_3-N	1	1	12,000	12,000	12,000	3	3	3,520	4,940	5,580
NO_3-N	1	1	19,600	19,600	19,600	3	3	5,860	7,780	9,160
	Dynamite					Ammonium nitrate				
BOD_5	2	2	6	6	8	1	1	90	90	90
COD	2	2	18	18	20	3	3	69	27	168
TSS	1	1	8	8	8					
TKN	2	2	41	41	45	3	3	248	97	582
Oil and grease										
TDS	1	1	320	320	320					
NH_3-N	2	2	33	33	33	3	3	165	83	350
NO_3-N	2	2	25	25	27	3	3	478	104	1,250

NOTE: Blanks indicate not analyzed or not reported.

TABLE 9.2-7. WASTEWATER CHARACTERIZATION FOR EXEMPLARY PLANTS IN THE FORMULATION AND PACKAGING OF BLASTING AGENTS, DYNAMITE, AND PYROTECHNICS INDUSTRY [1]

Pollutant	Plant 03				Plant 27	Plant 30				Plant 63	
	ANFO[a]	Slurry	AN	Plant	ANFO	Dynamite	ANFO	NCN	Plant	Pyrotechnics	Plant[b]
Metals and inorganics, ug/L											
Antimony	ND	350	ND	38[b]						ND	
Chromium											30
Copper					940					37	41
Cyanide				26[b]	14				30[b]	154	
Lead	ND	80	20		110	10	ND	20	80[b]	ND	
Nickel					100					ND	30
Silver					ND						
Zinc	ND	980	116		1,330	1,450	136	2,740	1,070[b]	45	
Organics, ug/L											
Benzene											23
1,2-Dichloroethylene									36[b]		
1,2-*Trans*-dichloroethylene									36[b]		
Trichlorofluoromethylene									90[b]		
Bis(2-ethylhexyl) phthalate										72	105
Isophorone											
2-Nitrophenol				30[b]							
Di-n-octyl phthalate				13[b]						ND	111
Phenol					65					15	130
Toluene									96[b]		
Conventional, mg/L											
BOD		2,260		69	3,120	8[c]			9		
COD		4,020	12	371	2,760	15[c]			130		
TKN		5,770	64	245	13,500	45[c]			155		
NH_3-N		5,580	61	215	12,000	33[c]			118		
NO_3-N		7,780	104	934	19,600	27[c]			317		
TDS		38,000			80,100	320[c]					
TSS		1,980			1,130	8[c]					
Oil and grease					1,300						
Influent flowrate, m^3/d	0.19	2.4	340	371	0.24	347	0.6	0.6	385	1.0	1.0

NOTE: Blanks indicate data not available.

[a]Slurry prepared by mixing 200 mg of ANFO or NCN product per liter of distilled deionized water.

[b]Screening data.

[c]Mix house and dope house effluents only; no washdown.

TABLE 9.2-8. WASTEWATER TOXIC AND CONVENTIONAL POLLUTANT LOADINGS FOR EXEMPLARY PLANTS IN THE FORMULATION AND PACKAGING OF BLASTING AGENTS, DYNAMITE, AND PYROTECHNICS INDUSTRY [1]

Pollutant	Plant 03			Plant 27[a]	Plant 30			Plant 63
	ANFO	Slurry	AN	ANFO	Dynamite	ANFO	NCN	Pyrotechnics
Metals and inorganics, g/d								
Antimony	<0.01	0.84	<3.4					<0.01
Chromium								
Copper								0.04
Cyanide								0.15
Lead	<0.01	0.19	6.8		3.5	<0.03	0.06	<0.01
Nickel								
Silver								
Zinc	<0.01	2.4	39.4	36.9	503	0.4	8.2	0.05
Organics, g/d								
Phenol				0.38				0.01
Conventional, kg/d								
BOD		5.4		0.75	2.8			
COD		9.6		0.67	5.2			
TKN		13.8		3.2	15.5			
NH_3-N		13.3		2.9	11.4			
NO_3-N		18.6		4.7	8.3			
TDS		90.8		19.2	110			
TSS		4.7		0.27				
Oil and grease								

NOTE: Blanks indicate data not available.

[a]Quantities calculated based on product concentration in wastewater of 1%. Screening data.

Control and treatment practices in use today can be divided into in-plant source control and end-of-pipe treatment.

II.9.2.4.1 In-Plant Wastewater Source Control

Control practices within the plant can consist of wastewater reduction, recycle, or isolation. Reduction of wastewater volume is accomplished by use of dry cleaning practices and cleanup water recycle. Dry cleanup consists of dry sweeping floor areas and shovel collection of waste, equipment cleanup with brushes, and use of wet vacuum systems. The material collected can be reused if not overly contaminated with foreign material.

Cleanup water recycle deals with the dust control wet scrubber system. Because dust must be controlled for safety and industrial hygiene reasons, the pollutant load in the raw wastewater from the dust control system cannot be reduced. However, the volume of the wastewater can be reduced significantly by recirculation of the wet scrubber water. This recirculation increases the ammonium nitrate loading and can make it feasible to recycle the wastewater to an AN plant. Alternative dust collectors, such as cyclone-type collectors, can reduce or eliminate this source of wastewater and must also be considered.

Direct recycle of wastewater into the product is not applicable in this industry. However, a few plants practice concentration by evaporation and reuse the concentrated wastewater in ammonium nitrate production. Care must be taken to prevent contamination of this recycle for safety reasons. Isolation or containment of wastewater is practiced by enclosing loading and unloading areas, diking or trenching storage areas, and collecting runoff in lagoons.

II.9.2.4.2 End-of-Pipe Treatment

Treatment methods being used by the explosives manufacturing industry to control pollutant levels in raw wastewater streams include ponding, land application, biological oxidation in conjunction with other raw waste loads, and solids removal by filtration, settling ponds, or air flotation. Only a few of the treatment systems used have any effluent discharge and most treat a combination of wastewater sources. Table 9.2-9 shows a summary of the treatment systems used by some Subcategory 5 plants.

Ponding. Ponding is the most common form of treatment for Subcategory 5 plants. Generally, the ponds are not lined and natural percolation could be occurring. Long winter seasons create some problems for ponding because of the large inventory storage with negligible percolation or evaporation. Evaporation ponds are very effective where the natural evaporation rate from stagnant water exceeds rainfall. This would generally include states west of the Mississippi. Increased evaporation by

TABLE 9.2-9. SUMMARY OF INDUSTRY CONTROLS FOR SUBCATEGORY 5 [1]

Control data	ANFO	Slurry	Dynamite	Pyrotechnics	Total
Total number of plants estimated	75	23[a]	7	45[b]	150
Number of plants studied	64	23	6	7[b]	100
Plants reporting no process-related wastewater	11	2[c]	1	2[b]	16
Plants reporting wastewater discharge without treatment	46	4	0	0	50
Plants using evaporative/percolative ponds	6	8	1	1	16
Plants using land application	3	4	1	0	8
Plants using solids separation only[d]	0	4	2	0	6
Plants discharging to a combined wastewater treatment system	1	1	1	2[e]	5

[a] Includes one plant which is reported to be inactive; includes two plants at one plant site.

[b] 38 plants produce fireworks only and are considered dry operations without wastewater discharge; 7 plants produce flares, distress signals, etc.

[c] Includes one plant which concentrates and recirculates process wastewater.

[d] Includes filtration, settling ponds or tanks, and air flotation. Settling sumps may be used at other plants prior to ponding or discharge to treatment plants.

[e] Includes one plant that has collected wastewater hauled by disposal firm.

mechanical methods, such as sprayers or cooling towers, may also be effective for other areas but is not in current use.

Slow-Rate Land Treatment. Land application of wastewater using spray irrigation is the second most often practiced method. Wastewater is collected in a pond and is applied to plant-covered land areas during the growing season. Mobile or stationary sprayers may be used. The amount of water applied per acre varies at each site according to the amount of wastewater produced and land area available. No negative effects have been observed on green plants in the treatment areas. Dilution may be necessary for wastewaters with very high nitrogen content.

Biological Treatment. Biological treatment is used at one plant to handle wastewater from several sources. Slurry plant wastewater is combined with explosives manufacturing plant wastewater for a combined flow of approximately 150 m^3/day (40,000 gpd). The water is treated in a diffused-air, extended aeration, activated sludge treatment system. Based on verification data from this plant, cyanide and ammonia nitrogen levels were reduced more than 90% and nitrate nitrogen increased from 900 mg/L to 1,400 mg/L.

Other combined wastewater treatment systems include septic tanks, equalization and neutralization ponds a facultative ponds, and activated sludge treatment.

Solids Separation. Suspended solids are found at various levels in wastewater from slurry and dynamite plants. Dynamite wastewater has very small particles which originate from the airborne dust collected by the wet scrubbers. Slurry wastewater generally contains larger particles, such as granular aluminum or glass microspheres. Small settling ponds, air flotation, and continuous paper belt filler are three methods used to remove these solids from the wastewater. Another method uses caustic to dissolve the aluminum present, then neutralizes the treated wastewater to convert the paint grade aluminum in the raw wastewater to a settleable sludge. The sludge is then recovered and reused.

Alternative Technologies. Several potential technologies for treating industrial wastewater containing high levels of ammonium and nitrate nitrogen have been studied. These technologies include biological processes involving a variety of process configurations, and physical/chemical unit processes, such as reverse osmosis, ammonia stripping, and ion exchange. Break point chlorination and electrodialysis have also been suggested.

II.9.2.5 References

1. Technical Review of the BAT Analysis of the Explosives Industry (draft contractor's report). U.S. Environmental Protection Agency, Washington, D.C., April 1979.

2. NRDC Consent Decree Industry Summary - Explosive Manufacturing.

3. Environmental Protection Agency Effluent Guidelines and Standards for Explosives Manufacturing. 40 CFR 457; 41 FR 10180, March 9, 1976.

II.9.3 GUM AND WOOD CHEMICALS

II.9.3.1 Industry Description

II.9.3.1.1 General Description [1]

The Gum and Wood Chemicals Industry in the United States is covered by Standard Industrial Classification (SIC) Code 2861. Within this classification are establishments primarily engaged in manufacturing hardwood and softwood distillation products, wood and gum naval stores, charcoal, natural dyestuffs, and natural tanning materials. SIC 2861 does not include establishments primarily engaged in manufacturing synthetic tanning materials and synthetic organic chemicals, or those engaged in the production of synthetic organic dyes; rather, these establishments are included within SIC Codes 2869 and 2865, respectively.

Some materials produced under SIC 2861, such as rosins, may be further processed into materials classified under different SIC codes. Those cases in which materials change classifications within the same plant are included in this description. Excluded are those cases where materials are purchased from one SIC 2861 plant for further processing in a different plant into a product with a different SIC code.

Table 9.3-1 summarizes pertinent information regarding the number of subcategories, the number of subcategories studied by Effluent Guidelines Division, and the number and type of dischargers in the Gum and Wood Chemicals Industry.

TABLE 9.3-1. INDUSTRY SUMMARY [1, 2]

Industry: Gum and Wood Chemicals
Total Number of Subcategories: 7
Number of Subcategories Studied: 4

Number of Dischargers in Industry:

- Direct: 14
- Indirect: 6
- Zero: 3

Best Practicable Technology (BPT) limitations currently promulgated for each subcategory are presented in Table 9.3-2. No information regarding limitations on the sulfate turpentine subcategory is available.

TABLE 9.3-2. BPT LIMITATIONS FOR THE GUM AND WOOD CHEMICALS MANUFACTURING INDUSTRY [3]

Subcategory	Concentration, kg/Mg: BOD_5 Daily maximum	BOD_5 30-day average	TSS Daily maximum	TSS 30-day average	pH
Char and charcoal briquets	No discharge of process wastewater pollutants to navigable waters				
Gum rosin and turpentine	1.42	0.755	0.077	0.026	6.0-9.0
Wood rosin, turpentine, and pine oil	2.08	1.10	1.38	0.475	6.0-9.0
Tall oil rosin, pitch, and fatty acids	0.99	0.53	0.705	0.243	6.0-9.0
Essential oils	22.7	12.0	9.01	3.11	6.0-9.0
Rosin-based derivatives	1.41	0.748	0.045	0.015	6.0-9.0
Sulfate turpentine[a]					

[a]No specific limitations for this subcategory are available; however, other subcategory limitations may address portions of this subcategory.

II.9.3.1.2 Subcategory Descriptions

The modern Gum and Wood Chemicals Industry is grouped into the following major areas:

(1) Char and charcoal briquets

(2) Gum rosin and turpentine

(3) Wood rosin, turpentine, and pine oil

(4) Tall oil rosin, fatty acids, and pitch

(5) Essential oils

(6) Rosin derivatives

(7) Sulfate turpentine

Three of the seven Gum and Wood Chemicals subcategories (char and charcoal briquets, gum rosin and turpentine, and essential oils) have been submitted for exclusion under Paragraph 8 of the NRDC Consent Decree. These subcategories are described herein; however, no wastewater characterizations are presented.

Char and Charcoal Briquets. The char and charcoal industry in the United States is comprised of some 80 plants primarily concentrated in the eastern section of the country. Char is produced from the destructive distillations of softwood and hardwood (primarily the latter). Char, in turn, may be processed into charcoal briquets or activated carbon. Charcoal, in itself, is one of the more economically important products of the Gum and Wood Chemicals Industry with its wide use in the chemical and metallurgical industries (although largely replaced therein by coke) and in other areas, including use as a filter for gaseous and liquid streams.

Exclusion of revised BAT and NSPS limitations has been recommended for all specific pollutants on the basis of Paragraph 8 of the NRDC Consent Decree since the existing BAT and NSPS require no discharge of process wastewater. The only discharge of water to surface water occurs from runoff which is regulated by BPT.

Gum Rosin and Turpentine. Currently, there are only seven plants identified in the gum rosin and turpentine subcategory, all of which are located in Georgia. The two largest plants have diversified and are now producing rosin-based derivatives in conjunction with gum rosin and turpentine. In terms of product value, gum rosin and turpentine products are a minor portion of the Gum and Wood Chemicals Industry.

Exclusion of BAT, NSPS, and pretreatment standards has been recommended for all specific toxic pollutants on the basis of Paragraph 8. Of seven plants in the industry, one is an indirect discharger, and the remaining six are self-contained dischargers. These six plants operate on a seasonal basis between May and September (approximately 180 days per year). Flows of process wastewaters in this subcategory are quite low (averaging about 5.3 m^3/day per plant).

The only toxic pollutants found during screening analysis of the indirect discharger were benzene, toluene, δ-BHC, and metals. However, this plant is also a rosin-based derivatives producer which is covered under the rosin derivatives subcategory of the Gum and Wood Chemicals Industry. Exclusion of the NSPS limitations is recommended since no new sources exist and most existing plants are expected to close within the next 10 years for economic reasons. Exclusion of pretreatment is recommended since only one indirect discharger exists, and the effluent from this plant will be regulated under the rosin derivatives subcategory.

Wood Rosin, Turpentine, and Pine Oil. The wood rosin, turpentine and pine oil industry consists of five plants in the United States. In a typical process, pine stumps are brought into the plant, conveyed, and washed. The water and sediment flows to a settling pond from which water is recycled back to the washing operation. Pine stumps are reduced to chips; the chips undergo an extraction process that enables them to be used as fuel (the solvent used during the extraction process is removed from the chips by steaming); and spent chips are removed from the retort and sent to the boilers as fuel. The solvent is recycled for use in the retorts.

The extract liquor is sent to a distillation column to separate the solvent from the products. The bottom stream from the first distillation column enters a second distillation column. The bottom stream from the second column is the finished wood rosin product.

The crude terpene, which has been removed in the second distillation column, is stored until a sufficient quantity has been accumulated for processing in a batch distillation column. The distillation column is charged with the crude terpene material, and the condensed material enters a separator. The terpene and pine oil products are removed from the separator.

Tall Oil Rosin, Fatty Acids, and Pitch. Twelve tall oil distillation plants, primarily located in the Southeastern United States, are currently in operation. Two additional plants are not in operation but could be made operational if economic conditions so dictated.

Crude tall oil is particularly attractive as a raw material because of its availability as a "waste" product of the kraft pulp and paper industry.

The crude tall oil is treated with dilute sulfuric acid to remove some residual lignins as well as mercaptans, disulfides, and color materials. Acid wash water is discharged to the process sewer. The stock then proceeds to the fractionation process, where the pitch is removed from the bottoms of the first column and is either sold, saponified for production of paper size, or burned in boilers as fuel. The remaining fraction of the tall oil (rosin and fatty acid) proceeds to the pale plant, where the quality of the raw materials is improved. The second column separates low-boiling-point fatty acid material, and the third column completes the separation of fatty and rosin acids.

The wastewater generated in this subcategory results from pulling a vacuum on the distillation towers. This water is generally recycled, but excess water is discharged to the plant sewer.

Essential Oils. The only essential oil being produced in this subcategory is cedarwood oil. Cedarwood oil is produced by steaming cedarwood sawdust in pressure retorts to remove the oil from the wood particles.

Exclusion of BAT, NSPS, and pretreatment standards has been recommended for all specific toxic pollutants on the basis of Paragraph 8. The subcategory includes seven plants, none of which is a direct discharger; one is an indirect discharger and the remaining six have no discharge. Flows of process wastewater in this subcategory are low (a maximum flow of 57 m^3/d from the indirect discharger under full-scale production). The only toxic pollutants detected during screening of the indirect discharger were benzene and metals, and all were at low levels.

Rosin Derivatives. Rosin derivatives are not included in SIC 2861, Gum and Wood Chemicals, but in SIC 2821, Plastics and Synthetic Materials. Derivatives production is a natural extension of processing in gum and wood chemicals plants since the rosin is available in the plants. This industry description is applicable only to those derivative operations which are located within and in conjunction with gum and wood chemicals facilities. Another derivatives operation that occurs in gum and wood chemicals plants is terpene derivatives. Derivative products include ink resins, paint additives, paper size, oil additives, adhesives, wetting agents, chewing gum base, and chemical-resistant resins.

Sixteen gum and wood chemicals plants currently are producing rosin or terpene derivatives. These plants are located within all four types of rosin-producing plants.

Process operating conditions in the reaction kettle are dependent on product specifications, raw materials, and other variables. A simple ester is produced under high temperature vacuum conditions. A steam sparge is used to remove excess water of esterification, and the condensable impurities are condensed in a noncontact condenser on the vacuum leg and stored in a receiver. Noncondensables escape to the atmosphere through the reflux vent and steam vacuum jets.

Wastewater is developed from the chemical reaction and separation of product.

Sulfate Turpentine. Sulfate turpentine was originally considered to be a waste product in the kraft pulp and paper process. However, modern technology allows it to be profitably recovered by a distillation process to such an extent that sulfate turpentine is the major source of turpentines in the Gum and Wood Chemicals Industry.

During the distillation of sulfate turpentine, the first tower is usually used to strip odor-causing mercaptans from the turpentine. Subsequent fractionation breaks the turpentine into its major components: α-pinene, β-pinene, dipentene, and sulfated pine oil.

The distillation of sulfate turpentine is an intermediate production step. The operations are usually batch reactions that take place in reaction kettles in the presence of some organic solvent and metal catalyst. The catalyst and solvent used depend on the type of products required. There are approximately 200 products produced in this area.

Wastewater usually is generated from the condensation in the distillation tower and from washdown of reactors.

II.9.3.1.3 Wastewater Flow Characterization

The volume of wastewater produced by the plants in the Gum and Wood Chemicals Industry ranges from 0 to 7,570 m^3/d. Discharge flow rates for each subcategory are difficult to quantify because most plants have combined processes that fall under several different subcategories, and all process wastewater typically is discharged to a common sewer. Although total plant flow can be determined from this discharge pipe, a breakdown into components from each process is not possible. Wastewater flows have been tabulated in Table 9.3-3 (next page) for each plant, and grouped according to the processes within the plant.

II.9.3.2 Wastewater Characterization [1]

Wastewater characteristics for the Gum and Wood Chemicals Industry demonstrate that organic solvents are generally the most

TABLE 9.3-3. TABULATED WASTEWATER FLOWS BY PLANT [1]

Subcategories[a]	Plant No.	Discharge type	Production, kg/d	Wastewater flow, m^3/d
G	009	Indirect	57,700	273
	885	Indirect	86,400	1,230
G,F	159	Direct	45,300	4,470
G,C,F	571	Indirect	218,000	2,200
	222	Indirect	465,000	1,750
G,D,F	743	Direct	209,000	681
	993	-b	467,000	1,360
B,F	485	Indirect	45,400	19
C	934	Direct	48,200	587
C,F	242	Direct	336,000	7,310
D,F	334	Direct	199,000	
	244	Direct	139,000	636
	714	Indirect	192,000	2,020
	660	Indirect	69,200	186
	454	-b	306,800	447
	040	-b	227,000	3,410
	049	-b	270,000	1,330
D	759	Direct	164,000	158
	436	Direct	152,000	2,270
	590	-b	193,000	984

[a]B = gum rosin and turpentine; C = wood rosin, turpentine, and pine oil; D = tall oil rosin, pitch, and fatty acid; F = rosin- and terpene-based derivatives; G = sulfate turpentine.

[b]Plant discharges into the waste treatment system of another plant.

prevalent pollutants. These solvents are used in the extraction processes across all subcategories. Some heavy metals have been listed as natural components of the raw materials (e.g., tree stumps) that are utilized in this industry.

Due to the nature of the Gum and Wood Chemicals Industry there is a great deal of overlap among the various subcategories. Although the subcategories were defined according to the principal product(s) peculiar to a set group, most of the plants within a subcategory secondarily produce products which are primary to another subcategory. The resulting overlap makes separation of available data relative to specific pollutants difficult to achieve.

II.9.3.2.1 Wood Rosin, Turpentine, and Pine Oil

Principal toxic pollutants observed were some organic solvents (particularly toluene), chromium, and zinc. Conventional pollutants included COD and BOD. Levels of methylene chloride and benzene in the groundwater are unusually high and probably indicate contamination.

Of the five plants that process wood stumps for their extractable components, only one has segregated wood rosin wastestreams (the remaining plants have multiprocess wastestreams). The multiprocess streams could not be used to characterize the wastewater from this subcategory; thus, Tables 9.3-4 and 9.3-5 present concentrations of toxic pollutants and conventional and classical pollutants for the wood rosin, turpentine, and pine oil subcategory based on sampling conducted at one plant.

TABLE 9.3-4. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN WOOD ROSIN, TURPENTINE, AND PINE OIL SUBCATEGORY WASTEWATER [1] (μg/L)

Toxic pollutant	Intake[a]	Raw wastewater[b]	Treated effluent[c]
Metals and inorganics			
Arsenic	<10	<10	<15[d]
Chromium	<10	1,500	110
Copper	<10	33	<12
Lead	<10	15	<10
Zinc	<10	160[e]	37[d]
Monocyclic aromatics			
Ethylbenzene	<10	50	<10
Toluene	<10	-[f]	<10
Halogenated aliphatics			
Chloroform	20	<10	17
Methylene chloride	910	190	340

[a]Process makeup water-well water.

[b]Influent to equalization basin.

[c]From aerated and settlinglagoon; average of three samples.

[d]Blank adjusted value is <10.

[e]Blank adjusted value is 130.

[f]Indeterminate because of high organic compound loading.

TABLE 9.3-5. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN WOOD ROSIN, TURPENTINE, AND PINE OIL SUBCATEGORY WASTEWATER [1] (mg/L)

Pollutant	Intake[a]	Raw wastewater[b]	Treated effluent[c]
BOD_5	<10	1,500	22
COD	11	1,200	230
Suspended solids	<10	240	55
Total phenols	0.12	0.46	<0.06
Oil and grease	<10	<10	<11

[a]Process makeup water-well water.

[b]Influent to equalization basin.

[c]From aerated and settling lagoon; average of three samples.

II.9.3.2.2 Tall Oil Rosin, Fatty Acids, and Pitch

Principal toxic pollutants observed were methylene chloride, benzene, copper, and chromium. Conventional pollutants included total phenols, COD, and oil and grease. Unusually high levels of methylene chloride, toluene, and benzene are probably due to contamination.

Three tall oil distillation plants currently in the industry perform only tall oil distillation and some rosin size operations. As indicated in Tables 9.3-6 and 9.3-7 (next page), one plant in this subcategory was sampled. The other tall oil distillation plants have combined processes, making their wastestreams unsuitable for characterization.

II.9.3.2.3 Rosin Derivatives

Principal toxic pollutants observed were ethylbenzene, toluene, methylene chloride, and zinc. Conventional pollutants included COD, BOD, and oil and grease.

In one plant the rosin derivatives process wastewater was separated from that of other processes. The results of the verification analyses are shown in Tables 9.3-8 and 9.3-9 for three sampling locations.

TABLE 9.3-6. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN TALL OIL ROSIN, PITCH, AND FATTY ACIDS SUBCATEGORY WASTEWATER [1] (μg/L)

Toxic pollutants	Intake[a,b]	Raw wastewater[a]	Treated effluent[a]
Metals and inorganics			
Chromium	110	83	88
Copper	<10	150	220
Lead	<10	14	<10
Nickel	13	19	43
Selenium	<10	11	<10
Zinc	<10	50	44
Monocyclic aromatics			
Benzene	120	120	120
Ethylbenzene	<10	20	<10
Toluene	20	20	20
Halogenated aliphatics			
Chloroform	10	10	10
Methylene chloride	740	710	85

[a]Values not blank adjusted. See Plant 949 in Section II.9.3.3 for identification of blank values.

[b]Process makeup water-well water.

TABLE 9.3-7. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN TALL OIL ROSIN, PITCH, AND FATTY ACIDS SUBCATEGORY WASTEWATER [1] (mg/L)

Pollutant	Intake	Raw wastewater	Treated effluent
BOD_5	<10	42	<10
COD	<10	1,100	130
Suspended solids	<10	44	19
Total phenols	<0.01	0.55	0.029
Oil and grease	<10	48	13

Note: Blanks indicate data not available.

TABLE 9.3-8. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN ROSIN DERIVATIVES SUBCATEGORY RAW WASTEWATER [1] (μg/L)

Toxic pollutant	Raw wastewater sample[a] 706	730	737
Metals and inorganics			
Arsenic	53	41	<10
Cadmium	120	95	100
Chromium	62	48	34
Copper	180	300	190
Lead	72	54	49
Nickel	34	100	35
Zinc	38,000	38,000	38,000
Phenols			
Phenol	14,000	>10,600	23,000
Monocyclic aromatics			
Benzene	170	<10	710
Ethylbenzene	2,200	12,000	28,000
Toluene	5,300	17,000	>4,000
Halogenated aliphatics			
Chloroethane	<10	<10	520
Methylene chloride	7,300	2,700	6,700
1,1,1-Trichloroethane	830	<10	<10

[a] Sample locations presented in Reference 1 in coded form; all location codes are for raw wastewater samples.

TABLE 9.3-9. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN ROSIN DERIVATIVES SUBCATEGORY RAW WASTEWATER [1] (mg/L)

Pollutant	Raw wastewater sample[a] 706	730	737
BOD_5	450	1,260	<10
COD	40,000	31,000	38,000
Suspended solids	87	71	70
Total phenols	46	41	53
Oil and grease	146	92	62

[a] Sample locations presented in Reference 1 in coded form; all location codes are for raw wastewater samples.

Note: Blanks indicate data not available.

effluents from other processing areas. Median concentrations of the three plants' wastewaters were used to determine the values in Tables 9.3-10 and 9.3-11 (next page), since the wastestream from one plant is very different from those of the other two. Wastestreams differ based on the types of end products manufactured by the various plants. The varying product lines of the sulfate turpentine fractionators make this subcategory very difficult to characterize.

II.9.3.3 Plant Specific Description [1]

Tables 9.3-12 through 9.3-15 present toxic pollutant and conventional pollutant data for gum and wood chemical process plants. The data in this section are based on the most current representative information available from four of the plants contacted. Verification sampling data are used to supplement historical data obtained from the plants for the conventional pollutants, and in most cases are the sole source of quantitative information for toxic pollutant raw waste loads.

II.9.3.4 Pollutant Removability [1]

II.9.3.4.1 Industry Application

A matrix of the current in-place treatment technology in the Gum and Wood Chemicals Industry is shown in Table 9.3-16. Many of the direct dischargers have primary treatment in place at this time. Pretreatment processes used by indirect dischargers depend on the requirements of the receiving treatment works. Six indirect dischargers discharge their wastewater to POTW's. Six plants discharge their wastewater to the wastestreams of other industries such as pulp and paper mills. The plants that discharge to POTW's have treatment equipment to meet POTW requirements. The plants that discharge to the wastestreams of other industries pretreat by skimming the surface oil and settling solids.

II.9.3.4.2 Treatment Methods

Oil Separation

Free oil removal - Oily products such as turpentine and fatty acids are a major factor in this industry. Gravity oil-water separation is used throughout the industry to recover oil for use as a fuel supplement or, in some cases, for recycle to the plant process. Oil-water separation, of course, reduces the toxicity and the oxygen demand of the wastewater by removing the oil.

A baffle separator at the effluent end of an equalization basin is the most common system used in the industry. The oil can be skimmed from the basin either manually or continously depending

TABLE 9.3-10. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN SULFATE TURPENTINE SUBCATEGORY WASTEWATER[a] [1]
(μg/L)

Toxic pollutants	Number of samples	Intake		Number of samples	Raw wastewater		Number of samples	Treated effluent	
		Range	Median		Range	Median		Range	Median
Arsenic	1		<10	3	<10-110	<10	3	<10	<10
Chromium	2	<10-120	65[b]	6	49-1,300	545	6	94-880	365
Copper	2	<10-250	130[b]	6	1,600-6,000	2,250	6	1,800-4,700	2,500
Lead	2	<10	<10[b]	6	<10-21	11.5	6	<10-19	13.5
Nickel	2	<10-36	23[b]	6	140-4,100	370	6	46-1,100	325
Selenium	1		<10	3	<10	<10	3	<10-14	<10
Zinc	2	<10	<10[b]	6	170-530	265	6	99-450	320
Bis(2-ethylhexyl) phthalate	1		<10	3	<10	<10	3	<10-1,900	<10
Phenol	1		<10	3	<10-760	130	3	<10-850	<10
Benzene	2	<10-74	42[b]	6	<10-140	<10	6	<10-240	165
Toluene	2	<10	<10[b]	6	<10-2,200	960	6	<10-2,000	635
Chloroform	1		<10	3	980-1,400	1,000	3	900-1,400	1,000
Methylene chloride	2	400-560	480[b]	6	<10-16,000	695	6	490-2,400	1,800

[a]Values not blank adjusted.

[b]Value averaged from two samples.

TABLE 9.3-11. CONCENTRATIONS OF CONVENTIONAL AND CLASSICL POLLUTANTS FOUND IN SULFATE TURPENTINE SUBCATEGORY WASTEWATER [1] (mg/L)

Toxic pollutants	Number of samples	Intake		Number of samples	Raw wastewater		Number of samples	Treated effluent	
		Range	Median		Range	Median		Range	Median
BOD_5	2	<10	<10[b]	6	1,200-3,400	2,100	6	300-4,800	1,500
COD	2	16-18	17[b]	6	5,400-15,000	7,400	6	3,800-7 400	5,700
TSS	2	<10	<10[b]	6	<10-300	120	6	30-520	160
Total phenols	2	0.018-0.028	0.023[b]	6	0.53-4.5	1.2	6	1-14	1.8
Oil and grease	2	<10	<10[b]	6	160-450	320	6	49-506	375

[a]Values not blank adjusted.

[b]Value arranged from two samples.

TABLE 9.3-12. WASTEWATER CHARACTERIZATION, PLANT 464 [1]

Category: Gum and Wood Chemicals
Subcategory: Wood rosin, turpentine, and pine oil
Wastewater Treatment Description: Biological treatment by aerated lagoon or settling basin. Unique pretreatment procedure includes mixing boiler wood ash with equalized wastewater.

Pollutant	Concentration							
	Process makeup and well water	Equalization basin influent	Equalization basin effluent[a]	Blank	Ash settling basin effluent	Blank	Final effluent[b]	Blank
Methylene chloride, μg/L	910	190	560	NA	260	NA	340	280
Chloroform, μg/L	20	<10	10	NA	30	NA	17	20
Ethylbenzene, μg/L	<10	50	10	NA	<10	NA	<10	<10
Toluene, μg/L	<10	-[c]	>400	NA	>400	NA	<10	<10
Arsenic, μg/L	<10	<10	<10	15	14	17	<15	<10
Copper, μg/L	<10	33	<10	<10	<10	<10	<12	21
Chromium, μg/L	<10	1,500	980	<10	620	<10	110	<10
Lead, μg/L	<10	15	17	<10	13	<10	<10	<10
Zinc, μg/L	<10	160	89	<10	150	46	37	56
Total phenols, μg/L	120	460	980	<10	10	<10	<60	<10
Suspended solids, mg/L	<10	240	220	<10	160	<10	55	<10
COD, mg/L	11	1,200	1,100	<10	730	<10	230	<10
BOD, mg/L	<10	1,500	650	<10	270	<10	22	<10
Oil and grease, mg/L	<10	<10	<10	<10	18	<10	<11	<10

[a] After 15-day retention.

[b] After aerated lagoon and settling basin; average of three samples.

[c] Indeterminate because of high organic compound loading.

Note: Values not blank adjusted.

TABLE 9.3-13. WASTEWATER CHARACTERIZATION, PLANT 949 [1]

Category: Gum and Wood Chemicals
Subcategory: Tall oil rosin, pitch, and fatty acids
Wastewater Treatment Description: Primary treatment supplemented by use of alum coagulation to enhance settling of emulsified oils. Biological treatment by aerated lagoons.

Pollutant	Concentration					
	Process makeup and well water	Raw wastewater	Blank	Initial settling effluent	Barametric condenser closed system	Treated effluent
Methylene chloride, μg/L	740	710	30	780	210	85
Chloroform, μg/L	10	10	<10	10	<10	10
Benzene, μg/L	120	120	<10	110	30	120
Ethylbenzene, μg/L	<10	20	<10	10	<10	<10
Toluene, μg/L	20	20	<10	50	70	20
Phenol, μg/L	<10	<10	<10	<10	7,500	<10
Copper, μg/L	<10	150	16	230	300	220
Chromium, μg/L	110	83	35	97	280	88
Lead, μg/L	<10	14	<10	<10	26	<10
Nickel, μg/L	13	19	20	24	66	43
Selenium, μg/L	<10	11	<10	<10	<10	<10
Zinc, μg/L	<10	50	70	27	80	44
Total phenols, μg/L	<10	550	<10	100	1,700	29
Suspended solids, mg/L	<10	44	<10	15	170	19
COD, mg/L	<10	1,100	<10	160	8,400	130
BOD, mg/L	<10	42	<10	12	176	<10
Oil and grease, mg/L	<10	48	<10	<10	167	13

Note: Values not blank adjusted.

TABLE 9.3-14. WASTEWATER CHARACTERIZATION, PLANT 097 [1]

Category: Gum and Wood Chemicals
Subcategory: Rosin Derivatives

Pollutant	Concentration			
	Sample 730	Sample 706	Sample 737	Blank
Chloroethane, μg/L	<10	<10	520	<10
Methylene Chloride, μg/L	2,700	7,300	6,700	630
1,1,1-Trichloroethane, μg/L	<10	830	<10	<10
Benzene, μg/L	<10	170	710	<10
Ethelbenzene, μg/L	12,000	2,200	28,000	<10
Toluene, μg/L	17,000	5,300	>4,000	<10
Phenol, μg/L	>10,600	14,000	23,000	<10
Arsenic, μg/L	41	53	ND	<10
Cadmium, μg/L	95	120	100	<10
Copper, μg/L	300	180	190	<10
Chromium, μg/L	48	62	34	<10
Lead, μg/L	54	72	49	<10
Nickel, μg/L	100	34	35	<10
Zinc, μg/L	38,000	38,000	38,000	<10
Total phenols, μg/L	41,000	46,000	53,000	<10
Suspended solids, mg/L	71	87	70	<10
COD, mg/L	31,000	40,000	38,000	<10
BOD, mg/L	1,260	450	<10	<10
Oil and grease, mg/L	92	146	62	<10

Note: Values not blank adjusted.

TABLE 9.3-15. WASTEWATER CHARACTERIZATION, PLANT 610 [1]

Category: Gum and Wood Chemicals
Subcategory: Sulfate Turpentine

	Concentration				
Pollutant	Plant influent	Raw wastewater	Blank	Treated effluent	Blank
Methylene chloride, µg/L	560	6,620	NA	2,000	300
Benzene, µg/L	<10	<53	NA	<77	<10
Toluene, µg/L	<10	<1,000	NA	<63	<10
Bis(2-ethylhexyl) phthalate, µg/L	<10	<10	<10	<640	<10
Arsenic, µg/L	<10	<43	<10	<10	<10
Copper, µg/L	250	2,000	190	2,970	220
Chromium, µg/L	120	200	36	150	16
Lead, µg/L	<10	<11	<10	16	<10
Nickel, µg/L	36	170	13	230	16
Selenium, µg/L	<10	<10	<10	<13	<10
Zinc, µg/L	<10	240	30	360	30
Total phenols, µg/L	18	6,330	<10	5,900	<10
Suspended solids, mg/L	<10	240	<10	420	<10
COD, mg/L	16	10,000	<10	4,700	<10
BOD, mg/L	<10	1,500	<10	440	<10
Oil and grease, mg/L	<10	290	<10	140	<10

Note: Values not blank adjusted.

[a]Average of three samples.

TABLE 9.3-16. SUMMARY OF IN-PLACE TREATMENT TECHNOLOGY

Description	Plant code																				
	778	476	976	068	291	649	017	110	687A	687B	974	474	573	877	286	102	140	479	864	943	767
Type of discharger[a]	D	O	D	I	I	O	I		I	D	I	O	O	D	D	D	O	I	D	O	D
Oil separation	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Equalization	X		X	X					X		X				X	X		X	X		X
Air flotation	X															X		X			X
Neutralization	X			X			X				X					X		X	X		X
Nutrient addition	X		X				X	X											X		X
Aerated lagoon	X		X				X	X						X	X						X
Chrome reduction																					
Metals removal																					
Clarification								X		X		X				X		X			
Filtration											X					X					
Granular carbon adsorption																X					
Chemical coagulation				X										X	X						
Settling	X	X	X	X	X	X	X		X	X			X	X	X	X	X	X	X	X	X
Mixing carbonaceous fly			X																		
Nonaerated pond															X				X		
Activated sludge																			X		

[a]D - direct, O - plant discharges into the wastestream of another plant, I - indirect.

on the wastewater flow and the quantity of oil products produced at the plant. In this study, free oil removal was not considered part of the treatment system, and wastewater characteristics across oil-water separators were not considered.

Chemical flocculation - Wastewater from the industry typically has high concentrations of emulsified oil, the quantity of which varies from plant to plant depending on the efficiency of the oil-water separator and the pH of the wastestream. At a pH less than 3, the emulsion problem is greatly reduced; however, the pH of the wastestreams in the industry typically ranges from 3 to 9.

Two plants in the industry are currently using chemical coagulation. One plant fractionates tall oil, and the other plant has major production in the wood rosin and turpene area. These plants reduce oil and grease by 65% to 85% using coagulation and settling equipment with a polymer as a flocculation aid. The flocculated effluent generally contains from 7 to 16 mg/L of oil and grease.

Equalization. Equalization is used in the treatment system to smooth out surges in both flow and pollutant concentration. Some type of equalization will be required by the industry in general.

Air Flotation. Air flotation devices are used by plants 778 and 767. A study conducted by plant 778 reported that air flotation removed 204 kg/day (450 lb/day) of BOD, 181 kg/day (400 lb/day) oil and grease, and 236 kg/day (521 lbs/day) of COD. Plant 767 is in the process of installing the flotation equipment, and pollutant removal rates are not available at this time.

Plant 102 is using a dissolved air flotation process. A study conducted by the plant showed a reduction of TOC across the flotation unit of 2,860 kg/day (6,300 lb/day). Oils recovered from the flotation unit are used as a fuel supplement.

Neutralization. Gum and wood chemicals industrial wastestreams vary in pH from 3 to 9. Neutralization is required to adjust the pH of the stream to levels necessary for the various treatment steps. Oil emulsion breaking requires a pH of less than 3; metals precipitation requires a pH of approximately 9; and biological treatment requires a pH of approximately 7. The pH adjustment can be made with the addition of either alkalies or acids, depending on what pH is required. Alkalies commonly used are lime, caustic, or soda ash. The acid used in neutralization is usually sulfuric acid.

Carbon Adsorption. Presently, there is one facility using activated carbon adsorption. Plant 102 has oil-water separation, neutralization, dissolved air flotation, filtration, and finally granular activated carbon (GAC). Before installing the GAC, carbon isotherm and pilot plant studies were performed.

Adsorption isotherms were developed by three separate laboratories using the parameter COD. The results were carbon loadings of between 0.85 and 1.2 kg COD/kg carbon (0.85 lb COD/1.2 lb carbon). The pilot plant studies revealed that the optimal conditions were flow rates of 176 to 293 m^3/m^2/day (3 to 5 gpm/ft^2) and a contact time of 45 to 50 minutes. At these conditions, COD removals were 75% to 85%. The pilot plant results confirmed the isotherm results by yielding a carbon loading of approximately 1.0 kg COD/kg carbon (lb COD/lb carbon).

The GAC system was designed and is operating at a carbon loading of approximately 1.2 kg COD/kg carbon (1.2 lb COD/lb carbon) and 0.44 kg TOC/kg carbon (lb TOC/lb carbon). Pollutant reductions were approximately 84% COD and 79% TOC. Representative performance data for the GAC system are shown in Table 9.3-17 (next page). The performance of the entire treatment system was better than 95% removal of COD and TOC. Typical performance data for the total treatment system are shown in Table 9.3-18.

Very little data are available on adsorption of toxic pollutants in gum and wood chemicals wastewater. Carbon adsorption is not effective for removing most metals. The organics commonly identified during screening and verification were benzene, toluene, ethylbenzene, and phenol.

As indicated in Table 9.3-19, the toxic pollutants found at plant 102 were benzene, toluene, phenol, and bis(2-ethylhexyl) phthalate. The bis(2-ethylhexyl) phthalate was found only in the effluent of the carbon adsorption unit.

Evaporation. Due to the significant volumes of plant wastewater generated, evaporation is not a feasible or widely used technology in the Gum and Wood Chemicals Industry for achieving no-discharge status. However, it may be applicable for disposal of specific, high strength, low volume, process wastestreams.

II.9.3.5 References

1. Technical Review of the Best Available Technology, Best Demonstrated Technology, and Pretreatment Technology for the Gum and Wood Chemicals Point Source Category (draft contractor's report). Environmental Science and Engineering, Inc.

2. NRDC Consent Decree Industry Summary - Gum and Wood Chemicals Industry.

3. Environmental Protection Agency - Effluent Guidelines and Standards for Gum and Wood Chemicals Manufacturing. 40 CFR 454; 41FR 20506, May 18, 1976.

TABLE 9.3-17 SECONDARY TREATMENT FEED AND EFFLUENT ANALYSIS AND PERFORMANCE DATA FOR PLANT 102 GRANULAR ACTIVATED CARBON SYSTEM [1]

Item	Influent	Effluent	Percent reduction	Removal, kg/day
Design				
12,260 m^3/day (3.24 MGD/d)				
COD, mg/L	600	125	79	5,810
TOC, mg/L	160	30	81	1,590
BOD, mg/L	250	50	80	2,450
Startup period				
9,810 m^3/day (2.59 MGD/d)				
COD, mg/L	975	152	84	8,070
TOC, mg/L	222	46	79	1,590
Typical operation				
9,810 m^3/day (2.59 MGD/d)				
COD, mg/L	752	160	79	5,810
TOC, mg/L	203	42	79	1,590
Selected samples				
9,810 m^3/day (2.592 MGD)				
BOD, mg/L	300	82	73	2,130
Phenols, mg/L	4.66	0.58	88	40
Ni, mg/L	1.02	0.33	68	6.8
Zn, mg/L	1.11	0.29	74	8.2
Cd, mg/L	0.91	0.22	76	6.8
Cu, mg/L	1.29	0.36	72	9.1
Cr, mg/L	1.12	0.26	77	8.6
TS, mg/L	1,210	965	20	2,400
SS, mg/L	81	13	84	680
DS, mg/L	1,130	952	16	1,720
Chlorides, mg/L	1.82	0.84	48	8.6
NO_2, mg/L	5.16	4.28	17	8.6
Oil and grease, mg/L	28.1	2.2	92	254

TABLE 9.3-18. TYPICAL TOTAL TREATMENT SYSTEM PERFORMANCE DATA[a] [1]

Parameter	Raw Waste-water mg/L	Primary Treated effluent, mg/L	Secondary Treated effluent, mg/L	Overall reduction, %
COD	3,200	670	143	95.5
TOC	1,200	198	37	96.9
BOD	1,600	267	73	95.4
TSS	320	72	12	96.3
Oil and grease	500	25	2	99.6

[a]Oil-water separation, neutralization, dissolved air flotation, filtration, and granular activated carbon at 9,810 m^3/d (2.592 MGD).

TABLE 9.3-19. REMOVAL OF ORGANIC PRIORITY POLLUTANTS FOR PLANT 102 ACROSS ACTIVATED CARBON COLUMN [1] (μg/L)

Pollutant	Sample prior to carbon column	Sample after carbon column		
		Day 1	Day 2	Day 3
Benzene	590	131	200	300
Toluene	2,500	180	400	1,300
Phenol	120	ND	ND	49
Bis(2-ethylhexyl) phthalate	ND	400	260	ND

II.9.5 PHARMACEUTICAL MANUFACTURING

II.9.5.1 INDUSTRY DESCRIPTION

II.9.5.1.1 General Description [1,2]

The pharmaceutical manufacturing industry produces hundreds of medicinal chemicals by means of many complex manufacturing technologies. The Pharmaceutical Manufacturing Point Source Category may be subdivided to cover the following products, processes, or activities [1]:

- Biological products covered by SIC Code 2831.
- Medicinal chemicals and botanical products covered by SIC Code 2833.
- Pharmaceutical products covered by SIC Code 2834.
- All fermentation, biological and natural extraction, chemical synthesis, and formulation products, which are considered to be pharmaceutical active ingredients by the Food and Drug Administration but are not covered by SIC Codes 2831, 2833, or 2834.
- Cosmetic preparations covered by SIC Code 2844 which function as skin treatments, excluding products which serve to enhance appearance or provide a pleasing odor.
- The portion of a product with multiple end uses which is attributable to the pharmaceutical manufacturing industry.
- Pharmaceutical research which includes biological, microbiological, and chemical research; product development; clinical, and pilot-plant activities.

Information on 436 pharmaceutical manufacturing plants is presently included in the EPA data base, representing the feedback from more than 900 308 Portfolios distributed. Most pharmaceutical manufacturing firms are located in New York, New Jersey, Pennsylvania, Indiana, Michigan, Missouri, Ohio, and California with production concentrated in the industrial areas of the east and midwest. Of the 436 plants identified in the EPA data base, approximately 80% are located in the eastern part of the United States.

Table 9.5-1 summarizes pertinent information regarding the total number of subcategories, the number of subcategories studied by EGD, and the number and type of discharges in the industry. Only 11% of the surveyed pharmaceutical plants have direct discharges, whereas the majority of the plants in the industry discharge their wastewaters to POTW's. Current Best Practicable Control Technology Currently Available (BPT) regulations pertaining to the pharmaceutical manufacturing industry are presented in Table 9.5-2.

TABLE 9.5-1. INDUSTRY SUMMARY [1,3]

Industry: Pharmaceutical Manufacturing
Total Number of Subcategories: 5
Number of Subcategories Studied: 5

Number of Dischargers in Industry:

- Direct: 50
- Indirect: 245
- Combined Direct and Indirect: 7
- Zero: 134[a]

[a]No process wastewater is disposed of at 104 plants; five plants use land application, four use subsurface disposal, five use a septic system, two use ocean disposal, seven use contract disposal, and seven use evaporation to achieve zero discharge.

TABLE 9.5-2. PHARMACEUTICAL MANUFACTURING BPT REGULATIONS [4]

Parameter	Subcategories	Current BPT regulation
BOD_5[a]	A,B,C,D,E	The allowable effluent discharge limitation for the daily average mass of BOD_5 in any calendar month shall be expressed in mass per unit time and shall specifically reflect not less than 90% reduction in the long-term daily average raw waste content of BOD_5 multiplied by a variability factor of 3.0.
COD[a]	A,B,C,D,E	The allowable effluent discharge limitation for the daily average mass of COD in any calendar month shall be expressed in mass per unit time and shall specifically reflect not less than 74% reduction in the long-term daily average raw waste content of COD multiplied by a variability factor of 2.2.
TSS	B,D,E	The average of daily TSS values for any calendar month shall not exceed 52 mg/L.
pH	A,B,C,D,E	The pH shall be within the range of 6.0 to 9.0 standard units.

[a]To assure equity in regulating discharges from the point sources covered by this subpart of the point source category, calculation of raw waste loads of BOD_5 and COD for the purpose of determining NPDES permit limitations (i.e., the base numbers to which the percent reductions are applied) shall exclude any waste load associated with solvents in those raw waste loads; *Provided*, that residual amounts of solvents remaining after the practice of recovery and/or separate disposal or reuse may be included in calculation of raw waste loads. These practices of removal, disposal or reuse include recovery of solvents from waste streams and incineration of concentrated solvent waste streams (including tar still bottoms). This regulation does not prohibit inclusion of such wastes in the raw waste loads in fact, nor does it mandate any specific practice, but rather describes the rationale for determining the permit conditions. These limits may be achieved by any one of several or a combination thereof of programs and practices.

II.9.5.1.2 Subcategory Descriptions [1,2]

Under the regulation established for BPT, the Pharmaceutical Manufacturing Point Source Category was grouped into the five product or activity areas shown below. This subcategorization was based on distinct differences in manufacturing processes, raw materials, products, and wastewater characteristics and treatability.

Subcategory A - Fermentation Products
Subcategory B - Biological and Natural Extraction Products
Subcategory C - Chemical Synthesis Products
Subcategory D - Formulation Products
Subcategory E - Pharmaceutical Research

- The EPA has decided to deemphasize pharmaceutical research (Subcategory E) because this activity does not fall within SIC Codes 2831, 2833, and 2834, which were identified in the Consent Decree.
- Many plants within the industry are involved in activities associated with more than one subcategory. Table 9.5-3 indicates that 78.9% of the plants in the EPA data base are involved in formulation (Subcategory D) activities. Table 9.5-4 presents a breakdown of the industry by manufacturing subcategory, listing the number of plants and the percent of total plants for each subcategory combination. Formulation (Subcategory D) is by far the most common manufacturing operation in this industry. Many plants having either Subcategory A or C operations also have Subcategory D activities.
- Table 9.5-5 gives the number of batch, continuous, and semi-continuous operations for each subcategory and for the total industry. Batch-type operations are by far the most prevalant form of pharmaceutical production activities.

Subcategory A - Fermentation Products

Fermentation, the basic method used for producing most antibiotics and steroids, involves three basic processing steps: inoculum and seed preparation, fermentation, and product recovery.

Production of a fermentation pharmaceutical begins with spores from the plant master stock. The spores are activated with water, nutrients, and heat. The cultures are then propagated under laboratory conditions to produce sufficient mass for transfer to the seed tank.

Fermentation is a batch process, although most large operations are highly automated. In each batch cycle, the broth is discharged from the previous cycle, and then the fermenter is washed down with water and sterilized with live steam. Sterilized raw materials are then charged into the vessel. After optimum conditions are achieved, the microorganisms in the seed tank are drained into the fermenter, and fermentation begins.

TABLE 9.5-3. PLANTS ASSOCIATED WITH OVERALL MANUFACTURING SUBCATEGORIES [3]

Overall manufacturing subcategory[a]	Number of plants	Percent of total plants
A	30	6.9
B	64	14.7
C	113	25.9
D	344	78.9

[a]Excludes subcategory E.

TABLE 9.5-4. PLANTS ASSOCIATED WITH MANUFACTURING SUBCATEGORY COMBINATIONS [3]

Manufacturing subcategory combination[a]	Number of plants	Percent of total plants
A	3	0.7
B	20	4.6
C	40	9.2
D	255	58.5
AC	3	0.7
AD	6	1.4
BC	7	1.6
BD	20	4.6
CD	41	9.4
ABC	1	0.2
ABD	3	0.7
BCD	6	1.4
ABCD	7	1.6

[a]Excludes subcategory E.

TABLE 9.5-5. PHARMACEUTICAL INDUSTRY SUBCATEGORY AND PRODUCTION OPERATION BREAKDOWN [3]

	Number of operations				
	Subcategory				
Parameter	A	B	C	D	Total
Type of operation					
Batch	25	60	109	327	521
Continuous	3	0	14	16	33
Semicontinuous	9	9	18	17	53
Number of operations	37	69	141	360	607
Percent of total operations	6.1	11.4	23.2	59.3	100.0

After a period of 12 hours to one week, depending on the fermentation process, the broth is ready for product recovery. The four common methods of product recovery are solvent extraction, direct precipitation, ion exchange, and carbon adsorption. In solvent extraction, an organic solvent is used to remove the pharmaceutical product from the aqueous broth to form a more concentrated, smaller volume solution. Direct precipitation consists of first precipitating the product from the aqueous broth, filtering the broth, and then extracting the product from the solid residues. Ion exchange and carbon adsorption involve removal of the product from the broth using a solid material (i.e., ion exchange resin or activated carbon). The product is then removed from the solid phase using an elutriant or a solvent and subsequently recovered.

Subcategory B - Biological and Natural Extraction

Many materials used as pharmaceuticals are derived by extraction from natural sources, which include roots and leaves of plants, animal glands, and parasitic fungi. All extractive pharmaceuticals are too complex to synthesize commercially. In addition, synthesis represents an expensive manufacturing process because extraction requires the collection and processing of very large volumes of specialized plant or animal matter to produce very small quantities of product.

The extraction process consists of a series of operating steps in which, following almost every step, there is a significant reduction in the volume of material being handled. In some processes, the volume reductions may be in orders of magnitude, and the complex final purification operations may be conducted on quantities of materials that are only a few thousandths of the amount handled in earlier steps. Therefore, neither continuous processing methods nor conventional batch methods are suitable for extraction processing. Instead, a unique processing method has been developed which can be described as assembly-line small-scale batch. In this method, material is transported in portable containers through the plant in batches of approximately 19.8 L to 26.4 L. A continuous line of such containers is sent past a series of operating stations. At each station, operators perform specific tasks on each batch in turn. As the volume of material being handled decreases, individual batches are successively combined to maintain reasonable operating volumes, and the line moves more slowly. When the volume is reduced to a very small quantity, the containers being used also become smaller, with laboratory-size equipment used in many cases.

An extractive plant may produce one product for a few weeks, and then, by simply changing the logistical movement of pots and redefining the tasks to be conducted at each station, it can convert almost overnight to the manufacture of a different product.

Subcategory C - Chemical Synthesis Products

Most of the compounds used today as drugs are prepared by chemical synthesis generally using a batch process. The basic equipment consists of a conventional batch reaction vessel, which is one of the most standardized equipment designs in industry. Synthetic pharmaceutical manufacture includes the use of one or several of these vessels to perform, in a step-by-step fashion, the various operations necessary to make the product. Following a definite recipe, the operator (or a programmed computer) adds reagents, increases or decreases the flow rate of cooling water, chilled water, or steam, and starts and stops pumps to withdraw the reactor contents into another similar vessel. At the appropriate steps of the process, solutions are pumped through filters or centrifuges, or pumped into solvent recovery headers or waste sewers.

Each pharmaceutical is usually manufactured in a "campaign" in which one or more process units are employed for a few weeks or months to manufacture enough compound to satisfy the projected sales demand. At the end of the campaign, another is scheduled, and the same equipment and operating personnel are used to make a completely different product, utilizing different raw materials, executing a different recipe, and generating different wastes.

Subcategory D - Formulation Products

Although pharmaceutical active ingredients are produced in bulk form, they must be prepared in dosage form for use by the consumer. Pharmaceutical compounds can be formulated into tablets, capsules, liquids or ointments, as described below.

Tablets are formed by blending the active ingredient, filler, and binder. The mixture is placed in a tablet press machine and sometimes coated by tumbling with a coating material and drying. The filler (usually starch or sugar) is required to dilute the active medicinal to the proper concentration; binder (such as corn syrup or starch) is necessary to bind the tablet particles together. A lubricant (such as magnesium stearate) may be added for proper tablet machine operation. After the tablets have been coated and dried, they are bottled and packaged.

Capsules are produced by first forming the hard gelatin shell. These shells are produced by machines that dip rows of rounded metal dowels into a molten gelatine solution and strip the capsules from the dowels after the capsules have cooled and solidified. The active ingredient and any filler are mixed and poured into the empty gelatin capsules by a machine operation. The filled capsules are bottled and packaged.

Liquid preparations can be formulated for use by injection or oral consumption. In either case, the liquid is weighed and then dissolved in water. Injectable solutions are packaged in bottles and heated or bulk sterilized by sterile filtration and poured into sterile bottles. Oral liquid preparations are bottled directly without subsequent sterilization.

Subcategory E - Pharmaceutical Research

Because of the high cost of a new drug and the general importance to the public health, companies are mainly interested in cures for the more common ailments. Nevertheless, many remedies for rare diseases and diagnostic agents have come from the laboratories of the pharmaceutical industry. The three areas of research in the pharmaceutical industry are chemical, microbiological, and biological.

Laboratory animals are used extensively at pharmaceutical research facilities. The types of animals used include dogs, cats, monkeys, rabbits, guinea pigs, rats, and mice. The animal colonies where the test animals are housed can be major wastewater sources. The animal cages are usually dry-cleaned and the residue washed into the plant sewer system. Collected feces and any animal carcasses are incinerated or landfilled if the waste matter is not infected. Exhaust gases from the incinerators pass through wet scrubbers, and the scrubber blowdown in subsequently discharged to the plant sewer system.

II.9.5.2 WASTEWATER CHARACTERIZATION [1,2]

Plants in the pharmaceutical manufacturing point source category operate continuously throughout the year. Their processes are largely characterized by batch operations, which have significant variations in pollution characteristics during any typical operating period. However, some continuous unit operations are used in the fermentation and chemical synthesis subcategories [2].

Plants in Subcategory A (Fermentation products) and Subcategory C (Chemical synthesis products) generate wastewaters with the highest pollutant concentrations. In Subcategory A, these high levels are primarily due to the spent solvents used in extraction processes and sewered fermentation beers. In Subcategory C, a myriad of organic chemicals are used as intermediates in the production of fine chemicals, and they contribute significant pollutant loads to plant wastewater effluents [2].

The major sources of process wastewaters in the pharmaceutical manufacturing point source category include product washings, product purification and separation, fermentation processes, concentration and drying procedures, equipment washdowns, barometric condensers, and pump-seal waters. Wastewaters from this point source category can be characterized as having high concentrations of BOD_5, COD, TSS, and volatile organics. Wastewaters from some wet chemical syntheses may contain heavy metals (iron, copper, nickel, and silver) or cyanide and may have antibacterial constituents, which can exert a toxic effect on biological waste treatment processes. Considerations significant to the design of treatment works are the highly variable BOD_5 loadings, high chlorine demand, presence of surface-active agents, the possibility of nutrient deficiency, and the possibility of potentially toxic substances [2].

Table 9.5-6 presents available wastewater characterization data by overall manufacturing subcategory in terms of median pollutant loadings and concentrations. As previously shown in Table 9.5-4, nearly 30% of the pharmaceutical manufacturing plants have processes associated with more than one of the four major subcategories. For this reason, the screening data shown in Table 9.5-7 are presented in terms of pollutant concentrations by manufacturing subcategory combinations.

II.9.5.2.1 Subcategory A - Fermentation Products

The sources of wastewater from fermentation operations are (1) spent fermentation beers; (2) floor and equipment wash waters; (3) chemical wastes, such as spent solvents from the extraction processes; and (4) barometric condenser water. Of these, spent fermentation beer is by far the most significant waste discharge [1]. Spent beer contains residual food materials such as sugars, starches, and vegetable oils not consumed in the fermentation process. Spent beer contains a large amount of organic material, protein, and other nutrients; frequently, it also contains large amounts of nitrogen, phosphate, and other growth factors as well as salts, such as sodium chloride and sodium sulfate [2].

TABLE 9.5-6. MEDIAN POLLUTANT LOADINGS AND CONCENTRATIONS BY OVERALL MANUFACTURING SUBCATEGORY [2]

	Subcategory									
	A		B		C		D		E	
Flow, m^3/d	1,500		400		2,300		280		180	
	Median value		Median value		Median value		Median value		Median value	
Pollutants	kg/d	mg/L	kg/d	mg/L	kg/d	mg/L	kg/d	mg/L	kg/d	mg/L
Toxic pollutant metals and inorganics:										
Arsenic	0.30[a]	0.15[a]	NA	NA	14[a]	12[a]	NA	NA	NA	NA
Chromium	0.09	0.06	NA	NA	0.20[a]	0.16[a]	NA	NA	NA	NA
Copper	ND[a]	ND[a]	0 10[a]	0.11[a]	NA	NA	0.13	0.12	0.19[a]	0.23[a]
Cyanide	0.015	0.009	0.023	0.23	0.02[a]	0.016[a]	0.03[a]	0.020[a]	NA	NA
Lead	ND[a]	ND[a]	0.13[a]	0.15[a]	NA	NA	0.085	0.093	0.040[a]	0.048[a]
Mercury	ND[a]	ND[a]	ND[a]	ND[a]	NA	NA	0.0005	0.0003	0.002[a]	0.0024[a]
Selenium	0.13[a]	0.063[a]	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	ND[a]	ND[a]	0.27[a]	0.31[a]	NA	NA	0.55	0.49	0.52[a]	0.62[a]
Other metals:										
Aluminum	ND[a]	ND[a]	0.04[a]	0.45[a]	NA	NA	NA	NA	NA	NA
Calcium	140	150	71[a]	81[a]	280	120	14	73	22	62
Iron	ND[a]	ND[a]	0.50[a]	0.57[a]	17[a]	2.4[a]	0.15	0.64	0.20	0.38
Magnesium	9.5	3.1	NA	NA	64[a]	52[a]	NA	NA	NA	NA
Manganese	0.009[a]	0.0044[a]	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	67	39	NA	NA	150[a]	120[a]	NA	NA	NA	NA
Sodium	240	190	50[a]	560[a]	4,900	810	5.6[a]	3,600[a]	2.5[a]	3.9[a]
Classical and conventional:										
BOD	4,500	2,500	17	150	2,500	1,900	210	380	20	200
COD	9,300	5,800	41	300	7,200	3,500	350	670	43	400
TSS		840		32		280		49		50
TDS	4,400	3,300	250	1,000	6,900	6,700	360	660	100	480
TKN	520	280	2.9	8.3	240	800	5.5	25	5.0	2.7
NO_3-N	0.0015	ND	ND	ND	0.085	0.13	0.15	0.13	0.02	0.031
Phosphorous(total)	61	43	2.2	3.7	131	44	1.6	10	0.95	10
Phenol(total)	0.30	0.18	0.006[a]	0.013[a]	2.5	1.2	NA	NA	0.053[a]	0.29[a]
Hardness	500	330	NA	NA	700[a]	570[a]	180[a]	120[a]	NA	NA
Oil and grease	530	390	0.31	2.1	200	86	21	15	3.1[a]	17[a]
Sulfate	210	130	42	64	2,600	1,700	22	39	32	72
Sulfide	NA	NA	NA	NA	NA	NA	0.021[a]	0.014[a]	NA	NA
Chloride	92	66	410[a]	470[a]	1,600	550	31	28	19	47

[a]Based upon single reported value.

TABLE 9.5-7. POLLUTANT CONCENTRATIONS BY MANUFACTURING SUBCATEGORY COMBINATIONS [1] (μg/L)

Toxic pollutant	A[a]		D[a]		AD[a,b]	CD[a]		CE[a]	
	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Metals and inorganics									
Antimony	28	50	ND	ND	ND	NA	90	ND	ND
Arsenic	31	47	ND	ND	ND	NA	7,000	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	6	ND
Chromium	ND	17	30	10	ND	NA	9	6	7
Copper	29	48	50	30	ND	NA	35	21	ND
Cyanide	ND	ND	ND	ND	ND	ND	ND	1,000	32
Mercury	ND	6.4	ND	ND	ND	ND	ND	ND	ND
Selenium	60	150	ND	ND	ND	NA	310	ND	ND
Zinc	89	120	300	200	ND	NA	70	60	36
Ethers									
Bis(2-chloroethyl) ether	ND	ND	ND	ND	ND	ND	ND	5	10
Phthalates									
Bis(2-ethylhexyl) phthalate	ND	ND	170	30	ND	ND	ND	6	8
Di-n-butyl phthalate	ND	ND	20	ND	ND	ND	ND	ND	ND
Nitrogen compounds									
1,2-Diphenylhydrazine	ND	ND	ND	ND	ND	ND	ND	10	ND
Phenols									
2-Nitrophenol	ND	ND	ND	ND	ND	13,000	4,100	ND	ND
4-Nitrophenol	1,600	ND	ND	ND	ND	3,500	1,100	ND	ND
Pentachlorophenol	ND	ND	62	ND	ND	ND	ND	ND	ND
Phenol	70	ND	ND	ND	ND	17,000	17,000	32	ND
2,4,6-Trichlorophenol	ND	ND	ND	ND	ND	ND	ND	7	ND
Aromatics									
Benzene	ND	ND	79	ND	390	ND	ND	20	ND
Ethylbenzene	ND	ND	11	ND	ND	ND	ND	71	ND
Toluene	ND	ND	900	ND	53	ND	ND	17,000	700
Halogenated aliphatics									
Carbon tetrachloride	ND	ND	ND	ND	300	ND	ND	6,000	ND
Chloroform	ND	ND	300	14	1,400	ND	ND	1,600	ND
1,2-Dichloroethane	ND	ND	19	ND	ND	ND	20	74	ND
1,1-Dichloroethylene	ND	ND	ND	ND	ND	30	370	95	ND
Methyl bromide	ND	ND	ND	ND	ND	ND	ND	15	ND
Methyl chloride	ND	ND	ND	ND	ND	ND	ND	1,500	ND
Methylene chloride	ND	70	470	12	200,000	ND	ND	20,000	100
Tetrachloroethylene	ND	ND	36	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	1,300	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	1,300	890	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND

(continued)

TABLE 9.5-7 (continued)

Toxic pollutant	A[a] Raw wastewater	A[a] Treated effluent	D[a] Raw wastewater	D[a] Treated effluent	AD[a,b] Effluent	CD[a] Raw wastewater	CD[a] Treated effluent	CE[a] Raw wastewater	CE[a] Treated effluent
Conventional, mg/L									
BOD	NA	140	260	19	-[c]	NA	NA	1,500	120
COD	NA	300	490	54	-[c]	NA	NA	3,500	750
TSS	NA	97	150	15	-[c]	NA	NA	84	210

Toxic pollutant	DE[a] Raw wastewater	DE[a] Treated effluent	ACD[a] Raw wastewater	ACD[a] Treated effluent	ACE[a] Raw wastewater	ACE[a] Treated effluent	ADE Raw wastewater	ADE Treated effluent	BDE[a] Raw wastewater	BDE[a] Treated effluent
Metals and inorganics										
Antimony	ND	ND	24	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	120	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	32	ND	ND	ND	ND	ND	ND	ND
Chromium	30	10	14	ND	145	15	ND	ND	ND	ND
Copper	80	20	27	ND	145	10	ND	ND	ND	ND
Cyanide	ND	ND	ND	ND	840	400	ND	ND	ND	ND
Lead	ND	ND	46	ND	10	ND	ND	ND	ND	ND
Mercury	ND	ND	ND	ND	0.8	ND	ND	ND	ND	ND
Nickel	ND	ND	89	56	200	100	ND	ND	ND	ND
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	ND	ND	250	16	250	50	ND	ND	ND	ND
Ethers										
Bis(2-chloroisopropyl) ether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phthalates										
Bis(2-ethylhexyl) phthalate	50	10	39	ND	100	200	ND	5	30	ND
Butyl benzyl phthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	20	ND	ND	ND	90	12	ND	ND	ND	ND
Phenols										
2-Chlorophenol	ND	ND	ND	ND	22	55	ND	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND	ND	5	4	ND	ND	ND	ND
2-Nitrophenol	ND	ND	ND	ND	60	3.5	ND	ND	ND	ND
4-Nitrophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	220	24	ND	11	ND	ND
2,4,6-Trichlorophenol	ND	ND	ND	ND	7	6	ND	ND	ND	ND

(continued)

TABLE 9.5-7 (continued)

Toxic pollutant	DE[a] Raw wastewater	DE[a] Treated effluent	ACD[a] Raw wastewater	ACD[a] Treated effluent	ACE[a] Raw wastewater	ACE[a] Treated effluent	ADE Raw wastewater	ADE Treated effluent	BDE[a] Raw wastewater	BDE[a] Treated effluent
Aromatics										
Benzene	ND	ND	820	ND	2,100	8	ND	ND	40	10
Chlorobenzene	ND	ND	ND	ND	600	200	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	5	1	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	86	3	ND	11	ND	ND
Nitrobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	10,000	ND	25	ND	ND	ND	ND	ND
Polycyclic aromatic hydrocarbons										
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	14	7	ND	ND	ND	ND
Halogenated aliphatics										
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	130	ND	1,200	ND	210	ND	ND	ND	ND	ND
1,2-Dichloroethane	15	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	800	250	20	ND	5,900	210	3,100	88	130	210
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	10	ND	ND	ND	ND	ND
Tetrachloroethylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	5	ND	ND
1,1,2-Trichloroethane	17	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	ND	ND	ND	ND	11	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides and metabolites										
Isophorone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Classical										
BOD	NA	NA	990	72	2,000	70	1,900	13	7,500	4,600
COD	NA	850	3,000	940	4,800	200	2,500	200	12,000	7,400
TSS	NA	350	400	200	NA	56	410[a]	82[a]	4,900	4,000

(continued)

TABLE 9.5-7 (continued)

Toxic pollutant	CDE[a] Raw wastewater	CDE[a] Treated effluent	ACDE[a] Raw wastewater	ACDE[a] Treated effluent	BCDE Raw wastewater	BCDE Treated effluent	ABCDE Raw wastewater	ABCDE Treated effluent
Metals and inorganics								
Antimony	ND	ND	ND	14	28	ND	10	ND
Arsenic	ND	ND	ND	ND	<20	ND	ND	10
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	10	16	16	94	23
Copper	ND	ND	ND	65	22	41	180	47
Cyanide	ND	ND	ND	0.02	120	ND	580	180
Lead	ND	ND	ND	5	ND	ND	7.5	10
Mercury	ND	ND	ND	ND	ND	ND	1.3	0.65
Nickel	ND	ND	ND	11	ND	ND	28	110
Selenium	ND	ND	ND	10	16	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	ND	24	ND
Zinc	ND	ND	ND	265	150	250	500	195
Ethers								
Bis(2-chloroethyl) ether	169	114	ND	ND	ND	ND	ND	ND
Phthalates								
Bis(2-ethylhexyl) phthalate	ND	ND	ND	380	130	28	12	ND
Butyl bentyl phthalate	360	ND	ND	ND	ND	ND	ND	ND
Di-n-butyl phthalate	10	ND	ND	ND	ND	ND	ND	ND
Diethyl phthalate	31	ND	ND	ND	ND	ND	ND	ND
Nitrogen compounds								
N-nitrosodiphenylamine	ND	ND	ND	ND	12	ND	ND	ND
Phenols								
2-Chlorophenol	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ND	8	ND	ND	ND	ND	ND	ND
2-Nitrophenol	ND	ND	ND	ND	ND	ND	ND	ND
4-Nitrophenol	ND	10	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	ND	ND	ND	ND
Phenol	10	ND	NA	7,100	ND	ND	230	ND
Cresols								
4,6-Dinitro-*o*-cresol	ND	ND	ND	ND	ND	ND	ND	ND
Aromatics								
Benzene	37	ND	ND	250	ND	ND	ND	12
Chlorobenzene	6	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
2,4-Dinitrotoluene	49	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	41	9	ND	ND	ND	ND	7	ND
Toluene	370	160	NA	350	ND	ND	190	>100

(continued)

TABLE 9.5-7 (continued)

Toxic pollutant	CDE[a] Raw wastewater	CDE[a] Treated effluent	ACDE[a] Raw wastewater	ACDE[a] Treated effluent	BCDE Raw wastewater	BCDE Treated effluent	ABCDE Raw wastewater	ABCDE Treated effluent
Polycyclic aromatic compounds								
Acenapthene	104	ND	ND	ND	ND	ND	ND	ND
Anthracene	7	ND	ND	ND	ND	ND	ND	ND
Fluorene	14	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	7	ND	ND	ND	ND	ND	ND	ND
Halogenated aliphatics								
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	13	9	NA	450	51	130	130	58
1,1-Dichloroethane	ND	ND	NA	28	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	7,000	ND	ND	14	33
1,1-Dichloroethylene	ND	ND	ND	10	ND	ND	ND	ND
1,2-*trans*-dichloroethylene	ND	ND	ND	550	ND	ND	ND	ND
Methylene chloride	320	60	ND	850,000	63	32	2,400	214
Tetrachloroethylene	13	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	131	6	ND	360,000	ND	ND	ND	ND
1,1,2-Trichloroethane	10	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	62	7	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND
Pesticides and metabolites								
Isophorone	500	ND	ND	ND	ND	ND	ND	ND
Conventional, mg/L								
BOD	600	29	NA	NA	4,100[a]	600[a]	5,900	140
COD	1,200	180	NA	NA	16,000[a]	NA[a]	39,000	7,500[a]
TSS	20	30	NA	NA	250[a]	1,000[a]	2,000[a]	390[a]

[a]Medians derived from less than three plants.

[b]Wastewater undergoes no treatment prior to discharge.

[c]Not applicable.

Disinfectants can contribute to the pollutant load from fermentation processes. Although steam is used to sterilize most equipment, many instruments cannot withstand high temperatures. Although there is no published information indicating which disinfecting agents are used, a number of toxic pollutants including phenol, can be used for that purpose. The fermentation process occasionally creates massive discharges of contaminated wastewater, which occur whenever a plant becomes infested with a phage [1].

Wastewaters from fermentation processes are generally characterized by high BOD, COD, and TSS concentrations; large flows; and a pH range of about 4.0 to 8.0 [1].

II.9.5.2.2 Subcategory B - Biological and Natural Extraction Products

The principal sources of wastewater from biological/natural extraction operations are (1) spent raw materials, such as waste plasma fractions, spent eggs, spent media broth, plant residues, etc.; (2) floor and equipment wash waters; (3) chemical wastes, such as spent solvents; and (4) spills [1]. Whenever possible, bad batches are recycled; if this is not feasible, the bad batches are discharged to the plant process sewer system [2].

Wastewaters from biological/natural extraction processes are generally characterized by low BOD, COD, and TSS concentrations; small flows; and a pH range of about 6.0 to 8.0 [1].

II.9.5.2.3 Subcategory C - Chemical Synthesis Products

Primary sources of wastewater from chemical synthesis operations are (1) process wastes, such as spent solvents, filtrates, centrates, etc.; (2) floor and equipment wash waters; (3) pump seal waters; (4) wet scrubber spent waters; and (5) spills [1].

Wastewaters from chemical synthesis operations are generally characterized as having high BOD, COD, and TSS concentrations; large flows; and an extremely variable pH ranging from 1.0 to 11.0 [1].

II.9.5.2.4 Subcategory D - Formulation Products

Sources of wastewater from mixing/compounding/formulation operations are (1) floor and equipment wash waters, (2) wet scrubbers, (3) spills, and (4) laboratory wastes. The use of water to clean out mixing tanks can flush materials of unusual quantity and concentration into the plant sewer system. The washouts from recipe kettles, which are used to prepare the master batches of the pharmaceutical compounds, may contain inorganic salts, sugars, syrup, etc. Dust fumes and scrubbers used in connection with building ventilation systems or, more directly, on dust and fume generating equipment, can be another source of wastewater depending on the characteristics of the material being removed from the air stream [1].

Wastewaters from mixing/compounding/formulations processes are generally characterized as having low BOD, COD, and TSS concentrations; relatively small flows; and a pH range of about 6.0 to 8.0 [1].

II.9.5.2.5 Subcategory E - Pharmaceutical Research

Generally, quantities of materials being discharged by research operations are relatively small compared with the volumes generated by production facilities. Research operations are frequently erratic with regard to quantity, quality, and time schedule when wastewater discharging occurs. Flammable solvents, especially volatile solvents such as ethyl ether, that can cause explosions and fires are the most common problem. The major sources of wastewater are vessel and equipment washings, animal cage wash water, and laboratory-scale production units. The wastewaters are generally characterized as having BOD_5 and COD concentrations similar to those in domestic sewage; pH values are between 6.0 and 8.0 [2].

II.9.5.3 PLANT SPECIFIC DESCRIPTIONS

Tables 9.5-8 through 9.5-21 present plant specific information for each of the subcategory combinations as follows:

- A
- D
- A,D
- C,D
- D,E
- A,C,D
- B,D,E
- C,E
- A,C,E
- A,D,E
- C,D,E
- A,C,D,E
- B,C,D,E
- A,B,C,D,E

In cases where sampling data were available for more than one plant in a particular subcategory combination, one plant was selected for inclusion in the plant specific description section based on consideration of effluent concentrations, percent removal, and amount of available data. For each of the following 14 plants, four types of information are presented: a summary of screening data, a description of the wastewater treatment plant, when available, performance results of the treatment system, and a flow diagram of the wastewater treatment plant.

Except for BOD and COD, all reported pollutant levels were obtained as a result of the screening program. The BOD and COD values were derived from data in the 308 portfolios.

It should be noted that all analysis of toxic pollutants was conducted on each sample from each plant. The screening summaries reported on Tables 9.5-8 through 9.5-21 present only those compounds which were detected. Only the influent and effluent levels are reported for each plant. Data from other locations within the plant, which may have been sampled, were omitted in order to highlight the effects of BPT-type treatment on the removal of toxic pollutants.

II.9.5.4 POLLUTANT REMOVABILITY

Wastewaters from pharmaceutical manufacturing activities vary in quantity and quality depending upon the type of operations employed. However, in general, the wastes are readily treatable. Table 9.5-22 presents a summary of the wastewater treatment technologies identified by the industry survey and the number of plants found to be using each particular process. End-of-pipe systems in the pharmaceutical manufacturing industry rely heavily upon the use of biological treatment methods, particularly the activated sludge process. A majority of the plants that are considered to have BPT treatment in-place use activated sludge systems. One facility has installed a pure oxygen system; another plant reported using powdered activated carbon in its activated sludge unit. Other biological methods identified in the survey include trickling filters, aerated lagoons, and waste stabilization ponds. Primary treatment includes equalization to minimize shock loads to downstream units at many of the plants. This finding is consistent with the fact that most pharmaceutical manufacturing operations produce wastewaters on an intermittent basis. Neutralization is required at almost two-thirds of the plants to neutralize acidic or alkaline wastes generated from the production of specific products.

Primary separation methods to remove solids were shown by the survey to be widely practiced. Physical/chemical systems also are being utilized to achieve higher levels of wastewater treatment. Thermal oxidation of strong chemical waste streams has proven successful at two pharmaceutical facilities. Another three sites reported using evaporation methods to reduce wastewater flows. Effluent polishing including polishing ponds, chemical flocculation/clarification, sand and multimedia filtration, and chlorination were identified at 22 pharmaceutical facilities.

Table 9.5-23 presents conventional pollutant removability and respective treatment for 20 plants identified in the Pharmaceutical Manufacturing Development Document [2] grouped according to manufacturing subcategory combinations. These data were from an initial verification survey for the conventional pollutants. Table 9.5-24 presents a key to the coded treatment operations listed in Table 9.5-23 and in all other tables in Section II.9.5.3.

Table 9.5-25 presents conventional pollutant removability and respective treatment for 27 plants identified in Reference 1 grouped according to manufacturing subcategory. These data were obtained from the 308 portfolios. Table 9.5-26 presents similar information for toxic pollutants; in this case the data was obtained from a toxic pollutant screening survey.

TABLE 9.5-8. SUMMARY OF SCREENING PROGRAM AT PLANT C [3]
SUBCATEGORY A

Summary of screening data

Toxic pollutants	Concentration, μg/L Raw wastewater	Treated effluent
Metals and inorganics		
Antimony	28[a]	50
Arsenic	31[a]	47
Chromium	ND	17
Copper	29[a]	48
Mercury	ND	6.4
Selenium	60[a]	150
Zinc	89[a]	120
Phenols		
4-Nitrophenol	1,600	ND
Phenol	70	ND
Halogenated aliphatics		
Methylene chloride	ND	70

Wastewater treatment plant description

Type of treatment: Biological
Unit operations: Activated sludge, aerated lagoon, sludge stabilization
Wastewater quantity, m^3/d = 1,140 (0.30 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal
BOD[b]	-[c]	143	-[d]
COD[b]	-[c]	297	-[d]
TSS	-[c]	97	-[d]

Wastewater Treatment Plant Flow Diagram

Not available.

[a]Highest value chosen.

[b]BOD and COD values were obtained from data in the 308 portfolios.

[c]Confidential.

[d]Intermediate.

TABLE 9.5-9. SUMMARY OF SCREENING PROGRAM AT PLANT L [3] SUBCATEGORY D

Summary of screening data

Toxic pollutants	Concentration, µg/L	
	Raw wastewater	Treated effluent
Metals and inorganics		
Chromium	30	10
Copper	50	30
Zinc	300	200
Phthalates		
Bis(2-ethylhexyl) phthalate	170	30
Di-n-butyl phthalate	20	ND
Phenols		
Pentachlorophenol	62	ND
Aromatics		
Benzene	79	ND
Ethylbenzene	11	ND
Toluene	900	ND
Halogenated aliphatics		
Chloroform	300	14
1,2-Dichloroethane	19	ND
Methylene chloride	470	12
Tetrachloroethylene	36	ND

Wastewater treatment plant description

Type of treatment: Biological

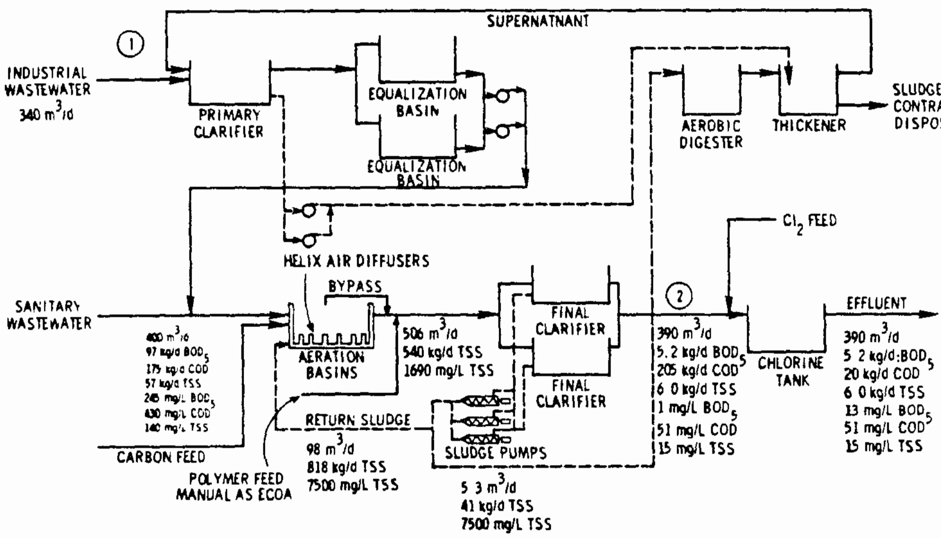
Unit operations: Equalization, primary sedimentation, activated sludge, other polishing, sludge stabilization, dewatering, landfill

Wastewater quantity, m^3/d = 300 (0.08 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L		Percent removal
	Raw wastewater	Treated effluent	
BOD[a]	259	19	92.7
COD[a]	489	54	89
TSS	146	15	89.7

Wastewater Treatment Plant Flow Diagram



NOTE: ALL FLOW RATES ARE DESIGN AVERAGES

SAMPLING PROGRAM

Sample location
1. Influent to treatment facilities - "Raw Wastewater".
2. Discharge from clarifier - "treated effluent".

[a] BOD and COD values were obtained from data in the 308 portfolios.

TABLE 9.5-10. SUMMARY OF SCREENING PROGRAM AT PLANT X [3]
SUBCATEGORIES A,D

Summary of screening data

Toxic pollutants	Concentration, µg/L Raw wastewater	Treated effluent
Aromatics		
Benzene	390	NA
Toluene	53	NA
Halogenated aliphatics		
Carbon tetrachloride	300	NA
Chloroform	1,400	NA
Methylene chloride	200,000	NA
1,1,1-Trichloroethane	1,300	NA

Wastewater treatment plant description

Type of treatment: None
Unit operations: Neutralization
Wastewater quantity, m^3/d = 530 (0.14 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal

Not applicable.

Wastewater Treatment Plant Flow Diagram

Not applicable.

TABLE 9.5-11. SUMMARY OF SCREENING PROGRAM AT PLANT W [3]
SUBCATEGORIES C,D

Summary of screening data

Toxic pollutants	Concentration, μg/L	
	Raw wastewater	Treated effluent
Metals and inorganics		
Antimony	NA	90[a]
Arsenic	NA	7,200[a]
Chromium	NA	9[a]
Copper	NA	35[a]
Selenium	NA	310[a]
Zinc	NA	70[a]
Phenols		
2-Nitrophenol	13,000[a]	4,100
4-Nitrophenol	3,500[a]	1,100
Phenol	17,000[a]	17,000
Halogenated aliphatics		
1,2-Dichlorethane	ND	20
1,1-Dichlorethylene	30	370
1,1,2-Trichloroethane	1,300	890
Trichlorofluoromethane	ND	80

Wastewater treatment plant description

Type of treatment: Chemical precipitation and clarifier

Unit operations: Equalization, neutralization, chemical precipitation, clarifier

Wastewater quantity, m^3/d = 1,700 (0.45 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L		Percent removal
	Raw wastewater	Treated effluent	

Not available.

Wastewater Treatment Plant Flow Diagram

Not available.

[a]Highest value chosen.

TABLE 9.5-13. SUMMARY OF SCREENING PROGRAM AT PLANT G [3]
SUBCATEGORIES A,C,D

Summary of screening data

Toxic pollutants	Concentration, µg/L Raw wastewater	Treated effluent
Metals and inorganics		
Antimony	24	ND
Arsenic	120	ND
Cadmium	32	ND
Chromium	14	ND
Copper	27	ND
Lead	46	ND
Nickel	89	56
Zinc	250	16
Phthalates		
Bis(2-ethylhexyl) phthalate	39	ND
Aromatics		
Benzene	820	ND
Toluene	10,000	ND
Halogenated aliphatics		
Chloroform	1,200	ND
Methylene chloride	20	ND

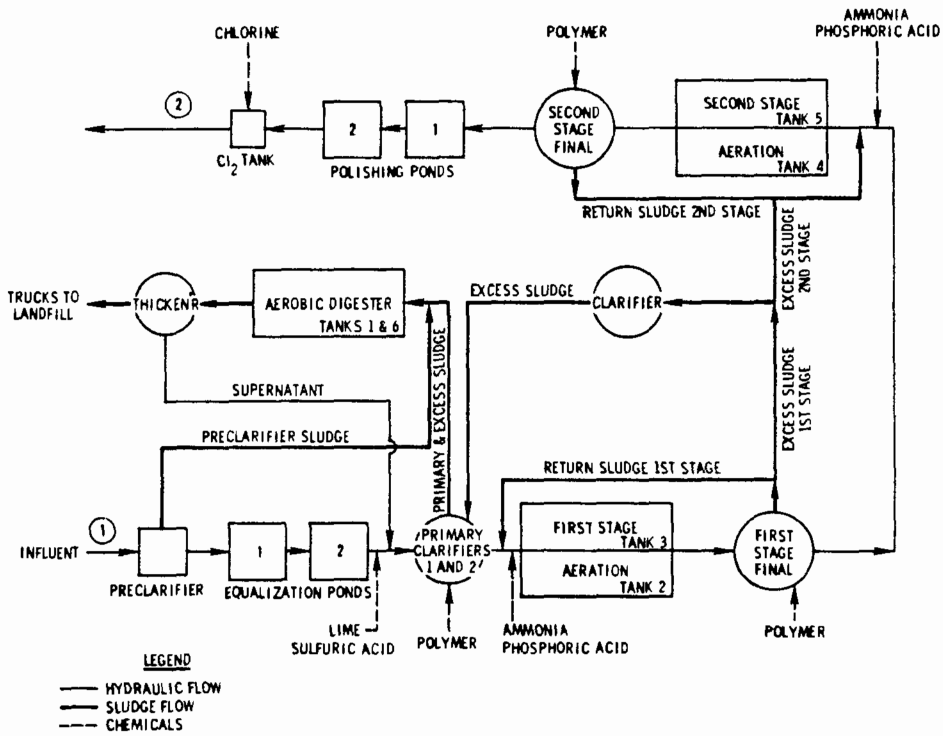
Wastewater treatment plant description

Type of treatment: Biological
Unit operations: Equalization, neutralization, coarse settleable solids, removal, primary sedimentation, activated sludge, physical/chemical treatment, multi-media filtration, flotation thickening, anaerobic digestion, sludge disposal.
Wastewater quantity, m^3/d = 3780 (1.00 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal
BOD[a]	987	72	92.7
COD[a]	2,978	944	68.3
TSS	398	196	50.8

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM

Sample location
1. Raw waste (combined) to WWTP
2. Discharge 001 - treated from WWTP

[a]BOD and COD values were obtained from data in the 308 portfolios.

TABLE 9.5-12. SUMMARY OF SCREENING PROGRAM AT PLANT S [3] SUBCATEGORIES D,E

Summary of screening data

Toxic pollutants	Concentration, µg/L Raw wastewater	Treated effluent
Metals and inorganics		
Chromium	30	10
Copper	80	20
Zinc	ND	100
Phthalates		
Bis(2-ethylhexyl) phthalate	50	10
Di-n-butyl phthalate	20	ND
Halogenated aliphatics		
Chloroform	130	ND
1,2-Dichloroethane	15	ND
Methylene chloride	800	250
1,1,2-Trichloroethane	17	ND

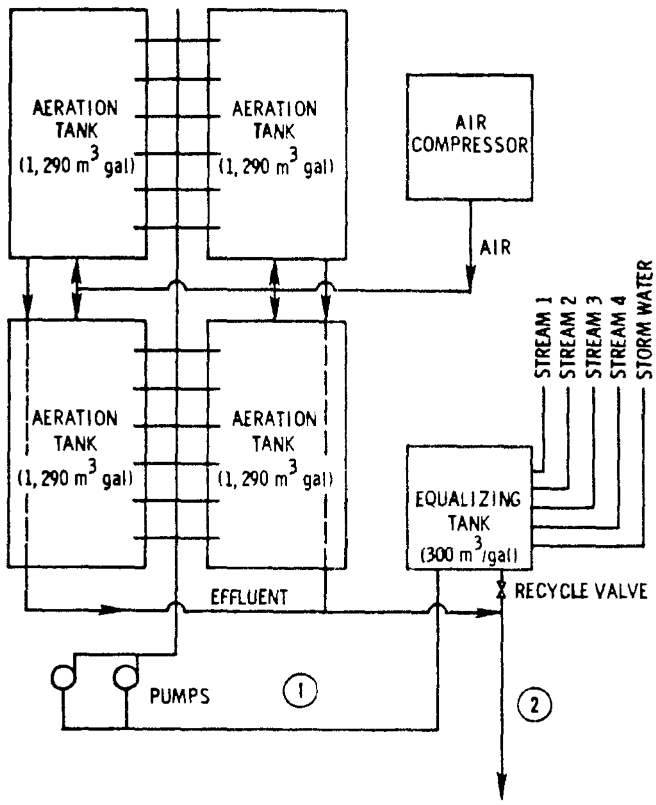
Wastewater treatment plant description

Type of treatment: Biological
Unit operations: Activated sludge, mechanical thickening, centrifugation, landfill
Wastewater quantity, m^3/d = 610 (0.16 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal
COD[a]	-[b]	847	-[c]
TSS	-[b]	349	-[c]

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM
Sample location
1. Influent to WWTP
2. Effluent from WWTP

[a]COD value was obtained from data in the 308 portfolios.
[b]Unknown.
[c]Indeterminate.

TABLE 9.5-14. SUMMARY OF SCREENING PROGRAM AT PLANT H [3] SUBCATEGORIES B,D,E

Summary of screening data

Toxic pollutants	Concentration, µg/L: Raw wastewater	Concentration, µg/L: Treated effluent
Phthalates		
Bis(2-ethylhexyl) phthalate	30	ND
Aromatics		
Benzene	40	10
Toluene	140	ND
Halogenated aliphatics		
Methylene chloride	130	210

Wastewater treatment plant description

Type of treatment: Biological

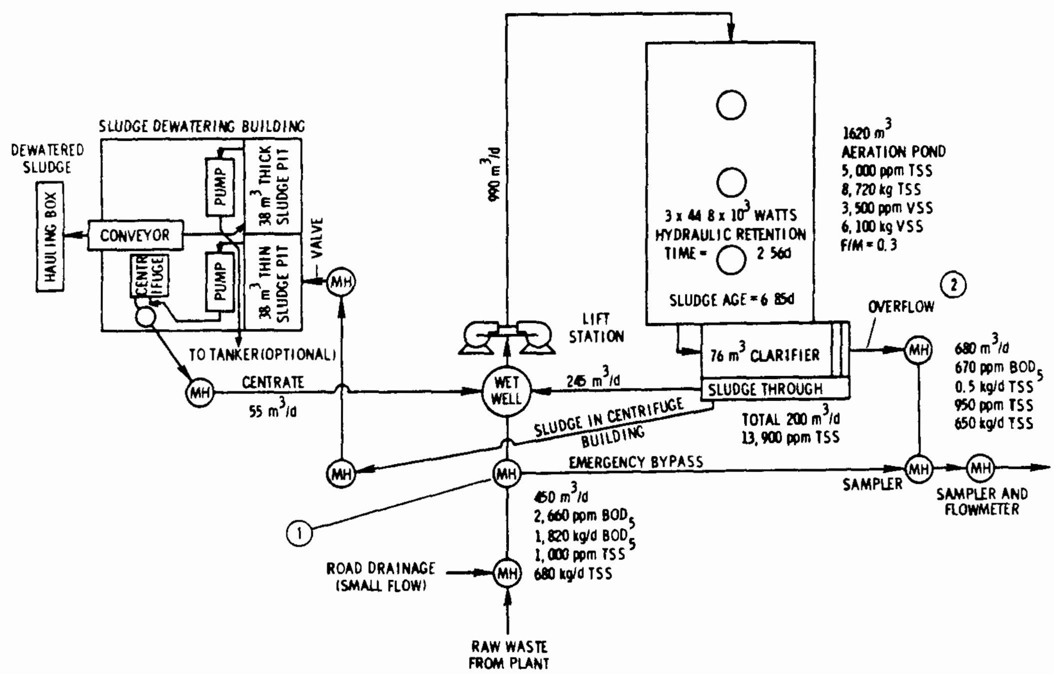
Unit operations: Activated sludge, chemical conditioning, centrifugation, dewatering, landfill

Wastewater quantity, m^3/d = 640 (0.17 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L: Raw wastewater	Concentration, mg/L: Treated effluent	Percent removal
BOD[a]	7,520	4,636	38.4
COD[a]	12,032	7,418	38.3
TSS	4,923	4,048	17.8

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM

Sampling location
1. Influent to pretreatment system
2. Effluent from pretreatment system

[a] BOD and COD values were obtained from data in the 308 portfolios.

TABLE 9.5-15. SUMMARY OF SCREENING PROGRAM AT PLANT P [3] SUBCATEGORIES C,E

Summary of screening data

Toxic pollutants	Concentration, µg/L Raw wastewater	Treated effluent
Metals and inorganics		
Cadmium	11	ND
Chromium	11	14
Copper	41	ND
Cyanide	2,000	63
Zinc	120	71
Phthalates		
Bis(2-ethylhexyl) phthalate	11	15
Phenols		
Phenol	64	ND
2,4,6-Trichlorophenol	13	ND
Aromatics		
Ethylbenzene	130	ND
Toluene	470	ND
Halogenated aliphatics		
Carbon tetrachloride	11,000	ND
Chloroform	3,200	ND
1,2-Dichloroethane	17	ND

Wastewater treatment plant description

Type of treatment: Biological

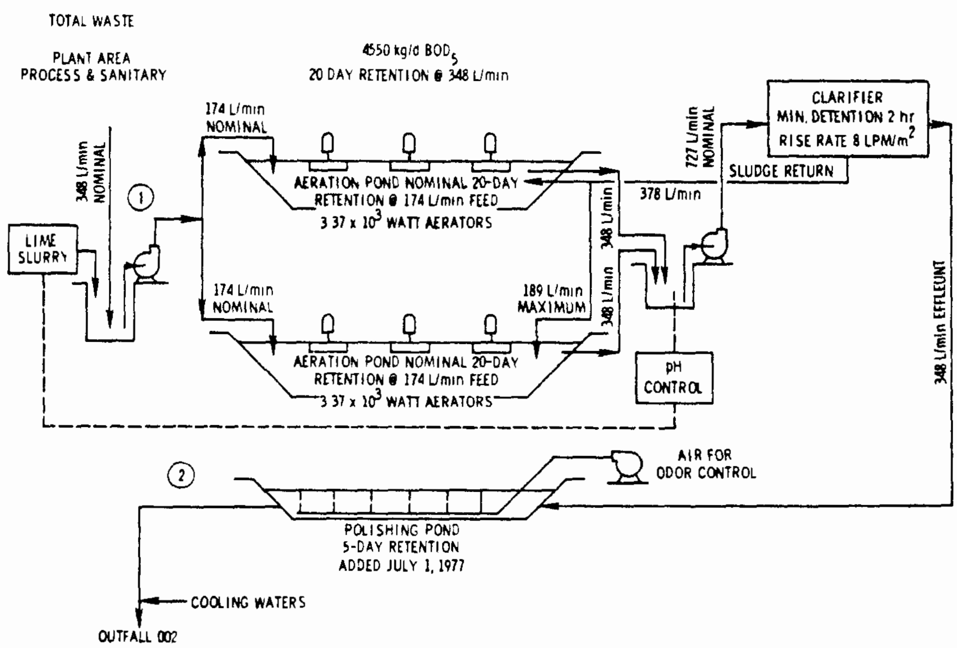
Unit operations: Equalization, neutralization, activated sludge, aerated lagoon, polishing pond, anaerobic digestion

Wastewater quantity, m^3/d = 300 (0.08 MGD)

Performance of Treatment System

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal
BOD[a]	1,865	93	95.0
COD[a]	4,240	946	77.7
TSS	84	326	-[b]

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM
Sample location
1. Influent to neutralization building
2. Discharge from treatment plant

[a]BOD and COD values were obtained from data in the 308 portfolios.

[b]Negative removal.

TABLE 9.5-16. SUMMARY OF SCREENING PROGRAM AT PLANT O [3]
SUBCATEGORIES A,C,E

Summary of screening data

Toxic pollutants	Concentration, µg/L Raw wastewater	Treated effluent
Metals and inorganics		
Chromium	200	ND
Copper	200	ND
Cyanide	1,500	400
Phenols		
2-Nitrophenol	120	ND
Aromatics		
Benzene	4,000	ND
Ethylbenzene	130	ND
Toluene	50	ND
Halogenated aliphatics		
Chloroform	370	ND
1,2-Dichloroethane	12	ND
Methylene chloride	11,000	240
Trichloroethylene	20	ND

Wastewater treatment plant description

Type of treatment: Three-stage biological

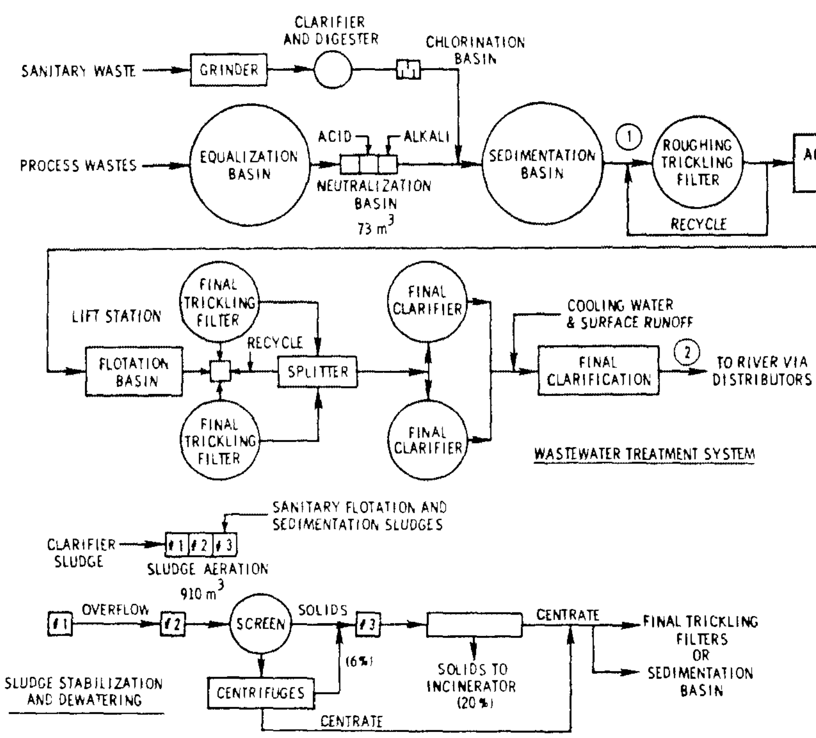
Unit operations: Equalization, neutralization, coarse settleable solids removal, primary sedimentation, primary chemical flocculation/clarification, activated sludge, trickling filter, waste stabilization ponds, flotation thickening, centrifugation, centrifugation dewatering, incineration, landfill

Wastewater quantity, m^3/d = 3780 (1.00 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal
BOD[a]	2,330	29	98.8
COD[a]	4,800	203	95.8
TSS	-[b]	29	-[c]

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM

Sample location
1. Sedimentation basin effluent - "Raw wastewater"
2. Final clarifier effluents DAF skimmings

[a] BOD and COD values were obtained from data in the 308 portfolios.
[b] Unknown.
[c] Indeterminate.

TABLE 9.5-17. SUMMARY OF SCREENING PROGRAM AT PLANT Q [3] SUBCATEGORIES A,D,E

Summary of screening data

Toxic pollutants	Concentration, μg/L Raw wastewater	Treated effluent
Metals and inorganics		
Chromium	16	10
Copper	73	ND
Mercury	1.7	ND
Selenium	280	30
Thallium	18	11
Zinc	250	100
Phthalates		
Bis(2-ethylhexyl) phthalate	180	68
Phenols		
Phenol	ND	80
Aromatics		
Benzene	260	ND
Toluene	310	ND
Halogenated aliphatics		
Carbon tetrachloride	16	ND
Chloroform	180	ND
1,1-Dichloroethylene	230	ND
Methylene chloride	6,200	ND
Tetrachloroethylene	14	ND
1,1,1-Trichloroethane	22	ND
Trichloroethylene	24	ND
Trichlorofluoromethane	970	ND

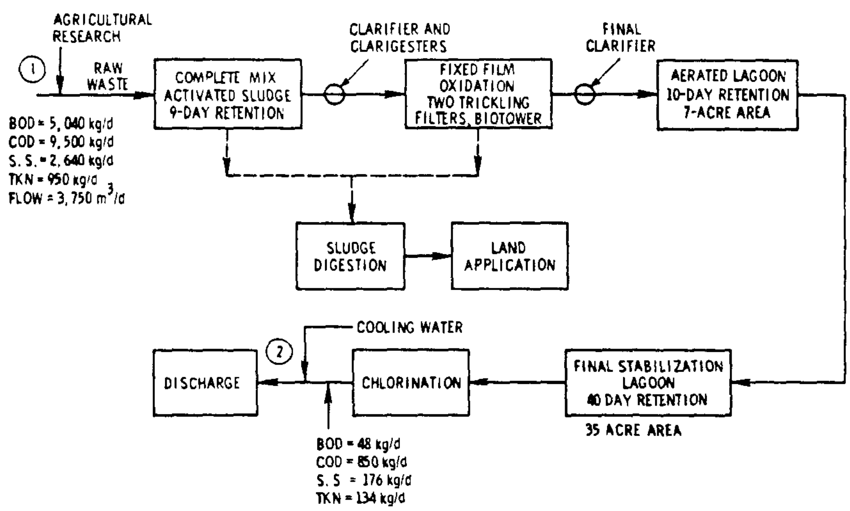
Wastewater treatment plant description

Type of treatment: Multiple-stage biological
Unit operations: Activated sludge, trickling filter, aerated lagoon, waste stabilization pond, polishing pond, sludge stabilization, cropland use
Wastewater quantity, m^3/d = 4,500 (1.2 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal
BOD[a]	1,340	13	99.1
COD[a]	2,520	197	92.1
TSS	705	44	93.8

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM

Sample location

1. Influent to wastewater treatment system
2. Discharge from treatment system

[a] BOD and COD values were obtained from data in the 308 portfolios.

TABLE 9.5-18. SUMMARY OF SCREENING PROGRAM AT PLANT R [3] SUBCATEGORIES C,D,E

Summary of screening data

Toxic pollutants	Concentration, µg/L	
	Raw wastewater	Treated effluent
Ethers		
Bis(2-chloroisopropyl) ether	300	180
Phthalates		
Butylbenzyl phthalate	720	ND
Di-n-butyl phthalate	19	ND
Diethyl phthalate	61	ND
Phenols		
2,4-Dimethyl phenol	ND	15
Aromatics		
Benzene	73	ND
Chlorobenzene	12	ND
2,4-Dinitrotoluene	65	ND
Ethylbenzene	82	17
Toluene	790	320
Polycyclic organic compounds		
Acenapthene	92	ND
Anthracene	14	ND
Fluorene	27	ND
Phenanthrene	14	ND
Halogenated aliphatics		
Chloroform	26	18
Methylene chloride	640	120
Tetrachloroethylene	26	ND
1,1,1-Trichloroethane	260	12
1,1,2-Trichloroethane	19	ND
Trichloroethylene	120	14
Pesticides and metabolites		
Isophorone	1,000	

Wastewater treatment plant description

Type of treatment: Biological
Unit operations: Equalization, neutralization, primary sedimentation, activated sludge, aerated lagoon, landfill
Wastewater quantity, m³/d = 38 (0.01 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L		Percent removal
	Raw wastewater	Treated effluent	
BOD[a]	600	30	95.0
COD[a]	1,200	60	95.0
TSS	20	30	-[b]

Wastewater Treatment Plant Flow Diagram

Raw waste-------► Neutralization-------► Primary sedimentation-------► Aeration units (activated sludge)-------► Lagooning.

Design considerations

Detention time of aerators: 2 hr
Detention time of lagoons: 60 d
Treatment plant capacity: 110 m³/d

Solvent wastes-------► Recovery

SAMPLING PROGRAM

Sample location
Industrial stream influent
Secondary clarifier effluent

[a]BOD and COD values were obtained from data in the 308 portfolios.
[b]Negative removal.

TABLE 9.5-19. SUMMARY OF SCREENING PROGRAM AT PLANT T [3]
SUBCATEGORIES A,C,D,E

Summary of screening data

Toxic pollutants	Concentration, µg/L	
	Raw wastewater	Treated effluent
Metals and inorganics		
Antimony	27	ND
Chromium	20	ND
Copper	130	ND
Cyanide	0.04	ND
Lead	10	ND
Nickel	22	ND
Selenium	20	ND
Zinc	530	ND
Phthalates		
Bis(2-ethylhexyl) phthalate	760	ND
Phenols		
Phenol	14,000	NA
Aromatics		
Toluene	2.0	NA
Halogenated aliphatics		
Chloroform	1.5	NA
1,1-Dichloroethane	1.7	NA

Wastewater treatment plant description

Type of treatment: None
Unit operations: No treatment provided
Wastewater quantity, m^3/d = 4,010 (1.06 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L		Percent removal
	Raw wastewater	Treated effluent	

(Not applicable)

Wastewater Treatment Plant Flow Diagram

(Not applicable)

TABLE 9.5-20. SUMMARY OF SCREENING PROGRAM AT PLANT E [3] SUBCATEGORIES B,C,D,E

Summary of screening data

Toxic pollutants	Concentration, µg/L Raw wastewater	Treated effluent
Metals and inorganics		
Antimony	68	ND
Arsenic	32	ND
Chromium	16	16
Copper	35	26
Cyanide	590	52
Lead	80	ND
Mercury	ND	1.6
Nickel	20	40
Selenium	30	ND
Thallium	ND	58
Zinc	150	99
Phthalates		
Bis(2-ethylhexyl) phthalate	38	28
Nitrogen compounds		
N-nitroso-diphenylamined	34	ND
Aromatics		
Toluene	290	ND
Halogenated aliphatics		
Chloroform	860	1,000
Methylene chloride	1,100	32

Wastewater treatment plant description

Type of treatment: Biological

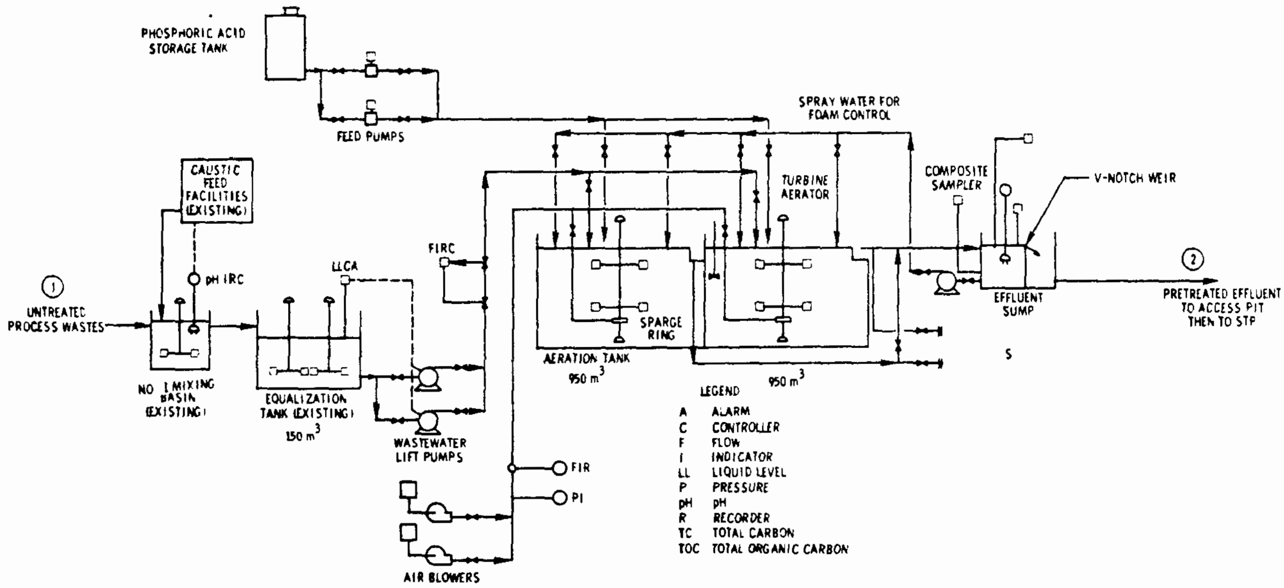
Unit operations: Equalization, neutralization, aerated lagoon, incineration

Wastewater quantity, m^3/d = 1,320 (0.35 MGD)

Performance of treatment system

Pollutant	Concentration, mg/L Raw wastewater	Treated effluent	Percent removal
BOD[a]	7,100	869	87.8
COD[a]	15,700	-[b]	-[c]
TSS	369	1,790	-[d]

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM

Sample location
1. Influent to pretreatment system
2. Effluent from pretreatment system

[a] BOD and COD values were obtained from data in the 308 portfolios.
[b] Unknown.
[c] Indeterminate.
[d] Negative removal.

TABLE 9.5-21. SUMMARY OF SCREENING PROGRAM AT PLANT K [3] SUBCATEGORIES A,B,C,D,E

Summary of screening data

Toxic pollutants	Concentration, µg/L Raw wastewater	Treated effluent
Metals and inorganics		
Chromium	160	26
Copper	3,100	63
Cyanide	860	300
Mercury	9.6	ND
Thallium	230	ND
Zinc	390	63
Phthalates		
Bis(2-ethylhexyl) phthalate	52	ND
Phenols		
Pentachlorophenol	11	ND
Phenol	3,100	ND
Aromatics		
Benzene	380	44
1,2-Dichlorobenzene	290	ND
1,4-Dichlorobenzene	10	ND
Ethylbenzene	1,600	160
Toluene	560	-[a]
Halogenated aliphatics		
Carbon tetrachloride	50	ND
Chloroform	130	56
1,2-Dichloroethane	3,000	65
1,1-Dichloroethylene	190	90
Methylene chloride	4,800	-[a]
Trichloroethylene	2,100	ND
Trichlorofluoromethane	620	280

Wastewater treatment plant description

Type of treatment:
Unit operations.

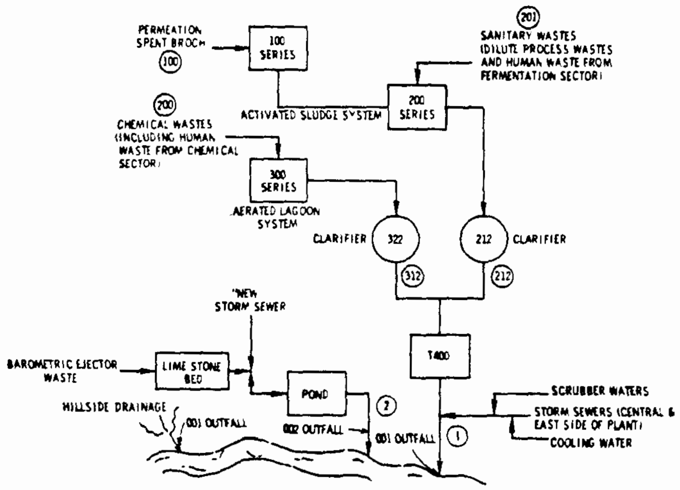
- Fermentation waste treatment system - equalization, neutralization, coarse settleable solids removal, primary sedimentation, activated sludge, anaerobic digestion, centrifugation dewatering, landfill
- Chemical waste treatment system - equalization, neutralization, coarse settleable solids removal, primary sedimentation, primary chemical flocculation/clarification, aerated lagoon, anaerobic digestion, centrifugation dewatering landfill
- Secondary thermal oxidation system - equalization, neutralization, primary separation, thermal oxidation
- Wastewater pretreatment system - physical/chemical treatment, heat conditioning

Wastewater quantity, m^3/d: 3,780 (1.00 MGD)

Performance of treatment system

	BOD[b] (mg/L) Raw wastewater	BOD[b] Treated effluent	BOD[b] Percent removal	COD[b] Raw wastewater	COD[b] Treated effluent	COD[b] Percent removal	TSS Raw wastewater	TSS Treated effluent	TSS Percent removal
Fermentation waste treatment system	12,400	244	98	24,000	1,450	94	4,530	306	93.2
Chemical waste treatment system	5,720	1,140	80.1	1,740	4,470	-[c]	4,480	457	98.8
Wastewater pretreatment system	-[d]	-[d]	-[e]	240,000	52,000	78.3	-[d]	-[d]	-[e]
Secondary thermal oxidation system		1	-	355,000	20	99.9	-[d]	10	-[e]

Wastewater Treatment Plant Flow Diagram



SAMPLING PROGRAM

Sample location

1. 001 Discharge
2. Combined effluent from limestone bed and hillside storm sewer

[a] Very high
[b] BOD and COD values were obtained from data in the 308 portfolios
[c] Negative removal.
[d] Unknown
[e] Indeterminate

TABLE 9.5-22. SUMMARY OF TREATMENT OPERATIONS UTILIZED IN THE PHARMACEUTICAL MANUFACTURING INDUSTRY[a] [3]

Treatment operations	Number of plants
Equalization	55
Neutralization	72
Coarse settleable solids removal	39
Primary sedimentation	33
Primary chemical flocculation/clarification	11
Dissolved air flotation	2
Activated sludge	45
pure oxygen	1
powdered activated carbon	1
Trickling filter	8
Aerated lagoon	19
Waste stabilization pond	8
Intermittent sand filtration	4
Physical/chemical treatment	15
thermal oxidation	2
evaporation	4
Polishing pond	9
Multimedia filtration	7
Activated carbon filtration	2
Other polishing such as chemical flocculation/clarification, sand filtration, chlorination	13

[a]From 308 data.

TABLE 9.5-23. CONVENTIONAL POLLUTANT REMOVABILITY AT 20 PHARMACEUTICAL PLANTS [2]

		BOD Concentration, mg/L			COD Concentration, mg/L			TSS Concentration, mg/L				
Subcategory	Plant	Raw wastewater	Treated effluent	Percent removal	Raw wastewater	Treated effluent	Percent removal	Raw wastewater	Treated effluent	Percent removal	Flow, m^3/d	Treatment
A	09	3,200	26	99	6,700	320	95	910	4	99	2,100	P3,S4,S7
	20	1,400	90	93	4,400	1,300	70	1,900	380	80	950	S1
B	08	19	5.8	70	77	48	38	15	30	-[a]	470	P4,P6,S4
	12	25	-[b]		46	-[b]		64	-[b]		89	M3,D1
C	10	1,200	47	96	2,800	1,400	52	150	122	19	6,800	S1,S6
	11	2,200	200	91	3,700	650	82	280	60	79	3,400	S1,W3,W10,D3
	15	10,000	2,000	80	15,000	3,700	75	270	47	83	150	C2,P3,S1
D	18	750	59	92	1,700	290	83	100	2	98	280	S1,S3,S7
E	05	310	0.22	99	570	0.42	99	21	0.015	99	64	M3
	14	100	13	87	240	32	84	240	10	96	180	S1,D3
AC	01	-[c]	-[c]	99	-[c]	-[c]	99	-[b]	-[b]	99	-[b]	T2,D1
	04	1,300	160	88	3,200	630	80	730	140	81	5,200	C1,C2,S1,S3,D1
	21	1,300	66	95	3,300	1,100	65		750	-[d]	4,600	S1,S3,S5,S6,W5,D4
	22	2,400	14	99	5,300	180	97		19	-[d]	1,600	C1,C2,P3,S1,S3
	25	800	280	65	5,300	4,100	23	83	NA	-[d]	1,000	S1
BD	03	178	-[b]		416	-[b]				-[d]		
DE	05	360	3.5	99	640	28	99		6.2	-[d]	220	M3
	24	90	8	91	300	82	73	60	29	52	290	C1,P1,S1,W5,W1
BDE	17	520	-[b]		850	-[b]				-[d]	2,700	C1,M2,M3
	23	11	2	82	98	67	32			-[d]	330	C1,S1
ABCDE	26	1,200	48	96	2,500	210	92	1,600	150	91	4,200[e]	S2

[a] Negative removal.
[b] Wastewaters pass (sometimes with pretreatment) to a muncipal treatment system.
[c] Nontypical values since waste is incinerated.
[d] Indeterminate.
[e] Assumed average flow.

Note: Blanks indicate data not available.

TABLE 9.5-24. KEY TO CODED TREATMENT OPERATIONS [2]

Wastewater conditioning	
C1	Equalization
C2	Neutralization
Primary wastewater treatment	
P1	Surface skimming
P2	Coarse settleable solids removal
P3	Primary sedimentation (clarification)
P4	Primary chemical flocculation/clarification (chemical precipitation)
P5	Primary separation
P6	Gas flotation with chemical addition
P7	Multimedia filtration
Secondary wastewater treatment	
S1	Activated sludge
S2	Activated sludge with pure oxygen
S3	Trickling filter
S4	Aerated lagoon
S5	Waste stabilization pond
S6	Polishing pond
S7	Other polishing
Tertiary wastewater treatment	
T1	Activated sludge with powdered activated carbon
T2	Multiple effect evaporation
Sludge treatment	
W1	Sludge stabilization
W2	Flotation thickening
W3	Mechanical thickening
W4	Centrifugal thickening
W5	Aerobic digestion
W6	Anaerobic digestion
W7	Chemical conditioning
W8	Chemical stabilization
W9	Thermal conditioning
W10	Vacuum filtration
W11	Dewatering
W12	Centrifugal dewatering
Disposal	
D1	Incineration
D2	Thermal oxidation
D3	Landfill
D4	Cropland use

TABLE 9.5-25. CONVENTIONAL POLLUTANT REMOVABILITY AT 27 PHARMACEUTICAL PLANTS[a] [1]

Sub-category	Plant	BOD Concentration, mg/L Raw wastewater	BOD Concentration, mg/L Treated effluent	BOD Percent removal	COD Concentration, mg/L Raw wastewater	COD Concentration, mg/L Treated effluent	COD Percent removal	TSS Concentration, mg/L Raw wastewater	TSS Concentration, mg/L Treated effluent	TSS Percent removal	Flow L/S	Flow (MGD)	Treatment
A	C	NA	140	-[b]	NA	300	-[b]	NA	97	-[b]	13	(0.30)	S1,S4,W1
D	L	260	19	93	490	54	89	150	15	90	3.5	(0.08)	C1,P3,S1,S7, W1,W11,D3
AD	X	-[c]	-[c]		-[c]	-[c]		-[c]	-[c]		6.1	(0.14)	C2
CD	W	NA	NA	-[b]	NA	NA	-[b]	NA	NA	-[b]	20	(0.45)	C1,C2,P3,P4
CE	N	1,000	150	86	2,700	550	80	NA	90	-[b]	39	(0.90)	C1,C2,P3,S1, W2,W8,W10, D3
	P	1,900	93	95	4,200	950	77	84	330	-[d]	3.5	(0.08)	C1,C2,S1,S4, S6,W6
DE	S	NA	NA	-[b]	NA	850	-[b]	NA	350	-[b]	7.0	(0.16)	S1,W3,W4,D3
ACD	G	990	72	93	3,000	940	69	400	200	50	44	(1.00)	M1,C1,C2,P2, P3,P7,S1, W2,W6,D6
ACE	M	1,600	110	93	NA	NA	-[b]	NA	83	-[b]	57	(1.30)	C1,C2,P2,P3, S1,S3,W3, W7,W10,D1, D3
	O	2,300	29	99	4,800	200	96	NA	29	-[b]	44	(1.00)	C1,C2,P2,P3, P4,S1,S3, S5,W2,W4, W12,D1,D3
ADE	A	2,500	200	92	NA	600	-[b]	100	50	50	21	(0.50)	C1,C2,P2,P3, S4,S5,W6, D3
	J	NA	7	-[b]	NA	40	-[b]	NA	70	-[b]	22	(0.05)	C1,C2,P2,P3, S1,W6,D6
	Q	1,300	13	99	2,500	200	92	710	44	11	53	(1.20)	S1,S3,S4,S5, S6,W1,D4
	U	-[c]	-[c]		-[c]	-[c]		-[c]	-[c]		1,300	(30.00)	C2
BDE	H	7,500	4,600	39	12,000	7,400	38	4,900	4,000		74	(0.17)	S1,W7,W12,D3
CDE	R	600	30	95	1,200	60	95	20	30	-[d]	0.44	(0.01)	C1,C2,P3,S1, S4,D3
	Z										4.4	(0.10)	C1,C2,M1,S7, W7,W8,W10, D3
	Z[e]	NA	28	-[b]	NA	290	-[b]	NA	29	-[b]			P2,M1,S7,T1, W8,W10,D3
ACDE	T	-[c]	-[c]		-[c]	-[c]		-[c]	-[c]		46	(1.06)	No treatment
	Y	NA	NA	-[b]	NA	NA	-[b]	NA	NA	-[b]	66	(1.50)	P2,P3,M1,W10, D3
	AA	-[c]	-[c]		-[c]	-[c]		-[c]	-[c]		18	(0.40)	No data avail.
BCDE	D	1,200	330	73	NA	NA	-[b]	120	250	-[d]	11	(0.26)	C2,S1,S4,W3, D6
	E	7,100	870	88	16,000	NA	-[b]	370	1,800	-[d]	15	(0.35)	C1,C2,S4,D1
	F	NA	NA	-[b]	NA	NA	-[b]	NA	NA	-[b]	0.40	(0.01)	S4
ABCDE	B	3,000	120	96	NA	NA	-[b]	950	500	47	21	(0.50)	C1,C2,S1,W4, D4
	I	1,200	150	88	2,600	410	84	2,000	320	84	53	(1.20)	C2,P2,P4,S2, W3,D5,W7, W10,D6
	K										44	(1.00)	
	K[f]	12,000	240	98	24,000	1,500	94	4,500	310	93			C1,C2,P2,P3, S1,W6,W12, D3
	K[g]	5,700	1,100	81	1,700	4,500	-[d]	4,500	460	90			C1,C2,P2,P3, P4,S4,W8, W12,D3
	K[h]	NA	NA	-[b]	240,000	52,000	78	NA	NA	-[b]			M1,W9
	K[i]	NA	1	-[b]	36,000	20	99	NA	10	-[b]			C1,C2,P5
	K[j]	37,000	60	99	NA	280	-[b]	NA	NA	-[b]			P2,P3,M1,W10, D3

[a] From 308 data.
[b] Indeterminate.
[c] Not applicable.
[d] Negative removal.
[e] Floor wash treatment.
[f] Fermentation waste treatment system.
[g] Chemical waste treatment system.
[h] Wastewater pretreatment system.
[i] Secondary thermal oxidation.
[j] Direct discharge treatment system.

TABLE 9-5.26. TOXIC POLLUTANT REMOVABILITY FOR SUBCATEGORIES AND SUBCATEGORY COMBINATIONS[a] [1]

	A		D		CD	
	Plant C		Plant L		Plant W	
Treatment operations:	S1,S4,W1		C1,P3,S1,S7,W1,W11,D3		C1,C2,P3,P4	
	Concentration, µg/L		Concentration, µg/L		Concentration, µg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Metals and inorganics						
Antimony	28[b]	50	ND	ND	NA	90[b]
Arsenic	31[b]	47	ND	ND	ND	7,200[b]
Chromium	ND	17	30	10	NA	9[b]
Copper	29[b]	48	50	30	NA	35[b]
Mercury	ND	6.4	ND	ND	ND	ND
Selenium	60[b]	150	ND	ND	NA	310[b]
Zinc	89[b]	120	300	200	NA	70[b]
Phthalates						
Bis(2-ethylhexyl) phthalate	ND	ND	170	30	ND	ND
Di-n-butyl phthalate	ND	ND	20	ND	ND	ND
Phenols						
2-Nitrophenol	ND	ND	ND	ND	13,000[b]	4,100
4-Nitrophenol	1,600	ND	ND	ND	3,500[b]	1,100
Pentachlorophenol	ND	ND	62	ND	ND	ND
Phenol	70	ND	ND	ND	17,000[b]	17,000
Aromatics						
Benzene	ND	ND	79	ND	ND	ND
Ethylbenzene	ND	ND	11	ND	ND	ND
Toluene	ND	ND	900	ND	ND	ND
Halogenated aliphatics						
Carbon tetrachloride	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	300	14	ND	ND
1,2-Dichloroethane	ND	ND	19	ND	ND	20
1,1-Dichloroethylene	ND	ND	ND	ND	30	370
Methylene chloride	ND	70	470	12	ND	ND
Tetrachloroethylene	ND	ND	36	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	1,300	890
Trichlorofluoromethane	ND	ND	ND	ND	ND	80

	CE				DE	
	Plant N		Plant P		Plant S	
Treatment operations:	C1,C2,P3,S1,W2,W8,W10,D3		C1,C2,S1,S4,S6,W6		S1,W3,W4,D3	
	Concentration, µg/L		Concentration, µg/L		Concentration, µg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Metals and inorganics						
Cadmium	ND	ND	11	ND	ND	ND
Chromium	ND	ND	11	14	30	10
Copper	ND	ND	41	ND	80	20
Cyanide	ND	ND	2,000	63	ND	ND
Zinc	ND	ND	120	79	ND	100
Ethers						
Bis(2-chloroethyl) ether	10	20	ND	ND	ND	ND
Phthalates						
Bis(2-ethylhexyl) phthalate	ND	ND	11	15	50	10
Di-n-butyl phthalate	ND	ND	ND	ND	20	ND
Nitrogen compounds						
1,2-Diphenylhydrazine	20	ND	ND	ND	ND	ND
Phenols						
Phenol	ND	ND	64	ND	ND	ND
2,4,6-Trichlorophenol	ND	ND	13	ND	ND	ND
Aromatics						
Benzene	40	ND	ND	ND	ND	ND
Ethylbenzene	12	ND	130	ND	ND	ND
Toluene	33,000	1,400	470	ND	ND	ND
Halogenated aliphatics						
Carbon tetrachloride	ND	ND	11,000	ND	ND	ND
Chloroform	16	ND	3,200	ND	130	ND
1,2-Dichloroethane	130	ND	17	ND	15	ND
1,1-Dichloroethylene	190	ND	ND	ND	ND	ND
Methyl bromide	30	ND	ND	ND	ND	ND
Methyl chloride	3,000	ND	ND	ND	ND	ND
Methylene chloride	40,000	200	ND	ND	800	250
1,1,2-Trichloroethane	ND	ND	ND	ND	17	ND

(continued)

TABLE 9.5-26 (continued)

	ACD		ACE			
	Plant G		Plant M		Plant O	
Treatment operations:	M1,C1,C2,P2,P3,P7,S1, W2,W6,D6		C1,C2,P2,P3,S1,S3,W3, W7,W10,D1,D3		C1,C2,P2,P3,P4,S1,S3, W2,W4,W12,D1,D3	
	Concentration, µg/L		Concentration, µg/L		Concentration, µg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Metals and inorganics						
Antimony	24	ND	ND	ND	ND	ND
Arsenic	120	ND	ND	ND	ND	ND
Cadmium	32	ND	ND	ND	ND	ND
Chromium	14	ND	90	30	200	ND
Copper	27	ND	90	20	200	ND
Cyanide	ND	ND	170	400	1,500	400
Lead	46	ND	20	ND	ND	ND
Mercury	ND	ND	1.6	ND	ND	ND
Nickel	89	56	400	200	ND	ND
Zinc	250	16	500	100	ND	ND
Phthalates						
Bis(2-ethylhexyl) phthalates	39	ND	200	400	ND	ND
Di-n-butyl phthalates	ND	ND	180	24	ND	ND
Phenols						
2-Chlorophenol	ND	ND	43	110	ND	ND
2,4-Dichlorophenol	ND	ND	9	7	ND	ND
2-Nitrophenol	ND	ND	ND	7	20	ND
Phenol	ND	ND	430	48	ND	ND
2,4,6-Trichlorophenol	ND	ND	14	12	ND	ND
Aromatics						
Benzene	820	ND	160	16	4,000	ND
Chlorobenzene	ND	ND	1,200	400	ND	ND
1,4-Dichlorobenzene	ND	ND	10	2	ND	ND
Ethylbenzene	ND	ND	42	6	130	ND
Toluene	10,000	ND	ND	ND	50	ND
Polycyclic aromoatic hydrocarbons						
Naphthalene	ND	ND	28	14	ND	ND
Halogenated						
Chloroform	1,200	ND	70	ND	370	ND
1,2-Dichloroethane	ND	ND	9,000	400	12	ND
Methylene chloride	20	ND	750	180	11,000	240
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	20	ND
Trichloroethylene	ND	ND	21	ND	ND	ND

	ADE							
	Plant A		Plant J		Plant Q		Plant U	
Treatment operations:	C1,C2,P2,P3,S4,S5,W6,D3		C1,C2,P2,P3,S1,W6,D6		S1,S3,S4,S5,S6,W1,D4		C2	
	Concentration, µg/L		Concentration, µg/L		Concentration, µg/L		Concentration, µg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Metals and inorganics								
Chromium	ND	ND	ND	ND	16	10	ND	ND
Copper	ND	ND	ND	ND	73	ND	ND	ND
Mercury	ND	ND	ND	ND	1.7	ND	ND	ND
Selenium	ND	ND	ND	ND	280	30	ND	ND
Thallium	ND	ND	ND	ND	18	11	ND	ND
Zinc	ND	ND	ND	ND	250	100	ND	ND
Ethers								
Bis(2-Chloroisopropyl) ether	ND	ND	450	ND	ND	ND	NA	300
Phthalates								
Bis(2-ethylhexyl) phthalate	ND	ND	ND	ND	180	68	NA	10
Butyl benzyl phthalate	ND	ND	18	ND	ND	ND	ND	ND
Phenols								
2-Chlorophenol	ND	ND	ND	ND	ND	ND	NA	31
4-Nitropnenol	ND	ND	ND	15	ND	ND	ND	ND
Pentachlorophenol	ND	ND	42	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	ND	ND	80	NA	21
Aromatics								
Benzene	ND	ND	ND	ND	260	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	NA	11
Ethylbenzene	ND	ND	ND	ND	18	ND	NA	21
Nitrobenzene	ND	ND	ND	ND	ND	ND	ND	22
Toluene	ND	ND	ND	ND	310	ND	ND	ND

(continued)

TABLE 9.5-26 (continued)

	ADE							
	Plant A		Plant J		Plant Q		Plant U	
Treatment operations:	C1,C2,P2,P3,S4,S5,W6,D3		C1,C2,P2,P3,S1,W6,D6		S1,S3,S4,S5,S6,W1,D4		C2	
	Concentration, μg/L		Concentration, μg/L		Concentration, μg/L		Concentration, μg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Polycyclic aromatics hydrocarbons								
Acenapthene	ND	ND	2	ND	ND	ND	ND	ND
Halogenated aliphatics								
Bromoform	ND	ND	ND	ND	ND	ND	NA	12
Carbon tetrachloride	ND	ND	ND	ND	18	ND	NA	490
Chloroform	ND	ND	ND	ND	180	ND	NA	700
1,1-Dichloroethylene	ND	ND	ND	ND	230	ND	ND	ND
1,3-Dichloropropene	ND	ND	100	ND	ND	ND	ND	ND
Methylene chloride	NA	72	77	350	6,200	ND	NA	99
Tetrachloroethylene	ND	ND	ND	ND	14	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	10	22	ND	NA	380
Trichloroethylene	ND	ND	ND	ND	24	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	970	ND	ND	ND
Pesticides and metabolites								
Isophorone	ND	ND	11	ND	ND	ND	ND	ND

	BDE		CDE			
	Plant H		Plant R		Plant Z	
Treatment operations	S1,W7,W12,D3		C1,C2,P3,S1,S4,D3		Chemical waste treatment system: C1, C2,M1,S7,W7,W8,W10, D3 Floor wash treatment system: P2,M1,S7 T1,W8,W10,D3	
	Concentration, g/L		Concentration, g/L		Concentration, g/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Ethers						
Bis(2-Chloroethyl) ether	ND	ND	300	180	38	48
Phthalates						
Bis(2-ethylhexyl) phthalate	30	ND	ND	ND	ND	ND
Butyl benzyl phthalate	ND	ND	720	ND	ND	ND
Di-n-butyl phthalate	ND	ND	19	ND	ND	ND
Diethyl phthalate	ND	ND	61	ND	ND	ND
Phenols						
2,4-Dimethylphenol	ND	ND	ND	15	ND	ND
4-Nitrophenol	ND	ND	ND	ND	ND	19
Phenol	ND	ND	ND	ND	19	ND
Aromatics						
Benzene	40	10	73	ND	ND	ND
Chlorobenzene	ND	ND	12	ND	ND	ND
2,4-Dinitrotoluene	ND	ND	65	ND	32	ND
Ethylbenzene	ND	ND	82	17	ND	ND
Toluene	140	ND	790	320	ND	ND
Polycyclic aromatic compounds						
Acenaphthene	ND	ND	92	ND	135	ND
Anthracene	ND	ND	14	ND	ND	ND
Fluorene	ND	ND	27	ND	ND	ND
Phenanthrene	ND	ND	14	ND	ND	ND
Halogenated aliphatics						
Chloroform	ND	ND	26	18	ND	ND
Methylene chloride	130	210	640	120	ND	ND
Tetrachloroethylene	ND	ND	26	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	260	12	ND	ND
1,1,2-Trichloroethane	ND	ND	19	ND	ND	ND
Trichloroethylene	ND	ND	120	14	ND	ND
Pesticides and metabolites						
Isophorone	ND	ND	1,000	ND	ND	ND

(continued)

TABLE 9.5-26 (continued)

	ACDE[c]		BCDE					
	Plant Y		Plant D		Plant E		Plant F	
Treatment operations:	P3,P3,M1,W10,D3		C2,S1,S4,W3,D6		C1,C2,S4,D1		S4	
	Concentration, μg/L		Concentration, μg/L		Concentration, μg/L		Concentration, μg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Metals and inorganics								
Antimony	ND	ND	28	ND	68	ND	ND	ND
Arsenic	ND	ND	<20	30	32	ND	ND	ND
Chromium	ND	ND	140	170	16	16	ND	12
Copper	ND	ND	22	41	35	26	60	110
Cyanide	ND	ND	ND	ND	590	52	120	ND
Lead	ND	ND	ND	ND	80	ND	ND	13
Mercury	ND	ND	0.9	0.5	ND	1.6	ND	ND
Nickel	ND	ND	NA	ND	20	40	ND	ND
Selenium	ND	ND	16	30	30	ND	ND	ND
Thallium	ND	ND	ND	ND	ND	58	ND	ND
Zinc	ND	ND	190	250	150	99	140	510
Phthalates								
Bis(2-ethylhexyl) phthalate	ND	ND	130	44	38	28	160	15
Nitrogen compounds								
N-nitrosodiphenylamine	ND	ND	12	ND	34	ND	ND	ND
Phenols								
Phenol	NA	280	45	ND	ND	ND	ND	ND
Cresols								
4,6-Dinitro-*o*-cresol	ND	ND	ND	15	ND	ND	ND	ND
Aromatics								
Benzene	NA	500	ND	ND	ND	ND	ND	10
1,2-Dichlorobenzene	ND	ND	12	ND	ND	ND	ND	ND
Toluene	NA	700	ND	ND	290	ND	ND	ND
Halogenated aliphatics								
Carbon tetrachloride	ND	ND	ND	ND	ND	ND	ND	61
Chloroform	NA	900	51	ND	860	1,000	ND	130
1,1-Dichloroethane	NA	54	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	NA	14,000	ND	ND	ND	ND	ND	ND
1,1-Dichloroethylene	NA	20	ND	ND	ND	ND	ND	ND
1,2-*trans*-Dichloroethylene	NA	1,100	ND	ND	ND	ND	ND	ND
Methylene chloride	NA	1,700,000	35	31	1,100	32	63	130
1,1,1-Trichloroethane	NA	720,000	ND	ND	ND	ND	ND	ND

	ABCDE							
	Plant B		Plant I		Plant K		Plant V	
Treatment operations:	C1,C2,S1,W4,D4		C2,P2,P4,S2,W3,D5,W7, W10,D6		Fermentation waste system: C1,C2,P2, P3,S1,W6,W12,D3 Chemical waste treatment system: C1,C2,P2,P3,P4,S4, W6,W12,D3 Wastewater pre-treatment system: M1,W9 Secondary thermal oxidation system: C1,C2,P5,D2		P2,P3,M1,W10,D3	
	Concentration, μg/L		Concentration, μg/L		Concentration, μg/L		Concentration, μg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Metals and inorganics								
Antimony	22[b]	ND	20	ND	ND	ND	ND	ND
Arsenic	70[b]	20	ND	ND	ND	ND	NA	20
Cadmium	ND	ND	ND	ND	ND	ND	NA	40
Chromium	680[b]	190	23	19	160	26	ND	ND
Copper	180[b]	31	88	16	3,100	63	NA	100
Cyanide	580[b]	7,700	ND	ND	860	300	NA	60
Lead	15[b]	24	63	20	ND	ND	ND	ND
Mercury	ND	ND	1.3	1.3	9.6	ND	NA	400
Nickel	630[b]	190	28	37	ND	ND	NA	300
Selenium	ND	ND	ND	ND	ND	ND	NA	26
Thallium	47[b]	29	ND	ND	230	ND	ND	ND
Zinc	540[b]	160	500	300	390	63	NA	230
Phthalates								
Bis(2-ethylhexyl) phthalate	24	33	ND	25	52	ND	ND	ND

(continued)

TABLE 9.5-26 (continued)

ABCDE

	Plant B		Plant I		Plant K		Plant V	
Treatment operations:	C1,C2,S1,W4,D4		C2,P2,P4,S2,W3,D5,W7, W10,D6		Fermentation waste system: C1,C2,P2, P3,S1,W6,W12,D3 Chemical waste treatment system: C1,C2,P2,P3,P4,S4, W6,W12,D3 Wastewater pre-treatment system: M1,W9 Secondary thermal oxidation system: C1,C2,P5,D2		P2,P3,M1,W10,D3	
	Concentration, µg/L		Concentration, µg/L		Concentration, µg/L		Concentration, µg/L	
Toxic pollutants	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent	Raw wastewater	Treated effluent
Phenols								
2-Chlorophenol	240[b]	ND	ND	ND	ND	ND	ND	ND
2,4-Dimethylphenol	ND	ND	62	ND	ND	ND	ND	ND
2-Nitrophenol	31[b]	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	ND	11	ND	ND	100
Phenol	230[b]	ND	38	ND	3,100	ND	NA	>100
Aromatics								
Benzene	ND	ND	ND	ND	380	44	NA	24
1,2-Dichlorobenzene	ND	ND	ND	ND	290	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	10	ND	ND	ND
Ethylbenzene	ND	ND	14	ND	1,600	160	ND	ND
Toluene	ND	ND	190	ND	560	-[f]	NA	>200
Halogenated aliphatics								
Carbon tetrachloride	ND	ND	ND	ND	50	ND		
Chloroform	ND	ND	150	90	130	56	NA	60
1,2-Dichloroethane	ND	290	28	ND	3,000	65		
1,1-Dichloroethylene	ND	ND	ND	ND	190	90		
Methylene chloride	ND	67	1,400	ND	4,800	-[f]	NA	360
1,1,1-Trichloroethane	ND	ND	27	33	ND	ND		
Trichloroethylene	ND	ND	ND	ND	2,100	ND		
Trichlorofluoromethane	ND	ND	ND	ND	620	280		

[a] No percent removal data is presented here due to the nature of the data.
[b] Highest value chosen.
[c] No data available for plant AA.

II.9.5.5 REFERENCES

1. Effluent Limitations Guidelines for the Pharmaceutical Manufac- Industry. (draft contractors report). U.S. Environmental Protection Agency, Washington, D.C., May 1979.

2. Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the Pharmaceutical Manufacturing Point Source Category. EPA 440/1-75/060. U.S. Environmental Protection Agency, Washington, D.C., December 1976. 344 pp.

3. Supplement to the Draft Contractor's Engineering Report for the Development of Effluent Limitations Guidelines for the Pharmaceutical Industry (BATEA, NSPS, BCT, BMP, Pretreatment). U.S. Environmental Protection Agency, Washington, D.C., July 1979.

4. Environmental Protection Agency Effluent Guidelines and Standards for Pharmaceutical Manufacturing. 40 CFR 439; 41 FR 50676, November 17, 1976; Amended by 42 FR 6813, February, 1977.

II.10 NONFERROUS METALS MANUFACTURING

II.10.1 INDUSTRY DESCRIPTION

II.10.1.1 General Description [1]

The nonferrous metals industry encompasses the primary smelting and refining of nonferrous metals [Standard Industrial Classification (SIC) Number 333] and the secondary smelting and refining of nonferrous metals (SIC Number 334). The industry does not include the mining and beneficiation of metal ores; rolling, drawing, or extruding metals; or scrap metal collection and preliminary grading.

Primary smelting and refining includes the final recovery of pure or usable metal from a metal ore. Some metals, such as aluminum, are produced by essentially one process, while others, e.g., copper and zinc, may be produced either pyrometallurgically or electrometallurgically. Byproducts and coproducts can often be produced as a result of the smelting or refining of the base metals.

Secondary recovery refers to processors of scrap. This scrap is generally collected from scrap dealers or industrial plants. Scrap often has a high level of impurities and generally needs classification to separate recoverable metal from nonmetallic material. Scrap metal can then be treated in a similar manner as in primary metal recovery or can be refined by other, more efficient recovery methods.

There are an estimated 800 plants in the United States involved in the primary or secondary recovery of nonferrous metals. These plants represent 61 subcategories. However, many of these subcategories are small, represented by only one or two plants, or do not discharge any wastewater. This report focuses on 296 facilities that produce the major nonferrous metals (aluminum, columbium (niobium), tantalum, copper, lead, silver, tungsten, and zinc). In 1973 these facilities produced 8,100,000 Mg (8,900,000 tons) of the listed nonferrous metals.

Nonferrous metal facilities are distributed throughout the United States. Most sites are located near ore production facilities, near adequate transportation facilities, or near adequate power supplies.

Table 10-1 presents an industry summary for the nonferrous metals industry indicating the number of subcategories and the number and type of dischargers.

TABLE 10-1. INDUSTRY SUMMARY [1, 2]

Industry: Nonferrous Metals

Total Number of Subcategories: 61
- Phase I Coverage: 26
- Phase II Coverage: 35

Number of subcategories studied: 12

Number of dischargers in industry:
- Direct: 129
- Indirect: 79
- Zero dischargers: 215

Table 10-2 presents best practicable technology limitations that have been promulgated and reported in the Federal Register.

TABLE 10-2. BPT LIMITATIONS FOR THE NONFERROUS METALS INDUSTRY[a,b] [3]

Parameter	Primary aluminum smelting, kg/MG of product	Secondary aluminum smelting: Chlorine demagging, kg/Mg of magnesium recovered	Secondary aluminum smelting: Wet processing, kg/Mg of product	Primary copper smelting,[c] mg/L	Primary copper refining,[c] mg/L	Primary copper refining[d] kg/Mg of product	Secondary copper,[c] mg/L	Primary lead,[c] mg/L	Primary lead,[c] kg/Mg of product	Primary zinc, kg/Mg of product
COD		6 5	1 0							
TSS	3 0	175	1 5	50	50	0.10	50	50	0 042	0 42
Oil and grease					20	0.04	20			
Ammonia (as nitrogen)			0 01							
pH	6 0-9 0	7 5-9 0	7 5-9 0	6 0-9 0	6 0-9 0	6.0-9.0	6 0-9.0	6 0-9 0	6 0-9 0	6 0-9 0
Fluoride	2 0		0 4							
Aluminum			1.0							
Arsenic				20	20	0 04			0 0008	0 0016
Cadmium				1.0				1 0		0 008
Copper			0.3	0 5	0.5	0.001	0 5			
Lead				1 0				1.0	0.0008	
Selenium				10	10	0.02				0 08
Zinc				10	10	0.02	10	10	0 008	0 08

Note: Blanks indicate parameter not regulated for BPT in this subcategory.

[a] Maximum daily discharge, 30 day average may not exceed one half reported amounts.

[b] pH is reported in pH units

[c] Zero discharge except for excess of monthly rainfall over monthly evaporation

[d] Located in a historic area of net precipitation

II.10.1.2 Subcategory Description [1]

The nonferrous metals industry is divided into 61 subcategories by the type and source of the metal to be smelted and/or refined and by similar wastewater sources. Twelve of these subcategories have been chosen for detailed study. The remainder of the subcategories lack sufficient data to be reported, and either have been deferred to Phase II of the nonferrous metals study or are Paragraph 8 exclusion subcategories. Table 10-3 lists the subcategories studied, deferred, and excluded for this report. The following subparagraphs describe the 12 subcategories chosen for detailed study.

TABLE 10-3. SUBCATEGORIES WITHIN THE NONFERROUS METALS INDUSTRY [1, 2]

Subcategories and SIC codes chosen for detailed study:	
Primary aluminum (3334)	Primary lead (3332)
Secondary aluminum (3341)	Secondary lead (3341)
Primary columbium (3339)[a]	Secondary silver (3341)
Primary tantalum (3339)[a]	Primary tungsten (3339)
Primary copper (3331)	Primary zinc (3333)[b]
Secondary copper (3341)	Primary cadmium (3339)[b]
Subcategories and SIC codes lacking sufficient data for study:	
Primary beryllium	Primary tellurium
Primary selenium	Primary silver
Subcategories to be deferred to phase II:	
Primary boron	Primary nickel
Secondary boron	Secondary nickel
Primary cesium	Secondary plutonium
Primary cobalt	Primary rare earths
Secondary cobalt	Primary rhenium
Secondary columbium	Secondary rhenium
Primary gallium	Primary rubidium
Primary germanium	Primary platinum group
Primary gold	Secondary tin
Secondary precious metals	Primary titanium
Primary hafnium	Secondary titanium
Indium	Secondary tungsten
Primary lithium	Primary uranium
Primary magnesium	Secondary uranium
Secondary magnesium	Secondary zinc
Primary mercury	Primary zirconium
Secondary mercury	Bauxite
Primary molybdenum	
Paragraph 8 exclusion subcategories and SIC codes:	
Primary arsenic (3339)	Secondary cadmium (3341)
Primary antimony (3339)	Primary calcium (3339)
Primary barium (3339)	Secondary tantalum (3341)
Secondary beryllium (3341)	Primary tin (3339)
Primary bismuth (3339)	Secondary babbitt (3341)

[a] Primary columbium and primary tantalum are studied together because of similar processes and wastewaters.

[b] Primary zinc and cadmium are studied together because simultaneous recovery is common.

Primary Aluminum

Aluminum metal is produced from alumina in electrolytic pots by the Hall-Heroult process. The pots are made of cast iron lined with carbon and contain an electrolytic solution composed of cryolite, calcium fluoride, and aluminum fluoride. Alumina is added to the pots periodically and electrical current causes the reduction of alumina to aluminum metal. Molten aluminum is removed from the bottom of the pot.

The carbon-lined pot and the molten aluminum which collects in the pot serve as the cathode. The anode is a carbon rod prepared from petroleum coke and pitch. During the reduction process that produces the aluminum the anodes are oxidized, producing carbon monoxide and carbon dioxide.

The molten aluminum is tapped and conveyed to holding furnaces for subsequent degassing and alloying. Degassing with chlorine (and sometimes nitrogen and carbon dioxide) serves to remove hydrogen and to mix the aluminum to ensure a uniform alloy. At most plants the final step is casting the finished metal.

Secondary Aluminum

In this subcategory the use of varied raw materials requires two operations: presmelting and smelting.

Presmelting varies with the raw material being recovered. With relatively pure feedstocks only sorting and perhaps oil removal by drying may be required. However, crushing, screening, and iron removal frequently are necessary.

Smelting of the cleaned, purified aluminum involves charging the furnace with scrap and flux, addition of any necessary alloying agents, "demagging" to remove magnesium, and skimming to remove waste slag.

Primary Columbium and Tantalum

Columbium (also known as niobium) and tantalum metals are produced from purified salts which are prepared from ore concentrates and slags resulting from foreign tin production. The concentrates and slags are leached with hydrofluoric acid to dissolve the metal salts. Solvent extraction or ion exchange is used to purify the columbium and tantalum. The salts of these metals are then reduced via one of several techniques, which include aluminothermic reduction, sodium reduction, carbon reduction, and electrolysis. Owing to the reactivity of these metals, special techniques are used to purify and work the metal produced.

Primary Copper

Smelters producing copper metal from ores use smelting and converting processes plus an optional roasting step. Roasting is used to reduce the content of sulfur and other impurities prior to smelting. Smelting converts the ore to a molten copper/iron sulfide material (matte) which is sent to a convertor. In the convertor, air is introduced and the iron sulfide is oxidized to sulfur dioxide and iron oxide. The resulting product, called blister copper, is cast into anodes and purified by electrolytic refining.

In the copper refining process blister copper purchased from a nonassociated smelter or transferred from an associated smelter is cast into anodes and electrolytically deposited on the cathode. All impurities become concentrated in the electrolytic solution and in insoluble slimes. The slimes are processed for byproduct recovery of copper, lead, selenium, tellurium, gold and other precious metals.

Secondary Copper

In secondary copper operations, scrap containing copper is processed to recover the copper. Low-grade copper waste such as slag is added in small amounts to copper alloy melts or is melted to produce black copper. Intermediate grade scrap is used to produce brass and bronze alloys after removal of some associated impurities. High grade scrap is dried and baled or sawed, then used to produce blister or refined copper.

Primary Lead

Lead is produced in a two-step process involving refining and smelting. Typically, both operations are carried out at the same site, but there are also nonintegrated smelters and refiners.

In the smelting process ore concentrates are blended with recycle products and fluxes, pelletized, and sintered. The sinter is fed with flux, coke and wastes (such as slag and dust) to a blast furnace from which lead bullion is drawn for refining. Slag and matte are frequently withdrawn and processed to recover any other metals present.

In the refining process the first step is dross decopperizing. In this step lead is maintained slightly above its melting point and copper slag is skimmed off the top. Additional slagging steps are carried out to remove antimony, tin, arsenic, gold, silver, and bismuth before the lead refining process is complete.

Secondary Lead

Scrap lead from batteries and other lead-base materials is charged to furnaces to produce soft or hard (antimonial) lead. The soft lead may be refined or oxidized to make battery paste. The hard lead may be used in the manufacture of battery plates or processed to make lead alloy.

Secondary Silver

Wastes containing silver include materials from photography, the arts, electrical components, industry, and miscellaneous sources. These wastes are processed by a wide variety of techniques to recover the silver. Because the process is highly specific for the type of waste, no attempt to discuss the various processes will be made in this document.

Primary Tungsten

There are several variations in the processes of this industry depending on the ore. In each process one of the intermediate products is tungstic acid. The tungstic acid is converted to ammonium tungstate, which is dried and heated to form ammonium paratungstate. This intermediate is converted to oxides in a nitrogen-hydrogen atmosphere. Finally, the oxides are reduced to tungsten metal powder at high temperature in a hydrogen atmosphere.

Primary Zinc - Primary Cadmium

In this industry, the concentrates are roasted to remove sulfur and other volatile impurities. The product, called calcine, is processed either pyrolytically or electrolytically to recover the zinc. All of these plants also recover cadmium and send their wastes to other processers for recovery of other metals.

Primary Beryllium

Primary beryllium production occurs at two plants within the United States; one of these plants discharges its wastewater to the environment. Because of the limited number of facilities, beryllium production will not be discussed in this document.

Primary Selenium

Primary selenium recovery occurs at a single site which does not discharge to the environment. Consequently, this subcategory is not discussed further in this document.

Primary Tellurium

No information is currently available for this nonferrous metal.

Primary Silver

There are four primary silver production facilities in the United States. Of these, two discharge wastewaters. No further information on this subcategory is currently available.

II.10.1.3 Wastewater Flow Characterization [1]

The volume of wastewater discharged in this industry varies from 0 to 540 m^3/Mg (0-160,000 gal/ton) of metal is produced. In the sampled plants, daily flows varied from 0.45 to 61,000 m^3/d (120 to 16 MGD).

II.10.2 WASTEWATER CHARACTERIZATION [1]

Each metal subcategory uses different processes and emits different pollutant concentrations and types in the process wastewater. The following subparagraphs and tables present information on the wastewater streams for each of the 12 subcategories studied.

II.10.2.1 Primary Aluminum

Process wastewater sources for this subcategory are primarily related to air pollution control. Wet air pollution controls on anode bake furnaces generate wastewater in plants utilizing prebaked anodes. Suspended solids, oil and grease, sulfur compounds, and fuel combustion products characterize this stream. Some organics may also be present due to coal tar products released by anode baking. Degassing with chlorine requires wet air pollution control methods and results in a wastewater stream. Cryolite recovery also produces a wastewater stream that has significant amounts of fluoride, suspended solids, and TOC. Other waste streams may also be produced by cooling water, cathode making, and storm water runoff.

Tables 10-4 and 10-5 present conventional and toxic verification data for the primary aluminum subcategory.

TABLE 10-4. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN PRIMARY ALUMINUM RAW WASTEWATER[a] [1]

Pollutant	Number of Analyses	Number of Times detected	Concentration,[b] mg/L Range	Concentration,[b] mg/L Median	Concentration,[b] mg/L Mean
COD	2	2	3.4 - 5,700		2,900
TOC	2	2	150 - 440		295
TSS	2	2	2,300 - 11,400		6,850
Total phenol	3	3	0.11 - 0.27	0.13	0.17
Oil and grease	2	2	4.2 - 5.5		4.85
Ammonia	1	1		120	120
Fluoride	3	3	2.4 - 13,000	190	4,400

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-6, Reference 1.

TABLE 10-5. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN PRIMARY ALUMINUM RAW WASTEWATER [1]

Toxic pollutant	Number of: Analyses	Number of: Times detected	Concentration, µg/L[a, b]: Range	Median	Mean
Metals and inorganics					
Antimony	3	2	ND - 770	99	290
Arsenic	3	2	ND - 260	130	130
Asbestos	1	1		2.2×10^{10} [c]	
Beryllium	3	2	ND - 76	33	36
Cadmium	3	3	2.3 - 200	24	75
Chromium	3	2	ND - 2,200	86	760
Copper	3	3	13 - 140	77	77
Cyanide	3	2	<0.004 - 29	0.022	9.7
Lead	3	3	0.58 - 780	650	480
Mercury	3	2	<0.1 - 1.3	0.40	0.60
Nickel	3	3	500 - 770	660	640
Selenium	3	2	ND - 450	0.20	150
Silver	3	2	ND - <250	0.40	83
Thallium	3	1	ND - <50	ND	<17
Zinc	3	2	ND - 540	25	188
Phthalates					
Bis(2-ethylhexyl) phthalate	7	5	ND - 40		82
Butyl benzyl phthalate	7	2	ND - 86		22
Di-n-butyl phthalate	7	1	ND - 120		19
Diethyl phthalate	7	1	ND - 2.5		0.4
Dimethyl phthalate	7	0			
Di-n-octyl phthalate	7	0			
Phenols					
Phenol	6	1	ND - 70	12	12
Aromatics					
Benzene	8	1	ND - 6.0	0.8	0.8
Ethylbenzene	8	0			
Toluene	8	1	ND - 1.0	0.2	0.2
Polycyclic aromatic hydrocarbons					
Acenaphthene	7	1	ND - 50	8.4	8.4
Acenaphthylene	7	1	ND - 30	7.6	5.6
Anthracene	7	4	ND - 150	8.6	40
Benz(a)anthracene	7	3	ND - 180		38
Benzo(a)pyrene	7	3	ND - 570		95
Benzo(b)fluoranthene	7	1	ND - 260		37

(continued)

TABLE 10-5 (continued)

Toxic pollutant	Number of Analyses	Times detected	Concentration, µg/L[a, b] Range	Median	Mean
Polycyclic aromatic hydrocarbons (continued)					
Benzo(k)fluoranthene	7	2	ND - 210		39
Chrysene	7	2	ND - 230		40
Dibenz(ah)anthracene	7	1	ND - 110		16
Fluoranthene	7	4	ND - 320	49	95
Fluorene	7	1	ND - 50		7.4
Indeno(1,2,3-cd)pyrene	7	2	ND - 350		53
Naphthalene	7	1	ND - 20		3.0
Pyrene	7	4	ND - 219		70
Polychlorinated biphenyls and related compounds					
Aroclor 1248	7	0			
Aroclor 1254	7	0			
Halogenated aliphatics					
Chloroform	8	1	ND - 6.0		0.8
1,2-Dichloroethane	8	0			
1,1-Dichloroethylene	8	0			
Methylene chloride	9	1	ND - 15		3.0
1,1,2,2-Tetrachloroethane	8	0			
Tetrachloroethylene	8	0			
Trichloroethylene	8	0			
Pesticides and metabolites					
Aldrin	7	0			
δ-BHC	7	0			
γ-BHC	7	1	ND - 0.01		
Chlordane	7	0			
4,4'-DDT	7	0			
Dieldrin	7	0			
Endrin aldehyde	7	0			
Heptachlor	7	0			
Heptachlor epoxide	7	0			
Isophorone	7	1	ND - 1.5		0.2

Note: Blanks indicate insufficient data.

[a]Except asbestos, which is given in Fibers/L.

[b]All concentrations except those for asbestos were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-5, Reference 1.

[c]Maximum value.

II.10.2.2 Secondary Aluminum

Sources of process wastewater in the secondary aluminum industry include demagging air pollution control, wet nulling of residues, and contact cooling water. Removal of magnesium (demagging) involves passage of chlorine or aluminum fluoride through the melt, causing the release of magnesium in heavy fuming. The wastestreams from the air pollution control devices contain significant levels of suspended solids and chlorides or flourides as well as moderate amounts of heavy metals. Milling streams also contain suspended solids, and contact cooling water contains oil and grease, chlorides, and suspended solids. Tables 10-6 and 10-7 present conventional and toxic pollutant concentrations found in the wastewater streams of this subcategory.

TABLE 10-6. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN THE RAW WASTEWATER OF THE SECONDARY ALUMINUM SUBCATEGORY[a] [1]

Pollutant	Number of Analyses	Number of Times detected	Concentration,[b] mg/L Range	Concentration,[b] mg/L Median	Concentration,[b] mg/L Mean
COD	4	4	9 - 580	35	160
TOC	4	3	ND - 140	4	36
TSS	4	4	63 - 20,000	150	5,100
Total phenol	4	4	0.003 - 0.025	0.010	0.012
Oil and grease	4	4	3.1 - 98	13	32
Ammonia	2	2	<0.10 - 140		70
Fluoride	1	1		400	400
Chloride	3	3	400 - 6,000	3,400	3,300

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-11, Reference 1.

II.10.2.3 Primary Columbium - Primary Tantalum

The production of columbium and tantalum involves the processing of ore concentrates and slags to obtain columbium and tantalum salts, and the subsequent reduction of those salts to the respective metals. The ore concentrates are dissolved by hydrofluoric acid, and the insoluble gangue is removed by filtration. Waste gangue is generally settled in holding ponds. Overflow from this pond is extremely acidic and contains metals, fluorides, and suspended solids. After filtration, the digested solution is extracted with an organic solvent and the raffinate is discharged as a wastestream with high concentrations of organics, fluorides, metals, and suspended solids. The organic stream is then stripped with water to yield aqueous solutions of columbium and

TABLE 10-7. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATERS OF THE SECONDARY ALUMINUM SUBCATEGORY [1]

Toxic pollutant	Number of		Concentration, µg/L[a,b]		
	Analyses	Times detected	Range	Median	Mean
Metals and inorganics					
Antimony	4	2	ND - 950	150	31
Arsenic	4	3	ND - 4,000	32	1,000
Asbestos	1	1		7.5×10^8	
Beryllium	4	4	<7.0 - 310	97	130
Cadmium	4	4	<35 - 2,000	240	630
Chromium	4	4	<5 - 1,200	380	490
Copper	4	4	<70 - 6,100	575	1,800
Cyanide	4	4	<0.001 - 0.008	0.004	0.004
Lead	4	3	ND - 5,600	1,000	1,900
Mercury	4	3	ND - 6.4	0.38	1.8
Nickel	4	3	ND - 620	28	170
Selenium	4	1	ND - 200	0	50
Silver	4	2	ND - 30	<12	14
Thallium	3	1	ND - 540	ND	180
Zinc	4	4	<2,000 - 5,900	2,200	3,000
Phthalates					
Bis(2-ethylhexyl) phthalate	6	4	ND - 2,000	46	380
Butyl benzyl phthalate	6	2	ND - 98		19
Di-n-butyl phthalate	6	3	ND - 44		16
Dimethyl phthalate	6	1	ND - 56	9.5	9.5
Di-n-octyl phthalate	6	1	ND - 25	4.2	4.2
Nitrogen compounds					
3,3'-Dichlorobenzidine	6	1	ND - 2.0	0.3	0.3
Aromatics					
Benzene	10	1	ND - 94		9.4
Chlorobenzene	10	0			
1,4-Dichlorobenzene	6	1	ND - 26		4.3
Ethylbenzene	10	0			
1,2,4-Trichlorobenzene	6	0			
Polycyclic aromatic hydrocarbons					
Acenaphthylene	6	1	ND - 17		2.8
Anthracene	6	1	ND - 4.0		0.7
Benzo(a)pyrene	6	1	ND - 12		2.0
Benzo(b)fluoranthene	6	0			
Benzo(ghi)perylene	6	0			
Benzo(k)fluoranthene	6	0			
Chrysene	6	1	ND - 190		32
Fluoranthene	6	2	ND - 12		
Naphthalene	6	1	ND - 1.0		0.2

(continued)

TABLE 10-7 (continued)

Toxic pollutant	Number of: Analyses	Number of: Times detected	Concentration, µg/L[a,b]: Range	Concentration, µg/L[a,b]: Median	Concentration, µg/L[a,b]: Mean
Polycyclic aromatic hydrocarbons (continued)					
Phenanthrene	6	1	ND - 10		1.7
Pyrene	6	1	ND - 24		4.5
Polychlorinated biphenyls and related compounds					
Aroclor 1248	6	1	ND - 0.3		0.1
Aroclor 1254	6	1	ND - 0.9		0.4
Halogenated aliphatics					
Bromoform	10	0			
Carbon tetrachloride	10	1	ND - 10		1.0
Chlorodibromomethane	10	0			
Chloroform	10	6	ND - 34		3.4
Dichlorobromomethane	10	1	ND - 19		1.9
1,1-Dichloroethane	10	0			
1,2-Dichloroethane	10	0			
1,2-*Trans*-dichloroethylene	10	5	ND - 57		19
Methylene chloride	10	1	ND - 93		9.3
1,1,2,2-Tetrachloroethane	10	0			
Tetrachloroethylene	10	1	ND - 310		32
1,1,1-Trichloroethane	10	0			
1,1,2-Trichloroethane	10	0			
Trichloroethylene	10	5	ND - 530		61
Pesticides and metabolites					
Aldrin	6	0			
α-BHC	6	1	ND - 0.1		
β-BHC	6	1	ND - 0.4		
γ-BHC	6	1	ND - 0.1		
Chlordane	6	1	ND - 0.3		0.1
4,4'-DDE	6	1	ND - 0.01		
4,4'-DDD	6	0			
4,4'-DDT	6	1	ND - 0.02		
Dieldrin	6	1	ND - 0.2		
α-Endosulfan	6	0			
Endrin	6	1	ND - 0.01		
Endrin aldehyde	6	1	ND - 0.4	0.1	0.1
Heptachlor	6	1	ND - 0.4		
Heptachlor epoxide	6	1	ND - 0.2		

Note: Blanks indicate insufficient data.

[a]Except asbestos in fibers/L.

[b]All concentrations except those for asbestos were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the conentration present in the intake; refer to Table V-10, Reference 1.

tantalum. Precipitation of the salts is accomplished by ammonia addition and is followed by filtration. The filtrate typically contains high concentrations of ammonia as well as significant levels of fluoride, various metals, and suspended solids. Conversion of the salts to metals produces wastewater from air pollution control scrubbers and reduction leachates. These streams contain high levels of dissolved solids and significant concentration of fluoride.

Tables 10-8 and 10-9 present conventional and toxic pollutant concentration data for this subcategory.

TABLE 10-8. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN THE RAW WASTEWATER OF THE PRIMARY COLUMBIUM AND PRIMARY TANTALUM SUBCATEGORIES[a] [1]

Pollutant	Number of Analyses	Number of Times detected	Concentration,[b] mg/L Range	Median	Mean
COD	3	3	140 - 6,700	400	2,400
TOC	3	3	45 - 1,000	120	390
TSS	3	3	570 - 8,700	3,900	4,400
Total phenol	3	3	0.016 - 0.10	0.018	0.045
Oil and grease	3	3	5.3 - 16	7.3	9.5
Ammonia	3	3	64 - 2,400	380	948
Fluoride	3	3	2,200 - 13,000	3,500	9,350
Chloride	1	1		120	120

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-19, Reference 1.

II.10.2.4 Primary Copper

Both smelting and refining are practiced by the primary copper industry. Some plants engage in smelting only, others practice only refining, and some facilities practice both operations. Significant differences in wastewater characteristics associated with smelting and refining are found.

Smelting process wastewater sources include acid plant blowdown, contact cooling, and slag granulation. Acid plant blowdown results from the recovery of sulfur from the smelting operation. Contact casting cooling water used by primary copper smelters is normally recycled after cooling in towers or ponds. Furnace slag is disposed of by either dumping or granulation. Molten slag is granulated by using high pressure water jets. The wastewater from this granulation is typically high in suspended and dissolved solids and contains some toxic metals.

TABLE 10-9. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATERS OF THE PRIMARY COLUMBIUM AND PRIMARY TANTALUM SUBCATEGORIES [1]

	Number of		Concentration, µg/L[a,b]		
Toxic pollutant	Analyses	Times detected	Range	Median	Mean
Metals and inorganics					
Antimony	3	2	ND - 11,000	10	3,700
Arsenic	3	3	180 - 14,000	380	4,900
Asbestos	3	1		1.4×10^{10}	
Beryllium	3	3	20 - 190	89	100
Cadmium	3	3	8.0 - 19,000	48	6,400
Chromium	3	3	3,000 - 520,000	3,000	180,000
Copper	3	3	400 - 260,000	500	87,000
Cyanide	3	3	0.002 - 0.012	0.004	0.006
Lead	3	3	3,000 - 2.7×10^7	3,000	9.0×10^6
Mercury	3	3	<0.1 - 36	6.0	14
Nickel	3	3	600 - 2,600	2,000	1,700
Selenium	3	2	ND - 24,000	<10	8,000
Silver	3	3	<20 - 610	60	230
Thallium	3	3	ND - <100	24	41
Zinc	3	3	540 - 700,000	6,000	240,000
Phthalates					
Bis(2-ethylhexyl) phthalate	15	12	ND - 1,100	22	150
Butyl benzyl phthalate	15	2	ND - 47		6.3
Di-n-butyl phthalate	15	5	ND - 60		12
Diethyl phthalate	15	1	ND - 17		1.7
Dimethyl phthalate	15	2	ND - 39		4.1
Di-n-octyl phthalate	15	1	ND - 95		6.6
Phenols					
Pentachlorophenol	8	1	ND - 17		2.1
Aromatics					
Benzene	22	2	ND - 44		4.4
Chlorobenzene	22	0			
2,4-Dinitrotoluene	15	1	ND - 16		1.7
2,6-Dinitrotoluene	15	1	ND - 16		1.7
Ethylbenzene	22	0			
Nitrobenzene	15	2	ND - 163		18
Toluene	22	0			
1,2,4-Trichlorobenzene	15	2	ND - 260		22
Polycyclic aromatic hydrocarbons					
Acenaphthene	15	1	ND - 17		1.1
Acenaphthylene	15	1	ND - 2.0		0.2
Anthracene	15	1	ND - 2.0		0.3
Benz(a)anthracene	15	1	ND - 1.0		0.1
Benzo(a)pyrene	15	1	ND - 1.0		0.1
Benzo(b)fluoranthene	15	0			
Benzo(ghi)perylene	15	1	ND - 2.0		0.2
Benzo(k)fluoranthene	15	0			
2-Chloronaphthalene	15	1	ND - 3.0		0.3
Chrysene	15	1	ND - 45		3.1
Dibenz(ah)anthracene	15	1	ND - 4.0		0.3

(continued)

TABLE 10-9 (continued)

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration, µg/L[a,b] Range	Median	Mean
Polycyclic aromatic hydrocarbons (continued)					
Fluoranthene	15	1	ND - 7.2		1.1
Fluorene	15	2	ND - 2.0		1.3
Indeno(1,2,3-cd)pyrene	15	1	ND - 4.0		0.3
Naphthalene	15	1	ND - 84		6.1
Phenanthrene	15	1	ND - 2.0		0.3
Pyrene	15	1	ND - 3.0		0.5
Polychlorinated biphenyls and related compounds					
Aroclor 1248	15	1	ND - 32		2.6
Aroclor 1254	15	1	ND - 52		4.1
Halogenated aliphatics					
Bromoform	22	1	ND - 21		1.2
Carbon tetrachloride	22	2	ND - 74		5.1
Chlorodibromomethane	22	3	ND - 81		5.2
Chloroform	22	7	ND - 140		7.8
Dichlorobromomethane	22	1	ND - 13		0.6
1,2-Dichloroethane	22	6	ND - 150		13
1,1-Dichloroethylene	22	1	ND - 22		1.4
1,2-*Trans*-dichloroethylene	22	6	ND - 480		49
Hexachloroethane	15	1	ND - 23		1.5
Methylene chloride	22	1	ND - 88,000		4,000
1,1,2,2-Tetrachloroethane	15	1	ND - 6.0		0.5
Tetrachloroethylene	22	1	ND - 65		3.6
1,1,1-Trichloroethane	22	2	ND - 40		2.5
1,1,2-Trichloroethane	22	2	ND - 29		2.1
Trichloroethylene	22	3	ND - 230		21
Pesticides and metabolites					
Aldrin	15	1	ND - 4.0		0.3
α-BHC	15	1	ND - 0.04		
β-BHC	15	1	ND - 4.5		0.4
δ-BHC	15	1	ND - 4.0		0.3
γ-BHC	15	1	ND - 0.03		
Chlordane	15	1	ND - 0.8		0.1
4,4'-DDE	15	1	ND - 0.4		
4,4'-DDT	15	1	ND - 1.0		0.1
Dieldrin	15	1	ND - 0.1		
α-Endosulfan	15	1	ND - 0.01		
Endosulfan sulfate	15	1	ND - 0.03		
Endrin	15	1	ND - 5.4		0.4
Endrin aldehyde	15	1	ND - 0.2		
Heptachlor	15	1	ND - 0.5		
Heptachlor epoxide	15	1	ND - 0.1		
Isophorone	15	1	ND - 29		2.1
Toxaphene	15	1	ND - 0.1		

Note: Blanks indicate insufficient data.

[a]Except asbestos, which is given in fibers/L.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-18, Reference 1.

Refining operations have two principal wastestreams, waste electrolyte and cathode and anode wash water. Spent electrolyte is normally recycled. A bleed stream is treated to reduce copper and impurity concentration. Varying degrees of treatment are necessary because of the differences in the anode copper. Anode impurities, including nickel, arsenic, and traces of antimony and bismuth, may be present in the effluent if the spent electrolyte bleed stream is discharged.

Table 10-10 and Table 10-11 present conventional and toxic pollutant data for raw wastewater in this subcategory.

TABLE 10-10. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN RAW WASTEWATER FROM THE PRIMARY COPPER SUBCATEGORY[a] [1]

Pollutant	Number of Analyses	Number of Times detected	Concentration,[b] mg/L Range	Median	Mean
COD	3	3	<2.0 - 730	24	252
TOC	3	3	3.5 - 7.0	4.9	5.1
TSS	3	3	5.3 - 4,400	18	1,500
Total phenol	2	2	0.005 - 0.033		0.019
Oil and grease	1	1		6.0	6.0

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-24, Reference 1.

II.10.2.5 Secondary Copper

Wastewater is generated by several processes in this subcategory. Slag milling and classification generates wastewater that is high in suspended solids, copper, lead, and zinc. Air pollution control at the site generates acidic wastewater that contains significant levels of copper. Other wastewater sources may include contact cooling, electrolyte disposal, and slag granulation.

Tables 10-12 and 10-13 present conventional and toxic pollutant data for the secondary copper recovery subcategory.

II.10.2.6 Primary Lead

Primary lead facilities have two major processes associated with wastewater generation. The smelting process generates a major wastestream from the sintering operation. These wastewaters are typically high in dissolved solids and metals such as cadmium, lead, and zinc. Acid plant blowdown, slag granulation, and air pollution control methods are also associated with smelting operations. Refining operations also generate wastewater from air pollution equipment and from noncontact cooling water.

TABLE 10-11. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATER FROM THE PRIMARY COPPER SUBCATEGORY [1]

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration,[a] μg/L Range	Median	Mean
Metals and inorganics					
Antimony	3	3	<50 - 3,300	100	1,200
Arsenic	3	3	<2.0 - 310,000	9,300	110,000
Beryllium	3	3	<2 - 7.7	6.0	5.2
Cadmium	3	3	<5 - 9,600	7.0	3,200
Chromium	3	3	<10 - 73	51	45
Copper	3	3	1,600 - 450,000	2,300	150,000
Cyanide	2	2	<0.001 - <0.02		0.01
Lead	3	3	<20 - 170,000	470	56,000
Mercury	3	3	<0.5 - 48	4.6	18
Nickel	3	3	<20 - 1,100	340	490
Selenium	3	3	6.0 - 310	15	110
Silver	3	3	20 - 480	54	185
Thallium	3	3	21 - <100	<100	74
Zinc	3	3	30 - 150,000	400	50,000
Phthalates					
Bis(2-ethylhexyl) phthalate	11	5	ND - 78		17
Butyl benzyl phthalate	11	1	ND - 1.0		0.1
Di-n-butyl phthalate	11	2	ND - 75	0.7	7.6
Di-n-octyl phthalate	11	1	ND - 3.0		0.3
Phenols					
2,4-Dimethylphenol	2	1	ND - 14		7.0
Aromatics					
Benzene	11	1	ND - 3.0		0.7
Chlorobenzene	11	1	ND - 40		8.4
Toluene	11	1	ND - 1.0		0.2
Polycyclic aromatic hydrocarbons					
Acenaphthylene	11	1	ND - 3.0		0.3
Anthracene	11	4	ND - 21		6.1
Benz(a)anthracene	11	1	ND - 1.0		0.1
Chrysene	11	0			
Fluoranthene	11	1	ND - 1.0		0.3
Fluorene	11	1	ND - 1.0		0.1
Phenanthrene	11	4	ND - 21	7.0	7.1
Pyrene	11	1	ND - 1.0		0.4
Polychlorinated biphenyls and related compounds					
Aroclor 1248	9	1	ND - 0.6		0.1
Aroclor 1254	11	1	ND - 0.7		0.1
Halogenated aliphatics					
Carbon tetrachloride	11	4	ND - 40		8.4
Chlorodibromomethane	11	2	ND - 13		1.2
Chloroform	11	4	ND - 93	5.0	16
Dichlorobromomethane	11	2	ND - 14		1.3
1,2-Dichloroethane	11	1	ND - 7.0		0.6
1,1-Dichloroethylene	11	0			
Methylene chloride	11	1	ND - 6.8		0.6
1,1,2,2-Tetrachloroethane	11	4	ND - 12		1.9
Tetrachloroethylene	11	5	ND - 15	4.0	5.4
1,1,1-Trichloroethane	11	0			
1,1,2-Trichloroethane	11	1	ND - 2.0		0.2
Trichloroethylene	11	1	ND - 9.0		1.5
Pesticides and metabolites					
β-BHC	11	1	ND - 0.01		
γ-BHC	11	1	ND - 0.04		
Chlordane	11	1	ND - 0.2		
4,4'-DDT	11	1	ND - 0.01		
4,4'-DDT	11	1	ND - 0.02		
Dieldrin	11	1	ND - 0.02		
α-Endosulfan	11	0			
β-Endosulfan	11	1	ND - 0.01		
Endosulfan sulfate	11	0			
Endrin	11	1	ND - 0.1		
Endrin aldehyde	11	1	ND - 0.4		0.1
Heptachlor	11	1	ND - 0.01		
Heptachlor epoxide	11	1	ND - 0.01		0.01
Isophorone	11	1	ND - 3.0		0.3

Note: Blanks indicate insufficient data.

[a]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-23, Reference 1.

TABLE 10-12. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN THE RAW WASTEWATER OF THE SECONDARY COPPER SUBCATEGORY[a] [1]

Pollutant	Number of		Concentration, mg/L		
	Analyses	Times detected	Range	Median	Mean
COD	5	5	9.7 - 900	75	230
TOC	5	5	6.0 - 99	30	40
TSS	5	5	4.0 - 11,000	65	2,700
Total phenol	4	4	0.0063 - 0.22	0.045	0.079
Oil and grease	4	4	1.7 - 30	4.2	10
Fluoride	1	1		0.29	0.29

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported; refer to Table V-29, Reference 1.

Tables 10-14 and 10-15 present conventional and toxic pollutant data of the raw wastewater generated in this subcategory.

II.10.2.7 Secondary Lead

The principal raw material for the secondary lead industry is scrap batteries. Wastewater is generated from battery acid streams, wash down streams, and saw cooling for cracking the batteries. These streams contain significant levels of suspended solids, antimony, arsenic, cadmium, lead, and zinc. Smelting operations for this subcategory generate wastewater from air pollution control devices and contact cooling streams.

Tables 10-16 and 10-17 present conventional and toxic pollutant data for the raw wastewater in this subcategory.

II.10.2.8 Secondary Silver

Secondary silver is recovered from photographic and nonphotographic sources. Wastewater sources from photographic wastes include leaching and stripping, precipitation and filtration of silver, electrolysis, and pollution control. Nonphotographic scrap wastewater is generated by similar processes. These wastewater streams contain significant concentrations of chromium, copper, lead, and zinc as well as some organic priority pollutants.

Tables 10-18 and 10-19 present pollutant data for this subcategory.

II.10.2.9 Primary Tugsten

Tungsten production involves processing ore concentrates to obtain the salt, ammonium paratungstate (APT), and subsequent reduction of APT to metallic tungsten. Wastewater is generated

TABLE 10-13. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATERS FROM THE SECONDARY COPPER SUBCATEGORY[a] [1]

Toxic pollutant	Number of		Concentration, µg/L[b]		
	Analyses	Times detected	Range	Median	Mean
Metals and inorganics					
Antimony	5	2	ND - 11,000	ND	2,200
Arsenic	5	3	ND - 4,200	100	940
Asbestos	2	2	3.3×10^{7} - 1.0×10^{11}		5.0×10^{10}
Beryllium	5	4	ND - 160	30	58
Cadmium	5	5	5.0 - 1,200	50	390
Chromium	5	5	5.0 - 2,100	<240	640
Copper	5	5	620 - 2.1×10^{6}	40,000	450,000
Cyanide	4	4	<0.001 - 0.026	0.006	0.010
Lead	5	5	450 - 53,000	10,000	17,000
Mercury	5	5	ND - 0.6	0.53	0.35
Nickel	5	5	7.0 - 3.1×10^{6}	3,000	620,000
Selenium	5	2	ND - 270	ND	98
Silver	5	3	ND - 1,600	≤10	370
Thallium	5	2	ND - 53	ND	21
Zinc	5	5	1,400 - 1.5×10^{6}	40,000	330,000
Phthalates					
Bis(2-ethylhexyl) phthalate	12	10	ND - 7,000	53	1,100
Butyl benzyl phthalate	12	2	ND - 56		5.3
Di-n-butyl phthalate	12	6	ND - 390	9.5	56
Diethyl phthalate	12	3	ND - 83		11
Dimethyl phthalate	12	0			
Di-n-octyl phthalate	12	2	ND - 67	5.8	
Aromatics					
Benzene	10	2	ND - 13		1.3
Ethylbenzene	10	1	ND - 4.0		0.4
Hexachlorobenzene	12	1	ND - 5,000		420
Nitrobenzene	12	0			
Toluene	10	1	ND - 10		1.7
Polycyclic aromatic hydrocarbons					
Acenaphthene	12	3	ND - 36		4.6
Acenaphthylene	12	4	ND - 120		23
Anthracene	12	3	ND - 3,000		260
Benzo(a)pyrene	12	1	ND - 1.0		0.1
Benzo(b)fluoranthene	12	0			
Benzo(k)fluoranthene	12	0			
Chrysene	12	3	ND - 10,000		840
Dibenz(ah)anthracene	12	0			
Fluoranthene	12	4	ND - 3,000	1.0	280
Fluorene	12	4	ND - 94		14
Indeno(1,2,3-cd)pyrene	12	0			

(continued)

TABLE 10-13 (continued)

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration, µg/L[b] Range	Concentration, µg/L[b] Median	Concentration, µg/L[b] Mean
Polycyclic aromatic hydrocarbons (continued)					
Naphthalene	12	4	ND - 5,000		550
Phenanthrene	12	4	ND - 3,000		260
Pyrene	12	4	ND - 7,000		610
Polychlorinated biphenyls and related compounds					
Aroclor 1248	14	1	ND - 2.0		0.5
Aroclor 1254	14	1	ND - 3.0		0.5
Halogenated aliphatics					
Carbon tetrachloride	10	2	ND - 120		12
Chloroform	10	6	ND - 1,000	7.0	130
Dichlorobromomethane	10	0			
1,2-Dichloroethane	10	1	ND - 32		3.2
1,1-Dichloroethylene	10	3	ND - 530		57
1,2-*Trans*-dichloroethylene	10	1	ND - 5.0		0.5
Methylene chloride	10	3	ND - 510		80
1,1,2,2-Tetrachloroethane	10	1	ND - 4.0		0.4
Tetrachloroethylene	10	3	ND - 72		8.8
Trichloroethylene	10	2	ND - 70		7.1
Pesticides and metabolites					
Aldrin	14	1	ND - 0.2		
α-BHC	14	1	ND - 0.2		
β-BHC	14	1	ND - 0.02		
δ-BHC	14	1	ND - 0.2		
γ-BHC	14	1	ND - 0.04		
Chlordane	14	1	ND - 0.7		0.1
4,4'-DDE	14	1	ND - 0.02		
4,4'-DDD	14	1	ND - 0.1		
4,4'-DDT	14	1	ND - 0.03		
Dieldrin	14	1	ND - 0.03		
α-Endosulfan	14	1	ND - 0.3		
β-Endosulfan	14	1	ND - 0.3		
Endrin	14	1	ND - 0.4		
Endrin aldehyde	14	1	ND - 0.3		
Heptachlor	14	1	ND - 0.02		
Heptachlor epoxide	14	0			
Toxaphene	14	1	ND - 0.4		

Note: Blanks indicate insufficient data.

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Except asbestos, which is given in fibers/L.

TABLE 10-14. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN THE PRIMARY LEAD SUBCATEGORY[a] [1]

Pollutant	Number of Analyses	Number of Times detected	Concentration, mg/L Range	Median	Mean
COD	3	2	ND - 170	3.7	58
TOC	1	1		3.3	3.3
TSS	1	1		26	26
Total phenol	2	2	0.012 - 0.050		0.031
Ammonia	2	2	0.43 - 3.8		2.1

[a]Some numbers in this table do not represent the concentration of the of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

TABLE 10-15. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATER OF THE PRIMARY LEAD SUBCATEGORY[a] [1]

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration,[b] μg/L Range	Median	Mean
Metals and inorganics					
Antimony	3	2	ND - <330	3	110
Arsenic	3	3	58 - 96	93	82
Beryllium	3	1	ND - 6.7	ND	2.2
Cadmium	3	3	690 - 2,700	1,300	1,600
Chromium	3	3	9.1 - 30	14	18
Copper	3	3	100 - 5,300	610	2,000
Cyanide	2	2	<0.02 - 0.13		0.08
Lead	3	3	7,900 - 24,000	10,000	14,000
Mercury	3	3	0.29 - 7.5	0.68	2.8
Nickel	3	3	50 - 150	130	110
Selenium	3	3	3.1 - <13	5.4	7.2
Silver	3	2	ND - <20	7.0	9.0
Thallium	3	2	ND - <100	15	38
Zinc	3	3	2,700 - 20,000	5,300	9,300
Polycyclic aromatic hydrocarbons					
Pyrene	3	1	ND - 7.0		2.3
Halogenated aliphatics					
Methylene chloride	4	2	ND - 25	3.0	7 8

Note. Blanks indicate insufficient data.

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration in the intake; refer to Table V-32, Reference 1.

TABLE 10-16. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN THE SECONDARY LEAD SUBCATEGORY[a] [1]

Pollutant	Number of Analyses	Number of Times detected	Concentration,[b] mg/L Range	Median	Mean
COD	3	3	65 - 220	150	145
TOC	3	3	4.0 - 130	70	68
TSS	4	4	0.06 - 3,700	760	1,300
Total phenol	4	4	<0.004 - 0.012	0.010	0.009
Oil and grease	3	3	6.4 - 40	35	27
Ammonia	1	1		12	12
Chloride	1	1		79	79

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration in the intake; refer to Table V-38, Reference 1.

TABLE 10-17. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATER OF THE SECONDARY LEAD SUBCATEGORY [1]

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration, μg/L[a,b] Range	Median	Mean
Metals and inorganics					
Antimony	4	4	1,700 - 80,000	38,000	39,000
Arsenic	3	3	3,000 - 13,000	7,000	7,700
Asbestos	1	1		1.3×10^{11}	
Beryllium	3	3	1.0 - 30	3.2	11
Cadmium	4	4	220 - 1,900	800	930
Chromium	4	4	110 - 1,000	480	520
Copper	4	4	220 - 8,200	3,200	3,700
Cyanide	4	4	0.002 - <0.01	0.006	0.006
Lead	4	4	7,000 - 1.8×10^6	22,000	460,000
Mercury	4	4	0.6 - 12	0.78	3.5
Nickel	4	4	210 - 2,000	960	1,000
Selenium	3	1	ND - <2.0	ND	0.67
Silver	3	3	90 - 250	100	150
Thallium	3	3	50 - 620	350	340
Zinc	4	4	790 - 15,000	3,600	5,700
Phthalates					
Bis(2-ethylhexyl) phthalate	5	5	ND - 580	30	180
Butyl benzyl phthalate	5	2	ND - 85		17
Di-n-butyl phthalate	5	4	ND - 27	13	12
Dimethyl phthalate	5	3	ND - 13		2.6
Di-n-octyl phthalate	5	3	ND - 27	2.0	9.0
Nitrogen compounds					
Benzidine	5	1	ND - 6.0		1.2
Aromatics					
Benzene	10	1	ND - 2.0		0.2
Chlorobenzene	10	1	ND - 5.0		0.5
Ethylbenzene	10	1	ND - 1.2		0.3
Nitrobenzene	5	2	ND - 16		3.2
Toluene	10	0			
Polycyclic aromatic hydrocarbons					
Acenaphthylene	5	2	ND - 35	3.0	8.6
Anthracene	5	2	ND - 20		4.0
Benzo(a)pyrene	5	2	ND - 10		2.0
Benzo(b)fluoranthene	5	1	ND - 5.3		1.6
Benzo(ghi)perylene	5	0			
Benzo(k)fluoranthene	5	1	ND - 5.3		1.6
Chrysene	5	3	ND - 540	40	140
Fluoranthene	5	3	ND - 27	1.0	7.6
Fluorene	5	1	ND - 2.0		0.4

(continued)

TABLE 10-17 (continued)

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration, µg/L[a, b] Range	Median	Mean
Polycyclic aromatic hydrocarbons (continued)					
Indeno(1,2,3-cd)pyrene	5	1	ND - 1.0		0.2
Naphthalene	5	1	ND - 4.0		0.8
Phenanthrene	5	2	ND - 20		4.6
Pyrene	5	3	ND - 38	1.0	10
Polychlorinated biphenyls and related compounds					
Aroclor 1248	5	1	ND - 3.1	1.3	1.4
Aroclor 1254	5	1	ND - 2.6	1.8	1.3
Halogenated aliphatics					
Bromoform	10	2	ND - 49		5.7
Chloroform	10	4	ND - 31	3.0	6.9
1,2-Dichloroethane	10	2	ND - 10	4.0	4.0
1,1-Dichloroethylene	10	2	ND - 10	2.0	3.7
1,2-*Trans*-dichloroethylene	10	0			
1,1,2,2-Tetrachloroethane	10	1	ND - 4.0		1.0
Tetrachloroethylene	10	1	ND - 5.0		1.1
1,1,2-Trichloroethane	10	0			
Trichloroethylene	10	1	ND - 6.0		0.8
Pesticides and metabolites					
Aldrin	5	1	ND - 0.1		
α-BHC	5	1	ND - 0.2		
β-BHC	5	1	ND - 0.3	0.1	0.1
γ-BHC	5	1	ND - 0.1		
Chlordane	5	1	ND - 0.2	0.2	0.2
4,4'-DDE	5	1	ND - 0.2		
4,4'-DDT	5	1	ND - 0.1		
Dieldrin	5	1	ND - 0.2		
α-Endosulfan	5	1	ND - 0.2		
β-Endosulfan	5	0			
Endrin	5	1	ND - 4.0		1.0
Endrin aldehyde	5	1	0.6		0.1
Heptachlor	5	1	ND - 0.3	0.1	0.1
Heptachlor epoxide	5	1	ND - 0.2	0.1	0.1
Isophorone	5	1	ND - 2.7		1.8

Note: Blanks indicate insufficient data.

[a]Except asbestos, which is given in fibers/L.

[b]All concentrations except for asbestos were calculated by multiplying the concentrations of the various waste-streams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-37, Reference 1.

TABLE 10-18. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN THE RAW WASTEWATER OF THE SECONDARY SILVER SUBCATEGORY[a] [1]

Pollutant	Number of: Analyses	Number of: Times detected	Concentration,[b] mg/L: Range	Concentration,[b] mg/L: Median	Concentration,[b] mg/L: Mean
COD	3	3	220 - 12,000	3,000	5,100
TOC	3	3	24 - 9,200	440	3,200
TSS	3	3	110 - 1,100	110	440
Total phenol	3	3	0.02 - 28	0.04	9.4
Oil and grease	3	3	8.0 - 110	17	45
Ammonia	2	2	12.0 - 1,500		760
Fluoride	1	1		1.2	1.2
Chloride	1	1		32,000	32,000

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration in the intake; refer to Table V-43, Reference 1.

during all three processes and results from the precipitation and filtration of the salt, the leaching to convert to tungstic acid, and the air pollution control methods associated with the processes. Wastewaters may be acidic and contain significant concentration of chlorides, arsenic, lead, zinc, and ammonia.

Tables 10-20 and 10-21 present pollutant data for the primary tungsten subcategory.

II.10.2.10 Primary Zinc - Primary Cadmium

Wastewater is generated in the primary zinc and primary cadmium recovery subcategories by acid plant blowdown, which results from sulfuric acid recovery, air pollution control, leaching, anode/cathode washing, and contact cooling. The streams may contain significant concentrations of lead, arsenic, cadmium, and zinc.

Tables 10-22 and 10-23 present pollutant data for the primary zinc-primary cadmium subcategories.

II.10.3 PLANT SPECIFIC DESCRIPTION [1]

Tables 10-24 through 10-32 provide plant specific data for the conventional and toxic metal pollutant concentrations found in the untreated and treated wastewaters for plants in the nonferrous metals industry. Data for toxic organic pollutants are not available on an individual plant basis. The available data cover 17 plants in 10 of the 12 subcategories studied. Primary copper and primary cadmium are not reported owing to lack of

TABLE 10-19. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATERS OF THE SECONDARY SILVER CATEGORY [1]

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration, µg/L[a,b] Range	Median	Mean
Metals and inorganics					
Antimony	3	1	ND - 25,000	ND	8,300
Arsenic	3	3	40 - 900	40	330
Asbestos	1	1	5.8×10^8		
Beryllium	3	2	ND - <20	19	13
Cadmium	3	3	1,000 - 80,000	3,200	28,000
Chromium	3	3	2,000 - 27,000	20,000	16,000
Copper	3	3	7,400 - 70,000	60,000	46,000
Cyanide	3	3	0.001 - 2.1	0.05	0.72
Lead	3	3	4,000 - 50,000	4,200	19,000
Mercury	3	1	ND - 5.5	ND	1.8
Nickel	3	3	1,100 - 800,000	30,000	280,000
Selenium	3	1	ND - 590	ND	200
Silver	3	3	<250 - 4,700	410	1,800
Thallium	3	1	ND - 510	ND	170
Zinc	3	3	8,400 - 2.0×10^6	20,000	680,000
Phthalates					
Bis(2-ethylhexyl) phthalate	5	5	7.0 - 34	11	18
Butyl benzyl phthalate	5	2	ND - 53		11
Di-n-butyl phthalate	5	5	ND - 300	15	75
Diethyl phthalate	5	2	ND - 38		7.6
Di-n-octyl phthalate	5	4	ND - 58	33	30
Aromatics					
Benzene	6	6	3.0 - 160	66	75
Chlorobenzene	6	1	ND - 9.0	0.5	2.8
Ethylbenzene	6	4	ND - 21		9.2
Toluene	6	6	3.0 - 55	18	21
Polycyclic aromatic hydrocarbons					
Acenaphthene	5	2	ND - 10		2.0
Anthracene	5	2	ND - 4.0		0.8
Fluoranthene	5	0			
Naphthalene	5	1	ND - 1.0		0.2
Phenanthrene	5	2	ND - 4.0		0.8
Pyrene	5	1	ND - 2,100		430
Polychlorinated biphenyls and related compounds					
Aroclor 1248	3	1	ND - 0.5		0.2
Aroclor 1254	3	1	ND - 0.7		0.2
Halogenated aliphatics					
Bromoform	6	1	ND - 65		11
Carbon tetrachloride	6	2	ND - 2,300		380
Chlorodibromomethane	6	2	ND - 64		11
Chloroform	6	1	ND - 890	8.5	160
1,2-Dichloroethane	6	4	ND - 560	21	120
1,1-Dichloroethylene	6	3	ND - 6,100		1,100
1,2-*Trans*-dichloroethylene	6	0			
Methylene chloride	6	4	ND - 3,100	170	1,000
1,1,2,2-Tetrachloroethane	4	2	ND - 32		8.0
Tetrachloroethylene	6	6	ND - 109	36	43
1,1,1-Trichloroethane	6	3	ND - 22		7.3
Trichloroethylene	6	6	ND - 900	230	360
Pesticides and metabolites					
Aldrin	3	1	ND - 1.1		0.4
α-BHC	3	0			
β-BHC	3	1	ND - 0.02		
δ-BHC	3	1	ND - 1.1		0.4
γ-BHC	3	0			
Chlordane	3	1	ND - 0.1		
4,4'-DDE	3	1	ND - 0.01		
4,4'-DDD	3	1	ND - 0.1		
4,4'-DDT	3	1	ND - 0.01		
Dieldrin	3	1	ND - 0.01		
Endrin	3	1	ND - 2.0		0.7
Endrin aldehyde	3	0			
Heptachlor	3	1	ND - 0.02		

Note: Blanks indicate insufficient data.

[a]Except asbestos, which is given in fibers/L.

[b]Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration in the intake; refer to Table V-42, Reference 1.

TABLE 10-20. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS IN THE WASTEWATER OF THE PRIMARY TUNGSTEN SUBCATEGORY[a] [1]

Pollutant	Number of		Concentration,[b] mg/L		
	Analyses	Times detected	Range	Median	Mean
COD	3	3	120 - 880	320	440
TOC	3	3	6.0 - 270	27	100
TSS	3	3	42 - 6,700	210	2,300
Total phenol	3	3	0.038 - 0.089	0.039	0.055
Oil and grease	3	3	6.3 - 17	6.8	10
Ammonia	3	3	3.9 - 1,600	900	830
Chloride	2	2	850 - 26,000		13,000

[a] Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b] Concentrations were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration present in the intake; refer to Table V-48, Reference 1.

sufficient data. When data on several plants were available, reported plants were selected based on the completeness of the data and on the overall pollutant removal efficiency.

The following subparagraphs briefly describe the selected plants.

II.10.31 Primary Aluminum

Plant B generates wastewater by contact cooling (830 m^3/d) and by cryolite recovery (220 m^3/d). Wastewater is treated by alkaline chlorination and neutralization.

Plant D generates wastewater from air pollution control equipment (4,900 m^3/d), paste plant waste (570 m^3/d) and anode cooling and baking. Treatment consists of settling.

II.10.3.2 Secondary Aluminum

Plant B in this subcategory generates wastewater by processes involving dross milling (140 m^3/d) and demagging air pollution control (95 m^3/d). Treatment consists of sodium hydroxide neutralization and settling prior to discharge.

Plant E generates wastewater by demagging air pollution control (90 m^3/d). Treatment consists of neutralization with soda ash.

II.10.3.3 Primary Columbium - Primary Tantalum

Plant B in this subcategory emits wastewater from leaching wastes and powder wash (310 m^3/d), gangue slurry pond overflow (53 m^3/d), and ammonia stripper supernatant (76 m^3/d). Treatment consists of lime addition followed by settling.

TABLE 10-21. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATER OF THE PRIMARY TUNGSTEN SUBCATEGORY[a] [1]

Toxic pollutant	Number of		Concentration, µg/L[b,c]		
	Analyses	Times detected	Range	Median	Mean
Metals and inorganics					
Antimony	3	1	ND - 700	ND	230
Arsenic	3	3	10 - 7,200	210	2,500
Asbestos	1	1	6.0×10^9		
Beryllium	3	3	<2.0 - 29	<10	14
Cadmium	3	3	19 - 190	<20	76
Chromium	3	3	44 - 2,000	48	700
Copper	3	3	95 - 5,000	120	1,700
Cyanide	3	3	0.002 - 0.14	0.013	0.052
Lead	3	3	<200 - 20,000	240	6,800
Mercury	3	3	0.20 - 3.00	1.0	1.4
Nickel	3	3	<50 - 1,000	92	380
Selenium	3	2	ND - 1,000	20	340
Silver	3	3	76 - 270	86	140
Thallium	3	2	ND - 600	200	270
Zinc	3	3	250 - 1,900	520	890
Phthalates					
Bis(2-ethylhexyl) phthalate	5	5	ND - 880	10.0	180
Di-n-butyl phthalate	5	3	ND - 23		
Diethyl phthalate	5	0			
Dimethyl phthalate	5	0			
Di-n-octyl phthalate	5	2	ND - 1.0		0.2
Aromatics					
Benzene	9	1	ND - 3.0		0.7
Chlorobenzene	9	0			
Ethylbenzene	9	1	ND - 11		2.2
Nitrobenzene	5	0			
Toluene	9	3	ND - 45	3.0	11
1,2,4-Trichlorobenzene	5	0			
Polycyclic aromatic hydrocarbons					
Acenaphthene	5	2	ND - 100		21
Acenaphthylene	5	2	ND - 110		23
Anthracene	5	2	ND - 150		30
Benzo(a)pyrene	5	1	ND - 1.0		0.2
Chrysene	5	2	ND - 240		48
Fluoranthene	5	1	ND - 1.0		0.2
Fluorene	5	2	ND - 55		11

(continued)

TABLE 10-21 (continued)

Toxic pollutant	Number of: Analyses	Number of: Times detected	Concentration, µg/L[b,c]: Range	Median	Mean
Polycyclic aromatic hydrocarbons (continued)					
Naphthalene	5	2	ND - 1,100		220
Phenanthrene	5	0			
Pyrene	5	0			
Polychlorinated biphenyls and related compounds					
Aroclor 1248	5	1	ND - 1.0	0.2	0.3
Aroclor 1254	5	1	ND - 5.4	0.4	1.4
Halogenated aliphatics					
Bromoform	9	3	ND - 48		9.3
Chlorodibromomethane	9	2	ND - 38		4.2
Chloroform	9	3	ND - 1,800		210
Dichlorobromomethane	9	0			
1,2-Dichloroethane	9	1	ND - 8.0		2.1
1,1-Dichloroethylene	9	3	ND - 19		4.3
1,2-*Trans*-dichloroethylene	9	1	ND - 2.0		0.2
1,1,2,2-Tetrachloroethane	9	2	ND - 35		5.2
Tetrachloroethylene	9	6	ND - 69		20
1,1,1-Trichloroethane	9	2	ND - 10		1.1
Trichloroethylene	9	3	ND - 19		2.9
Pesticides and metabolites					
Aldrin	5	1	ND - 7.0		1.4
α-BHC	5	1	ND - 0.6		0.1
β-BHC	5	1	ND - 0.1		
γ-BHC	5	1	ND - 0.2		0.1
Chlordane	5	1	ND - 1.2		0.2
4,4'-DDD	5	1	0		
4,4'-DDT	5	1	ND - 0.1		
Dieldrin	5	1	ND - 0.1		0.1
α-Endosulfan	5	2	ND - 15	0.1	3.2
β-Endosulfan	5	2	ND - 15		3.1
Endrin	5	1	ND - 0.8		0.2
Endrin aldehyde	5	1	ND - 0.9	0.2	0.3
Heptachlor	5	1	ND - 0.2		0.1
Heptachlor epoxide	5	1	ND - 0.2		0.1
Isophorone	9	0			

Note: Blanks indicate insufficient data.

[a]Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

[b]Except asbestos, which is given in Fibers/L.

[c]All concentrations except those for cyanide and asbestos were calculated by multiplying the concentrations of the various wastestreams by the normalized percentage of the total flow and then subtracting the concentration in the intake; refer to Table V-47, Reference 1.

TABLE 10-22. CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS FOUND IN THE RAW WASTEWATER OF THE PRIMARY ZINC SUBCATEGORY[a] [1]

Pollutant	Number of Analyses	Number of Times detected	Concentration, mg/L Range	Concentration, mg/L Median	Concentration, mg/L Mean
COD	2	2	20 - 59		40
TOC	2	2	7.3 - 9.3		8.3
TSS	2	2	13 - 15		14
Total phenol	4	4	<0.002 - 0.025	0.007	0.010
Oil and grease	2	2	10 - 14		12

[a] Some numbers in this table do not represent the concentration of the combined total wastewater from the plant but instead represent only one or several wastestreams. This is due to one or more of the streams not having concentration values reported.

TABLE 10-23. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW WASTEWATERS OF THE PRIMARY ZINC SUBCATEGORY [1]

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration, µg/L[a,b] Range	Concentration, µg/L[a,b] Median	Concentration, µg/L[a,b] Mean
Metals and inorganics					
Antimony	4	4	<2.0 - 2,100	58	550
Arsenic	4	4	3.0 - 3,000	150	820
Asbestos	2	2	3.2×10^7 - 4.3×10^7		3.8×10^7
Beryllium	4	4	<2.0 - <20	7.5	9.3
Cadmium	4	4	350 - 44,000	3,400	13,000
Chromium	4	4	<24 - 610	64	190
Copper	4	4	37 - 26,000	1,200	7,100
Cyanide	4	4	0.002 - 0.38	0.007	0.099
Lead	4	4	280 - 18,000	4,400	6,700
Mercury	4	4	2.9 - 52	5.4	16
Nickel	4	4	<50 - 4,300	590	1,400
Selenium	4	4	24 - 1,200	360	490
Silver	4	4	<25 - 740	58	220
Thallium	2	2	<20 - 360		190
Zinc	4	4	8,700 - 1.7×10^6	160,000	630,000
Phthalates					
Bis(2-ethylhexyl) phthalate	9	7	ND - 98	15	28
Butyl benzyl phthalate	9	2	ND - 30		3.3
Di-n-butyl phthalate	9	2	ND - 26	5.0	3.6
Diethyl phthalate	9	2	ND - 18		2.7
Dimethyl phthalate	9	2	ND - 22		2.4
Di-n-octyl phthalate	9	0			
Nitrogen compounds					
3,3'-Dichlorobenzidine	9	0			
Phenols					
Pentachlorophenol	9	1	ND - 8.0		0.9
Aromatics					
Benzene	9	2	ND - 24		2.7
Ethylbenzene	9	1	ND - 2.0		0.2
Hexachlorobenzene	9	2	ND - 100		11
Toluene	9	2	ND - 54	7.0	7.5
1,2,4-Trichlorobenzene	9	0			

(continued)

TABLE 10-23 (continued)

Toxic pollutant	Number of Analyses	Number of Times detected	Concentration, µg/L[a,b] Range	Median	Mean
Polycyclic aromatic hydrocarbons					
Acenaphthylene	9	2	ND - 18		2.0
Anthracene	9	1	ND - 0.4		
Chrysene	9	2	ND - 11		2.2
Fluoranthene	9	2	ND - 15		1.7
Fluorene	9	2	ND - 14		1.6
Naphthalene	9	0			
Phenanthrene	9	0			
Pyrene	9		ND - 15		3.2
Polychlorinated biphenyls and related compounds					
Aroclor 1248	9	0			
Aroclor 1254	9	0			
Halogenated aliphatics					
Bromoform	9	0			
Chloroform	9	3	ND - 71	53	16
1,1-Dichloroethane	9	2	ND - 180		20
1,2-Dichloroethane	9	2	ND - 22		2.9
1,1-Dichloroethylene	9	2	ND - 23		2.6
Methylene chloride	9	5	ND - 2,600		350
Tetrachloroethylene	9	1	ND - 8.0		0.9
Trichloroethylene	9	2	ND - 160	7.2	19
Trichlorofluoromethane	9	2	ND - 100		12
Pesticides and metabolites					
Aldrin					
α-BHC	9	0			
β-BHC	9	0			
Chlordane	9	0			
4,4'-DDE	9	0			
4,4'-DDT	9	0			
Dieldrin	9	0			
Heptachlor	9	0			
Heptachlor epoxide	9	0			
Isophorone	9	2	ND - 18		2.0

Note: Blanks indicate insufficient data.

[a]Except asbestos, which is given in fibers/L.

[b]All concentrations except those for cyanide and asbestos were calculated by multplying the concentrations of the various wastestreams by the normalized percentages of the total flow and then subtracting the concentration in the intake; refer to Table V-52, Reference 1.

TABLE 10-24. CONCENTRATION OF POLLUTANTS IN THE RAW AND TREATED WASTEWATERS OF PLANTS IN THE PRIMARY ALUMINUM SUBCATEGORY [1]

Parameter	Plant B Raw	Plant B Treated	Plant B Percent removal	Plant D Raw	Plant D Treated	Plant D Percent removal
Conventional,[a] mg/L						
COD	5,700	18	99	3.8	120	-[b]
TOC	440	16	96	150	44	71
TSS	11,400	220	98	2,300	80	97
Total phenol	0.11	0.0063	94	0.13	0.0061	95
Oil and grease	4.2	4.0	5	5.5	10	-[b]
Ammonia	120	31	74			
Fluoride	2,800	68	98	190	2.4	99
Toxic inorganic, µg/L[c]						
Antimony				770	370	57
Arsenic	130	ND	>99	260	35	87
Asbestos				2.2×10^{10}		
Beryllium	76	ND	>99	33	<8.0	76
Cadmium	24	ND	>99	200	<80	60
Chromium	86	ND	>99	2,200	<100	95
Copper	140	10	93	77	24	69
Cyanide	29	0.022	>99	7.5	0.0043	>99
Lead	780	ND	>99	650	<260	60
Mercury	1.3	ND	>99	<0.1	0.2	-[b]
Nickel	660	ND	>99	500	200	60
Selenium				450	23	95
Silver				<250	<100	60
Thallium				<50	<50	-[d]
Zinc	ND	540	-[b]	ND	890	-[b]

Note. Blanks indicate no data currently available.

[a]All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b]Negative removal.

[c]Except asbestos, which is given in fibers/L.

[d]Negligible removal.

TABLE 10-25. CONCENTRATION OF POLLUTANTS FOUND IN THE RAW AND TREATED WASTEWATER OF PLANTS IN THE SECONDARY ALUMINUM SUBCATEGORY [1]

Parameter	Plant B Raw	Plant B Treated	Plant B Percent removal	Plant E Raw	Plant E Treated	Plant E Percent removal
Conventional,[a] mg/L						
COD	580	54	91	48	40	17
TOC	140	9.0	94	3.0	120	-[b]
TSS	20,000	240	99	89	2,000	-[b]
Total phenol	0.009	0.02	-[b]	0.025	0.011	56
Oil and grease	17	13	13	98	7.3	93
Ammonia	140	16	89	<0.10	<0.10	-[c]
Chloride	400	5,500	-[b]	6,000	4,100	32
Toxic inorganic, µg/L[d]						
Antimony	ND	ND		300	60	80
Arsenic	6.0	ND	>99	4,000	<2.0	>99
Asbestos				7.5×10^{8}		
Beryllium	110	19	83	310	170	45
Cadmium	440	<18	96	2,000	1,000	50
Chromium	1,200	<41	97	97	76	22
Copper	6,100	<40	99	210	200	5
Cyanide	0.008	0.004	50	<0.001	<0.001	-[b]
Lead	5,600	1,000	82	2,000	≤180	91
Mercury	0.66	0.1	85	6.4	3.5	45
Nickel	620	<50	92	<50	≤200	-[b]
Selenium	ND	ND		200	20	90
Silver	30	ND	>99	<25	<25	-[c]
Thallium	540	ND	>99			
Zinc	5,900	≤540	91	2,000	10,000	-[b]

Note: Blanks indicate no data currently available.

[a]All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b]Negative removal.

[c]Negligible removal.

[d]Except asbestos, which is given in fibers/L.

TABLE 10-26. CONCENTRATION OF POLLUTANTS FOUND IN THE RAW AND TREATED WASTEWATERS OF THE COLUMBIUM AND TANTALUM SUBCATEGORIES [1]

Parameter	Plant B Raw	Plant B Treated	Plant B Percent removal	Plant D Raw	Plant D Treated	Plant D Percent removal
Conventional,[a] mg/L						
COD	400	44	89	6,700	150	98
TOC	120	9	93	1,000	27	97
TSS	3,900	36	99	8,700	89	99
Total phenol	0.018	0.012	33	0.016	0.030	-[b]
Oil and grease	5.3	3.5	34	16	4.0	>5
Ammonia	380	240	37	64	27	58
Fluoride	3,500	16	>99	13,000	6.0	>99
Toxic inorganic, μg/L						
Antimony	ND	ND		11,000	200	98
Arsenic	380	ND	>99	14,000	450	97
Beryllium	89	ND	>99	190	20	89
Cadmium	48	2	96	19,000	<200	99
Chromium	3,000	3	>99	520,000	<240	>99
Copper	400	4	99	260,000	110	>99
Cyanide	0.004	0.0017	58	0.012	0.007	42
Lead	3,000	50	98	2.7×10^7	5,000	>99
Mercury	6.0	ND	>99	36	0.8	98
Nickel	2,000	55	97	2,600	500	81
Selenium	ND	ND	-[c]	24,000	4.5	>99
Silver	60	ND	>99	610	<250	59
Thallium	ND	ND	-[c]	24	50	-[b]
Zinc	540	ND	>99	700,000	6,000	99

Note: Blanks indicate no data currently available.

[a]All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b]Negative removal.

[c]Negligible removal.

TABLE 10-27. CONCENTRATION OF POLLUTANTS FOUND IN RAW AND TREATED WASTEWATERS OF PLANTS IN THE SECONDARY COPPER SUBCATEGORY [1]

Parameter	Plant A Raw	Plant A Treated	Plant A Percent removal	Plant E Raw	Plant E Treated	Plant E Percent removal
Conventional,[a] mg/L						
COD	36	20	44	75	1,300	-[b]
TOC	43	21	51	30	21	30
TSS	4.0	3.3	18	65	200	-[b]
Total phenol	0.0063	0.006	5	0.080	0.11	-[b]
Oil and grease	4.7	3.7	21	3.7	4.3	-[b]
Fluoride					0.43	-[b]
Toxic inorganic, μg/L[c]						
Antimony	ND	ND	-[d]	11,000	4,000	64
Arsenic	ND	ND	-[d]	4,200	2,000	52
Asbestos				3.3×10^7		
Beryllium	0.3	ND	>99	30	30	-[d]
Cadmium	6.0	ND	>99	1,200	2,300	-[b]
Chromium	140	ND	>99	2,100	2,200	-[b]
Copper	15,000	ND	>99	2.1×10^6	27,000	99
Cyanide	0.026	0.015	42	0.004	0.0027	33
Lead	450	ND	>99	20,000	26,000	-[b]
Mercury	0.07	ND	>99	0.53	0.23	57
Nickel	7,000	5.0	>99	3.1×10^6	310,000	90
Selenium	ND	ND	-[d]	220	2,300	-[b]
Silver	≤10	ND	>99	1,600	250	84
Thallium	ND	ND	-[d]	53	60	-[b]
Zinc	1,400	3	>99	97,000	100,000	-[b]

Note: Blanks indicate no data currently available.

[a]All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b]Effluent concentration exceeds influent concentration.

[c]Except asbestos, which is given in fibers/L.

[d]Negligible removal.

TABLE 10-28. CONCENTRATIONS OF POLLUTANTS FOUND IN THE RAW AND TREATED WASTEWATERS OF PLANT B OF THE PRIMARY LEAD SUBCATEGORY [1]

Parameter	Raw	Treated	Percent removal
Conventional,[a] mg/L			
COD	ND	ND	-[b]
Total phenol	0.012	0.009	25
Ammonia	0.43	0.25	42
Toxic inorganic, μg/L			
Antimony	3.1	ND	>99
Arsenic	96	19	80
Beryllium	ND	ND	-[b]
Cadmium	2,700	110	96
Chromium	9.1	6.0	34
Copper	5,300	50	99
Cyanide		<0.001	
Lead	10,000	1,400	86
Mercury	0.29	0.02	93
Nickel	150	20	87
Selenium	3.1	2.7	13
Silver	7.0	ND	>99
Thallium	15	7.4	51
Zinc	2,700	970	64

Note: Blanks indicate no data currently available.

[a]All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b]Negligible removal.

TABLE 10-29. CONCENTRATION OF POLLUTANTS IN RAW AND TREATED WASTEWATERS OF PLANTS IN THE SECONDARY LEAD SUBCATEGORY [1]

Parameter	Plant A			Plant C		
	Raw	Treated	Percent removal	Raw	Treated	Percent removal
Conventional,[a] mg/L						
COD	220	32	85	150	59	61
TOC	130	19	85	70	34	51
TSS	3,700	350	91	1,100	68	94
Total phenol	0.010	0.009	10	0.012	0.005	58
Oil and grease	35	15	57	6.4	4.5	30
Chloride	56	110	-[b]			
Toxic inorganic, μg/L[c]						
Antimony	60,000	2,000	97	80,000	52	>99
Arsenic	7,000	2,900	59	13,000	<10	>99
Asbestos				1.3×10^{11}	1.3×10^{11}	-[d]
Beryllium	1.0	<9	-[b]	3.2	<1.0	69
Cadmium	900	370	59	1,900	11	99
Chromium	320	200	38	1,000	55	95
Copper	3,300	1,000	70	8,200	25	>99
Cyanide	0.008	0.002	75	0.005	0.001	80
Lead	29,000	6,000	79	1.8×10^6	200	>99
Mercury	0.81	12	-[b]	0.3	<0.1	67
Nickel	920	580	37	2,000	12	99
Selenium	ND	ND	-[d]	ND	<10	-[b]
Silver	100	ND	>99	90	<20	78
Thallium	350	100	71	620	100	84
Zinc	4,200	2,900	31	15,000	100	99

Note: Blanks indicate no data currently available.

[a]All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b]Negative removal.

[c]Except asbestos, which is given in fibers/L.

[d]Negligible removal.

TABLE 10-30. CONCENTRATION OF POLLUTANTS IN THE RAW AND TREATED WASTEWATERS OF PLANTS IN THE SECONDARY SILVER SUBCATEGORY [1]

Parameter	Plant B Raw	Plant B Treated	Plant B Percent removal	Plant C Raw	Plant C Treated	Plant C Percent removal
Conventional,[a] mg/L						
COD	230	5.0	92	12,000	30,000	-[b]
TOC	24	1.0	96	9,200	14,000	-[b]
TSS	110	10	91	1,100	120	89
Total phenol	0.04	0.01	75	28	25	11
Oil and grease	8.0	10	-[b]	110	67	39
Ammonia	12	0.6	95			
Fluoride			79			
Chloride	3,200	670				
Toxic inorganic, μg/L[c]						
Antimony	ND	1,500	-[b]	25,000	450	98
Arsenic	40	1,300	-[b]	900	700	22
Asbestos				5.8×10^8		
Beryllium	ND	<9	-[b]	<20	<20	-[d]
Cadmium	1,000	2,000	-[b]	3,200	3,000	6
Chromium	2,000	8,000	-[b]	27,000	8,000	70
Copper	70,000	300,000	-[b]	7,400	1,000	86
Cyanide	0.05	0.05	-[d]	2.1	1.5	29
Lead	4,000	20,000	-[b]	4,200	3,000	29
Mercury	ND	0.1	-[b]	5.5	1.6	71
Nickel	30,000	60,000	-[b]	1,100	4,000	-[b]
Selenium	ND	ND	-[d]	590	400	32
Silver	410	7,000	-[b]	<250	<250	-[d]
Thallium	ND	ND	-[d]	510	640	-[b]
Zinc	20,000	30,000	-[b]	8,400	5,000	40

Note: Blanks indicate no data currently available.

[a] All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b] Negative removal.

[c] Except asbestos, which is given in fibers/L.

[d] Negligible removal.

TABLE 10-31. CONCENTRATION OF POLLUTANTS FOUND IN RAW AND TREATED WASTEWATERS OF PLANT B IN THE PRIMARY TUNGSTEN SUBCATEORY [1]

Parameter	Raw	Treated	Percent removal
Conventional[a] mg/L			
COD	320	53	83
TOC	6.0	10	-[b]
TSS	210	150	29
Total phenol	0.089	0.91	-[b]
Oil and grease	6.3	4.6	27
Ammonia	3.9	5.2	-[b]
Chloride	26,000	19,000	27
Toxic inorganic, μg/L			
Antimony	ND	ND	-[c]
Arsenic	7,200	70	99
Beryllium	29	<10	66
Cadmium	190	72	62
Chromium	2,000	<50	98
Copper	5,000	60	99
Cyanide	0 013	0.0037	72
Lead	20,000	<200	99
Mercury	1.0		
Nickel	1,000	95	91
Selenium	20	ND	>99
Silver	270	10	96
Thallium	600	800	-[b]
Zinc	1,900	520	73

[a] All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b] Negative removal

[c] Negligible removal

TABLE 10-32. CONCENTRATION OF POLLUTANTS FOUND IN RAW AND TREATED WASTEWATERS FROM PLANTS IN THE PRIMARY ZINC SUBCATEGORY [1]

Parameter	Plant C			Plant E		
	Raw	Treated	Percent removal	Raw	Treated	Percent removal
Conventional,[a] mg/L						
COD	59	17	71	20	17	15
TOC	9.3	8.3	11	7.3	8.3	-[b]
TSS	15	9.3	38	13	<1.0	92
Total phenol	0.004	0.009	-[b]	0.025	0.009	64
Oil and grease	14	1.3	91	10	7.3	27
Toxic inorganic, μg/L[c]						
Antimony	67	51	24	<2.0	2.7	-[b]
Arsenic	12	10	17	3	2.3	23
Asbestos	4.3×10^7			3.2×10^7		
Beryllium	7.0	3.0	57	<2.0	<2.0	-[d]
Cadmium	5,000	36	99	350	630	-[b]
Chromium	610	160	74	<24	<24	-[d]
Copper	560	53	91	37	18	51
Cyanide	0.003	0.007	-[b]	0.38	0.008	98
Lead	3,000	250	92	280	<60	79
Mercury	6.9	2.0	71	2.9	0.5	83
Nickel	4,300	620	86	<50	<50	-[d]
Selenium	270	40	85	24	27	-[b]
Silver	<25	16	36	<25	<25	-[d]
Thallium		<50				
Zinc	100,000	1,200	99	8,700	7,700	11

Note: Blanks indicate no data currently available.

[a]All conventional pollutant concentrations are corrected for blanks and concentrations found in the water supply.

[b]Negative removal.

[c]Except asbestos, which is given in fibers/L.

[d]Negligible removal.

Plant D generates wastewater from extraction raffinate (870 m^3/d) and digester air pollution control (870 m^3/d). Treatment consists of ammonia stripping, lime addition, and settling.

II.10.3.4 Secondary Copper

Plant A has a sole source of raw wastewater from the furnace scrubbers in the acid plant (380 m^3/d). This wastewater is treated by lime and sodium hydroxide neutralization, and polymer addition followed by settling.

Plant E generates wastewater by the disposal of waste electrolyte and area cleaning water (110 m^3/d). This wastewater is treated by settling.

II.10.3.5 Primary Lead

Plant B generates wastewater from several sources. The acid plant sump combines blast furnace blowdown, and slag and material granulation (4,500 m^3/d) into one stream. Other undefined process wastes (1,100 m^3/d) are also treated. Treatment consists of simple settling.

II.10.3.6 Secondary Lead

Plant A of the secondary lead subcategory generates wastewater from the battery electrolyte process (8 m^3/d) and from saw cooling during battery cracking (16 m^3/d). Treatment consists of ammoniation, lime neutralization, and settling.

Plant C of this subcategory releases wastewater from the saw wash down (11 m^3/d) and battery electrolyte processes (11 m^3/d). Treatment consists of lime addition and settling.

II.10.3.7 Secondary Silver

Plant B treats spent plant liquor, contact cooling, and air pollution control wastewater (10 m^3/d) by lime neutralization, ferrous chloride addition, and aluminum chloride addition followed by settling.

Plant C uses neutralization, polymer addition, settling, and filtration to treat slurry supernatants (3 m^3/d), film waste effluent (8 m^3/d), and sludge tank effluent (3 m^3/d).

II.10.3.8 Primary Tungsten

Plant B in this subcategory treats tungstic acid precipitant rinsewater (130 m^3/d) by lime addition followed by settling.

II.10.5.9 Primary Zinc

Plant C generates wastewater from air pollution control equipment, boiler blowdown, and preleaching filtrate (1,600 m^3/d). Treatment consists of lime addition followed by settling.

Plant E in this subcategory uses settling to control roaster and reduction wastewater, cooling water, and scrubber wastewater (1,600 m^3/d).

II.10.4 POLLUTANT REMOVABILITY [1]

There are several methods for pollutant removal currently used in this industry. Some are used industry-wide; others are used only in specific applications.

Those used industry-wide include: physical-chemical methods (precipitation, coagulation and flocculation, pH adjustment, and ammonia stripping) and physical separation methods (filtration, sedimentation and centrifugation). Lime, caustic, soda ash, and calcium chloride are used as precipitants in the industry, especially for removal of the soluble metals. In the coagulation-flocculation system polymer, lime, and iron or aluminum salts are mixed into the waste stream to facilitate breakdown of colloidal suspensions. Air and steam stripping are widely practiced techniques for the reduction of volatile compounds such as ammonia, hydrogen sulfide, and organics.

The physical separation methods find wide application in this industry because of the nature of the wastes. Centrifugation may be feasible in some applications but is not suitable for abrasive or very fine particles (less than 5 μm).

There are several potential treatment technologies that may be applicable, but are more expensive, than the methods currently used. These potential treatments are: sulfide precipitation, ultrafiltration, reverse osmosis, deep-well disposal activated carbon or activated alumina absorption, solidification, or ion exchange.

Pollutant removal data for toxic organic pollutants in subcategories studied are presented in Tables 10-33 through 10-42. The average removal percentage was determined by comparing the average raw wastewater concentrations found in the Wastewater Characterization section with the average treated wastewater concentrations presented in these tables. In some instances insufficient data were available to determine accurately an average concentration. Removal data for toxic metals and conventional pollutant data are presented on an individual facility basis in the plant specific section.

TABLE 10-33. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATER IN THE PRIMARY ALUMINUM SUBCATEGORY [1]

Toxic pollutant	Number of Samples	Number of Times detected	Treated effluent concentration, µg/L Range	Median	Mean	Average percent removal
Phthalates						
Bis(2-ethylhexyl) phthalate	9	3	ND - 120		17	79
Butyl benzyl phthalate	9	1	ND - 75		9.6	56
Di-n-butyl phthalate	9	4	ND - 30		5.0	74
Diethyl phthalate	9	0				>99
Dimethyl phthalate	9	1	ND - 5.0		1.0	-[a]
Di-n-octyl phthalate	9	2	ND - 13		1.8	-[a]
Phenols						
Phenol	4	0				>99
Aromatics						
Benzene	14	3	ND - 33		4.0	-[a]
2,4-Dinitrotoluene	9	1	ND - 7.0		0.9	-[a]
2,6-Dinitrotoluene	9	1	ND - 1.0		0.1	-[a]
Ethylbenzene	14	2	ND - 12		0.8	-[a]
Toluene	14	1	ND - 6.8		0.5	-[a]
Polycyclic aromatic hydrocarbons						
Acenaphthene	9	5	ND - 13		5.0	40
Acenaphthylene	9	1	ND - 7.0		1.9	66
Anthracene	9	3	ND - 11	2.6	4.7	88
Benz(a)anthracene	9	1	ND - 6.0		0.7	98
Benzo(a)pyrene	9	2	ND - 8.0		2.1	98
Benzo(b)fluoranthene	9	1	ND - 6.0		0.7	98
Benzo(ghi)perylene	9	1	ND - 11		0.1	>99
Benzo(k)fluoranthene	9	1	ND - 6.0		1.1	97
Chrysene	9	1	ND - 140		17	58
Dibenz(ah)anthracene	9	0				100
Fluoranthene	9	4	ND - 79	11	22	77
Fluorene	9	1	ND - 1.0		0.2	97
Indeno(1,2,3-cd)pyrene	9	1	ND - 1.0		0.1	>99
Naphthalene	9	1	ND - 1.0		0.1	97
Phenanthrene	9	3	ND - 11		0.1	12
Pyrene	9	4	ND - 80	9.0	20	71
Halogenated aliphatics						
Chloroform	14	3	ND - 320		23	-[a]
1,2-Dichloroethane	14	2	ND - 5.5		0.4	-[a]
1,1-Dichloroethylene	14	2	ND - 4,000			-[a]
Methylene chloride	14	7	ND - 4,200		360	-[a]
1,1,2,2-Tetrachloroethane	14	1	ND - 1.0		0.1	-[a]
Tetrachloroethylene	14	2	ND - 61		44	-[a]
Trichloroethylene	14	2	ND - 120		8.5	-[a]
Pesticides and metabolites						
Aldrin	8	1	ND - 0.1			-[a]
δ-BHC	8	1	ND - 0.1			-[a]
γ-BHC	8	1	ND - 0.01			-[a]
Chlordane	8	1	ND - 0.1			-[a]
4,4'-DDT	8	1	ND - 0.01			-[a]
Dieldrin	8	1	ND - 0.1			-[a]
Endrin aldehyde	8	1	ND - 0.2			-[a]
Heptachlor	8	1	ND - 0.2			-[a]
Heptachlor epoxide	8	1	ND - 0.2			-[a]
Isophorone	9	0				>99

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-34. REMOVAL OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTE-WATER IN THE SECONDARY ALUMINUM SUBCATEGORY [1]

Toxic pollutant	Number of Samples	Times detected	Treated effluent concentration, μg/L Range	Median	Mean	Average percent removal
Phthalates						
Bis(2-ethylhexyl) phthalate	7	7	ND - 1,200	5.3	290	24
Butyl benzyl phthalate	7	1	ND - 2.0		0.6	97
Di-n-butyl phthalate	7	4	ND - 50		13	19
Dimethyl phthalate	7	1	ND - 3.0		0.6	94
Di-n-octyl phthalate	7	2	ND - 100		15	-[a]
Nitrogen compounds						
3,3'-Dichlorobenzidine	7	0				>99
Aromatics						
Benzene	11	1	ND - 5.0		0.7	93
Chlorobenzene	11	1	ND - 7.0		1.5	-[a]
1,4-Dichlorobenzene	7	0				1
Ethylbenzene	11	1	ND - 6.0		0.5	-[a]
1,2,4-Trichlorobenzene	7	1	ND - 2.0		0.3	-[a]
Polycyclic aromatic hydrocarbons						
Acenaphthylene	7	0				>99
Benzo(a)pyrene	7	1	ND - 1.0		0.1	95
Benzo(b)fluoranthene	7	1	ND - 2.0		0.3	-[a]
Benzo(k)fluoranthene	7	1	ND - 2.0		0.3	-[a]
Chrysene	7	1	ND - 2.5		0.4	99
Fluoranthene	7	0				>99
Naphthalene	7	1	ND - 1.0		0.1	50
Pyrene	7	1	ND - 1.0		0.1	
Halogenated aliphatics						
Bromoform	11	2	ND - 4.7		1.0	-[a]
Carbon tetrachloride	11	1	ND - 6.0		0.5	50
Chlorodibromomethane		3	ND - 29		4.9	
Chloroform	11	7	ND - 170		32	-[a]
Dichlorobromomethane	11	4	ND - 18		3.0	-[a]
1,1-Dichloroethane	11	1	ND - 7.0		0.6	-[a]
1,2-Dichloroethane	11	2	ND - 20		2.3	-[a]
1,2-*Trans*-dichloroethylene	11	3	ND - 75	1.0	9.2	52
Methylene chloride	11	2	ND - 200		18	-[a]
1,1,2,2-Tetrachloroethane	11	1	ND - 1.0		0.1	-[a]
1,1,1-Trichloroethane	11	1	ND - 5.0		0.5	-[a]
1,1,2-Trichloroethane	11	2	ND - 8.5		2.3	-[a]
Pesticides and metabolites						
Isophorone	7	0				>99

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-35. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATER IN THE PRIMARY COLUMBIUM AND PRIMARY TANTALUM SUBCATEGORIES [1]

Toxic pollutant	Number of Samples	Number of Times detected	Treated effluent concentration, µg/L Range	Median	Mean	Average percent removal
Phthalates						
Bis(2-ethylhexyl) phthalate	4	3	ND - 9.5	2.8	3.8	97
Butyl benzyl phthalate	4	0				>99
Di-n-butyl phthalate	4	1	ND - 9.0		2.2	82
Diethyl phthalate	4	1	ND - 2.0		0.5	71
Dimethyl phthalate	4	2	ND - 20		5.0	-[a]
Di-n-octyl phthalate	4	1	ND - 2.0		0.5	92
Phenols						
Pentachlorophenol	2	0				>99
Aromatics						
Benzene	7	2	ND - 40		6.9	-[a]
Chlorobenzene	7	1	ND - 65		13	-[a]
2,4-Dinitrotoluene	4	0				>99
2,6-Dinitrotoluene	4	0				
Ethylbenzene	7	2	ND - 49		7.0	-[a]
Nitrobenzene	4	0				>99
Toluene	7	3				-[a]
1,2,4-Trichlorobenzene	4	3	ND - 17	7.5	8.9	64
Polycyclic aromatic hydrocarbons						
Acenaphthene	4	3	ND - 16	6.9	7.4	-[a]
Acenaphthylene	4	1	ND - 2.8	0.9	1.2	-[a]
Anthracene	4	1	ND - 12	1.5	3.8	-[a]
Benz(a)anthracene	4	0				>99
Benzo(a)pyrene	4	0				>99
Benzo(b)fluoranthene	4	1	ND - 2.0		0.5	-[a]
Benzo(ghi)perylene	4	1	ND - 1.0		0.2	0
Benzo(k)fluoranthene	4	1	ND - 2.0		0.5	-[a]
2-Chloronaphthalene	4	0				>99
Chrysene	4	0				>99
Dibenz(ah)anthracene	4	0				>99
Fluoranthene	4	0				>99
Fluorene	4	1	ND - 69		17	-[a]
Indeno(1,2,3-cd)pyrene	4	0				>99
Naphthalene	4	0				>99
Phenanthrene	4	1	ND - 12	1.5	3.8	-[a]
Pyrene	4	1	ND - 4.9	0.4	1.4	-[a]

(continued)

TABLE 10-35 (continued)

Toxic pollutant	Number of Samples	Number of Times detected	Treated effluent concentration, µg/L Range	Median	Mean	Average percent removal
Polychlorinated biphenyls and related compounds						
Aroclor 1248	3	0				>99
Aroclor 1254	3	0				>99
Halogenated aliphatics						
Bromoform	7	0				>99
Carbon tetrachloride	7	3	ND - 110		21	-[a]
Chlorodibromomethane	7	1	ND - 5.0		0.7	87
Chloroform	7	4	ND - 47		9.0	-[a]
Dichlorobromomethane	7	2	ND - 16		2.3	>99
1,2-Dichloroethane	7	3	ND - 18	3.0	5.9	55
1,1-Dichloroethylene	7	3	ND - 140		21	-[a]
1,2-*Trans*-dichloroethylene	7	0				>99
Hexachloroethane	4	0				>99
Methylene chloride	7	2	ND - 600		85	98
1,1,2,2-Tetrachloroethane	7	2	ND - 190	10	54	-[a]
Tetrachloroethylene	7	5	ND - 190	10	54	-[a]
1,1,1-Trichloroethane	7	0				>99
1,1,2-Trichloroethane	7	1	ND - 5.0			
Trichloroethylene	7	3	ND - 190		32	-[a]
Pesticides and metabolites						
Aldrin	3	1	ND - 0.5		0.2	33
α-BHC	3	1	ND - 0.01			
β-BHC	3	1	ND - 0.3	0.1	0.1	75
δ-BHC	3	1	ND - 0.5		0.2	33
γ-BHC	3	0				
Chlordane	3	1	ND - 1.0			-[a]
4,4'-DDE	3	0				
4,4'-DDT	3	0				>99
Dieldrin	3	1	ND - 0.01			90
α-Endosulfan	3	0				
Endosulfan sulfate	3	0				
Endrin	3	1	ND - 0.01			>99
Endrin aldehyde	3	0				
Heptachlor	3	1	ND - 0.3		0.1	-[a]
Heptachlor epoxide	3	0				
Isophorone	4	1				>99
Toxaphene	3	0				

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-36. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATERS IN THE PRIMARY COPPER SUBCATEGORY [1]

Toxic pollutant	Number of Samples	Times detected	Treated effluent concentration, µg/L Range	Median	Mean	Average percent removal
Phthalates						
Bis(2-ethylhexyl) phthalate	5	5	ND - 480	17	110	-[a]
Butyl benzyl phthalate	5	2	ND - 48		9.6	-[a]
Di-n-butyl phthalate	5	3	ND - 73		25	-[a]
Di-n-octyl phthalate	5	2	ND - 190		38	-[a]
Phenols						
2,4-Dimethylphenol	2	0				>99
Aromatics						
Benzene	5	0	ND - 1.0		0.4	43
Chlorobenzene	5	0	ND - 6.0		1.2	-[a]
Toluene	5	0				>99
Polycyclic aromatic hydrocarbons						
Acenaphthylene	5	0				>99
Anthracene	5	4	ND - 17		6.2	0
Benz(a)anthracene	5	0				>99
Chrysene	5	1	ND - 2.0		0.4	-[a]
Fluoranthene	5	1	ND - 2.0		0.4	-[a]
Fluorene	5	1	ND - 14		2.8	-[a]
Phenanthrene	5	1	ND - 17		3.4	52
Pyrene	5	0				>99
Polychlorinated biphenyls and related compounds						
Aroclor 1248	5	1	ND - 1.0	1.0	0.8	-[a]
Aroclor 1254	5	1	ND - 1.5		0.5	-[a]
Halogenated aliphatics						
Carbon tetrachloride	5	0				>99
Chlorodibromomethane	5	0				>99
Chloroform	5	0				>99
Dichlorobromomethane	5	0				>99
1,2-Dichloroethane	5	0				>99
1,1-Dichloroethylene	5	2	ND - 10		3.8	-[a]
Methylene chloride	5	0				>99
1,1,2,2-Tetrachloroethane	5	1	ND - 9.0		3.2	-[a]
Tetrachloroethylene	5	1	ND - 3.0		1.0	81
1,1,1-Trichloroethane	5	2	ND - 10		3.4	-[a]
1,1,2-Trichloroethane	5	0				>99
Trichloroethylene	5	1	ND - 3.0		0.6	60
Pesticides and metabolites						
β-BHC	5	1	ND - 0.2			-[a]
γ-BHC	5	1	ND - 0.01			
Chlordane	5	1	ND - 0.9		0.2	-[a]
4,4'-DDE	5	1	ND - 0.1			
4,4'-DDT	5	1	ND - 0.1			
Dieldrin	5	0				
α-Endosulfan	5	1	ND - 0.04			
β-Endosulfan	5	0				
Endosulfan sulfate	5	1	ND - 0.2		0.1	-[a]
Endrin	5	1	ND - 0.1			
Endrin aldehyde	5	1	ND - 0.4			0
Heptachlor	5	1	ND - 0.2			
Heptachlor epoxide	5	1	ND - 0.1			>99
Isophorone	5	0				>99

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-37. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATER IN THE SECONDARY COPPER SUBCATEGORY [1]

Toxic pollutant	Number of		Treated effluent concentration, µg/L			Average percent removal
	Samples	Times detected	Range	Median	Mean	
Phthalates						
Bis(2-ethylhexyl) phthalate	13	2	ND - 590	34.0	84	92
Butyl benzyl phthalate	13	3	ND - 23		3.3	38
Di-n-butyl phthalate	13	2	ND - 110	16.0	32	43
Diethyl phthalate	13	2	ND - 82		15	-[a]
Dimethyl phthalate	13	2	ND - 1.3E3	1.0	210	-[a]
Di-n-octyl phthalate	13	2	ND - 170		15	-[a]
Aromatics						
Benzene	13	1	ND - 36		2.8	85
Ethylbenzene	13	1	ND - 2.0		0.2	50
Hexachlorobenzene	13	1	ND - 220		30	93
Nitrobenzene	13	0	ND - 1.0			-[a]
Toluene	13	2	ND - 69		5.6	-[a]
Polycyclic aromatic hydrocarbons						
Acenaphthene	13	1	ND - 36		2.8	39
Acenaphthylene	13	0	ND - 36		2.8	>99
Anthracene	13	5	ND - 140	5.0	19	93
Benzo(a)pyrene	13	1	ND - 9.0		1.5	-[a]
Benzo(b)fluoranthene	13	1	ND - 12			
Benzo(k)fluoranthene	13	1	ND - 12			
Chrysene	13	2	ND - 8.0		0.8	>99
Dibenz(ah)anthracene	13	0	ND - 8.0		0.6	-[a]
Fluoranthene	13	2	ND - 17	2.0	3.9	99
Fluorene	13	3	ND - 100		23	-[a]
Indeno(1,2,3-cd)pyrene	13	1	ND - 8.0		0.6	84
Naphthalene	13	1	ND - 930		87	-[a]
Phenanthrene	13	5	ND - 140	5.0	19	99
Pyrene	13	4	ND - 38	3.0	7.8	99
Polychlorinated biphenyls and related compounds						
Aroclor 1248	13	1				60
Aroclor 1254	13	1				60
Halogenated aliphatics						
Carbon tetrachloride	13	2	ND - 260		20	-[a]
Chloroform	13	5	ND - 320		43	67
Dichlorobromomethane	13	1	ND - 7.0		0.5	-[a]
1,2-Dichloroethane	13	1	ND - 1.0			
1,1-Dichloroethylene	13	0				>99
1,2-*Trans*-dichloroethylene	13	0				>99
Methylene chloride	13	0				>99
1,1,2,2-Tetrachloroethane	13	2	ND - 14		2.6	-[a]
Tetrachloroethylene	13	2	ND - 12		1.7	81
Trichloroethylene	13	1	ND - 2.0		0.2	97
Pesticides and metabolites						
Aldrin	13	0				
α-BHC	13	1	ND - 0.2			
β-BHC	13	1	ND - 0.2			
δ-BHC	13	1	ND - 0.01			
γ-BHC	13	0	ND - 0.1			
Chlordane	13	1	ND - 0.5		0.1	0
4,4'-DDE	13	1	ND - 0.1		0.1	
4,4'-DDD	13	1	ND - 0.04			
4,4'-DDT	13	1	ND - 0.1		0.1	
Dieldrin	13	1	ND - 0.2			
α-Endosulfan	13	1	ND - 0.6		0.1	
β-Endosulfan	13	1	ND - 0.1			
Endrin	13	1	ND - 0.1			
Endrin aldehyde	13	1	ND - 0.4		0.1	
Heptachlor	13	1	ND - 0.2			
Heptachlor epoxide	13	1	ND - 0.1			
Toxaphene	13	0				

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-38. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATER IN THE PRIMARY LEAD SUBCATEGORY [1]

Toxic pollutant	Number of		Treated effluent concentration, µg/L			Average percent removal
	Samples	Times detected	Range	Median	Mean	
Polycyclic aromatic hydrocarbons						
Pyrene	1	0				>99
Halogenated aliphatics						
Methylene chloride	1	1		54	54	-[a]

Note: Blanks indicate insufficient data; not calculable.

[a]Negative removal.

TABLE 10-41. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATERS IN THE PRIMARY TUNGSTEN SUBCATEGORY [1]

Toxic pollutant	Number of		Treated effluent concentration, µg/L			Average percent removal
	Samples	Times detected	Range	Median	Mean	
Phthalates						
Bis(2-ethylhexyl) phthalate	2	2	32 - 730		380	-[a]
Di-n-butyl phthalate	2	2	22 - 66		44	-[a]
Diethyl phthalate	2	2	ND - 16		8.0	-[a]
Dimethyl phthalate	2	2	ND - 230		120	-[a]
Di-n-octyl phthalate	2	2	ND - 43		22	-[a]
Aromatics						
Benzene	4	2	ND - 17	7.5	8.0	-[a]
Chlorobenzene	4	1	ND - 1.0			
Ethylbenzene	4	1	ND - 1.0		0.3	86
Nitrobenzene	2	1	ND - 5.5		2.8	-[a]
Toluene	4	1	ND - 1.0		0.3	97
1,2,4-Trichlorobenzene	2	1	4.0 - 55		4.8	-[a]
Polycyclic aromatic hydrocarbons						
Acenaphthene	2	0				>99
Acenaphthylene	2	0				>99
Anthracene	2	1	ND - 8.0		4.0	87
Benzo(a)pyrene	2	1	ND - 1.0		0.5	-[a]
Chrysene	2	0				>99
Fluoranthene	2	1	ND - 1.0		0.5	-[a]
Fluorene	2	0				>99
Naphthalene	2	2	ND - 32		16	93
Phenanthrene	2	1	ND - 8.0		4.0	-[a]
Pyrene	2	2	ND - 15		7.5	-[a]
Polychlorinated biphenyls and related compounds						
Aroclor 1248	2	1	ND - 2.4		1.2	-[a]
Aroclor 1254	2	1	ND - 1.9		1.0	-[a]
Halogenated aliphatics						
Bromoform	4	0				>99
Chlorodibromomethane	4	0				
Chloroform	4	3	ND - 870	29	230	-[a]
Dichlorobromomethane	4	2	ND - 12	6.0	6.0	-[a]
1,2-Dichloroethane	4	3	ND - 29	7.5	11	-[a]
1,1-Dichloroethylene	4	3	ND - 29	10	12	-[a]
1,2-*Trans*-dichloroethylene	4	1	ND - 2.0		0.5	-[a]
1,1,2,2-Tetrachloroethane	4	1	ND - 9.0	5.3	5.0	4
Tetrachloroethylene	4	2	3.0 - 20	7.0	9.3	54
1,1,1-Trichloroethane	4	0				>99
Trichloroethylene	4	4	ND - 88		41	-[a]
Pesticides and metabolites						
Aldrin	2	0				>99
α-BHC	2	0				>99
β-BHC	2	0				>99
γ-BHC	2	1	ND - 0.1			>99
Chlordane	2	1	ND - 0.5		0.3	-[a]
4,4'-DDD	2	1	ND - 0.2		0.1	-[a]
4,4'-DDT	2	0				
Dieldrin	2	0				>99
α-Endosulfan	2	1	ND - 0.6		0.3	91
β-Endosulfan	2	1	ND - 0.2		0.1	97
Endrin	2	0				>99
Endrin aldehyde	2	0				>99
Heptachlor	2	0				>99
Heptachlor epoxide	2	0				>99
Isophorone	2	1	ND - 6.0		3.0	-[a]

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-42. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATER IN THE PRIMARY ZINC SUBCATEGORY [1]

Toxic pollutant	Number of: Samples	Number of: Times detected	Treated effluent concentration, μg/L: Range	Treated effluent concentration, μg/L: Median	Treated effluent concentration, μg/L: Mean	Average percent removal
Phthalates						
Bis(2-ethylhexyl) phthalate	11	5	ND - 170	14	22	21
Butyl benzyl phthalate	11	1	ND - 0.1			
Di-n-butyl phthalate	11	2	ND - 12	4.0	1.6	56
Diethyl phthalate	11	1	ND - 0.9		0.1	96
Dimethyl phthalate	11	0				96
Di-n-octyl phthalate	11	1	ND - 1.0		0.1	-[a]
Nitrogen compounds						
3,3'-Dichlorobenzidine	11	1	ND - 2.0		0.2	-[a]
Phenols						
Pentachlorophenol	11	0				>99
Aromatics						
Benzene	11	1	ND - 3.0		0.4	85
Ethylbenzene	11	1	ND - 6.0			-[a]
Hexachlorobenzene	11	0				>99
Toluene	11	1	ND - 5.3	3.0	0.8	89
1,2,4-Trichlorobenzene	11	2	ND - 47		4.3	-[a]
Polycyclic aromatic hydrocarbons						
Acenaphthylene	11	1	ND - 8.0		0.7	65
Anthracene	11	1	ND - 9.0	7.0	1.6	
Chrysene	11	1	ND - 0.7			
Fluoranthene	11	0				>99
Fluorene	11	1	ND - 3.0		0.3	81
Naphthalene	11	1	ND - 6.0		0.5	-[a]
Phenanthrene	11	1	ND - 9.0		1.4	-[a]
Pyrene	11	1	ND - 8.0		0.9	72
Polychlorinated biphenyls and related compounds						
Aroclor 1248	11	1	ND - 9.8		0.9	6
Aroclor 1254	11	2	ND - 7.0		0.6	-[a]
Halogenated aliphatics						
Bromoform	11	2	ND - 44		4.0	-[a]
Chloroform	11	2	ND - 54		5.4	66
1,1-Dichloroethane	11	0				>99
1,2-Dichloroethane	11	0				>99
1,1-Dichloroethylene	11	0				>99
Methylene chloride	11	1	ND - 7.0		0.8	>99
Tetrachloroethylene	11	2	ND - 22		2.6	-[a]
Trichloroethylene	11	2	ND - 19		2.0	89
Trichlorofluoromethane	11	0				>99
Pesticides and metabolites						
α-BHC	11	1	ND - 0.7		0.1	-[a]
β-BHC	11	1	ND - 0.03			
Chlordane	11	1	ND - 1.6		0.2	-[a]
4,4'-DDE	11	1	ND - 0.2		0.01	-[a]
4,4'-DDT	11	1	ND - 0.4		0.03	-[a]
Dieldrin	11	1	ND - 0.03			
Heptachlor	11	1	ND - 0.7		0.1	-[a]
Heptachlor epoxide	11	1	ND - 0.7		0.1	-[a]
Isophorone	11	0				>99

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-39. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATERS IN THE SECONDARY LEAD SUBCATEGORY [1]

Toxic pollutant	Number of: Samples	Number of: Times detected	Treated effluent concentration, µg/L: Range	Median	Mean	Average percent removal
Phthalates						
Bis(2-ethylhexyl) phthalate	4	4	ND - 22	9.5	5.5	97
Butyl benzyl phthalate	4	1	ND - 4.0		1.0	94
Di-n-butyl phthalate	4	2	ND - 35	1.5	9.5	21
Dimethyl phthalate	4	0				>99
Di-n-octyl phthalate	4	1	ND - 2.0		0.5	78
Nitrogen compounds						
Benzidine	4	0				>99
Aromatics						
Benzene	7	1	ND - 7.0		1.0	-[a]
Chlorobenzene	7	0				>99
Ethylbenzene	7	1	ND - 4.0		0.6	-[a]
Nitrobenzene	4	0				>99
Toluene	7	1	ND - 1.0		0.3	-[a]
Polycyclic aromatic hydrocarbons						
Acenaphthylene	4	0				>99
Anthracene	4	1	ND - 2.0		0.5	88
Benzo(a)pyrene	4	0				>99
Benzo(b)fluoranthene	4	0				>99
Benzo(ghi)perylene	4	1	ND - 1.0		0.3	-[a]
Benzo(k)fluoranthene	4	0				>99
Chrysene	4	1	ND - 2.0		0.5	99
Fluoranthene	4	0				>99
Fluorene	4	0				>99
Indeno(1,2 3-cd)pyrene	4	0				>99
Naphthalene	4	1	ND - 3.0		0.8	0
Phenanthrene	4	1	ND - 2.0		0.5	89
Pyrene	4	0				>99
Polychlorinated biphenyls and related compounds						
Aroclor 1248	4	1	ND - 1.9	1.3	1.1	36
Aroclor 1254	4	1	ND - 1.6	1.0	0.9	15
Halogenated aliphatics						
Bromoform	7	0				>99
Chloroform	7	4	ND - 32		4.6	-[a]
1,2-Dichloroethane	7	1	ND - 2.0		0.3	93
1,1-Dichloroethylene	7	2	ND - 17		2.4	-[a]
1,2-*Trans*-dichloroethylene	7	2	ND - 22		3.1	-[a]
1,1,2,2-Tetrachloroethane	7	0				>99
Tetrachloroethylene	7	1	ND - 3.0		0.6	45
1,1,2-Trichloroethane	7	1	ND - 7.2		1.0	-[a]
Trichloroethylene	7	2	ND - 28		4.7	-[a]
Pesticides and metabolites						
Aldrin	4	0				
α-BHC	4	1	ND - 0.04			
β-BHC	4	1	ND - 0.3		0.1	0
γ-BHC	4	1	ND - 0.02			
Chlordane	4	1	ND - 31	9.0	4.6	-[a]
4,4'-DDE	4	1	ND - 0.02			
4,4'-DDT	4	1	ND - 0.1			
Dieldrin	4	1	ND - 0.4	0.2	0.1	
α-Endosulfan	4	0				
β-Endosulfan	4	1	ND - 0.1			
Endrin	4	0				>99
Endrin aldehyde	4	0				>99
Heptachlor	4	1	ND - 0.3		0.1	0
Heptachlor epoxide	4	1	ND - 0.1			>99
Isophorone	4	0				>99

Note: Blanks indicate insufficient data.

[a]Negative removal.

TABLE 10-40. REMOVABILITY OF TOXIC ORGANIC POLLUTANTS FROM RAW WASTEWATER IN THE SECONDARY SILVER SUBCATEGORY [1]

Toxic pollutant	Number of: Samples	Number of: Times detected	Treated effluent concentration, µg/L: Range	Median	Mean	Average percent removal
Phthalates						
Bis(2-ethylhexyl) phthalate	5	5	3.4 - 120	17	37	-[a]
Butyl benzyl phthalate	5	3	ND - 52	1.0	18	-[a]
Di-n-butyl phthalate	5	2	ND - 79	7.0	19	75
Diethyl phthalate	5	0				>99
Di-n-octyl phthalate	5	3	ND - 69		16	47
Aromatics						
Benzene	9	5	ND - 59		14	81
Chlorobenzene	9	1	ND - 4.0		0.4	86
Ethylbenzene	9	3	ND - 14		3.9	58
Toluene	9	2	ND - 19		2.7	87
Polycyclic aromatic hydrocarbons						
Acenaphthene	5	0				>99
Anthracene	5	0				>99
Fluoranthene	5	2	ND - 200		40	-[a]
Naphthalene	5	0				>99
Phenanthrene	5	0				>99
Pyrene	5	2	ND - 180		36	92
Polychlorinated biphenyls and related compounds						
Aroclor 1248	2	1	0.2 - 2.6		1.4	-[a]
Aroclor 1254	2	1	0.3 - 1.9		1.1	-[a]
Halogenated aliphatics						
Bromoform	9	2	ND - 13		1.4	87
Carbon tetrachloride	9	6	ND - 1,700	19	310	26
Chlorodibromomethane	9	1	ND - 2,800		750	-[a]
Chloroform	9	6	ND - 2,900	130	440	-[a]
Dichlorobromomethane						4
1,2-Dichloroethane	9	4	ND - 240	2.0	48	60
1,1-Dichloroethylene	9	4	ND - 3,400		390	65
1,2-*Trans*-dichloroethylene	9	2	ND - 44		4.9	-[a]
Methylene chloride	9	3	ND - 790		160	84
1,1,2,2-Tetrachloroethane	8	3	ND - 25		5.9	26
Tetrachloroethylene	9	6	ND - 35		8.3	81
1,1,1-Trichloroethane	9	1	ND - 5.0		0.6	92
Trichloroethylene	9	4	ND - 330		51	86
Pesticides and metabolites						
Aldrin	2	1				>99
α-BHC	2	1	ND - 0.1			
β-BHC	2	1	0.01 - 0.04			
δ-BHC	2	1	ND - 0.03			>99
γ-BHC	2	0				
Chlordane	2	1	ND - 0.1		0.1	
4,4'-DDE	2	1	ND - 0.01			
4,4'-DDD	2	1	ND - 0.01			
4,4'-DDT	2	1	0.02 - 0.03			
Dieldrin	2	1	ND - 0.1			
Endrin	2	1	ND - 0.2		0.1	86
Endrin aldehyde	2	1	ND - 0.5		0.2	-[a]
Heptachlor	2	1	0.01 - 0.04			

Note: Blanks indicate insufficient data.

[a]Negative removal.

II.10.5 References

1. Draft Development Document for Effluent Limitations Guidelines and Standards for the Nonferrous Metals Manufacturing Point Source Category, Effluent Guidelines Division, Office of Water and Waste Management, U.S. Environmental Protection Agency, September, 1979.

2. NRDC Consent Decree Industry Summary - Nonferrous Metals Manufacturing Industry.

3. Environmental Protection Agency - Effluent Guidelines and Standards for Nonferrous Metals. 40 CFR 421; 39 FR 12822, April 8, 1974; Amended by 40 FR 8514, February 27, 1975; 40 FR 48348, October 15, 1975; 41 FR 54850, December 15, 1976.

II.11 ORE MINING AND DRESSING

II.11.1 INDUSTRY DESCRIPTION [1]

II.11.1.1 General Description

Subgroups of the metal mining industries are identified as major group 10 in the Standard Industrial Classification (SIC) Manual, which includes establishments engaged in mining ores for the production of metals, and includes all ore dressing and beneficiating operations, whether performed at mills operating in conjunction with the mines served or at mills operated separately. These include mills which crush, grind, wash, dry, sinter, or leach ore, or perform gravity separation or flotation operations.

As mined, most ores contain the valuable metals whose recovery is sought, disseminated in a matrix of less valuable rock called gangue. The purpose of ore beneficiation is the separation of the metal-bearing minerals from the gangue to yield a product that is higher in metal content. To accomplish this, the ore must generally be crushed and/or ground small enough for each particle to contain either the mineral to be recovered or mostly gangue. Separation of the particles on the basis of some difference between the ore mineral and the gangue can then yield a concentrate high in metal value, as well as waste rock (tailings) containing very little metal. The separation is never perfect, and the degree of success attained is generally described by two parameters: (1) percent recovery, and (2) grade of the concentrate. Widely varying results are obtained in beneficiating different ores; recoveries may range from 60% or less to greater than 95%. Similarly, concentrates may contain less than 60% or more than 95% of the primary ore mineral. In general, for a given ore and process, concentrate grade and recovery are inversely related. (Higher recovery is achieved only by including more gangue, yielding a lower grade concentrate.)

Many properties are used as the basis for separating valuable minerals from gangue, including specific gravity, conductivity, magnetic permeability, affinity for certain chemicals, solubility, and the tendency to form chemical complexes. Separation processes in general use are gravity concentration, magnetic separation, electrostatic separation, flotation, and leaching. Amalgamation and cyanidation, which are variants of leaching, deserve special mention. Solvent extraction and ion exchange are widely applied techniques for concentrating metals from leaching solutions, and for separating them from dissolved contaminants. All of these processes are discussed in general terms in the paragraphs that follow. This discussion is not meant to be all-inclusive; rather, its purpose is to discuss the primary processes in current use in the ore mining and milling industry.

Gravity-concentration processes utilize the differences in density to separate valuable ore minerals (values) from gangue. Several techniques (e.g., jigging, tabling, spirals, and sink/float separation) are used to achieve the separation. Each is effective over a somewhat limited range of particle sizes, the upper bound of which is set by the size of the apparatus and the need to transport ore within it, and the lower bound by the point at which viscosity forces predominate over gravity and render the separation ineffective. Selection of a particular gravity-based process for a given ore will be strongly influenced by the size to which the ore must be crushed or ground to separate values from gangue, as well as by the density difference and other factors.

Ores can be leached by dissolving away either gangue or values in aqueous acids or bases, liquid metals, or other special solutions. The examples below illustrate various leaching possibilities.

(1) Water-soluble compounds of sodium, potassium, and boron can be mined, concentrated, and separated by leaching with water and recrystallizing the resulting brines.

(2) Vanadium and some other metals form anionic species that occur as insoluble ores. Roasting of such insoluble ores with sodium compounds converts the values to soluble sodium salts. After cooling, the water-soluble sodium salts are removed from the gangue by leaching in water.

(3) Uranium ores are only mildly soluble in water, but they dissolve quickly in acid or alkaline solutions.

(4) Native, finely divided gold is soluble in mercury and can be extracted by amalgamation (i.e., leaching with a liquid metal). One process for nickel concentration involves reduction of the nickel using ferrosilicon at a high temperature and extraction of the nickel metal into molten iron. This process, called skip-lading, is related to liquid-metal leaching.

(5) Certain solution (e.g., potassium cyanide) dissolve specific metals (e.g., gold) or their compounds, and leaching with such solutions immediately concentrates the values.

In the amalgamation process, mercury is alloyed with some other metal to produce an amalgam. The process is applicable to free milling precious-metal ores, those in which the gold is free, relatively coarse, and has clean surfaces. Lode or placer gold/silver that is partly or completely filmed with iron oxides, greases, tellurium, or sulfide minerals cannot be effectively amalgamated. Hence, prior to amalgamation auriferrous ore is typically washed and ground to remove any films on the precious-metal particles. Although the amalgamation process has been used in the past extensively for the extraction of gold and silver from pulverized ores, it has largely been superseded in recent years by the cyanidation process owing to environmental considerations.

In the cyanidation process, gold and/or silver are extracted from finely crushed ores, concentrates, tailings, and low-grade mine-run rock in dilute, weakly alakaline solutions of potassium or sodium cyanide. The gold is dissolved by the solution and subsequently sorbed onto activated carbon ("carbon-in-pulp" process) or precipitated with metallic zinc. The gold particles are recovered by filtering, and the filtrate is returned to the leaching operation.

Ion exchange and solvent extraction processes are used on pregnant leach solutions to concentration values and to separate the from impurities. Ion exchange and solvent extraction are based on the same principle: polar organic molecules tend to exchange a mobile ion in their structure [typically, Cl^-, NO_3^-, HSO_4^-, or $CO_3^=$ (anions) or H+ or Na+ (cations)] for an ion with a greater charge or a smaller ionic radius.

Table 11-1 presents industry summary data for the Ore Mining and Dressing point source category in terms of the total number of subcategories, the number of subcategories studies by EGD, and the number and types of dischargers [1-3].

TABLE 11-1. INDUSTRY SUMMARY [1-3]

Industry: Ore Mining and Dressing
Total Number of Subcategories: 7
Number of Subcategories Studied: 7

Number of Dischargers in Industry: Undefined
- Direct: 750
- Indirect: 0
- Zero: No definition for this industry

Table 11-2 presents current BPT limitations for each subcategory in the Ore Mining and Dressing Industry.

TABLE 11-2. BPT LIMITATION REGULATIONS FOR THE ORE MINING AND DRESSING INDUSTRY [4]

Subcategory	Parameter	Maximum for 1 day, mg/L	30-Day average, mg/L
Iron ore			
Mines and mine drainage	TSS	30	20
	Fe (dissolved)	2.0	1.0
Physical/chemical beneficiation	TSS	30	20
	Fe (dissolved)	2.0	1.0
	pH (= 6 to 9)		
Magnetic/physical beneficiation		No discharge[a]	
Aluminum ore	TSS	30	20
	Fe	1.0	0.5
	Al	2.0	1.0
	pH (= 6 to 9)		
Base and precious metals[a]			
Open pit and underground mines	TSS	30	20
	Cu	0.30	0.15
	Zn	1.5	0.75
	Pb	0.6	0.3
	Hg	0.002	0.001
	pH (= 6 to 9)		
Froth flotation process	TSS	30	20
	Cu	0.3	0.15
	Zn	1.1	0.5
	Pb	0.6	0.3
	Hg	0.002	0.001
	Cd	0.1	0.005
	pH (= 6 to 9)		
Amalgamation process	TSS	30	20
	Cu	0.3	0.15
	Zn	1.0	0.5
	Hg	0.002	0.001
	pH (= 6 to 9)		
Gravity separation[b]			
Uranium			
Mine drainage	TSS	30	20
	COD	200	100
	Ra 226 (dissolved)	10[c]	3[c]
	Ra 226 (total)	30[c]	2
	U	4	2
	Zn	1.0	0.5
	pH (= 6 to 9)		
Mills using acid leach, alkaline leach, combined leaching, including mill-mine *in-situ* leaching	TSS	30	20
	COD		500
	As	1.0	
	Ra 226 (dissolved)	10[c]	3[c]
	Ra 226 (total)	30[c]	10[c]
	NH_3		100
	pH (=6 to 9)		

(continued)

TABLE 11-2 (continued)

Subcategory	Parameter	Maximum for 1 day, mg/L	30-Day average, mg/L
Ferralloy			
Mine drainage from mines producing 5,000 metric ton/yr	TSS	30	20
	Cd	0.1	0.005
	Cu	0.3	0.015
	Zn	1.0	0.5
	Pb	0.6	0.3
	As	1.0	0.5
	pH (= 6 to 9)		
Drainage from mines producing less than 5,000 metric tons/yr and mills processing less than 5,000 metric ton/yr	TSS	50	30
	pH (= 6 to 9)		
Drainage from mills processing greater than 5,000 metric/ton yr using froth flotation	TSS	30	20
	Cd	0.1	0.05
	Cu	0.3	0.15
	Zn	1.0	0.5
	As	1.0	0.05
	CN	0.2	0.1
	pH (= 6 to 9)		
Mercury			
Mine drainage	TSS	30	20
	Hg	0.002	0.001
	Ni	0.2	0.1
	pH (= 6 to 9)		
Mills - gravity separation[d]			
Mills - froth separation[d]			
Metal ore not elsewhere classified			
Titanium			
Mine drainage	TSS	30	20
	Fe	2	1
	pH (= 6 to 9)		
Mill beneficiating using electrostatic, magnetic, physical, or flotation methods	TSS	30	20
	Zn	1.0	0.5
	Ni	0.2	0.1
	pH (= 6 to 9)		
Mine drainage from dredge mining	TSS	30	20
	Fe	2	1
	pH (- 6 to 9)		

[a]No discharge from mines and mills that employ dump, heap, *in-situ* leach, or vat leach process to extract copper or ore waste. No discharge from gold or silver mills that use the cyanidation process. Discharge is allowed if rainfall exceeds evaporation in the discharge area. Volume of discharge allowed is equal to the amount needed to equalize rainfall and evaporation.

[b]No BPT regulations promulgated for this process.

[c]Picocuries/L.

[d]Discharge is allowed, if rainfall exceeds evaporation in the discharge area. Volume of discharge allowed is equal to the amout needed to equalize rainfall and evaporation.

II.11.1.2 Subcategory Descriptions

Based on similarities in types of processing, technology, wastewater, end products, and other factors, the following subcategories of the Ore Mining and Dressing Industry were established [1,2]:

- Iron Ore (SIC Code 1011)
- Aluminum (SIC Code 1051)
- Base and Precious Metals (SIC Codes 1021, 1031, 1041, and 1044)
- Uranium (SIC Code 1094)
- Ferroalloy (SIC Code 1061)
- Mercury (SIC Code 1092)
- Metal Ore Not Elsewhere Classified (SIC Code 1099)

Subcategory 1 - Iron Ore

This subcategory covers mining and/or milling operations involved in the excavation and extraction of iron ore.

Subcategory 2 - Aluminum (Bauxite)

The bauxite mining industry is classified as SIC 1051, which includes establishments engaged in mining and milling bauxite and other aluminum ores. However, no other aluminum ores are being commercially exploited on a full-scale basis at present, and the bauxite mining industry serves as the sole representative of SIC 1051.

Subcategory 3 - Base and Precious Metals

This subcategory encompasses the mining and milling of copper, zinc, lead, gold, and silver, falling under SIC Codes 1021, 1031, 1041, and 1044.

Subcategory 4 - Uranium

The factors evaluated in consideration of subcategorization of the uranium, radium, and vanadium mining and ore dressing industry are: end product, type of processing, ore mineralogy, waste characteristics, treatability of wastewater, climate, rainfall, and location. Based upon an intensive literature search, plant inspections, NPDES permits, and communications with the industry, this category is categorized by milling process and mineralogy (and, thus, product). The milling processes of this industry involve complex hydrometallurgy. Such point discharges as might occur in milling processes (i.e., the production of concentrate) are expected to contain a variety of pollutants that need to be limited. Mining for the ores is expected to lead to a smaller set of contaminants. While mining or milling of ores for uranium or radium produces particularly noxious radioactive pollutants, these are largely absent in an operation recovering vanadium only.

Subcategory 5 - Ferroalloy

A tentative subcategorization of the industry was developed after collection and review of initial data, based primarily on end product (e.g., tungsten, molybdenum, manganese, etc.), with further division on the basis of process, in some cases. Further data, particularly chemical data on effluents and more complete process data for past operations, indicated that process was the dominant factor influencing wastestream character and treatment effectiveness. Examination of the industry additionally showed that size of operation could also be of great importance. Other factors, except as they are reflected in or derived from the above, are not believed to warrant industry subcategorization.

Subcategory 6 - Mercury

The mercury industry in the United States currently is at a reduced level of activity due to depressed market prices. Two facilities were found to be operating at present, although it is thought that activity will increase with increasing demand and rising market prices. The decreased use of mercury due to stringent air and water pollution regulations in the industrial sector may be offset in the future by increased demand in dental, electrical, and other uses. Historically, little beneficiating of mercury ores has been known in the industry. Common practice for most producers (since relatively low production characterizes most operators) has been to feed the cinnabar-rich ore directly to a kiln or furnace without beneficiation. Water use in most of the operations is at a minimum.

Subcategory 7 - Metal Ore Not Elsewhere Classified

This group of metal ores was considered on a metal-by-metal basis because of the wide diversity of mineralogies, processes of extraction, etc. Most of the metal ores in this group do not have high production figures and represent relatively few operations. For this entire group, ore mineralogies and type of process formed the basis of subcategorization. The metals ores examined under this category are ores of antimony, beryllium, platinum, tin, titanium, rare earths (including monazite), and zirconium.

II.11.2 WASTEWATER CHARACTERIZATION [1]

The wastewater situation evident in the mining segment of the ore mining and dressing industry is unlike that encountered in most other industries. Usually, industries (such as the milling segment of this industry) utilize water in the specific processes they employ. This water frequently becomes contaminated in the process and must be treated prior to discharge. In the mining segment, process water is not normally utilized in the actual mining of ores, except where it is used in placer mining operations (hydraulic mining and dredging) and in dust control.

Water is a natural feature that interferes with mining activities. It enters mines by groundwater infiltration and surface runoff and comes into contact with materials in the host rock, ore, and overburden. An additional source of water in deep underground mines is the water that results from the backfilling of slopes with the coarse fraction of the mill tailings. Transportation of these sands underground is typically accomplished by sluicing. Mill wastewater is usually the source of the sluice water. The mine water then requires treatment depending on its quality before it can be safely discharged into the surface drainage network. Generally, mining operations control surface runoff through the use of diversion ditching and grading to prevent, as much as possible, excess water from entering the working area. The quantity of water from an ore mine thus is unrelated, or only indirectly related, to production quantities.

Water is used in the ore mining and dressing industry for several principal uses under three major categories:

(1) Noncontact cooling water

(2) Process water: wash water
transport water
scrubber water
process and product consumed water

(3) Miscellaneous water: dust control
domestic/sanitary uses
washing and cleaning
drilling fluids

Noncontact cooling water is defined as cooling water that does not come into direct contact with any raw material, intermediate product, by-product, or product used in or resulting from the process. Process water is defined as that water which, during the beneficiation process, comes into direct contact with any raw material, intermediate product, by-product, or product used in or resulting from the process.

Wastewater characteristics for the Ore Mining and Dressing Industry in general reflect the diversity of the mining and milling operations associated with the various ores mined and processed. Each ore exhibits its own particular set of waste characteristics, as shown in Table 11-3. The peculiarities were, in part, criteria used to determine the various subcategories.

Table 11-3 presents available data, by subcategory, for raw wastewater pollutant concentrations for subcategories 1, 3, 4, 5, and 6 [1]. Data for subcategory 2, aluminum, have been excluded because they are extremely limited. Subcategory 7, Metal Ore Not Elsewhere Classified, has been excluded because of the small size

TABLE 11-3. RAW WASTWATER POLLUTANT CONCENTRATIONS BY SUBCATEGORY [1]

Parameter	Number of mines	Range	Median	Number of mills	Range	Median
			Subcategory 1 - Iron Ore			
Conventional, mg/L						
pH[a]	8	7.2 - 8.4	7.5[b]	6	7.3 - 9.5	8.2[c]
COD	8	1.0 - 48	17[b]	7	<1.0 - 23	12[b]
TSS	8	<1 - 48	13[b]	7	12 - 55	28[b]
TDS	8	120 - 1,300	500[b]	7	200 - 2,400	670[b]
Inorganics, μg/L						
Fe, total	8	<20 - 4,500	900[b]	7	400 - 1,200,000	210,000[b]
Fe, dissolved	8	<20 - 80	30[b]	7	<20 - 160	60[b]
Manganese	8	<20 - 3,200	400[b]	7	32 - 330,000	110,000[b]
		Subcategory 3 - Base and Precious Metals, Copper[c]				
Conventional, mg/L						
pH[a]	7	3.5 - 9.6	7.0	4	8.1 - 10	8.9
COD	7	4 - 39	<10			
TOC	7	2.3 - 31	10			
TSS	7	2 - 40	8	4	110,000 - 470,000	350,100
TDS	7	450 - 29,000	2,200	4	400 - 4,300	2,700
Oil and grease	7	<1.0 - 17	1	4	<0.05 - 1	<0.6
Toxic inorganics, μg/L						
Antimony	7	<20 - <500	<500	1		<500
Arsenic	7	<10 - <70	<70	2	<20 - <70	<50
Copper	7	500 - 92,000	5,300	4	150,000 - 910,000	270,000
Cyanide				4	<10 - 170	10
Lead	7	<50 - <500	<100	4	<10 - 21,000	1,400
Mercury	7	<0.1 - 78	0.5	4	0.6 - 6.0	2.0
Nickel	7	<50 - 240	<100	1		2,800
Selenium	6	<3 - 96	25	1		<3.0
Silver				1		<100
Zinc	7	<50 - 170,000	2,800	4	4,800 - 310,000	8,100
Other inorganics, μg/L						
Aluminum				1		<500
Boron	7	10 - 2,200	100			
Cobalt	7	<50 - 1,900	60	1		1,680
Gold				1		<50
Iron	7	<400 - 2,000,000	6,000	4	550,000 - 19,000,000	7,700,000
Manganese	7	<50 - 100,000	1,400	1		31,000
Molybdenum	7	<200 - <500	<500	1		29,000
Strontium	7	90 - 120,000	830	1		1,200
		Subcategory 3 - Base and Precious Metals, Lead/Zinc[d,e]				
Conventional, mg/L						
pH[a]	8	3.0 - 8.1		5	7.9 - 11	
COD	8	<10 - 630				
TOC	8	<1 - 11				
TSS	8	<2 - 1,000		3	21,000 - 270,000	
TDS	8	260 - 1,700				
Oil and grease	8	0 - 29				
Toxic inorganics, μg/L						
Cadmium	8	<2 - 80		3	1,200 - 16,000	
Chromium	8	<20 - 420		3	9,800 - 40,000	
Copper	8	<20 - 2,100		3	4,800 - 500,000	
Lead	8	100 - 4,900		3	76,000 - 560,000	
Mercury	4	<0.1 - 0.1				
Zinc	8	30 - 38,000		3	160,000 - 3,000,000	
Other inorganics, μg/L						
Iron	8	<20 - 22,000		3	2,900,000 - 35,000,000	
Manganese	8	<20 - 57,000		3	300,000 - 570,000	

(continued)

TABLE 11-3 (continued)

Parameter	Number mines	Range	Median	Number mills	Range	Median
		Subcategory 3 - Base and Precious Metals, Gold				
Convention, mg/L						
pH[a]	2	3.3 - 6.2	4.8			
COD	3	27 - 3,800	35	4	11 - 220	110
TOC	1		12	4	12 - 97	42
TSS	3	5 - 81	14	4	2 - 550,000	490,000
TDS	3	530 - 4,700	1,200	4	460 - 4,500	1,100
Oil and grease	3	<0.1 - 1.0	1			
Toxic inorganics, μg/L						
Antimony	1		<100			
Arsenic	2	30 - 80	60	3	50 - 3,700	<70
Beryllium	1		<2.0			
Cadmium	3	<20 - 40	25	4	<10 - 100	<20
Chromium	1		<20			
Copper	3	<20 - 1,700	56	4	30 - 200	480
Cyanide	3	<10 - 440	<10	4	<10 - 81,000	2,600
Lead	2	<100 - 820	450	4	60 - <100	<10
Mercury	1		<0.1	3	1.1 - 4.2	4.0
Nickel	2	60 - 100	80			
Silver	1		20			
Thallium	1		50			
Zinc	3	<10 - 7,300	2,300	4	130 - 3,100	760
Other inorganics, μg/L						
Aluminum	2	140 - <200	170			
Barium	1		<500			
Boron	1		180			
Calcium	1		87,000			
Iron (total)	3	1,200 - 210,000	25,000	4	<500 - 77,000	1,200
Magnesium	1		80,000			
Manganese	2	140 - 12,000	6,700			
Molybdenum	1		<200			
Potassium	1		44,000			
Sodium	1		80,000			
Strontium	1		780			
Tellurium	1		100			
Titanium	1		<500			
Vanadium	1		0			
Organics, μg/L						
Phenol	1		<10			
		Subcategory 3 - Base and Precious Metals, Silver[f]				
Conventional, mg/L						
pH[a]	1		8.0			
COD	2	12 - 20	16	4	16 - 220	41
TOC	2	16 - 17	17	4	12 - 29	23
TSS	2	<2	<2	4	2 - 550,000	150,000
TDS	2	500 - 620	560	4	470 - 1,200	770
Oil and grease	2	2 - 4	3			
TKN	1		<0.2			
Toxic inorganics, μg/L						
Antimony	2	<200	<200	3	<200 - 1,850	<200
Arsenic	2	<70	<70	4	<70 - 3,500	<70
Beryllium	2	<2.0	<2.0			
Cadmium	2	<20	<20	4	<10 - 20	<20
Chromium	2	<100	<100	4	30 - 780	240
Copper	2	<20	<20			
Cyanide	2	<10	<10			
Lead	2	<100 - 180	140	4	<100 - 560	<100
Mercury	2	0.4 - 2.0	1.2	4	0.8 - 130	3.0

(continued)

TABLE 11-3 (continued)

Parameter	Number of mines	Range	Median	Number of mills	Range	Median
Toxic inorganics, μg/L (continued)						
Nickel	2	60 - 90		4	50 - 140	100
Selenium	2	6.8 - 126		2	140 - 150	150
Silver	2	<20		3	<20	<20
Thallium	2	<100				
Zinc	2	<20 - <30		3	20 - 370	170
Toxic organics, μg/L						
Phenol	2	<10				
Other inorganics, μg/L						
Aluminum	2	<20				
Barium	2	<500 - <600				
Boron	2	80 - 110				
Calcium	2	45,000 - 46,000				
Iron (total)	2	330 - 2,100				
Magnesium	2	28,000 - 32,000				
Manganese	2	430 - 6,300				
Molybdenum	2	<200		4	50 - 540	<200
Potassium	2	8,000 - 15,000				
Sodium	2	7,000 - 12,000				
Strontium	2	150 - 210				
Tellurium	2	<300		3	<300	<300
Titanium	2	<500				
Vanadium	2	<200				

Subcategory 4 - Uranium[f]

Parameter	Number of mines	Range	Alkaline process: Number of mills	Alkaline process: Range	Acid process: Number of mills	Acid process: Range
Conventional, mg/L						
COD	2	240 - 600	2	28 - 56	1	64 - 630
TOC	2	16 - 25	2	<1 - 450	2	6 - 24
TSS	1	300	2	110,000 - 290,000	2	250,000 - 530,000
Toxic inorganics, μg/L						
Arsenic			2	330 - 1,400	2	130 - 2,300
Copper			2	<500 - 1,100	2	680 - 1,700
Lead			2	<5 - 690	2	840 - 2,100
Nickel			1	520	1	1,400
Zinc			1	<500		<500
Other inorganics, μg/L						
Aluminum			1	18,000	2	740,000 - 1,600,000
Calcium	2	93,000 - 120,000	1	32,000,000	1	220,000
Iron	2	230 - 470	2	920 - 1,600	1	330,000
Magnesium	2	36,000 - 45,000	1	190,000	1	550,000
Manganese			2	<200 - 38,000	2	110,000 - 210,000
Molybdenum	2	500 - 530	2	<300	2	300 - 16,000
Radium[g]	2	2,700,000 - 3,200,000	2	110,000 - 19,000,000	2	230,000 - 690,000
Thorium	1	<100	1	<100		
Titanium			1	400	1	3,000
Uranium	2	12,000	2	3,900 - 44,000	2	31,000 - 170,000
Vanadium	2	500 - 1,000	2	500 - 17,000	2	120,000 - 130,000

(continued)

TABLE 11-3 (continued)

Parameter	Number of mines	Range	Median	Number of mills	Range	Median
Conventional, mg/L						
pH[a]	4	4.5 - 7.3	6.8	2	3.5 - 8.6	6.1
COD				4	24 - 170	40
TSS				3	2.30 - 500,000	150,000
TDS				5	210 - 2,600	2,300
Oil and grease	3	1.0 - 14	2.0	5	1 - 15	3.4
Ammonia	2	0.12 - 0.15	0.14	2	0.16 - 1.4	0.78
Toxic inorganics, µg/L						
Arsenic	4	<10 - <70	<40	5	10 - 100	<70
Cadmium	4	<5 - 70	<10	5	<5 - 740	30
Chromium				2	20 - 30	
Copper	4	<20 - 3,800	<40	5	30 - 51,000	520
Cyanide (total)				4	<10 - 450	<10
Lead	3	60 - 190	140	5	<20 - 9,800	<100
Zinc	4	50 - 7,000	90	4	<20 - 27	50
Other inorganics, µg/L						
Calcium				1		206,000
Iron				4	440 - 1,500,000	24,000
Manganese	4	210 - 6,800	5,400	5	190 - 57,000	50,000
Molybdenum	4	<100 - 500	<100	5	500 - 18,000	2,200
Vanadium	3	<500	<500	2	<500	<500
Subcategory 6 - Mercury[f,h]						
Conventional, mg/L						
pH[a]	2	6.5 - 8.2	7.4			
Toxic organics, µg/L						
Antimony	2	<500 - 3,800	2,200			
Arsenic	2	20	20			
Cadmium	1		420			
Copper	1		1,300			
Lead	1		580			
Mercury	1		28,000			
Zinc	1	140 - 1,000	620			
Other inorganics, µg/L						
Iron	2	<500 - 2,900,000	1,500,000			
Manganese	2	7,000 - 50,000	29,000			
Tellurium	1		<80			

[a]Values in pH units.

[b]Average value.

[c]Flow range for seven copper mines was 1.08×10^5 to 1.1×10^7 gpd with a median of 8.65×10^5 gpd; flow range for four copper mills was 5.10×10^6 to 7.35×10^7 gpd with a median of 2.73×10^7 gpd.

[d]The mines concerned use seepage and seepage plus drill cooling water combined.

[e]The form of the data did not permit determination of median values.

[f]Median values not presented for silver mines, uranium mines and mills, and mercury mills due to insufficient data.

[g]Values in picocuries/L.

[h]Water not used; surface and groundwater, if encountered, are not discharged.

of operations involved, the diversity of this subcategory, and the lack of specific reference material pertinent to this classification.

II.11.3 PLANT SPECIFIC DESCRIPTION [1, 2]

Tables 11-4 through 11-13 present pollutant concentrations observed at several mines, mills, and mine/mill complexes throughout the industry. All subcategories are encompassed. Some data are screening sampling values, and other data are verification sampling values. Footnotes with each table indicate the type of data reported. The tables do not list influent flowrates because they are not clearly defined for this industry.

Plants were selected by the amount of information available, treatment process, number of streams, and removal efficiency. Some plants combine mine and mill wastewaters; this combination often depends on the location and water reuse rate of the plant.

II.11.4 POLLUTANT REMOVABILITY

Pollutants in the Ore Mining and Dressing industry originate from two distinct sources: particles from raw ores, and beneficiation (dressing) reagents. Pollutants from various ores generally consist of heavy metals contained in the ore. These pollutants are normally in a natural state as dissolved or suspended particles resulting from contact with rainwater and seepage water. The beneficiation or dressing process generally contributes cyanide or phenols and may result in high volumes of waste loads when combined with the natural pollutants.

In-process recycle of wastestreams after thickening or filtering is used at several plants within the industry. Water also may be recovered by dewatering tailings prior to final discharge. The recovered water may be reused as makeup or as a process control measure for additional metal recovery. In-process recycle may reduce the volume of wastewater discharged by 5% to 17%; when tailing wastewater is recovered, the wastewater volume may be reduced by up to 50%. This reduction allows for a smaller wastewater treatment system. Mine drainage also has been used as mill makeup water, which has a similar effect on the treatment system.

Several treatment methods are currently being used by the Ore Mining and Dressing industry. Settling, chemical treatment, and filtration, are techniques commonly employed. Other methods for wastewater treatment also are used but on a smaller basis.

Chemical treatment involves the addition of a chemical compound, usually lime or alum, to precipitate dissolved metals. Preliminary settling may be used to remove larger particles prior to chemical treatment, which is generally followed by sedimentation.

TABLE 11-4. WASTEWATER CHARACTERIZATION, MINE 1108[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Iron Ore
Wastewater treatment description: Settling pond
Discharge method: To surface
Effluent flowrate: 15.8×10^3 m^3/d (4.17×10^6 gpd)

Pollutant	Mine water and wastewater characterization	
	Settling pond influent	Settling pond effluent
Classical pollutants		
pH	7.65	7.25
TSS, mg/L	110,000	<1
VSS, mg/L	80	<1
COD, mg/L	96	4
TOC, mg/L	22	11
Toxic pollutants, µg/L, except as noted		
Antimony	<100	<50
Arsenic	<10	<2
Beryllium	<20	<20
Cadmium	<5	<5
Chromium	500	10
Copper	130	100
Lead	80	<20
Mercury	<0.5	<0.5
Nickel	2,700	<20
Selenium	20	<5
Silver	20	<10
Thallium	<100	<100
Zinc	500	30
Asbestos, fibers/L,		
Total	2.3×10^{11}	4.3×10^7
Chrysotile	3.8×10^{10}	4.1×10^6
Total cyanides, mg/L	<0.04	<0.02
Total phenols, mg/L	<0.004	0.006
Benzene	6.2	4.2
Diethyl phthalate	55	ND

[a]Data based on screening sampling.

TABLE 11-5. WASTEWATER CHARACTERIZATION, MINE 5102[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Aluminum
Wastewater treatment description: Lime neutralization, settling pond
Discharge method: To surface
Effluent flowrate: 4.16×10^4 m^3/d (1.1×10^7 gpd)

Pollutant	Mine water and wastewater characterization: Treatment pond influent	Treatment pond effluent
Classical pollutants		
pH	3.05	8.60
TSS, mg/L	2.8	6
VSS, mg/L	1.6	5
COD, mg/L	<2	<2
TOC, mg/L	2	4
Toxic pollutants, µg/L, except as noted		
Antimony	<50	<50
Arsenic	<2	<2
Beryllium	<20	<2
Cadmium	<5	<5
Chromium	30	25
Copper	60	50
Lead	<20	<20
Mercury	37	84
Nickel	60	<20
Selenium	<5	<5
Silver	<10	<10
Thallium	<100	<100
Zinc	570	<20
Asbestos, fibers/L,		
Total	3.5×10^7	1.4×10^9
Chrysotile	5.5×10^6	2.0×10^8
Total cyanides, mg/L	<0.02	<0.02
Total phenols, mg/L	<0.002	<0.002
Phenol	ND	210
Bis(2-ethylhexyl) phthalate	ND	50
Butyl benzyl phthalate	ND	66
Di-n-butyl phthalate	ND	140
Diethyl phthalate	ND	1.9
Dimethyl phthalate	ND	3.1

[a]Data based on screening sampling.

TABLE 11-6. WASTEWATER CHARACTERIZATION, MINE/MILL 2120[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Base and Precious Metals, Copper
Wastewater treatment description: Lime precipitation, settling, pH adjustment, partial recycle to mill
Discharge method: To surface
Effluent flowrate: 2.596×10^4 m^3/d (9.50×10^6 gpd)[b]

	Plant water and wastewater characterization				
Pollutant	Tailings pond influent	Tailings pond recycle	Combined treatment pond effluent and surge pond overflow	Treatment pond influent	Treatment pond effluent
Classical pollutants					
pH	12.00	9.90	11.20	11.75	3.45
TSS, mg/L	164,000	13	3	14	4
VSS, mg/L	NA	NA	NA	NA	NA
COD, mg/L	3,210	10	14	10	18
TOC, mg/L	12	10	17	19	12
Toxic pollutants, µg/L except as noted					
Antimony	<100	<100	<100	<100	<100
Arsenic	3,600	<2	20	40	30
Beryllium	30	<5	<5	<5	<5
Cadmium	120	<5	<5	<5	<5
Chromium	800	<20	400	<20	<20
Copper	370,000	<20	120	500	80
Lead	18,000	<20	<20	40	40
Mercury	22	<1	<1	<1	1
Nickel	1,500	<20	150	<20	30
Selenium	1,000	<5	<5	<5	<5
Silver	1,700	<10	40	<10	<10
Thallium	<100	<100	<100	<100	<100
Zinc	27,000	<20	50	160	<20
Asbestos, fibers/L,					
Total	1.3×10^{13}	7.8×10^7	8.6×10^6	2.3×10^8	2.7×10^7
Chrysotile	1.7×10^{12}	1.2×10^7	1.3×10^6	9.1×10^6	1.7×10^6
Total cyanides, mg/L	<0.02	<0.02	<0.02	<0.02	<0.02
Total phenols, mg/L	0.014	0.024	0.012	0.018	0.012

[a] Data based on verification sampling.

[b] Combined mine/mill operation.

TABLE 11-7. WASTEWATER CHARACTERIZATION, MINE/MILL/ SMELTER/REFINERY 3107[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Base and Precious Metals, Lead and Zinc
Wastewater treatment description: Combined wastestreams; stopes backfilled with sand tails, settling pond
Discharge method: To surface
Effluent flowrate: 1.36×10^4 m³/d (3.59×10^6 gpd)

Pollutant	Plant water and wastewater characterization: Mine water drainage[b]	Mine tailings wastewater[b]	Smelter wastewater[b]
Classical pollutants			
pH	4.92	8.88	10.08
TSS, mg/L	3,600	101,950	18.5
VSS, mg/L	170	4,300	4.5
COD, mg/L	138	3,150	5
TOC, mg/L	1	7	4.5
Toxic pollutants, µg/L, except as noted			
Antimony	<100	<525	<100
Arsenic	2,750	1,500	60
Beryllium	<5	<5	<5
Cadmium	145	620	660
Chromium	70	935	35
Copper	1,015	14,750	70
Lead	10,500	154,500	5,350
Mercury	18	30	6.5
Nickel	380	3,700	<20
Selenium	28	100	17.5
Silver	45	450	20
Thallium	<100	<265	<100
Zinc	85,000	222,500	3,500
Asbestos, fibers/L,			
Total	1.7×10^{10}	1.8×10^{11}	6.3×10^7[c]
Chrysotile	3.93×10^5	4.1×10^{10}[c]	1.1×10^7[c]
Total cyanides, mg/L	0.33	3.0	<0.02
Total phenols, mg/L	0.007	0.011	0.072
Bis(2-ethylhexyl) phthalate	NA	NA	NA
Di-n-butyl phthalate	NA	NA	NA
Benzene	4	3	<1[c]
Methylene chloride	163	425	6[c]
Toluene	<1	<1	NA
Chloroform	3[c]	<1	4
Trichlorofluoromethane	<1[c]	<1	NA
Carbon tetrachloride	NA	NA	<1
Other pollutants, µg/L			
Iron	NA	NA	NA
Ore refinery			
Classical pollutants			
pH	2.15	2.7	6.7
TSS, mg/L	109	12.5	19
VSS, mg/L	19	NA	NA
COD, mg/L	210	11	3
TOC, mg/L	2	1	2
Toxic pollutants, µg/L, except as noted			
Antimony	<100	<500	<500
Arsenic	400	28	4
Beryllium	<5	<5	<5
Cadmium	7,500	3,050	220
Chromium	105	75	25
Copper	1,800	705	60
Lead	24,200	2,750	215
Mercury	9	30	1.7
Nickel	205	275	75
Selenium	12.5	<5	<5
Silver	140	<20	<20
Thallium	<100	NA	NA
Zinc	545,000	86,000	5,500
Asbestos, fibers/L,			
Total	3.3×10^8[c]	NA	NA
Chrysotile	6.8×10^7[c]	NA	NA
Total cyanides, mg/L	<0.02	0.175	0.035
Total phenols, mg/L	<0.002	0.02	0.032[c]
Bis(2-ethylhexyl) phthalate	NA	NA	16[c]
Di-n-butyl phthalate	NA	NA	0.3[c]
Benzene	NA	NA	<1[c]
Methylene chloride	201	NA	NA
Toluene	NA	NA	NA
Chloroform	NA	NA	NA
Trichlorofluoromethane	NA	NA	NA
Carbon tetrachloride	NA	NA	NA
Other pollutants, µg/L			
Iron	NA	58,000	2,350

[a]Data based on verification sampling.

[b]Average of two values.

[c]One sample only.

TABLE 11-8. WASTEWATER CHARACTERIZATION, MINE/MILL 4401[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Base and Precious Metals, Silver
Wastewater treatment description: Multiple pond settling
Discharge method: Decant to surface; recycle
Effluent flowrate: 2.93×10^3 m^3/d (7.21×10^5 gpd)

	Plant water and wastewater characterization			
Pollutant	Raw mine water	Treated mine water to recycle or discharge	Tailings pond influent	Supernatant from decant tower
Classical pollutants				
pH	7.40	7.70	7.40	7.80
TSS, mg/L	23	3	397,000	13
VSS, mg/L	6	3	62,800	3
COD, mg/L	19	4	15,100	18
TOC, mg/L	16	1	25	11
Toxic pollutants, µg/L, except as noted				
Antimony	<50	<50	18,000	200
Arsenic	20	10	800	20
Beryllium	<2	<2	<20	<2
Cadmium	<5	<5	<10	<5
Chromium	<10	<10	380	15
Copper	160	100	15,000	620
Lead	<20	20	27,000	30
Mercury	0.5	<0.5	7.2	<0.5
Nickel	40	40	390	50
Selenium	<5	<5	<40	<5
Silver	20	30	2,200	<10
Thallium	<100	<100	<100	<100
Zinc	50	30	4,600	20
Asbestos, fibers/L,				
Total	3.8×10^7	5.7×10^7	7.1×10^{11}	2.1×10^9
Chrysotile	1.1×10^7	1.1×10^6	1.1×10^{11}	1.8×10^8
Total cyanides, mg/L	<0.02	<0.02	<0.02	<0.02
Total phenols, mg/L	0.004	<0.002	<0.01	<0.002
Benzene	0.26	ND	ND	ND
Methylene chloride	5.0	ND	ND	ND
Bis(2-ethylhexyl) phthalate	0.1	0.02	15	8.6
Tetrachloroethylene	11	ND	ND	ND
Toluene	ND	0.64	0.83	2.1
Di-n-butyl phthalate	ND	ND	27	ND
Diethyl phthalate	ND	ND	51	ND
Butyl benzyl phthalate	ND	ND	ND	32
Carbon tetrachloride	ND	ND	1.0	ND

[a]Data based on screening sampling.

TABLE 11-9. WASTEWATER CHARACTERIZATION, MINE/MILL 4105[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Base and Precious Metals, Gold
Wastewater treatment description: Not available
Discharge method: Mill makeup
Effluent flowrate: 3.79×10^3 m^3/d (1.37×10^6 gpd)

Pollutant	Plant water and wastewater characterization: Raw mine water	Sand plant thickener overflow	Tails and city sewage to creek
Classical pollutants			
pH	7.95	9.00	8.65
TSS, mg/L	26	97	60,200
VSS, mg/L	3.2	8	1,290
COD, mg/L	8	8	700
TOC, mg/L	14	5	18
Toxic pollutants, µg/L, except as noted			
Antimony	<50	100	<100
Arsenic	40	5	200,000
Beryllium	<2	<20	30
Cadmium	<5	<5	<5
Chromium	45	50	1,600
Copper	50	280	2,600
Lead	<20	20	370
Mercury	6.3	540	15
Nickel	<20	<20	<500
Selenium	<5	5	150
Silver	<10	<10	100
Thallium	<100	<100	<100
Zinc	50	420	3,900
Asbestos, fibers/L,			
Total	TNTC[b]	5.5×10^8	1.1×10^{11}
Chrysotile	5.5×10^6	4.4×10^7	2.7×10^9
Total cyanides, mg/L	<0.02	0.90	6.8
Total phenols, mg/L	0.01	<0.002	<0.002
Tetrachloroethylene	ND	ND	3,560

[a]Data based on screening sampling.

[b]Total fibers too numerous to count.

TABLE 11-10. WASTEWATER CHARACTERIZATION, MINE/MILL 9411[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Uranium
Wastewater treatment description: $BaCl_2$ coprecipitation, settling
Discharge method: To surface
Effluent flowrate: 1.36 x 10^4 m^3/d (3.59 x 10^6 gpd)

Pollutant	Plant water and wastewater characterization: Raw mine water	Treated mine water
Classical pollutants		
pH	8.05	8.15
TSS, mg/L	280	7
VSS, mg/L	28	1
COD, mg/L	37	17
TOC, mg/L	8	<1
Toxic pollutants, µg/L, except as noted		
Antimony	50	<50
Arsenic	3	<2
Beryllium	<20	<2
Cadmium	<5	<5
Chromium	50	25
Copper	40	<20
Lead	40	50
Mercury	3.8	<0.5
Nickel	<20	<20
Selenium	5	10
Silver	<10	<10
Thallium	<100	<100
Zinc	60	30
Asbestos, fibers/L,		
Total	2.3 x 10^9	5.7 x 10^8
Chrysotile	1.1 x 10^8	2.7 x 10^7
Total cyanides, mg/L	<0.02	<0.02
Total phenols, mg/L	<0.002	<0.002
Bis(2-ethylhexyl) phthalate	47	2.4
Other pollutants, pCi/L[b]		
Total radium 226	56.9[c]	<2[c]
Dissolved radium 226	60.2	-[d]

[a]Data based on screening sampling.

[b]Picocuries/L.

[c]Within sensitivity limits; most Ra 226 is dissolved.

[d]Analysis unreliable.

TABLE 11-11. WASTEWATER CHARACTERIZATION, MINE/MILL 6102[a] [1, 2]

Category: Ore Mining and Dressing
Subcategory: Ferroalloy
Wastewater treatment description: Tailings pond, recycle, chlorination, electrocoagulation, flotation
Effluent discharge: Mine to mill treatment: 3.8×10^3 m^3/d (1.0×10^6 gpd)
Mill treatment discharge: 1.1×10^4 m^3/d (2.91×10^6 gpd)

Pollutant	Plant water and wastewater characterization: Mine water	Mill tailings	Treated effluent
Classical pollutants			
pH	6.4	10.8	6.45
TSS, mg/L	550	426,000	1
VSS, mg/L	35	6,930	1.5
COD, mg/L	33	38	5
TOC, mg/L	3.5	14	3
Toxic pollutants, μg/L, except as noted			
Antimony	<200	<200	<200
Arsenic	1.5	75.5	<1
Beryllium	13.5	37.5	<5
Cadmium	27.5	140	10
Chromium	65	2,150	25
Copper	740	9,350	<20
Lead	65	5,550	60
Mercury	<1	45	<1
Nickel	100	1,800	75
Selenium	4.5	75	<5
Silver	<50	450	<50
Thallium	<100	<100	<100
Zinc	1,680	18,750	25
Asbestos, fibers/L,			
Total	6.05×10^9	1.45×10^{12}	4.2×10^6
Chrysotile	9.56×10^8	3.7×10^8	1.5×10^5
Total cyanides, mg/L	<0.02	0.32	0.048
Total phenols, mg/L	0.009	<0.004	<0.002
1,1,1-Trichloroethane	0.99	0.352[b]	0.63
Chloroform	0.065	0.035[b]	4.6
Methylene chloride	2.9	2.10	2.5
β-BHC	<10[b,c]	ND	ND
Diethyl phthalate	0.007[b]	0.058[b]	ND
Aldrin	-[d]	ND	<10[c]
γ-BHC	-[d]	ND	ND
α-BHC	ND	<10[c]	ND
Trichlorofluoromethane	ND	0.061[b]	ND
Toluene	ND	0.226	ND
Dichlorobromomethane	ND	ND	0.02[b]
Butyl benzyl phthalate	ND	ND	0.418
Other pollutants, μg/L			
Molybdenum	9,150	14.5	5.5

[a]Data based on screening sampling (average of two values except where noted).

[b]One sample only.

[c]Unconfirmed.

[d]Detected as <10 μg/L in one sample but not confirmed.

TABLE 11-12. WASTEWATER CHARACTERIZATION, MINE 9202[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Mercury
Wastewater treatment description: Total recycle
Discharge method: None
Effluent flowrate: 0 m^3/d

Pollutant	Mine water and wastewater characterization: Tailings pond influent	Decant water from recycle sump
Classical pollutant		
pH	8.00	8.30
TSS, mg/L	139,000	1.6
VSS, mg/L	4,300	<1
COD, mg/L	60	22
TOC, mg/L	<1	13
Toxic pollutants, µg/L, except as noted		
Antimony	53,000	200
Arsenic	1,100	110
Beryllium	90	<20
Cadmium	560	6
Chromium	460	15
Copper	850	50
Lead	1,000	<20
Mercury	230,000	50
Nickel	1,600	<20
Selenium	<10	<5
Silver	10	<10
Thallium	200	<100
Zinc	2,400	40
Asbestos, fibers/L,		
Total	1.3×10^{12}	7.7×10^{8}
Chrysotile	1.5×10^{11}	5.7×10^{7}
Total cyanides, mg/L	<0.05	<0.02
Total phenols, mg/L	0.92	0.22
2,4-Dimethylphenol	140	270
Phenol	76	66
Bis(2-ethylhexyl) phthalate	9.2	15
Di-n-butyl phthalate	56	40
Diethyl phthalate	66	9.6
Ethylbenzene	ND	8.8
Dimethyl phthalate	ND	9.5

[a] Data based on screening sampling.

TABLE 11-13. WASTEWATER CHARACTERIZATION, MINE/MILL 9905[a] [1,2]

Category: Ore Mining and Dressing
Subcategory: Metal Ore Not Elsewhere Classified
Wastewater treatment description: Settling, partial recycle
Discharge method: To surface
Effluent flowrate: 2.65×10^3 m^3/d (7.01×10^5 gpd); varies with precipitation

Pollutant	Plant water and wastewater characterization: Mine pit effluent	Raw mill water	Treated mill water to recycle
Classical pollutants			
pH	7.95	7.50	7.65
TSS, mg/L	<1	57,900	<1
VSS, mg/L	<1	<1	<1
COD, mg/L	2	47	4
TOC, mg/L	8	3	5
Toxic pollutants, μg/L, except as noted			
Antimony	<50	200	100
Arsenic	<2	<10	<2
Beryllium	<2	<2	<2
Cadmium	<5	<5	<5
Chromium	<10	740	<10
Copper	20	880	100
Lead	20	50	40
Mercury	<0.5	<0.5	<0.5
Nickel	<20	630	40
Selenium	<5	15	<5
Silver	<10	<10	<10
Thallium	<100	<100	<100
Zinc	20	3,500	20
Asbestos, fibers/L,			
Total	1.9×10^6	7.1×10^9	1.5×10^8
Chrysotile	1.4×10^5	1.1×10^9	1.3×10^6
Total cyanides, mg/L	<0.02	<0.02	<0.02
Total phenols, mg/L	0.03	0.01	0.01
Bis(2-ethylhexyl) phthalate	12	ND	7.4
Di-n-butyl phthalate	6.3	ND	ND
Chloroform	ND	ND	1.1
Methylene chloride	ND	ND	8
Toluene	ND	ND	0.44
Ethylbenzene	ND	7.2	ND

[a]Data based on screening sampling.

Land quantities of sludge may be produced that may be disposed of in an abandoned mine.

Settling is used at mine/mill 1108, where the tailing-pond effluent is treated with alum, followed by polymer addition and secondary settling to reduce suspended solids from approximately 200 mg/L to an average of 6 mg/L. At mine/mill 3121, initiation of the practice of polymer addition to the tailings has greatly improved the treatment system capabilities. Mean concentrations of total suspended solids, lead, and zinc in the tailing-pond effluent were reduced by 64%, 43%, and 17%, respectively, over those previously attained as shown in Table 11-14.

TABLE 11-14. IMPROVEMENT IN TREATMENT SYSTEM CAPABILITY RESULTING FROM POLYMER ADDITION TO EFFLUENT AT MINE/MILL 3121

	Effluent levels attained prior to use of polymer, mg/L		Effluent levels attained subsequent to use of polymer, mg/L	
Parameter	Mean	Range	Mean	Range
TSS	39	15 - 80	14	4 - 34
Pb	0.51	0.24 - 0.80	0.29	0.14 - 0.67
Zn	0.46	0.23 - 0.86	0.38	0.06 - 0.69

Similarly, the use of a polymer at mine 3130 reduced mean concentrations of total suspended solids, lead and zinc in treated effluent by 89%, 76%, and 41%, respectively, over those attained prior to use of polymer as shown in Table 11-15.

TABLE 11-15. IMPROVEMENT IN TREATMENT SYSTEM CAPABILITY RESULTING FROM POLYMER ADDITION TO EFFLUENT AT MINE 3130

	Effluent levels attained prior to use of polymer and secondary settling pond[a], mg/L		Effluent levels attained subsequent to use of polymer and secondary settling pond[a], mg/L	
Parameter	Mean	Range	Mean	Range
TSS	19	4 - 67	2	0.2 - 6.2
Pb	0.34	0.11 - 1.1	0.08	<0.05 - 0.10
Zn	0.45	0.23 - 1.1	0.32	0.18 - 0.57

[a]Secondary settling pond with 0.5-hour retention time.

Filtration is used as a polishing or pretreatment step to primary treatment methods. Microscreens or granular-media filtration are used to remove solids from wastewater. Both full-scale and pilot-scale operations are currently being studied by this industry. A full-scale multimedia filtration unit is currently in operation at molybdenum mine/mill 6102. The filtration system consists of four individual filters, each composed of a mixture of anthracite, garnet and pea gravel. This system functions as a polishing step following settling, ion exchange, lime precipitation, electrocoagulation, and alkaline chlorination. Since its startup in July 1978, the filtration unit has been operating at a flow of 63 L/s (1,000 gpm) and four months of monitoring data have demonstrated significant reductions in TSS, iron, and zinc. Suspended-solids concentrations have been reduced by approximately 92%, from an average 62 mg/L to less than or equal to 5 mg/L. Zinc removals from 0.08 mg/L (influent) to 0.06 mg/L (effluent) and iron removals of 0.50 mg/L (influent) to 0.38 mg/L (effluent) have also been achieved.

Cyanide is often used in the beneficiation process for several ores and is normally present in the wastewater. Because of its toxicity, treatment methods are needed to reduce cyanide concentration. Alkaline chlorination and ozonation are two methods being used to achieve cyanide destruction.

A full-scale system has been implemented at mill 6102 for cyanide reduction. The unit is an integral part of a total treatment system employing lime precipitation, electrocoagulation-flotation, alkaline chlorination, and multimedia filtration, followed by final pH adjustment. The alkaline-chlorination system involves on-site generation of sodium hypochlorite by electrolysis of sodium chloride. The hypochlorite is injected into the wastewater following the elctrocoagulation-flotation process and immediately preceding the filtration unit. At this point in the system, some cyanide removal has already been realized incidental to the lime precipitation-electrocoagulation treatment. Operating data from the first four months show the concentration of cyanide at 0.09 mg/L prior to the electrocoagulation unit. Concentrations of cyanide progressively decrease from 0.04 mg/L (electrocoagulation effluent) to less than or equal to 0.01 mg/L after filtration and less than 0.01 mg/L after the final retention pond. Mill personnel expect this removal efficiency to continue throughout the optimization period of the system. The problem of chlorine residuals elevated levels has not yet been resolved.

Ozonation tests in the laboratory showed substantial destruction of cyanide. Although the target level of less than 0.025 mg/L of cyanide was not achieved and the tests under pilot-plant conditions showed less favorable results, ozonation did result in substantial removal of manganese as well as cyanide.

Phenolic compounds are also used to dress the raw ores. The low-concentration, high-volume phenolic wastes generated lend themselves most readily to treatment by chemical oxidation or aeration. Aeration is the only treatment currently in use although phenols may be incidentally reduced by treatment of traditional parameters such as TSS. No individual plant data on the treatment systems used are currently available.

Radium 226, a product of the radioactive decay of uranium, occurs in both dissolved and insoluble forms and is found in wastewater resulting from uranium mining and milling. Coprecipitation of radium with a barium salt is typically used for wastestream removal of radium. Dosages vary from 10 mg/L to 300 mg/L depending on the characteristics of the wastestream.

At uranium mine/mill 9452, a unique mine-water treatment system exists that employs radium 226 ion exchange in addition to flocculation, barium chloride coprecipitation, settling, and uranium ion exchange. The mine water to be treated is pumped from an underground mine to a mixing tank where flocculant is added. The water is then settled in two ponds, in series, before barium chloride is added. After barium chloride addition, the water is mixed and flows to two additional settling ponds (also in series). The decant from the final pond is acidified before it proceeds to the uranium ion-exchange system. The effluent from the uranium ion exchange column is pumped to the radium 226 system. After treatment for removal of radium 226, the final effluent is pumped to a holding tank for either recycle to the mill or discharge. The unique feature of this treatment approach is the radium 226 ion exchange system, which consists of two up-flow ion exchange columns operated in parallel. Each column is constructed of fiber-reinforced plastic (FRP) and contains approximately 11.3 m^3 (400 ft^3) of resin, supported on a FRP distribution plate. Mining personnel have estimated that the theoretical life of the resin at the present loading is 50,000 years. The total treatment system at mine/mill 9452 is capable of reducing radium 226 from levels of 955 picocuries/L (total) and 93.4 picocuries/L (dissolved) to 7.18 picocuries/L (total) and less than 1 picocurie/L (dissolved). This performance represents 99.2% removal of total radium 226 and greater than 98.9% removal of dissolved radium 226.

Asbestos is often found in the ores from this industry. Although several bench-scale and pilot-scale plants have been proposed, only settling ponds are currently in use. For mill treatment systems consisting primarily of tailing ponds and settling or polishing ponds, some facilities have demonstrated reductions of 10^4 and 10^5 fibers/L. Examination of these treatment systems indicates several factors in common: high initial suspended-solids loading, effective removal of suspended solids, large systems or systems with long residence times, and/or the presence of additional settling or polishing ponds.

Other methods, which are used to a lesser extent and normally in the pilot-plant stage, include: flocculation, centrifugation, oxidation, adsorption, and solvent extraction.

II.11.5 REFERENCES

1. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Ore Mining and Dressing Point Source Category, Volumes I and II. U.S. Environmental Protection Agency, Washington, DC, July 1978.

2. Development Document for BAT Effluent Limitations Guidelines and New Source Performance Standards for the Ore Mining and Dressing Industry (draft contractor's report). Contract No. 68-01-4845, U.S. Environmental Protection Agency, Washington, DC, 25 September 1979.

3. NRDC Consent Decree. Industry Summary - Ore Mining and Dressing.

4. Environment Reporter, EPA Effluent Guidelines and Standards for Ore Mining and Dressing, (40CRF440, November 6, 1975; 41FR21191, May 24, 1976; 42FR3165, January 17, 1977, 43FR29771, July 11, 1978; 44FR7953, February 8, 1979; 44FR11546, March 1, 1979), pg 135:0881.

II.13 PAINT AND INK FORMULATION

II.13.1 INDUSTRY DESCRIPTION [1, 2]

The Paint and Ink Formulation Industry can be divided into two general categories: paint manufacturing and ink formulation. Each of these categories is described below. Table 13-1 summarizes information pertaining to the paint and ink formulation industry in terms of the number of subcategories and the number and types of dischargers in the industry [3].

TABLE 13-1. INDUSTRY SUMMARY [1-3]

Industry: Paint and Ink
Total Number of Subcategories: 4
Number of Subcategories Studied: 2

Number of Dischargers in Industry:

- Direct: 4
- Indirect: 1,211
- Zero: 845

The following limitations establish the quantity and quality of pollutants or pollutant properties which may be discharged by a point source resulting from the production of oil-base paint or oil-base ink (where the tank washing system uses solvents) after application of the best practicable control technology currently available: There shall be no discharge of process waste water pollutants to navigable waters [4, 5]. Appropriate BPT effluent limitations for water and/or caustic wash and solvent wash indirect dischargers are yet to be established.

II.13.1.1 General Description of the Paint Industry [1]

Overall, the paint industry consists of an estimated 1,400 to 1,600 manufacturing sites operated by 1,150 to 1,300 companies. The two major products of the paint industry (SIC 2851) are trade sales paints, which are primarily off-the-shelf exterior and interior paints for buildings and other structures, and industrial finishes, also called chemical coatings, which are sold to manufacturers for factory application to diverse products such as automobiles, aircraft, furniture, and machinery.

In addition to paints, the industry also produces varnishes and lacquers, which consist of film-forming binders (resins or drying oils) dissolved in volatile solvents or dispersed in water. All paints and most lacquers contain pigments and extenders such as calcium carbonate, clays, and silicates. Other common allied products produced by the paint industry are plasticols, epoxy compounds, asphaltic coatings, adhesives, sealants, paint removers and stains.

Paint manufacturers can also be classified by the percent of water base (also called latex-base) paints and the percent of solvent-base (or solvent-thinned) paints produced. Thirty-three percent of the paint plants produce 90 percent or more solvent-base paints but only 8 percent of the plants produce a like percentage of water-base paints. The "average" plant produces approximately 60 percent solvent-base paint and only 35 percent water-base paints. Generally, plants making primarily solvent-base paint produce mostly industrial coatings, while the plants dedicated to water-base products manufacture primarily trade sales products, with a high proportion of white or tint-base paints.

There is little difference in the production processes used to produce either solvent-base or water-base paints. The major production difference is the carrying agent; solvent-base paints are dispersed in an oil mixture, while water-base paints are dispersed in water with a biodegradable surfactant as the dispersing agent. The cleanup procedure also differs for each production process. Because the water-base paints contain surfactants, formulating tanks can be easily cleaned with water. Tanks used to make solvent-base paint are generally cleaned with an organic solvent, but cleaning with a strong caustic solution is also common practice.

The principal raw materials used in paint manufacture, in terms of pounds consumed, are oils, resins, pigments, and solvents. Drying oils, such as linseed oil, are used as the film-forming binder in some solvent-base paints. Semidrying oils are used in the manufacture of water-base (latex) paints.

The paint industry is a large consumer of solvents, which are used as the volatile vehicles in coatings and certain specialty products. Mineral spirits, toluene, xylene, naphtha, ketones, esters, alcohols, and glycols are the major solvents used. In addition, the industry consumes a wide variety of other additives and chemical specialties such as dryers, bactericides and fungicides, defoamers, dispersants, and thickeners.

All paints are generally made in batches. Batch size is an indicator of paint plant size. A small paint plant will produce batches of 400 to 1,900 liters (100 to 500 gallons), while a large plant will manufacture batches up to 23,000 liters (6,000 gallons). Because of the large number of color formulations generally produced, a continuous process is not feasible.

Solvent-Base Paint Production

The three major steps involved in the solvent-base paint manufacturing process are (1) mixing and grinding of raw materials, (2) tinting and thinning, and (3) filling operations.

At most plants, the mixing and grinding of raw materials for solvent-base paints are accomplished in one production step. For high-gloss paints, the pigments and a portion of the binder and vehicle are mixed into a paste of specified consistency. The paste is fed to a grinder or mill, which disperses the pigments by breaking down particle aggregates rather than reducing the particle size. For other paints, raw materials are mixed and dispersed in a mixer.

Following the mixing and grinding of raw materials, the paint is transferred to tinting and thinning tanks in which the remaining binder and liquid, as well as various additives and tinting colors, are incorporated. The paint is then analyzed, and the composition is adjusted as necessary to obtain the correct formulation for the type of paint being produced. The finished product is then transferred to a filling operation for filtering, packaging, and labeling.

Water-Base Paint Production

The pigments and extending agents for water-base paints are usually received in proper particle size, and the dispersion of the pigment, surfactant, and binder into the vehicle is accomplished with a saw-toothed high-speed dispenser. In small plants, the paint is thinned and tinted in the same tank; in larger plants, the paint is transferred to special tanks for final thinning and tinting. Once the formulation is correct, the paint is transferred to a filling operation for filtering, packaging, and labeling.

Other Manufacturing Operations

Some of the large paint plants manufacture their own synthetic resins such as the usual alkyd resin, a water-soluble alkyd resin, or an acrylic resin. For the purposes of this manual, the wastewater resulting from the manufacture of such resins is not associated with the paint industry; hence, it is not further discussed herein.

Following the production of either solvent- or water-base paints, considerable waste or "clingage" remains affixed to the sides of the preparation tanks. Three specific methods of tank cleaning are used in the paint industry: (1) solvent wash, (2) caustic wash, and (3) water wash. Solvent wash is used exclusively for cleaning tanks used for solvent-base paint formulation. When solvent washing is used in solvent-base operations, essentially no wastewater is discharged. Caustic-wash techniques may be used to clean both solvent-base and water-base paint manufacturing tanks. Water-wash techniques are also used in both the solvent-base and water-base segments of the industry. For solvent-base operations, water washing is usually used only to follow the caustic washing of solvent-base tanks. For water-base operations, water washes often constitute the only tank cleaning operation. However, periodic caustic cleaning of water-base paint is also a common practice.

Because the paint industry has simple technology and low capital investment, it includes many small companies. About 41 percent of the companies have less than 10 employees and account for less than 5 percent of industry sales. According to the Kline Guide, the four largest companies (Sherwin Williams, Du Pont, PPG Industries, and SCM-Glidden) accounted for over 30 percent of industry sales in 1974. Total paint production in 1974 was valued at $3.67 billion ($1.87 billion from trade sales and $1.80 billion from industrial finishes).

Geographically, paint plants tend to be clustered around population centers, due to the expense of transporting paint long distances. Approximately 46 percent of all paint plant sites are contained in five states (California, New Jersey, New York, Illinois, and Ohio) and 87 percent in twenty states.

II.13.1.2 General Description of the Ink Industry [2]

The printing ink industry (SIC 2893) includes establishments primarily engaged in the manufacture of printing ink; it does not include captive ink establishments that produce ink only for use within the parent plant. Captive plants are considered to be contained in SIC 27, which includes printed items manufactured as final products.

The printing ink industry consists of an estimated 460 to 500 manufacturing sites operated by approximately 200 companies. The plant sites are dispersed throughout the nation with higher concentrations in the North Central and Coastal Areas. Five states (California, Illinois, New Jersey, New York, and Ohio) contain 42 percent of the plants and ten states include 65 percent. Plants are located near population centers due to transportation costs and the need to be near customers. A large majority (71 percent) of the ink manufacturing facilities are small and employ less than 20 personnel.

Ink Production

Ink production involves three major ingredients: the vehicle, pigment, and drying agent. The vehicle, normally water or solvent, is used to transport the pigment, which may be either an inorganic or organic compound. The drying agent may be a separate compound or the vehicle for the ink. The drying agent aids in the preliminary fixing of the ink on the surface and functions by oxidation, absorption, or evaporation.

In the ink industry, the primary plant operation is the blending of the ingredients to produce various sized batches of ink. Blending is accomplished with the use of high-speed mixers and/or a wide variety of mixing mills. The blending occurs in a series of steps, normally one or two; the number of steps depends on the dispersion characteristics of the ingredients. Ink is often custom manufactured and may be continuously produced, as in newspaper inks, or batch produced in quantities as small as five pounds.

After the ink product has been removed, the formulation tub is normally cleaned. A solvent-base solvent wash is often used to clean solvent-base ink from a tub. A caustic wash, followed by a water rinse, is also commonly used for solvent-base inks. This technique is also used for water-base inks, although a water-only wash is more common. This water can be reused or treated and released.

Major Types of Ink

There are four major types of ink; each type has its own ingredients and characteristics. Letterpress inks are viscous tacky pastes that use an oil or varnish base and dry by oxidation of the vehicle. Lithographic inks are similar to letterpress inks but have a higher concentration of pigment to offset the thinner film used in printing this type of ink. Flexographic inks are liquids that may be solvent or water-based and dry by evaporation, absorption, or decomposition. Gravure ink is a liquid that dries by solvent evaporation and used for a variety of purposes. Varnish, an allied product of the industry, is produced by 20 percent of the ink formulation plants.

Product Mix

Approximately half of the plants in the ink industry specialize primarily in either paste or liquid ink. The remaining half produce both types of ink, with a wide variety of fractional mix. An "average" plant, based on all plants, produces 65 percent paste ink and 35 percent liquid ink. Ink manufacturers may also be classified by the percentage of water-base ink and solvent- or oil-base ink produced. Thirty-seven percent of the plants produce

100 percent solvent- or oil-base ink, and only 3 percent produce 100 percent water-base ink.

Using this type of classification, the "average" plant would produce 60 percent oil-base ink, 25 percent solvent-base ink, and 15 percent water-base ink. Plants that manufacture primarily solvent- and oil-base ink also produce primarily paste inks; plants that manufacture primarily water-base ink produce primarily liquid inks.

II.13.1.3 Subcategory Description

The paint and ink formulation industry is divided into the following two subcategories based on the tank cleaning techniques used: (1) water-wash and/or caustic-wash, and (2) solvent-wash (solvent-base solvent-wash).

Water-Wash and/or Caustic-Wash Subcategory

This subcategory encompasses those facilities using either water-wash or caustic-wash operations to clean their formulation tanks. Rinse waters generated following caustic wash are sometimes less concentrated than wastewaters generated exclusively from water rinse, although the pollutants contained in these two types of wastewater are similar. Consequently, the methods of treatment and disposal are essentially the same.

Solvent-Wash (Solvent-Base Solvent-Wash) Subcategory

This subcategory encompasses those facilities using solvent-wash operations to clean their formulation tanks. Effluent Limitations Guidelines for the solvent-base solvent-wash have already been promulgated except for existing indirect dischargers (EPA 440/1-75, 050a). Hence, solvent-base wash operations will not be considered

II.13.2 WASTEWATER CHARACTERIZATION

The paint industry, in total, generates approximately 5.7 million liters (1.5 million gallons) of process wastewater daily. About half of this water is actually discharged; the other half is reused by paint plants, evaporated, or drummed for disposal as a solid waste. The ink industry, on the other hand, generates about 150,000 liters (40,000 gallons) of wastewater daily, of which 75 percent is actually discharged. For the purposes of this manual, process water is defined as only that wastewater which has an opportunity to contact paint solids, such as tank or filling equipment wash water, caustic-wash rinse water, and floor wash water. Other wastewaters, such as sanitary or noncontact cooling water, are not considered to be part of the process wastewater stream.

The percentage of solvent-base and water-base paints or inks produced is the most important factor that affects the volume of process wastewater generated and discharged at both paint and ink plants. Due to their greater use of water-wash, plants producing 90 percent or more water-base paint (or ink) discharge more wastewater than plants producing 90 percent or more solvent-base paint (or ink). Additional factors influencing the amount of wastewater produced include the pressure of the rinse water and the existence or absence of floor drains. Where no troughs or floor drains exist, equipment is often cleaned by hand with rags; when wastewater drains are present, there is a greater tendency to use hoses.

II.13.2.1 Water-Wash and/or Caustic-Wash Subcategory

Batch mixing tanks for water-base paint (or ink) that are rinsed with water generate considerable quantities of wastewater. The spent tank and equipment rinse water is usually handled in one of four ways: (1) reuse in the next compatible batch of paint (or ink) as part of the formulation, (2) reuse either with or without treatment, to clean tanks and equipment until spent (if sludge settles out, it is disposed of as a solid waste), (3) discharge with or without treatment as wastewater, and (4) disposal as a solid waste.

Plants that use caustic-rinse systems usually rinse the residue with water, although a few plants allow the caustic to evaporate from the tanks. Evaporation of caustic solution, however, can leave a residue that will interfere with some types of paint formulas. There are two major types of caustic systems commonly used by the paint and ink industries. In one type of system, caustic is maintained in a holding tank (usually heated) and is pumped into the tank to be cleaned. The caustic drains to a floor drain or sump where it is returned to the holding tank. In the second type of system, a caustic solution is prepared in the tank to be cleaned, and the tank is soaked until clean. Most plants using caustic reuse the solution until it loses some of its cleaning ability. At that time, the caustic is disposed of either as a solid waste or wastewater, with or without treatment.

The water rinse following a caustic wash is rarely reused in a subsequent batch of paints (or ink). Generally, any generated wastewater is combined with the regular clean-up water, and disposed of by one of the same methods.

II.13.2.2 Solvent-Wash (Solvent-Base Solvent-Wash) Subcategory

Batches of solvent-base paint or ink that are rinsed with solvent ordinarily generate no wastewater. The used solvent is generally (1) used in the next compatible batch of paint (or ink) as part of the formulation, or (2) collected and redistilled, either by the plant or by an outside company, for subsequent reuse or resale, or (3) reused with or without settling to clean tanks and equipment until spent, and then drummed for disposal. If sludge settles out, it is also drummed for disposal as a solid waste.

In addition to process wastewater generated as a result of tank and equipment cleaning, there are other sources of pollutants within the typical paint or ink plant and these include: (1) bad or spoiled batches that are not reused in other products or discharged as a solid waste, and (2) residue from spills that is discharged to the sewer or combined with other wastewater.

Tables 13-2 and 13-3 present information on the toxic and classical pollutants found in detectable concentrations for the plant water supply, raw wastewater, and treated effluents for the "water-wash and/or caustic-wash" subcategory of the paint industry. Similar data are presented in Tables 13-4 and 13-5 for the ink industry. Values for both the paint and ink industries were generated from verification and field sampling results representing 22 paint plants and 6 ink plants.

Not included in Table 13-2 are 19 toxic pollutants of concentratio less than 10 mg/L that were detected in one or more samples of the untreated wastewater. They are acrolein, 2-chloronapthalene, 3,3'-di-chlorobenzidine, 2,4-dichlorophenol, fluoranthene, bis(2-chloroethoxy) methane, 4,6-dinitro-o-cresol, diethyl phthalate, benzo(a)pyrene, anthracene, aldrin, dieldrin, 4,4'-DDE, b-endosulfan, heptachlor epoxide, a-BHC, b-BHC, q-BHC, and w-BHC.

Also not included in Table 13-2 are eight toxic pollutants found in one or more treated effluent samples above the detectable limit and eleven toxic pollutants detected once or twice at less than 10 mg/L. The pollutants found in one or more treated effluent samples above the detectable limits are arsenic, selenium, 1,2-dichloropropylene, bis(2-chloroethoxy) ether, 2,4-dinitrophenol, di-n-octyl phthalate, butyl benzyl phthalate, and dimethyl phthalate. The pollutants detected once or twice at less than 10 mg/L are chlorobenzene, chloroethane, 1,2-diphenylhydrazine, diethyl phthalate, acenaphthylene, anthracene, phenanthrene, 4,4'-DDD, b-endosulfan, endrin aldehyde, and b-BHC.

Eighteen additional toxic pollutants not reported in Table 13-2 were found in one or more tap water samples. They are chlorobenzene, arsenic, selenium, 2,4,6-trichlorophenol, 3,3'-dichlorobenzidene, 2,4-dichlorophenol, 2,4-dinitrotoluene, fluoranthene, bromoform, butyl benzyl phthalate, diethyl phthalate, benzo(b)-fluoranthene, benzo(k)fluoranthene, anthracene, endrin aldehyde, a-BHC, b-BHC, and q-BHC. Quantitative values were not available.

Not included in Table 13-4 (for the ink industry) are 21 toxic pollutants that were detected in one or two samples of untreated wastewaters at concentrations less than 10 mg/L. They are acenaphthene, 1,2,4-trichlorobenzene, 2,4,6-trichlorophenol, p-chloro-m-cresol, 1,2-dichlorobenzene, 1,4-dichlorobenzene,

TABLE 13-2. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN PAINT PLANT WASTEWATER AND INTAKE [1] (μg/L)

Toxic pollutant	Untreated wastewater: Number of: Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum	Treated wastewater: Number of: Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum
Metals and inorganics												
Antimony	49	49	9	72	25	1,000	43	43	4	28	25	180
Arsenic	41	41	22	120	52	800						
Beryllium	51	51	9	13	<10	100	45	45	1	9	<10	20
Cadmium	51	51	22	80	20	810	45	45	10	29	20	200
Chromium	51	51	42	2,900	200	40,000	45	45	24	1,300	50	30,000
Copper	51	51	50	2,300	500	40,000	45	45	36	2,000	120	60,000
Cyanide	54	54	9	73	20	310	48	48	10	51	20	530
Lead	51	51	37	6,300	800	80,000	45	45	17	1,100	200	40,000
Mercury	50	50	40	10,000	1,100	120,000	45	45	35	830	200	4,400
Nickel	51	51	14	1,000	50	40,000	45	45	12	3,500	50	80,000
Silver	51	51	5	16	<10	100	42	42	32	13,000	2,100	100,000
Thallium	51	51	8	17	<10	200	45	45	3	12	<10	100
Zinc	51	51	49	84,000	10,000	900,000	45	45	31	8,500	1,000	100,000
Phthalates												
Bis(2-ethylhexyl) phthalate	27	9	8	500	140	2,800	23	7	2	33	<10	160
Di-n-butyl phthalate	27	18	13	8,000	260	69,000	23	9	4	310	<10	1,300
Phenols												
Pentachlorophenol	27	6	5	6,000	750	27,000	23	6	3	120	11	490
Phenol	27	8	7	1,000	110	3,800	23	13	7	140	16	1,200
Aromatics												
Benzene	27	17	17	2,000	440	9,900	23	14	12	680	310	3,800
Ethylbenzene	27	21	21	2,600	1,200	15,000	23	15	13	5,800	370	74,000
Nitrobenzene	27	3	2	100	110	180	23	17	17	1,800	960	7,200
Toluene	27	23	23	20,000	2,500	260,000	23	10	8	78	15	300
Polycyclic aromatic hydrocarbons												
Naphthalene	27	9	8	3,000	54	18,000	23	7	4	380	16	1,800
Halogenated aliphatics												
Carbon tetrachloride	27	8	7	3,800	14	30,000	23	3	2	640	120	1,800
Chlorodibromomethane	27	0	0			0	23	0	0			0
Chloroform	27	14	14	200	108	900	23	15	14	390	34	4,700
Dichlorobromomethane	27	1	1	27	27	27	23	0	0			0
1,1-Dichloroethane	27	1	0	<10	<10	<10	23	2	1	95	95	180
1,2-Dichloroethane	27	5	4	120	33	420	23	4	3	71	53	170
1,1-Dichloroethylene	27	5	3	140	23	620	23	4	2	19	11	44
1,2-*Trans*-dichloroethylene	27	2	1	140	135	260	23	6	4	51	27	190
1,2-Dichloropropane	27	3	2	330	12	970	23	2	2	210	210	400
Methylene chloride	27	17	17	34,000	790	210,000	23	19	19	5,600	1,700	31,000
Tetrachloroethylene	27	17	16	600	230	4,900	23	8	7	190	35	700
1,1,1-Trichloroethane	27	15	14	150	82	930	23	14	10	89	29	560
1,1,2-Trichloroethane	27	5	2	570	<10	2,800	23	4	3	930	810	2,100
Trichloroethylene	27	15	<10	90	52	250	23	10	8	78	15	300
Pesticides and metabolites												
Isophorone	27	0	0			0	23	2	2	110	110	200

(continued)

TABLE 13-2 (continued)

Toxic pollutant	Sludge: Number of Samples analyzed	Sludge: Number of Times detected	Sludge: Number of Times detected above min	Sludge: Average	Sludge: Median	Sludge: Maximum	Intake water: Number of Samples analyzed	Intake water: Number of Times detected	Intake water: Number of Times detected above min	Intake water: Average	Intake water: Median	Intake water: Maximum
Metals and inorganics												
Antimony	11	11	5	1,700	25	13,000	20	20	2	12	<10	25
Arsenic												
Beryllium	31	31	18	20	20	100	21	21	1	8	<10	20
Cadmium	31	31	20	170	100	600	21	21	7	31	20	200
Chromium	31	31	29	7,300	700	90,000	21	21	8	43	20	200
Copper	31	31	31	7,800	1,000	80,000	21	21	11	150	60	700
Cyanide	31	31	4	1,300	20	36,500	22	22	2	20	20	93
Lead	31	31	29	11,000	3,000	80,000	20	20	4	130	100	400
Mercury	31	31	26	29,000	2,300	220,000	21	21	10	290	0	6,000
Nickel	31	31	21	12,000	100	200,000	20	20	2	41	20	200
Silver	31	31	7	23	<10	100	21	21	1	<10	<10	30
Thallium	4	4	0	<200	<200	<200	19	19	0	11	<10	20
Zinc	31	31	29	270,000	100,000	2,000,000	20	20	13	1,200	600	8,000
Phthalates												
Bis(2-ethylhexyl) phthalate	7	6	4	570	410	1,900	25	3	0	<10	<10	<10
Di-n-butyl phthalate	7	5	4	3,600	70	18,000	25	4	0	<10	<10	<10
Phenols												
Pentachlorophenol	7	4	4	350	130	1,100	25	1	0	<10	<10	<10
Phenol	7	4	3	400	240	1,100	25	0	0			0
Aromatics												
Benzene	7	5	4	410	30	1,900	25	11	9	90	16	570
Ethylbenzene	7	6	6	18,000	240	99,000	25	3	2	163	61	420
Nitrobenzene	7	0	0			0	25	1	0	<10	<10	<10
Toluene	7	6	6	59,000	1,300	350,000	25	9	3	310	<10	2,700
Polycyclic aromatic hydrocarbons												
Naphthalene	7	4	3	370	200	1,100	25	0	0			0
Halogenated aliphatics												
Carbon tetrachloride	7	2	0	<10	<10	<10	25	3	2	13	14	15
Chlorodibromomethane	7	0	0			0	25	10	4	22	<10	110
Chloroform	7	2	2	920	920	1,000	25	15	12	130	41	570
Dichlorobromomethane	7	0	0			0	25	13	8	26	15	86
1,1-Dichloroethane	7	0	0			0	25	0	0			0
1,2-Dichloroethane	7	0	0			0	25	0	0			0
1,1-Dichloroethylene	7	0	0			0	25	9	3	13	<10	40
1,2-*Trans*-dichloroethylene	7	0	0			0	25	0	0			0
1,2-Dichloropropane	7	0	0			0	25	0	0			0
Methylene chloride	7	7	7	170,000	2,600	900,000	25	17	16	430	67	2,200
Tetrachloroethylene	7	5	4	2,100	170	8,200	25	2	1	25	25	40
1,1,1-Trichloroethane	7	7	4	870	14	3,200	25	11	6	36	18	110
1,1,2-Trichloroethane	7	0	0			0	25	2	1	14	14	18
Trichloroethylene	7	5	2	45	<10	130	25	4	0	<10	<10	<10
Pesticides and metabolites												
Isophorone	7	0	0			0	25	0	0			0

TABLE 13-3. CONCENTRATIONS OF CLASSICAL POLLUTANTS FOUND IN PAINT PLANT WASTEWATER AND INTAKE [1]
(mg/L except as noted)

	Untreated wastewater						Treated wastewater					
	Number of						Number of					
Pollutant	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum
BOD_5	54	54	54	9,900	4,900	66,000	48	48	46	5,300	3,500	32,000
COD	54	54	54	56,000	40,000	350,000	47	47	47	21,000	11,000	260,000
TOC	49	49	49	10,000	8,500	34,000	44	44	44	4,000	2,800	25,000
TSS	51	51	51	20,000	13,000	150,000	48	48	48	2,000	240	22,000
Total phenols[a]	54	54	47	290	140	1,900	49	49	43	230	90	1,900
Oil and grease	50	50	50	1,200	980	3,400	43	43	42	230	24	1,700
pH[b]	53	53	53		7	12	46	46	46		7	11

	Sludge						Intake water					
	Number of						Number of					
Pollutant	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum
BOD_5	31	31	31	26,000	12,000	150,000	21	21	1	3	2	6
COD	32	32	32	190,000	140,000	950,000	22	22	13	10	6	40
TOC	31	31	31	37,000	30,000	110,000	20	20	18	8	8	20
TSS	31	31	31	100,000	70,000	470,000	20	20	17	3	3	11
Total phenols[a]	32	32	25	630	200	6,000	22	22	5	15	16	40
Oil and grease	30	30	30	8,600	2,900	130,000	18	18	4	1	1	5
pH[b]	29	29	29		7	12	20	20	20		7	9

[a]Values in µg/L.

[b]Values in pH units.

TABLE 13-4. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN INK PLANT WASTEWATER AND INTAKE [2] (µg/L)

	Untreated wastewater						Treated wastewater					
	Number of						Number of					
Toxic pollutant	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum
Metals and inorganics												
Antimony	9	9	3	310	25	2,200	1	1	1	<25	<25	<25
Arsenic	9	9	0	25	25	25						
Beryllium	9	9	0	8	<10	<10	1	1	0	<10	<10	<10
Cadmium	9	9	3	34	20	90	1	1	1	20	20	20
Chromium	9	9	9	38,000	20,000	200,000	1	1	1	<50	<50	<50
Copper	9	9	9	14,000	800	100,000	1	1	1	<60	<60	<60
Cyanide	10	10	8	330	110	2,000	1	1	1	30	30	30
Lead	9	9	9	170,000	50,000	900,000	1	1	1	<200	<200	<200
Mercury	7	7	3	170	11	1,100						
Nickel	9	9	0	44	50	50	1	1	1	<50	<50	<50
Silver	9	9	0	8	<10	<10	1	1	0	<10	<10	<10
Thallium	9	9	0	<10	<10	<10	1	1	0	<10	<10	<10
Zinc	9	9	6	4,400	1,000	20,000	1	1	1	1,000	1,000	1,000
Phthalates												
Bis(2-ethylhexyl) phthalate	9	6	2	15,000	<10	87,000	1	1	0	<10	<10	<10
Di-n-butyl phthalate	9	5	2	170	<10	770	1	1	0	<10	<10	<10
Phenols												
Pentachlorophenol	9	2	1	660	660	1,300	1	0	0			0
Phenol	9	5	2	120	<10	540	1	0	0			0
Aromatics												
Benzene	9	6	5	370	130	1,600	1	1	1	96	96	96
Ethylbenzene	9	3	3	4,200	5,500	6,700	1	1	1	2,400	2,400	2,400
Toluene	9	8	7	1,400	330	6,000	1	1	1	1,100	1,100	1,100
Polycyclic aromatic hydrocarbons												
Naphthalene	9	3	2	13	14	17	1	1	0	<10	<10	<10
Halogenated aliphatics												
Carbon tetrachloride	9	1	1	96	96	96	1	0	0			0
Chlorodibromomethane	9	1	1	43	43	43	1	0	0			0
Chloroform	9	4	2	37	14	110	1	0	0			0
Dichlorobromomethane	9	0	0			0	1	0	0			0
1,1-Dichloroethane	9	2	2	21	21	33	1	0	0			0
1,2-Dichloroethane	9	2	1	89	89	170	1	0	0			0
1,1-Dichloroethylene	9	3	1	15	<10	25	1	0	0			0
1,2-*Trans*-dichloroethylene	9	1	0	<10	<10	<10	1	0	0			0
1,2-Dichloropropane	9	1	1	22	22	22	1	0	0			0
Methylene chloride	9	4	4	1,100	820	2,900	1	1	1	29	29	29
Tetrachloroethylene	9	5	5	1,300	170	3,100	1	0	0			0
1,1,1-Trichloroethane	9	2	2	560	560	1,000	1	0	0			0
1,1,2-Trichloroethane	9	1	0	<10	<10	<10	1	0	0			0
Trichloroethylene	9	4	4	1,800	1,200	5,000	1	0	0			0
Pesticides and metabolites												
Isophorone	9	1	1	44,000	44,000	44,000	1	1	1	46	46	46

(continued)

TABLE 13-4 (continued)

Toxic pollutant	Intake water: Number of: Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum
Metals and inorganics						
Antimony	5	5	1	32	<10	100
Arsenic	5	5	0	25	25	25
Beryllium	6	6	0	8	<10	20
Cadmium	6	6	1	12	14	20
Chromium	6	6	5	370	50	2,000
Copper	6	6	5	110	80	300
Cyanide	7	7	0	20	20	40
Lead	6	6	4	3,500	150	20,000
Mercury	4	4	2	1	0	5
Nickel	6	6	0	28	30	50
Silver	6	6	0	5	6	<10
Thallium	5	5	0	<10	<10	<10
Zinc	6	6	1	350	400	600
Phthalates						
Bis(2-ethylhexyl) phthalate	7	2	1	87	87	160
Di-*n*-butyl phthalate	7	2	0	<10	<10	<10
Phenols						
Pentachlorophenol	7	0	0			0
Phenol	7	0	0			0
Aromatics						
Benzene	7	4	3	58	43	140
Ethylbenzene	7	0	0			0
Toluene	7	4	0	<10	<10	<10
Polycyclic aromatic hydrocarbons						
Naphthalene	7	0	0			0
Halogenated aliphatics						
Carbon tetrachloride	7	0	0			0
Chlorodibromomethane	7	2	1	42	42	74
Chloroform	7	6	4	99	28	350
Dichlorobromomethane	7	2	2	55	55	87
1,1-Dichloroethane	7	0	0			0
1,2-Dichloroethane	7	1	0	<10	<10	<10
1,1-Dichloroethylene	7	0	0			0
1,2-*Trans*-dichloroethylene	7	0	0			0
1,2-Dichloropropane	7	0	0			0
Methylene chloride	7	6	6	150	51	410
Tetrachloroethylene	7	0	0			0
1,1,1-Trichloroethane	7	1	0	<10	<10	<10
1,1,2-Trichloroethane	7	0	0			0
Trichloroethylene	7	1	0	<10	<10	<10
Pesticides and metabolites						
Isophorone	7	1	0	<10	<10	<10

TABLE 13-5. CONCENTRATIONS OF CLASSICAL POLLUTANTS FOUND IN INK PLANT WASTEWATER AND INTAKE [2] (mg/L except as noted)

	Untreated wastewater						Treated wastewater					
	Number of						Number of					
Pollutant	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum
BOD_5	10	10	10	14,000	1,500	73,000	1	1	1	2,600	2,600	2,600
COD	9	9	9	42,000	3,000	270,000	1	1	1	4,800	4,800	4,800
TOC	9	9	9	10,000	520	66,000	1	1	1	940	940	940
TSS	10	10	10	990	740	2,200	1	1	1	110	110	110
Total phenols[a]	10	10	10	240	98	700	1	1	1	30	30	30
Oil and grease	10	10	9	620	110	2,400	1	1	1	260	260	260
pH[b]	9	9	9		9	13	1	1	1		13	13

	Intake water					
	Number of					
Pollutant	Samples analyzed	Times detected	Times detected above min	Average	Median	Maximum
BOD_5	7	7	0	2	2	2
COD	6	6	5	12	11	25
TOC	6	6	6	8	8	13
TSS	6	6	6	3	2	6
Total phenols[a]	7	7	3	16	20	20
Oil and grease	7	7	3	2	1	5
pH[b]	7	7	7		7	8

[a]Values in µg/L.

[b]Values in pH units.

2,4-dimethylphenol, 2,4-dinitrotoluene, 2,6-dinitrotoluene, fluoranthene, bis(2-chloroisopropyl) ether, trichlorofluoromethane, N-nitrosodiphenylamine, butyl benzyl phthalate, dimethyl phthalate, chrysene, acenaphthylene, fluorene, phenanthrene, pyrene, and dieldrin. Also not included in Table 13-4 or 13-5 are ten toxic pollutants found in one or more of the tap water samples at less than the detectable limit. They are acenapthene, 1,2,4-trichlorobenzene, trichlorofluoromethane, butyl benzyl phthalate, diethyl and q-BHC.

II.13.3 PLANT SPECIFIC DESCRIPTION

Production characterization and statistics concerning wastewater generation and treatment for each of the 22 paint plants and 6 ink plants are presented in Table 13-6.

Table 13-7 through 13-10 present toxic pollutant and classical pollutant data for four of the 22 paint plants representing the "water-wash and/or caustic-wash" subcategory of the paint industry. Tables 13-11 through 13-14 present similar data for four of the six plants representative of the ink industry. Unless otherwise noted, all values are generated from screening data and averaged from two or more batches based upon batch sampling. Whenever a "less-than" quantity was encountered, its numerical value was used to determine the given average. Unless all of the values used in the determination were "less-than" quantities, the "F" symbol was dropped in the final average.

TABLE 13-6. PAINT AND INK PLANT CHARACTERIZATION [1, 2]

Plant code	Percent of production: Water thinned	Percent of production: Solvent thinned	Percent of pigments: Organic	Percent of pigments: Inorganic	Batch or continuous	Size of batch, gal	Major sources[a]	Wastewater generation: Liter H_2O/liter paint	Wastewater generation: Percent of flow to treatment process/cleaning	Percent reuse	Water pressure, lb/in²	Caustic washer, yes/no	Treatment type[b]	Chemicals used for treatment
Paint plants														
1	75	25	5	95	Batch	5,000	Wt	0.15[c]	100	0	50[d]	No	PC	Sodium bisulfate, anionic and cationic polymer
2	100	0	40	60	Batch	4,000	Wt	0.25	75	0	200	No	PC	Alum, potassium hydroxide
3	90	10	75	25	Batch	6,000	Wt	0.27	45	50	150	No	PC	Deerborn proprietary Aquafloc 409, polymer
4	100	0	5	95	Batch	5,500	Wt	0.3[c]	70	0	50[d]	No	PC	Aluminum sulfate, lime
5	35	65	15	85	Batch	5,700	Wt, CR	0.15[c]	65	0	50[d]	Yes	PC	Sodium aluminate Nalco 7722
6	100	0	15	85	Batch	4,000	Wt	0.1[c]	85	0	200	No	PC	Alum ferric, polymer caustic
8	75	25	5	95	Batch	4,800	Wt	0.16[c]	99	0	50[d]	Yes[e]	PC	Ferric chloride, polymer Aqua Ammonia
9	75	25	35	65	Batch	900	Wt	0.17	100	0	60[c]	Yes[e]	PC	Nalco 7742A
11	15	85	25	75	Batch	6,000	Wt	0.3	100	0	150	Yes[e]	GS	
12	10	90	20	80	Batch	700	CR	0.3	100	0		Yes	Neut	Phosphoric acid
13	65	35	45	55	Batch	300	Wt	0.15	100	0	75	No	PC	Nalco 3174
14	65	35	15	85	Batch	750	Wt	0.08	100	0	100	No	PC	Nalco 634
15	25	75	10	90	Continuous		Wt, St	0.04	100	0	50[d]	No	GS	Mobil Floc Resin 9000
16	50	50	10	90	Batch	1,500	Wt	0.13	100	50	50[d]	No	PC	Cosan C-Floc 18
17	85	15			Continuous		Wt	0.15	100	0	50[d]	No	PC	Alum, lime, soda ash, ferric chloride
18	65	35	10	90	Batch	1,000	Wt	0.25[c]	100	75	50[d]	No	PC	Caustic, ferrous sulfate, DuBois Floc 551
20	65	35			Batch	800	Wt	0.03[c]	100	25	50[d]	No	PC	Ferrous sulfate
24	100	0	15	85	Batch	6,000	Wt	0.7	100	0	125	Yes	PC	Drew Amerfloc
25	40	60	5	95	Batch	200	Wt, CP	0.23[c]	100	0	60[c]	Yes	PC	Ferric floc, sulfuric acid, caustic
26	65	35	5	95	Batch	25,000	Wt	0.31[c]	100	0	60[c]	No	PC	Sulfuric acid, lime
27	85	15	85	15	Batch	11,000	Wt	0.07		10	80	No	PC	Amerfloc, cationic polymer
28	65	35	5	95	Batch	300	Wt	0.13[c]	100	0	50[c]	Yes	PC	HCl, Cosan C-Floc
Ink plants														
7	30	70	60	40			WR					No		
10	25	75[c]	35	65			CR_2					Yes	GS	
19	0	100	5	95			CR_2					Yes		
21	35	65	15	85			WR, CR_1, C					No		
22	0	100	65	35			CR_1, CR_2, SC					Yes	GS, Sk, Neut	
23	20	80	65	35			CR_2					Yes	GS	

[a] Wt = water-thinned operation, St = Solvent-thinned operation, CR = caustic rinse, CR_1 = primary water rinse from caustic washer, CR_2 = secondary water rinse to caustic washer (primary rinse is recycled to caustic), WR = water rinse of ink tubs, SC = condensate from steam tub cleaner, C = spent caustic.

[b] PC = physical chemical, GS = gravity separation, Neut = neutralization, Sk = skimming.

[c] Estimated from 308 survey

[d] Estimate of city water pressure

[e] No discharge to treatment system

TABLE 13-7. WASTEWATER CHARACTERIZATION, PLANT 1 (PAINT)[a] [1]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic wash
Wastewater treatment description: Neutralization, settling and clarification, chemical treatment (alum, polymer)
Untreated wastewater flowrate, gpd: 1,000-6,000

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake[b]
Metals, µg/L				
Silver	13	<10	NA	30
Aluminum	220,000	5,000	NA	600
Arsenic	NA	NA	NA	NA
Barium	400	330	NA	100
Beryllium	<10	<10	NA	<10
Cadmium	<20	<20	NA	<20
Cobalt	2,200	320	NA	<50
Chromium	1,200	130	NA	100
Copper	400	77	NA	200
Iron	46,000	3,300	NA	2,000
Mercury	59	27	NA	0.8
Manganese	800	193	NA	<50
Molybdenum	30	60	NA	<50
Nickel	2,000	<50	NA	200
Lead	5,000	<200	NA	400
Antimony	<25	<25	NA	<10
Tin	500	<50	NA	200
Titanium	4,500	<200	NA	200
Thallium	<10	<10	NA	<10
Zinc	1,700	600	NA	1,000
Toxic organics, µg/L[b]				
Benzene	300	ND	NA	ND
Carbon tetrachloride	ND	ND	NA	<10
1,2-Dichloroethane	25	ND	NA	ND
1,1,1-Trichloroethane	ND	<10	NA	ND
1,1-Dichloroethane	ND	ND	NA	ND
1,1,2-Trichloroethane	ND	ND	NA	ND
Chloroform	160	ND	NA	45
1,1-Dichloroethylene	ND	<10	NA	ND
1,2-*Trans*-dichloroethylene	ND	ND	NA	ND
1,2-Dichloropropane	<10	ND	NA	ND
Ethylbenzene	1,300	390	NA	ND
Methylene chloride	4,800	110	NA	690
Dichlorobromomethane	ND	ND	NA	ND
Chlorodibromomethane	ND	ND	NA	ND
Isophorone	ND	ND	NA	ND
Naphthalene	ND	ND	NA	ND
Nitrobenzene	ND	ND	NA	ND
Pentachlorophenol	ND	ND	NA	ND
Phenol	ND	ND	NA	ND
Bis(2-ethylhexyl) phthalate	ND	<10	NA	ND
Di-n-butyl phthalate	ND	ND	NA	ND
Tetrachloroethylene	18	ND	NA	10
Toluene	2,700	720	NA	ND
Trichloroethylene	250	17	NA	10
Classical and others				
pH, pH units	7.0	6.4	NA	6
BOD, mg/L	3,000	2,800	NA	<2.4
COD, mg/L	51,000	13,000	NA	<5
TOC, mg/L	10,000	3,200	NA	<1
Oil and grease, mg/L	1,200	150	NA	<1
Cyanide, µg/L	<107	<80	NA	<20
Total phenol, µg/L	55	80	NA	12
TS, mg/L	16,000	5,600	NA	59
TDS, mg/L	5,100	3,100	NA	56
TSS, mg/L	11,000	2,600	NA	3
TVS, mg/L	11,000	4,300	NA	30
VSS, mg/L	5,300[c]	290	NA	2
Calcium, mg/L	150	<50	NA	<50
Magnesium, mg/L	22	3	NA	3
Sodium, mg/L	260	300	NA	<150

[a]All data from 3-batch sampling except as noted.
[b]Data from 1-batch sampling.
[c]Value from 2-batch sampling.

TABLE 13-8. WASTEWATER CHARACTERIZATION, PLANT 2 (PAINT)[a] [1]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic wash
Wastewater treatment description: Settling and clarification, chemical treatment (alum)
Untreated wastewater flowrate, gpd: 1,000-6,000

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake
Metals, μg/L[b]				
Silver	<10	<7	<8	<10
Aluminum	140,000	1,900	1,500,000	<500
Arsenic	NA	NA	NA	NA
Barium	26,000	<37	18,000	<50
Beryllium	<10	<7	27	<10
Cadmium	103	<15	270	60
Cobalt	1,000	40	2,600	<50
Chromium	1,300	40	1,800	100
Copper	400	110	800	<60
Iron	80,000	1,400	270,000	2,000
Mercury	<5	3.5	<5	<0.5
Manganese	320	630	4,700	70
Molybdenum	150	37	1,600	<50
Nickel	320	37	2,400	<50
Lead	350	150	2,000	<200
Antimony	15	<10[c]	<460[d]	12
Tin	300	700	2,000	200
Titanium	10,500	<140	40,000	<200
Thallium	<10	<10	NA	<10
Zinc	59,500	8,900	230,000	2,000
Toxic organics, μg/L				
Benzene	ND	ND	NA	ND
Carbon tetrachloride	ND	ND	NA	ND
1,2-Dichloroethane	ND	17	NA	ND
1,1,1-Trichloroethane	ND	ND	NA	ND
1,1-Dichloroethane	ND	<10	NA	ND
1,1,2-Trichloroethane	ND	ND	NA	ND
Chloroform	ND	22	NA	ND
1,1-Dichloroethylene	ND	ND	NA	ND
1,2-*Trans*-dichloroethylene	ND	ND	NA	ND
1,2-Dichloropropane	ND	ND	NA	ND
Ethylbenzene	ND	4,600	NA	420
Methylene chloride	85	ND	NA	ND
Dichlorobromomethane	ND	ND	NA	ND
Chlorodibromomethane	ND	ND	NA	ND
Isophorone	ND	ND	NA	ND
Naphthalene	ND	ND	NA	ND
Nitrobenzene	110	35	NA	ND
Pentachlorophenol	ND	ND	NA	ND
Phenol	96	ND	NA	ND
Bis(2-ethylhexyl) phthalate	ND	ND	NA	ND
Di-n-butyl phthalate	160	ND	NA	ND
Tetrachloroethylene	ND	45	NA	ND
Toluene	ND	ND	NA	ND
Trichloroethylene	210	190	NA	<10
Classical and others[b]				
pH, pH units	7.3	7.3	6.8	7
BOD, mg/L	2,500	2,900	50,000	<6
COD, mg/L	27,000	7,600	150,000	<5
TOC, mg/L	7,300	1,500	27,000	3
Oil and grease, mg/L	1,600	11	6,200	<1
Cyanide, μg/L	<65	<20	<80	<20
Total phenol, μg/L	107	70	<80	<10
TS, mg/L	17,000	8,600	126,000	1,100
TDS, mg/L	7,900	8,500	35,000	1,100
TSS, mg/L	8,900	50	74,000	6
TVS, mg/L	9,500	3,700	55,000	190
VSS, mg/L	6,700	13	32,000	2
Calcium, mg/L	290	240	503	190
Magnesium, mg/L	67	45	137	79
Sodium, mg/L	280	300	270	160

[a] All data from 1-batch sampling except as noted.

[b] Data for untreated wastewater from 4-batch sampling; data for treated effluent and for sludge from 3-batch sampling except as noted.

[c] Value from 2-batch sampling.

[d] Value from 1-batch sampling.

TABLE 13-9. WASTEWATER CHARACTERIZATION, PLANT 4 (PAINT)[a] [1]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic wash
Wastewater treatment description: Gravity separation, chemical treatment (alum, lime)
Untreated wastewater flowrate, gpd: 1,000-6,000

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake[b]
Metals, μg/L				
Silver	<10	<8	23	<10
Aluminum	37,000	7,700	700,000	<500
Arsenic	NA	NA	NA	NA
Barium	4,300	<43	18,000	<50
Beryllium	<10	<8	23.3	<10
Cadmium	47	<10	160	<20
Cobalt	67	<43	100	<50
Chromium	57	93	600	<50
Copper	500	63	1,700	<60
Iron	12,000	<2,000	220,000	<2,000
Mercury	9	2	40	<0.5
Manganese	97	<50	670	<50
Molybdenum	57	<50	770	<50
Nickel	<50	<50	230	<50
Lead	370	<200	1,600	<200
Antimony	<25	<25	<10[b]	<10
Tin	460	100	2,000	200
Titanium	330	200	60,000	<200
Thallium	<10	<10	NA	<10
Zinc	170,000	1,100	270,000	<600
Toxic organics, μg/L[b]				
Benzene	24	ND	<10	ND
Carbon tetrachloride	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND
1,1,1-Trichloroethane	50	35	<10	<10
1,1-Dichloroethane	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND
1,1-Dichloroethylene	ND	ND	ND	<10
1,2-*Trans*-dichloroethylene	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND
Ethylbenzene	460	43	62	ND
Methylene chloride	4,200	4,100	4,600	2,200
Dichlorobromomethane	ND	ND	ND	ND
Chlorodibromomethane	ND	ND	ND	ND
Isophorone	ND	ND	ND	ND
Naphthalene	54	16	1,100	ND
Nitrobenzene	ND	ND	ND	ND
Pentachlorophenol	ND	ND	ND	<10
Phenol	36	94	340	ND
Bis(2-ethylhexyl) phthalate	ND	ND	590	ND
Di-n-butyl phthalate	57	ND	250	ND
Tetrachloroethylene	270	13	30	ND
Toluene	580	150	180	<10
Trichloroethylene	ND	ND	<10	ND
Classical and others				
pH, pH units	7.7	8.8	8.9	7.1
BOD, mg/L	3,300	3,900	4,800	<6
COD, mg/L	150,000	8,000	120,000	<5
TOC, mg/L	13,000	2,300	20,000	3
Oil and grease, mg/L	830	16	3,200	<1
Cyanide, μg/L	150	31	<20	<20
Total phenol, μg/L	1,100	1,300	700	<5
TS, mg/L	66,000	4,800	200,000	460
TDS, mg/L	52,000	4,300	3,600	459
TSS, mg/L	14,000	480	190,000	1.2
TVS, mg/L	17,000	1,700	42,000	140
VSS, mg/L	11,000	420	41,000	1
Calcium, mg/L	1,300	680	4,300	<50
Magnesium, mg/L	35	7.5	120	<1
Sodium, mg/L	230	230	250	240

[a]All data from 4-batch sampling except as noted.
[b]Verification data from 1-batch sampling.

TABLE 13-10. WASTEWATER CHARACTERIZATION, PLANT 9 (PAINT)[a] [1]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic wash
Wastewater treatment description: Neutralization, chemical treatment (polymer)
Untreated wastewater flowrate, gpd: 500-1,000

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake
Metals, µg/L				
Silver	<10	<10	<10	<10
Aluminum	200,000	1,000	150,000	<500
Arsenic	NA	NA	NA	NA
Barium	4,700	67	18,000	70
Beryllium	<10	<10	<10	<10
Cadmium	<20	<20	<20	<20
Cobalt	360	<50	330	<50
Chromium	53	<50	57	<50
Copper	700	200	600	<60
Iron	110,000	3,000	260,000	<2,000
Mercury	14,000	600	115,000	0.5
Manganese	5,000	130	9,300	<50
Molybdenum	150	53	150	<50
Nickel	<50	<50	53	<50
Lead	300	<200	470	<200
Antimony	<25	28	NA	<10
Tin	730	300	700	<50
Titanium	7,700	<200	15,000	<200
Thallium	<10	<10	NA	<10
Zinc	830	<600	1,200	<600
Toxic organics, µg/L[b]				
Benzene	9,900	2,400	NA	13
Carbon tetrachloride	10	ND	NA	ND
1,2-Dichloroethane	ND	ND	NA	ND
1,1,1-Trichloroethane	ND	10	NA	ND
1,1-Dichloroethane	ND	ND	NA	ND
1,1,2-Trichloroethane	ND	ND	NA	<10
Chloroform	92	ND	NA	220
1,1-Dichloroethylene	ND	<10	NA	ND
1,2-*Trans*-dichloroethylene	ND	ND	NA	ND
1,2-Dichloropropane	ND	ND	NA	ND
Ethylbenzene	240	<10	NA	ND
Methylene chloride	310	ND	NA	530
Dichlorobromomethane	ND	ND	NA	71
Chlorodibromomethane	ND	ND	NA	113
Isophorone	ND	ND	NA	ND
Naphthalene	ND	ND	NA	ND
Nitrobenzene	ND	ND	NA	ND
Pentachlorophenol	ND	ND	NA	ND
Phenol	ND	16	NA	ND
Bis(2-ethylhexyl) phthalate	15	<10	NA	ND
Di-n-butyl phthalate	100	<10	NA	ND
Tetrachloroethylene	4,900	210	NA	ND
Toluene	1,700	180	NA	<10
Trichloroethylene	18	<10	NA	ND
Classical and others				
pH, pH units	7.4	7.3	7.2[c]	7.9
BOD, mg/L	6,700	2,400	14,800	<2.4
COD, mg/L	84,000	8,300	210,000	<5
TOC, mg/L	20,000[c]	2,300	49,000	8
Oil and grease, mg/L	1,800	50	3,900	<1
Cyanide, µg/L	160	110	<167	<20
Total phenol, µg/L	170	190	477	24
TS, mg/L	30,000	2,200	12,000	380
TDS, mg/L	10,000	1,900	13,000	380
TSS, mg/L	20,000	310	17,000	3
TVS, mg/L	22,000	1,200	11,000	24
VSS, mg/L	14,000	250	9,400	1
Calcium, mg/L	640	<50	1,300	<50
Magnesium, mg/L	25	7	34	6
Sodium, mg/L	180	250	220	<150

[a]All data from 3-batch sampling except as noted.

[b]Data from 1-batch sampling.

[c]Data from 2-batch sampling.

TABLE 13-11. WASTEWATER CHARACTERIZATION, PLANT 10 (INK)[a] [2]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic rinse
Wastewater treatment description: Gravity separation
Untreated wastewater flowrate, gpd: 101-250

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake
Metals, μg/L[b]				
Silver	<10	NA	NA	<10
Aluminum	1,000	NA	NA	<500
Arsenic	NA	NA	NA	NA
Barium	500	NA	NA	70
Beryllium	<10	NA	NA	<10
Cadmium	<20	NA	NA	<20
Cobalt	<50	NA	NA	<50
Chromium	8,700	NA	NA	70
Copper	430	NA	NA	80
Iron	2,300	NA	NA	<2,000
Mercury	10	NA	NA	5.9
Manganese	53	NA	NA	<50
Molybdenum	490	NA	NA	100
Nickel	<50	NA	NA	<50
Lead	21,000	NA	NA	400
Antimony	<25	NA	NA	<100
Tin	2,200	NA	NA	300
Titanium	2,300	NA	NA	<200
Thallium	<10	NA	NA	<10
Zinc	<600	NA	NA	<600
Toxic organics, μg/L				
Benzene	300	NA	NA	40
Carbon tetrachloride	ND	NA	NA	ND
1,2-Dichloroethane	ND	NA	NA	ND
1,1,1-Trichloroethane	ND	NA	NA	ND
1,1-Dichloroethane	ND	NA	NA	ND
1,1,2-Trichloroethane	<10	NA	NA	ND
Chloroform	110	NA	NA	350
1,1-Dichloroethylene	25	NA	NA	ND
1,2-*Trans*-dichloroethylene	ND	NA	NA	ND
1,2-Dichloropropane	ND	NA	NA	ND
Ethylbenzene	ND	NA	NA	ND
Methylene chloride	1,600	NA	NA	40
Dichlorobromomethane	ND	NA	NA	87
Chlorodibromomethane	ND	NA	NA	74
Isophorone	ND	NA	NA	ND
Naphthalene	ND	NA	NA	ND
Nitrobenzene	ND	NA	NA	ND
Pentachlorophenol	1,300	NA	NA	ND
Phenol	41	NA	NA	ND
Bis(2-ethylhexyl) phthalate	ND	NA	NA	ND
Di-n-butyl phthalate	72	NA	NA	ND
Tetrachloroethylene	ND	NA	NA	ND
Toluene	10	NA	NA	ND
Trichloroethylene	ND	NA	NA	ND
Classical and others[b]				
pH, pH units	8.5[c]	NA	NA	7.5
BOD, mg/L	400	NA	NA	<2.4
COD, mg/L	1,100	NA	NA	16
TOC, mg/L	230	NA	NA	13
Oil and grease, mg/L	76	NA	NA	<1
Cyanide, μg/L	93	NA	NA	<20
Total phenol, μg/L	72	NA	NA	8
TS, mg/L	2,200	NA	NA	710
TDS, mg/L	1,900	NA	NA	709
TSS, mg/L	270	NA	NA	1
TVS, mg/L	400	NA	NA	98
VSS, mg/L	120	NA	NA	0.7
Calcium, mg/L	<50	NA	NA	<50
Magnesium, mg/L	23	NA	NA	29
Sodium, mg/L	570	NA	NA	<150

[a]All data from 1-batch sampling except as noted.

[b]Untreated wastewater data from 3-batch sampling.

[c]Value from 2-batch sampling.

TABLE 13-12. WASTEWATER CHARACTERIZATION, PLANT 21 (INK)[a] [2]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic rinse
Wastewater treatment description: None
Untreated wastewater flowrate, gpd: 251-500

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake
Metals, μg/L				
Silver	<10	NA	NA	<10
Aluminum	30,000	NA	NA	<500
Arsenic	NA	NA	NA	NA
Barium	20,000	NA	NA	<50
Beryllium	<10	NA	NA	<10
Cadmium	80	NA	NA	<20
Cobalt	<50	NA	NA	<50
Chromium	60,000	NA	NA	100
Copper	100,000	NA	NA	80
Iron	10,000	NA	NA	<2,000
Mercury	1,100	NA	NA	<0.5
Manganese	80	NA	NA	60
Molybdenum	600,000	NA	NA	300
Nickel	<50	NA	NA	<50
Lead	200,000	NA	NA	<200
Antimony	50	NA	NA	<10
Tin	1,000	NA	NA	<50
Titanium	3,000	NA	NA	<200
Thallium	<10	NA	NA	<10
Zinc	10,000	NA	NA	<600
Toxic organics, μg/L				
Benzene	33	NA	NA	47
Carbon tetrachloride	ND	NA	NA	ND
1,2-Dichloroethane	ND	NA	NA	ND
1,1,1-Trichloroethane	120	NA	NA	ND
1,1-Dichloroethane	10	NA	NA	ND
1,1,2-Trichloroethane	ND	NA	NA	ND
Chloroform	ND	NA	NA	170
1,1-Dichloroethylene	<10	NA	NA	ND
1,2-*Trans*-dichloroethylene	ND	NA	NA	ND
1,2-Dichloropropane	ND	NA	NA	ND
Ethylbenzene	ND	NA	NA	ND
Methylene chloride	26	NA	NA	ND
Dichlorobromomethane	ND	NA	NA	23
Chlorodibromomethane	ND	NA	NA	ND
Isophorone	ND	NA	NA	ND
Naphthalene	ND	NA	NA	ND
Nitrobenzene	ND	NA	NA	ND
Pentachlorophenol	ND	NA	NA	ND
Phenol	ND	NA	NA	ND
Bis(2-ethylhexyl) phthalate	87,000	NA	NA	ND
Di-n-butyl phthalate	770	NA	NA	ND
Tetrachloroethylene	170	NA	NA	ND
Toluene	580	NA	NA	ND
Trichloroethylene	19	NA	NA	ND
Classical and others				
pH, pH units	9.9	NA	NA	6.3
BOD, mg/L	73,000	NA	NA	<2.4
COD, mg/L	270,000	NA	NA	6.4
TOC, mg/L	66,000	NA	NA	5.5
Oil and grease, mg/L	1,500	NA	NA	1
Cyanide, μg/L	540	NA	NA	<20
Total phenol, μg/L	510	NA	NA	<20
TS, mg/L	51,000	NA	NA	200
TDS, mg/L	51,000	NA	NA	190
TSS, mg/L	275	NA	NA	4
TVS, mg/L	78,000	NA	NA	92
VSS, mg/L	220	NA	NA	4
Calcium, mg/L	<50	NA	NA	<50
Magnesium, mg/L	2	NA	NA	3
Sodium, mg/L	1,100	NA	NA	<150

[a]All data from 1-batch sampling.

TABLE 13-13. WASTEWATER CHARACTERIZATION, PLANT 22 (INK)[a] [2]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic rinse
Wastewater treatment description: Gravity separation, settling and clarification, neutralization
Untreated wastewater flowrate, gpd: 1,000+

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake
Metals, μg/L				
Silver	<10	<10	NA	<10
Aluminum	20,000	600	NA	5,000
Arsenic	NA	NA	NA	NA
Barium	20,000	100	NA	1,000
Beryllium	<10	<10	NA	<10
Cadmium	90	<20	NA	<20
Cobalt	900	<50	NA	<50
Chromium	10,000	<50	NA	2,000
Copper	10,000	<60	NA	300
Iron	30,000	<2,000	NA	<2,000
Mercury	NA	NA	NA	NA
Manganese	400	<50	NA	<50
Molybdenum	700	<50	NA	<2,000
Nickel	<50	<50	NA	<50
Lead	90,000	<200	NA	20,000
Antimony	<25	<25	NA	<10
Tin	<50	<50	NA	<50
Titanium	3,000	3,000	NA	300
Thallium	<10	<10	NA	<10
Zinc	1,000	1,000	NA	<600
Toxic organics, μg/L[b]				
Benzene	110	96	NA	ND
Carbon tetrachloride	ND	ND	NA	ND
1,2-Dichloroethane	<5	ND	NA	<5
1,1,1-Trichloroethane	ND	ND	NA	ND
1,1-Dichloroethane	ND	ND	NA	ND
1,1,2-Trichloroethane	ND	ND	NA	ND
Chloroform	<5	ND	NA	13
1,1-Dichloroethylene	ND	ND	NA	ND
1,2-*Trans*-dichloroethylene	ND	ND	NA	ND
1,2-Dichloropropane	ND	ND	NA	ND
Ethylbenzene	3,400	2,400	NA	ND
Methylene chloride	22.5	29	NA	36
Dichlorobromomethane	ND	ND	NA	ND
Chlorodibromomethane	21.5	ND	NA	ND
Isophorone	22,000	46	NA	ND
Naphthalene	8.5	<10	NA	ND
Nitrobenzene	ND	ND	NA	ND
Pentachlorophenol	<5	ND	NA	82
Phenol	<5	ND	NA	ND
Bis(2-ethylhexyl) phthalate	<10	<10	NA	<5
Di-*n*-butyl phthalate	<5	<10	NA	<5
Tetrachloroethylene	11	ND	NA	ND
Toluene	1,800	1,100	NA	<10
Trichloroethylene	ND	ND	NA	ND
Classical and others				
pH, pH units	12.9	12.5	NA	8.5
BOD, mg/L	2,100	2,600	NA	<2.4
COD, mg/L	32,000	4,800	NA	25
TOC, mg/L	4,000	940	NA	11
Oil and grease, mg/L	2,400	260	NA	3
Cyanide, μg/L	2,000	600	NA	<40
Total phenol, μg/L	330	30	NA	<20
TS, mg/L	23,000	5,600	NA	181
TDS, mg/L	21,000	5,500	NA	180
TSS, mg/L	1,600	110	NA	1
TVS, mg/L	6,300	200	NA	20
VSS, mg/L	1,000	47	NA	1
Calcium, mg/L	71	<50	NA	<50
Magnesium, mg/L	13	9	NA	3
Sodium, mg/L	3,700	450	NA	2,300

[a]All data from 1-batch sampling except as noted.
[b]Untreated wastewater data from 2-batch sampling.

TABLE 13-14. WASTEWATER CHARACTERIZATION, PLANT 23 (INK)[a] [2]

Category: Paint and Ink Formulation
Subcategory: Water and/or caustic rinse
Wastewater treatment description: Gravity separation, settling and clarification
Untreated wastewater flowrate, gpd: 1-100

Pollutant	Untreated wastewater	Treated effluent	Sludge	Intake
Metals, μg/L				
Silver	<5	NA	NA	<1
Aluminum	1,000	NA	NA	<50
Arsenic	NA	NA	NA	NA
Barium	500	NA	NA	9
Beryllium	<5	NA	NA	<1
Cadmium	<10	NA	NA	<2
Cobalt	<30	NA	NA	<5
Chromium	200	NA	NA	<5
Copper	100	NA	NA	<6
Iron	<900	NA	NA	<200
Mercury	NA	NA	NA	NA
Manganese	<30	NA	NA	<5
Molybdenum	100	NA	NA	<5
Nickel	<30	NA	NA	<5
Lead	4,000	NA	NA	<20
Antimony	<25	NA	NA	NA
Tin	200	NA	NA	30
Titanium	<80	NA	NA	<20
Thallium	<10	NA	NA	NA
Zinc	1,000	NA	NA	<60
Toxic organics, μg/L				
Benzene	ND	NA	NA	ND
Carbon tetrachloride	ND	NA	NA	ND
1,2-Dichloroethane	ND	NA	NA	ND
1,1,1-Trichloroethane	ND	NA	NA	ND
1,1-Dichloroethane	ND	NA	NA	ND
1,1,2-Trichloroethane	ND	NA	NA	ND
Chloroform	<10	NA	NA	41
1,1-Dichloroethylene	ND	NA	NA	ND
1,2-*Trans*-dichloroethylene	ND	NA	NA	ND
1,2-Dichloropropane	ND	NA	NA	ND
Ethylbenzene	ND	NA	NA	ND
Methylene chloride	ND	NA	NA	15
Dichlorobromomethane	ND	NA	NA	ND
Chlorodibromomethane	ND	NA	NA	ND
Isophorone	ND	NA	NA	<10
Naphthalene	14	NA	NA	ND
Nitrobenzene	ND	NA	NA	ND
Pentachlorophenol	ND	NA	NA	ND
Phenol	<10	NA	NA	ND
Bis(2-ethylhexyl) phthalate	<10	NA	NA	ND
Di-n-butyl phthalate	<10	NA	NA	ND
Tetrachloroethylene	ND	NA	NA	ND
Toluene	88	NA	NA	<10
Trichloroethylene	ND	NA	NA	ND
Classical and others				
pH, pH units	12.9	NA	NA	7.2
BOD, mg/L	48	NA	NA	<2.4
COD, mg/L	190	NA	NA	24
TOC, mg/L	46	NA	NA	13
Oil and grease, mg/L	<1	NA	NA	<1
Cyanide, μg/L	26	NA	NA	<20
Total phenol, μg/L	47	NA	NA	9
TS, mg/L	1,100	NA	NA	190
TDS, mg/L	980	NA	NA	180
TSS, mg/L	120	NA	NA	6
TVS, mg/L	46	NA	NA	60
VSS, mg/L	NA	NA	NA	5
Calcium, mg/L	<25	NA	NA	29
Magnesium, mg/L	3	NA	NA	7
Sodium, mg/L	3,700	NA	NA	<15

[a]All data from 1-batch sampling.

II.13.4 POLLUTANT REMOVABILITY

Paint and ink plants treat wastewater in several ways. Generally the plants can reduce or reuse the wastewater, or release it with or without treatment. Because a majority of the plants release the wastewater into municipal sewage systems, treatment is often a function of the municipal restrictions on the plant.

II.13.4.1 Reduction or Reuse of Wastewater

There are two widely used general strategies for reducing the amount of wastewater that paint and ink plants discharge to the environment. The first is to reduce the amount of wastewater generated; the second is to reuse as much wastewater as possible within plant processes. The amount of wastewater generated is influenced by the water pressure used for tank and equipment cleaning, the degree of cleaning required, and the use of dry cleaning techniques.

Several methods in use by some plants reduce the water usage. Cleaning a tank with a squeegee prior to a water rinse reduces the quantity of water needed to clean the tank. High pressure hoses can also clean a tank in less time using less water. Wastewater volume can also be reduced by eliminating or sealing floor drains, assuring that water will not be used to clean the floors. The use of these methods can significantly reduce the wastewater volume of a paint or ink plant.

Reuse of wash or rinse water is common in the paint and ink industry. Wash water can be transferred directly to a second tub or can be reused as makeup water. The paint industry often uses wash water for makeup in a batch of similar color paint. Ink plants reuse the rinse water from a caustic rinse as makeup for a caustic wash. These techniques can reduce raw material costs as well as treatment costs. Generally, reuse of wastewater is more prevalent in small plants than in larger ones.

II.13.4.2 Treatment Systems

Less than 26 percent of all paint plants and 15 percent of all ink plants practice any types of wastewater treatment. The majority of the plants that release wastewater discharge it to municipal sewage systems. Of the plants that discharge their wastewater to a municipal sewer, less than 40 percent of the paint plants and 33 percent of the ink plants pretreated the wastewater prior to discharge.

The most common methods used by paint and ink plants for treating or pretreating wastewater prior to disposal are gravity separation, settling, and neutralization. The paint industry also uses physical/chemical treatment. Few plants from either industry use biological treatment, and those that do usually have a combined treatment plant for wastes from other plant processes. No paint or ink plants use advanced wastewater treatment methods such as activated carbon or ultrafiltration.

Gravity Separation or Settling

Gravity separation or settling of paint and ink wastewater removes many of the suspended solids but leaves a supernatant layer that is high in solids and other pollutants. This treatment usually requires large areas to achieve a reasonable removal of solids.

Neutralization

Neutralization is used to adjust the pH of the wastewater stream to levels necessary for other treatment steps. The pH adjustment can be made with the addition of either alkalies or acids depending on what pH is required. This technique can often significantly reduce the dissolved metals by precipitation.

Physical/Chemical Treatment

Physical/chemical (P/C) treatment systems take advantage of the natural tendency of paint wastewater to settle. Most plants operate the treatment on a batch basis, collecting the wastewater in a holding tank. If necessary, the pH is adjusted to an optimal level, a coagulant (lime, alum, ferric chloride, or iron salts) and/or a coagulant aid is added and mixed, and the batch is allowed to settle (1 to 48 hours). The supernatant is discharged and the sludge is treated as a solid waste. P/C removes some metals and some organic priority pollutants, and achieves a reduction in conventional pollutants.

Biological Treatment

Biological treatment has been used as a secondary treatment (usually following P/C) at several paint plants. Most of the plants pretreat the raw wastewater and then combine it with other plant wastewater. Data from this treatment indicate that biological treatment in an aerated lagoon can reduce conventional, metal, and organic pollutant concentrations to low levels. Use of this technique can be practical for paint plants in rural areas that wish to further treat P/C effluent for both conventional and toxic pollutants.

Biological treatment at ink plants is probably not feasible due to the low flow (less than 1,000 gal/d) found in most ink plants.

Potential Wastewater Treatment Systems

Other treatment systems which have been suggested for use in the paint and ink industry, but for which no data were available, include ultrafiltration, carbon adsorption, reverse osmosis, steam stripping, dissolved air flotation, and sand filtration.

The following tables present data on several treatment processes. Table 13-15 shows the average effluent characteristics and removal efficiencies for batch physical/chemical treatment at several paint plants. Table 13-16 presents data from one paint plant that uses an aerated lagoon as a secondary treatment. Table 13-17 presents data from an ink plant that practices gravity separation, settling and clarification, and neutralization and shows average effluent concentrations and removal efficiencies.

II.13.5 REFERENCES

1. Technical Study Report BATEA-NSPS-PRETREATMENT, Effluent Limitations Guidelines for the Paint Manufacturing Industry (draft contractor's report). Contract 68-01-3502, U.S. Environmental Protection Agency, Washington, D.C., January 1979.

2. Technical Study Report BATEA-NSPS-PRETREATMENT, Effluent Limitations Guidelines for the Ink Manufacturing Industry (draft contractor's report). Contract 68-01-3502, U.S. Environmental Protection Agency, Washington, D.C., January 1979.

3. NRDC Consent Decree Industry Summary - Paint and Ink Formulation.

4. Environmental Protection Agency Effluent Guidelines and Standards for Paint Formulating. 40CFR446; 40FR31723, July 28, 1975.

5. Environmental Protection Agency Effluent Guidelines and Standards for Ink Formulating. 40CFR447; 40FR31723, July 28, 1975.

TABLE 13-15. EFFLUENT CHARACTERISTICS AND REMOVALS FROM PAINT PLANTS WITH BATCH PHYSICAL/CHEMICAL TREATMENT SYSTEMS [1]

Parameter	Average concentration[a]	Percent removal	
		Average	Median
Classical pollutants, mg/L			
BOD	5,600	35	21
COD	20,000	68	74
TOC	3,600	65	75
Oil and grease	110	90	97
Cyanide	54	23	0
Total solids	6,100	68	80
TDS	4,700	35	17
TSS	1,300	82	98
TVS	2,500	77	88
Metals, μg/L			
Silver	<10	14	0
Beryllium	<10	19	0
Cadmium	30	31	0
Chromium	1,500	43	32
Copper	2,300	56	70
Mercury	400	68	93
Nickel	4,200	19	0
Lead	1,300	54	68
Antimony	30	11	0
Thallium	12	6	0
Zinc	7,900	68	85
Toxic organics, μg/L			
Benzene	740	54	65
Carbon tetrachloride	65	75	100
1,2-Dichloroethane	40	61	84
1,1,1-Trichloroethane	95	39	30
1,1,2-Trichloroethane	540	62	100
Chloroform	390	50	57
1,1-Dichloroethylene	19	33	0
1,2-Dichloropropane	210	52	58
Ethylbenzene	6,200	65	79
Methylene chloride	5,500	54	67
Naphthalene	440	47	66
Nitrobenzene	35	89	100
Pentachlorophenol	48	59	96
Phenol	49	28	0
Bis(2-ethylhexyl) phthalate	35	60	86
Di-n-butyl phthalate	180	88	99
Tetrachloroethylene	190	70	100
Toluene	1,900	54	70
Trichloroethylene	80	51	62

[a] Average of concentrations when detected.

TABLE 13-16. BIOLOGICAL TREATMENT BY AERATED LAGOON AT ONE PAINT PLANT[a] [1]

Parameter	Untreated wastewater	P/C effluent	Lagoon	Tap water
Classical pollutants[b]				
pH[c]	7.4	7.0	8.3	7.6
BOD	>25,000	23,400	17	<1
COD	70,000	260,000	675	10
TOC	7,500	25,000	200	4
Total phenol	1.2	1.1	0.003	<0.002
TSS	46,000	400	42	<5
Metals, µg/L				
Silver	<10	<10	<10	<10
Arsenic	440	<100	<20	2.8
Beryllium	7	2	<1	2
Cadmium	130	58	<2	<2
Chromium	1,500	100	9	7
Copper	260	120	7	16
Mercury	1,010	140	0.1	0.1
Nickel	450	<5	<5	<5
Lead	12,000	98	<20	<20
Antimony	<1,000	170	30	<2
Selenium	<200	400	<200	20
Thallium	<200	100	<20	<2
Zinc	60,000	4,200	<60	<60
Toxic organics, µg/L				
Benzene	280	200	<10	ND
1,1,1-Trichloroethylene	120	560	22	<10
Chloroform	ND	23	ND	37
Ethylbenzene	730	ND	ND	ND
Methylene chloride	6,300	31,000	1,000	740
Dichlorobromomethane	ND	ND	ND	<10
Chlorodibromomethane	ND	ND	ND	<10
Pentachlorophenol	<10	<10	ND	ND
Phenol	<10	<10	ND	ND
Bis(2-ethylhexyl) phthalate	ND	ND	<10	<10
Di-n-butyl phthalate	<10	<10	ND	ND
Tetrachloroethylene	110	25	ND	ND
Toluene	290	200	ND	ND

[a]Sampling was by EPA regional Surveillance and Analysis personnel without technical contractor or Effluent Guidelines representation.

[b]Values in mg/L except as noted.

[c]Values in pH units.

TABLE 13-17. TREATED WASTEWATER CONCENTRATIONS AND PERCENT REMOVALS FROM INK PLANT 22 [2]

Parameter	Average concentration	Average percent removal
Classical pollutants, mg/L		
pH[a]	12.5[b]	
Oil and grease	260	89
BOD	2,600	87
COD	4,800	0
TOC	940	76
Total solids	5,600	75
TDS	5,500	73
TSS	110	93
TVS	200	96
Metals, μg/L		
Cadmium	20	78
Chromium	<50	>99
Copper	<60	>99
Lead	<200	>99
Zinc	1,000	-[c]
Toxic organics, μg/L		
Benzene	96	56
Ethylbenzene	2,400	64
Methylene chloride	29	36
Chlorodibromomethane	ND	>99
Isophorone	46	-[d]
Naphthalene	<10	>41
Pentachlorophenol	ND	>99
Bis(2-ethylhexyl) phthalate	<10	-[c]
Di-n-butyl phthalate	10	-[c]
Tetrachloroethylene	ND	>99
Toluene	1,100	69

NOTE: Toxic pollutants not measured in either stream are not indicated.

[a]Value in pH units.

[b]The plant's neutralization system malunctioned during sampling.

[c]Negligible removal.

[d]Negative removal.

II.14 PETROLEUM REFINING

II.14.1 INDUSTRY DESCRIPTION

II.14.1.1 General Description

The petroleum refining industry in the United States, as defined by Standard Industrial Classification (SIC) Code 2911 of the U.S. Department of Commerce, produces a wide variety of intermediates and finished products. Table 14-1 summarizes information pertaining to the petroleum refining industry in terms of the number of subcategories, number of dischargers, pollutants and toxics found in significant quantities, number of toxic pollutants detected in raw wastewater and treated effluent, and candidate treatment and control technologies. Production of crude oil or natural gas from wells, natural gasoline production, other activities associated with such production (those covered under SIC Code 1311 for example), distribution activities (such as gasoline stations), and petroleum product transportation are not within the scope of SIC Code 2911, and they are therefore excluded from this study of the petroleum refining industry. Some other activities that are outside the scope of SIC Code 2911 are included because they are inherent to such integrated refinery operations as steam generation, hydrogen production, and soap manufacture for the production of greases, or they are part of refinery pollution control such as treatment of ballast water resulting from product transportation.

A petroleum refinery is a complex combination of interdependent operations engaged in the separation of crude molecular constituents, molecular cracking, molecular rebuilding and solvent finishing to produce the products listed under SIC Code 2911. The refining operations may be divided among general categories, where each category defines a group of refinery operations. The categories are storage and transportation, crude processes, coking processes, cracking and thermal processes, hydrocarbon processing, petrochemical operations, lube manufacturing processes, treating and finishing, asphalt production, and auxiliary activities [2].

II.14.1.2 Subcategory Description

No subcategorization has yet been developed for BAT standards or toxic pollutant wastewater characteristics [4].

TABLE 14-1. INDUSTRY SUMMARY [1-4]

Industry: Petroleum Refining
Total Number of Subcategories: 1 (5 for BPT)
Number of Subcategories Studied: 1 (5 for BPT)

Number of Dischargers in Industry:

	1973 [2]	1976 [3]	1976 [4]
• Direct:		230	182
• Indirect:		26	48[a]
• Zero:			55[b]
• Total:	247	256	285

Pollutants and Toxics Found in Significant Quantities:

- For direct discharge:

  BOD_5
  COD
  TOC
  TSS
  Oil and grease
  Ammonia nitrogen
  Phenolic compounds
  Sulfides
  Chromium
  Zinc
  Cyanide
  Pyrenes
  Phthalate esters

- For indirect discharge:

  Ammonia
  Sulfides
  Oil and grease
  Phenols
  Chromium
  Zinc
  Cyanide
  Pyrenes
  Phthalate esters

Number of Toxic Pollutants Found in:

- Raw wastewater: 40
- Treated effluent: 32

Candidate Treatment and Control Technologies:

- Recycle/reuse
- Powdered activated carbon
- Metals removal (precipitation)

Note: Blanks indicate data not available.

[a]Six of these refineries indicate intent to connect to POTW in the near future. Some of these refineries discharge only a portion of their wastewater to the POTW.

[b]Six of these refineries reported no wastewater generation.

Subcategories were previously developed for BPT using linear regression analysis on both refinery throughputs and process capacities. These subcategories are listed in Table 14-2 [2]. Wastewater characterization data for the total industry and for these subcategories are presented in the following section. The size and process factors developed are listed in Reference 2.

TABLE 14-2. SUBCATEGORIZATION OF THE PETROLEUM REFINING INDUSTRY FOR BPT REFLECTING SIGNIFICANT DIFFERENCES IN WASTEWATER CHARACTERISTICS [2]

Subcategory	Basic refinery operations included
Topping	Topping and catalytic reforming whether or not the facility includes any other process in addition to topping and catalytic process. This subcategory is not applicable to facilities which include thermal processes (coking, visbreaking, etc.) or catalytic cracking.
Cracking	Topping and cracking, whether or not the facility includes any processes in addition to topping and cracking, unless specified in one of the subcategories listed below.
Petrochemical	Topping, cracking, and petrochemical operations, whether or not the facility includes any process in addition to topping, cracking, and petrochemical operations,[a] except lube oil manufacturing operations.
Lube	Topping, cracking, and lube oil manufacturing processes, whether or not the facility includes any process in addition to topping, cracking, and lube oil manufacturing processes, except petrochemical operations.[a]
Integrated	Topping, cracking, lube oil manufacturing processes, and petrochemical operations, whether or not the facility includes any processes in addition to topping, cracking, lube oil manufacturing processes, and petrochemical operations.[a]

[a] The term "petrochemical operations" shall mean the production of second generation petrochemicals (i.e., alcohols, ketones, cumene, styrene, etc.) or first generation petrochemical and isomerization products (i.e., BTX, olefins, cyclohexane, etc.) when 15% or more of refinery production is as first generation petrochemicals and isomerization products.

II.14.2 WASTEWATER CHARACTERIZATION

II.14.2.1 Industry Description

Toxic Pollutants

Table 14-3 presents the number of values, ranges and concentrations (mass loadings were not available) of toxic pollutants found during a screening study at 17 petroleum refineries. Intake water, raw wastewater, and final effluent samples were taken for three consecutive 24-hr periods [4,5]. Raw wastewater has been defined in the petroleum refining industry as the effluent from the API separator, which is considered an integral part of refinery process operations for product/raw material recovery prior to final wastewater treatment [2]. The medians were developed from individual plant data. No assumptions were made as to sample locations for combining results. If sample "names" were not the same, the results were not combined to find medians.

Conventional Pollutants

Table 14-4 presents the number of values, ranges, and median concentrations of conventional pollutants found during the screening study.

Wastewater Flows

It is apparent that significant reductions in the volume of wastewater discharges have occured in this industry. At a number of refineries, less wastewater than that which formed the basis of BPT effluent limitations is being discharged. Not all plants are well operated from the standpoint of wastewater generation. However, a wastewater management policy can be instituted in many cases as a first step to reduce wastewater discharge. There is a potential for even further reduction of wastewater discharge through recycle techniques (i.e., reuse of treated effluent as cooling tower makeup).

The average wastewater flow is 28.3 gal of water per barrel of feedstock throughput [4].

II.14.2.2 Subcategory Wastewater Characterization

Toxic Pollutants

No data are available to characterize wastewater by subcategories in the petroleum refining industry for toxic pollutants [4].

TABLE 14-3. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND DURING A SCREENING STUDY, IN PETROLEUM REFINING WASTEWATER [4,5] (μg/L)

Toxic pollutants	Intake			API separator effluent			DAF effluent		
	Number of values[b]	Range	Median	Number of values[b]	Range	Median	Number of values[b]	Range	Median
Metals and inorganics									
Antimony[c]	17	<1-<25	<25	10	<1-360	<13	7	1-<25	<25
Arsenic[c]	18	3-35	<20	14	3-480	<20	7	<4-<20	20
Asbestos[d]	4		ND	3	ND-3.4	ND			
Beryllium[c]	85	<1-<20	<2	50	<1-<20	<2	35	<1-<20	<2
Cadmium[c]	85	<1-<200	<20	50	<1-<200	<20	35	<1-<200	<2
Chromium[c]	85	1-3,000	<24	58	1-2,000	<240	38	<5-2,000	270
Copper[c]	86	1-300	10	54	2-1,400	32	35	3-400	9
Cyanide	52	10-60	20	36	<5-1,500	<60	20	10-3,000	45
Lead[c]	88	<1-700	<60	54	2-960	<60	38	<15-<600	<60
Mercury[c]	70	<0.1-7	<0.5	53	<0.1-78	0.8	20	<0.1-1.1	<0.5
Nickel[c]	88	<1-790	<50	53	<1-770	<50	35	1-<500	<18
Selenium[c]	23	2-<20	<10	25	<4-<20	9	10	5-<20	<12
Silver[c]	85	<1-<250	<25	50	<1-<250	<25	30	<1-<250	<2.5
Thallium[c]	34	<1-<25	<2	25	<1-<15	<1	11	<1-<15	<15
Zinc[c]	90	<1-2,800	62	66	24-3,400	280	38	30-3,000	91
Pthalates									
Bis(2-ethylhexyl) phthalate	6	ND-1,100	550	6	ND-700	300	1		1,100
Di-n-butyl phthalate	5	ND-30	0.4	3	ND-1.3	ND	2		ND
Diethyl phthalate	2		ND	2	ND-12	6			
Dimethyl phthalate	3	ND-20	ND	2		ND	1		ND
Phenols									
2-Chlorophenol	1		ND	1		315			
2,4-Dichlorophenol	1		ND	1		ND			
2,4-Dinitrophenol	3		ND	2	110-11,000	5,600	1		2,700
2,4-Dimethylphenol	9		ND	5	ND-1,200	>100	4	>100-18,000	6,000
2-Nitrophenol	1		<10	1		1,400			
4-Nitrophenol	4	ND-<10	ND	2	20-5,800	2,900	2	ND-1,400	700
Pentachlorophenol	1		ND	1		ND			
Phenol	14	ND-10	ND	10	13-4,900	250	5	ND-34,000	1,900
4,6-Dinitro-o-cresol	1		ND	1		60			
Parachlorometa cresol	3		ND	1		ND	2		ND
Aromatics									
Benzene	16	ND-14	<1	12	ND-2,400	>100	4[e]	ND-2,000	>100
1,2-Dichlorobenzene	1		<0.5				1		ND
1,4-Dichlorobenzene	1		<0.5				1		ND
Ethylbenzene	10		ND	9	ND-810	>100	1		>100
Toluene	14	ND-<10	ND	10	ND-12,000	>100	4	<10-76,000	<100

TABLE 14-3 (continued)

Toxic pollutants	Intake: Number of values[b]	Intake: Range	Intake: Median	API separator effluent: Number of values[b]	API separator effluent: Range	API separator effluent: Median	DAF effluent: Number of values[b]	DAF effluent: Range	DAF effluent: Median
Polycrylic aromatic hydrocarbons									
Acenaphthene	7	ND-29	ND	5	ND-520	37	2	150-390	270
Acenaphthylene	5	ND-0 2	ND	4	ND-660	41	1		530
Anthracene	2		ND	1		660	1		1,800
Benzo(a)pyrene	2	ND-33	17	1		190			
Chrysene	8	ND-49	ND	5	0.1-40	20	3	ND-0.3	ND
Fluoranthene	8	ND-29	ND	5	ND-40	8	3		ND
Fluorene	4	ND-1	ND	2	ND-270	140	2	110-495	300
Naphthalene	11	ND-2	ND	9	ND-3,200	302	3	106-3,700	700
Phenanthrene	11	ND-160	ND	8	5-1,100	165	3	50-1,800	600
Pyrene	6	ND-140	<0.1	3	ND-16	11	1		5
Polychlorinated biphenyls and related compounds									
Aroclor 1016	7		ND	5	ND-40	1 9	3	7 9-<10	<10
Aroclor 1221	7		ND	4	ND-<10	<5	2		<10
Aroclor 1232	8		ND	6	ND-<10	0.7	3	3 5-<10	<10
Aroclor 1242	8	ND-0.2	ND	6	ND-<10	3.2	4	0 2-<10	<5
Aroclor 1248	4		ND	2		<10	2		<10
Aroclor 1254	4		ND	2		<10	2		<10
Aroclor 1260	4		ND	2		<10	2		<10
Halogenated aliphatics									
Carbon tetrachloride	4	ND->50	<5	1		ND	2	ND-<10	<5
Chloroform	8[e]	ND-70	<8	9	ND-100	10	1[e]		13
Dichlorobromomethane	1		ND	1		24			
1,2-Dichloroethane	2		ND	2	ND-16	8			
1,2-*Trans*-dichloroethylene	3	ND-11	ND	3	ND-20	ND			
Methylene chloride	10[e]	ND-130	<85	7[e]	ND-1,600	>100	3[e]	ND-560	30
1,1 2,2-Tetrachloroethane	2	ND-<10	<5	2		ND			
Tetrachloroethylene	4	ND-50	<10	3	ND->50	ND	1		ND
1,1,1-Trichloroethane	1		<50						
Trichloroethylene	2	<10-20	<15	1		ND	1		ND
Pesticides and metabolites									
Aldrin	2		ND	2	<5-12	<8			
α-BHC	1		ND				1		<10
β-BHC	3		ND	1		<5	1		<5
δ-BHC	2		ND	2	<5-12	<8			
γ-BHC	1		ND				1		<5
Chlordane	1		2.8						
4,4'-DDE	1		ND	1		7			
4,4'-DDD	1		ND				1		<5
α-Endosulfan	1		ND	1		ND	1		0.1
β-Endosulfan	1		ND	1		13			
Endosulfan sulfate	1		ND				1		<5
Heptachlor	2		ND	1		<5	1		<5
Heptachlor epoxide	2		ND	2	ND-<5	<2.5			
Isophorone	2		ND	1		3,600	1		2,500

TABLE 14-3 (continued)

Toxic pollutants	Second API separator effluent			Third API separator effluent			Fourth API separator effluent		
	Number of values[b]	Range	Median	Number of values[b]	Range	Median	Number of values[b]	Range	Median
Metals and inorganics									
Antimony[c]	2	<1-<25	<13	1		<1	1		1
Arsenic[c]	2	5-<20	<12	1		3	1		3
Asbestos[d]									
Beryllium[c]	10	<1-<3	<2	5	<1-<2	<2	5	<1-<2	<2
Cadmium[c]	10	<1-<20	<20	5	<1-<20	<20	5	<1-<20	<20
Chromium[c]	13	390-1,100	780	8	350-1,200	640	8	840-1,900	1,400
Copper[c]	10	<1-69	<50	5	2-25	16	5	10-77	38
Cyanide[c]	5	10-210	10	3		10	3	50-60	60
Lead[c]	13	17-2,100	190	5	2-120	<60	5	12-80	<60
Mercury[c]	11	0.1-5.0	0.6	7	<0.1-1.0	0.6	8	0.2-7.0	1.5
Nickel[c]	10	<1-69	<50	5	<1-120	<50	5	<1-<50	<50
Selenium[c]	6	5-<20	13	4	6-31	15	4	4-25	18
Silver[c]	10	<1-<25	<25	5	1-<25	<25	4	2-<25	<25
Thallium[c]	5	<1-<15	3	4	<1-<2	<1	4	<1-<2	<1
Zinc[c]	13	290-2,100	380	8	150-280	230	8	260-620	380
Pthalates									
Bis(2-ethylhexyl) phthalate	1		300	1		50	1		600
Di-n-butyl phthalate									
Diethyl phthalate	1		ND	1		ND	1		ND
Dimethyl phthalate	1		ND	1		ND	1		ND
Phenols									
2-Chlorophenol									
2,4-Dichlorophenol									
2,4-Dinitrophenol									
2,4-Dimethylphenol	2	ND->100	<50	1		ND	1		650
2-Nitrophenol									
4-Nitrophenol									
Pentachlorophenol	1		ND	1		ND	1		850
Phenol	2	>100-160	>130	1		ND	1		16,000
4,6-Dinitro-o-cresol									
Parachlorometa cresol									
Aromatics									
Benzene	1		>100						
1,2-Dichlorobenzene									
1,4-Dichlorobenzene									
Ethylbenzene	1		>100						
Toluene	1		>100						

TABLE 14-3 (continued)

Toxic pollutants	Second API separator effluent			Third API separator effluent			Fourth API separator effluent		
	Number of values[b]	Range	Median	Number of values[b]	Range	Median	Number of values[b]	Range	Median
Polycrylic aromatic hydrocarbons									
Acenaphthene	2		<1,500	1		ND			50
Acenaphthylene	1		ND						
Anthracene									
Benzo(a)pyrene									
Chrysene	2	2-30	16	1		50	1		40
Fluoranthene	2	ND-9	5	1		ND	1		20
Fluorene	2	ND-300	150	1		ND	1		80
Naphthalene	2	280-350	315	1		ND	1		ND
Phenanthrene	2	ND-90	45	1		ND	1		230
Pyrene	1		7						
Polychlorinated biphenyls and related compounds									
Aroclor 1016	1		0.2	1		ND	1		ND
Aroclor 1221									
Aroclor 1232	1		0.5	1		ND	1		ND
Aroclor 1242	2	ND-0.5	0.3	1		ND	1		ND
Aroclor 1248									
Aroclor 1254									
Aroclor 1260									
Halogenated aliphatics									
Carbon tetrachloride									
Chloroform	1		10						
Dichlorobromomethane									
1,2-Dichloroethane									
1,2-*Trans*-dichloroethylene									
Methylene chloride	1		50						
1,1,2,2-Tetrachloroethane									
Tetrachloroethylene									
1,1,1-Trichloroethane									
Trichloroethylene									
Pesticides and metabolites									
Aldrin									
α-BHC									
β-BHC									
δ-BHC									
γ-BHC									
Chlordane									
4,4'-DDE									
4,4'-DDD									
α-Endosulfan									
β-Endosulfan									
Endosulfan sulfate									
Heptachlor									
Heptachlor epoxide									
Isophorone									

TABLE 14-3 (continued)

Toxic pollutants	Fifth API separator effluent: Number of values[b]	Range	Median	Biopond influent: Number of values[b]	Range	Median	Chemical plant effluent: Number of values[b]	Range	Median
Metals and inorganics									
Antimony[c]	1		<1	1		<1	1		<25
Arsenic[c]	1		9	1		<2	1		<20
Asbestos[d]									
Beryllium[c]	5	<1-2	<2	5	<1-<2	<2	5	<2-<3	<2
Cadmium[c]	8	4-<20	<15	5	<1-<20	<20	5	<1-<20	<20
Chromium[c]	8	1,500-4,900	2,100	8	5-29	<23	5	500-800	680
Copper[c]	5	45-180	51	5	2-41	7	5	<4-13	7
Cyanide	3		20	3	220-340	260	3	<30-<60	<60
Lead[c]	5	2-160	<60	5	3-72	<60	5	<15-<60	<60
Mercury[c]	7	<0.1-2.0	0.5	3	2.0-6.0	3.0	5	<0.1-<0.5	0.2
Nickel[c]	5	1-190	<50	5	<1-<50	<50	5	<15-<50	<50
Selenium[c]	4	7-29	21	4	10-22	19	1		<20
Silver[c]	5	<1-31	<25	5	<1-<25	<25	5	<5-<25	<25
Thallium[c]	4	<1-6	<3	4	<1-<2	<1	1		<15
Zinc[c]	8	420-760	560	4	54-150	60	5	4,100-6,500	4,800
Pthalates									
Bis(2-ethylhexyl) phthalate	1		ND	1		210			
Di-n-butyl phthalate									
Diethyl phthalate	1		ND	1		ND			
Dimethyl phthalate	1		ND	1		ND			
Phenols									
2-Chlorophenol									
2,4-Dichlorophenol									
2,4-Dinitrophenol									
2 4-Dimethylphenol	1		ND	1		750	1		<100
2-Nitrophenol									
4-Nitrophenol									
Pentachlorophenol	1		ND	1		ND			
Phenol	1		ND	1		>12,000	1		40
4,6-Dinitro-o-cresol									
Parachlorometa cresol							1		10
Aromatics									
Benzene							1		90
1,2-Dichlorobenzene									
1,4-Dichlorobenzene									
Ethylbenzene							1		20
Toluene							1		>100

TABLE 14-3 (continued)

Toxic pollutants	Fifth API separator effluent			Biopond influent			Chemical plant effluent		
	Number of values[b]	Range	Median	Number of values[b]	Range	Median	Number of values[b]	Range	Median
Polycrylic aromatic hydrocarbons									
Acenaphthene	1		ND	1		ND	1		ND
Acenaphthylene							1		ND
Anthracene									
Benzo(a)pyrene									
Chrysene	1		ND	1		ND	1		<0.1
Fluoranthene	1		ND	1		ND	1		ND
Fluorene	1		ND	1		ND			
Naphthalene	1		ND	1		ND	1		27
Phenanthrene	1		ND	1		ND	1		1
Pyrene							1		1
Polychlorinated biphenyls and related compounds									
Aroclor 1016	1		ND	1		ND	1		1.3
Aroclor 1221							1		ND
Aroclor 1232	1		ND	1		ND	1		0.1
Aroclor 1242	1		ND	1		0.1			
Aroclor 1248									
Aroclor 1254									
Aroclor 1260									
Halogenated aliphatics									
Carbon tetrachloride									
Chloroform							1		10
Dichlorobromomethane									
1,2-Dichloroethane									
1,2-Trans-dichloroethylene									
Methylene chloride							1		<100
1,1,2,2-Tetrachloroethane									
Tetrachloroethylene									
1,1,1-Trichloroethane									
Trichloroethylene									
Pesticides and metabolites									
Aldrin									
α-BHC									
β-BHC									
δ-BHC									
γ-BHC									
Chlordane									
4,4'-DDE									
4,4'-DDD									
α-Endosulfan									
β-Endosulfan									
Endosulfan sulfate									
Heptachlor									
Heptachlor epoxide							1		4.6
Isophorone									

TABLE 14-3 (continued)

Toxic pollutants	Cooling tower blowdown			Treated effluent			Final effluent		
	Number of values[b]	Range	Median	Number of values[b]	Range	Median	Number of values[b]	Range	Median
Metals and inorganics									
Antimony[c]	1		<25	1		1	17	<1-<25	<25
Arsenic[c]	1		41	1		6	18	<4-800	<20
Asbestos[d]							4		ND
Beryllium[c]	5	<2-<3	<2	5	<1-<2	<2	85	<1-<3	<2
Cadmium[c]	5	<1-<20	<20	8	9-<20	<18	86	<1-20	<20
Chromium[c]	5	44-79	57	8	130-1,000	480	87	1-1,200	50
Copper[c]	5	280-510	400	8	26-260	80	85	3-300	6
Cyanide[c]	3	520-830	830	3	80-170	120	59	<5-320	<30
Lead[c]	5	<15-<60	<60	5	17-330	<60	87	2-210	<60
Mercury[c]	5	0.4-0.7	0.5	9	0.6-9.0	1.2	73	<0.1-12.0	<0 5
Nickel[c]	5	64-130	88	8	6-<50	<47	89	<1-74	20
Selenium[c]	1		<10	4	<6-15	9	31	3-32	19
Silver[c]	5	<5-<250	<25	5	<1-<25	<25	84	<1-<25	<25
Thallium[c]	1		<15	4		<1	32	<1-<15	4
Zinc[c]	5	230-450	340	9	440-4,800	780	92	<10-1,300	84
Pthalates									
Bis(2-ethylhexyl) phthalate				1		900	6	<10-2,000	450
Di-n-butyl phthalate							6	ND-10	ND
Diethyl phthalate							4	ND-30	1
Dimethyl phthalate							3	ND-3	ND
Phenols									
2-Chlorophenol							1		ND
2,4-Dichlorophenol							1		10
2,4-Dinitrophenol							3		ND
2,4-Dimethylphenol							10	ND-<10	ND
2-Nitrophenol							1		ND
4-Nitrophenol							4	ND-<10	ND
Pentachlorophenol							1		ND
Phenol				1		ND	15	ND-<10	ND
4,6-Dinitro-o-cresol							1		ND
Parachlorometa cresol							3	ND-10	<10
Aromatics									
Benzene				1		ND	12[e]	ND-12	<10
1,2-Dichlorobenzene							2		ND
1,4-Dichlorobenzene							2		ND
Ethylbenzene				1		ND	9	ND-<10	ND
Toluene							13	ND-35	ND

TABLE 14-3 (continued)

Toxic pollutants	Cooling tower blowdown: Number of values[b]	Cooling tower blowdown: Range	Cooling tower blowdown: Median	Treated effluent: Number of values[b]	Treated effluent: Range	Treated effluent: Median	Final effluent: Number of values[b]	Final effluent: Range	Final effluent: Median
Polycrylic aromatic hydrocarbons									
Acenaphthene							7	ND-6	ND
Acenaphthylene							5		ND
Anthracene							2		ND
Benzo(a)pyrene	1		10				2	1 3-3	2.2
Chrysene	1		7				9	ND-1 4	ND
Fluoranthene	1		ND				9	ND-<0.1	ND
Fluorene							5		ND
Naphthalene				1		ND	11	ND-0.1	ND
Phenanthrene	1		2	1		ND	12	ND-1	ND
Pyrene	1		10				7	ND-7	<0.1
Polychlorinated biphenyls and related compounds									
Aroclor 1016							7	ND-<10	<10
Aroclor 1221	1		0.1				7	ND-<10	<10
Aroclor 1232							8	ND-<10	<5
Aroclor 1242							9	ND-<10	ND
Aroclor 1248							4		<10
Aroclor 1254							4		<10
Aroclor 1260							4		<10
Halogenated aliphatics									
Carbon tetrachloride	1		ND				4	ND-<10	<10
Chloroform				1		ND	8[e]	ND-66	ND
Dichlorobromomethane							1		ND
1,2-Dichloroethane				1		ND	2	ND-<10	<5
1,2-_Trans_-dichloroethylene							3	ND-<10	ND
Methylene chloride	1		70	0[e]			8[e]	ND->100	<70
1,1,2,2-Tetrachloroethane							2		<10
Tetrachloroethylene							4	ND-<10	<5
1,1,1-Trichloroethane	1		ND				1		ND
Trichloroethylene							2	ND-<10	<5
Pesticides and metabolites									
Aldrin							2		ND
α-BHC							1		ND
β-BHC			0.7				3		ND
δ-BHC							2		ND
γ-BHC							1		ND
Chlordane	1		ND				1		ND
4,4'-DDE							1		ND
4,4'-DDD							1		ND
α-Endosulfan							1		ND
β-Endosulfan							1		ND
Endosulfan sulfate							1		ND
Heptachlor							2	ND-<5	<2.5
Heptachlor epoxide							2		ND
Isophorone							2		ND

Note: Blanks mean compound data not available or, if in "range" column, range is not defined.
ND - Not detected in sample.

[a]Values are corrected for blanks when blank values are reported.

[b]Values include samples which contained non-detectable quantities.

[c]Values include 3-day composite samples.

[d]Units of million fibers per liter.

[e]Not all values counted because values in blanks greater than values in sample(s).

TABLE 14-4. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND DURING A SCREENING STUDY IN PETROLEUM REFINING WASTEWATER [4]

	Intake			API separator effluent			DAF effluent		
Pollutant	Number of values	Range	Median	Number of values	Range	Median	Number of values	Range	Median
BOD_5,[a] mg/L	40	<1 - 42	<3	25	20 - 320	79	21	36 - 280	120
COD, mg/L	49	1 - 350	16	28	91 - 860	330	21	150 - 1,200	440
TOC, mg/L	48	1 - 110	10	25	25 - 240	88	21	39 - 360	110
TSS, mg/L	51	<1 - 290	9	30	10 - 490	68	21	7 - 380	37
Ammonia, mg/L	49	<1 - 68	<1	28	1 - 52	12	21	5.3 - 40	12
Cr^{+6}, mg/L	48	<0.02 - 0.25	<0.02	27	<0.02 - 7	0.02	21	<0.02 - 0.75	<0.02
S^{-2}, mg/L	50	<0.1 - 1.6	0.3	27	0.3 - 35	4.1	18	0.4 - 30	1.5
Oil and grease, mg/L	27	2 - 31	8	17	24 - 150	51	12	10 - 590	18
pH	44	6.3 - 9.0	7.7	28	5.7 - 11	8.6	17	6.9 - 10.4	8.2
Cyanides, mg/L	51	<0.005 - <0.10	<0.02	32	<0.005 - 1.5	0.05	20	0.01 - 3.0	0.04
Phenols, mg/L	51	<0.0001 - 0.21	<0.005	32	<0.001 - 62	2.8	21	0.7 - 110	11
BOD_5[b], mg/L	29	<1 - 52	<3	16	<15 - 280	90	19	25 - <360	<120
BOD_5[c], mg/L	12	<1 - 35	4	16	39 - 260	82	7	34 - 250	80
Flow, MGD	18	1.5 - 35	4	10	3 - 18	4.1	4	1.8 - 5.4	1.8

	Second API separator effluent			Third API separator effluent			Fourth API separator effluent		
BOD_5[a], mg/L	4	32 - 85	>42	2	15 - 20	18	2	70 - >80	>75
COD, mg/L	6	170 - 690	260	3	160 - 660	180	3	270 - 430	310
TOC, mg/L	6	46 - 230	57	3	45 - 230	52	3	58 - 97	66
TSS, mg/L	5	36 - 200	64	3	38 - 110	62	3	26 - 94	36
Ammonia, mg/L	6	7.8 - 15	8.7	3	3.0 - 8.4	6.2	3	3 - 8.4	7.3
Cr^{+6}, mg/L	6	<0.02 - 0.05	<0.02	3		0.02	3	<0.02 - 0.05	<0.02
S^{-2}, mg/L	6	0.8 - 15	3.6	3	1.8 - 15	5.3	3	5.1 - 9.1	6.8
Oil and grease, mg/L	3	84 - 250	140	3	23 - 250	25	3	34 - 150	65
pH	6	6.3 - 8.4	8.2	3	7.3 - 8.2	7.4	3	7.6 - 7.8	7.7
Cyanides, mg/L	6	0.01 - 0.21	0.05	3	0	0.01	3	0.05 - 0.06	0.06
Phenols, mg/L	5	1 - 22	2.1	3	0.27 - 1.3	0.69	3	1.5 - 9.5	2.0
BOD_5[b], mg/L	3	31 - 42	38						
BOD_5[c], mg/L	6	34 - >84	>42	3	22 - >84	58	3	55 - 100	60
Flow, MGD	3	5.0 - 7.2	5.4	3	0.42 - 0.46	0.44			

(continued)

TABLE 14-4 (continued)

Pollutant	Fifth API separator effluent: Number of values	Range	Median	Biopond influent: Number of values	Range	Median	Chemical plant effluent: Number of values	Range	Median
BOD_5[a], mg/L	2	10 - 12	11	1		>84			
COD, mg/L	3	83 - 92	75	3	480 - 610	570	3	240 - 810	340
TOC, mg/L	3	22 - 31	23	3	50 - 120	100	3	69 - 240	93
TSS, mg/L	3	16 - 48	26	3	16 - 24	18	3	78 - 40	36
Ammonia, mg/L	3	<1 - 2.0	1.0	3	20 - 24	22	3	<1.0 - 2.0	1.1
Cr^{+6}, mg/L	3	0.09 - 0.14	0.13	3	0.08 - 0.10	0.08	3		<0.02
S^{-2}, mg/L	3	<0.1 - 12	1.0	3	3.5 - 49	14	3	0.7 - 0.9	0.9
Oil and grease, mg/L	3	7 - 25	9	3	9 - 20	11			
pH	3	7.1 - 8.1	8.1	3	7.4 - 7.9	7.7	3	6.6 - 68	6.7
Cyanides, mg/L	3		0.02	3	0.22 - 0.34	0.26	3	<0.02 - <0.10	<0.05
Phenols, mg/L	3	0.214 - 0.294	0.246	3	83 - 120	110	3	0.062 - 0.073	0.068
BOD_5[b], mg/L							1		34
BOD_5[c], mg/L	3	10 - 18	10	1		>84	2	74 - 140	110
Flow, MGD							3	0.8 - 0.95	0.9
	Cooling tower blowdown			Treated effluent			Final effluent		
BOD_5[a], mg/L	3	25 - 130	47	3	28 - 40	34	43	<1 - 210	<10
COD, mg/L	3	210 - 350	300	3	120 - 130	130	48	28 - 820	120
TOC, mg/L	3	62 - 95	78	3	38 - 44	41	47	7 - 290	36
TSS, mg/L	3	64 - 80	76	3	18 - 28	20	47	2 - 110	21
Ammonia, mg/L	3	3.9 - 19	10	3	4.5 - 8.4	5.6	48	<1 - 53	5.0
Cr^{+6}, mg/L	3	0.05 - 0.41	0.09	3		<0.02	45	0.01 - 0.11	<0.02
S^{-2}, mg/L	2	<0.1 - 1.0	<0.05	3	0.2 - <0.5	<0.5	49	<0.1 - 2.1	0.5
Oil and grease, mg/L				3	8 - 15	11	27	3 - 53	13
pH	3	6.8 - 7.1	7.3	3	7.6 - 7.8	7.7	48	6.9 - 8.8	7.7
Cyanides, mg/L	4	0.02 - 0.83	0.68	4	0.05 - 0.17	0.10	53	<0.005 - 0.80	<0.03
Phenols, mg/L	4	0.037 - 0.056	0.048	3	<0.001 - 0.016	<0.001	49	<0.001 - 0.080	0.013
BOD_5[b], mg/L	3	36 - >160	42						
BOD_5[c], mg/L							38	<1 - 92	7
Flow, MGD	1		0.17	3	0.074 - 0.153	0.085	38	0.017 - 17.6	2.27

Note: Blanks indicate data not available.

[a]Seed from domestic sewage treatment plant.

[b]Seed from refinery final effluent.

[c]No seed.

Conventional Pollutants

Table 14-5 presents ranges and median concentrations in wastewater of conventional pollutants for the petroleum refining industry subcategories. BOD_5, COD, TOC, oil and grease, ammonia as nitrogen, phenolic compounds, sulfide, chromium, and TSS have been selected as significant pollutant parameters [2,3].

Table 14-6 presents the number of plants, ranges, and median concentrations in wastewater for conventional pollutants for indirect discharges from the topping and cracking subcategories of petroleum refining. The available data were not sufficient for the other subcategories. These data tend to confirm that there are no significant differences in raw wastewater characteristics (flow, and conventional and classical pollutants) for indirect dischargers and for the petroleum refining industry as a whole, and further analysis confirmed this [3].

Table 14-7 presents ranges and median loadings in raw wastewater of conventional pollutants for the petroleum refining industry subcategories [2].

Wastewater Flows

Table 14-8 presents the median flows for the petroleum refining industry subcategories [2,4].

II.14.3 PLANT SPECIFIC DESCRIPTIONS

Screening studies were undertaken to do the following (a) analyze for the presence of the 129 toxic pollutants in the plants' intake water sources, (b) analyze the plants' raw wastewaters to determine the net production of toxic pollutants as a result of refinery process operations, and (c) analyze the plants' final effluents for the presence of toxic pollutants and to determine an indication of the removal efficiencies of BPT-type wastewater treatment systems for these pollutants.

The screening studies were conducted by the Robert S. Kerr Environmental Research Laboratory (RSKERL) and Burns and Roe (B&R). The details of how the plants were selected in both studies are available in Reference 4. The combined studies sampled 17 refineries, at which intake water, raw wastewater, and final effluent samples were collected for three consecutive 24-hr periods. Preserved samples were analyzed by the following laboratories:

(1) (EPA) Robert S. Kerr Environmental Research Laboratory (RSKERL), Ada, Oklahoma -- metals, cyanides, phenolics, mercury

TABLE 14-5. RAW WASTEWATER CHARACTERIZATION BY SUBCATEGORY IN PETROLEUM REFINING [2,3] (mg/L)

Characteristics	Topping subcategory Range	Topping subcategory Median	Cracking subcategory Range	Cracking subcategory Median	Petrochemical subcategory Range	Petrochemical subcategory Median
BOD_5	10 - 50	23.3	30 - 600	138	50 - 800	144
COD	50 - 150	107	150 - 400	383	300 - 600	418
TOC	10 - 50	20	50 - 500	66.3	100 - 250	135
TSS	10 - 40		10 - 100		50 - 200	
Nitrogen, ammonia as	0.05 - 20	2.72	0.5 - 200	28.6	4 - 300	42.1
Phenolic compounds	0 - 200	0.80	0 - 100	6.04	0.5 - 50	10.0
Sulfides	0 - 5	0.240	0 - 400	1.24	0 - 200	176
Oil and grease	10 - 50	25	15 - 700	52.8	20 - 250	44.9
Total chromium	0 - 3	0	0 - 6	0.109	0 - 5	0.471

Characteristics	Lube subcategory Range	Lube subcategory Median	Integrated subcategory Range	Integrated subcategory Median
BOD_5	100 - 700		100 - 800	114
COD	400 - 700		300 - 600	261
TOC	100 - 400		50 - 500	51.5
TSS	80 - 300		20 - 200	
Nitrogen, ammonia as	1 - 120		1 - 250	14.5
Phenolic compounds	0.1 - 25		0.5 - 50	2.25
Sulfides	0 - 40		0 - 60	1.24
Oil and grease	40 - 400		20 - 500	44.1
Total chromium	0 - 2		0 - 2	0.272

TABLE 14-6. RAW WASTEWATER CHARACTERIZATION BY SUBCATEGORY IN PETROLEUM REFINING FOR INDIRECT DISCHARGERS [3]

Characteristics	Topping subcategory Number of plants	Topping subcategory Range	Topping subcategory Median	Cracking subcategory Number of plants	Cracking subcategory Range	Cracking subcategory Median
Flow, MGD	6	0.006 - 0.258	0.127	11	0.80 - 4.42	1.34
BOD_5, mg/L	1	205 - 323	-[a]	5	38 - 756	75
COD, mg/L	6	71 - 905	275	7	179 - 5,970	463
Ammonia, mg/L	5	0.617 - 127	34.0	9	3.2 - 1,130	21.4
Phenolics, mg/L	6	<0.05 - 63.4	<1.96	11	0.19 - 213	10.5
Sulfides, mg/L	6	<0.01 - 75.3	<0.05	10	0 - 51.6	0.9
Oil and grease, mg/L	6	0.8 - 195	32	10	2 - 160	40
Total chromium, mg/L	6	<0.005 - 8	<0.62	9	0.3 - 330	0.844

[a]Insufficient data.

TABLE 14-7. RAW WASTEWATER[a] LOADINGS IN NET KILOGRAMS/1,000 m^3 OF FEEDSTOCK THROUGHOUT BY SUBCATEGORY IN PETROLEUM REFINING [2]

Characteristics	Topping subcategory Range[b]	Topping subcategory Median	Cracking subcategory Range[b]	Cracking subcategory Median	Petrochemical subcategory Range[b]	Petrochemical subcategory Median
Flow[c]	8.00 - 558	66.6	3.29 - 2,750	93.0	26.6 - 443	109
BOD_5	1.29 - 217	3.43	14.3 - 466	72.9	40.9 - 715	172
COD	3.43 - 486	37.2	27.7 - 2,520	217	200 - 1,090	463
TOC	1.09 - 65.8	8.01	5.43 - 320	41.5	48.6 - 458	149
TSS	0.74 - 286	11.7	0.94 - 360	18.2	6.29 - 372	48.6
Sulfides	0.002 - 1.52	0.054	0.01 - 39.5[d]	0.94[d]	0.009 - 91.5	0.86
Oil and grease	1.03 - 88.7	8.29	2.86 - 365	31.2	12.0 - 235	52.9
Phenols	0.001 - 1.06	0.034	0.19 - 80.1	4.00	2.55 - 23.7	7.72
Ammonia	0.077 - 19.5	1.20	2.35 - 174	28.3	5.43 - 206	34.3
Chromium	0.0002 - 0.29	0.007	0.0008 - 4.15	0.25	0.014 - 3.86	0.234

Characteristics	Lube subcategory Range	Lube subcategory Median	Integrated subcategory Range	Integrated subcategory Median
Flow[c]	68.6 - 772	117	40.0 - 1.370	235
BOD_5	62.9 - 758	217	63.5 - 615	197
COD	166 - 2.290	543	72.9 - 1,490	329
TOC	31.5 - 306	109	28.6 - 678	139
TSS	17.2 - 312	71.5	15.2 - 226	59.1
Ammonia	6.5 - 96.2	24.1		
Phenols	4.58 - 52.9	8.29	0.61 - 22.6	3.78
Sulfides	0.00001 - 20.0	0.014	0.52 - 7.87[d]	2.00[d]
Oil and grease	23.7 - 601	120	20.9 - 269	74.9
Chromium	0.002 - 1.23	0.046	0.12 - 1.92	0.49

[a] After refinery API separator.

[b] Probability of occurrence less than or equal to 10% or 90% respectively.

[c] 1,000 m^3/1,000 m^3 of feedstock throughput.

[d] Sulfur.

TABLE 14-8. SUBCATEGORY WASTEWATER FLOWS [2,4]

Subcategory	Median flow, gal/bbl feedstock throughput		1974 Guidelines	
	1974	1977	BPT flow basis, gal/bbl feedstock throughput	BAT flow basis, gal/bbl feedstock throughput
Topping	23.3	7.8	20	10.5
Cracking	32.5	17.3	25	14
Petrochemical	155	24.9	30	19
Lube	41	40.1	45	30.5
Integrated	480	36.0	48	36.5

(2) EPA Region V Laboratory, Chicago, Illinois -- metals, mercury

(3) Midwest Research Institute (MRI), Kansas City, Missouri -- volatile and semivolatile organics

(4) Ryckman, Edgerley, Tomlinson, and Associates, Inc. (RETA), St. Louis, Missouri -- volatile and semivolatile organics, pesticides, cyanides, phenolics, mercury, metals, asbestos, traditional parameters

(5) Gulf South Research Institute, Baton Rouge, Louisiana -- volatile and semivolatile organics

(6) NUS Corporation, Pittsburgh, Pennsylvania -- volatile and semivolatile organics, pesticides

The conventional parameters for which refinery wastewater samples were analyzed include BOD_5, COD, TOC, TSS, oil and grease, ammonia, sulfides, hexavalent chromium, and pH. Each of the three consecutive 24-hr composites collected at each sampling location in a given refinery was tested for eight of these parameters. Grab samples collected at the end of each sample day were used for the oil and grease analyses. Three seeding alternatives were used in performing the BOD_5 analyses. Method 1 used a seed from a domestic sewage treatment plant; Method 2 used refinery final effluent as a seed; and no seed at all was used in Method 3.

Analyses for semivolatiles, acid extractables, and base-neutrals were completed.

Pesticides were looked for in samples from 11 of the refineries, but without GC/MS verification.

Samples were collected in each 24-hr period for cyanides, phenolics, and mercury, and reported as Day 1, 2, or 3 results. RSKERL and RETA analyzed for cyanides, mercury, and phenolics, and "mercury (laboratory 2)" results are from EPA's Region V Laboratory. Samples from each 24-hr period and a 72-hr composite were analyzed for toxic pollutant metals. These analyses were performed by RSKERL, RETA, and EPA's Region V Laboratory.

Asbestos was looked for in samples from four refineries (I, L, M, and P). It is thought that asbestos contributions within a refinery may be affected by rainfall; two of the four refineries tested had dry weather, and two had significant rainfall.

Tables 14-9 through 14-25 present the analytical results on a refinery-by-refinery basis.

II.14.4 POLLUTANT REMOVABILITY

II.14.4.1 Toxic Pollutants

Based on the limited data received, it appears that BPT technology (including biological treatment plus effluent polishing) provides effective removal of toxic pollutants identified as being present in petroleum refining raw wastewaters. It has been shown that after the application of BPT-type technology, effluent metals concentrations occur at the range typical of what would occur after the application of precipitation techniques. In all cases for which complete data are available, organic toxic pollutants present in the raw wastes, sometimes at levels in the low mg/L range, have been shown to be removed to levels in the low µg/L range (generally less than 10 µg/L). No data on removability of toxic pollutants other than that shown in Table 14-3 in ranges and median concentrations for intake, raw wastewater, and final effluent are available for toxic pollutants [4,5].

II.14.4.2 Conventional Pollutants

End-of-pipe control technology in the petroleum refining industry relies heavily upon the use of biological treatment methods. These are supplemented by appropriate pretreatment to insure that proper conditions, especially sufficient oil removal and pH adjustment, are present in the feed to the biological system. When used, initial treatment most often consists of neutralization for control of pH and equalization basins to minimize shock loads on the biological systems. The incorporation of solids removal ahead of biological treatment is not as important as it is in treating municipal wastewaters.

The selection of plants was not based on a cross section of the entire industry, but rather was biased in favor of those segments of the industry that had the more efficient wastewater treatment

TABLE 14-9. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY A [4,5]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Comp.[a]	Intake Comp.[a]	Separator effluent Day 1	Separator effluent Day 2	Separator effluent Day 3	Separator effluent Comp.	Separator effluent Comp.	Final effluent Day 1	Final effluent Day 2	Final effluent Day 3	Final effluent Comp.	Final effluent Comp.
Conventional pollutants, mg/L[b]															
BOD-1	<2	<1	2			20	20	25			<2	<2	3		
BOD-2	<2	<1	4			24	18	30							
BOD-3											<2	<2	2		
COD	4	4	8			130	91	99			36	40	28		
TOC	1	2	2			36	25	36			11	11	11		
TSS	5	4	<1			490	390	260			44	30	42		
Total phenols	<10	<10	<11			<520	140	150			<21	10	<11		
Sulfide	<0.1	<0.1	0.2			9.0	6.9	8.5			0.2	0.2	0.4		
pH	7.9	9.0	8.8			8.6	8.5	9.0			6.9	7.4	7.0		
Ammonia	<1.0	11	1.0			13	11	11			16	11	9.0		
Metals and inorganics, μg/L															
Antimony					<25					<25					<25
Arsenic					<10					12					<10
Beryllium	<2	<2	<2	<2	<3	<2	<2	<2	<2	<3	<2	<2	<2	<2	<3
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	<24	<24	<24	<24	<5	<24	<24	1,220	30	32	<24	<24	<24	<24	5
Chromium +6	<20	<20	<20			90	30	50			40	<20	<20		
Copper	<4	<4	<4	<4	<5	26	23	39	23	17	<4	<4	6	5	<5
Cyanides	<10	<10	<10			50	60	40			<30	<30	<30		
Lead	<60	<60	<60	<60	<15	149	109	224	114	64	<60	<60	<60	<60	<15
Mercury	0.1	0.1	0.1	0.1	<0.5	0.2	0.2		0	<0.5	0.2	0.2	0.2	0.3	<0.5
Nickel	<50	<50	<50	<50	<15	<50	<50	<50	<50	23	<50	<50	<50	<50	<15
Selenium					<10					<10					<10
Silver	<25	<25	<25	<25	<5	<25	<25	<25	<25	<5	<25	<25	<25	<25	<5
Thallium					<25					<15					<15
Phthalates, μg/L															
Di-n-butyl phthalate				0.2					0.9					0.7	
Diethyl phthalate				ND[c]					1.3					ND	
Phenols, μg/L															
Phenol				ND					13					ND	
Aromatics, μg/L															
Benzene				ND					>100					ND	
Ethylbenzene				ND					>100					ND	
Toluene				ND					>100					ND	
Polycyclic aromatic hydrocarbons, μg/L															
Acenaphthene				ND					12					ND	
Acenaphthylene				ND					37					ND	
Anthracene/phenanthrene				<0.1					5					ND	
Naphthalene														ND	
Halogenated aliphatics, μg/L															
Chloroform				70					<5					<5	
1,2-*Trans*-dichloroethylene				ND					20					ND	
Methylene chloride				>100					>100					>100	
Tetrachloroethylene									>50					<10	
Flow, MGD											0.433	0.427	0.432		

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, μg/L; pH, pH units.

[c] Not detected in sample.

TABLE 14-10. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY B [4,5]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Comp.[a]	Intake Comp.[a]	DAF effluent Day 1	DAF effluent Day 2	DAF effluent Day 3	DAF effluent Comp.	DAF effluent Comp.	Final effluent Day 1	Final effluent Day 2	Final effluent Day 3	Final effluent Comp.	Final effluent Comp.
Conventional pollutants, mg/L[b]															
BOD-1	<3	<3	2			130	170	270			15	9	30		
BOD-2	<3	<3	<3			140	110	220							
BOD-3											14	7	7		
COD	9	9	9			420	440	500			150	120	120		
TOC	13	25	18			100	110	110			47	39	43		
TSS	9	13	11			38	50	38			22	24	20		
Total phenols	<10	<5	<5			32,000	34,000	22,000			64	48	45		
Sulfide	0.2	0.2	0.4			0.6	1.0	1.2			0.5	0.5	0.6		
Oil and grease	19	7	6			33	18	11			53	24	15		
pH	8.2	8.1	8.3			9.2	8.6	9.5			7.2	7.6	7.4		
Ammonia	<1.0	<1.0	<1.0			8.4	7.3	6.7			18	16	18		
Metals and inorganics, µg/L															
Antimony					<25					<25					<25
Arsenic					<20					<20					<20
Beryllium	<1	<1	<1	<1	<3	<1	<1	<1	<1	<3	<1	<1	<1	<1	<3
Cadmium	<2	<2	7	<2	<1	<2	<2	3	<2	<1	8	<2	<2	<2	<1
Chromium	30	30	50	60	<5	50	50	60	60	<5	70	70	40	50	<5
Chromium +6	<20	<20	<20			<20	100	<20			<20	<20	<20		
Copper	30	20	40	30	<5	<6	9	10	10	7	<6	<6	<6	<6	<5
Cyanides	<20	<20	<20			40	50	40			<20	<20	<20		
Lead	60	60	50	70	<15	<20	<20	<20	<20	<15	<20	<20	<20	<20	<15
Mercury				<0.5					<0.5					<0.5	
Nickel	6	6	20	20	<15	<5	<5	<5	<5	<15	<5	<5	<5	<5	<15
Selenium					<20					<20					<20
Silver	<1	<1	<2	<2	<5	<1	<1	<1	<1	<5	<1	<1	<1	<1	<5
Thallium					<15					<15					<15
Zinc	<60	<60	100	100	15	<60	<60	<60	<60	30	<60	<60	<50	<60	25
Phenols, µg/L															
2,4-Dimethylphenol					ND[c]					10,000					<10
4-Nitrophenol					ND					ND					<10
Phenol					ND					ND					<10
p-Chloro-*m*-cresol					ND					ND					<10
Aromatics, µg/L															
Benzene					ND					ND					<10
Polychlorinated biphenyls and related compounds, µg/L															
Aroclor 1016					ND					<10					<10
Aroclor 1221					ND					<10					<10
Aroclor 1232					ND					<10					<10
Aroclor 1242					ND					<10					<10
Aroclor 1248					ND					<10					<10
Aroclor 1254					ND					<10					<10
Aroclor 1260					ND					<10					<10
Halogenated aliphatics, µg/L															
Chloroform					<10					11					<10
Methylene chloride					22					30					ND
Pesticides and metabolites, µg/L															
β-BHC					ND					<5					<5
γ-BHC					ND					<5					ND
4,4'-DDD					ND					<5					ND
Endosulfan sulfate					ND					<5					ND
Heptachlor					ND					<5					<5
Flow, MGD	3.91	3.86	4.12			1.78	1.81	1.81			1.69	2.07	1.48		

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, µg/L; pH, pH units.

[c] Compound was not detected.

TABLE 14-11. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY C [4,5]

Pollutant	Intake					Separator effluent				
	Day 1	Day 2	Day 3	Composite[a]	Day 4	Day 1	Day 2	Day 3	Composite	Day 4
Conventional pollutants, mg/L[b]										
BOD-1	2	<3	<2			150	160	79		
BOD-3						110	120	85		
COD	1	1	2			380	370	220		
TOC	12	8	5			88	75	49		
TSS	<1	<1	<1			22	36	26		
Total phenols (laboratory 3)	4	6	4			12,000	3,200	1,500[d]		
Sulfide	<0.5	<0.5	0.3			<0.5	3.8	<0.3		
Oil and grease	8	10	4			150	100	28		
pH	7.6	7.8	7.4			8.6	9.1	8.7		
Ammonia	<1.0	<1.0	<1.0			52	50	13		
Metals and inorganics, µg/L										
Antimony				1					<1	
Arsenic				4					8	
Beryllium				<1					<1	
Cadmium				<1					<1	
Chromium				2		770	820	940	880	
Chromium +6	<20	<20	<20			50	<20	<20		
Copper				2					190	
Cyanides (laboratory 3)	1	1	1		<20	1,100	120	70		
Lead	<1	<1	<1	1					<2	
Mercury (laboratory 1)	1.4	1.6	1.3	1.3		1.1	1.2	1.5	1.2	
Mercury (laboratory 3)	1.0	6.0	1.0		<0.1	<1.0	6.0		4.9[d]	<0.4
Nickel	<2	<2	<2	1					<1	
Selenium	4	13	4	5		11	8	9	15	
Silver				<1					<1	
Thallium	<1	3	<1	<2	<1	<1	<1	<1		<1
Zinc				20	<1	630	670	550	690	679
Phthalates, µg/L										
Bis(2-ethylhexyl) phthalate				150					290	
Phenols, µg/L										
Phenol				ND[c]					2,200	
Aromatics, µg/L										
Benzene				ND					417	
Ethylbenzene				ND					38	
Polycyclic aromatic hydrocarbons, µg/L										
Anthracene/phenanthrene				ND					190	
Naphthalene				ND					950	
Halogenated aliphatics, µg/L										
Chloroform				<1					ND	
1,2-Dichloroethane				ND					16	
Methylene chloride				85					3	
Flow, MGD										

(continued)

TABLE 14-11 (continued)

Pollutant	Treated effluent Day 1	Treated effluent Day 2	Treated effluent Day 3	Treated effluent Composite	Treated effluent Day 4	Final effluent Day 1	Final effluent Day 2	Final effluent Day 3	Final effluent Composite	Final effluent Day 4
Conventional pollutants, mg/L[b]										
BOD-1	28	34	40			37	40	45		
BOD-3										
COD	130	120	120			130	130	100		
TOC	44	39	41			42	37	36		
TSS	20	18	28			20	22	16		
Total phenols (laboratory 3)	<1	14[d]	<1			2	6	2		
Sulfide	<0.5	<0.5	0.2			0.5	0.5	0.4		
Oil and grease	8	15	11			7	11	11		
pH	7.8	7.7	7.6			8.0	8.1	7.0		
Ammonia	8.4	5.6	4.5			7.8	17	3.9		
Metals and inorganics, µg/L										
Antimony				1					3	
Arsenic				6					5	
Beryllium				<1					<1	
Cadmium	13	9	15	16					<1	
Chromium	940	470	1,100	490					3	
Chromium +6	<20	<20	<20			<20	<20	<20		
Copper	100	190	260	230					10	
Cyanides (laboratory 3)						30	45[d]	60		70
Lead				17		26	58	26	50	
Mercury (laboratory 1)	0.8	1.0	1.0	1.2		1.1	1.4	1.3	1.3	
Mercury (laboratory 3)	2.0	5.0	7.5		<0.2	1.0	1.0	6.0	0.3	0.5
Nickel	9	6	44	18		7	7	7	15	
Selenium	10	<6	8	15		13	10	19	19	
Silver				<1					<1	
Thallium	<1	<1	<1		<1	3	7	<1	<2	<1
Zinc	930	440	930	780	519	590	620	590	700	545
Phthalates, µg/L										
Bis(2-ethylhexyl) phthalate				900						310
Phenols, µg/L										
Phenol				ND					ND	
Aromatics, µg/L										
Benzene				ND					ND	
Ethylbenzene				ND					ND	
Polycyclic aromatic hydrocarbons, µg/L										
Anthracene/phenanthrene				ND					ND	
Naphthalene				ND					ND	
Halogenated aliphatics, µg/L										
Chloroform				ND					ND	
1,2-Dichloroethane				ND					ND	
Methylene chloride				7					20	
Flow, MGD	0.0915	0.0848	0.1526			0.1787	0.1411	0.2357		

Note: Blanks indicate data not available.

[a]24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b]Total phenols, µg/L; pH, pH units.

[c]Not detected in sample.

[d]Average value.

TABLE 14-12. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY D [4,5]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Comp.[a]	Intake Comp.[a]	DAF effluent Day 1	DAF effluent Day 2	DAF effluent Day 3	DAF effluent Comp.	DAF effluent Comp.	Final effluent Day 1	Final effluent Day 2	Final effluent Day 3	Final effluent Comp.	Final effluent Comp.
Conventional pollutants, mg/L[b]															
BOD-1	<5	1	3			160	140	142			50	110	150		
BOD-2	20	4	6			<220		<360							
BOD-3											40	62	90		
COD	20	4	4			1,000	500	390			820	670	490		
TOC	10	5	8			300	150	100			290	220	150		
TSS	24	32	16			62	36	32			64	60	60		
Total phenols			23			3,700	5,100	8,000							
Sulfide	<0.1	<0.1	<0.1			15	18	15			1.7	1.1	0.8		
pH	7.3	7.4	7.3			8.9	8.5	8.6			7.7	7.7	7.6		
Ammonia	<1.0	2.2	2.0			36	29	40			36	42	39		
Metals and inorganics, µg/L															
Antimony					<25					<25					<25
Arsenic					<10					<10					<10
Beryllium	<20	<20	<20	<20	<3	<20	<2	<2	<2	<3	- <2	<2	<2	<2	<3
Cadmium	<200	<200	<200	<200	<1	<200	<20	<20	<20	<1	<20	<20	<20	<20	[illegible]
Chromium	<240	<240	<240	<240	<14	1,020	681	479	719	730	1,230	1,160	875	1,080	[illegible]
Chromium +6	<20	<20	<20			<20	<20	<20			<20	<20	30		
Copper	<40	<40	<40	<40	<5	<40	15	6	7	<5	<4	<4	<4	<4	<5
Cyanides	<20	<20	<20			50	60	40			30	30	<20		
Lead	<600	<600	<600	<600	<15	<600	<60	<60	<60	<15	<60	<60	<60	<60	<15
Mercury	0.1	0.1	0.1	0.2	<0.5	0.2	0.1	0.2	<0.5	<0.1	0.2	0.2	0.2	0.2	0.5
Nickel	<500	<500	<500	<500	<15	<500	<50	<50	<50	<15	<50	<50	<50	<50	<15
Selenium					<10					<10					<10
Silver	<250	<250	<250	<250	<5	<250	<25	<25	<25	<5	<25	<25	<25	<25	<5
Thallium					<15					<25					<25
Zinc	<250	<250	<250	<250	33	410	242	181	262	280	515	480	338	430	400
Aromatics, µg/L															
Benzene				ND[c]					>100					ND	
Ethylbenzene				ND					>100					ND	
Toluene				ND					>100					ND	
Polycyclic aromatic hydrocarbons, µg/L															
Anthracene/phenanthrene				<0.1					140					ND	
Benzo(a)pyrene				ND					ND					3	
Chrysene				ND					0.1					1.4	
Fluoranthene				ND					3					ND	
Naphthalene				2					190					ND	
Pyrene				ND					11					7	
Polychlorinated biphenyls and related compounds, µg/L															
Aroclor 1221				ND					ND					<5	
Aroclor 1242				ND					1.1					ND	
Flow, MGD							0.932					0.93[illegible]			

Note: Blanks indicate data not available.

[a]24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b]Total phenol, µg/L; pH, pH units.

[c]Not detected in sample

TABLE 14-13. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY E [4,5]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Composite[a]	Intake Composite	DAF effluent Day 1	DAF effluent Day 2	DAF effluent Day 3	DAF effluent Composite	DAF effluent Composite
Conventional pollutants, mg/L[b]										
BOD-1	3	2	2			54	52	45		
BOD-2	4	3	3			56	41	44		
BOD-3										
COD	43	59	39			160	160	150		
TOC	15	15	15			48	42	39		
TSS	14	19	28			17	13	16		
Total phenols	<11	15	<10			6,800	9,900	11,000		
Sulfide	<0.1	<0.1	<0.1			1.8	1.5	1.5		
pH	7.7	7.6	7.5			7.3	7.1	7.2		
Ammonia	1.0	7.8	7.8			13	12	15		
Metals and inorganics, µg/L										
Antimony					<25					<25
Arsenic					<10					<10
Beryllium	<2	<2	<2	<2	<3	<2	<2	<2	<2	<3
Cadmium	<20	<20	<20	<20	2	<20	<20	<20	<20	<1
Chromium	25	58	35	42	35	104	86	89	89	76
Chromium +6	<0.02	<0.02	<0.02			<0.02	<0.02	<0.02		
Copper	5	8	15	10	8	<4	<4	<4	<4	<5
Cyanides	30	<30	<30			<30	<30	<30		
Lead	<60	<60	<60	<60	23	<60	<60	<60	<60	<15
Mercury	<0.1	<0.1	<0.1	<0.5	<0.1	<0.1	<0.1	<0.1	<0.5	<0.1
Nickel	<50	<50	<50	<50	51	<50	<50	<50	<50	28
Selenium					<10					<10
Silver	<25	<25	<25	<25	<5	<25	<25	<25	<25	<5
Thallium					<15					<15
Zinc	141	102	130	127	110	61	47	54	74	50
Phthalates, µg/L										
Di-n-butyl phthalate				0.4					ND[c]	
Phenols										
Phenol				ND					>100	
2,4-Dimethylphenol				ND					>100	
Aromatics, µg/L										
Benzene				ND					>100	
1,2-Dichlorobenzene				<0.5					ND	
1,4-Dichlorobenzene				<0.5					ND	
Ethylbenzene				ND					>100	
Toluene				ND					>100	
Polycyclic aromatic hydrocarbons, µg/L										
Acenaphthene				1.8					150	
Anthracene/phenanthrene				ND					50	
Chrysene				ND					0.3	
Fluoranthene				<0.2					ND	
Fluorene				ND					110	
Naphthalene				ND					106	
Pyrene				<0.1					5	
Polychlorinated biphenyls and related compounds, µg/L										
Aroclor 1242				ND					0.2	
Halogenated aliphatics, µg/L										
Methylene chloride				50					10	
Tetrachloroethylene				50					ND	
Trichloroethylene				20					ND	

(continued)

TABLE 14-13 (continued)

Pollutant	Final effluent				
	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]					
BOD-1	18	2	<1		
BOD-2					
BOD-3	18	<1	<1		
COD	47	75	55		
TOC	10	7	13		
TSS	9	20	13		
Total phenols	13	11	<10		
Sulfide	0.3	0.5	0.6		
pH	7.6	7.5	7.5		
Ammonia	35	11	13		
Metals and inorganics, µg/L					
Antimony					<25
Arsenic					<10
Beryllium	<2	<2	<2	<2	<3
Cadmium	<20	<20	<20	<20	<1
Chromium	42	52	44	42	36
Chromium +6	<0.02	<0.02	<0.02		
Copper	<4	<4	<4	<4	<5
Cyanides	<30	<30	<30		
Lead	<60	<60	<60	<60	<15
Mercury	0.1	<0.1	0.1	<0.5	0.1
Nickel	<50	<50	<50	<50	<19
Selenium					12
Silver	<25	<25	<25	<25	<5
Thallium					<15
Zinc	49	77	59	44	30
Phthalates, µg/L					
Di-n-butyl phthalate				ND	ND
Phenols					
Phenol				ND	ND
2,4-Dimethylphenol					
Aromatics, µg/L					
Benzene				ND	
1,2-Dichlorobenzene				ND	ND
1,4-Dichlorobenzene				ND	ND
Ethylbenzene				ND	
Toluene				ND	
Polycyclic aromatic hydrocarbons, µg/L					
Acenaphthene					
Anthracene/phenanthrene				<0.5	<0.1
Chrysene				<0.1	ND
Fluoranthene				ND	ND
Fluorene				ND	ND
Naphthalene				ND	ND
Pyrene				<0.5	<0.5
Polychlorinated biphenyls and related compounds, µg/L					
Aroclor 1242					
Halogenated aliphatics, µg/L					
Methylene chloride				10	
Tetrachloroethylene				ND	
Trichloroethylene				ND	

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, µg/L; pH, pH units.

[c] Not detected in sample.

TABLE 14-14. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY F [4,5]

Pollutant	Intake					Cooling tower				
	Day 1	Day 2	Day 3	Composite[a]	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	40	40	42			25	130	47		
BOD-2	50	52				42	>160	36		
BOD-3			35							
COD	340	350	340			210	300	350		
TOC	96	110	97			62	78	95		
TSS	68	68	40			64	76	80		
Total phenols	210	210	210			37	1	57		
Sulfide	1.6	0.9	0.7				1.0	<0.1		
pH	8.2	8.1	8.0			7.3	8.1	6.8		
Ammonia	1.7	68	63			3.9	10	19		
Metals and inorganics, μg/L										
Antimony					<25					<25
Arsenic					27					41
Beryllium	<20	<20	<2	<2	<3	<2	<2	<2	<2	<3
Cadmium	<200	<200	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	<240	<240	72	58	60	50	60	79	57	44
Chromium +6	<20	<20	<20			50	90	410		
Copper	50	190	184	151	210	278	350	510	405	500
Total cyanide	<30	<30	<30			520	830	830		
Lead	<600	<600	<60	<60	<15	<60	<60	<60	<60	<15
Mercury	<0.2	<0.7	<0.9	<0.5	0.6	0.4	0.5	0.7	<0.5	
Nickel	<500	<500	57	62	58	64	101	134	88	77
Selenium					12					<10
Silver	<250	<250	<250	<250	<5	<250	<250	<25	<25	<5
Thallium					<15					<15
Zinc	<250	<250	127	133	120	229	342	452	342	330
Polycyclic aromatic hydrocarbons, μg/L										
Anthracene/phenanthrene				164					1.8	
Chrysene/benz(a)anthracene				49					6.5	
Benzo(a)pyrene/perylene				33					10	
Fluoranthene				29					ND[c]	
Pyrene				140					10	
Polychlorinated biphenyls and related compounds, μg/L										
Aroclor 1221				ND					0.1	
Halogenated aliphatics, μg/L										
Carbon tetrachloride				>50					ND	
Methylene chloride				<10					70	
1,1,1-Trichloroethane				>50					ND	
Pesticides and metabolites, μg/L										
β-BHC				ND					0.7	
Chlordane				2.8					ND	
Flow, MGD		1.5[d]					0.17[d]			

(continued)

TABLE 14-14 (continued)

Pollutant	Final effluent Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]					
BOD-1	18	36	20		
BOD-2					
BOD-3	18	36	18		
COD	260	270	260		
TOC	110	75	82		
TSS	110	96	100		
Total phenols	22	24	26		
Sulfide		2.0	<0.1		
pH	8.6	8.5	8.6		
Ammonia	3.9	2.8	3.9		
Metals and inorganics, μg/L					
Antimony					
Arsenic					31
Beryllium	<2	<2	<2	<2	<3
Cadmium	<20	<20	<20	<20	<1
Chromium	73	31	29	45	7
Chromium $^{+6}$	<0.02	<0.02	0.03		
Copper	199	86	84	125	125
Total cyanide	60	70	80		
Lead	<60	<60	<60	<60	<15
Mercury	0.3	0.3	0.3	0.5	0.4
Nickel	68	74	71	64	58
Selenium					<10
Silver	<25	<25	<25	<25	<5
Thallium					<15
Zinc	125	151	112	132	100
Polycyclic aromatic hydrocarbons, μg/L					
Anthracene/phenanthrene[d]				ND	
Chrysene/benz(a)anthracene				0.8	
Benzo(a)pyrene/perylene				1.3	
Fluoranthene				ND	
Pyrene				10	
Polychlorinated biphenyls and related compounds, μg/L					
Aroclor 1221				ND	
Halogenated aliphatics, μg/L					
Carbon tetrachloride				ND	
Methylene chloride				<10	
1,1,1-Trichloroethane				ND	
Pesticides and metabolites, μg/L					
β-BHC				ND	
Chlordane				ND	
Flow, MGD		0.017[d]			

Note: Blanks indicate data not available.

[a] Composite sample.

[b] Total phenols, μg/L; pH, pH units.

[c] Not detected in sample.

[d] Average flow during 24-hr sampling period.

TABLE 14-15. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY G [4,5]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Composite[a]	Intake Composite[a]	Intake Day 4	Separator effluent Day 1	Separator effluent Day 2	Separator effluent Day 3	Separator effluent Composite	Separator effluent Composite	Separator effluent Day 4
Conventional pollutants, mg/L[b]												
BOD-1	<3	<3	<3				240	250	260			
BOD-2	<3	<3	<3				280	240	290			
BOD-3			<3				260					
COD	20	28	24				820		860			
TOC	12	16	8				240		220			
TSS	<1	18	16				54	252	112			
Total phenols	10	<1	8				23,500	25,000	23,000			
Sulfide	<0.1	0.6	0.3				22	32	28			
Oil and grease	23	7	8				130	56	110			
pH	7.6	7.7	7.7				10.2	10.3	10.6			
Ammonia	<1.0	<1.0	<1.0				20		8.0			
Metals and inorganics μg/L												
Antimony					<1						<1	
Arsenic					5						5	
Beryllium	<2	<2	<2	<2	<1		<2	<2	<2	<2	<1	
Cadmium	<20	<20	<20	<20	<1		<20	<20	<20	<20	<1	
Chromium	<24	<24	<24	<24			615	676	73	606		
Chromium[c]					1		820	790	1,200		1,000	
Chromium +6	<0.02	<0.02	<0.02				0.02	0.02	<0.02			
Copper	<4	<4	<4	<4	7		6	53	<4	8	7	
Cyanides	<10	<10	<10	<20		<20	1,200	1,200	1,500			600
Lead	78	102	<60	<60			181	308	<60	181		
Lead[c]					2		420	160	430		278	
Mercury (laboratory 1)	1.3	2.1	2.3	0.8			1.7	0.9	1.8	0.3		
Mercury (laboratory 3)	0.5	0.4	<0.5				<0.2	<0.2	0.2			
Nickel	<50	52	<50	<50	<1		<50	85	<50	93	<1	
Selenium	<1	<1	<1		3		9	10	6		6	
Silver	<25	<25	<25	<25	<1		<25	<25	<25	<25	<1	
Thallium					<2	<1	<1	<1	<1		<2	<1
Zinc	52	72	28	30			125	117	170	179		
Zinc[c]	<1	<1	<1		36		60	24	110		66	
Phthalates, μg/L												
Bis(2-ethylhexyl) phthalate				1,100						700		
Phenols, μg/L												
Phenol				10						4,900		
Aromatics, μg/L												
Benzene					<1					409		
Toluene					<1					96		
Polycyclic aromatic hydrocarbons, μg/L												
Anthracene/phenanthrene				ND[d]						1,100		
Chrysene/benz(a)anthracene				ND						40		
Fluoranthene/pyrene				ND						40		
Naphthalene				ND						1,100		
Polychlorinated biphenyls and related compounds, μg/L												
Aroclor 1016				ND						1.8		
Aroclor 1232				ND						ND		
Aroclor 1242				ND						0.5		
Halogenated aliphatics μg/L												
Methylene chloride				22						293		
Pesticides and metabolites, μg/L												
α-Endosulfan				ND						ND		
Flow, MGD	3.22	3.20					10.2	10.3	10.6			

(continued)

TABLE 14-15 (continued)

Pollutant	DAF effluent Day 1	Day 2	Day 3	Composite[a]	Composite[a]	Day 4	Final effluent Day 1	Day 2	Day 3	Composite	Composite	Day 4
Conventional pollutants, mg/L[b]												
BOD-1	240	280	220				15	10	6			
BOD-2	270	280	260									
BOD-3	250						12	<10	<14			
COD	860	900	1,200				200	220	210			
TOC	200	360	290				60	64	56			
TSS	64	152	176				36	76	64			
Total phenols	22,000	26,000	22,000				47	20	32			
Sulfide	18	28	30				2.0	1.8	2.1			
Oil and grease	190	250	220				24	9	10			
pH	9.9	10.2	10.4				8.3	8.0	8.0			
Ammonia	14	12	10				15	15	12			
Metals and inorganics, µg/L												
Antimony					1						<1	
Arsenic					<4						5	
Beryllium	<2	<2	<2	<2	<1		<2	<2	<2	<2	<2	
Cadmium	<20	<20	<20	24	<1		<20	<20	<20	<20	<1	
Chromium	526	414	73	425			89	86	73	<24		
Chromium[c]	710	680	930		800						1	
Chromium +6	<20	<20	<20				<20	<20	<20			
Copper	<4	<4	<4	8	3		<4	<4	<4	<4	7	
Cyanides	1,900	2,000	3,000			130	90	70	300			170
Lead	159	115	<60	144			107	90	<60	<60		
Lead[c]	270	320	360		260						2	
Mercury (laboratory 1)	1.1	1.1	1.0	0.3	0.4							
Mercury (laboratory 3)	<0.2	0.5	1				0.85	<0.2	0.5			
Nickel	<50	<50	<50	104	1		57	63	<50	<50	<1	
Selenium	5	13	7		9		32	9	7		3	
Silver	<25	<25	<25	<25	<1		<25	<25	<25	<25	<1	
Thallium	<1	<1	<1		<2	<1	6	12	5		<2	<1
Zinc	93	94	64	139			51	46	64	30		
Zinc[c]	44	87	92		53						36	
Phthalates, µg/L												
Bis(2-ethylhexyl) phthalate				1,100						850		
Phenols, µg/L												
Phenol				2,400						ND		
Aromatics, µg/L												
Benzene				2,000							<1	
Toluene				76,000							<1	
Polycyclic aromatic hydrocarbons, µg/L												
Anthracene/phenanthrene				600						ND		
Chrysene/benz(a)anthracene				ND						ND		
Fluoranthene/pyrene				ND						ND		
Naphthalene				700						ND		
Polychlorinated biphenyls and related compounds, µg/L												
Aroclor 1016				7.9						ND		
Aroclor 1232				3.5						ND		
Aroclor 1242				0.5						ND		
Halogenated aliphatics, µg/L												
Methylene chloride				563						12		
Pesticides and metabolites, µg/L												
α-Endosulfan				0.1						ND		
Flow, MGD							2.60	2.27	2.04			

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, µg/L; pH, pH units.

[c] Grab samples collected during second visit.

[d] Not detected in sample.

TABLE 14-16. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY H [4,5]

	Intake					Separator effluent				
Pollutant	Day 1	Day 2	Day 3	Composite[a]	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	<2	<2	2			60	20	30		
BOD-2	<2	<2	2			80	<15	31		
BOD-3										
COD	12		23				200	180		
TOC	9		14				57	50		
TSS	14	113	167			120	66	121		
Total phenols	11	<5	5			2,300	2,200	1,900		
Sulfide	0.3	<0.1	0.1			3.7	4.4	1.2		
Oil and grease	31	13	8			80	51	24	37	13
pH	8.2	8.5	7.9			7.3		8.6		
Ammonia	<1		<1				7.3	6.2		
Metals and inorganics, µg/L										
Antimony					<25					<25
Arsenic					<20					<20
Beryllium	<1	<1	<1	<1	<3	<1	<1	<1	<1	<3
Cadmium	<2	<2	8	<2	<1	<2	<2	<2	<2	<1
Chromium	20	10	20	10	<5	10	7	20	10	<5
Chromium +6	<20	<20	400			<20	20	40		
Copper	<6	9	10	7	<5	30	20	30	30	7
Cyanides	<20	<20	<20			160	70	80		
Lead	<20	<20	<20	<20	<15	<20	<20	<20	<20	<15
Mercury				<0.5					<0.5	
Nickel	<5	<5	<5	<5	<15	<5	<5	<5	<5	<15
Selenium					<20					<20
Silver	<1	<1	<1	<1	<5	<1	<1	<1	<1	<5
Thallium					<15					<15
Zinc	<60	<60	<60	<60	<15	<60	<60	70	<60	30
Phthalates, µg/L										
Bis(2-ethylhexyl) phthalate				ND[c]					ND	
Phenols, µg/L										
2,4-Dichlorophenol				ND					ND	
2,4-Dimethylphenol				ND					175	
Phenol				ND					440	
Flow, MGD	35					5.04				

(continued)

TABLE 14-16 (continued)

Pollutant	Final effluent				
	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]					
BOD-1	<6	<6	3		
BOD-2					
BOD-3	<6	<6	3		
COD	40	36	48		
TOC	20	18	21		
TSS	8	10	8		
Total phenols	<10	10	12		
Sulfide	0.2	0.2	0.1		
Oil and grease	3				
pH	7.4	8.4	7.8		
Ammonia	6.2	5.0	5.0		
Metals and inorganics, μg/L					
Antimony					<25
Arsenic					<20
Beryllium	<1	<1	<1	<1	<3
Cadmium	<2	<2	20	<2	<1
Chromium	20	10	10	10	<5
Chromium +6	<20	<20	<20		
Copper	10	10	9	7	<5
Cyanides	20	10	20		
Lead	80	30	<20	30	<15
Mercury					<0.5
Nickel	<5	<5	<5	<5	<15
Selenium					20
Silver	<1	<1	<1	<1	<5
Thallium					<15
Zinc	<60	60	<60	<60	25
Phthalates, μg/L					
Bis(2-ethylhexyl) phthalates				<10	
Phenols, μg/L					
2,4-Dichlorophenol				10	
2,4-Dimethylphenol				ND	
Phenol				ND	
Flow, MGD	1.2				

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, μg/L; pH, pH units.

[c] Not detected in sample.

TABLE 14-17. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY I [4,5]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Composite[a]	Intake Composite	Separator effluent Day 1	Separator effluent Day 2	Separator effluent Day 3	Separator effluent Composite	Separator effluent Composite
Conventional pollutants, mg/L[b]										
BOD-1[a]	<3	<3	<3			88	76	55		
BOD-2[b]							32	66		
BOD-3[c]						77				
COD	4	5				260	260	260		
TOC	5	4				89	80	75		
TSS	<1	<1	2			38	46	32		
Total phenols	<1	<1	4			5,800	4,400	5,100		
Sulfide	0.5		0.4			0.5		0.6		
Oil and grease	2	4	5			30	25	42		
pH	7.8	8.6	7.6			5.7	9.1	8.9		
Ammonia	<1.0	<1.0				3.4	4.5	5.0		
Metals and inorganics, μg/L										
Antimony				<1					<1	
Arsenic				<4					5	
Beryllium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	<24	<24	<24	<24	1	98	91	102	98	3
Copper	<4	6	20	16	10	157	167	146	157	6
Total cyanide	<5	<5	<5			10	15	<5		
Lead	<60	<60	79	78	2	<60	<60	90	168	2
Mercury (laboratory 1), μg/L	1.3	1.1	1.4			1.2	2.8	1.1		
Mercury (laboratory 3)	0.7	0.5	0.7			<0.2	0.8	0.8		
Nickel	<50	<50	<50	<50	<1	7	<2	<2	5	<50
Selenium				2		<4	<4	7	4	
Silver	<25	<25	<25	<25	<1	<25	<25	<25	<25	<1
Thallium	<1	<1	<1	<1		<1	<1	<1	<2	
Zinc	69	52	836	25		110	100	100	100	1,120
Phthalates, μg/L										
Bis(2-ethylhexyl) phthalate				950					300	
Di-n-butylphthalate				30					ND	
Phenols, μg/L										
Phenol				ND[c]					390	
Polycyclic aromatic hydrocarbons, μg/L										
Naphthalene				ND					290	
Flow, MGD	3.53	3.53	3.53			2.99	3.26	3.29		

(continued)

TABLE 14-17 (continued)

Pollutant	Final effluent				
	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]					
BOD-1[a]	<12	<12	<12		
BOD-2[b]					
BOD-3[c]	<12	<12			
COD	88	76	72		
TOC	34	29	29		
TSS	6	8	10		
Total phenols	18	14	12		
Sulfide	0.7		0.4		
Oil and grease	5	3	9		
pH	7.1	7.2	7.5		
Ammonia	<1.0	<1.0	1.7		
Metals and inorganics, µg/L					
Antimony				<1	
Arsenic				<4	
Beryllium	<2	<2		<2	<1
Cadmium	<20	<20		<20	<1
Chromium	<24	<24		<24	1
Copper	85	22		71	3
Total cyanide	<5	<5	<5		
Lead	<60	<60		211	2
Mercury (laboratory 1), µg/L	4.2	1.2			
Mercury (laboratory 3)	<0.2	<0.2	1.0		
Nickel	<50			<50	<1
Selenium	25	23		16	
Silver	<25	<25		<25	<1
Thallium	<1	<1		<2	
Zinc	69	69		2,000	60
Phthalates, µg/L					
Bis(2-ethylhexyl) phthalate				600	
Di-n-butylphthalate				10	
Phenols, µg/L					
Phenol					
Polycyclic aromatic hydrocarbons, µg/L					
Naphthalene					
Flow, MGD	2.76	2.27	2.44		

Note: Blanks indicate data not available.

[a]24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b]Total phenols, µg/L; pH, pH units.

[c]Compound was not detected.

TABLE 14-18. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY J [4,5]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Composite[a]	Intake Composite	Separator 1 effluent Day 1	Separator 1 effluent Day 2	Separator 1 effluent Day 3	Separator 1 effluent Composite	Separator 1 effluent Composite
Conventional pollutants, mg/L[b]										
BOD-1	<5	2				51	76			
BOD-3			3			39	78	50		
COD	16	40	20			210	160	160		
TOC	14	19	10			60	39	55		
TSS	10	3	1			54	82	22		
Total phenols	17	24	2			1,000	1,000	200		
Sulfide	<0.1	<0.1	0.3			0.7	1.8	1.8		
Oil and grease	16	11	11			74	120	36		
pH	7.5	7.8	7.3			8.9	8.2	7.9		
Ammonia	2.0	<1.0	<1.0			2.0	1.0	1.7		
Metals and inorganics, μg/L										
Antimony					<1					<1
Arsenic					3					3
Beryllium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	<24	<24	<24	<24		36	620	50	52	
Chromium[c]					<1		100	16		76
Chromium $^{+6}$	<20	20	<20			20	<20	30		
Copper	5	10	<4	<4	1	<4	1,370	33	25	2
Cyanides	10	10	<10			10	10	10		
Lead	<60	<60	<60	<60	2	<60	958	<60	<60	4
Lead[c]										
Mercury (laboratory 1)	0.7	0.9	1.9	0.5		0.1	1.2	1.2	0.5	
Mercury (laboratory 3)	0.2[d]	0.2	2.0			3.0	<0.1	1		
Nickel	<50	<50	<50	<50	1	<50	771	<50	<50	<1
Selenium					3	7	16	<4		5
Silver	<25	<25	<25	<25	<1	<25	<25	<25	<25	<1
Thallium	<1	<1	<1		<2	<1	<1	<1		<2
Zinc	72	54	62	72		150	499	432	257	
Zinc[c]					54	120	250	420		320
Phthalates, μg/L										
Bis(2-ethylhexyl) phthalate				110					180	
Diethyl phthalate				ND[e]					ND	
Dimethyl phthalate				ND					ND	
Phenols, μg/L										
2,4-Dimethylphenol				ND					ND	
Pentachlorophenol				ND					ND	
Phenol				ND					420	
Polycyclic aromatic hydrocarbons, μg/L										
Acenaphthene				ND					ND	
Anthracene/phenanthrene				ND					30[d]	
Chrysene/benz(a)anthracene				ND					30[d]	
Fluoranthene/pyrene				ND					30[d]	
Fluorene				ND					ND	
Naphthalene				ND					ND	
Polychlorinated biphenyls and related compounds, μg/L										
Aroclor 1016				ND					ND	
Aroclor 1232				ND					ND	
Aroclor 1242				ND					ND	
Flow, MGD										

(continued)

TABLE 14-18 (continued)

Pollutant	Separator 2 effluent Day 1	Day 2	Day 3	Composite	Composite	Separator 3 effluent Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	85	>84				15	20			
BOD-3	>84	>84	>84			58	22	32		
COD	310	690	660			160	180	220		
TOC	57	200	230			52	45	63		
TSS	64	196	108			62	38	34		
Total phenols	1,000	2,000	2,500			690	1,300	270		
Sulfide	5.5	11	15			1.8	5.3	1.5		
Oil and grease	84	140	250			25	23	54		
pH	8.2	8.2	8.2			7.4	7.3	7.3		
Ammonia	8.4	14	8.4			3.0	6.2	4.5		
Metals and inorganics, µg/L										
Antimony					<1					<1
Arsenic					5					3
Beryllium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	440	1,050	411	584		547	1,010	350	626	
Chromium[c]	450	1,100	390		780	830	1,200	660		570
Chromium +6	<20	40	20			20	20	40		
Copper	<4	231	<4	55	7	14	16	16	25	2
Cyanides	10	10	10			10	10	10		
Lead	190	2,080	876	810		123	<60	<60	71	
Lead[c]	190	2,000	380		870					2
Mercury (laboratory 1)	2.8	1.6	0.3	0.6		0.2	0.6	0.9	1.0	
Mercury (laboratory 3)	0.1	5	<1			<0.1	1.0	0.6		
Nickel	<50	69	<50	61	<1	118	<50	<50	63	<1
Selenium	16	12	14		8	17	13	31		6
Silver	<25	<25	<25	<25	<1	<25	<25	<25	<25	1
Thallium	3	<1	<1		3	<2	<1	<1		<2
Zinc	316	1,400	790	658		194	245	280	215	
Zinc[c]	290	2,100	680		740	150	210	280		260
Phthalates, µg/L										
Bis(2-ethylhexyl) phthalate				300					50	
Diethyl phthalate				ND					ND	
Dimethyl phthalate				ND					ND	
Phenols, µg/L										
2,4-Dimethylphenol				ND					ND	
Pentachlorophenol				ND					ND	
Phenol				160					ND	
Polycyclic aromatic hydrocarbons, µg/L										
Acenaphthene				ND					ND	
Anthracene/phenanthrene				90[d]					ND	
Chrysene/benz(a)anthracene				30[d]					50	
Fluoranthene/pyrene				ND					ND	
Fluorene				ND					ND	
Naphthalene				350					ND	
Polychlorinated biphenyls and related compounds, µg/L										
Aroclor 1016				0.5					ND	
Aroclor 1232				0.5					ND	
Aroclor 1242				0.5					ND	
Flow, MGD						0.464	0.122	0.572		

(continued)

TABLE 14-18 (continued)

Pollutant	Separator 4 effluent Day 1	Day 2	Day 3	Composite	Composite	Separator 5 effluent Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	>80	70				10	12			
BOD-3	100	55	60			10	10	18		
COD	310	270	430			83	75	92		
TOC	66	58	97			23	22	31		
TSS	36	26	94			26	16	48		
Total phenols	9,500	2,000	1,500			294	214	246		
Sulfide	6.8	9.1	5.1			<0.1	1.0	12		
Oil and grease	65	34	150			7	9	25		
pH	7.7	7.3	7.6			8.1	8.1	7.1		
Ammonia	3	7.3	8.4			2.0	1.0	<1.0		
Metals and inorganics, μg/L										
Antimony					1					<1
Arsenic					3					9
Beryllium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	7
Chromium	835	1,210	1,860	1,300		1,580	2,790	1,500	2,010	
Chromium[c]	1,500	1,300	1,700		1,900	2,200	4,900	1,800		3,600
Chromium +6	<20	<20	50			140	130	90		
Copper	38	21	77	42	10	51	47	51	45	182
Cyanides	60	50	60			20	20	20		
Lead	80	<60	<60	69		164	<60	<60	101	
Lead[c]					12					2
Mercury (laboratory 1)	0.2	1.3	1.6	0.4		0.3	1.1	1.6	0.5	
Mercury (laboratory 3)	0.2	6.0[d]	2.0			<0.1	0.2	2.0		
Nickel	<50	<50	<50	50	<1	189	<50	<50	79	[illegible]
Selenium	25	24	4		11	7	29	19		23
Silver	<25	<25	<25	<25	2	31	<25	<25	<25	<1
Thallium	<1	<1	<1		<2	<1	4	6		<2
Zinc	411	261	579	304		464	609	417	491	
Zinc[c]	340	290	620		560	600	740	520		760
Phthalates, μg/L										
Bis(2-ethylhexyl) phthalate				600					ND	
Diethyl phthalate				ND					ND	
Dimethyl phthalate				ND					ND	
Phenols, μg/L										
2,4-Dimethylphenol				650					ND	
Pentachlorophenol				850					ND	
Phenol				1,600					ND	
Polycyclic aromatic hydrocarbons, μg/L										
Acenaphthene				50					ND	
Anthracene/phenanthrene				230					ND	
Chrysene/benz(a)anthracene				40					ND	
Fluoranthene/pyrene				20					ND	
Fluorene				80					ND	
Naphthalene				ND					ND	
Polychlorinated biphenyls and related compounds, μg/L										
Aroclor 1016				ND					ND	
Aroclor 1232				ND					ND	
Aroclor 1242				ND					ND	
Flow, MGD										

(continued)

TABLE 14-18 (continued)

Pollutant	Biopond influent Day 1	Day 2	Day 3	Composite	Composite	Final effluent Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	96	<84				6	6			
BOD-3			>84					6		
COD	610	570	480			87	87	92		
TOC	50	100	120			34	26	32		
TSS	24	16	18			20	7	8		
Total phenols	120,000	110,000	83,000			8	24	2		
Sulfide	14	49	3.5			0.2	1.0	0.9		
Oil and grease	11	9	20			20	6	16		
pH	7.4	7.7	7.5			7.0	7.3	7.9		
Ammonia	22	24	20			6.8	5.0	5.6		
Metals and inorganics, µg/L										
Antimony					<1					<11
Arsenic					<2					<4
Beryllium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	<24	<25	<24	29		96	94	102	82	
Chromium[c]	9	5	6		22	150	27	27		54
Chromium +6	80	100	80			<20	<20	<20		
Copper	41	7	<4	17	2	9	<4	6	<4	32
Cyanides	220	340	260			70	80	80		
Lead	72	<60	<60	<60		82	<60	<60	<60	
Lead[c]					3					9
Mercury (laboratory 1)						0.8	1.3	0.9	0.5	
Mercury (laboratory 3)	2.0	6	3.0			<0.1	6	4		
Nickel	<50	<50	<50	<50	<1	53	<50	65	<50	3
Selenium	20	10	18		22	20	27	16		12
Silver	<25	<25	<25	<25	<1	<25	<25	<25	<25	<1
Thallium	<1	<1	<1		<2	<1	<1	<1		<2
Zinc	148	54	65	55		130	51	46	62	
Zinc[c]										62
Phthalates, µg/L										
Bis(2-ethylhexyl) phthalate				210					190	
Diethyl phthalate				ND					30	
Dimethyl phthalate				ND					3	
Phenols, µg/L										
2,4-Dimethylphenol				750					ND	
Pentachlorophenol				ND					ND	
Phenol				<12,000					ND	
Polycyclic aromatic hydrocarbons, µg/L										
Acenaphthene				ND					ND	
Anthracene/phenanthrene				ND					ND	
Chrysene/benz(a)anthracene				ND					ND	
Fluorantnene/pyrene				ND					ND	
Fluorene				ND					ND	
Naphthalene				ND					ND	
Polychlorinated biphenyls and related compounds, µg/L										
Aroclor 1016				ND					ND	
Aroclor 1232				ND					ND	
Aroclor 1242				0.1					ND	
Flow, MGD						2.70	2.55	2.73		

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, µg/L; pH, pH units.

[c] A second laboratory analyzed samples and reported these values.

[d] Average value.

[e] Not detected in sample.

TABLE 14-19. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY K [4,5]

Pollutant	Intake					DAF effluent				
	Day 1	Day 2	Day 3	Composite[a]	Composite[a]	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	4	4	<6			<120	220	<120		
BOD-2						<120	210	<120		
BOD-3	4	4	<6			80	200	<120		
COD	27	23	24			530	1,000	540		
TOC		11	10			180	350	180		
TSS	12	14	10			260	380	210		
Total phenols		<10					700			
Sulfide	0.4	0.4	0.3			0.8	1.6	0.6		
Oil and grease	9	6	14			590	100	98		
pH	8.1		7.4			7.8		7.3		
Ammonia	<1.0	<1.0	1.0			6.7	6.7	6.2		
Metals and inorganics, µg/L										
Antimony					<25					<25
Arsenic					<20					<20
Beryllium	<1	<1	<1	<1	<3	<1	<1	<1	<1	<3
Cadmium	<2	<2	3	<2	<1	<2	<2	<2	<2	3
Chromium	20	10	10	20	5	1,000	2,000	1,000	1,000	1,600
Chromium $^{+6}$	<20	<20	<20			<20	40	20		
Copper	10	10	10	10	6	200	400	200	300	280
Total cyanide		<20					<20			
Lead	70	40	80	40	<15	50	200	60	100	70
Mercury				<0.5					<0.5	
Nickel	<5	<5	<5	<5	<15	9	20	<5	20	28
Selenium					<20					<20
Silver	<1	<1	<1	<1	<5	<1	<1	<1	<1	<5
Thallium					<15					<15
Zinc	200	70	60	70	45	1,000	3,000	1,000	2,000	1,400
Phenols, µg/L										
2-Chlorophenol				ND[c]					315	
2,4-Dinitrophenol				ND					11,000	
2,4-Dimethylphenol				ND					1,150	
4-Nitrophenol				ND					5,800	
Phenol				ND					105	
Aromatics, µg/L										
Benzene				ND					20	
Ethylbenzene				ND					ND	
Toluene				ND					<10	
Polychlorinated biphenyls and related compounds, µg/L										
Aroclor 1016				ND					<10	
Aroclor 1221				ND					<10	
Aroclor 1232				ND					<10	
Aroclor 1242				ND					<10	
Aroclor 1248				ND					<10	
Aroclor 1254				ND					<10	
Aroclor 1260				ND					<10	
Halogenated aliphatics, µg/L										
Chloroform				<10					ND	
1,2-Dichloroethane				ND					ND	
1,2-*trans*-Dichloroethylene				ND					ND	
Methylene chloride				ND					1,100	
1,1,2,2-Tetrachloroethane				ND					ND	
Tetrachloroethylene				ND					ND	
Pesticides and metabolites, µg/L										
Heptachlor epoxide				ND					<5	

(continued)

TABLE 14-19 (continued)

Pollutant	Final effluent				
	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]					
BOD-1	8	<6	11		
BOD-2					
BOD-3	7	6	10		
COD	96	130	140		
TOC		39	42		
TSS	21	16	32		
Total phenols		29			
Sulfide	0.5	0.3	0.3		
Oil and grease	31	15	12		
pH	7.7		7.3		
Ammonia	2.2	3.4	3.9		
Metals and inorganics, μg/L					
Antimony					<25
Arsenic					<20
Beryllium	<1	<1	<1	<1	<3
Cadmium	<2	<2	<2	<2	1
Chromium	100	60	100	100	73
Chromium +6	<20	<20	<20		
Copper	60	10	20	30	18
Total cyanide		<20			
Lead	<20	<20	<20	<20	<15
Mercury				<0.5	
Nickel	<5	<5	<5	<5	<15
Selenium					<20
Silver	<1	<1	<1	<1	<5
Thallium					<15
Zinc	100	70	100	1,000	120
Phenols, μg/L					
2-Chlorophenol				ND	
2,4-Dinitrophenol				ND	
2,4-Dimethylphenol				ND	
4-Nitrophenol				ND	
Phenol				ND	
Aromatics, μg/L					
Benzene				ND	
Ethylbenzene				<10	
Toluene				ND	
Polychlorinated biphenyls and related compounds, μg/L					
Aroclor 1016				<10	
Aroclor 1221				<10	
Aroclor 1232				<10	
Aroclor 1242				<10	
Aroclor 1248				<10	
Aroclor 1254				<10	
Aroclor 1260				<10	
Halogenated aliphatics, μg/L					
Chloroform				<10	
1,2-Dichloroethane				<10	
1,2-*trans*-Dichloroethylene				<10	
Methylene chloride				ND	
1,1,2,2-Tetrachloroethane				<10	
Tetrachloroethylene				<10	
Pesticides and metabolites, μg/L					
Heptachlor epoxide				ND	

Note: Blanks indicate data not available.

[a]24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b]Phenolics, μg/L; pH, pH units.

[c]Compound was not detected.

TABLE 14-20. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY L [4,5]

Pollutant	Intake					Separator 1 effluent				
	Day 1	Day 2	Day 3	Composite[a]	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	2		<2			100		180		
BOD-2	3	<5	<3			130	100	170		
BOD-3	2	<3	<5			120	98	150		
COD	56	20	24			390	350	530		
TOC	13	10	6			110	110	140		
TSS	290	220	120			140	110	120		
Total phenols	<1	<1	<1			51,400	50,900	61,800		
Sulfide	0.1	1.0	1.0			0.9	1.5	1.2		
pH	7.2	7.5	7.1			7.9	8.3	8.6		
Ammonia	<1.0	<1.0	<1.0			6.2	10	20		
Metals and inorganics, µg/L										
Antimony					<25					<25
Arsenic					<20					<20
Asbestos, millions fibers/L									3.4	
Beryllium	<20	<20	<2	<20	<3	<20	<20	<20	<20	<3
Cadmium	<200	<200	<20	<200	<1	<200	<200	<200	<200	<1
Chromium	<240	<240	<24	<240	30	1,000	<240	<240	<240	290
Chromium +6	250	<20	50			<20	<20	70		
Copper	<40	<40	22	<40	20	170	<40	100	100	180
Cyanides	<100	<50	<50			190	360	600		
Lead	<600	700	64	<600	40	<600	<600	<600	<600	45
Mercury (laboratory 1)	<0.5	<0.5	<0.5			<0.5	<0.5	<0.5		
Mercury (laboratory 2)	<0.1	0.2	0.2	0.2		1.4	1.4	0.8	1.5	
Nickel	<500	<500	<50	<500	21	<500	<500	<500	<500	70
Selenium					<20					<20
Silver	<250	<250	<25	<250	<5	<250	<250	<250	<250	<5
Thallium					<15					<15
Zinc	810	<250	125	<250	120	490	290	290	360	370
Phenols, µg/L										
2,4-Dimethylphenol									>100	
Phenol									>100	
Aromatics, µg/L										
Benzene				ND[c]					>100	
Ethylbenzene				ND					>100	
Toluene				ND					>100	
Polycyclic aromatic compounds, µg/L										
Acenaphthene				29					ND	
Acenaphthylene				0.2					ND	
Anthracene/phenanthrene				1					230	
Chrysene				ND					20	
Fluoranthene				0.2					ND	
Fluorene				1.0					270	
Naphthalene				1.0					500	
Pyrene				0.3					ND	
Polychlorinated biphenyls and related compounds, µg/L										
Aroclor 1242				0.2					5.2	
Halogenated aliphatics, µg/L										
Chloroform				ND					10	
Methylene chloride				40					>100	
Flow, MGD						3.88	3.86	4.28		

(continued)

TABLE 14-20 (continued)

Pollutant	Separator 2 effluent Day 1	Day 2	Day 3	Composite	Composite	Final effluent Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	32		40			3		11		
BOD-2	38	31	42							
BOD-3	34	42	40			3	<4	8		
COD	200	210	170			75	44	71		
TOC	49	56	46			19	15	14		
TSS		36	48			34		21		
Total phenols		21,600	2,100			8	15	21		
Sulfide	0.8	1.7	0.9			0.4	0.3	0.9		
pH	8.0	6.3	8.4			7.2	6.9	7.2		
Ammonia	7.8	15	9.0			<1.0	3.4	3.0		
Metals and inorganics, µg/L										
Antimony					<25					<25
Arsenic					<20					<20
Asbestos, millions fibers/L										
Beryllium	<2	<2	<2	<2	<3	<2	<2	<2	<2	<3
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	773	831	928	802	870	205	119	165	144	190
Chromium +6	50	<20	<20			<20	110	10		
Copper	43	54	31	42	50	24	19	31	24	39
Cyanides	160	210	80			<100	800	80		
Lead	<60	<60	<60	<60	13	<60	<60	<60	<60	<15
Mercury (laboratory 1)	<0.5	<0.5	<0.5			<0.5	<0.5	<0.5		
Mercury (laboratory 2)	0.6	0.4	0.4	0.5		0.3	0.3	0.3	0.3	
Nickel	<50	<50	<50	<50	16	<50	<50	<50	<50	<15
Selenium					<20					<20
Silver	<25	<25	<25	<25	<5	<25	<25	<25	<25	<5
Thallium					45					<15
Zinc	382	304	314	325	290	174	157	161	174	140
Phenols										
2,4-Dimethylphenol				>100						
Phenol				>100						
Aromatics, µg/L										
Benzene				>100					ND	
Ethylbenzene				>100					ND	
Toluene				>100					ND	
Polycyclic aromatic compounds, µg/L										
Acenaphthene				3,000					6.0	
Acenaphthylene				ND					ND	
Anthracene/phenanthrene				ND					1	
Chrysene				2					0.3	
Fluoranthene				9					<0.1	
Fluorene				300					ND	
Naphthalene				280					0.1	
Pyrene				7.0					<0.1	
Polychlorinated biphenyls and related compounds, µg/L										
Aroclor 1242				ND					ND	
Halogenated aliphatics, µg/L										
Chloroform				<10					ND	
Methylene chloride				50					60	
Flow, MGD	7.15	5.37	4.98			11.03	9.23	9.26		

Note: Blanks indicate data not available.

[a]24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b]Total phenols, µg/L; pH, pH units.

[c]Not detected in sample.

TABLE 14-21. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY M [4,5]

	Intake					DAF effluent					Final effluent				
	Day 1	Day 2	Day 3	Composite[a]	Composite	Day 1	Day 2	Day 3	Composite	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]															
BOD-1	<6	<6	<6			[illegible]	50	36			<12	<6	<6		
BOD-2						25	52	40							
BOD-3	<6		<6			34	40	34			<12	<6	<6		
COD	10	9	8			260	220	220			92	86	73		
TOC	6	10	4			72	62	66			18	16	14		
TSS	<1	<1	<1			18	9	7			8	[illegible]	11		
Total phenols	<10	<10	<10			4,700	4,200	4,300			<10	<10	<10		
Sulfide	0.2	0.2	0.3			0.6	0.5	0.4			0.4	0.4	0.3		
Oil and grease	4	8	11			16	18	18			13	12	14		
pH	8.0	8.0	8.1			6.9	8.4	8.2			7.7	7.9	7.8		
Ammonia	<1.0	<1.0	<1.0			13	9.5	12			1.0	<1.0	1.0		
Metals and inorganics, µg/L															
Antimony					<25					<25					<25
Arsenic					<20					<20					<20
Beryllium	<1	<1	<1	<1	<3	2	2	2	2	<3	2	2	<1	<1	<3
Cadmium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1	3	<2	<2	<2	<1
Chromium	30	10	20	20	<5	200	100	90	100	73	90	100	90	100	24
Chromium +6	<20	<20	<20			750	<20	<20			20	<20	<20		
Copper	300	100	100	200	180	10	10	9	10	6	10	10	20	20	8
Cyanides	<20	<20	<20			10	20	30			20	<20	<20		
Lead	200	<20	40	60	25	<20	<20	<20	<20	<15	<20	50	<20	30	<15
Nickel	10	5	<5	<5	<15	<5	<5	<5	<5	<15	<5	<5	10	20	<15
Selenium					<20					<20					<20
Silver	<1	<1	<1	<1	<5	<1	<1	<1	<1	<5	<1	<1	4	4	<5
Thallium					<15					<15					<15
Zinc	200	90	100	100	75	200	100	90	100	140	90	100	100	200	90
Phenols, µg/L															
2,4-Dinitrophenol				ND					2,660					ND	
2,4-Dimethylphenol				ND					18,300					ND	
4-Nitrophenol				ND					1,400					ND	
Phenol				<10					33,500					<10	
p-chloro-*m*-cresol				ND					ND					10	
Aromatics, µg/L															
Benzene				14					12[d]					11[d]	
Toluene				<10					<10					<10	
Polychlorinated biphenyls and related compounds, µg/L															
Aroclor 1016				ND					<10					<10	
Aroclor 1221				ND					<10					<10	
Aroclor 1232				ND					<10					<10	
Aroclor 1242				ND					<10					<10	
Aroclor 1248				ND					<10					<10	
Aroclor 1254				ND					<10					<10	
Aroclor 1260				ND					<10					<10	
Halogenated aliphatics, µg/L															
Carbon tetrachloride				ND					10[d]					<10[d]	
Chloroform				44					55[d]					<10[d]	
Methylene chloride				91					180[d]					<10[d]	
Flow, MGD											1.64	1.52	1.47		

Note: Blanks indicate data not available.

[a]24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b]Total phenols, µg/L; pH, pH units.

[c]Not detected in sample.

[d]Compound was detected at greater level in sample blank

TABLE 14-22. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY N [4,5]

Pollutant	Intake					Separator effluent				
	Day 1	Day 2	Day 3	Composite[a]	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-2		<5	<2							
BOD-3	<1					83	100	120		
COD	40	16	28			360	440	40		
TOC	12	8	12			88	120	100		
TSS	18	22	26			68	112	76		
Total phenols	<10	<11	<10			6,200	6,570	4,700		
Sulfide	0.3	0.8	1.1			2.9	8.1	9.2		
pH	8.4	7.7	7.3			8.1	8.1	7.9		
Ammonia	<1.0	<1.0	<1.0			12	15	13		
Metals and inorganics, μg/L										
Antimony					<25					<25
Arsenic					<20					<20
Beryllium	<2	<2	<20	<2	<3	<20	<20	<2	<2	<3
Cadmium	<20	<20	<200	<20	<1	<200	<200	<20	<20	<1
Chromium	<24	<24	3,000	<24	7	1,000	2,000	980	1,280	1,400
Chromium +6	<20	70	90			<20	<20	<20		
Copper	<4	<4	<40	<4	<5	<40	<40	7	14	61
Cyanides	<60	<30	<60			<60	40	<60		
Lead	<60	<60	<600	<60	<15	<600	<600	<60	<60	18
Mercury	<0.2	<0.1	<0.2	<0.5	<0.2	0.4	0.6	0.4	<0.5	0.5
Nickel	<50	<50	790	<50	<15	<500	<500	<50	<50	16
Selenium					<20					<20
Silver	<25	<25	<250	<25	<5	<250	<250	<25	<25	<5
Thallium					<15					<15
Zinc	56	29	<250	36	19	480	760	573	603	570
Phenols, μg/L										
2,4-Dimethyl phenol				ND[c]					71	
Aromatics, μg/L										
Benzene				ND					>100	
Ethylbenzene				ND					>100	
Toluene				ND					>100	
p-Chloro-m-cresol				ND					ND	
Phenol				ND					>100	
Polycyclic aromatic hydrocarbons, μg/L										
Acenaphthene				ND					522	
Acenaphthylene				ND					87	
Anthracene/phenanthrene				ND					140	
Chrysene				ND					5.5	
Fluoranthene				ND					8	
Naphthalene				ND					302	
Pyrene				ND					16	
Polychlorinated biphenyls and related compounds, μg/L										
Aroclor 1016				ND					1.9	
Aroclor 1221				ND					0.1	
Aroclor 1232				ND					0.5	
Halogenated aliphatics, μg/L										
Chloroform				ND					15	
Methylene chloride				>100					>100	
Pesticides and metabolites, μg/L										
Heptachlor epoxide				ND					ND	
Flow, MGD	24.69	26.84	25.91			15.25	15.25	18.25		

(continued)

TABLE 14-22 (continued)

Pollutant	Chemical plant effluent					Final effluent				
	Day 1	Day 2	Day 3	Composite	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-2			34							
BOD-3	74	140				10	8	10		
COD	340	810	240			140	120	140		
TOC	93	240	69			33	33	36		
TSS	28	36	40			50	40	44		
Total phenols	<260,000	73	74			<15	<11			
Sulfide	0.7	0.9	0.9			0.6	0.9	0.9		
pH	6.8	6.6	6.7			8.6	7.4	7.4		
Ammonia	1.1	<1.0	2.0			6.2	6.7	3.0		
Metals and inorganics, µg/L										
Antimony					<25					<25
Arsenic					<20					<20
Beryllium	<2	<2	<2	<2	<3	<2	<2	<2	<2	<3
Cadmium	<20	<20	<20	<20	<1	<20	<20	<20	<20	<1
Chromium	805	679	499	701	650	<24	159	131	137	120
Chromium +6	<20	<20	<20			<20	<20	<20		
Copper	<4	8	7	<4	13	<4	<4	<4	<4	11
Cyanides	<60	<30	<60			<60	<30	<60		
Lead	<60	<60	<60	<60	<15	<60	<60	<60	<60	<15
Mercury	<0.1	<0.4	<0.2	<0.5	<0.2	0.4	0.2	0.1	<0.5	<0.1
Nickel	<50	<50	<50	<50	<15	<50	<50	<50	<50	<15
Selenium					<20					<20
Silver	<25	<25	<25	<25	<5	<25	<25	<25	<25	<5
Thallium					<15					<15
Zinc	6,520	4,110	4,260	5,210	4,800	<25	118	61	104	35
Phenols, µg/L										
2,4-Dimethyl phenol				>100					ND	
Phenol				40					ND	
Aromatics, µg/L										
Benzene				90					6	
Ethylbenzene				20					ND	
p-Chloro-*m*-cresol				10					ND	
Toluene				>100					35	
Polycyclic aromatic hydrocarbons, µg/L										
Acenaphthene				ND					ND	
Acenaphthylene									ND	
Anthracene/phenanthrene				1					ND	
Chrysene				<0.1					ND	
Fluoranthene				ND					ND	
Naphthalene				27					ND	
Pyrene				1					ND	
Polychlorinated biphenyls and related compounds, µg/L										
Aroclor 1016				1.3					ND	
Aroclor 1221				ND					ND	
Aroclor 1232				0.1					ND	
Halogenated aliphatics, µg/L										
Chloroform				10					ND	
Methylene chloride				>100					>100	
Pesticicdes and metabolites, µg/L										
Heptachlor epoxide				4.6					ND	
Flow, MGD	0.8	0.95	0.9			14.75	15.9	17.6		

Note: Blanks indicate data not available.

[a]24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b]Total phenols, µg/L; pH, pH units.

[c]Not detected in sample.

TABLE 14-23. SCREENING STUDY WASTEWATER CHARACTERISTICS BY PLANT, REFINERY O [4,5]

	Intake					DAF effluent					Final effluent				
Pollutant	Day 1	Day 2	Day 3	Composite[a]	Composite	Day 1	Day 2	Day 3	Composite	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]															
BOD-1	<2	<5	<3			120	100	85			6	<10	94		
BOD-2		<5	<2				75	88							
BOD-3								8				<10	<8		
COD	11	26	12			380	410	480			150	140	120		
TOC	10	21	25			120	110	180			48	40	52		
TSS	10	10	14			21	32	42			24	26	24		
Total phenols	<10	<5	<5			11,000	10,000	11,000			52	49	36		
Sulfide	0.5	<0.1	0.1			3.9	4.1	2.9			0.6	0.5	0.4		
pH	7.1	6.8	7.0			8.4	8.6	8.8			7.9		7.8		
Ammonia	<1.0	<1.0	<1.0			5.3	6.4	18			2.5	3.1	2.5		
Metals and inorganics, μg/L															
Antimony					<25				<25					<25	
Arsenic					<20				<20					<20	
Beryllium	<1	<1	<1	<1	<3	<1	<1	<1	<1	<3	<1	<1	<1	<1	<3
Cadmium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1
Chromium	<5	<5	<5	<5	8	200	300	300	200	240	50	50	50	50	110
Chromium +6	<20	20	20			<20	<20	<20			<20	20	<20		
Copper	<6	<6	<6	<6	<5	30	18	8	20	30	<6	<6	<6	<6	<5
Cyanides	<20	<20	<20			210	160	130			<30	<30	<30		
Lead	<20	<20	<20	<20	<15	<20	<20	<20	<20	<27	<20	<20	<20	<20	<15
Mercury				<0.5					<0.5					<0.5	
Nickel	<5	<5	<5	<5	<15	<5	< 5	<5	<5	<15	<5	<5	<5	<5	<15
Selenium					<20					<20					<15
Silver	<1	<1	<1	<1	<5	<1	<1	<1	<1	<5	<1	<1	<1	<1	<5
Thallium					<15					<15					<15
Zinc	<60	<60	<60	<60	<10	<60	<60	100	60	74	<60	<60	<60	<60	<10
Phthalates, μg/L															
Di-n-butyl phthalate				ND[c]					ND					ND	
Dimethyl phthalate				ND					ND					ND	
Phenols, μg/L															
2,4-Dimethylphenol				ND					2,000					ND	
Phenol				ND					1,900					ND	
Aromatics, μg/L															
Benzene				ND					<10					<10[d]	
Toluene				<10					16					ND	
Polycyclic aromatic hydrocarbons, μg/L															
Acenaphthene				ND					390					ND	
Acenaphthylene				ND					530					ND	
Anthracene				ND					1,750					ND	
Chrysene				ND					ND					ND	
Fluoranthene				ND					ND					ND	
Fluorene				ND					495					ND	
Naphthalene				ND					3,750					ND	
Phenanthrene				ND					1,750					ND	
Pyrene				ND					ND					ND	
Halogenated aliphatics, μg/L															
Chloroform				55					13					32[d]	
Methylene chloride				130					ND					44[d]	
Pesticides and metabolites, μg/L															
α-BHC				ND					<10					ND	
Isophorone				ND					2,500					ND	
Flow, MGD							2.88					2.88			

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, μg/L; pH, pH units.

[c] Not detected in sample.

[d] Compound was detected at a greater level in sample blank than sample.

TABLE 14-24. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY P [4,5]

Pollutant	Intake					Separator effluent				
	Day 1	Day 2	Day 3	Composite[a]	Composite	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]										
BOD-1	<2	<5	<2			320	210	150		
BOD-2		<5	<2				220	160		
BOD-3										
COD	4	6	<4			600	540	470		
TOC	3	7	7			170	140	140		
TSS	<1	<1	<1			68	78	42		
Total phenols	<10	<5	<5			106,000		29,000		
Sulfide	<0.1	<0.1	<0.1			25	25	23		
pH	7.0	6.8	6.3				10.1	9.9		
Ammonia	<1.0	<1.0	<1.0			11	16	18		
Metals and inorganics, μg/L										
Antimony					<25					360
Arsenic					<20					<20
Beryllium	<1	<1	<1	<1	<3	<1	<1	<1	<1	<3
Cadmium	<2	<2	<2	<2	<1	<2	<2	<2	<2	<1
Chromium	<5	<5	<5	<5	40	900	50	700	600	72
Chromium +6	20	<20	<20			<20	150	50		
Copper	<6	<6	<6	<6	<5	<6	<6	<6	<6	<5
Total cyanide	<30	<20	<20			90	60	40		
Lead	<20	<20	<20	<20	<15	<20	<20	<20	<20	<15
Mercury				<0.5					<0.5	
Nickel	<5	<5	<5	<5	<15	<5	<5	<5	<5	<15
Selenium					<20					<20
Silver	<1	<1	<1	<1	<5	<1	<1	<1	<1	<5
Thallium					<15					<15
Zinc	<60	<60	<60	60	61	<60	<60	<60	<60	55
Phenols, μg/L										
2,4-Dinitrophenol				ND[c]					110	
2-Nitrophenol				<10					1,350	
4-Nitrophenol				<10					20	
4,6-Dinitro-*o*-cresol				ND					60	
Aromatics, μg/L										
Benzene				<10					1,100	
Ethylbenzene				ND					28	
Toluene				<10					655	
Polycyclic aromatic hydrocarbons, μg/L										
Acenaphthene				ND					315	
Acenaphthylene				ND					665	
Anthracene				ND					660	
Naphthalene				ND					3,200	
Phenanthrene				ND					660	
Halogenated aliphatics, μg/L										
Carbon tetrachloride				ND					ND	
Chloroform				<10					100	
1,2-*trans*-Dichloroethylene				11					ND	
Methylene chloride				ND					1,600	
1,1,2,2-Tetrachloroethane				<10					ND	
Tetrachloroethylene				<10					ND	
Trichloroethylene				<10					ND	
Pesticides and metabolites, μg/L										
Aldrin				ND					12	
β-BHC				ND					<5	
δ-BHC				ND					12	
β-Endosulfan				ND					13	
Heptachlor				ND					<5	
Isophorone				ND					3,500	

(continued)

TABLE 14-24 (continued)

Pollutant	Final effluent				
	Day 1	Day 2	Day 3	Composite	Composite
Conventional pollutants, mg/L[b]					
BOD-1	<5	<5	<3		
BOD-2					
BOD-3		<5	<3		
COD	64	49	41		
TOC	16	24	31		
TSS	11	2	7		
Total phenols	12	11	10		
Sulfide	0.3	0.6	<0.1		
pH		7.7	7.5		
Ammonia	1.4	2.0	2.0		
Metals and inorganics, μg/L					
Antimony					370
Arsenic					<20
Beryllium	<1	<1	<1	<1	<3
Cadmium	<2	<2	<2	<2	<1
Chromium	<5	<5	<5	<5	40
Chromium +6	<20	<20	<20		
Copper	<6	<6	<6	<6	<5
Total cyanide	<30	<30	<30		
Lead	<20	<20	<20	<20	<15
Mercury				<0.5	
Nickel	<5	<5	<5	<5	<15
Selenium					<20
Silver	<1	<1	<1	<1	<5
Thallium					<15
Zinc	<60	<60	<60	<60	43
Phenols, μg/L					
2,4-Dinitrophenol				ND	
2-Nitrophenol				ND	
4-Nitrophenol				ND	
4,6-Dinitro-*o*-cresol				ND	
Aromatics, μg/L					
Benzene				<10	
Ethylbenzene				ND	
Toluene				ND	
Polycyclic aromatic hydrocarbons, μg/L					
Acenaphthene				ND	
Acenaphthylene				ND	
Anthracene				ND	
Naphthalene				ND	
Phenanthrene				ND	
Halogenated aliphatics, μg/L					
Carbon tetrachloride				<10	
Chloroform				<10	
1,2-*trans*-Dichloroethylene				ND	
Methylene chloride				41	
1,1,2,2-Tetrachloroethane				<10	
Tetrachloroethylene				ND	
Trichloroethylene				<10	
Pesticides and metabolites, μg/L					
Aldrin				ND	
β-BHC				ND	
δ-BHC				ND	
β-Endosulfan				ND	
Heptachlor				ND	
Isophorone				ND	

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Total phenols, μg/L; pH, pH units; flow, MGD - million gallons per day.

[c] Not detected in sample.

TABLE 14-25. SCREENING STUDY WASTEWATER CHARACTERIZATION BY PLANT, REFINERY Q [4]

Pollutant	Intake Day 1	Intake Day 2	Intake Day 3	Intake Composite[a]	Intake Day 4	Separator effluent Day 1	Separator effluent Day 2	Separator effluent Day 3	Separator effluent Composite	Separator effluent Day 4	Final effluent Day 1	Final effluent Day 2	Final effluent Day 3	Final effluent Composite	Final effluent Day 4
Conventional pollutants, mg/L[b]															
BOD-1	<2	<2	<3			80	40	66			28	20	30		
BOD-3						50	70	64							
COD	4	4	24			370	330	260			260	250	230		
TOC	8	11	9			91	84	65			59	78	60		
TSS	3	2	<1			28	10	12			38	22	26		
Total phenols	<1	4	10			108	116	118			16	18	14		
Sulfide	0.4	0.3	0.3			9.3	5.6	2.4			0.7	0.6	0.5		
Oil and grease	5	9	13			62		38			45	45	37		
pH	7.1	7.4	7.5			9.2	9.3	9.8			8.8	8.3	8.7		
Ammonia	<1.0	<1.0	<1.0			45	48	39			53	49	42		
Metals and inorganics, µg/L															
Antimony				<1					<1					-	
Arsenic				7	35	480	460	460	440	350	790	900	680	800	500
Beryllium (laboratory .	<2	<2	<2	<2		<2	<2	<2	<2		<2	<2	<2	<2	
Beryllium (laboratory 3				<1					<1					<1	
Cadmium (laboratory 1)	<20	<20	<20	<20		<20	<20	<20	<20		<20	<20	<20	<20	
Cadmium (laboratory 3)				<1					<1		<1	<1	<1	5	
Chromium (laboratory 1)	<24	<24	<24	<24		<24	<24	<24	<24		<24	<24	<24	<24	
Chromium (laboratory 3)				1					1					2	
Chromium +6	<20	<20	<20			<20	<20	<20			<20	<20	<20		
Copper (laboratory 1)	37	37	20	53		7	<4	6	15		11	20	<24	23	
Copper (laboratory 3)				120	240	60	140	60	210	380				180	130
Total cyanide	<10	20	<10		<20	<10	<10	30		<20	<10	320	10		<20
Lead (laboratory 1)	<60	<60	<60	167		<60	<60	<60	101		<60	<60	<60	102	
Lead				2					10					15	
Mercury (laboratory 1)	2.1	1.2	3.4			0.2	0.3	0.3			0.3	0.3	0.8		
Mercury (laboratory 3)		1.0	6.0		<0.1	6.0	<0.2	<0.2		<0.2	6.1	<1.1	<0.2		<0.1
Nickel (laboratory 1)	<50	<50	<50	<50		<50	<50	<50	<50		<50	<50	<50	<50	
Nickel (laboratory 3)				<1					<1					<1	
Selenium	<6	6	10	6		9	7	6	10		11	10	22	20	
Silver (laboratory 1)	<25	<25	<25	<25		<25	<25	<25	<25		<25	<25	<25	<25	
Silver (laboratory 3)				<1					<1					<1	
Zinc (laboratory 1)	70	62	329	2,820		274	444	511	1,460		245	329	300	1,270	
Zinc (laboratory 3)				35	<1	330	470	640	470	262	380	360	350	340	167
Thallium	<1	<1	<1	<2		<1	<1	<1	<2		<1	<1	<1	<2	
Phthalates, µg/L															
Bis(2-ethylhexyl) phthalate				1,100					320					2,000	
Di-n-butyl phthalate				20					ND					ND	
Dietnyl phthalate														1	
Dimethyl phthalate				20					ND[c]					ND	
Phenols, µg/L															
Phenol				10					60					ND	
Aromatics, µg/L															
Benzene				<1					894					ND	
Halogenated aliphatics, µg/L															
Toluene				ND					107					ND	
Chloroform				ND					6					ND	
Dichlorobromomethane				ND					24					ND	
Methylene chloride				6					4					3	
Flow, MGD											0.2783	0.3086	0.3186		

Note: Blanks indicate data not available.

[a] 24-hr composite samples on 3 consecutive days were collected. Each was analyzed for the "traditional" parameters and a composite of the three was analyzed for the toxic pollutants.

[b] Phenolics, µg/L; pH, pH units.

[c] Not detected in sample.

facilities. Table 14-26 indicates the types of treatment technology and performance characteristics which were observed during the survey [2]. In most of the plants analyzed, some type of biological treatment was utilized to remove dissolved organic material. Table 14-27 summarizes the expected effluents from wastewater treatment processes throughout the petroleum refining industry. Typical efficiencies for these processes are shown in Table 14-28.

During the survey program, wastewater treatment plant performance history was obtained when possible. These historical data were analyzed statistically and the individual plant's performance evaluated in comparison to the original design basis. After this evaluation, a group of plants was selected as being exemplary, and data from these plants were presented in Table 14-26. The treatment data in Table 14-28 represent the annual daily average performance (50% probability of occurrence). There were enough plants involving only one subcategory to make the interpretation meaningful [2].

II.14.5 REFERENCES

1. NRDC Consent Decree Industry Summary - Petroleum Refining.

2. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Petroleum Refining Point Source Category. EPA-440/1-74-014-a, U.S. Environmental Protection Agency, Washington, D.C., April 1974. 195 pp.

3. Interim Final Supplement for Pretreatment to the Development Document for the Petroleum Refining Industry Existing Point Source Category. EPA-440/1-76/083A, U.S. Environmental Protection Agency, Washington, D.C., March 1977. 115 pp.

4. Draft Development Document Including the Data Base for the Review of Effluent Limitations Guidelines (BATEA), New Source Performance Standards, and Pretreatment Standards for the Petroleum Refining Point Source Category. U.S. Environmental Protection Agency, Washington, D.C., March 1978.

5. Development Document for Proposed Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Petroleum Refining Point Source Category. EPA 440/1-79/014-b, U. S. Environmental Protection Agency, Washington, D. C., December 1979.

TABLE 14-26. OBSERVED REFINERY TREATMENT SYSTEM AND EFFLUENT LOADINGS [2]

		Observed average effluent loadings, net kg/1,000 m^3 of feedstock (lb/1,000 bbl of feedstock)						
Subcategory	Treatment type	BOD_5	COD	TSS	Oil and grease	NH_3-N	Phenolic compounds	Sulfide
Topping	Oxidation pond		--	--	2.0 (0.7)	--	0.14 (0.05)	0.03 (0.009)
Cracking	Aerated lagoon, polishing pond	8 (2.8)	39 (13.8)	--	2.3 (0.8)	--	0.003 (0.001)	--
Cracking	Aerated lagoon, filtration	8.0 (4.4)	68 (24)	25 (8.7)	9 (3.2)	--	0.4 (0.145)	0.2 (0.07)
Cracking	Equalization, dissolved air flotation, activated sludge	5.9 (2.1)	96 (34)	34 (12)	4.0 (1.4)	--	0.37 (0.13)	0 (0)
Cracking	Oxidation pond	10 (3.6)	71 (25.0)	8.5 (3.0)	--	4.8 (1.7)	0.05 (0.018)	0.03 (0.010)
Cracking	Dissolved air flotation, aerated lagoon, polishing pond	3.7 (1.3)	39 (13.8)	4.2 (1.5)	2.8 (1.0)	0.14 (0.05)	0.006 (0.002)	0.014 (0.005)
Petrochemical	Dissolved air flotation, activated sludge	13 (4.6)	67 (23.5)	13.6 (4.8)	6.5 (2.3)	4.5 (1.6)	0.06 (0.023)	0.05 (0.018)
Petrochemical	Dissolved air flotation, activated sludge	2.7 (0.95)	--	8.5 (3.0)	--	--	--	--
Petrochemical	Dissolved air flotation, aerated lagoon, polishing pond	2.6 (0.91)	54 (19)	7 (2.5)	--	2 (0.7)	--	--
Lube	Equalization, trickling filter, activated sludge	7.4 (2.6)	57 (20)	12 (4.3)	4 (1.4)	1.2 (0.44)	0.17 (0.06)	--
Lube	Equalization, activated sludge	14 (5.0)	136 (48)	38 (13.5)	7.2 (2.55)	--	--	--
Integrated	Dissolved air flotation, activated sludge, polishing pond	17.5 (6.2)	320 (113)	36 (12.7)	22 (7.7)	2.3 (0.8)	0.017 (0.006)	0.20 (0.07)

TABLE 14-27. EXPECTED EFFLUENTS FROM PETROLEUM TREATMENT PROCESSES [2]

Process	Process influent[a]	Effluent concentration, mg/L							
		BOD_5	COD	TOC	SS	Oil	Phenol	Ammonia	Sulfide
API separator	Raw waste	250 - 350	260 - 700		50 - 200	20 - 100	6 - 100	15 - 150	
Clarifier	1	45 - 200	130 - 450		25 - 60	5 - 35	10 - 40		
Dissolved air flotation	1	45 - 200	130 - 450		25 - 60	5 - 20	10 - 40		
Granular media filter	1	40 - 170	100 - 400		5 - 25	6 - 20	3 - 35		
Oxidation pond	1	10 - 60	50 - 300		20 - 100	1.6 - 50	0.01 - 12	3 - 50	0 - 20
Aerated lagoon	2,3,4	10 - 50	50 - 200		10 - 80	5 - 20	0.1 - 25	4 - 25	0 - 0.2
Activated sludge	2,3,4	5 - 50	30 - 200	20 - 80	5 - 50	1 - 15	0.01 - 2.0	1 - 100	0 - 0.2
Trickling filter	1	25 - 50	80 - 350		20 - 70	10 - 80	0.5 - 10	25 - 100	0.5 - 2
Cooling tower	2,3,4	25 - 50	47 - 350	70 - 150	4.5 - 100	20 - 75	0.1 - 2.0	1 - 30	
Activated carbon	2,3,4	5 - 100	30 - 200		10 - 20	2 - 20	<1	10 - 140	
Granular media filter	5-9			25 - 61	3 - 20	3 - 17	0.35 - 10		
Activated carbon	5-9 and 11	3 - 10	30 - 100	1 - 17	1 - 15	0.8 - 2.5	0 - 0.1	1 - 100	0 - 0.2

Note: Blanks indicate data not available.

[a]Number(s) indicates which process(es) from the process column preceeds the process discussed.

TABLE 14-28. TYPICAL REMOVAL EFFICIENCIES FOR OIL REFINERY TREATMENT PROCESSES [2]

Process	Process influent[a]	Removal efficiency, %							
		BOD_5	COD	TOC	SS	Oil	Phenol	Ammonia	Sulfide
API separator	Raw waste	5 - 40	5 - 30		10 - 50	60 - 99	0 - 50		
Clarifier	1	30 - 60	20 - 50		50 - 80	60 - 95	0 - 50		
Dissolved air flotation	1	20 - 70	10 - 60		50 - 85	70 - 85	10 - 75		
Filter	1	40 - 70	20 - 55		75 - 95	65 - 90	5 - 20		
Oxidation pond	1	40 - 95	30 - 65	60	20 - 70	50 - 90	60 - 99	0 - 15	70 - 100
Aerated lagoon	2,3,4	75 - 95	60 - 85		40 - 65	70 - 90	90 - 99	10 - 45	95 - 100
Activated sludge	2,3,4	80 - 99	50 - 95	40 - 90	60 - 85	80 - 99	95 - 99+	33 - 99	97 - 100
Trickling filter	1	60 - 85	30 - 70		60 - 85	50 - 80	70 - 98	15 - 90	70 - 100
Cooling tower	2,3,4	50 - 90	40 - 90	10 - 70	50 - 85	60 - 75	75 - 99+	60 - 95	
Activated carbon	2,3,4	70 - 95	70 - 90	50 - 80	60 - 90	75 - 95	90 - 100	7 - 33	
Filter granular media	5-9			50 - 65	75 - 95	65 - 95	5 - 20		
Activated carbon	5-9 and 11	91 - 98	86 - 94	50 - 80	60 - 90	70 - 95	90 - 99	33 - 87	

Note: Blanks indicate data not available.

[a]Number(s) indicates which process(es) from the process column preceeds the process discussed.

II.16 PULP, PAPER, AND PAPERBOARD MILLS

II.16.1 INDUSTRY DESCRIPTION [1]

II.16.1.1 General Description

The pulp, paper, and paperboard industry includes 730 operating mills, making this one of the largest industries in the United States. (Six hundred forty four of these mills responded to 308 surveys used for data in Reference 1.) Included in this industry are mills that produce (1) only pulp, (2) both pulp and paper products, and (3) only paper products from pulp manufactured elsewhere. Included in this industry are mills that use secondary fibers (usually waste paper) to produce paper and paperboard products.

Production operations range from large integrated kraft pulp, paper, and paperboard mills producing 1,814 Mg/d (2,000 ton/d) of product to nonintegrated single-machine mills producing less than 0.9 Mg/d (1 ton/d) of product. Total annual production for the industry is 239,516 Mg (264,075 ton).

The pulp, paper, and paperboard industry manufactures a variety of products. The various papers differ basically in durability, weight, thickness, flexibility, brightness, opacity, smoothness, printability, strength, and color. These characteristics are a function of raw material selection, pulp methods, and papermaking techniques. End products of the industry include stationery, tissue, printing newspapers, boxes, builder papers, and numerous other grades of industrial and consumer papers.

There are three general classifications of mills: integrated mills; secondary fiber mills; and nonintegrated mills. At integrated mills, pulp is produced from wood and nonwood raw materials and used to manufacture paper and board products on site. At secondary fiber mills no pulp is produced on site with most of the furnish (i.e., the raw materials placed in a beater for making paper pulp) derived from waste paper. At nonintegrated mills, the furnish consists of purchased wood pulp (or other fibers). No pulp is made on site, but some waste paper can be used providing the mill does not have a full deink process.

At mills that produce pulp on site, the raw materials must be prepared for the pulping process. The preparation of wood for pulping may require log washing, bark removal, and chipping. Depending on the form in which raw materials arrive at the mill, all of these steps, or none of them, may be used.

Pulping processes at integrated mills range from simple groundwood operations, using only mechanical defibration of full logs and limited bleaching operations, to complex dissolving pulp mills employing extensive chemical pulping operations and attendant recovery systems coupled with multistage bleaching operations. Pulping operations include groundwood and modified groundwood operations, sulfite (acid) processes, unbleached and bleached kraft or soda processes (alkaline), and modified high-yield processes utilizing mild chemical treatments coupled with mechanical defibration.

After pulping, the unbleached pulp is brown or deeply colored. The pulp is then bleached to remove the color bodies and produce a light colored or white product. Bleaching is usually accomplished in a series of steps, using chlorination and alkaline extraction, and various chemicals, such as chlorine dioxide, and hypochlorite.

In recent years, secondary fiber sources such as waste paper of various classifications have gained increasing acceptance as a raw material fiber source. Such secondary fiber can frequently be used without processing. For some applications, however, the reclaimed waste papers must be deinked prior to use.

Table 16-1 presents industry summary data for the pulp and paper point source category in terms of the total number of subcategories, the number of subcategories studied by EGD (Effluent Guidelines Division), and the number and type of dischargers.

TABLE 16-1. INDUSTRY SUMMARY [1,2]

Industry: Pulp and Paper
Total Number of Subcategories: 24[a]
Number of Subcategories Studied: 24

Number of Dischargers Responding to Survey: 644
- Direct Dischargers: 359
- Indirect Dischargers: 230
- Zero Dischargers: 55

[a]Excludes three mill groupings, which are not considered to be subcategories.

II.16.1.2 Subcategory Descriptions

As part of the BATEA review program, an updated and more complete data base was developed; this result led to the review and revision of the previous subcategorization. The previous and revised subcategorization is shown in Table 16-2, as reported in Reference 1.

TABLE 16-2. PREVIOUS AND REVISED INDUSTRY SUBCATEGORIZATION [1]

Previous subcategories	Revised subcategories[a]
<u>Phase I</u>	
Unbleached kraft	Alkaline-dissolving
NSSC - ammonia	Alkaline-market
NSSC - sodium	Alkaline-BCT
Unbleached kraft-NSSC	Alkaline-fine
Paperboard from wastepaper	Alkaline-unbleached
	Semi-chemical
<u>Phase II</u>	Alkaline unbleached and semi-chemical
	Alkaline-newsprint
Dissolving kraft	Sulfite-dissolving
Market kraft	Sulfite-papergrade
BCT-kraft	Thermo-mechanical pulp
Fine kraft	Groundwood-CMN
Papergrade sulfite	Groundwood-fine
- blow pit wash (plus allowances)	Deink-fine and tissue
Papergrade sulfite-drum wash	Deink-newsprint
- drum wash (plus allowances)	Wastepaper-tissue
Dissolving sulfite (allowances by	Wastepaper-board
grade)	Wastepaper-molded products
Groundwood chemi-mechanical	Wastepaper-construction products
Groundwood thermo-mechanical	
Groundwood-CMN	Nonintegrated-fine
Groundwood-fine	Nonintegrated-tissue
Soda	Nonintegrated-lightweight
Deink	Nonintegrated-filter and nonwoven
Nonintegrated-fine	Nonintegrated-paperboard
Nonintegrated-tissue	
- from waste paper	

[a]Excludes three groupings of miscellaneous mills: integrated miscellaneous (including alkaline miscellaneous, groundwood chemi-mechanical, and nonwood pulping), secondary fiber-miscellaneous, and nonintegrated-miscellaneous.

The BPT effluent limitations for the previous subcategorizations (as they appear in Table 16-2) are shown in Table 16-3. BPT limitations for the revised subcategorizations are not currently available.

As a part of the review of previous subcategories, raw waste loads were assessed taking into account the size and age of the mills, the treatability of the wastes produced, and the effect of unique geographical factors. With the revised subcategorization, 512 of the 644 mills responding to the data request fit

TABLE 16-3. BPT EFFLUENT LIMITATIONS FOR THE PREVIOUS SUBCATEGORIES [1]

	BOD_5, kg/Mg			TSS, kg/Mg			
Subcategory	Daily max	30-Day ave	Annual daily ave	Daily max	30-Day ave	Annual daily ave	pH, units Range
Unbleached kraft	5.6	2.8		12	6.0		6 to 9
Sodium based NSSC	8.0	4.4		11	5.5		6 to 9
Ammonia based NSSC	8.0	4.0		10	5.0		6 to 9
Unbleached kraft-NSSC	8.0	4.0		12	6.2		6 to 9
Paperboard FWP	3.0	1.5		5	2.5		6 to 9
Dissolving kraft	24	12.25	6.9	37	20	11	5 to 9
Market kraft	15	8	4.5	30	16	20	5 to 9
BCT kraft	14	7.1	4.0	24	13	7.1	5 to 9
Fine kraft	11	5.5	3.1	22	12	6.6	5 to 9
Papergrade sulfite-blow pit wash	32	17	9.3	44	24	13	5 to 9
Papergrade sulfite-drum wash	27	14	7.8	44	24	13	5 to 9
Papergrade sulfite-market pulp	40	21		40	2.6		5 to 9
Dissolving sulfite	41	22	12	71	38	21	5 to 9
Groundwood chemi-mechanical	14	7	4	20	11	5.8	5 to 9
Groundwood thermo-mechanical	11	5.6	3.1	16	8.4	4.6	5 to 9
Groundwood CMN	7.4	3.9	2.2	13	6.8	3.8	5 to 9
Groundwood fine	6.8	3.6	2.0	12	6.3	3.4	5 to 9
Soda	14	7.1	4.0	24	13	7.2	5 to 9
Deink	18	9.4	5.3	24	13	7.1	5 to 9
Nonintegrated-fine	8.2	4.2	2.4	11	5.9	3.2	5 to 9
Nonintegrated-tissue	11	6.2	3.5	10	5.0	2.8	5 to 9
Nonintegrated-tissue FWP	14	7.1	4.0	17	9.2	5	5 to 9

Note: Blanks indicate no data available.

into the subcategories shown below, which are grouped as intetrated mills, secondary fiber mills, and nonintegrated mills.

II.16.1.2.1 Integrated Mills

In integrated mill operations, pulp is produced and processed into pulp, pulp bales, paper, or paperboard at the same site.

Alkaline-Dissolving. At alkaline-dissolving mills, a highly bleached wood pulp is produced in a full-cook process using a sodium hydroxide and sodium sulfide cooking liquor and a precook operation called "prehydrolysis". The principal product is a highly purified dissolving pulp.

Alkaline-Market. At alkaline-market mills, a bleached papergrade market wood pulp is produced in a full-cook process using a highly alkaline sodium hydroxide cooking liquor. Sodium sulfide is also usually present in the cooking liquor in varying amounts.

Alkaline-BCT. At alkaline-BCT mills, bleached alkaline pulp is produced and manufactured into paperboard, coarse, and tissue (BCT) grades of paper. Bleached alkaline pulp is produced in a process similar to that presented above for the alkaline-market subcategory.

Alkaline-Fine. At alkaline-fine mills, bleached alkaline pulp is produced and manufactured into fine papers, including business, writing, and printing papers. The pulping process is the same as that discussed in the previous two subcategories.

Alkaline-Unbleached. At alkaline-unbleached mills, an unbleached wood pulp is produced in a full-cook process using a highly alkaline sodium hydroxide cooking liquor. Sodium sulfide is also usually present in the cooking liquor in varying amounts. The products are coarse papers and paperboard, and may include market pulp, unbleached kraft specialties, towers, and corrugating medium and tube stock.

Semi-Chemical. At semi-chemical mills, a high-yield wood pulp is produced and manufactured into corrugating medium, insulating board, partition board, chip board, tube stock, and specialty boards. A variety of cooking liquors is used to cook the wood chips under pressure; the cooked chips are usually refined before being converted into board or similar products.

Alkaline-Unbleached and Semi-Chemical. At mills in this subcategory, high-yield semi-chemical pulp (as defined in the semi-chemical subcategory) and unbleached kraft pulp (as defined in the alkaline-unbleached subcategory) are produced. Cooking liquors from both processes are recovered in the same recovery furnace. Major products include linerboard, corrugating medium, and market pulp.

Alkaline-Newsprint. At alkaline-newsprint mills, bleached alkaline pulp (as defined in the alkaline-market subcategory) and groundwood pulp (as defined in the groundwood-CMN and thermo-mechanical pulp subcategories) are produced. Newsprint is the principal product.

Sulfite-Dissolving. At sulfite-dissolving mills, a highly bleached and purified wood pulp is produced in a full-cook process using strong solutions of calcium, magnesium, ammonia or sodium bisulfite, and sulfur dioxide. The pulps produced are viscose, nitration, cellophane or acetate grades; they are used principally for the manufacture of rayon and other products that require the virtual absence of lignin and high alpha-cellulose content.

Sulfite-Papergrade. At sulfite-papergrade mills, sulfite pulp and paper or papergrade market pulp are produced. The sulfite wood pulp is produced by a full-cook process using strong solutions of calcium, magnesium, ammonia or sodium bisulfite, and sulfur dioxide. Purchased groundwood, secondary fibers or virgin pulp are commonly used in addition to sulfite pulp to produce tissue paper, fine paper, newsprint, market pulp, chip board, glassine, wax paper, and sulfite specialties.

Thermo-Mechanical Pulp (TMP). At thermo-mechanical pulp mills, wood pulp is produced in a process using rapid steaming followed by refining. A cooking liquor, such as sodium sulfite, is added. The principal products are fine paper, newsprint, and tissue papers.

Groundwood-CMN. At groundwood-CMN mills, groundwood pulp is produced using stone grinders or refiners; no separate steaming vessel is used before the defibration. Purchased fibers are used in addition to groundwood pulp to produce coarse papers, molded fiber products, and newsprint (CMN).

Groundwood-Fine. At groundwood-fine mills, groundwood pulp is produced using stone grinders or refiners; no separate steaming vessel is used before the defibration. Purchased fibers are used in addition to groundwood pulp to produce fine papers, including business, writing, and printing papers.

II.16.1.2.2 Secondary Fiber Mills

No pulp is produced at secondary fiber mills; most of the new material furnish is waste paper. Some secondary fiber mills include deinking to produce a pulp, paper or paperboard product.

Deink-Fine and Tissue. At deink-fine and tissue mills, a deink pulp is produced from waste paper. The principal products made from the deinked pulp including printing, writing, business, and tissue papers; they may also include products such as wallpaper, converting stock, and wadding.

Deink-Newsprint. Deink-newsprint mills produce newsprint from deink pulp derived mostly from over-issue and waste news.

Wastepaper-Tissue. In wastepaper-tissue mills, paper stock furnish is derived from waste paper without deinking. The principal products are facial and toilet paper, paper towels, glassine, paper diapers and wadding.

Wastepaper-Board. Wastepaper-board mills use a furnish derived from waste paper without deinking. A wide range of products are made, including setup and folding boxboards, corrugating medium, tube stock, chip board, gypsum liner, and linerboard. Other board products include fiber and partition board; building board; shoe board; bogus, blotting, cover, auto, filter, gasket, tag, liner, and electrical board; fiber pipe; food board; and wrapper and speciality boards.

Wastepaper-Molded Products. At wastepaper-molded products mills, most of the furnish is obtained from waste paper without deinking. The principal products are molded items, such as fruit and vegetable packs and similar throwaway containers and display items.

Wastepaper-Construction Products. Mills in the wastepaper-construction products subcategory primarily produce saturated and coated building paper and boards. Waste paper is the furnish; no deinking is employed. The principal products include roofing felt, shingles, and rolled and prepared roofing. Asphalt may be used for saturating, and various mineral coatings may be used. Some asbestos and nonwood fibers (fiberglass) may also be used. At many mills, some groundwood, defibrated pulp or wood flour may be processed and used to produce the final product.

II.16.1.2.3 Nonintegrated Mills

Nonintegrated mills purchase wood pulp or other fiber source(s) to produce paper or paperboard products.

Nonintegrated-Fine. Nonintegrated-fine mills produce fine papers from wood pulp or secondary fibers prepared at another site. No deinking is employed at the papermill site. The principal products are printing, writing, business, and technical papers; bleached bristols; and rag papers.

Nonintegrated-Tissue. Nonintegrated-tissue mills produce sanitary or industrial tissue papers from wood pulp or secondary fiber prepared at another site. No deink pulp is prepared at the papermill site. The principal products are facial and toilet paper, paper towels, glassine, paper diapers, wadding, and wrapping.

Nonintegrated-Lightweight. Nonintegrated lightweight mills produce lightweight or thin papers from wood pulp or secondary fiber prepared at another site, as well as from nonwood fibers and additives. The principal products are uncoated thin papers, such as carbonizing, cigarette papers, and some special grades of tissue, such as capacitor, pattern, and interleaf.

Nonintegrated-Filter and Nonwoven. Nonintegrated-filter and nonwoven mills produce filter papers and nonwoven items using a furnish of purchased wood pulp, waste paper, and nonwood fibers. The principal products are filter and blotting paper, nonwoven packaging and specialties, insulation, technical papers, and gaskets.

Nonintegrated-Paperboard. Nonintegrated-paperboard mills produce various types of paperboard from purchased wood pulps or secondary fibers. Products include linerboard; folding boxboard; milk cartons; and food, chip, stereotype, pressboard, electrical, and other specialty board grades.

In addition to the above, there are three miscellaneous groupings which are not considered subcategories because they do not fit into any one subcategory definition. These groups include integrated-miscellaneous (including alkaline miscellaneous, groundwood chemi-mechanical, and nonwood pulping), secondary fiber-miscellaneous, and nonintegrated-miscellaneous; and they are described below.

Integrated-Miscellaneous. This mill grouping includes three types of miscellaneous mills: 1) mills employing more than one pulping process (exceptions are the alkaline-newsprints and the alkaline-unbleached and semi-chemical subcategories); 2) miscellaneous processes not described above (i.e., nonwood pulping, chemi-mechanical, miscellaneous acid and alkaline pulping mills); and 3) mills producing a wide variety of products not covered above.

Secondary Fiber-Miscellaneous. This mill grouping manufactures products or product mixes not included in the wastepaper-tissue, wastepaper-board, wastepaper-molded products and wastepaper construction products subcategories. Their furnish is more than 50 percent waste paper without deinking. Products may include market pulp from waste paper and polycoated waste, filters, gaskets, mats, absorbent papers, groundwood specialties, and other grade mixtures. A mill producing less than 50 percent construction paper or any other combination of products, other than secondary fiber subcategory products, would be classified in this grouping.

Nonintegrated-Miscellaneous. This grouping includes any nonintegrated mill not included in the above subcategories. Included are mills making mostly asbestos and synthetic products; paper and paperboard products that are too diverse to be classified; or products with unique process or product specifications, commonly called specialty items.

Total production by subcategory is given in Table 16-4, as reported in Reference 1.

II.16.1.3 Wastewater Flow Characterization

Total wastewater flow for the mills sampled is 2,662.7 m^3/Mg (640 kgal/ton) of product formed. Wastewater flows for each subcategory are included in Table 16-7, which is shown in Section II.16.2.1. Points of effluent discharge for a typical paper mill are shown in Figure 16-1.

II.16.2 WASTEWATER CHARACTERIZATION [1]

II.16.2.1 Conventional Pollutants

Raw waste load data were collected to establish effluent limitation guidelines and the cost of achieving such guidelines. To meet these objectives, two representative conceptual mills were established: the model mill and the pure mill, as described below.

TABLE 16-4. REPORTED PULP AND PAPER PRODUCTION BY SUBCATEGORY [1]

Subcategory	No. of mills	Average mill production Mg/d	(t/d)	Average production per machine Mg/d	(t/d)	Total annual production Mkg	(1,000 t)
Integrated mills							
Alkaline-dissolving	3	1,020	(1,130)	430	(480)	1,110	(1,220)
Alkaline-market	9	750	(830)	470	(520)	2,440	(2,690)
Alkaline-BCT	8	790	(970)	250	(280)	2,280	(2,510)
Alkaline-fine	18	640	(700)	55	(61)	4,140	(4,570)
Alkaline-unbleached	29	790	(870)	400	(440)	8,230	(9,070)
Semi-chemical	19	410	(460)	240	(270)	1,640	(1,810)
Alkaline-unbleached and semi-chemical	10	1,190	(1,320)	340	(370)	4,300	(4,740)
Alkaline-newsprint	3	1,210	(1,340)	300	(330)	1,310	(1,440)
Sulfite-dissolving	6	490	(540)	490	(540)	1,070	(1,180)
Sulfite-papergrade	18	320	(360)	83	(91)	2,100	(2,310)
Thermo-mechanical pulp	2	260	(280)	100	(110)	180	(200)
Groundwood-CMN	6	250	(280)	74	(82)	540	(590)
Groundwood-fine	8	420	(460)	120	(140)	1,210	(1,340)
Secondary fiber mills							
Deink-fine	17	150	(170)	52	(57)	930	(1,030)
Deink-newsprint	3	320	(360)	240	(270)	350	(390)
Wastepaper-tissue	22	30	(33)	12	(13)	240	(260)
Wastepaper-board	147	130	(150)	130[a]	(140)[a]	7,060	(7,780)
Wastepaper-molded products	15	44	(49)	5	(5)	240	(260)
Wastepaper-construction products	58	74	(82)	54	(60)	1,550	(1,710)
Nonintegrated mills							
Nonintegrated-fine	39	190	(210)	73	(81)	2,100	(2,310)
Nonintegrated-tissue	26	110	(130)	58	(64)	1,190	(1,320)
Nonintegrated-lightweight	18	52	(57)	19	(21)	320	(350)
Nonintegrated-filter and nonwoven	16	18	(19)	39	(43)	100	(110)
Nonintegrated-paperboard	12	33	(36)	20	(22)	160	(180)
Subtotal	512					226,000	(249,000)
Miscellaneous groups	134					13,300	(14,700)
Total	646					240,000	(264,000)

[a]Estimated.

Note: Blanks indicate not applicable.

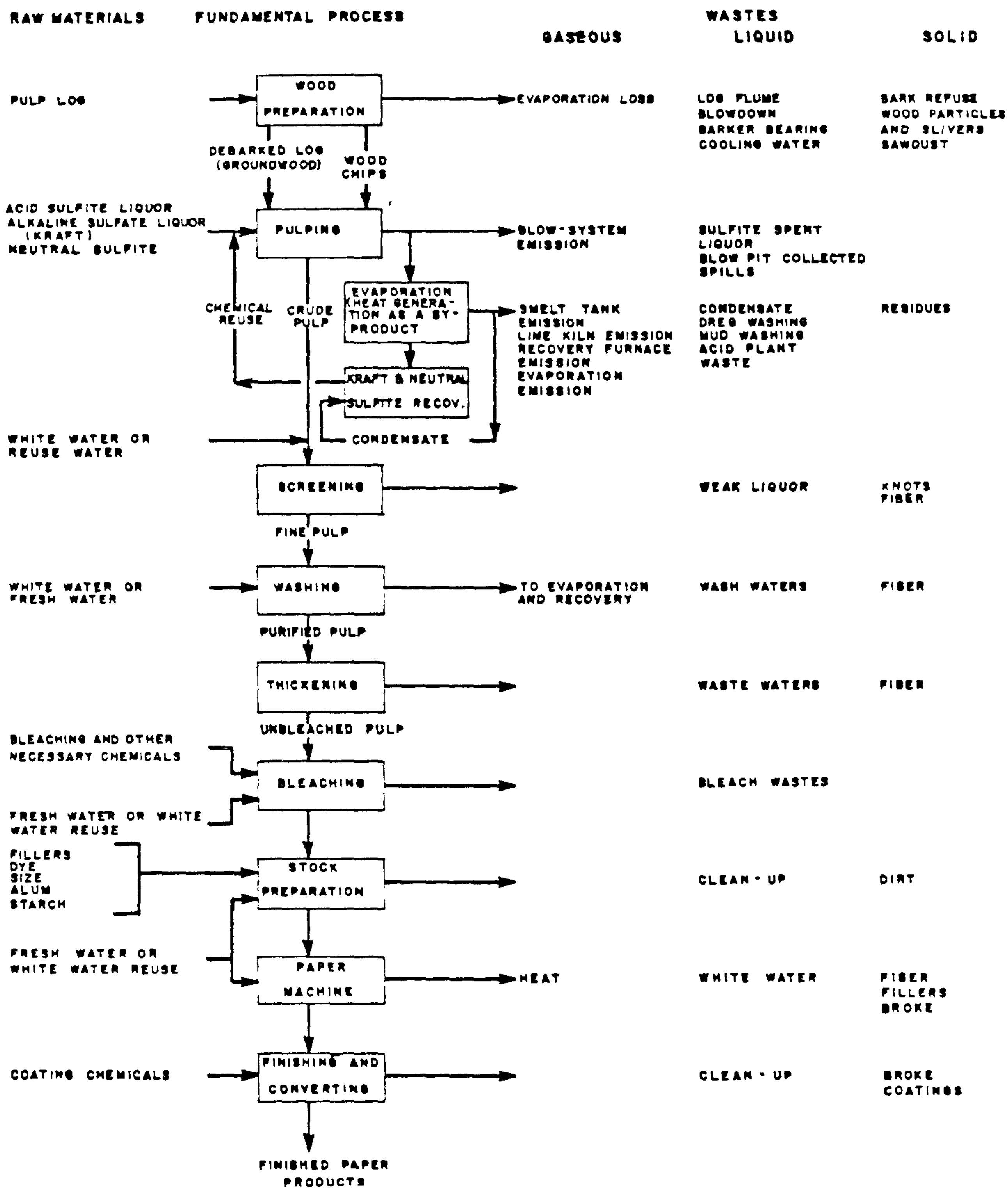


Figure 16-1. General flow sheet - pupling and papermaking [1].

A model mill was developed for each subcategory in order to present a typical operation of mills within the subcategory. The model mill was selected to serve as the basis for subsequent cost and energy evaluation. The raw waste load presented for the model mill in some subcategories is the average raw waste load of mills within the subcategory. In other cases, the model mill raw waste load may reflect an operation or set of operations that typify the subcategory but may not be the arithmetic average of the subcategory. Raw waste loads of conventional pollutants for model mills in each subcategory are presented in Table 16-5.

TABLE 16-5. SUMMARY OF MODEL MILL RAW WASTE LOADS [1]

Subcategory	Model mill size		Raw waste load: Flow		BOD_5		TSS	
	Mg/d	(t/d)	m^3/Mg	(kgal/t)	kg/Mg	(lb/t)	kg/Mg	(lb/t)
Alkaline-dissolving	910	(1,000)	200	(48)	54	(110)	77	(150)
Alkaline-market	540	(600)	180	(43)	42	(83)	32	(64)
Alkaline-BCT	725	(800)	150	(36)	46	(91)	42	(85)
Alkaline-fine	725	(800)	110	(26)	30	(61)	66	(130
Alkaline-unbleached	910	(1,000)	47	(11)	14	(28)	16	(33)
Semi-chemical	385	(425)	32	(7.8)	18	(37)	22	(43)
Alkaline-unbleached and semi-chemical	1,360	(1,500)	56	(13)	19	(37)	24	(47)
Alkaline-newsprint	1,270	(1,400)	94	(22)	21	(42)	57	(110)
Sulfite-dissolving	540	(600)	260	(62)	150	(310)	90	(180)
Sulfite-papergrade	410	(450)	150	(37)	49	(97)	33	(66)
Thermo-mechanical pulp	320	(350)	60	(14)	18	(37)	39	(77)
Groundwood-CMN	540	(600)	88	(21)	19	(37)	48	(97)
Groundwood-fine	450	(500)	68	(16)	18	(35)	54	(110)
Deink-fine and tissue	160	(180)	81	(20)	49	(97)	140	(290)
Deink-newsprint	360	(400)	68	(16)	16	(32)	120	(250)
Wastepaper-tissue	41	(45)	39	(9.4)	8.8	(18)	27	(54)
Wastepaper-board	140	(160)	15	(3.7)	6.5	(13)	7.7	(15)
Wastepaper-molded products	45	(50)	47	(11)	5.7	(11)	11	(21)
Wastepaper-construction products	91	(100)	9.2	(2.2)	5.8	(12)	8.2	(16)
Nonintegrated-fine	190	(220)	48	(12)	8.5	(17)	30	(60)
Nonintegrated-tissue	160	(180)	73	(18)	13	(26)	39	(78)
Nonintegrated-lightweight	54	(60)	270	(64)	15	(31)	46	(91)
Nonintegrated-filter	18	(20)	170	(41)	5	(10)	25	(50)
Nonintegrated-paperboard	36	(40)	100	25	10	(20)	42	84

The pure mill concept was used to establish a basis for the development of effluent guidelines and standards which can be applied to each mill in this industry. Because most mills are combinations of complex processes and products, it is necessary to isolate distinct operations that can be found in the industry. Raw waste loads attributable to each distinct process can then be prorated to match the combination of processes that may be found at a particular mill. Pure mill raw waste loads are presented for each subcategory in Table 16-6. For some subcategories that are particularly well defined and discrete, the pure mill and model mill raw waste loads may be the same.

Table 16-7 presents the average raw waste loads for all mills sampled in each of the subcategories.

TABLE 16-6. SUMMARY OF "PURE MILL" RAW WASTELOADS [1]

Subcategory	Raw waste load: Flow m^3/Mg	(kgal/t)	BOD_5 kg/Mg	(lb/t)	TSS kg/Mg	(lb/t)
Alkaline-dissolving	220	(53)	65	(130)	97	(190)
Alkaline-market	160	(40)	38	(75)	48	(97)
Alkaline-BCT	150	(36)	46	(91)	42	(85)
Alkaline-fine	110	(26)	29	(57)	53	(110)
Alkaline-unbleached						
· Linerboard	47	(11)	14	(28)	16	(32)
· Bag	70	(17)	19	(38)	21	(41)
Semi-chemical						
· 80%	32	(7.8)	18	(37)	22	(43)
· 100%	48	(12)	19	(39)	38	(77)
Alkaline-unbleached and semi-chem	56	(13)	19	(37)	24	(47)
Alkaline-news	94	(22)	21	(42)	57	(110)
Sulfite-dissolving	270	(64)	170	(340)	100	(200)
Sulfite-papergrade						
· 67%	150	(37)	49	(97)	33	(66)
· 100%	200	(49)	68	(140)	35	(69)
Thermo-mechanical pulp	60	(14)	18	(36)	39	(77)
Groundwood-CMN						
· 74%	88	(21)	19	(37)	44	(97)
· 100%	130	(32)	23	(46)	78	(160)
Groundwood-fine						
· 59%	68	(16)	18	(35)	54	(110)
· 100%	110	(27)	19	(37)	55	(110)
Deink-fine						
· Pure tissue	81	(20)	49	(97)	140	(290)
· Pure fine	110	(26)	50	(100)	220	(430)
Deink-newsprint	68	(16)	16	(32)	120	(250)
Wastepaper tissue[a]						
· 100% Industrial	57	(14)	13	(26)	40	(81)
Wastepaper-board						
· Board	15	(3.7)	11	(21)	9.9	(20)
· Linerboard	28	(6.7)	8.9	(18)	11	(22)
· Corrugated	4.2	(1.0)	5.3	(11)	4	(7.9)
· Chip and filler	10	(2.4)	3.5	(6.9)	4.5	(8.9)
· Folding box	16	(3.9)	6.1	(12)	7.1	(14)
· Set-up box	20	(4.9)	7.3	(15)	5.7	(11)
· Gypsum	12	(2.8)	5.8	(12)	16	(32)
Wastepaper-molded products[a]	52	(13)	6.5	(13)	11	(23)
Wastepaper-construction products[a]						
· 100% waste paper	15	(3.5)	7.6	(15)	19	(39)
· 50% WP/50% TMP	12	(3.0)	14	(28)	10	(20)
Nonintegrated-fine	48	(12)	8.5	(17)	30	(60)
Nonintegrated-tissue	73	(18)	13	(20)	39	(78)
Nonintegrated-lightweight	270	(64)	15	(31)	46	(91)
· Lightweight-electrical	410	(98)	12	(23)	38	(75)
Nonintegrated-filter and nonwoven	170	(41)	5	(10)	25	(50)
Nonintegrated						
· Board	100	(25)	10	(20)	42	(84)
· Electrical board	250	(59)	--	(--)	--	(--)

[a]Excludes self-contained mills.

TABLE 16-7. SUMMARY OF AVERAGE RAW WASTE LOADS FOR MILLS SAMPLED [1]

Subcategory	Raw waste load					
	Flow		BOD_5		TSS	
	m^3/Mg	(kgal/t)	kg/Mg	(lb/t)	kg/Mg	(lb/t)
Alkaline-dissolving	200	(48)	61	(130)	77	(150)
Alkaline-market	130	(32)	33	(65)	29	(58)
Alkaline-BCT	150	(36)	46	(91)	42	(85)
Alkaline-fine	110	(26)	30	(61)	66	(130)
Alkaline-unbleached	70	(17)	19	(38)	28	(57)
Semi-chemical[a]	32	(7.8)	18	(37)	22	(43)
Alkaline-unbleached and semi-chemical	56	(13)	19	(37)	24	(47)
Alkaline-newsprint	94	(22)	21	(42)	57	(110)
Sulfite-dissolving	260	(62)	150	(310)	90	(181)
Sulfite-papergrade	140	(34)	58	(120)	46	(91)
Thermo-mechanical pulp	60	(14)	18	(36)	39	(77)
Groundwood-CMN	110	(27)	19	(39)	67	(130)
Groundwood-fine	68	(16)	18	(35)	54	(110)
Deink-fine and tissue	93	(22)	52	(100)	160	(320)
Deink-newsprint	68	(16)	16	(32)	120	(250)
Wastepaper tissue	140	(32)	36	(72)	94	(190)
Wastepaper-board	15	(3.7)	(6.5)	(13)	7.7	(15)
Wastepaper-molded products	68	(16)	7.2	(14)	14	(27)
Wastepaper-construction products	9.2	(2.2)	5.8	(12)	8.2	(16)
Nonintegrated-fine	48	(12)	8.5	(17)	30	(60)
Nonintegrated-tissue	85	(20)	10	(20)	28	(56)
Nonintegrated-lightweight	270	(64)	15	(31)	46	(91)
Nonintegrated-filter	170	(41)	9.8	(20)	39	(78)
Nonintegrated-paperboard	100	(25)	10	(20)	42	(84)

[a]Mills with liquor recovery.

II.16.2.2 Toxic and Nonconventional Pollutants

Approximately 200 organic compounds have been identified in pulp, paper, and paperboard wastewaters. Those not specified by the NRDC Consent Decree are herein considered nonconventional pollutants. A summary of verification data for toxic and nonconventional pollutants for each subcategory is presented in Tables 16-8 through 16-30. The available data do not include the subcategories alkaline-dissolving and sulfite-dissolving, but do include three miscellaneous groupings not considered subcategories: chemi-mechanical pulp, nonwood pulping, and nonintegrated miscellaneous.

II.16.3 PLANT SPECIFIC DESCRIPTIONS

Limited plant specific data are presently available from Reference 1. Table 16-31 presents waste load flow, BOD_5, and TSS for selected mills within each subcategory and the subdivisions of the subcategories.

These selected mills were chosen by the approximate mid-range value of the pollutant wasteloads for the sampled plants. No data on treated wastewater for specific plants are currently available.

II.16.4 POLLUTANT REMOVABILITY [1]

The pulp, paper and paperboard industry employs many types of wastewater treatment systems to reduce the levels of pollutants

TABLE 16-8. ALKALINE-MARKET SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Alkaline-market									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	2	0	2	6	0	12	6	0	26	-[a]
Copper	2	0	22	6	0	31	6	0	14	55
Lead	2	0	<1	6	0	9	6	0	10	-[a]
Mercury	2	0	<1	6	0	<1	6	0	<1	-[b]
Nickel	2	0	3	6	0	31	6	0	14	55
Zinc	2	0	15	6	0	150	6	0	70	55
Phthalates										
Bis(2-ethylhexyl) phthalate	2	0	43	5	1	11	6	0	32	-[a]
Di-n-butyl phthalate				5	1	3	5	1	8	-[a]
Diethyl phthalate				2	4	<1				
Phenols										
2,4-Dichlorophenol				4	2	4	4	2	4	-[b]
Phenol				5	1	15	5	1	1	93
2,4,6-Trichlorophenol				5	1	11	6	0	5	55
Monocyclic aromatics										
Benzene				1	5	<1	2	4	<1	-[b]
Ethylbenzene				1	5	14				
Toluene				3	3	1				
Halogenated aliphatics										
Chloroform				5	1	1,200	6	0	12	99
Methylene chloride	1	1	<1	3	3	<1	2	4	<1	-[b]
Nonconventional pollutants										
Abietic acid				5	1	180	2	4	580	-[a]
Dehydroabietic acid	1	1	12	5	1	220	4	2	430	-[a]
Isopimaric acid				3	3	58	3	3	200	-[a]
Pimaric acid				3	3	78	3	3	210	-[a]
Oleic acid				5	1	300	6	0	150	49
Linoleic acid				5	1	700	3	3	47	93
Linolenic acid				1	5	35				
1-Chlorodehydroabietic acid				4	2	50	3	3	42	16
Dichlorodihydroabietic acid				3	3	29	3	3	19	34
3,4,5-Trichloroguaiacol				3	3	9				
Tetrachloroguaiacol				6	0	11				

[a]Negative removal.

[b]Negligible removal.

NOTE: Blanks indicate no data available.

TABLE 16-9. ALKALINE-BCT SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory. Alkaline-BCT									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	1	9	0	85	9	0	55	35
Copper	2	0	21	9	0	46	9	0	17	62
Lead	3	0	4	9	0	17	9	0	18	-[a]
Mercury	3	0	<1	9	0	<1	9	0	<1	-[b]
Nickel	3	0	3	9	0	36	9	0	12	67
Zinc	3	0	58	9	0	140	9	0	110	29
Phthalates										
Bis(2-ethylhexyl) phthalate	1	2	2	8	1	3	6	3	2	33
Di-n-butyl phthalate				5	4	2	1	8	<1	50
Phenols										
2,4-Dichlorophenol				4	5	1	2	7	<1	-[b]
Pentachlorophenol				3	6	6	3	6	6	-[b]
Phenol	1	2	<1	9	0	55	4	5	5	91
2,4,6-Trichlorophenol				8	1	8	1	8	<1	88
Monocyclic aromatics										
Benzene	1	2	<1				1	8	<1	
Ethylbenzene							1	8	<1	
Toluene				6	3	1				
Polycyclic aromatic Hydrocarbons										
Anthracene				1	8	<1				
Halogenated aliphatics										
Chloroform				9	0	1,550	8	1	6	99
Methylene chloride	1	2	1	7	2	2	5	4	2	-[b]
Tetrachloroethylene				3	6	<1				
Trichloroethylene				3	6	<1				
Nonconventional pollutants										
Abietic acid				7	2	1,040	7	2	120	88
Dehydroabietic acid				8	1	740	9	0	120	83
Isopimaric acid				7	2	96	7	2	21	78
Pimaric acid				7	2	110	6	3	22	81
Oleic acid				7	2	1,080				
Linoleic acid				6	3	510				
1-Chlorodehydroabietic acid				5	4	52	3	6	6	88
Dichlorodihydroabietic acid				2	7	2	1	8	<1	50
3,4,5-Trichloroguaiacol				1	8	<1				
Tetrachloroguaiacol				6	3	5	1	8	<1	80

[a] Negative removal.

[b] Negligible removal

NOTE: Blanks indicate no data available

TABLE 16-10. ALKALINE-UNBLEACHED SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Alkaline-unbleached									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	7	8	1	14	6	0	12	14
Copper	3	0	4	9	0	19	6	0	9	53
Lead	3	0	21	9	0	14	6	0	16	-[a]
Mercury	3	0	<1	9	0	<1	6	0	<1	-[b]
Nickel	3	0	7	9	0	6	6	0	5	16
Zinc	3	0	14	9	0	110	6	0	81	30
Phthalates										
Bis(2-ethylhexyl) phthalate	1	2	<1	5	4	18	1	5	<1	94
Butyl benzyl phthalate				2	7	8				
Di-n-butyl phthalate				4	5	2	3	0	1[b]	50
Phenols										
Phenol	2	1	<1	9	0	85	3	0	3[b]	96
Monocyclic aromatics										
Benzene				1	8	<1	2	4	<1	--[b]
Ethylbenzene				3	6	<1				
Toluene				7	2	4				
Halogenated aliphatics										
Chloroform				3	6	<1				
Methylene chloride	1	2	3	7	2	34	5	1	4	88
Tetrachloroethylene				2	7	<1				
Nonconventional pollutants										
Abietic acid				9	0	2,030	6	0	120	94
Dehydroabietic acid				9	0	740	6	0	52	93
Isopimaric acid				9	0	330	3	3	15	95
Pimaric acid				9	0	320	4	2	17	95
Oleic acid				9	0	1,070	6	0	110	90
Linoleic acid				9	0	450				
Linolenic acid				3	6	170				
Dichlorodehydroabietic acid				1	8	<1				
Xylenes				6	3	14				

[a]Negative removal.

[b]Negligible removal.

NOTE: Blanks indicate no data available.

TABLE 16-11. ALKALINE-FINE SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Alkaline-fine									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	2	9	0	26	9	0	7	74
Copper	3	0	6	9	0	22	9	0	8	64
Lead	3	0	3	9	0	6	9	0	6	–[a]
Mercury	3	0	<1	9	0	<1	9	0	<1	–[a]
Nickel	3	0	2	9	0	16	9	0	8	50
Zinc	3	0	19	9	0	150	9	0	71	52
Phthalates										
Bis(2-ethylhexyl) phthalate	2	1	4	7	2	28	6	3	16	43
Di-n-butyl phthalate				2	7	<1	1	8	<1	–[a]
Diethyl phthalate				1	8	<1				
Phenols										
2,4-Dichlorophenol	1	2	2	2	7	<1	1	8	<1	–[a]
Pentachlorophenol				3	6	3	1	2	2	33
Phenol				6	3	7	2	7	<1	86
2,4,6-Trichlorophenol				9	0	11	7	2	3	73
Monocyclic aromatics										
Toluene				8	1	23				
Halogenated aliphatics										
Chloroform				6	3	780	9	0	52	93
Dichlorobromomethane				2	7	4				
Methylene chloride	1	2	2	3	6	<1	2	7	<1	–[a]
Tetrachloroethylene				1	8	<1				
1,1,1-Trichloroethane				1	8	8				
Nonconventional pollutants										
Abietic acid				4	5	190	1	8	1	99
Dehydroabietic acid				6	3	180	4	5	3	99
Isopimaric acid				6	3	48				
Pimaric acid				6	3	40				
Oleic acid				3	6	180	2	7	18	90
Linoleic acid				3	6	94	1	8	10	89
9,10-Epoxystearic acid	1	2	37							
Dichlorodehydroabietic acid				2	7	4				
3,4,5-Trichloroguaiacol	1	2	4	4	5	2	1	8	<1	50
Tetrachloroguaiacol	1	2	8	7	2	6	3	6	2	67
Xylenes				2	7	1				

[a]Negligible removal.

NOTE: Blanks indicate no data available.

TABLE 16-12. SEMI-CHEMICAL SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

Subcategory: Semi-chemical

Pollutant	Raw water			Aeration influent			Final effluent			Percent removal
	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	
Toxic pollutants										
Metals										
Chromium	2	0	2	6	0	29	6	0	19	35
Copper	2	0	4	6	0	79	6	0	25	68
Cyanide	3	0	9	3	0	9	3	0	9	-[a]
Lead	3	0	4	6	0	95	6	0	35	63
Mercury	1	1	<1	6	0	<1	6	0	<1	-[a]
Nickel	2	0	3	6	0	12	6	0	10	17
Zinc	2	0	2	6	0	143	6	0	61	58
Phthalates										
Bis (2-ethylhexyl) phthalate	1	1	11	5	1	21	6	0	14	29
Butyl benzyl phthalate				1	5	<1				
Di-n-butyl phthalate				6	0	4				
Phenols										
Pentachlorophenol				1	5	<1	1	5	<1	-[a]
Phenol	1	1	2	6	0	230	6	0	14	94
Monocyclic aromatics										
Benzene				3	3	3	2	4	<1	67
Ethylbenzene				2	4	<1	2	4	<1	-[a]
Toluene				3	3	2	3	3	1	50
Polycyclic aromatic hydrocarbons										
Naphthalene				2	4	2				
Halogenated aliphatics										
Chloroform				3	3	1				
Methylene chloride				4	2	6	6	0	5	16
Trichloroethylene				3	3	5				
Nonconventional pollutants										
Abietic acid				3	3	130	3	3	19	85
Dehydroabietic acid				6	0	170	4	2	14	92
Isopimaric acid				6	0	34	3	3	7	79
Pimaric acid				3	3	27	1	5	2	93
Oleic acid				6	0	120	1	5	6	95
Linoleic acid				3	3	61	2	4	4	93
Linolenic acid				3	3	49				
1-Chlorodehydroabietic acid				2	4	4				
Dichlorodehydroabietic acid				2	4	7				
Xylenes				2	4	<1	3	3	<1	-[a]

[a] Negligible removal.

NOTE: Blanks indicate no data available.

TABLE 16-13. ALKALINE UNBLEACHED AND SEMI-CHEMICAL SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Alkaline unbleached and semi-chemical									
	Raw water			Aeration influent			Final effluent			
	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	2	0	2	6	0	29	6	0	19	35
Copper	2	0	8	6	0	38	6	0	15	61
Cyanide	6	0	10	6	0	16	6	0	10	38
Lead	2	0	2	6	0	24	6	0	13	46
Mercury	2	0	<1	6	0	<1	6	0	<1	-[a]
Nickel	2	0	2	6	0	10	6	0	5	50
Zinc	2	0	6	6	0	40	6	0	25	38
Phthalates										
Bis(2-ethylhexyl) phthalate				5	1	10	5	1	10	-[a]
Di-n-butyl phthalate				4	2	5				
Diethylphthalate				2	4	7				
Phenols										
Pentachlorophenol				1	5	1				
Phenol				6	0	56				
Monocyclic aromatics										
Benzene				3	3	2				
Toluene				3	3	1				
Polychlorinated biphenyls and related compounds										
Aroclor 1232	1	1	<1							
Aroclor 1254	2	0	2	3	3	<1	4	2	2	-[b]
Halogenated aliphatics										
Chloroform	1	1	<1	2	4	1				
Methylene chloride	1	1	3	3	3	58	1	5	13	78
1,1,1-Trichloroethane				3	3	3				
Trichloroethylene				2	4	<1				
Nonconventional pollutants										
Abietic acid	1	1	24	6	0	1,400	6	0	710	50
Dehydroabietic acid	1	1	9	6	0	610	6	0	230	61
Isopimaric acid				6	0	550	6	0	190	66
Pimaric acid				6	0	150	6	0	95	38
Oleic acid				6	0	620	6	0	410	34
Linoleic acid				6	0	440	3	3	59	86
9,10-Epoxystearic acid				3	3	130	2	4	57	57
Xylenes				3	3	11				

[a] Negligible removal.

[b] Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-14. SULFITE PAPERGRADE SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Sulfite papergrade									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	4	0	6	7	2	13	9	3	7	46
Copper	4	0	15	7	2	81	9	3	29	64
Lead	4	0	5	7	2	13	9	3	10	23
Mercury	4	0	<1	9	0	<1	12	0	<1	-[a]
Nickel	4	0	3	7	2	16	9	3	6	63
Zinc	4	0	26	9	0	91	12	0	120	-[b]
Phthalates										
Bis(2-ethylhexyl) phthalate	2	2	66	7	2	38	11	1	21	45
Di-n-butyl phthalate				1	8	<1				
Diethyl phthalate				1	8	<1	1	11	1	-[b]
Phenols										
2-Chlorophenol							3	9	9	-[b]
2,4-Dichlorophenol				3	6	<1	3	9	27	-[b]
Pentachlorophenol	1	3	<1	3	6	4	1	11	<1	75
Phenol	1	3	2	8	1	53	8	4	41	15
2,4,6-Trichlorophenol				3	6	4	5	7	39	-[b]
Monocyclic aromatics										
Benzene				3	3	1	5	7	12	77
Toluene				3	3	0.2	7	5	14	6
Halogenated aliphatics										
Chloroform				8	1	3,200	12	0	430	86
Dichlorobromomethane				3	6	9	1	11	<1	89
1,1-Dichloroethane				3	6	4				
Methylene chloride				7	2	460	12	0	270	42
1,1,1-Trichloroethane	3	6	414	2	1	3	3	9	2	33
Trichloroethylene				3	6	5	2	10	<1	80
Nonconventional pollutants										
Abietic acid				6	3	140	6	6	51	64
Dehydroabietic acid				9	0	560	9	3	250	55
Isopimaric acid				6	3	62	7	5	13	79
Pimaric acid				2	7	8	1	11	4	50
Oleic acid				9	0	170	7	5	47	72
Linoleic acid				6	3	57	4	8	26	54
Linolenic acid				2	7	12				
9,10-Epoxystearic acid				2	7	49	1	11	2	96
1-Chlorodehydroabietic acid				6	3	82	3	9	20	75
Dichlorodehydroabietic acid				1	8	<1	1	11	<1	-[a]
3,4,5-Trichloroguaiacol							2	10	<1	-[b]
Tetrachloroguaiacol				1	8	<1				
Xylenes				3	6	<1				

[a]Negligible removal

[b]Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-15. CHEMICAL-MECHANICAL PULP SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Chemi-mechanical pulp									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	1	0	2	3	0	3	3	0	4	-[a]
Copper	1	0	2	3	0	40	3	0	16	60
Cyanide	3	0	10	3	0	13	3	0	9	30
Lead	1	0	2	3	0	2	3	0	3	-[a]
Mercury	3	0	<1	1	0	<1	3	0	<1	-[b]
Nickel	1	0	2	3	0	3	3	0	6	-[a]
Zinc	1	0	14	3	0	400	3	0	110	73
Phthalates										
Bis(2-ethylhexyl) phthalate				2	1	7				
Phenols										
Phenol				3	0	31				
Monocyclic aromatics										
Ethylbenzene				1	2	<1				
Toluene				2	1	3	1	2	1	67
Polychlorinated biphenyls and related compounds										
Aroclor 1254				1	2	<1	1	2	<1	-[b]
Halogenated aliphatics										
Methylene chloride	1	0	4	2	1	5	2	1	6	-[a]
Nonconventional pollutants										
Abietic acid				3	0	2,700	3	0	140	95
Dehydroabietic acid				3	0	1,400	3	0	100	93
Isopimaric acid				3	0	1,020	3	0	67	93
Pimaric acid				3	0	750	3	0	42	94
Oleic acid				3	0	1,300	3	0	66	95
Linoleic acid				3	0	300				
1-Chlorodehydroabietic acid				3	0	54				
Xylenes				2	1	57	1	2	1	98

[a]Negative removal.

[b]Negligible removal.

NOTE: Blanks indicate no data available.

TABLE 16-16. GROUNDWOOD-CMN SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Groundwood-CMN									
	Raw water			Oxidation influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	1	0	2	3	0	6	3	0	4	33
Copper	1	0	16	3	0	15	3	0	5	67
Cyanide	1	0	10	3	0	9	3	0	9	-[a]
Lead	1	0	2	3	0	13	3	0	2	85
Mercury	1	0	1	3	0	<1	3	0	<1	-[a]
Nickel	1	0	2	3	0	8	3	0	7	12
Zinc	1	0	10	3	0	480	3	0	1,600	-[b]
Phthalates										
Bis(2-ethylhexyl) phthalate	1	0	6	3	0	8	3	0	9	-[b]
Phenols										
Phenol	1	0	8	3	0	16	3	0	11	31
Monocyclic aromatics										
Benzene				3	0	9	1	2	<1	89
Toluene				3	0	290	3	0	87	70
Halogenated aliphatics										
Chloroform				1	2	<1				
Methylene chloride							1	2	<1	-[b]
Nonconventional pollutants										
Abietic acid				2	1	220				
Dehydroabietic acid	1	0	31	3	0	430	3	0	45	89
Isopimaric acid				2	1	14				
Oleic acid				3	0	74				
Linoleic acid				1	2	16				
Xylenes				2	1	4				

[a] Negligible removal.

[b] Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-17. GROUNDWOOD-FINE SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Groundwood-fine									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	2	0	2	6	0	5	6	0	3	40
Copper	2	0	5	6	0	28	6	0	14	50
Lead	2	0	2	6	0	9	6	0	8	11
Mercury	2	0	<1	6	0	<1	6	0	<1	-[a]
Nickel	2	0	5	6	0	5	6	0	5	-[a]
Zinc	2	0	22	6	0	74	6	0	45	39
Phthalates										
Bis(2-ethylhexyl) phthalate	1	1	2	4	2	3	5	1	4	-[b]
Di-n-butyl phthalate				3	3	<1	3	3	<1	-[a]
Phenols										
Pentachlorophenol				3	3	3	2	4	<1	67
Phenol	1	1	2	6	0	28	4	2	2	93
Monocyclic aromatics										
Benzene	1	1	3							
Ethylbenzene				1	5	<1				
Toluene	1	1	2	6	0	13	3	3	<1	92
Halogenated aliphatics										
Chloroform				6	0	99	9	0	15	85
Methylene chloride				1	1	<1	1	5	2	-[b]
Tetrachloroethylene				1	5	<1				
Nonconventional pollutants										
Abietic acid				6	0	180	2	4	5	98
Dehydroabietic acid				6	0	150	6	0	26	84
Isopimaric acid				5	1	29	4	2	2	93
Pimaric acid				2	4	50	1	5	3	94
Oleic acid				5	1	170	2	4	13	92
Linoleic acid	1	1	17	3	3	170	3	3	39	77
Linolenic acid				3	3	130				

[a]Negligible removal.

[b]Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-18. NONWOOD PULPING SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Nonwood pulping									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, μg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	3	6	0	5	6	0	5	-[a]
Copper	3	0	9	6	0	39	6	0	15	62
Cyanide	3	0	10	3	0	9	3	0	9	-[a]
Lead	3	0	7	6	0	17	6	0	11	35
Mercury	3	0	<1	6	0	<1	6	0	<1	-[a]
Nickel	3	0	3	6	0	5	6	0	3	40
Zinc	3	0	66	6	0	75	6	0	33	56
Phthalates										
Bis(2-ethylhexyl) phthalate	3	0	15	4	2	8	5	1	45	-[b]
Di-n-butyl phthalate				2	4	<1	2	4	<1	-[a]
Diethyl phthalate				5	1	2				
Phenols										
Pentachlorophenol				4	2	12	1	5	<1	92
Phenol	2	1	<1	3	3	5	4	2	3	40
2,4,6-Trichlorophenol				1	5	3	1	5	<1	67
Monocyclic aromatics										
Toluene				1	5	<1	3	3	55	-[b]
Halogenated aliphatics										
Chloroform	1	2	6	3	3	420	3	3	5	99
Methylene chloride				2	4	<1	1	5	<1	-[a]
1,1,1-Trichloroethane				3	3	33				
Nonconventional pollutants										
Abietic acid				3	3	82	2	4	18	78
Dehydroabietic acid				4	2	250	3	3	120	53
Isopimaric acid				1	5	16	2	4	8	50
Pimaric acid				1	5	10	1	5	4	60
Oleic acid				4	2	220	2	4	43	80
Linoleic acid				3	3	270	1	5	<1	99
1-Chlorodehydroabietic acid				1	5	6	1	5	<1	83
Dichlorodehydroabietic acid				1	5	<1	1	5	3	-[b]
Xylenes				3	3	4				

[a] Negligible removal.

[b] Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-19. DEINK NEWSPRINT SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Deink newsprint					
	Raw water			Discharge, POTW		
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L
Toxic pollutants						
Metals						
Chromium	1	0	3	3	0	29
Copper	1	0	54	3	0	76
Lead	1	0	10	3	0	160
Mercury	1	0	<1	3	0	1
Nickel	1	0	3	3	0	15
Zinc	1	0	10	3	0	340
Phthalates						
Bis(2-ethylhexyl) phthalate	1	0	14	3	0	13
Butyl benzyl phthalate				3	0	5
Di-n-butyl phthalate				1	2	<1
Diethyl phthalate				1	2	1
Phenols						
Phenol				1	2	1
Monocyclic aromatics						
Ethylbenzene				2	1	2
Toluene				3	0	14
Halogenated aliphatics						
Chloroform	1	0	<1	3	0	<1
Methylene chloride	1	0	3	1	2	<1
Nonconventional pollutants						
Abietic acid				3	0	3,500
Dehydroabietic acid				3	0	3,700
Isopimaric acid				3	0	510
Pimaric acid				3	0	260
Oleic acid				3	0	1,400
Linoleic acid				3	0	750

NOTE: Blanks indicate no data available.

TABLE 16-20. DEINK-FINE AND TISSUE SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Deink-fine and tissue									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	5	9	0	22	9	0	6	72
Copper	3	0	4	9	0	34	9	0	10	71
Cyanide	9	0	10	9	0	68	9	0	89	-[a]
Lead	3	0	3	9	0	61	9	0	13	79
Mercury	3	0	<1	9	0	<1	9	0	<1	[b]
Nickel	3	0	6	9	0	8	9	0	3	63
Zinc	3	0	17	9	0	150	9	0	41	72
Phthalates										
Bis(2-ethylhexyl) phthalate				6	3	7	7	2	2	71
Di-n-butyl phthalate	1	2	<1	4	5	5	4	5	4	80
Diethyl phthalate				1	8	1	2	7	<1	-[b]
Phenols										
2,4-Dichlorophenol				4	5	2	2	7	<1	50
Pentachlorophenol				6	3	18	6	3	15	16
Phenol				5	4	38	1	8	8	79
2,4,6-Trichlorophenol				5	4	18	4	5	16	11
2-Chlorophenol				1	8	<1				
Monocyclic aromatics										
Benzene				3	6	2	5	4	2	[b]
Chlorobenzene				3	6	14				
Ethylbenzene				3	6	11				
Toluene				9	0	25	1	8	<1	96
Polycyclic aromatic hydrocarbons										
Naphthalene				4	5	42				
Polychlorinated biphenyls and related compounds										
Aroclor 1242				1	8	1				
Aroclor 1260				1	8	<1				
Halogenated aliphatics										
Chloroform	1	0	1	9	0	1,800	9	0	68	96
1,2-Dichloroethane				2	7	<1				
Methylene chloride				3	6	4	3	6	<1	75
Tetrachloroethylene				3	6	32				
1,1,1-Trichloroethane				3	6	7				
Trichloroethylene				6	3	170	3	6	2	99
Nonconventional pollutants										
Abietic acid				9	0	640	6	3	56	91
Dehydroabietic acid				8	1	2,200	8	1	210	99
Isopimaric acid				8	1	300	3	6	5	98
Pimaric acid				8	1	69				
Oleic acid				9	0	550	7	2	290	48
Linoleic acid				6	3	150				
Linolenic acid				2	7	40				
1-Chlorodehydroabietic acid				5	4	130	2	7	[illegible]	96
Dichlorodehydroabietic acid				2	7	2				
3,4,5-Trichloroguaiacol				2	7	5	3	6	5	-[b]
Tetrachloroguaiacol				3	6	3	3	6	3	-[b]
Xylenes				3	6	4				

[a]Negative removal.

[b]Negligible removal.

NOTE. Blanks indicate no data available.

TABLE 16-21. WASTEPAPER-TISSUE SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Wastepaper-tissue									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	10	6	0	20	9	0	10	50
Copper	3	0	4	6	0	55	9	0	34	38
Cyanide	9	0	9	6	0	9	9	0	9	-[a]
Lead	3	0	4	6	0	44	9	0	26	36
Mercury	3	0	<1	6	0	<1	9	0	<1	-[a]
Nickel	3	0	11	6	0	21	9	0	9	57
Zinc	3	0	4	6	0	490	9	0	68	86
Phthalates										
Bis(2-ethylhexyl) phthalate				5	1	10	4	5	2	80
Di-n-butyl phthalate				1	5	3				
Diethyl phthalate				2	4	13				
Phenols										
Phenol				6	0	41	4	5	2	95
Monocyclic aromatics										
Benzene				1	8	<1				
Ethylbenzene							3	3	13	
Toluene				5	1	2	2	7	1	50
Polycyclic aromatic hydrocarbons										
Naphthalene				3	0	26	2	7	6	77
Polychlorinated biphenyls and related compounds										
Arcolor 1254				1	5	<1				
Halogenated aliphatics										
Chloroform				1	5	2	1	8	<1	50
Methylene chloride	1	2	2	3	3	87	2	7	<1	99
Tetrachloroethylene				2	1	74	1	8	6	92
Nonconventional pollutants										
Abietic acid				4	2	54	2	7	24	55
Dehydroabietic acid				6	0	370	7	2	97	74
Isopimaric acid				3	3	16				
Pimaric acid				1	5	3				
Oleic acid				6	0	180	6	3	140	25
Xylenes				5	1	28	1	8	1	96

[a] Negligible removal.

NOTE: Blanks indicate no data available.

TABLE 16-22. WASTEPAPER-BOARD SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Wastepaper-board									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	4	[illegible]	2	2	1	[illegible]	12	6	[illegible]	81
Copper	4	2	3	2	1	110	12	6	37	[illegible]
Cyanide	18	0	10	3	0	74	18	0	14	81
Lead	4	2	3	7	2	150	12	6	31	81
Mercury	6	0	<1	3	0	<1	18	0	<1	–[a]
Nickel	4	2	4	2	1	37	12	6	17	54
Zinc	6	0	22	3	0	1,400	18	0	340	76
Phthalates										
Bis(2-ethylhexyl) phthalate	3	3	3	3	0	23	13	5	73	–[b]
Butyl benzyl phthalate	3	0	100	3	0	80	3	15	11	86
Di-n-butyl phthalate				2	1	32	3	15	7	84
Diethyl phthalate				3	0	79	6	12	69	13
Phenols										
Pentachlorophenol	1	5	9	3	0	1,050	3	15	200	81
Phenol	2	4	<1	3	0	460	5	13	72	84
2,4,6-Trichlorophenol	1	5	4	3	0	360	5	13	72	8
Monocyclic aromatics										
Benzene				1	8	<1[c]	1	17	<1	–[a]
Toluene				3	0	4	9	9	2	50
Polychlorinated biphenyls and related compounds										
Aroclor 1248				2	1	<1	3	15	<1	–[a]
Aroclor 1254	1	5	<1	2	1	<1	4	14	<1	–[a]
Halogenated aliphatics										
Bromoform				1	2	40[c]	1	17	3	93
Chloroform	1	5	17	9	0	19[c]	3	15	2	89
Dibromochloromethane	2	4	1							
Dichlorobromomethane	1	5	6	1	2	<1	3	15	<1	–[a]
Methylene chloride	1	5	<1	5	4	1	6	12	9	–[b]
Tetrachloroethylene				2	4	3	1	8	<1	67
1,1,1-Trichloroethane				2	1	2[c]	3	15	<1	50
Trichloroethylene	1	5	4	4	5	1[c]				
Nonconventional pollutants										
Abietic acid				3	0	410	6	12	16	96
Dehydroabietic acid				3	0	470	15	3	62	86
Isopimaric acid				3	0	84	1	17	<1	99
Pimaric acid				3	0	41	5	4	27	34
Oleic acid	1	5	1	3	0	290[c]	10	8	65	77
Linoleic acid				5	4	42[c]				
Linolenic acid				3	6	23[c]	1	17	<1	96
Xylenes				1	2	<1				

[a] Negligible removal.

[b] Negative removal.

[c] Oxidation influent.

NOTE: Blanks indicate no data available.

TABLE 16-23. WASTEPAPER MOLDED PRODUCTS SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Wastepaper molded products									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metal										
Chromium	2	0	2	3	0	9	3	0	3	67
Copper	2	0	27	3	0	16	3	0	4	75
Cyanide	6	0	10	3	0	9	3	0	9	-[a]
Lead	2	0	4	3	0	22	3	0	12	45
Mercury	2	0	3	3	0	<1	3	0	<1	-[a]
Nickel	2	0	6	3	0	23	3	0	3	87
Zinc	2	0	12	3	0	390	3	0	52	88
Phthalates										
Bis(2-ethylhexyl) phthalate	2	0	5	3	0	2	1	2	<1	50
Phenols										
Pentachlorophenol	1	1	2	1	2	2	1	2	2	
Phenol	1	1	2	3	0	8	1	2	<1	87
Monocyclic aromatics										
Benzene	1	1	2							
Toluene	1	1	<1							
Halogenated aliphatics										
Methylene chloride	1	1	<1	2	1	<1	1	2	<1	-[a]
Nonconventional pollutants										
Abietic acid				3	0	210				
Dehydroabietic acid	1	1	37	3	0	450	1	2	57	87
Isopimaric acid				3	0	48	3	0	94	-[b]
Pimaric acid				3	0	57				
Oleic acid				3	0	490	3	0	360	27
Linoleic acid				3	0	210	3	0	120	41
9,10-Epoxystearic acid				1	2	10	1	2	9	10

[a] Negligible removal.

[b] Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-24. WASTEPAPER CONSTRUCTION PRODUCTS SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Wastepaper construction products					
	Raw water			Discharge, POTW		
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L
Toxic pollutants						
Metals						
Chromium	5	0	24	9	0	81
Copper	5	0	40	9	0	140
Cyanide	13	0	21	9	0	350
Lead	6	0	38	9	0	260
Mercury	4	0	<1	9	0	<1
Nickel	5	0	29	9	0	40
Zinc	5	0	240	9	0	1,000
Phthalates						
Bis(2-ethylhexyl) phthalate	2	3	20	8	1	30
Butyl benzyl phthalate	1	4	2	3	6	3
Di-n-butyl phthalate	1	4	<1	7	2	16
Diethyl phthalate	1	4	<1	6	3	29
Phenols						
Pentachlorophenol	1	4	6	4	4	35
Phenol	1	4	17	8	1	100
Monocyclic aromatics						
Benzene				2	7	<1
Ethylbenzene	1	4	<1	2	7	1
Toluene	1	4	14	7	2	81
Polychlorinated biphenyls and related compounds						
Aroclor 1248				2	7	1
Aroclor 1254				2	7	<1
Halogenated aliphatics						
Chloroform	2	3	10	2	7	3
Dichlorobromomethane	1	4	6	1	8	2
Methylene chloride	2	3	<1	3	6	<1
Dibromochloromethane	1	4	2	1	8	<1
Tetrachloroethylene				1	8	<1
1,1,1-Trichloroethane	1	4	6	6	3	6
Trichloroethylene	1	4	<1	5	4	7
Trichlorofluoromethane				1	8	<1
Bromoform	1	4	14			
Nonconventional pollutants						
Abietic acid				8	1	4,200
Dehydroabietic acid	1	4	94	8	1	900
Isopimaric acid	1	4	42	8	1	960
Pimaric acid	1	4	14	8	1	470
Oleic acid	1	4	110	9	0	1,300
Linoleic acid	1	4	50	8	1	850
Xylenes	1	4	3	8	1	16

NOTE: Blanks indicate no data available.

TABLE 16-25. NONINTEGRATED FINE SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcagegory: Nonintegrated fine									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	<1	6	0	3	9	0	1	67
Copper	3	0	9	6	0	13	9	0	18	-[a]
Lead	3	0	6	6	0	3	9	0	6	-[a]
Mercury	2	0	<1	6	0	<1	9	0	<1	-[b]
Nickel	3	0	4	6	0	5	9	0	4	20
Zinc	3	0	26	6	0	55	9	0	51	7
Phthalates										
Bis(2-ethylhexyl) phthalate	1	2	1	3	3	3	7	2	290	-[a]
Phenols										
Phenol	1	2	<1	4	2	6	3	6	13	-[a]
Monocyclic aromatics										
Benzene	1	2	<1				2	7	<1	
Toluene	1	2	<1				3	6	<1	
Halogenated aliphatics										
Chloroform				3	3	6	6	3	3	50
1,2-Dichloroethane				1	5	<1	3	6	<1	-[b]
Methylene chloride				1	5	<1	4	5	2	-[a]
Nonconventional pollutants										
Abietic acid				4	2	210				
Dehydroabietic acid	1	2	3	6	0	440	7	2	52	88
Isopimaric acid				4	2	40				
Pimaric acid				3	3	12				
Oleic acid				2	4	19				
Linoleic acid				1	5	33				

[a]Negative removal.

[b]Negligible removal.

NOTE: Blanksindicate no data available.

Date: 6/23/80

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TABLE 16-26. NONINTEGRATED-TISSUE SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

Subcategory: Nonintegrated-tissue

Pollutant	Raw water			Aeration influent			Final effluent			Percent removal
	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	
Toxic pollutants										
Metals										
Chromium	1	1	<1	3	0	2	4	2	2	-[a]
Copper	1	1	4	3	0	19	4	2	15	21
Lead	1	1	<1	3	0	2	4	2	1	50
Mercury	2	0	<1	3	0	<1	6	0	<1	-[b]
Nickel	1	1	<1	3	0	2	4	2	2	-[a]
Zinc	2	0	32	3	0	53,000	6	0	56	99
Phthalates										
Bis(2-ethylhexyl) phthalate	2	0	18	3	0	30	5	1	15	50
Butyl benzyl phthalate				3	0	800[c]	1	5	3	99
Di-n-butyl phthalate				1	2	<1[c]				
Diethyl phthalate				1	2	12[c]				
Phenols										
Phenol	1	1	3	3	0	5	4	2	3	40
Monocyclic aromatics										
Ethylbenzene				3	0	13,000[c]	3	3	74	99
Toluene				3	0	130[c]	3	3	3	98
Halogenated aliphatics										
Chloroform				3	0	3[c]	3	3	2	33
Tetrachloroethylene							3	3	4	-[b]
Trichloroethylene				1	1	<1				
Nonconventional pollutants										
Abietic				3	0	53[c]				
Dehydroabietic acid				3	0	210[c]	3	3	49	77
Isopimaric acid				3	0	37[c]	1	5	<1	97
Pimaric acid				2	1	10[c]				
Oleic acid				3	0	13	4	2	27	-[b]
Xylenes				3	0	14,000	3	3	400	97

[a]Negligible removal.

[b]Negative removal.

[c]Flotation influent.

NOTE: Blanks indicate no data available.

TABLE 16-27. NONINTEGRATED-MISCELLANEOUS SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Nonintegrated-miscellaneous									
	Raw water			Clarification influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	3	0	2	9	0	13	8	1	2	85
Copper	3	0	6	9	0	46	10	1	8	83
Cyanide	1	0	9	3	0	9	3	0	9	-[a]
Lead	3	0	14	9	0	14	9	0	5	64
Mercury	3	0	<1	9	0	<1	9	0	<1	-[a]
Nickel	3	0	3	8	1	20	9	0	5	75
Zinc	3	0	16	9	0	540	9	0	140	75
Phthalates										
Bis(2-ethylhexyl) phthalate	3	0	6	9	0	26	8	1	6	62
Phenols										
Pentachlorophenol				2	7	24	1	8	8	67
Phenol	2	1	58	6	3	5	5	4	2	60
2,4,6-Trichlorophenol	1	2	<1	3	6	6	3	6	6	-[a]
Monocyclic aromatics										
Benzene	1	2	<1	2	7	<1	1	8	<1	-[a]
Ethylbenzene							2	7	4	-[b]
Toluene				1	8	<1	5	4	2	-[b]
Polychlorinated biphenyls and related compounds										
Aroclor 1254				1	6	1	1	6	<1	-[a]
Halogenated aliphatics										
Chloroform				3	6	3	3	6	1	67
1,1,1-Trichloroethane	1	2	4	6	3	7	6	3	4	43
Nonconventional pollutants										
Abietic acid				3	6	59				
Dehydroabietic acid	1	2	3	8	1	120	6	3	93	23
Isopimaric acid				3	6	28	1	8	2	93
Pimaric acid				2	7	11				
Linoleic acid	1	2	19	1	8	9				
Xylenes				3	6	3	3	6	49	-[b]

[a]Negligible removal.

[b]Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-28. NONINTEGRATED-LIGHTWEIGHT SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Nonintegrated-lightweight									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	1	0	2	2	1	2	2	1	2	-[a]
Copper	1	0	23	2	1	19	2	1	4	79
Cyanide	3	0	10	3	0	9	3	0	9	-[a]
Lead	1	0	4	2	1	6	2	1	<1	83
Mercury	1	0	<1	3	0	<1	3	0	<1	-[a]
Nickel	1	0	2	2	1	1	2	1	<1	-[a]
Zinc	1	0	5	3	0	16	2	1	4	75
Phthalates										
Bis(2-ethylhexyl) phthalate	1	0	4	3	0	5	3	0	7	-[b]
Di-n-butyl phthalate				1	2	<1	1	2	2	-[b]
Phenols										
Phenol	1	0	7	2	2	2	2	1	2	-[a]
Monocyclic aromatics										
Ethylbenzene				2	1	2	2	1	<1	50
Toluene				2	1	2	2	1	<1	50
Halogenated aliphatics										
Chloroform				3	0	27	3	0	3	89
Methylene chloride	1	0	2	1	2	<1	2	1	<1	-[a]
Nonconventional pollutants										
Xylenes			2	1	5					

[a]Negligible removal.

[b]Negative removal.

NOTE: Blanks indicate no data available.

TABLE 16-29. NONINTEGRATED-FILTER AND NONWOVEN SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATION [1]

	Subcategory: Nonintegrated-filter and nonwoven									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	1	1	<1	3	0	6	5	1	2	67
Copper	1	1	4	3	0	61	5	1	7	88
Cyanide	3	0	10	3	0	11	3	0	9	18
Lead	1	1	<1	3	0	4	5	1	3	25
Mercury	2	0	<1	3	0	<1	6	0	<1	-[a]
Nickel	1	1	<1	3	0	2	5	1	2	-[a]
Zinc	2	0	3	3	0	160	6	0	34	79
Phthalates										
Bis(2-ethylhexyl) phthalate	1	1	39	3	0	85	4	2	16	81
Phenols										
Phenol	1	1	2	3	0	65	3	3	6	91
Monocyclic aromatics										
Benzene	1	1	2				1	5	<1	
Ethylbenzene				1	2	<1				
Toluene				1	2	2				
Polychlorinated biphenyls and related compounds										
Aroclor 1254	1	1	<1	2	0	15[b]	1	4	<1	93
Nonconventional pollutants										
Dehydroabietic acid				2	1	33				
Linoleic acid							1	5	2	

[a]Negligible removal.

[b]Clarifier influent.

NOTE: Blanks indicate no data available.

TABLE 16-30. NONINTEGRATED-PAPERBOARD SUBCATEGORY - SUMMARY OF VERIFICATION DATA FOR TOXIC AND NONCONVENTIONAL POLLUTANT CONCENTRATIONS [1]

	Subcategory: Nonintegrated-paperboard									
	Raw water			Aeration influent			Final effluent			
Pollutant	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	No. of samples in which pollutant was detected	No. of samples in which pollutant was not detected	Average concentration of pollutant in all samples analyzed, µg/L	Percent removal
Toxic pollutants										
Metals										
Chromium	2	0	2	3	0	26	6	0	6	77
Copper	2	0	4	3	0	27	6	0	4	85
Cyanide	6	0	9	3	0	9	6	0	26	-[a]
Lead	2	0	2	3	0	2	6	0	9	-[a]
Mercury	2	0	<1	3	0	<1	6	0	<1	-[b]
Nickel	2	0	3	3	0	18	6	0	5	72
Zinc	2	0	15	3	0	1,300	6	0	72	94
Phthalates										
Bis(2-ethylhexyl) phthalate	1	1	42	3	0	7	3	3	2	71
Di-n-butyl phthalate				3	0	180				
Diethyl phthalate				1	2	4[c]	2	4	29	-[a]
Phenols										
Phenol				3	0	6	3	3	1	83
Monocyclic aromatics										
Benzene				1	2	<1	1	5	<1	-[b]
Ethylbenzene				3	0	3[c]	2	4	<1	67
Toluene				3	0	3[c]	4	2	<1	67
Halogenated aliphatics										
Methylene chloride	1	1	3	1	2	<1[b]				
Tetrachloroethylene				3	0	3				
Nonconventional pollutants										
Abietic acid				1	2	7				
Dehydroabietic acid				3	0	160	4	2	64	58
Isopimaric acid				3	0	8				
Pimaric acid				3	0	25[c]				
Oleic acid				3	0	260[c]				
Xylenes				3	0	8[c]	3	3	2	

[a] Negative removal.

[b] Negligible removal.

[c] Oxidation influent.

Note: Blanks indicate no data available.

TABLE 16-31. RAW WASTE LOADS FOR SELECTED MILLS [1]

Subcategory/subdivisions	Mill number	Production, Mg/d	Raw waste load: Flow, m^3/Mg	Raw waste load: Bod_5, kg/Mg	Raw waste load: TSS, kg/Mg
Alkaline-dissolving	032003		240	54	82
Alkaline-market					
Softwood mills	030018	490	180	39	48
Hardwood mills	030005	340	73	18	20
Mixed mills	030028	1,500	150	36	24
Alkaline-BCT	030004	870	190	58	42
Alkaline-fine					
High clay mills	030027	690	72	22	33
Low clay mills	030046	680	130	31	80
High softwood	030051	560	94	33	41
Mills making some groundwood	030045	870	150	65	130
High clay-high softwood	030020	380	120	26	78
High clay-high hardwood	030034	640	120		
Low clay-high hardwood	030060	460	160	39	100
Alkaline-unbleached					
Linerboard	010002	850	44	13	25
Packaging items	010048	360	220	33	23
Bag	010032	750	47	18	17
Semi-chemical					
Mills with liquor recovery	060004	450	49	28	55
Mills with no liquor recovery	020005	170	47	56	52
One third wastepaper	020001	270	19	24	8.1
Mills not representative of subcategory	020010	560	60	18	49
Alkaline-unbleached and semi-chemical	015003	1,620	50	19	29
Alkaline-newsprint	054003	940	94	12	56
Sulfite-dissolving	046403	420	360	280	15
Sulfite-papergrade	040017	370	120	97	37
Thermo-mechanical pulp	070001	140	79	18	39
Groundwood-CMN	054006	45	110	19	56
Groundwood-fine	052004	440	66	29	79
Deink-fine and tissue					
Mills utilizing mainly deink furnish	140021	140	78	10	3.5
Fine mills utilizing mixed furnish	140007	320	54	55	160
Tissue mills utilizing mixed furnish	140010	69	120	56	130
Wastepaper-tissue					
Industrial tissue mills	085006	42	140	38	100
Sanitary tissue mills	090010	150	77	19	59
Wastepaper-board					
Wastepaper-molded products	150006	40	46	10	19
Wastepaper-construction products					
Predominantly wastepaper furnish	120014	19	14	33	10
Furnish includes TMP	120012	210	7.4	13	5.1
Furnish includes other groundwood	120005	150	4.2	5.5	1.5
Other furnish	140065	54	8.9	3.9	6.5
Nonintegrated-fine	080046	300	61	14	32
Nonintegrated-tissue	090020	810	80	13	44
Nonintegrated-lightweight					
Electrical paper	105071	24	260	12	19
Misscellaneous tissue and carbonizing	090015	58	150	2.9	150
Printing and thin paper	150020	180	200	8.2	16
Carbonize, thin, cigarette	105013	18	135	20	57
Nonintegrated-filter and nonwoven	105050	11	170	4.9	20
Nonitegrated-paperboard	105073	14	110	13	42

NOTE: Blanks indicate no data available.

contained in mill effluents. Biological treatment systems are currently employed extensively by pulp, paper, and paperboard mills to reduce BOD_5 and TSS loads. A summary of treatment systems currently employed in the pulp, paper and paperboard industry is shown in Table 16-32. As noted, aerated stabilization is the most common treatment process employed at mills discharging directly to a receiving water. Primary treatment only is employed at a relatively large number of plants in the nonintegrated and secondary fiber subcategories. Primary treatment can often achieve substantial BOD_5 reductions, if BOD_5 is predominantly contained in suspended solids.

The mills with treatment systems exhibiting the greatest percent BOD_5 and TSS removals are shown in Table 16-33 for each subcategory. BOD_5 removals for these mills range from 70% to 99% with effluent concentrations between 9 and 235 mg/L. Activated sludge is employed at 9 of the 18 mills.

II.16.4.1 Primary and Preliminary Treatment

Often primary treatment is necessary to remove suspended organic and inorganic materials that may damage or clog downstream treatment equipment. This can be accomplished by sedimentation, flotation or filtration. Sedimentation can involve mechanical clarifiers, flotation units, or sedimentation lagoons. Mechanical clarification is the most common technology for removing suspended solids.

II.16.4.1.1 Dissolved Air Flotation

Dissolved air flotation (DAF) units also have been applied to effluents from paper mills and have, in some cases, effectively removed suspended solids. DAF units are somewhat limited because of their inability to handle high pollutant concentrations and shock loads.

II.16.4.1.2 Primary Clarification

Because of the biodegradable nature of a portion of the settleable solids present in pulp, paper and paperboard wastewaters, clarification results in some BOD_5 reduction. Typical BOD_5 removals through primary clarification in integrated pulp and paper mills varies between 10% and 30%. The exact BOD_5 removal depends on the relative amount of soluble BOD_5 present in the raw wastewater. Primary clarification can result in significantly higher BOD_5 reductions at nonintegrated mills than at integrated mills. Responses to the data request program indicate that roughly 50% of the raw wastewater BOD_5 is commonly removed at nonintegrated mills through primary clarification.

TABLE 16-32. SUMMARY OF METHOD OF DISCHARGE AND INPLACE TECHNOLOGY [1]

Subcategory	No. of mills	Method of discharge: Direct	Method of discharge: Indirect	Method of discharge: Self contained	Treatment scheme - Direct discharge: No external treatment	Primary only	Aerated lagoon	Lagoon w/ polishing pond	Activated sludge	Trickling filter	Other
Alkaline-dissolving	3	3					2		1		
Alkaline-market	9	9			2		4	1	1		1
Alkaline-BCT	8	8					3	4			1
Alkaline-fine	18	14	4				2	2	5		5
Alkaline-unbleached	29	28	1			2	9	5	4	1	7
Semi-chemical	19	17	2		2	1	1	6	3		4
Alkaline-unbleached and Semi-chemical	10	9	1				7		1		1
Alkaline-newsprint	3	3						1	1		1
Sulfite-dissolving	6	6				3	1		1		1
Sulfite-papergrade	18	17	1		2	6	3		1		5
Thermo-mechanical pulp	2	2				1			1		
Groundwood-CMN	6	5	1			1			1		3
Groundwood-fine	8	7	1		1	1			3		2
Deink-fine and tissue	17	10	5	2	1		2		7		
Deink-newsprint	3		3								
Wastepaper-tissue	22	11	3	8	2	4	2		1		2
Wastepaper-board	147	45	84	18	3	8	21		4		9
Wastepaper-molded products	15	2	11	2		1	1				
Wastepaper-construction products	58	4	36	18	1	1		2			
Nonintegrated-fine	39	18	19	2	3	6	3	1	2		3
Nonintegrated-tissue	26	14	12		1	10	2				1
Nonintegrated-lightweight	18	14	4			6	1			1	6
Nonintegrated-filter and nonwoven	16	6	10			3	1		1		1
Nonintegrated-paperboard	12	5	7			3	2				
Subtotal	512	257	205	50	18	57	67	21	40	2	53
Miscellaneous mills[a]	132	102	25	5	4	23	22	10	19	2	21
Total	644	359	230	55	22	80	89	31	59	4	74

[a]Miscellaneous mills not included in subcategorization.

Note: Data for 1976 calendar year.

TABLE 16-33. MILLS REPORTING BEST PERCENT REMOVAL OF BOD_5 AND TSS BY SUBCATEGORY [1]

Subcategory	Production		Final effluent average day: Flow		BOD_5			TSS			Treatment type[a]	Percent reduction	
	Mg/d	(tons/d)	M^3/Mg	(kgal/t)	kg/Mg	(lb/ton)	(mg/L)	kg/Mg	(lb/ton)	(mg/L)		BOD_5	TSS
Alkaline-dissolving	1,040	(1,150)	240	(57)	7.5	(15)	34	15	(29)	61	ASB	86	82
Alkaline-market	660	(722)	170	(41)	2.7	(5.4)	16	3.1	(6.1)	18	ASB w/Hold.	94	88
Alkaline-BCT	280	(310)	190	(45)	2.1	(4.2)	11	3.9	(7.7)	21	ASB	94	91
Alkaline-fine	690	(760)	70	(17)	0.6	(1.2)	9	1.9	(3.9)	30	Act. Sl.	97	94
Alkaline-unbleached	970	(1,070)	48	(12)	0.7	(1.5)	16	1.7	(3.3)	34	ASB	94	99
Semi-chemical	440	(490)	34	(8.1)	1.3	(2.5)	38	1.5	(2.9)	43	Act. Sl.	95	97
Alkaline-unbleached and semi-chemical	1,540	(1,700)	52	(12)	2.0	(4.1)	40	3.5	(6.9)	67	Act. Sl.	87	86
Alkaline-newsprint	1,420	(1,560)	98	(24)	2.3	(4.6)	23	2.4	(4.7)	24	ASB	91	95
Sulfite-dissolving	350	(390)	170	(42)	41	(82)	240	11	(22)	64	ASB	71	92
Sulfite-papergrade	450	(490)	93	(22)	5.1	(10)	60	7.5	(15)	80	Act. Sl.	87	92
Thermo-mechanical pulp	140	(160)	81	(20)	5.6	(11)	68	29	(59)	360	Act. Sl.	71	29
Groundwood-CMN	890	(980)	120	(28)	6.4	(13)	54	4.5	(9)	38	Act. Sl.	70	90
Groundwood-fine	710	(790)	58	(14)	0.5	(1.0)	9	2.0	(3.9)	34	Act. Sl.	95	96
Deink-fine and tissue	770	(840)	90	(22)	3.5	(6.9)	38	6.3	(12)	69	Act. Sl.	95	97
Wastepaper-tissue	150	(160)	88	(21)	1.3	(2.6)	15	0.4	(0.8)	5	Act. Sl.	93	99
Wastepaper-board	290	(320)	5.8	(1.4)	0.1	(0.1)	11	0.3	(0.5)	41	ASB	99	98
Nonintegrated-fine	370	(411)	110	(26)	1.8	(3.5)	16	2.7	(5.4)	25	ASB w/Hold.	88	94
Nonintegrated-tissue	180	(190)	68	(16)	2.1	(4.2)	31	0.6	(1.1)	9	No Sec. Trtmt	86	99
Nonintegrated-lightweight	58	(64)	220	(54)	8.1	(16)	36	2.4	(4.7)	10	Trick. Filter	86	98
Nonintegrated-filter and nonwoven	39	(43)	290	(69)	2.1	(4.1)	7	3.1	(6.2)	11	ASB	87	92

[a]ASB: aerated stabilization basin; Hold.: holding pond; Act. Sl.: activated sludge; Sec. Trtmt: secondary treatment; Trick. Filter: trickling filter.

NOTE: Data represents 1976 calendar year.

II.16.4.2 Biological Treatment

Currently, the most common types of biological treatment used in the pulp, paper and paperboard industry include oxidation basins, aerated stabilization basins, and the activated sludge process or its modifications. Other biological systems include oxygen activated sludge, the Zurn/Attisholz process, rotating biological contactors, and anaerobic contact filters.

II.16.4.2.1 Oxidation Basins

Oxidation basins were the first type of biological treatment systems used in the pulp, paper and paperboard industry. Typical design BOD_5 loads range from 56 to 67 kilograms per hectare (kg/ha) of surface area/day (50 to 60 lb/acre/day). Retention times can vary from 20 to over 60 days. Literature presenting data on the removal of toxic and nonconventional pollutants through application of oxidation basin technology is limited.

II.16.4.2.2 Aerated Stabilization Basins

The aerated stabilization basin (ASB) evolved from the necessity of increasing performance of existing oxidation basins due to increasing effluent flows and/or more stringent water quality standards. The removal efficiency of an ASB treating unbleached kraft waste was evaluated over a 1-month period in late 1976. Although the raw wastewater exhibited an LC-50 of 1% and 2% by volume, all but one of the 26 treated effluent samples either were nontoxic or exhibited greater than 50% fish survival after 96 hours of exposure. The one failure was attributed to a black liquor spill at the mill. Average reductions of 87% BOD_5, 90% toxicity and 96% total resin acids were achieved.

Pilot-scale ASB treatment of bleached kraft wastewater was evaluated over a 5-month period. Two basins, one with a 5-day and one with a 3-day hydraulic detention time, were studied with and without surge equalization. The raw wastewater BOD_5 varied from 108 mg/L to 509 mg/L and was consistently toxic. The median survival times (MST) of fish ranged from 7 to 1,440 minutes. Mean BOD_5 removals with surge equalization were 85% for the 5-day basin and 77% for the 3-day basin. Mean effluent BOD_5 levels with surge equalization were 40 mg/L for the 5-day basin and 59 mg/L for the 3-day basin. Mean reported effluent BOD_5 values for the 5-day and 3-day basins without equalization were 51 mg/L and 67 mg/L, respectively.

II.16.4.2.3 Activated Sludge Processes

The activated sludge process is a high-rate biological wastewater treatment system. The ability of activated sludge basins to detoxify bleached kraft mill effluents was analyzed over a 5-month period. Two pilot-scale activated sludge systems (8-hour and 24-hour detention times) were operated with and without surge equalization. Raw wastewater BOD_5 varied from 108 to 509 mg/L. Mean BOD_5 removals for the 8-hour and 24-hour activated sludge lagoon with a 12-hour surge equalization basin achieved an average of 76% and 72% BOD_5 removal, respectively. Effluent BOD_5 concentration for the 24-hour system ranged from 5 mg/L to 263 mg/L with a mean of 64 mg/L. The 8-hour activated sludge system removed an average of 72% of the BOD_5. Final effluent BOD_5 concentrations ranged from 14 to 270 mg/L, with a mean of 64 mg/L.

The pure oxygen activated sludge process uses oxygen, rather than air, to stimulate biological activity. Field test data by Union Carbide Corp. confirms that the oxygen activated sludge process is capable of achieving final effluent BOD_5 concentrations on the order of 20 to 30 mg/L with pulp, paper, and paperboard mill wastes. Effluent TSS after clarification was generally in the range of 40 to 60 mg/L. A summary of pilot-scale information is presented in Table 16-34.

TABLE 16-34. OXYGEN ACTIVATED SLUDGE TREATABILITY PILOT SCALE [1]

Production process	Retention, hrs	BOD_5, mg/L		TSS, mg/L	
		Influent	Effluent	Influent	Effluent
Alkaline-unbleached	1.3 - 2.2	280 - 460	20 - 41	57 - 86	46 - 61
Alkaline-unbleached	1.8 - 3.0	210 - 210	16 - 22	120 - 120	36 - 36
Alkaline-unbleached	2.0 - 2.9	265 - 300	25 - 30	95 - 120	60 - 70

Sulfite/newsprint effluent was treated using an oxygen activated sludge pilot-plant facility over an 11-month period. BOD_5 reductions during this time were over 90%. Final BOD_5 and TSS concentrations ranged from 23 to 42 mg/L and 61 to 111 mg/L, respectively.

Zurn/Attisholz System. Seven full-scale Zurn/Attisholz (Z/A) systems are currently in use at pulp and paper mills in the United States. These installations treat wastewaters from the following types of manufacturing:

Deink-fine and tissue	(5 mills)
Sulfite-papergrade	(1 mill)
Integrated-miscellaneous	(1 mill)

Most of these mills reportedly maintain final effluent BOD_5 and TSS concentrations in the range of 20 to 25 mg/L each. One mill reportedly achieves BOD_5 and TSS levels in the range of 5 to 10 mg/L each. Another mill also attained a 96% BOD_5 and 99% TSS reduction using the Z/A process.

A pilot study comparing a two-stage to a single-stage activated sludge system has recently been performed. The two-stage system achieved a higher toxicity reduction in treating bleached kraft wastewater than did a single-stage system.

Rotating Biological Contactor (RBC). This system involves a series of discs on a shaft supported above a basin containing wastewater. Pilot-scale evaluations of the RBC system treating bleached kraft wastewater with an average influent BOD_5 content of 235 mg/L have resulted in substantial BOD_5 reductions.

II.16.4.3 Chemically Assisted Clarification

Recent experience with full-scale alum-assisted clarification of biologically treated kraft mill effluent suggests that with proper pH adjustment, final effluent qualities of 15 mg/L each of BOD_5 and TSS can be achieved. The desired alum dosage to attain these levels would be between 100 and 150 mg/L. A significantly lower alum dosage could provide insufficient floc formation, while a higher dosage would result in proportionately high levels of chemical solids and sludge quantities that must be removed and disposed.

As part of an EPA-sponsored study, biologically treated effluent from an alkaline kraft mill was evaluated with alum precipitation on a laboratory scale. Existing full-scale treatment consisted of a primary clarifier, aerated stabilization basin and polishing pond. Twenty-four hour composite samples of the polishing pond effluent were taken on three separate days. The samples were adjusted to pH 4.6 with alum and four drops of polymer per liter of sample were added. The results are summarized in Table 16-35.

TABLE 16-35. LABORATORY EVALUATION OF ALUM PRECIPITATION ON ALKALINE KRAFT MILL POLISHING POND EFFLUENT [1]

	Concentration range, mg/L	
	Polishing pond effluent	Alum-treated effluent
Total resin and fatty acids	2.8 - 3.8	ND
Total chlorinated derivatives	0.43 - 0.45	ND - 0.04
Chloroform	0.025 - 0.032	0.018 - 0.022
BOD_5	43. - 51.	0. - 14.

ND - Not detected.

In a recent EPA-sponsored laboratory study, alum, ferric chloride and lime in combination with five polymers were evaluated in further treatment of biological effluent from four pulp and paper mills. Of the three chemical coagulants, alum provided the most consistent flocculation at minimum dosages; lime was the least effective of the three. The optimum alum dose was determined for four of the effluents and ranged between 40 and 180 mg/L at a constant dosage of 2 mg/L polymer.

II.16.4.4 Filtration

Filtration is an available technology for application in treating pulp, paper, and paperboard wastewaters. If properly designed and operated, filtration can yield significant solids removal. Table 16-36 shows the results of a study evaluating the efficiency of sand filtration on four pulp and paper mill effluents.

TABLE 16-36. SAND FILTRATION RESULTS [1]

Mill No.	Initial TSS, mg/L	TSS removal, percent w/chemical addition	TSS removal, percent w/o chemical addition
1	110	64	14
2	5.5		36
3	70	71	68
5	60		23

I.16.4.5 Activated Carbon Adsorption

Researchers have indicated that pulp and paper mill wastewater suitable for reuse can be obtained using granular carbon without a biological oxidation step, particularly if the raw waste exhibits a BOD_5 of 200 to 300 mg/L. Color due to refractory organic compounds contained in pulping effluents can also be reduced by such treatment. Table 16-37 presents the pilot-plant results obtained by the authors.

Extensive pilot-plant tests for treating unbleached kraft mill wastewater with granular and fine activated carbon (AC) (the fine activated carbon system is subject to a patent application) have been run. The 113 L/min (30 gpm) pilot plant utilized four different treatment processes, as follows:

1. Clarification followed by downflow granular carbon activated columns;
2. Lime treatment and clarification followed by granular activated carbon columns;
3. Biological oxidation and clarification followed by granular activated carbon columns; and
4. Lime treatment and clarification followed by fine activated carbon effluent treatment (subject of a patent application).

Table 16-38 presents the results of the pilot-plant investigation.

TABLE 16-37. RESULTS OF GRANULAR ACTIVATED CARBON COLUMN PILOT-PLANT TREATING UNBLEACHED DRAFT MILL WASTE [1]

Property[a]	AC columns preceded by lime precipitation and biological oxidation[a]			AC columns preceded by lime precipitation[a]					
				Run 1			Run 2		
	Influent	Effluent	Removal, percent	Influent	Effluent	Removal, percent	Influent	Effluent	Removal, percent
BOD_5, mg/L	48	23	52	100	32	69	82	12	85
COD, mg/L	-	-	-	-	-	-	320	200	35
SS, mg/L	-	-	-	-	-	-	120	74	36
Turbidity, JTU	-	-	-	-	-	-	35	35	0
Color, Pt-Co units	-	-	-	-	-	-	28	0	100
Odor	365	13	96	185	23	88	-	-	-
pH, pH units	-	-	-	-	-	-	12	10	12
TSS, mg/L	-	-	-	-	-	-	1,280	1,200	6

[a]Columns loaded at 3.6-4.0 gpm/ft².

Note: Dashes indicate no data available.

TABLE 16-38. RESULTS OF ACTIVATED CARBON PILOT PLANTS TREATING UNBLEACHED KRAFT MILL EFFLUENT [1]

Description of carbon process	AC columns preceded by biological oxidation and clarification			AC columns preceded by primary clarification			AC columns preceded by primary clarification			AC columns preceded by lime treatment and clarification			FACET system[a]		
	Influent	Effluent	Removal, percent	Influent	Effluent	Removal, percent	Influent	Effluent	Removal, percent	Influent	Effluent	Removal, percent	Influent	Effluent	Removal, percent
Hydraulic load, gpm/ft²	2.13			1.42			0.71			1.42			NA		
Carbon	Granular			Granular			Granular			Granular			Intermediate		
Contact time, min.	140									108					
Parameters															
BOD, mg/L												26			
TOC, mg/L	150	57	61	220	83	62	310	120	61	180	100	44	160	100	36
Color, units	740	210	71	920	180	80	1,160	200	83	250	76	70	160	73[b]	
Fresh carbon dosage															
kg/m³	1.0			2.5			3.5			0.3			0.5		
(lb carbon/ 1,000 gal)	(8)			(20)			(28)			(2.5)			(3.9)		

[a]Fine activated carbon effluent treatment.

[b]Filtered.

Note: Blanks indicate no data available.

II.16.5 REFERENCES

1. Preliminary Data Base for Review of BATEA Effluent Limitations Guidelines, NSPS, and Pretreatment Standards for the Pulp, Paper, and Paperboard Point Source Category. Prepared for USEPA by E. C. Jordan, Co., Inc., Portland, Maine 04112. Contract No. 68-01-4624, June 1979.

2. NRDC Consent Decree Industry Summary - Pulp, Paper, and Paperboard Industry.

3. Environmental Protection Agency Effluent Guidelines and Standards for Pulp, Paper and Paperboard (40 CFR 430; FR 18742, May 12, 1974; Amended as shown in Volume 40 Code of Federal Regulations, Revised as of July 1, 1976; 41 FR 27732, July 6, 1976; 42 FR 1398; January 6, 1977).

II.17 RUBBER PROCESSING

II.17.1 INDUSTRY DESCRIPTION [1]

II.17.1.1 General Description

The Rubber Processing Industry in the United States is covered by seven SIC codes. They are:

- SIC 2822: Synthetic Rubber Manufacturing (Vulcanizable Elastomers)
- SIC 3011: Tire and Inner Tube Manufacturing
- SIC 3021: Rubber Footwear
- SIC 3031: Reclaimed Rubber
- SIC 3041: Rubber Hose and Belting
- SIC 3069: Fabricated Rubber Products, Not Elsewhere Classified
- SIC 3293: Rubber Gaskets, Packing and Sealing Devices

This industry includes a wide variety of production activities ranging from polymerization reactions closely aligned with the chemical processing industry to the extrusion of automotive window sealing strips. There are approximately 1,650 plants in this industry divided into the 11 subcategories described below. Plant production ranges from 1.6×10^3 Mg/yr (3.6×10^6 lb/yr) to 3.7×10^5 Mg/yr (8.2×10^8 lb/yr).

Table 17-1 presents a summary of the Rubber Processing Industry regarding the number of subcategories and the number and types of discharges. Table 17-2 presents a subcategory profile of BPT regulations (daily maximum and 30-day averages).

TABLE 17-1. INDUSTRY SUMMARY [1, 2]

Industry: Rubber Processing
Total Number of Subcategories: 11
Number of Subcategories Studied: 3[a]

Number of Dischargers in Industry:

- Direct: 1,054
- Indirect: 504
- Zero: 100

[a]Wet digestion, although not a Paragraph 8 exclusion, was not studied due to the lack of plant specific data. Emulsion and solution crumb rubber, although candidates for exclusion, were studied, because of data availability.

TABLE 17-2. BPT LIMITATIONS FOR SUBCATEGORIES OF RUBBER PROCESSING INDUSTRY [3] (kg/Mg)

pH limitation, all subcategories: 6 to 9

Pollutant	Tire and inner tube plants[a]		Emulsion crumb rubber		Solution crumb rubber		Latex rubber		Small GMEF[b]		Medium GMEF[b]	
	Daily max	30-Day av	Daily max	30-Day av	Daily max	30-Day av	Daily max	30-Day av	Daily max	30-Day av	Daily max	30-Day av
COD			12.0	8.0	5.91	3.94	10.27	6.85				
BOD_5			0.60	0.40	0.60	0.40	0.51	0.34				
TSS	0.096	0.064	0.98	0.65	0.98	0.65	0.82	0.55	1.28	0.64	0.80	0.40
Oil and grease	0.0024	0.016	0.24	0.16	0.24	0.16	0.21	0.14	0.70	0.25	0.42	0.15
Zinc												

Pollutant	Large GMEF[b]		Wet digestion reclaimed		Pan, dry digestion, mechanical reclaimed		LDEM[c]		Latex foam	
COD			14.7	6.11						
BOD_5							3.72	2.2	2.4	1.4
TSS	0.50	0.25	1.04	0.52	0.384	0.192	6.96	2.9	2.26	0.94
Oil and grease	0.26	0.093	0.40	0.144	0.40	0.144	2.0	0.73		
Zinc									0.058	0.024

[a]Oil and grease limitations for nonprocess wastewater from plants placed in operation before 1959: daily max, 10 mg/L; 30-day av, 5 mg/L.

[b]General molded, extruded, and fabricated rubber.

[c]Latex-dipped, latex-extruded, and latex-molded goods.

Note: Blanks indicate data not available

II.17.1.2 Subcategory Descriptions

The Rubber Processing Industry is divided into 11 subcategories based on raw waste loads as a function of production levels, presence of the same or similar toxic pollutants resulting from similar manufacturing operations, the nature of the wastewater discharges, frequency and volume of discharges, and whether the discharge is composed of contact or noncontact wastewaster. Other primary considerations are treatment facilities and plant size, age, and location. The 11 subcategories are listed below. A brief description of each subcategory follows.

Subcategory 1:	Tire and Inner Tube Manufacturing
Subcategory 2:	Emulsion Crumb Rubber Production
Subcategory 3:	Solution Crumb Rubber Production
Subcategory 4:	Latex Rubber Production
Subcategory 5:	Small-Sized General Molding, Extruding, and Fabricating Rubber Plants
Subcategory 6:	Medium-Sized General Molding, Extruding, and Fabricating Rubber Plants
Subcategory 7:	Large-Sized General Molding, Extruding, and Fabricating Rubber Plants
Subcategory 8:	Wet Digestion Reclaimed Rubber
Subcategory 9:	Pan, Dry Digestion, and Mechanical Reclaimed Rubber
Subcategory 10:	Latex-Dipped, Latex-Extruded, and Latex-Molded Goods
Subcategory 11:	Latex Foam.

Subcategory 1 - Tire and Inner Tube Manufacturing

The production of tires and inner tubes involves three general steps: mixing and preliminary forming of the raw materials, formation of individual parts of the product, and constructing and curing the final product. Seventy-three plants use these general steps to produce tires in the United States.

The initial step in tire construction is the preparation or compounding of the raw materials. The basic raw materials for the tire industry include synthetic and natural rubber, reinforcing agents, fillers, extenders, antitack agents, curing and accelerator agents, antioxidants, and pigments. The fillers, extender, and reinforcing agents, pigments, and antioxidant agents are added and mixed into the raw rubber stock. This stock is nonreactive and can be stored for later use. When curing and accelerator agents are added the mixer becomes reactive, which means it has a short shelf life and must be used immediately.

After compounding, the stock is sheeted out in a roller mill and extruded into sheets or pelletized. This new rubber stock is tacky and must be coated with an antitack solution, usually a soapstone solution or clay slurry, to prevent the sheets or pellets from sticking together during storage.

The rubber stock, once compounded and mixed, must be molded or transformed into the form of one of the final parts of the tire. This consists of several parallel process by which the sheeted rubber and other raw materials, such as cord and fabric, are made into the following basic tire components: tire beads, tire treads, tire cords, and the tire belts (fabric). Tire beads are coated wires inserted in the pneumatic tire at the point where the tire meets the steel wheel rim (on which it is mounted); they insure a seal between the rim and the tire. The tire treads are the part of the tire that meets the road surface; their design and composition depend on the use of the tire. Tire cords are woven synthetic fabrics (rayon, nylon, polyester) impregnated with rubber; they are the body of the tire and supply it with most of its strength. Tire belts stabilize the tires and prevent the lateral scrubbing or wiping action that causes tread wear.

The processes used to produce the individual tire components usually involve similar steps. First the raw stock is heated and subjected to a final mixing stage before going to a roller mill. The material is then peeled off rollers and continuously extruded into the final component shape. Tire beads are directly extruded onto the reinforcing wire used for the seal, and tire belt is produced by calendering rubber sheet onto the belt fabric.

The various components of the tire are fitted together in a mold to build green, or uncured, tires which are then cured in an automatic press. Curing times range from less than one hour for passenger car tires to 24 hours for large, off-the-road tires. After curing, the excess rubber on the tire is ground off (deflashed) to produce the final product.

This subcategory is often subdivided into two groups of plants: (1) those starting operations prior to 1959, and (2) those starting operations after 1959. (Thirty-nine plants were in operation prior to 1959.) The subdivision must be recognized in applying limitations on plant effluents of oil and grease because its BPT limitations are different for the two groups of plants. For plants placed in operation after 1959, the 30-day average oil and grease limitation is 0.016 kg/Mg of product. For plants placed in operation prior to 1959, the limitation is the same (0.016 kg/Mg) but only for process wastewater. Process wastewater for these pre-1959 plants comes from soapstone solution applications, steam cleaning operations, air pollution control equipment, unroofed process oil unloading areas, mold cleaning operations, latex applications, and air compressor receivers. Water used only for tread cooling and discharges from other areas of such plants is classified as non-process wastewater, in which oil and grease levels are limited to 5 mg/L as a 30-day average and 10 mg/L as a maximum for a single day.

Subcategory 2 - Emulsion Crumb Rubber Production

Emulsion polymerization, the traditional process for synthetic rubber production, is the bulk polymerization of droplets of monomers suspended in water. Emulsion polymerization is operated with sufficient emulsifier to maintain a stable emulsion and is usually initiated by agents that produce free radicals. This process is used because of the high conversion and the high molecular weights that are possible. Other advantages include a high rate of heat transfer through the aqueous phase, easy removal of unreacted monomers, and high fluidity at high concentrations of product polymer. Over 90% of styrene butadiene rubber (SBR) is produced by this method. Approximately 17 plants use the emulsion crumb rubber process.

Raw materials for this process include styrene, butadiene, catalyst, activator, modifier, and soap solution.

Polymerization proceeds stepwise through a train of reactors. This reactor system contributes significantly to the high degree of flexibility of the overall plant in producing different grades of rubber. The reactor train is capable of producing either "cold" (277 K to 280 K, 103 kPa to 206 kPa) or "hot" (323 K, 380 kPa to 517 kPa) rubber. The cold SBR polymers, produced at the lower temperature and stopped at 60% conversion, have improved properties when compared to hot SBR's. The hot process is the older of the two. For cold polymerization, the monomer-additive emulsion is cooled prior to entering the reactors. Each reactor has its own set of cooling coils and is agitated by a mixer. The residence time in each reactor is approximately one hour. Any reactor in the train can be bypassed. The overall polymerization reaction is ordinarily carried to no greater than 60% conversion of monomer to rubber since the rate of reaction falls off beyond this point and product quality begins to deteriorate. The product rubber is formed in the milky white emulsion phase of the reaction mixture called latex. Short stop solution is added to the latex exiting the reactors to quench the polymerization at the desired conversion. The quenched latex is held in blowdown tanks prior to the stripping operation.

The stripping operation removes the excess butadiene by vacuum stripping, then removes the excess styrene and water in a perforated plate stripping column. The water and styrene from the styrene stripper are separated by decanting and the water is discharged to the treatment facility. The recovered monomers are recycled to the monomer feed stage. The latex is now stabilized and is precipitated by an electrolyte and a dilute acid. This coagulation imparts different physical characteristics to the rubber depending on the type of coagulants used. Carbon black and oil can be added during this coagulation/precipitation step to improve the properties of the rubber. This coagulated crumb is separated from the liquor, resuspended and washed with water, then dewatered, dried, and pressed into bales for shipment. The underflow from the washing is sent to the wastewater treatment facility.

<u>Subcategory 3 - Solution Crumb Rubber Production</u>

Solution polymerization is bulk polymerization in which excess monomer serves as the solvent. Solution polymerization, used at approximately 13 plants, is a newer, less conventional process than emulsion polymerization for the commercial production of crumb rubber. Polymerization generally proceeds by ionic mechanisms. This sytem permits the use of stereospecific catalysts of the Ziegler-Natta or alkyl lithium types which make it possible to polymerize monomers into a *cis* structure characteristic which is very similar to that of natural rubber. This *cis* structure yields a rubbery product as opposed to a *trans* structure which produces a rigid product that is similar to plastics.

The production of synthetic rubbers by solution polymerization processes is a stepwise operation very similar in many aspects to production by emulsion polymerization. There are distinct differences in the two technologies, however. For solution polymerization the monomers must be extremely pure and the solvent should be completely anhydrous. In contrast to emulsion polymerization, where the monomer conversion is taken to approximately 60%, solution polymerization systems are polymerized to conversion levels typically in excess of 90%. The polymerization reaction is also more rapid, usually complete in 1 to 2 hours.

Fresh monomers often have inhibitors added to them while in storage to prevent premature polymerization. These inhibitors and any water that is present in the raw materials must be removed by caustic scrubbers and fractionating drying columns to provide the solution process with the high purity and anhydrous materials needed. The purified solvent and monomers are then blended into what is termed the "mixed feed," which may be further dried in a desiccant column.

The dried mixed feed is now ready for the polymerization step, and catalysts can be added to the solution (solvent plus monomers) just prior to the polymerization stage or in the lead polymerization reactor.

The blend of solution and catalysts is polymerized in a series of reactors. The reaction is highly exothermic and heat is removed continuously by either an ammonia refrigerant or by chilled brine or glycol solutions. The reactors are similar in both design and operation to those used in emulsion polymerization. The mixture leaves the reactor train as a rubber cement, i.e., polymeric rubber solids dissolved in solvent. A short stop solution is added to the cement after the desired conversion is reached.

The rubber cement is then sent to storage tanks where antioxidants and extenders are mixed in. The rubber cement is pumped from the storage tank to the coagulator where the rubber is precipitated with hot water under violent agitation. The solvent and unreacted monomer are steam stripped overhead, then they are condensed, decanted, and recycled to the feed stage. The bottom water layer is discharged to the wastewaster treatment facility.

The stripped crumb slurry is further washed with water, then dewatered, dried, and baled as final product. Part of the water from this final washing is recycled to the coagulation stage, and the remainder is discharged for treatment.

Subcategory 4 - Latex Rubber Production

The emulsion polymerization process is used by 17 production facilities to produce latex rubber products as well as solid crumb rubber. Latex production follows the same processing steps as emulsion crumb rubber production up to the finishing process. Between 5% and 10% of emulsion polymerized SBR and nearly 30% of nitrile rubber production (NBR) are sold as latex. Latex rubber is used to manufacture dipped goods, paper coatings, paints, carpet backing, and many other commodities.

Monomer conversion efficiencies for latex production range from 60% for low temperature polymerization to 98% for high temperature conversion.

The monomers are piped from the tank farm to the caustic soda scrubbers where the inhibitors are removed. Soap solution, catalysts, and modifiers are added to produce a feed emulsion which is fed to the reactor train. Fewer reactors are normally used than the number required for a crumb product line. When polymerization is complete, the latex is sent to a holding tank where stabilizers are added.

A vacuum stripper removes any unwanted butadiene, and the steam stripper following it removes the excess styrene. Neither the styrene nor butadiene is recycled. Solids are removed from the latex by filters, and the latex may be concentrated to a higher solids level.

Subcategories 5, 6, 7 - Small -, Medium-, and Large-Sized General Molding, Extruding, and Fabricating Plants

These three closely related subcategories are divided based on the volume of wastewater emanating from each. These subcategories include a variety of processes such as compression molding, transfer molding, injection molding, extrusion, and calendering. An estimated 1,385 plants participate in these subcategories.

A common step for all of the above processes is the compounding and mixing of the elastomers and compounding ingredients. The mixing operation is required to obtain a thorough and uniform dispersion of the rubber and other ingredients. Wastewater sources from the mixing operation generally derive from leakage of oil and grease from the mixers.

Compression molding is one of the oldest and most commonly used manufacturing processes in the rubber fabrication industry. General steps for the processes include warming the raw materials, preforming the warm stock into the approximate shape, cooling and treating with antitack solution, molding by heat and pressure, and finally deflashing (removing excess rubber). Major products from this process include automotive parts, medical supplies, and rubber heels and soles.

Transfer molding involves the forced shifting of the uncured rubber stock from one part of the mold to another. The prepared rubber stock is placed in a transfer cavity where a ram forces the material into a heated mold. The applied force combined with the heat from the mold softens the rubber and allows it to flow freely into the entire mold. The molded item is cured, then removed and deflashed. Final products include V-belts, tool handles, and bushings with metal inserts.

Injection molding is a sophisticated, continuous, and essentially automatic process that uses molds mounted on a revolving turret. The turret moves the molds through a cyclic process that includes rubber injection, curing, release agent treatment and removal. Deflashing occurs after the product has been removed. A wide range of products are made by this process, including automative parts, diaphragms, hot-water bottles, and wheelbarrow tires.

Extrusion forces unvulcanized rubber through a die to give long lengths of rubber of a definite cross section. There are two general subdivisions of this technique; one extrudes simple products, and the other builds products by extruding the rubber onto metal or fabric reinforcement. Products from these techniques include tire tread, cable coating, and rubber hose.

Calendering involves passing unformed or extruded rubber through a set or sets of rolls to form sheets or rolls of rubber product. The thickness of the material is controlled by the space between the rolls. The calendar may also produce patterns, double the product thickness by combining sheets, or add a sheet of rubber to a textile material. The temperature of the calender rolls is controlled by water and steam. Products produced by this process include hospital sheeting and sheet stock for other product fabrication.

Subcategory 8 - Wet Digestion Reclaimed Rubber

This subcategory represents a process that is used to recover rubber from fiber-bearing scrap. Scrap rubber, water, reclaiming and defibering agents, and plasticizers are placed in a steam-jacketed, agitator-equipped autoclave. Reclaiming agents used to speed up depolymerization include petroleum and coal tar-base oils and resins as well as various chemical softeners such as phenol alkyl sulfides and disulfides, thiols, and amino acids. Defibering agents chemically do the work of the hammer mill by hydrolyzing the fiber; they include caustic soda, zinc chloride, and calcium chloride.

A scrap rubber batch is cooked for up to 24 hours and then discharged into a blowdown tank where water is added to facilitate subsequent washing operations. Digester liquor is removed by a series of screen washings. The washed rubber is dewatered by a press and then dried in an oven. Two major sources of wastewater are the digester liquor and the washwater from the screen washings.

Two rubber reclaiming plants use the wet digestion method for reclamation of rubber.

Subcategory 9 - Pan, Dry Digestion, and Mechanical Reclaimed Rubber

This subcategory combines processes that involve scrap size reduction before continuing the reclaiming process. The pan digestion process involves scrap rubber size reduction on steel rolls, followed by the addition of reclaiming oils in an open mixer. The mixture is discharged into open pans which are stacked on cars and rolled into a single-cell pressure vessel where live steam is used to heat the mixture. Depolymerization occurs in 2 to 18 hours. The pans are then discharged and the cakes of rubber are sent on for further processing. The steam condensate is highly contaminated and is not recycled.

The mechanical rubber reclaiming process, unlike pan digestion, is continuous and involves fiber-free scrap being fed into a horizontal cylinder containing a screw that works the scrap against the heated chamber wall. Reclaiming agents and catalysts are used for depolymerization. As the depolymerized rubber is extruded through an adjustable orifice it is quenched. The quench vaporizes and is captured by air pollution control equipment. The captured liquid cannot be reused and is discharged for treatment.

Nine plants use these techniques to reclaim rubber.

Subcategory 10 - Latex-Dipped, Latex-Extruded, and Latex-Molded Goods

These three processes involve the use of latex in its liquid form to manufacture products. Latex dipping consists of immersing an impervious male mold or article into the latex compound, withdrawing it, cleaning it, and allowing the adhering film to air dry. The straight dip process is replaced by a coagulant dip process when heavier films are desired. Fabric or other items may be dipped in latex to produce gloves and other articles. When it has the required coating the mold is leached in pure water to improve physical and electrical properties. After air drying the items are talc-dusted or treated with chlorine to reduce tackiness. Water is often used in several processes, for makeup, cooling, and stripping. Products from dipping include gloves, footwear, transparent goods, and unsupported mechanical goods.

Latex molding employs casts made of unglazed porcelain or plaster of paris. The molds are dusted with talc to prevent sticking, then the latex compound is poured into the mold and allowed to develop the required thickness. The mold is emptied of excess rubber and then oven dried. The mold is removed and the product is again dried in an oven. Casting is used to manufacture dolls, prosthetics, printing matrices, and relief maps.

No description of latex extrusion is available.

Subcategory 11 - Latex Foam

No latex foam facilities are known to be in operation at this time.

II.17.2 WASTEWATER CHARACTERIZATION

The raw wastewater emanating from rubber manufacturing plants contains toxic pollutants that are present due to impurities in the monomers, solvents, or the actual raw materials, or are associated with wastewater treatment steps. Both inorganic and organic pollutants are found in the raw wastewater, and conventional pollutants may be present in significant loadings.

Table 17-3 presents an industry-wide profile of the concentration of toxic pollutants found at facilities in each subcategory (no data are available for Subcategories 9 through 11). Table 17-4 gives a subcategory profile of the pollutant loadings (no data are available for Subcategories 8, 10, and 11). These tables were prepared from available 308 questionnaire data and sampling data.

In-plant management practices may often control the volume and quality of the treatment system influent. Volume reduction can be attained by process wastewater segregation from noncontact water, by recycling or reuse of noncontact water, and by the modification of plant processes. Control of spills, leakage, washdown, and storm runoff can also reduce the treatment system load. Modifications may include the use of vacuum pumps instead of steam ejectors, recycling caustic soda solution rather than discharging it to the treatment system, and incorporation of a more efficient solvent recovery system.

II.17.2.1 Tire and Inner Tube Manufacturing

The tire and inner tube manufacturing industry has several potential areas for wastewater production, but water recycle is used extensively. The major area for water use is in processes requiring noncontact cooling. The general practice of the industry is to recirculate the majority of this water with a minimal blowdown to maintain acceptable concentrations of dissolved solids. Another water use area is contact water used in cooling tire components and in air pollution control devices. This water is also recirculated. Steam condensate and hot and cold water are used in the molding and curing areas. The majority of the water is recycled back to the boiler or hot water tank for use in the next recycle. Soapstone areas and plant and equipment cleanup are the final water use areas. Most facilities try to recycle soapstone solution because of its high solids content. Plant and equipment cleanup water is generally sent to the treatment system. Table 17-5 presents a summary of the potential wastewater sources and the general waste characterization for this subcategory.

Grease and oils and suspended solids make up the major pollutants within this industry. Organic pollutants, pH, and temperature may also require treatment. The organics are present due generally to poor housekeeping procedures.

II.17.2.2 Emulsion Crumb Rubber Production

In-process controls for the reduction of wastewater flows and loads for emulsion crumb rubber plants include recycling of finishing line wastewaters and steam stripping of heavy monomer decanter wastewater. Recycling of finishing line wastewater

TABLE 17-3. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE RUBBER PROCESSING INDUSTRY BY CATEGORY [1] (mg/L)

Toxic pollutants	Tire and inner tube manufacturing							
	Treatment influent				Treatment effluent			
	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals and inorganics								
Cadmium								
Chromium								
Copper	1	0.07		0.07				
Lead	2	25		50				
Mercury	1	10		10	1	0.35		0.35
Nickel								
Selenium								
Zinc	5	250	150	770				
Phthalates								
Bis(2-ethylhexyl) phthalate								
Di-n-butyl phthalate								
Dimethyl phthalate								
Nitrogen compounds								
Acrylonitrile								
N-nitrosodiphenylamine								
Phenols								
2-Nitrophenol								
Pentachlorophenol								
Phenol								
2,4,6-Trichlorophenol					1	<14		<14
Aromatics								
Benzene								
Ethylbenzene					1	>100		>100
Toluene					1	<10		<10
Halogenated aliphatics								
Carbon tetrachloride								
Chloroethane								
Chloroform								
1,1-Dichloroethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene					1	16		16
Methylene chloride					2	20		20
1,1,2,2-Tetrachloroethane								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene					1	40		40
Pesticides and metabolites								
Isophorone					1	<7		<7

(continued)

TABLE 17-3 (continued).

Toxic pollutants	Emulsion crumb rubber manufacturing							
	Treatment influent				Treatment effluent			
	Number re-ported	Av	Med	Max	Number re-ported	Av	Med	Max
Metals and inorganics								
Cadmium	3	270	90	720	2	33		67
Chromium	2	210		250	1	220		220
Copper	1	200		200				
Lead	1	390		390				
Mercury	3	2.5	2.5		3	2.4	17	4.7
Nickel	2	380		590	1	400		400
Selenium	1	20		20	1	<24		<24
Zinc	1	290		290				
Phthalates								
Bis(2-ethylhexyl) phthalate	3	310	260	530	3	190	200	430
Di-n-butyl phthalate								
Dimethyl phthalate	2	1		14	2	9		14
Nitrogen compounds								
Acrylonitrile	1	<23,000		<23,000	1	<23,000		<23,000
N-nitrosodiphenylamine								
Phenols								
2-Nitrophenol	1	9.4		9.4	1	4.9		4.9
Pentachlorophenol								
Phenol	3	170	60	440	3	25	19	37
2,4,6-Trichlorophenol								
Aromatics								
Benzene	2	70		10	1	<10		<10
Ethylbenzene	1	0.1		0.1	1	<0.1		<0.1
Toluene	4	150	230	350	4	110	10	420
Halogenated aliphatics								
Carbon tetrachloride	1	4.6		4.6	1	0.2		0.2
Chloroethane								
Chloroform	3	45	100	270	2	3		4
1,1-Dichloroethane	1	<2		<2	1	<2		<2
1,2-Dichloroethane	1	93		93				
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene								
Methylene chloride	3	30	20	70	3	220	150	520
1,1,2,2-Tetrachloroethane	1	1.5		1.5	1	<0.1		<0.1
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene								
Pesticides and metabolites								
Isophorone								

(continued)

TABLE 17-3 (continued).

Toxic pollutants	Solution crumb rubber manufacturing: Treatment influent: Number reported	Av	Med	Max	Treatment effluent: Number reported	Av	Med	Max
Metals and inorganics								
Cadmium	3	30	1	90	2	1.2		1.3
Chromium	4	350	310	720				
Copper	3	70	9	200	3	160	67	405
Lead	1	390		390	2	9.4		14
Mercury	2	1.6		2	2	1.5		2
Nickel	1	160		160				
Selenium								
Zinc	2	8,100		15,900	1	195,000		195,000
Phthalates								
Bis(2-ethylhexyl) phthalate	3	260	140	530	3	190	120	430
Di-n-butyl phthalate								
Dimethyl phthalate	1	9		9	1	6		6
Nitrogen compounds								
Acrylonitrile								
N-nitrosodiphenylamine								
Phenols								
2-Nitrophenol								
Pentachlorophenol								
Phenol	3	200	170	440	3	18	11	37
2,4,6-Trichlorophenol								
Aromatics								
Benzene	3	1,140	50	3,360	3	10	10	10
Ethylbenzene	2	5		11	2	<1		<2
Toluene	3	3	3	10	4	110	10	420
Halogenated aliphatics								
Carbon tetrachloride	1	350		350	1	1,410		1,410
Chloroethane	1	4,930		4,930	1	2,260		2,260
Chloroform	2	12		22		1.1		1.3
1,1-Dichloroethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene								
Methylene chloride	2	8		15	2	260		520
1,1,2,2-Tetrachloroethane	1	<0.1		<0.1	1	<0.1		<0.1
1,1,1-Trichloroethane								
1,1,2-Trichloroethane	1	<0.1		<0.1	1	<0.1		<0.1
Trichloroethylene	1	<0.1		<0.1	1	<0.1		<0.1
Pesticides and metabolites								
Isophorone								

(continued)

TABLE 17-3 (continued)

	Latex rubber manufacturing							
	Treatment influent				Treatment effluent			
Toxic pollutants	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals and inorganics								
Cadmium					1	1,480		1,480
Chromium								
Copper								
Lead								
Mercury								
Nickel								
Selenium								
Zinc					1	2,350		2,350
Phthalates								
Bis(2-ethylhexyl) phthalate	1	100		100	1	<10		<10
Di-n-butyl phthalate								
Dimethyl phthalate								
Nitrogen compounds								
Acrylonitrile								
N-nitrosodiphenylamine								
Phenols								
2-Nitrophenol								
Pentachlorophenol	1	31		31	1	<10		<10
Phenol	1	31		31	1	<5		<5
2,4,6-Trichlorophenol								
Aromatics								
Benzene								
Ethylbenzene	1	1,500		1,500	1	<5		<5
Toluene								
Halogenated aliphatics								
Carbon tetrachloride								
Chloroethane								
Chloroform								
1,1-Dichloroethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene								
Methylene chloride								
1,1,2,2-Tetrachloroethane								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene								
Pesticides and metabolites								
Isophorone								

(continued)

TABLE 17-3 (continued).

Toxic pollutants	General molding, extruding, and fabricating							
	Treatment influent				Treatment effluent			
	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals and inorganics								
Cadmium								
Chromium								
Copper								
Lead	1	20		20	1	9		9
Mercury								
Nickel								
Selenium								
Zinc					1	970		970
Phthalates								
Bis(2-ethylhexyl) phthalate	1	17		17	1	16		16
Di-n-butyl phthalate					1	36		36
Dimethyl phthalate								
Nitrogen compounds								
Acrylonitrile								
N-nitrosodiphenylamine	2	35		53				
Phenols								
2-Nitrophenol								
Pentachlorophenol	1	2		2				
Phenol					1	11,800		11,800
2,4,6-Trichlorophenol								
Aromatics								
Benzene					11	8		8
Ethylbenzene								
Toluene								
Halogenated aliphatics								
Carbon tetrachloride								
Chloroethane								
Chloroform	1	25		25	2	10		100
1,1-Dichloroethane					1	110		110
1,2-Dichloroethane					1	4		4
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene								
Methylene chloride								
1,1,2,2-Tetrachloroethane					1	4		4
1,1,1-Trichloroethane					1	7,100		7,100
1,1,2-Trichloroethane					1	1		1
Trichloroethylene					1	1,600		1,600
Pesticides and metabolites								
Isophorone								

(continued)

TABLE 17-3 (continued).

	Wet digestion reclaimed rubber							
	Treatment influent				Treatment effluent			
Toxic pollutants	Number re-ported	Av	Med	Max	Number re-ported	Av	Med	Max
Metals and inorganics								
Cadmium	1	10		10				
Chromium								
Copper								
Lead	1	50		50				
Mercury								
Nickel								
Selenium								
Zinc	2	250		350				
Phthalates								
Bis(2-ethylhexyl) phthalate								
Di-n-butyl phthalate								
Dimethyl phthalate								
Nitrogen compounds								
Acrylonitrile								
N-nitrosodiphenylamine								
Phenols								
2-Nitrophenol								
Pentachlorophenol								
Phenol								
2,4,6-Trichlorophenol								
Aromatics								
Benzene								
Ethylbenzene								
Toluene								
Halogenated aliphatics								
Carbon tetrachloride								
Chloroethane								
Chloroform								
1,1-Dichloroethane								
1,2-Dichloroethane								
1,1-Dichloroethylene								
1,2-*Trans*-dichloroethylene								
Methylene chloride								
1,1,2,2-Tetrachloroethane								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene								
Pesticides and metabolites								
Isophorone								

Note: Blanks indicate data not available or not applicable (in the case of medians where less than 3 samples were analyzed).

TABLE 17-4. INDUSTRY PROFILE OF TOXIC AND CONVENTIONAL POLLUTANT LOADINGS [1]

	Tire and inner tube							
	Effluent				Effluent			
Toxic pollutant	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals, kg/Mg								
Cadmium								
Chromium					1	0.000005		0.000005
Copper	1	0.001		0.001				
Lead	1	0.001		0.001				
Mercury								
Nickel								
Selenium								
Zinc	3	0.0034	0.0038	0.006	1	0.0007		0.0007
Organics, kg/Mg								
Bis(2-ethylhexyl) phthalate								
Di-n-butyl phthalate								
Dimethyl phthalate								
Acrylonitrile								
N-nitrosodiphenylamine								
2-Nitrophenol								
Pentachlorophenol								
Phenol								
Benzene								
Ethylbenzene								
Nitrobenzene								
Toluene								
Carbon tetrachloride								
Chloroform								
1,1-Dichloroethane								
1,1-Trans-dichloroethylene								
1,2-Dichloroethane								
Methylene chloride								
1,1,2,2-Tetrachloroethane								
Tetrachloroethylene								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene								
Others, kg/Mg								
Dichlorobromomethane								
Chloromethane								
Conventionals								
BOD_5, kg/d								
COD, kg/d								
TSS, kg/d	3	44	39	92	36	110	26	782
Oil and grease, kg/d	3	9.6	3.2	25	27	12	1.9	110
pH, pH units	6	7.8	7.5	9.4	40	7.9	7.5	10.3

(continued)

TABLE 17-4 (continued).

	Emulsion crumb rubber							
	Effluent				Effluent			
Toxic pollutant	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals, kg/Mg								
Cadmium	2	0.0003		0.0006	1	0.00013		0.00013
Chromium	3	4.3	0.00095	13.1	2	5.8		11.7
Copper	1	0.0033		0.0033				
Lead	1	0.006		0.006				
Mercury	3	0.056	0.0095	0.17	4	0.06	0.007	0.25
Nickel	1	<1.1		<1.1	1	1.26	0.007	1.26
Selenium								
Zinc	2	0.006		0.007	1	0.005		0.005
Organics, kg/Mg								
Bis(2-ethylhexyl) phthalate	3	2.4	0.0069	<7.3	3	2.3	0.0056	<7.0
Di-n-butyl phthalate								
Dimethyl phthalate	2	0.00015		0.00018	2	0.00013		0.00018
Acrylonitrile					1	<1,207.1		<1,200
N-nitrosodiphenylamine								
2-Nitrophenol	1	<1.1		<1.1	1	1.3		1.3
Pentachlorophenol								
Phenol	3	1.0	0.0058	3.0	3	0.33	0.0005	0.98
Benzene	2	0.007		0.013	1	0.00013		0.00013
Ethylbenzene	1	<0.05		<0.05	1	<0.005		<0.005
Nitrobenzene	1	<0.00039		<0.00039	1	<0.00039		<0.00039
Toluene	4	0.015	0.003	0.05	3	0.0018	0.00013	0.005
Carbon tetrachloride	1	0.00001		0.00001	1	<0.000002		<0.000002
Chloroform	3	0.14	0.0003	0.40	2	0.044		0.089
1,1-Dichloroethane	1	0.00002		0.00002	1	<0.000002		<0.000002
1,1-Trans-dichloroethylene								
1,2-Dichloroethane								
Methylene chloride	3	1.3	0.0002	<3.8	3	1.9	0.0.0000068	<5.7
1,1,2,2-Tetrachloroethane	1	0.00002		0.00002	1	0.000013		0.000013
Tetrachloroethylene								
1,1,1-Trichloroethane	1	0.00012		0.00012	1	0.000005		0.000005
1,1,2-Trichloroethane								
Trichloroethylene								
Others, kg/Mg								
Dichlorobromomethane	1	<1.6		1.6	1	7.0		7.0
Chloromethane								
Conventionals								
BOD_5, kg/d	6	976	992	2,378	7	305	310	639
COD, kg/d	5	2,544	1,441	7,696	7	2,084	2,378	5,864
TSS, kg/d	5	460	106	1,875	7	461	92	2,130
Oil and grease, kg/d	2	108.4		210	6	48	43.6	125
pH, pH units	1	7.5			3	7.5	7.5	8.9

(continued)

TABLE 17-4 (continued).

Toxic pollutant	Solution crumb rubber							
	Effluent				Effluent			
	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals, kg/Mg								
Cadmium	3	0.01	0.0007	0.04	2	0.04		0.09
Chromium	4	8.2	0.009	<17	3	0.6	0.0004	<1.3
Copper	3	0.09	0.0003	<0.28	2	0.17		<0.34
Lead	1	0.006		0.006	3			
Mercury	2	2.2		4.5	2	0.07		0.136
Nickel								
Selenium								
Zinc	2	0.07		0.14	1	1.9		1.9
Organics, kg/Mg								
Bis(2-ethylhexyl) phthalate	3	1.3	0.007	<5.4	2	0.003		0.006
Di-n-butyl phthalate								
Dimethyl phthalate	1	0.0001		0.0001	1	0.00008		0.00008
Acrylonitrile								
N-nitrosodiphenylamine								
2-Nitrophenol								
Pentachlorophenol								
Phenol	3	3.6	0.006	7.1	3	0.38	0.0005	<0.76
Benzene	3	67	0.0007	135	2	0.003		<0.007
Ethylbenzene	2	0.002		0.004	2	0.003		0.003
Nitrobenzene								
Toluene	3	0.001	0.0001	0.004	4	0.004	0.001	0.007
Carbon tetrachloride	1	0.0003		0.0003				
Chloroform	2	0.06		0.12	2	0.3		0.63
1,1-Dichloroethane								
1,1-Trans-dichloroethylene								
1,2-Dichloroethane								
Methylene chloride	2	0.001		0.0002	2	0.004		0.007
1,1,2,2-Tetrachloroethane	1	0.004		0.004	1	0.007		0.007
Tetrachloroethylene								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane	1	<0.00008		<0.00008	1	<0.00001		<0.00001
Trichloroethylene	1	<0.00008		<0.00008				
Others, kg/Mg								
Dichlorobromomethane								
Chloromethane	1	0.04		0.04	2	0.01		0.02
Conventionals								
BOD_5, kg/d	6	2,532	1,080	12,405	9	171	70	934
COD, kg/d	4	2,068	1,851	2,361	8	407	400	1,120
TSS, kg/d	3	619	480	1,124	8	253	108	1,014
Oil and grease, kg/d	3	251	92	120	7	21	11	80
pH, pH units	1	9.5		9.5	4	6.7	7.3	8.2

(continued)

TABLE 17-4 (continued).

	Latex rubber production							
	Effluent				Effluent			
Toxic pollutant	Number re-ported	Av	Med	Max	Number re-ported	Av	Med	Max
Metals, kg/Mg								
Cadmium								
Chromium								
Copper								
Lead								
Mercury								
Nickel								
Selenium								
Zinc								
Organics, kg/Mg								
Bis(2-ethylhexyl) phthalate	1	0.0004		0.0004	1	0.00004		0.00004
Di-n-butyl phthalate								
Dimethyl phthalate								
Acrylonitrile								
N-nitrosodiphenylamine								
2-Nitrophenol								
Pentachlorophenol	1	0.0001		0.0001	1	0.00004		0.00004
Phenol	1	0.0001		0.0001	1	0.00002		0.00002
Benzene								
Ethylbenzene	1	0.006		0.006	1	0.00002		0.00002
Nitrobenzene								
Toluene								
Carbon tetrachloride								
Chloroform								
1,1-Dichloroethane								
1,1-Trans-dichloroethylene								
1,2-Dichloroethane								
Methylene chloride								
1,1,2,2-Tetrachloroethane								
Tetrachloroethylene								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene								
Others, kg/Mg								
Dichlorobromomethane								
Chloromethane								
Conventionals								
BOD_5, kg/d					5	59	13	223
COD, kg/d					3	105	129	140
TSS, kg/d	1	566.8			5	121	18	5,116
Oil and grease, kg/d					3	2.5	2.8	3.6
pH, pH units					3	8.4	8.5	8.7

(continued)

TABLE 17-4 (continued).

	General molding, extruding, and fabricating rubber							
	Effluent				Effluent			
Toxic pollutant	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals, kg/Mg								
Cadmium								
Chromium								
Copper								
Lead	1	0.0003			1	0.0001		0.0001
Mercury								
Nickel								
Selenium								
Zinc					1	0.14		0.14
Organics, kg/Mg								
Bis(2-ethylhexyl) phthalate	1	0.0002		0.0002	1	0.002		0.002
Di-n-butyl phthalate					1	0.005		0.005
Dimethyl phthalate								
Acrylonitrile								
N-nitrosodiphenylamine	1	0.0007		0.0007				
2-Nitrophenol								
Pentachlorophenol	1	0.00003		0.00003				
Phenol					1	0.17		0.17
Benzene					1	0.001		0.001
Ethylbenzene								
Nitrobenzene								
Toluene								
Carbon tetrachloride								
Chloroform					1	0.0003		0.0003
1,1-Dichloroethane					1	0.2		0.2
1,1-Trans-dichloroethylene					1	0.4		0.4
1,2-Dichloroethane					1	0.0006		0.0006
Methylene chloride								
1,1,2,2-Tetrachloroethane								
Tetrachloroethylene					1	0.0006		0.0006
1,1,1-Trichloroethane					1	1.0		1.0
1,1,2-Trichloroethane					1	0.0002		0.0002
Trichloroethylene					1	0.23		0.23
Others, kg/Mg								
Dichlorobromomethane								
Chloromethane								
Conventionals								
BOD_5, kg/d								
COD, kg/d								
TSS, kg/d								
Oil and grease, kg/d								
pH, pH units								

(continued)

TABLE 17-4 (continued).

Toxic pollutant	Pan, dry digestion, and mechanical reclaimed							
	Effluent				Effluent			
	Number reported	Av	Med	Max	Number reported	Av	Med	Max
Metals, kg/Mg								
Cadmium								
Chromium								
Copper								
Lead								
Mercury								
Nickel								
Selenium								
Zinc								
Organics, kg/Mg								
Bis(2-ethylhexyl) phthalate								
Di-n-butyl phthalate								
Dimethyl phthalate								
Acrylonitrile								
N-nitrosodiphenylamine								
2-Nitrophenol								
Pentachlorophenol								
Phenol								
Benzene								
Ethylbenzene								
Nitrobenzene								
Toluene								
Carbon tetrachloride								
Chloroform								
1,1-Dichloroethane								
1,1-Trans-dichloroethylene								
1,2-Dichloroethane								
Methylene chloride								
1,1,2,2-Tetrachloroethane								
Tetrachloroethylene								
1,1,1-Trichloroethane								
1,1,2-Trichloroethane								
Trichloroethylene								
Others, kg/Mg								
Dichlorobromomethane								
Chloromethane								
Conventionals								
BOD_5, kg/d	2	390		775	2	49		96
COD, kg/d	1	570			2	520		690
TSS, kg/d	2	3.2		5.2	3	13	17	22
Oil and grease, kg/d	2	13.9		24.4	3	2.6	0.07	7.7
pH, pH units	1	7.2			2	7.3		7.5

Note: Blanks indicate data not available or not applicable (in the case of medians where less than 3 samples were analyzed).

TABLE 17-5. SUMMARY OF POTENTIAL PROCESS-ASSOCIATED WASTEWATER SOURCES FROM THE TIRE AND INNER TUBE INDUSTRY [1]

Plant area	Source	Nature and origin of wastewater contaminants
Oil storage	Runoff	Oil.
Compounding	Washdown, spills, leaks, discharges from wet air pollution equipment	Solids from soapstone dip tanks. Oil from seals in roller mills. Oil from solids from Banbury seals. Solids from air pollution equipment discharge.
Bead, tread, tube formation	Washdown, spills, leaks	Oil and solvent-based cements from the cementing operation. Oil from seals in roller mills.
Cord and belt formation	Washdown, spills, leaks	Organics and solids from dipping operation. Oil from seals, in roller mills, calenders, etc.
Green tire painting	Washdown, spills, air pollution equipment	Organics and solids from spray painting operation. Soluble organics and solids from air pollution equipment discharge.
Molding and curing	Washdown, leaks	Oil from hydraulic system. Oil from presses.
Tire finishing	Washdown, spills, air pollution equipment	Solids and soluble organics from painting operation. Solids from air pollution equipment discharge.

occurs at nearly all emulsion crumb plants with the percent recycle depending primarily upon the desired final properties of the crumb. Approximately 75% recycle is an achievable rate, with recycle for white masterbatch crumb below this level and that for black masterbatch crumb exceeding it.

Organic toxic pollutants found at emulsion crumb rubber plants come from the raw materials, impurities in the raw materials, and additives to noncontact cooling water. BOD, COD and TSS levels may also reach high loadings.

Table 17-6 lists potential wastewater sources and general wastewater contaminants for the emulsion crumb rubber industry.

TABLE 17-6. SUMMARY OF WASTEWATER SOURCES FROM EMULSION CRUMB RUBBER PRODUCTION FACILITIES [1]

Processing unit	Source	Nature of wastewater contaminants
Caustic soda scrubber	Spent caustic solution	High pH, alkalinity, and color. Extremely low average flow rate.
Monomer recovery	Decant water layer	Dissolved and separable organics. Source of high BOB and COD discharges.
Coagulation	Coagulation liquor overflow	Acidity, dissolved organics, suspended and high dissolved solids, and color. High wastewater flow rates relative to other sources.
Crumb dewatering	Crumb rinse water overflow	Dissolved organics, and suspended and dissolved solids. Source of highest wastewater volume from emulsion crumb rubber production.
Monomer strippers	Stripper cleanout rinse water	Dissolved organics, and suspended and dissolved solids. High quantities of uncoagulated latex.
Tanks and reactors	Cleanout rinse water	Dissolved organics, and suspended and dissolved solids. High quantities of uncoagulated latex.
All plant areas	Area washdowns	Dissolved and separable organics, and suspended and dissolved solids.

II.17.2.3 Solution Crumb Rubber Production

Solution crumb rubber production plants have lower raw wastewater loads than emulsion crumb plants due to the thorough steam stripping of product cement to remove solvent and permit effective coagulation. Recycling in this industry is comparable to that in the emulsion crumb industry with about 75% of the wastewater being recirculated.

Toxic pollutants found in the wastewater streams are normally related to solvents and solvent impurities, product additives, and cooling water treatment chemicals. Table 17-7 presents a listing of the potential wastewater sources and the associated contaminants for this industry.

TABLE 17-7. SUMMARY OF WASTEWATER SOURCES FROM SOLUTION CRUMB RUBBER PRODUCTION [1]

Processing unit	Source	Nature of wastewater contaminants
Caustic soda scrubber	Spent caustic solution	High pH, alkalinity, and color. Extremely low average flow rate.
Monomer and solvent drying columns	Water removed from monomers and solvent	Dissolved and separable organics. Very low flow.
Solvent purification	Fractionator bottoms	Dissolved and separable organics.
Monomer recovery	Decant water layer	Dissolved and separable organics.
Crumb dewatering	Crumb rinse water overflow	Dissolved organics, and suspended and dissolved solids. Source of highest volume wastewater flow.
All plant areas	Area washdowns	Dissolved and separable organics, and suspended and dissolved solids.

II.17.2.4 Latex Rubber Production

No in-process contact water is currently used by the latex rubber industry. No raw material recycling is practiced because of poor control of monomer feeds and the buildup of impurities in the water.

Organic toxic pollutants and chromium are present in the raw wastewater and normally consist of raw materials, impurities, and metals used as cooling water corrosion inhibitors.

Table 17-8 presents potential wastewater sources and general contaminants for this industry.

II.17.2.5 General Molding, Extruding, and Fabricating Rubber Plants

Toxic pollutants resulting from production processes within this industry are generally the result of leaks, spills, and poor housekeeping procedures. Pollutants include organics associated with the raw materials and lead from the rubber curing process.

TABLE 17-8. SUMMARY OF WASTEWATER SOURCES FROM LATEX RUBBER PRODUCTION [1]

Processing unit	Source	Nature of wastewater contaminants
Caustic soda scrubber	Spent caustic solution	High pH, alkalinity, and color. Extremely low average flow rate.
Excess monomer stripping	Decant water layer	Dissolved and separable organics.
Latex evaporators	Water removed during latex concentration	Dissolved organics, suspended and dissolved solids. Relatively high wastewater flow rates.
Tanks, reactors, and strippers	Cleanout rinse water	Dissolved organics, suspended and dissolved solids. High quantities of uncoagulated latex.
Tank cars and tank trucks	Cleanout rinse water	Dissolved organics, suspended and dissolved solids. High quantities of uncoagulated latex.
All plant areas	Area washdowns	Dissolved and separable organics, and suspended and dissolved solids.

II.17.2.6 Rubber Reclamation

Wastewater effuents from this industry contain high levels of toxic organic and inorganic pollutants. These pollutants generally result from impurities in the tires and tubes used in the reclamation process. The wastewater from the pan process is of low volume (0.46 m^3/Mg [56 gal/1,000 lb]), but is highly contaminated, requiring treatment before discharge. The mechanical reclaiming process uses water only to quench the reclaimed rubber, but it uses a much higher quantity (1.1 m^3/Mg). Steam generated from the quenching process is captured in a scrubber and sent to the treatment system. Wet digestion uses 5.1 m^3 of water per Mg (604 gal/1,000 lb) of product in processing, of which 3.4 m^3/Mg (407 gal/1,000 lb) of product is used in air pollution control.

II.17.2.7. Latex-Dipped, Latex-Extruded, and Latex-Molded Goods

Wastewater sources in this industry are the leaching process, makeup water, cooling water, and stripping water. Toxic pollutants are present only in insignificant levels in the wastewater discharges.

II.17.2.8 Latex Foam

No information is available on the wastewater characteristics of this industry.

II.17.3 PLANT SPECIFIC DESCRIPTION

Only two subcategories of the rubber industry have not been recommended as Paragraph 8 exclusions of the NRDC consent decree: Wet Digestion Reclaimed Rubber, and Pan, Mechanical, and Dry Digestion Reclaimed Rubber. Of these two, plant specific data are available only for the latter. Of the nine remaining subcategories, plant specific information is available only for Emulsion Crumb Rubber and Solution Crumb Rubber, and it is presented below. Two plants in each subcategory are described. They were chosen as representative of their industries based on available data.

II.17.3.1 Emulsion Crumb Rubber Production

Plant 000012 produces 3.9 x 10^4 Mg/yr (8.7 x 10^7 lb/yr) of emulsion crumb rubber, primarily neoprene. The contact wastewater flow rate is approximately 8.45 m^3/d (5.90 x 10^5 gpd) and includes all air pollution control equipment, sanitary waste, maintenance and equipment cleanup, and direct contact wastewater. The treatment process consists of activated sludge, secondary clarification, sludge thickening, and aerobic sludge digestion. Noncontact wastewater, with a flow rate of approximately 1.31 x 10^5 m^3/d (3.46 x 10^7 gpd), is used on a once-through basis and is returned directly to the river source. Contact wastewater is also returned to the surface stream after treatment.

Plant 000033 produces three types of emulsion crumb rubber in varying quantities. Styrene butadiene rubber (SBR) is the bulk of production, at nearly 3.7 x 10^5 Mg/yr (8.2 x 10^8 lb/yr), with nitrile butadiene rubber (NBR) and polybutadiene rubber (PBR) making up the remainder of production (4.5 x 10^4 Mg/yr [1.0 x 10^8 lb/yr] and 4.5 x 10^3 Mg/yr [1 x 10^7 lb/yr], respectively). Wastewater consists of direct contact process water, MEC, noncontact blowdown, and noncontact ancillary water. The total flow of contact water is approximately 1.27 x 10^4 m^3/d (3.365 x 10^6 gpd), and of noncontact water, it is 340.4 m^3/d (90 x 10^4 gpd). Treatment of the wastewater consists of coagulation, sedimentation, and biological treatment with extended aeration. Treated wastewater is discharged to a surface stream.

Tables 17-9 and 17-10 present plant specific toxic pollutant data for the selected plants. Table 17-11 gives plant specific conventional pollutant data, including BPT regulations set for each specific plant. Both plants are within BPT regulations for the sampling data. Plant 000012 is not within the standards for the 308 data available.

TABLE 17-9. PLANT SPECIFIC VERIFICATION DATA FOR EMULSION CRUMB RUBBER PRODUCTION PLANT 000012[a] [1]

Flow rate, m^3/d: contact, 8.45; noncontact, 1.31×10^5

Pollutant	Location in process line												
	Stripper decant			Spray wash water			Treatment influent			Treatment effluent			Raw intake water[b]
	Av	Med	Max	Av	Med	Max	Av	Med	Max	Av	Med	Max	
Cadmium	<1	<1	<1	<1	<1	<1	<2	<1	4	<1	<1	<1	<1.0
Mercury	1.5	0.7	3.4	2.0	1.1	3.8	2.5	3.4	3.6	1.6	0.7	3.4	1.5
Nickel	60	90	90	690	720	740	610	560	720	400	400	430	<10
Bis(2-ethylexyl) phthalate	290	250	550	490	260	1,000	260	260	270	230	110	520	262
Dimethyl phthalate	<14	<14	<16	<14	<14	<16	<14	<14	<16	<14	<14	<16	<16
N-nitrosodiphenylamine	1.5	<1.0	2.5	1.0	<1.0	1.0	5.2	4.0	10.4	2.0	1.8	3.1	<1.0
Phenol	16	18	26	29	32	36	40	40	60	19	19	20	<2
Nitrobenzene	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
Toluene	370	310	780	<0.5	<0.5	<0.5	250	290	370	<0.5	<0.5	<0.5	<0.5
Carbon tetrachloride	41	46	49	0.1	0.1	0.2	4.7	4.0	7.9	0.2	<0.1	0.3	0.3
Chloroform	108	120	130	14	11	22	27	25	33	4.1	2.2	8.5	8.5
1,1-Dichloroethylene	51	71	81	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Methylene chloride	4.8	3.0	8.7	1.0	0.1	2.8	<0.1	<0.1	<0.1	1.0	<0.1	2.8	<0.1
Tetrachloroethylene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.4	0.9	3.2	<0.1	<0.1	<0.1	<0.1
1,1,1-Trichloroethane	1.6	<0.1	4.6	0.3	0.2	0.6	1.1	0.9	2.2	0.3	0.2	0.6	0.2

[a]Based on three 24-hour sample composite analyses.

[b]Based on second 24-hour sample composite analyses.

TABLE 17-10. PLANT SPECIFIC VERIFICATION DATA FOR EMULSION CRUMB RUBBER PRODUCTION PLANT 000033[a] [1] (µg/L)

Flow rate, m^3/d: SBR - contact, 1.02×10^4; noncontact, 1.9×10^2
NBR - contact, 1.25×10^3; noncontact, 75.7
PBR - contact, 1.25×10^3, noncontact, 75.7
Total - contact, 1.27×10^4; noncontact, 340.4

	Location in process line											
	SBR stripper			Finishing comp.			NBR finishing			Treatment influent		
Pollutant	Av	Med	Max	Av	Med	Max	Av	Med	Max	Av	Med	Max
Cadmium	<1	<1	<1	80	80	80	1	<1	2	40	50	50
Chromium	6	4	10	400	400	610	20	25	25	250	280	280
Copper	70	100	110	80	80	80	<1	<1	<1	1,400	1,300	1,800
Mercury	0.8	0.6	1.1	60	10	170	2.2	2.0	3.6	3.2	3.6	3.6
Selenium	<4	<4	<4	<40	<40	<40	6	<4	10	<20	<20	<20
Bis(2-ethylhexyl) phthalate	350	410	530	210	160	350	170	<110	280	100	<110	190
Acrylonitrile	26,000	<23,000	33,000	<23,000	<23,000	<23,000	94,000	98,000	128,000	32,000	33,000	35,000
2-Nitrophenol	<4	<4	<4	<4	<4	<4	17	<4	44	10	7	19
Phenol	41	11	110	67	61	81	32	36	45	61	57	120
Ethylbenzene	38	<0.1	113	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2
Toluene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chloroform	1.4	1.5	1.5	2.2	1.9	3.8	5	6.2	7.8	8.3	9.6	13
Dichlorobromomethane	0.3	<0.1	0.8	0.1	<0.1	0.1	0.5	0.6	0.9	0.3	0.4	0.5
Methylene chloride	110	140	180	<0.1	<0.1	<0.1	80	<0.1	240	70	52	150

	Treatment effluent			NBR decant			Raw intake, well[b]	Raw intake, river[b]
Pollutant	Av	Med	Max	Av	Med	Max		
Cadmium	40	40	50	2	2	4	<1	<1
Chromium	220	230	240	10	9	16	6	5
Copper	410	410	430	1	1	2	1	<1
Mercury	3.1	3.2	3.6	-[c]	-[c]	-[c]	0.7	0.6
Selenium	25	<20	50	6	<4	10	<4	<4
Bis(2-ethylhexyl) phthalate	130	<110	180	115	115	120	<110	<110
Acrylonitrile	<23,000	<23,000	<23,000	48,000	46,000	63,000	<23,000	<23,000
2-Nitrophenol	5	<4	7	5	<4	7	<4	<4
Phenol	20	27	30	16	6	40	10	<3
Ethylbenzene	<0.1	<0.1	<0.2	23[d]	<0.1[d]	70[d]	<0.1	<0.1
Toluene	<0.1	<0.1	<0.1	25[d]	25[d]	51[d]	<0.1	<0.1
Chloroform	1.8	1.9	2.6	40	32	60	1.2	41
Dichlorobromomethane	0.1	0.1	0.2	5.2	4.3	8.5	<0.1	6.2
Methylene chloride	100	59	260	180	160	300	<2	<2

[a] Based on results of three 24-hour composite samples.

[b] Based on first 24-hour composite sample.

[c] No analysis due to interference.

[d] Based on first and third 24-hour composite samples. Second sample was obscured.

TABLE 17-11. PLANT SPECIFIC CONVENTIONAL POLLUTANT VERIFICATION DATA FOR SELECTED EMULSION CRUMB RUBBER PRODUCTION PLANTS [1]

Parameter	Waste load,[a] plant 000012									
	Influent				Effluent					
	308 data		Sampling data		308 data		Sampling data		BPT regulation	
BOD_5	1,400	(3,090)	1,200	(2,639)	45	(100)	4.8	(10.6)	44	(96.7)
COD	2,300	(5,000)	2,100	(4,574)	900	(2,000)	130	(281)	880	(1,933)
TSS	400	(870)	10	(17.6)	250	(560)	35	(77.4)	71	(157)
Oil and grease			<8	(<17.6)			8	(17.6)	18	(38.7)
pH	7				8.2				6 to 9	
Cyanide										
Ammonia										
	Waste load,[a] plant 000033									
BOD_5	380	(840)	2,700	(5,947)	99	(219)	143	(315)	463	(1,019)
COD	5,700	(12,600)	8,730	(19,240)	2,620	(5,777)	2,700	(5,947)	9,250	(20,376)
TSS	1,760	(3,886)	2,130	(4,688)	330	(731)	250	(542)	750	(1,656)
Oil and grease			240	(525)	35	(78)	140	(314)	185	(408)
pH	5.5				7.0				6 to 9	
Cyanide	70	(155)	0.4	(0.9)	0.59	(1.3)	0.16	(0.35)		
Ammonia	35	(76)								

[a]Values in kg/d (lb/d) except for pH values; they are given in pH units.

Note: Blanks indicate data not available.

II.17.3.2 Solution Crumb Rubber Production

Plant 000005 produces approximately 3.2 x 10^4 Mg/yr (7.0 x 10^7 lb/yr) of isobutene-isopropene rubber. Wastewater generally consists of direct processes and MEC water. Contact wastewater flow rate is approximately 1,040 m^3/d (2.75 x 10^3 gpd), and noncontact water flows at about 327 m^3/d (8.64 x 10^4 gpd). Treatment consists of coagulation, flocculation and dissolved air flotation, and the treated effluent becomes part of the noncontact cooling stream of the on-site refinery.

Plant 000027 produces polyisoprene crumb rubber (4.5 x 10^4 Mg/yr [1 x 10^8 lb/yr]), polybutadiene crumb rubber (4.5 x 10^4 mg/yr [1.0 x 10^8 lb/yr]), and ethylene-propylene-diene-terpolymer rubber (EPDM; 4.5 x 10^4 Mg/yr [1.0 x 10^8 lb/yr]). Wastewater consists of contact process water, MEC, cooling tower blowdown, boiler blowdown, and air pollution control. Wastewater is produced at about 12,100 m^3/day (3.2 x 10^6 gpd). Treatment consists of API separators, sedimentation, stabilization, and lagooning, followed by discharge to a surface stream.

Tables 12-12 and 17-13 show plant specific toxic pollutant data for the above plants. Conventional pollutant data and BPT regulations are presented in Table 17-14.

II.17.3.3 Dry Digestion Reclaimed Rubber

An analytical data summary for plant 000134 is given in Table 17-15. Production, wastewater flow, and treatment data are currently not available for a plant within this subcategory.

II.17.4 POLLUTANT REMOVABILITY

In this industry, numerous organic compounds, BOD, and COD are typically found in the plant wastewater effluent. Industry-wide flow and production data show that these pollutants can be reduced by biological treatment. In emulsion crumb and latex plants, uncoagulated latex contributes to high suspended solids. Suspended solids are produced by rubber crumb fines and include both organic and inorganic materials. Removal of such solids is possible using a combination of coagulation/flocculation and dissolved air flotation.

Solvents, extender oils, and insoluble monomers are used throughout the rubber industry. In addition, miscellaneous oils are used to lubricate machinery. Laboratory analysis indicates the presence of oil and grease in the raw wastewater of these plants. Oil and grease entering the wastewater streams is removed by chemical coagulation, dissolved air flotation and, to some extent, biological oxidation.

TABLE 17-12. PLANT SPECIFIC VERIFICATION DATA FOR SOLUTION CRUMB PRODUCTION PLANT 000005[a] [1] (μg/L)

Flow rate, m^3/d: contact, 1,040; noncontact, 327

Pollutant	Location in process line: Screen - tank 1 and 2 comp. Av	Med	Max	Expeller - 1 and 2 comp. Av	Med	Max	DAF influent Av	Med	Max
Cadmium	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	3	3	4	6	4	10	75	95	100
Copper	6	5	9	7	7	11	9	9	10
Zinc	13,000	14,000	14,000	11,000	12,000	12,000	14,000	14,000	16,000
Bis(2-ethylhexyl) phthalate	60	46	130	100	62	220	200	120	450
Phenol	9	8	16	5	<4	8	7	8	8
Benzene	<22	<11	<43	13	<11	16	22	11	43
Ethylbenzene	<40	<2	<110	<2	<2	<2	12	<11	22
Toluene	<26	<3	<72	<3	<3	<3	26	3	<72
Carbon tetrachloride	0.06	0.06	0.07	0.06	0.06	0.06	35	31	65
Chloroform	0.90	0.88	0.94	0.88	0.90	0.94	3.0	2.0	3.0
Methyl chloride	14,000	14,000	14,000	2,600	2,700	2,900	4,900	3,900	7,200
Methylene chloride	<1	<1	<1	<1	<1	<1	<1	<1	<1
1,1,2-Trichloroethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Trichloroethylene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Pollutant	Location in process line: DAF effluent Av	Med	Max	Well water[b]	Boiler feedwater[b]	Boiler blowdown Av	Med	Max
Cadmium	<1	<1	<1	<1	<1			
Chromium	430	400	540	3	3	5,400	6,000	7,300
Copper	14	14	18	3	7			
Zinc	13,000	18,000	19,000	30	13,000	3,700	4,000	4,700
Bis(2-ethylhexyl) phthalate	24	17	55	98	50			
Phenol	5	4	8	<2	6			
Benzene	110	<11	320	<43	<43			
Ethylbenzene	<38	<2	<110	<110	<110			
Toluene	<26	<3	<72	<72	<72			
Carbon tetrachloride	14	10	24	0.10	0.06			
Chloroform	1.3	1.7	2.0	1.0	0.98			
Methyl chloride	2,000	2,000	4,000	190	31			
Methylene chloride	<1	<1	<1	<1	35			
1,1,2-Trichloroethane	<0.1	<0.1	<0.1	<0.1	<0.1			
Trichloroethylene	<0.1	<0.1	<0.1	<0.1	<0.1			

[a]Results based on three 24-hour composite samples.

[b]Results based on the first 24-hour composite sample.

Note: Blanks indicate data not available.

TABLE 17-13. PLANT SPECIFIC VERIFICATION DATA FOR SOLUTION CRUMB RUBBER PRODUCTION PLANT 000027[a] [1] (μg/L)

Total flow rate: 12,100 m^3/d

Pollutant	SN/CB process			EPDM process			Treatment influent			Treatment effluent			Well water[b]	Boiler blowdown[b]
	Av	Med	Max	Av	Med	Max	Av	Med	Max	Av	Med	Max		
Cadmium	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	2	<1	<1
Chromium	450	410	570	820	850	950	440	420	690	19	13	43	2	2,600
Copper	3	4	5	2	<1	3	7	4	17	5	7	7	2	<1
Mercury	1.8	1.9	2.8	2.3	2.0	3.6	1.1	0.8	1.8	2.0	1.2	3.8	4.0	1.4
Bis(2-ethylhexyl) phthalate	77	76	110	115	110	190	140	<46	330	124	<46	280	170	<46
Phenol	12	16	18	670	510	1,400	180	150	290	12	16	17	<2	7
Benzene	<0.1	<0.1	<0.1	39,000	17,000	92,000	3,300	3,300	5,500	<0.1	<0.1	<0.1	<0.1	<0.1
Ethylbenzene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Toluene	<0.1	<0.1	<0.1	43	<0.1	130	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chloroform	1.0	1.1	1.1	22	7.4	52	3.2	3.9	3.9	0.9	0.9	1.1	1.1	1.0
1,1,2,2-Tetrachloroethene	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	F0.1

[a]Results based on three 24-hour composite samples.

[b]Results based on first 24-hour composite sample.

TABLE 17-14. PLANT SPECIFIC CONVENTIONAL PLANT VERIFICATION DATA FOR SELECTED SOLUTION CRUMB RUBBER PRODUCTION PLANTS [1]

Parameter	Waste load[a]											
	Plant 000005						Plant 000027					
	Influent		Treated effluent		BPT regulation		Influent		Treated effluent[b]		BPT regulation	
BOD_5	93.7	(206.4)	66.6	(146.8)	51.4	(113.3)	1,226	(2,701)	<90	(<200)	165	(363.9)
COD	250	(550.4)	135.4	(298.2)	504.3	(1110.7)	2,680	(5,903)	450	(1,000)	1,618	(3,564.5)
TSS	18.8	(41.3)	11.4	(25.2)	83.6	(184.2)	1,276	(2,811)	11	(25)	268	(591.0)
Oil and grease	104.1	(229.4)	13.5	(29.8)	20.6	(45.3)	45	(100)	<90	(<200)	66	(145.5)
pH					6 to 9						6 to 9	
Cyanide	<0.02	(<0.05)	<0.02	(<0.05)					<0.2	(<0.5)		
Phenol	0.006	(0.0128)	0.006	(0.013)			1.03	(2.26)	0.16	(0.35)		

[a]Values in kg/d (lb/d) except for pH values; they are in pH units.

[b]Effluent flow rate was twice influent flow rate.

Note: Blanks indicate data not available.

TABLE 17-15. PLANT SPECIFIC VERIFICATION DATA FOR PAN, DRY RUBBER DIGESTION, AND MECHANICAL RECLAIMING PLANT 000134[a] [1] (μg/L)

	Location in process line								
	Treatment influent[b]			Treatment effluent			Treatment effluent[b]		
Pollutant	Av	Med	Max	Av	Med	Max	Av	Med	Max
Cadmium	1	<1	2	1	1	2	3	3	3
Chromium	6	6	8	4	4	4	20	15	40
Copper	31	30	38	<1	<1	<1	12	12	15
Lead	70	67	100	290	130	670	670	670	830
Mercury		-[c]		1.9	1.8	2.4	2.3	2.6	2.8
Zinc	100	100	120	2,700	1,800	4,500	2,500	2,600	3,200
Bis(2-ethylhexyl) phthalate	16,000	19,000	23,000	<80	<80	<80	4,000	960	12,000
Di-n-butyl phthalate									
2,4-Dimethylphenol	58,000	61,000	110,000	56,000	52,000	66,000	14,000	13,000	22,000
Phenol	26,000	37,000	40,000	20,000	20,000	24,000	4,900	5,200	7,100
Benzene	60	<0.1	180	10	<0.1	30	<0.1	<0.1	<0.1
Chlorobenzene[d]									
Ethylbenzene	8,600	2,500	23,000	<0.1	<0 1	<0.1	<0.1	<0.1	<0.1
Toluene	2,700	1,400	6,500	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	33	<20	<64	<8	<8	<8	<8	<8	<8
Anthracene[d]									
Phenanthrene[d]	1,400	290	3,800	49	<4	140	300	<4	900
Fluorene	2,000	96	6,000	40	<12	95	<12	<12	<12
Naphthalene	102,000	61,000	210,000	<12	<12	<12	44	49	71
Pyrene	7,000	5,800	10,000	9	<8	13	14	<8	25
Chloroform	1.9	1.9	2.3	1.3	1.0	2.4	1.4	1.7	1.9
Methylene chloride[d]									

	Cooling tower blowdown			Steam condensate			Boiler blowdown[e]	Intake water[d]
Pollutant	Av	Med	Max	Av	Med	Max		
Cadmium	1	<1	1	35	42	43	1	<1
Chromium	2	2	4	33	45	52	2	<1
Copper	3	3	4	20	25	25	6	<1
Lead	29	25	42	330	330	330	22	10
Mercury	0.5	0.6	0.7	1.0	0.9	1.4	0.9	0.8
Zinc	100	100	110				220	30
Bis(2-ethylhexyl) phthalate	120	110	160	2,800	2,800	5,400	940	1,300
Di-n-butyl phthalate				1,900	2,200	2,200		
2,4-Dimethylphenol	500	330	1,200	730	680	980	11	<6
Phenol	130	64	330	950	770	1,200	12	<4
Benzene	<0.1	<0.1	<0.1	26[f]	26	29	<0.1	<0.1
Chlorobenzene[d]				25,000[f]	23,000	26,000		
Ethylbenzene	<0.1	<0.1	<0.1	<0.1[f]	<0.1	<0.1	<0 1	<0.1
Toluene	<0.1	<0.1	<0.1	<0.1[f]	<0.1	<0.1	<0.1	<0.1
Acenaphthylene	<8	<8	<8	16	<8	31	<8	<8
Anthracene[d]				190	15	539		
Phenanthrene[d]	110	<4	310	140	<4	410	340	<4
Fluorene	<12	<12	<12	<12	<12	<12	<12	<12
Naphthalene	17	<12	20	1,400	66	4,200	<12	<12
Pyrene	36	9	270	29	16	64	<8	15
Chloroform	4.9	5.1	5.5	3.2[f]	3.2	5.9	1.0	36
Methylene chloride[d]				1,300[e]	1,200	1,300		

[a]Results based on three 24-hour grab composite samples unless otherwise indicated.

[b]Results based on three 24-hour composite samples from an automatic sampler.

[c]Interference precluded analysis.

[d]May be due to sampling procedure.

[e]Based on first 24-hour composite sample.

[f]Based on second and third 24-hour composite samples.

Note. Blanks indicate data not available.

Wastewater sampling indicates that toxic pollutants found in the raw wastewater can be removed. Biological oxidation (activated sludge) adequately treats all of the organic toxic pollutants identified in rubber industry wastewater streams. Significant removal of metals was also observed across biological treatment. The metals are probably absorbed by the sludge mass and removed with the settled sludge. Treatment technologies currently in use are described in the following subcategory descriptions.

II.17.4.1 Emulsion Crumb Rubber Plants

There are a total of 17 plants in the United States producing emulsion-polymerized crumb rubber. Five of these plants discharge to POTW's; 10 discharge to surface streams; 1 plant discharges to an evaporation pond; and 1 plant employs land application with hauling of settled solids. Of the five plants discharging POTW's, four pretreat using coagulation and primary treatment, and one employs equalization with pH adjustment. All 10 of the plants discharging to surface streams employ biological waste treatment ranging from conventional activated sludge to nonaerated wastewater stabilization lagoons.

Organic pollutants are generally found to be reduced to insignificant levels (<10 µg/L) by biological treatment. Most metals are also found to be reduced across biological treatment; they are generally very low levels in the treated effluent. However, significant metal concentrations may be found in some treated effluent.

At emulsion crumb rubber facilities, a well-operated biological treatment facility permits compliance with BPT limitations and reduces ogranic toxic pollutants to acceptable levels. Toxic metals that may not be reduced include chromium, cadmium, copper, selenium, and mercury. The need for advanced technologies such as ion exchange and chemical precipitation will depend on allowable limits adopted by US EPA. Tables 17-16 and 17-17 show pollutant removal efficiencies at two emulsion crumb plants.

II.17.4.2 Solution Crumb Rubber Plants

There are 13 solution crumb rubber plants in the United States. Twelve of these plants discharge treated wastewater to surface streams; the other plant discharges its treated wastewater into a neighboring oil refinery's noncontact cooling water system.

Ten of the plants discharging to surface streams employ some form of biological treatment for waste load reduction. Two of the plants discharging to surface streams use in-process controls, oil removal, and primary treatment prior to discharge. In-process control employed at one plant consists of steam stripping of wastewaters, while in-process control at the second plant was not disclosed. The plant discharging to the oil refinery noncontact cooling water system used coagulation, flocculation, and dissolved air flotation prior to discharge.

The results of the verification program showed that all organic toxic pollutants were reduced across biological treatment. Chloromethane, used as a solvent at plant 000005, was present at significant levels in treated effluent.

TABLE 17-16. TOXIC POLLUTANT REMOVAL EFFICIENCY AT EMULSION CRUMB RUBBER PLANT 000012 [1]

Treatment technology: Activated sludge
Discharge point: Surface stream

Pollutant	Concentration,[a] μg/L Influent	Concentration,[a] μg/L Effluent	Percent removal
Cadmium	1	<1	100
Mercury[b]	2.5	1.6	36
Nickel	610	400	34
Bis(2-ethylhexyl) phthalate[c]	260	220	15
Dimethyl phthalate	<14	<14	-[d]
N-nitrosodiphenylamine	5.2	1.6	69
Phenol[e]	41	19	54
Nitrobenzene	<30	<30	-[d]
Toluene	250	<0.1	100
Carbon tetrachloride	4.7	0.1	98
Chloroform	27	4.1	85
1,1-Dichloroethylene	<1.7	<1.7	-[d]
Methylene chloride	<0.1	0.9	-[f]
Tetrachloroethene	1.4	<0.1	100
1,1,1,-Trichloroethane	1.0	3.3	-f

[a]Values presented are averages of the values observed for the three 24-hr composite samples.

[b]Intake measured at 1.5 μg/L, making plant's contribution minimal.

[c]Analytical methodology for phthalates is questionable. Therefore, significance of values reported is unknown.

[d]Negligible removal.

[e]Screening data indicate reduction to below significant level across treatment.

[f]Negative removal.

TABLE 17-17. TOXIC POLLUTANT REMOVAL EFFICIENCY AT EMULSION CRUMB RUBBER PLANT 000033 [1]

Treatment technology: Primary flocculation/separation, aerated lagoons
Discharge point: Surface stream

Pollutant	Concentration,[a] μg/L Influent	Concentration,[a] μg/L Effluent	Percent removal
Cadmium[b]	40	40	-[c]
Chromium[b]	250	220	12
Copper[b]	1,400	410	71
Mercury[b]	3.2	4.9	-[d]
Selenium[b]	<20	20	-[c]
Bis(2-ethylhexyl) phthalate[e]	65-140 (100)	59-130 (94)	~6
Acrylonitrile[f]	32,000	23,000	>28
2-Nitrophenol	9	3	67
Phenol[g]	60	19	68
Ethylbenzene	<0.1	<0.1	-[c]
Toluene	<0.1	<0.1	-[c]
Chloroform	8.2	1.8	78
Dichlorobromomethane	0.3	0.1	67
Methylene chloride[h]	66	110	-[d]

[a]Values presented are averages of the values observed for the three 24-hr composite samples.

[b]Found at potentially significant levels in treatment effluent although generally higher than during screening.

[c]Negligible removal.

[d]Treatment effluent concentration exceeds that of treatment influent.

[e]Analytical methodology for phthalates is questionable. Therefore, significance of values reported is unknown.

[f]Screening data where purge and trap procedures were used indicated a reduction of 400 μg/L to <50 μg/L across treatment.

[g]Screening data indicate reduction to below significant level across treatment.

[h]Suspected contaminant from glassware cleaning procedures or analytical method.

Tables 17-18 and 17-19 show pollutant removal efficiencies at two selected solution crumb rubber plants.

II.17.4.3 Latex Rubber Plants

There are 17 latex rubber production facilities in the United States. Of these, nine plants discharge to POTW's; seven discharge to surface streams; and one employs land application with contractor disposal of solids. All seven plants discharging to surface streams employ biological treatment before discharge. Pretreatment for the POTW dischargers consists of coagulation, flocculation, and primary treatment for seven of the nine dischargers, equalization for one discharger, and biological treatment for the other plant.

In latex rubber production, BPT regulations require that toxic pollutants be removed across an activated sludge treatment which will permit compliance with the regulations when applied to raw wastewater. The application of steam stripping to heavy monomer decanter water, although not practiced, could significantly reduce waste loads to plants employing cold polymerization; however, steam stripping is not a viable option in plants employing hot polymerization with high monomer conversion efficiency.

II.17.4.4 Tire and Inner Tube Manufacturing

There are a total of 73 tire and inner tube manufacturing facilities in the United States, of which 39 were placed in operation prior to 1959. Twenty-three of the pre-1959 plants do not treat their wastewaters, and six of these plants discharge to POTW's. A total of 17 plants placed in operation since 1959 provide no treatment to their wastewaters, and 10 of these plants discharge into POTW's.

The toxic pollutants present in raw wastewaters from tire and inner tube manufacturing operations are volatile organic pollutants that are used as degreasing agents in tire production. These toxic pollutants (methylene chloride, toluene, trichloroethylene) were found to be reduced to insignificant levels across sedimentation ponds.

The application of oil separation, filtration, or sedimentation followed by oil separation could permit compliance of tire plant treated effluents with BPT regulations.

II.17.4.5 Rubber Reclamation Plants

There are nine rubber reclaiming plants in the United States. two of these use wet digestion, and all nine use pan, mechanical, and dry digestion. Eight of the plants discharge to POTW's. The other plant employs cartridge filtration and activated carbon

TABLE 17-18. TOXIC POLLUTANT REMOVAL EFFICIENCY AT SOLUTION CRUMB RUBBER PLANT 000005 [1]

Treatment technology: Primary flocculation/clarification (DAF)
Discharge point: Treated effluent is discharged to a nearby oil refinery's cooling water system

Pollutant	Concentration,[a] μg/L Influent	Concentration,[a] μg/L Effluent	Percent removal
Cadmium	<1	<1	-[b]
Copper	9	14	-[c]
Chromium	75	410	-[c]
Zinc	14,000	13,000	7
Bis(2-ethylhexyl) phthalate[d]	180	24	87
Phenol	7	5	29
Benzene	<22	110[e]	-[b]
Ethylbenzene	<46	<39	-[b]
Toluene	<26	<26	-[b]
Carbon tetrachloride	35	14	60
Chloroform	2.2	1.3	41
Methyl chloride	4,900	2,200[f]	55
Methylene chloride	<1.0	<1.0	-[b]
1,1,2-Trichloroethane	<0.1	<0.1	-[b]
Trichloroethylene	<0.1	<0.1	-[b]

[a]Values presented are averages of the values observed for the three 24-hr composite samples.

[b]Negligible removal.

[c]Treatment effluent concentration exceeds that of treatment influent.

[d]Analytical methodology for phthalates is questionable. Therefore, significance of values reported is unknown.

[e]Average of 320 μg/L, <11 μg/L and <11 μg/L.

[f]Found at significant levels in treatment effluent.

TABLE 17-19. TOXIC POLLUTANT REMOVAL EFFICIENCY AT SOLUTION CRUMB RUBBER PLANT 000027 [1]

Treatment technology: Sedimentation, waste stabilization lagoons
Discharge point: Surface stream

Pollutant	Concentration,[a] μg/L Influent	Effluent	Percent removal
Cadmium	<1	1	-[b]
Chromium	440	20	95
Copper	7	5	29
Mercury[c]	1.1	2.0	-[d]
Bis(2-ethylhexyl) phthalate[e]	120	110	8
Phenol[f]	180	11	94
Benzene	3,200	<0.1	100
Ethylbenzene	<0.1	<0.1	-[b]
Toluene	<0.1	<0.1	-[b]
Chloroform	3.0	0.9	70
1,1,2,2-Tetrachloroethane	<0.1	<0.1	-[b]

[a] Values presented are averages of the values observed for the three 24-hr composite samples.

[b] Negligible removal.

[c] Intake measured at 4 μg/L, making plant's contribution zero.

[d] Effluent concentration greater than influent concentration.

[e] Analytical methodology for phthalates is questionable. Therefore, significance of values reported is unknown.

[f] Screening data indicate reduction to below significant level across treatment.

for oil removal, followed by activated sludge. Table 17-20 shows the pollutant removal efficiency at a dry digestion reclaiming plant.

TABLE 17-20. TOXIC POLLUTANT REMOVAL EFFICIENCY AT DRY DIGESTION RECLAIMING PLANT 000134 [1]

Treatment technology: Cartridge filtration, activated carbon (oil removal), activated sludge, sedimentation

Discharge point: Noncontact cooling water system, blowdown of this system to surface stream

Pollutant	Concentration, μg/L		Percent removal	Cooling tower blowdown,[b] μg/L	Percent removal[b]
	Treatment influent[a]	Treatment effluent[a,b]			
Cadmium	1	3	-[c]	<1	100
Chromium	6	21	-[c]	2	90
Copper[d]	28	12	57	2	83
Lead	70	670	-[c]	29	96
Mercury	-[e]	2.3		0.5	78
Zinc	100	2,500	-[c]	100	96
Bis(2-ethylhexyl) phthalate[f]	16,000	4,200	74	100	98
2,4-Dimethylphenol[d]	58,000	25,000	57	120	100
Phenol[g]	26,000	4,900	81	27	99
Benzene	60	<0.1	100	<0.1	-[h]
Ethylbenzene	8,600	<0.1	100	<0.1	-[h]
Toluene	2,700	<0.1	100	<0.1	-[h]
Acenaphthylene	<33	<8	76	<8	-[h]
Flourene	2,000	<12	100	<12	-[h]
Naphthalene[i]	100,000	42	100	13	69
Phenanthrene	1,300	300	77	<4	100
Pyrene	6,800	11	100	4	64
Chloroform	1.9	1.4	26	4.9	-[c]

[a]Values presented are averages of the values observed for the three 24-hour composite samples.

[b]Effluent from treatment goes into cooling tower and is discharged with noncontact cooling water as cooling tower blowdown.

cNegative removal.

[d]Potentially significant levels observed in cooling tower blowdown.

[e]Interferences precluding analysis.

[f]Analytical methodology for phthalates is questionable. Therefore, significance of values reported is unknown.

[g]Potentially significant levels observed in cooling tower blowdown although screening data indicate reduction to below detection limits in treatment effluent.

[h]Negligible removal.

[i]Significance of blowdown value questionable due to high detection limit, low values observed in the carbon column effluent (treatment influent), and fact that compound is not a metabolic byproduct of activated sludge treatment.

II.17.4.6 Rubber Fabricating Operations

Rubber fabricating operations include latex dipped, extruded, and molded goods (LDEM) and general molded, extruded, and fabricated rubber (GMEF). There are an estimated 1,385 rubber fabricating plants in the United States.

No treatment method descriptions are currently available for this industry. Wastewater treatment technology consistent with equalization and sedimentation may permit compliance with BPT regulations.

II.17.5 REFERENCES

1. Review of Best Available Technology for the Rubber Processing Point Source Category (draft contractor's report). Contract 68-01-4673, U.S. Environmental Protection Agency, Washington, D.C., July 1978.

2. NRDC Consent Decree Industry Summary - Rubber Processing.

3. Environmental Protection Agency Effluent Guidelines and Standards for Rubber Processing. 40 CFR 428; 39 FR 6660, February 21, 1974 (amended by 39 FR 26423, July 19, 1974; 40 FR 2334, January 10, 1975; 40 FR 18172, April 25, 1975 [effective May 27, 1975]; and 43 FR 6230, February 14, 1978).

II.18 SOAP AND DETERGENT MANUFACTURING

II.18.1 INDUSTRY DESCRIPTION

II.18.1.1 General Description [1, 2]

The uses of soaps, detergents and their derivatives in many of the nation's industries and households make the soap and detergent manufacturing industry one of the most lucrative commercial successes in America. The industry consists of approximately 640 plants which produce a total of 28,000 Mg (62 million pounds) of soap and related products per day [2]. A vast portion of these products or their components will invariably be deposited in the nation's waterways and wastewater treatment facilities from various production plant operations or after actual household use.

Four large companies dominate the industry by owning nearly 5% of all the plants, selling 50% of all soap products, and accounting for 54% of total industry employment. Of these institutions, three are multinational corporations having individual annual sales over one billion dollars from the sale of household products and health and beauty aids [3]. These large corporations are able to own and economically operate innovative production processes and large, efficient wastewater treatment facilities and other pollution control equipment.

The medium to small plant operations that make up the remainder of the industry (approximately 95%), are limited to large population centers and state of the art technology. These plants must, in most cases, use publicly owned treatment facilities and operate with less capital for advanced process technologies and pollution abatement equipment.

The industry is covered under Standard Industrial Classification (SIC) Code 2841 which includes provisions for the manufacture of soap, synthetic organic detergents, and organic alkaline detergents, or any combination of these. SIC code 2841 also includes the manufacture of crude and refined glycerine from vegetable and animal fats and oils. The EPA Effluent Guidelines Division has devised a subcatergorization of this industry based upon the specific types of manufacturing processes undertaken at a given establishment. Table 18-1 gives information regarding the total number of these subcategories, the number of subcategories studied for this report, and the projected discharge status of 637 soap and detergent manufacturing plants in the United States.

TABLE 18-1. INDUSTRY SUMMARY [1, 2]

Industry: Soap and detergent manufacture
Total Number of Subcategories:
Number of Subcategories Sutdied: 13
Number of Dischargers in Industry:
• Direct: 10
• Indirect: 535
• Zero: Unknown

Projected industry statistics by SIC 2841 unit operation subcategories are included in Table 18-2, which lists all subcategories. This profile audit shows that there are an estimated 1,523 process installations which produce 28,000 Mg (62 million pounds) of soap, detergent, and glycerine per day. Liquid detergent and dry blended detergent manufacturing account for 47% of this production. As shown in Table 18-2, over 75% (124,000 m^3/d) of the normalized approximate total wastewater flow (143,000 m^3/d) is estimated to come from the 40 glycerine recovery (concentration and distillation) installations.

II.18.1.2 Subcategory Descriptions [1]

The method for subcategorizing the soap and detergent manufacturing industry mentioned above was established to identify potential wastewater sources and controls, provide a permit granting authority with a way to analyze a specific plant regardless of its complexity, and permit monitoring for compliance without undue complication or expense [1]. The categorization consists of 2 major categories and 19 subcategories. The major categories follow the natural division of soap manufacturing (production of alkaline metal salts and fatty acids derived from natural fats and oils) and detergent manufacturing (production of sulfated and sulfonated cleaning agents from manufactured raw materials, primarily petroleum derivatives). The subcategories are based on discrete manufacturing units employed by the industry for conversion of raw materials to intermediate products and conversion of intermediate products to finished/marketed products. A manufacturing unit may contain a single process (e.g., continuous neutralization for production of neat soap by fatty acid neutralization) or a number of processes (e.g., crutching, drying, milling, plodding, stamping, and packaging for production of bar soaps from neat soap).

In general, establishments in SIC 2841 employ between one and nine subcategory technologies. Table 18-3 presents the predominant subcategory combinations employed in such establishments.

TABLE 18-2. PROCESS INDUSTRY STATISTICS BY SIC 2841
UNIT OPERATION SUBCATEGORIES [2]

Subcategory	Subcategory title	Projected number of installations	Approx. total production, 10^3 kg/day	Normalized approx. total wastewater flow, m^3/day
1	Soap Manufacture by Batch Kettle	151	590	85.9
2	Fatty Acid Manufacture by Fat Splitting	22	1,940	4,200
3	Soap Manufacture by Fatty Acid Neutralization	177	2,220	86.7
4 5	Glycerine Concentration Glycerine Distillation — Glycerine Recovery	40	415	124,000
6	Soap Flakes and Powders	141	200	1.59
7	Bar Soaps	69	1,100	26.6
8	Liquid Soaps	223	1,600	21.1
9[a]	Oleum Sulfonation and Sulfation			
10[a]	Air-SO_3Sulfation and Sulfonation			
11[a]	SO_3 Solvent and Vacuum Sulfonation			
12[a]	Sulfamic Acid Sulfation			
13[a]	Chlorosulfonic Acid Sulfation			
14[a]	Neutralization of Sulfuric Acid Esters and Sulfonic Acids			
15	Spray Dried Detergent Manufacture	54	6,540	8,860
16	Liquid Detergent Manufacture	341	9,680	1,080
17	Detergent Manufacture by Dry Blending	289	3,390	24.1
18	Drum Dried Detergents	5	36	122
19	Detergent Bars and Cakes	11	293	4,320
	Totals	1,523	28,000	143,000

[a]Intermediate process; statistics are included in other subcategory totals.

TABLE 18-3. PREDOMINANT SUBCATEGORY COMBINATIONS USED BY THE INDUSTRY[a] [2]

Number of subcategories for each establishment	Total number of establishments involved	Predominant subcategories employed	Number of establishments employing subcategories	Percent of establishments involved
1	187	a. 16	61	33
		b. 17	54	29
2	235	a. 16, 17	109	46
		b. 15, 17	20	9
3	112	a. 3, 16, 17	31	28
		b. 3, 8, 16	24	21
4	51	a. 1, 3, 8, 16	14	27
		b. 6, 8, 16, 17	7	14
5	17	a. 1, 4 and 5[b], 7, 15, 16	7	41
6	17	a. 1, 4 and 5[b], 7, 15, 16, 17	7	41
7	17	a. 2, 3, 4 and 5[b], 7, 15, 16, 17	10	59
8	0	a. --	0	0
9	2	a. 1, 2, 3, 4 and 5[b], 6, 7, 16, 17, 19	1	50
		b. 2, 3, 4 and 5[b], 6, 7, 15, 16, 17, 19	1	50
Totals	638		346	

[a]The predominant subcategories employed are reported as the two largest groups under each division set up in column one, with a. the largest group, and b. the second largest group.

[b]Subcategories 4 and 5 are counted as one subcategory because they are normally used together for glycerine recovery.

As can be seen, 346 out of the total of 638 establishments, or 54% of the total, utilize the 13 subcategory combinations listed. The remaining 292 establishments (46%) utilize another 70 different subcategory combinations.

The subcategories are described below.

Subcategory 1 - Soap Manufacture by Batch Kettle

Most of the soap made by this process finds its way into toilet bar form for household usage. This use demands freedom from offensive odors and from displeasing colors. In order to meet this requirement, the starting fats and oils must be refined. There is a direct relationship between quality of the fats and quality of the finished soap.

Fat Refining and Bleaching. There are several ways in which fats are refined. One of the most frequently used methods employs activated clay as the extraction agent. Activated clay, having a large ratio of surface area to weight, is agitated with warm oil and filtered. Bleaching occurs as color bodies, dirt, etc., are removed, usually through a plate and frame press. The clay is disposed of as solid waste. A small amount of clay remains in the refined fat.

Other ways in which fats are refined include caustic extraction, steam stripping, and use of proprietary aqueous chemicals.

Soap Boiling. Although a very old process, kettle boiling still makes a very satisfactory product, and in several well integrated manufacturing plants this process has a very low discharge of wastewater effluents. In this process vegetable and animal fats and oils are alternately heated in the presence of alkaline materials and inorganic salts to yield two fractions: (1) a crude, unfinished soap called neat soap; and (2) crude, dilute glycerine.

Salt Usage. In order to maintain suitable solubility for proper processing, salt is added to the soap-making process to maintain the required electrolytic balance. Most of the salt charged into the process is ultimately returned to it from the glycerine concentration step, which will be discussed later. Practically every kettle boiling soap manufacturer concentrates the glycerine stream, although only a few go on to the distillation of glycerine.

Subcategory 2 - Fatty Acid Manufacture by Fat Splitting

By means of fat splitting very low grade fats and oils are upgraded to high value products by splitting the glycerides into their two components, fatty acids and glycerine. Fat splitting is a hydrolytic reaction which proceeds as follows:

$$Fat + Water \rightarrow Fatty\ Acid + Glycerine$$

Vegetable and animal fats and oils are heated to 260°C under pressure, in the presence of various catalysts, to yield two fractions: (1) a crude mixture of fatty acids in water, and (2) crude, dilute glycerine. The glycerine byproduct can be produced at a variety of concentrations depending upon how complete a fat hydrolysis is desired. More concentrated glycerine can be provided at some expense to fatty acid yields. Catalysts employed include zinc, tin, or an aromatic sulfonic acid. The crude mixture of fatty acids is then distilled to recover those applicable to soap manufacturing. Sometimes this fraction is subjected to flash hydrogenation, using nickel as a catalyst, to reduce the amount of unsaturated fatty acids present. As in Subcategory 1, the raw fats and oil are sometimes refined prior to any other processing.

Subcategory 3 - Soap from Fatty Acid Neutralization

Soap making by fatty acid neutralization exceeds the kettle boil process in speed and minimization of wastewater effluent. Widely used by the large soap producers, it is also very popular with the smaller manufacturer.

This route from the acids is faster, simpler (no by product dilute glycerine stream to handle), and "cleaner" than the kettle boil process. Distilled, partially hydrogenated acids are usually used.

The reaction that takes place is substantially:

$$Caustic + Fatty\ Acid \rightarrow Soap$$

The resulting neat soap, containing about 30% moisture, is further processed into bars or liquid formulations in the same manner as the product from kettle boiling.

Subcategory 4 - Glycerine Concentration

The kettle boiling soap process generates an aqueous stream referred to as sweet water lyes. This stream will contain 8% to 10% glycerine, a heavy salt concentration, and some fatty materials. It is processed by first adding a mineral acid (HCl) to reduce the alkalinity. This is followed by the addition of alum, which precipitates insoluble aluminum soaps. The precipitate carries other impurities down with it. If the stream were not treated with alum, there would be severe foaming in the evaporators, and the contaminant would be carried forward into the glycerine. The cleaned up glycerine solution is sent to the evaporators, which are heated under reduced pressure. As the glycerine is concentrated, the salt comes out of solution and is removed from the evaporation kettle, filtered, and returned to the soap-making process. In many plants this separating function is performed continuously by a centrifuge, with the filtrate being returned to the evaporator.

The glycerine is usually concentrated to 80% by weight and then either run to a still to be made into finished glycerine, or stored and sold to glycerine refiners.

The sweet water glycerine from fat splitting is flashed to atmospheric pressure, thereby releasing a considerable amount of water very quickly. This can provide a glycerine stream of 20% glycerine or more going to the evaporators. Since there is no salt used in fat splitting there will be none in the sweet water.

Subcategory 5 - Glycerine Distillation

In this process, the concentrated glycerine (80%) is run into a still which, under reduced pressure, yields a finished product of 98+% purity. At room temperature, the still bottoms (also called glycerine foots) are a glassy, dark brown, amorphous solid rather rich in salt. Water is mixed with the still bottoms before they are run into the wastewater stream.

Some glycerine refining is done by passing the dilute stream over ion exchange resin beds, both cationic and anionic, and then evaporating it to 98+% glycerine content as a bottoms product. There are frequently three sets, in series, of both cation and anion exchange resins used in this process. Each step is designed to reduce the input load by 90%. Some of the fat splitting plants are equipped with this type of unit.

Subcategory 6 - Soap Flakes and Powders

Neat soap (65% to 70% hot soap solution) may or may not be blended with other products before flaking or powdering. Neat soap is sometimes filtered to remove gel particles and run into a crutcher for mixing with builders.

After thorough mixing, the finished formulation is run into a flaker. This unit normally consists of a two-roll "mill." The small upper roll is steam heated while the larger, lower one is chilled. The soap solidifies on the lower roll and is slit into ribbons as it sheets off the mill.

The ribbons are fed into a continuous oven heated by hot air. The emerging flakes contain 1% moisture. All of the evaporated moisture goes to the atmosphere, creating no wastewater effluent.

In spray drying, crutched, heated soap solution is sprayed into a spray tower, or flash dried by heating the soap solution under pressure and releasing the steam in the spray dryer under reduced pressure. In either case the final soap particle has a high ratio of surface area to unit of weight, which makes it readily soluble in water.

Subcategory 7 - Bar Soaps

In some bar soap processes additives are mixed with the neat soap in a crutcher before any drying takes place. Another approach is to begin the drying process with the hot neat soap going to an "atmospheric" flash dryer followed by a vacuum drying operation in which the vacuum is drawn by a barometric condenser. Soap is then double extruded into short ribbons or curls and sent to plodders for further blending or physical processing. At this point the soap will normally have 8% to 14% moisture depending upon the previous course of processing.

Next, a milling operation affords the opportunity to blend in additives and to modify the physical properties of the soap. The mill consists of two polished rolls rotating at different speeds to maximize the shearing forces. After milling, the soap is cut into ribbons and sent to the plodder.

The plodder extrudes and cuts the soap into small chips, after which further mixing melts all of the individual pieces together into a homogeneous mass.

Plodding completed, the soap is extruded continuously in a cylindrical form, cut to size, molded into the desired form, and wrapped for shipment. Most of the scrap in this operation is returned to the plodder.

The amount of water used in bar soap manufacture varies greatly. In many cases the entire bar soap processing operation is done without generating a single wastewater stream. The equipment is all cleaned dry, without any washups. In other cases, due to housekeeping requirements associated with the particular bar soap process, there are one or more wastewater streams for air scrubbers.

Subcategory 8 - Liquid Soaps

In the liquid soap process neat soap (often the potassium soap of fatty acids) is blended in a mixing tank with other ingredients such as alcohols or glycols to produce a finished product, or with pine oil and kerosene for a product with greater solvency and versatility. The final blended product may be, and often is, filtered to achieve a sparkling clarity before being drummed.

In making liquid soap, water is used to wash out the filter press and other equipment. Wastewater effluent is minimal.

Subcategory 9 - Oleum Sulfonation and Sulfation (Batch and Continuous

One of the most important active ingredients of detergents is alcohol sulfate or alkyl benzene sulfonate, particularly in products made by the oleum route.

In most cases the sulfonation/sulfation process is carried out continuously in a reactor where the oleum (a solution of sulfur trioxide in sulfuric acid) is brought into intimate contact with the hydrocarbon or alcohol. Reaction is rapid. The stream is then mixed with water and sent to a settler.

Prior to the addition of water the stream is a homogeneous liquid. With the addition of water, two phases develop and separate. The dilute sulfuric acid is drawn off and usually returned to an oleum manufacturer for reprocessing up to the original strength. The sulfonated/sulfated material is sent on to be neutralized with caustic.

Subcategory 10 - Air-SO_3 Sulfation and Sulfonation (Batch and Continuous)

This process for surfactant manufacture has numerous unique advantages and is used extensively. In the oleum sulfation of alcohols, formation of water stops the reaction short of completion because it reaches a state of equilibrium, resulting in low yields. With SO_3 sulfation, no water is generated, hydrolysis cannot occur, and the reaction proceeds in one direction only.

SO_3 sulfonation/sulfation is also quite amenable to batch processing, which can produce products having a minimum of sodium sulfate (all of the excess SO_3, or sulfuric acid in the case of oleum sulfonation, will be converted into sodium sulfate in the neutralization step with caustic). Another advantage of the SO_3 process is its ability to successively sulfate and sulfonate an alcohol and a hydrocarbon respectively.

Subcategory 11 - SO_3 Solvent and Vacuum Sulfonation

Undiluted SO_3 and organic reactant are fed into the vacuum reactor through a mixing nozzle in this process. Recycle is accomplished by running the flashed product through a heat exchanger back into the reactor. The main advantage of the system is that under vacuum the SO_3 concentration and operating temperature are kept low, thereby assuring high product quality. Offsetting this is the high operating cost of maintaining the vacuum.

Subcategory 12 - Sulfamic Acid Sulfation

Sulfamic acid, a mild sulfating agent, is used only in very specialized quality areas because of the high reagent price. The system is of particular value in the sulfation of ethoxylates.

The small specialty manufacturer may use this route for making high quality alcohol sulfates, equivalent to those from the chlorosulfonic acid route, substituting high reagent cost for the high capital costs of the chlorosulfonic route.

Subcategory 13 - Chlorosulfonic Acid Sulfation

For products requiring high quality sulfates, chlorosulfonic acid is an excellent agent. It is a mild sulfating agent, yields no water of sulfation, and generates practically no side reactions. It is a corrosive agent and generates HCl as a by product.

An excess of about 5% chlorosulfonic acid is often used. Upon neutralization it will yield an inorganic salt which is undesirable in some applications because it can result in salt precipitation in liquid formulations, etc.

Subcategory 14 - Neutralization of Sulfuric Acid Esters and Sulfonic Acids

This step is essential in the manufacture of detergent active ingredients; it converts the acidic hydrophylic portion of the molecule to a neutral salt.

Alcohol sulfates are somewhat more difficult to neutralize than the alkylbenzene sulfonic acids due to the sensitivity to hydrolysis of the alcohol derivative. For this reason, neutralization is usually carried out as a pH above 7 and as rapidly as possible.

Subcategory 15 - Spray Dried Detergents

In this segment of processing, the neutralized sulfonates and/or sulfates are brought to the crutcher where they are blended with requisite builders and additives. From here the slurry is pumped to the top of a spray tower where nozzles around the top spray out detergent slurry of approximately 70% concentration.

Wastewater streams are rather numerous. They include many washouts of equipment, from the crutchers to the spray tower itself. One wastewater flow with high loadings comes from the air scrubber which cleans and cools the hot gases exiting from the spray tower. This is only one of the several units in series utilized to minimize the particulate matter being sent into the atmosphere.

After the powder comes from the spray tower it is further blended and then packaged. Solid wastes from this area are usually recycled.

Subcategory 16 - Liquid Detergents

For liquid detergents the sulfonated and sulfated products for the processes described in subcategories 9 through 14 are pumped into mixing tanks where they are blended with numerous ingredients, ranging from perfumes to dyes. From here, the fully formulated liquid detergent is run down to the filling line.

Subcategory 17 - Dry Detergent Blending

In this process fully dried "active" (surfactant) materials are blended with additives, including builders, in dry mixers. In the more sophisticated plants mixing time is utilized to the maximum by metering components into weighing bins prior to loading into mixers. When properly mixed, the homogeneous dry product is packed for shipment.

Subcategory 18 - Drum Dried Detergents

Drum drying of detergents is an old process. Much of the equipment still in use is well over 30 years old. The process yields a fairly friable product which can become quite dusty with any extensive handling.

A thin layer of the filler cake on the drum is removed continuously by a knife blade onto conveyors. The powder is substantially anhydrous. The vapors coming off are often collected and removed through a vapor head between the drums.

This operation should be essentially free of generated wastewater discharge except that from an occasional washdown.

Subcategory 19 - Detergent Bars and Cakes

In answer to the need for a "bar soap" which performs satisfactorily in hard water, the detergent industry manufactures and markets detergent bars. They constitute about 20% of the toilet bar market.

There are two types of "detergent" bars: those made of 100% synthetic surfactant and those blended from synthetic surfactant and soap. Most products are the latter type.

Blending methods and types of equipment are essentially the same as those used for conventional soap.

II.18.2 Wastewater Characterization [1]

There are essentially three types of in-plant pollutants in the wastewater effluent streams:

- Impurities removed from raw materials
- By products or degradation products made in the process
- Very dilute product (in aqueous solution) resulting from leaks, spills, and equipment cleanout.

TABLE 18-4. MAJOR WASTEWATER POLLUTANTS FROM PROCESSES IN SUBCATEGORIES OF THE SOAP AND DETERGENT MANUFACTURING INDUSTRY[a] [1]

	Subcategory	Major wastewater pollutants	Source(s) of pollutants in process
1	Soap manufacture by batch kettle	Fats and oils; unrecovered NaCl, Na_2SO_4, and NaOH; spilled and lost soaps and by products (glycerine)	Fat refining and bleaching, fat heating, neutralization of batch, fat handling.
2	Fatty acid manufacture by fat splitting	Fatty acids, unreacted fats and glycerine; sodium salts and NaOH; zinc and alkaline earth metals, nickel	Fat heating, catalytic splitting, flash hydrogenation, neutralization
3	Soap from fatty acid neutralization	Fats and oils; unrecovered NaCl, Na_2SO_4, and NaOH; spilled and lost soaps and by-products (glycerine)	Fat heating, catalytic splitting, flash hydrogenation, neutralization
4 and 5	Glycerine concentration and distillation (glycerine recovery)	Glycerine, glycerine polymers, NaCl, and Na_2SO_4	Lye treatment, glycerine distillation
6	Soap flakes and powders[a]	Pure soap, small amounts of free fatty material, NaCl from spills and leaks	Flaking, crutching and drying, spray drying, packaging
7	Bar soaps	Pure soap, small amounts of free fatty material, NaCl from spills and leaks	Soap milling, crutching and drying, packaging

(continued)

TABLE 18-4 (continued)

	Subcategory	Major wastewater pollutants	Source(s) of pollutants in process
8	Liquid soaps	Solvents (alcohols or glycols), builders, dyes, perfumes, and potassium salts	Receiving and storage, blending, packaging
9	Oleum Sulfonation and Sulfation[a]	Oily raw materials, sulfuric acid, and surfactant sulfonic acid	Receiving and storage, oleum fume scrubber, cooling water, reactor leaks and spills, reactor and mixer washouts
10	Air-SO_3 sulfation and sulfonation[a]	Oily raw materials, sulfuric acid, and surfactant sulfonic acid	Receiving and storage, vaporizer condensate, dryer and reactor washouts
11	SO_3 solvent and vacuum sulfonation[a]	Oily raw materials, sulfuric acid, surfactant sulfonic acid, and sulfate	Receiving and storage, vaporizer condensate, scrubber and degasser
12	Sulfamic acid sulfation[a]	Unsulfated ethoxy alcohols, sulfamic acid, ammonium ether sulfates, fatty alcohols, alcohol ethoxylates, alkyl phenol ethoxylates, ammonium, sodium, and triethanol amine salts, hydrochloric and sulfuric acid, ammonium and sodium ions.	Receiving and storage, reactor washouts
13	Chlorosulfonic acid sulfation[a]	No information available	

(continued)

TABLE 18-4 (continued)

	Subcategory	Major wastewater pollutants	Source(s) of pollutants in process
14	Neutralization of sulfuric acid esters and sulfonic acids[a]	Products of subcategories 9, 10, and 11; neutralized products; the various cations	Receiving and storage, neutralization
15	Spray dried detergents[a]	LAS, amide, nonionic and alcohol surfactants; sodium phosphate, carbonate and silicate builders; carboxmethyl cellulose, brighteners, perborate, dyes, fillers, and perfume	Receiving and storage, transfer, fume scrubbers, crutching, spray drying, blending and packaging
16	Liquid detergents	Organic surface active agents from cleanup and washdown; citrate builders and solvents (ethanol); potassium phosphate; silicates; sodium xylene sulfonates, urea, various additives	Storage and transfer areas, blending washes, packaging leaks and spills
17	Dry detergent blending	LAS, amide, nonionic and alcohol surfactants; sodium phosphate, carbonate and silicate builders; carboxmethyl cellulose, brighteners, perborate, dyes, fillers, and perfume	Dry blending and packaging washouts

(continued)

TABLE 18-4 (continued)

	Subcategory	Major wastewater pollutants	Source(s) of pollutants in process
18	Drum dried detergents[a]	Raw material and surfactants	Drum drying and packaging washouts
19	Detergent bars and cakes[a]	Pure soap, small amounts of free fatty material, NaCl from spills and leaks, and synthetic surfactants	Soap milling, crutching, and drying, packaging

[a]Subcategory process typically requires scrubber use.

Major types of wastewater pollutants from the subcategories of the soap and detergent manufacturing industry can be found in Table 18-4. This table shows that resultant wastewaters depend upon process operating parameters and the kind of soap or detergent material produced.

Of these pollutants, several are of particular environmental concern. Synthetic surface active agents not only create BOD_5 and COD, but they cause water to foam and, in high concentrations, they can be toxic to fish and other organisms. Nutrients, particularly phosphate produced in part by liquid detergent manufacture, are of concern because of their contribution to euthrophication of lakes. Soap production leads to wastewaters with high alkalinity, high salt, and high oxygen demand. Spills of raw materials contribute to oil and grease levels. Most of the suspended solids come from organics (i.e., calcium soaps), and many are of the volatile rather than nonvolatile type. Since strong acids and strong alkalies are used in most of these subcategories, pH can be very high or very low in wastewaters [1].

II.18.3 PLANT SPECIFIC DESCRIPTION [2]

In 1977, a survey of the industry was undertaken for the U.S. Environmental Protection Agency. Four hundred and nine forms were sent to U.S. establishments, and 170 responses applicable to SIC 2841 were obtained. The survey asked for information on parameters such as production levels, process subcategories at a given facility, and the fate and characteristics of the wastewater generated in each subcategory. This survey included a sampling and analysis review to establish the presence or absence of toxic compounds in wastewaters discharged from the various subcategories.

The results of the review, however, were suspect for all subcategories except subcategory 15. This was due to possible deviations from EPA's analytical protocol involving excessive lag times between sample collection and extraction.

As a result, an additional sampling and analysis review was performed in 1979. Wastewaters from subcategories 6, 8, and 17 were not examined in 1979 because they comprise only 0.03% of the industry's total discharges and because of the difficulty associated with scheduling sampling and analysis surveys coincident with the low intermittent discharge flow rates of these three subcategories. Also, since the only wastewater from subcategory 18 evolves from pump seal water and the washdown of off-specification product, wastewater samples were not collected from subcategory 18. In addition, no sampling data from this effort are available for Subcategories 9 through 14. Based on similarities in raw materials used in each subcategory, process technologies employed for each subcategory, and resultant subcategory final products it was generally felt that if toxic substances were found in the wastewaters from the omitted subcategories, they

TABLE 18-5. TOXIC POLLUTANTS DETECTED IN THE 1979 SAMPLING REVIEW OF THE SOAP AND DETERGENT INDUSTRY [2]

Total wastewater, m^3/1,000 kg of product: Subcategory 1, 1.9; Subcategory 2, 7.59; Subcategory 3, 0.0075; Subcategories 4 and 5, 180; Subcategory 7, 7.34; Subcategory 15, 4.76; Subcategory 16, 1.02; Subcategory 19, 21.6

Toxic pollutant	Subcategory concentration, µg/L							
	1	2	3	4 and 5	7	15	16	19
Metals and inorganics:								
Antimony							1.0	
Arsenic					20		1.0	
Cadmium							1.0	
Chromium		13		99		22	4.9	
Copper	3,400	65	67	38	6.7	19	31	17
Cyanide	10	9.5		0.1				16
Lead				15	13	36	13	57
Mercury	76							
Nickel		29	67	39		2.3	11	
Silver					1.8	69	94	
Thallium					18		5.9	
Zinc	1,600	2,500	67	15		26	91	20
Phthalates:								
Bis(2-ethylhexyl) phthalate							20	
Di-n-butyl phthalate		13		0.5		15		
Phenols:								
2-Chlorophenol	96							
Pentachlorophenol		150					3.9	
Phenol	4,400	7.1		34		30	28	
2,4,6-Trichlorophenol						7.3		
p-Chloro-m-cresol						2.9		

(continued)

TABLE 18-5 (continued)

Total wastewater, m^3/1,000 kg or product: Subcategory 1, 1.9; Subcategory 2, 7.59; Subcategory 3, 0.0075; Subcategories 4 and 5, 180; Subcategory 7, 7.34; Subcategory 15, 4.76; Subcategory 16, 1.02; Subcategory 19, 21.6

	Subcategory concentration, µg/L							
Toxic pollutant	1	2	3	4 and 5	7	15	16	19
Aromatics:								
Benzene		0.7		0.1				
Chlorobenzene						22		0.6
Polycyclic aromatic hydrocarbons:								
Phenanthrene/trichloroethylene		1.8		0.4		27		
Halogenated aliphatics:								
1,1-Dichloroethylene				18			11	25
1,2-*Trans*-dichloroethylene								3.3
Trichloromethane						4.8		1.1
Methylene chloride	59						19	1.1
Chloroethylene								12
Trichloroethylene[a]								
Tetrachloroethylene	15							
Pesticides and metabolites:								
r-BHC						2.2		

[a]See phenanthrene.

would be comparable to those detected in the wastewaters from subcategories actually involved in the sampling and analysis review.

Raw wastewater data resulting from the sampling and analysis review are presented in Table 18-5. Establishments surveyed in 1979 utilized, among others, Subcategories 7, 8, and 16. At the establishment employing subcategory 7 there were six production lines. Only one line had a continuous wastewater discharge and that amounted to less than 0.5 gal/hr of a salt water solution. In general, all six production lines were cleaned without the use of water; however, there was the possibility of periodic small volumes of washdown water being discharged to the POTW. At the establishment employing subcategory 8, any subcategory wastewaters generated were recycled to extinction and, thus, were never discharged from the establishment. The wastewater was not analyzed because of the nondischarge situation. The establishment employing subcategory 16 had a very small intermittent discharge of wastewater resulting mainly from equipment washdowns. However, noncommingled samples of ths wastewater could not be collected. It should be further noted that this establishment was installing a complete recycle/reuse system for all of the wastewater generated in subcategory 16.

The data from Table 18-5 were used to calculate the volumes of toxic pollutants in the raw wastewaters discharged from all of the subcategories in SIC 2841 for all 638 establishments in the industry. Values are presented in Table 18-6. The missing data for subcategory 3 were calculated by averaging unit wastewater data from subcategories 2 and 7. Unit wastewater data from subcategories 1, 3, and 7 were then averaged to develop the values for subcategories 6 and 8. Similarly, data for subcategories 17 and 18 were obtained from subcategories 15, 16, and 19.

The toxic pollutant data are further summarized, by subcategory, in Table 18-7 where the pollutants are categorized into inorganic and organic fractions. Of the total mass of 100 kg/day (230 lb/day) of toxic pollutants present in the industry's raw wastewaters, 72% are inorganic and 28% are organic in nature.

To project typical establishment raw wastewater characteristics, the subcategory production rates obtained by the 1977 survey were combined with the toxic pollutant information given in Table 18-6 and the predominant subcategory combinations shown in Table 18-3. The projections for small establishments are shown in Table 18-8 and for large establishments in Table 18-9. Table 18-10 presents the volumes of toxic pollutants in the direct discharges from six establishments having NPDES permits. These discharges approximate 11.5% of the total industry's wastewater volume, yet contain only 2.8% of the total industry's inorganic toxic pollutant discharges and 1.6% of the total industry's organic toxic pollutant discharges.

TABLE 18-6. CONCENTRATIONS OF TOXIC POLLUTANTS IN TOTAL INDUSTRY RAW WASTEWATERS [2] (g/d)

Toxic pollutant	Subcategory											
	1	2	3	4 and 5	6	7	8	15	16	17	18	19
Metals and inorganics												
Antimony									9.53	0.907		
Arsenic			167		37.6	165	299		9.53	0.907		
Cadmium									9.53	0.907		
Chromium		195		7,400				687	48.5	124	1.36	
Copper	3,800	961	2.27	2,840	9.98	54	79.8	595	300	553	5.9	130
Cyanide	11.3	140		2.27								97.5
Lead				1,090	19.5	108	156	1,100	126	1,590	16.8	358
Mercury	84.8											
Nickel		425	2.27	2,940	0.454		1.36	72.1	107	24.5	0.454	
Silver					2.72	14.5	20.4	2,150	929	480	5.0	
Thallium					26.3	144	209		58.1	6.8		
Zinc	1,850	36,800	2.27	1,100	0.454		1.36	1,620	900	386	4.08	127
Phthalates												
Bis(2-ethylhexyl) phthalate									194	22.7	0.454	
Di-n-butyl phthalate		186	109	35.8	5.0		39	465		80.3	9.07	
Phenols												
2-Chlorophenol	108				18.1		145					
Pentachlorophenol		2,210	1,270		57.2	455		38.6	4.54			
Phenol	4,950	105	59.9	2,570	844		6,710	1,880	271	356	3.63	
2,4,6-Trichlorophenol								230		39.5	0.454	
p-Chloro-*m*-cresol								91.6		15.9	0.454	
Aromatics												
Benzene		9.53	5.44	9.98	0.454		1.81					
Chlorobenzene								674		130	1.36	3.63
Polycyclic aromatic hydrocarbons												
Acenaphthene												
Phenanthrene/trichloroethylene		27.2	15.4	30.4	0.907		5.9	824		142	1.36	
Halogenated aliphatics												
1,1,-Dichloroethylene				1,310					107	622	6.8	167
1,2-*Trans*-dichloroethylene										81.2	0.907	20.9
Trichloromethane								151		53.1	0.454	6.8
Methylene chloride	66.2				11.3		89.4		184	48.5	0.454	6.8
Chloroethylene										293	3.18	75.7
Trichloroethylene[a]												
Tetrachloroethylene	16.3				2.72		2.22					
Pesticides and metabolites												
γ-BHC								72.1		12.7		

Blanks indicate no data available.

TABLE 18-7. INORGANIC AND ORGANIC TOXIC POLLUTANTS IN TOTAL INDUSTRY RAW WASTEWATERS [2]

	Inorganic pollutants		Organic pollutants		All pollutants	
Subcategory	kg/day	Percent of total	kg/day	Percent of total	kg/day	Percent of total
1	5.74	7.78	5.14	17.80	10.9	10.60
2	38.5	52.22	2.54	8.79	41.1	40.00
3	0.172	0.24	1.66	5.05	1.63	1.59
4 and 5	15.4	20.84	3.96	13.72	19.3	18.84
6	0.095	0.13	0.939	3.25	1.03	1.01
7	0.485	0.66	0.00	0.00	0.486	0.47
8	0.767	1.04	7.47	25.87	8.24	8.02
15	6.23	8.45	4.39	15.18	10.6	10.34
16	2.50	3.38	0.794	2.75	3.29	3.20
17	3.17	4.29	1.90	6.58	5.07	4.94
18	0.032	0.05	0.018	0.07	0.050	0.05
19	0.69	0.94	0.272	0.94	0.962	0.94
Totals	73.8	100.02	28.9	00.00	103	100.00

TABLE 18-8. CONCENTRATIONS OF TOXIC POLLUTANTS IN SMALL FACILITY PREDOMINANT SUBCATEGORY COMBINATION RAW WASTEWATERS [2]
(mg/day)

	Subcategory combination						
Toxic pollutant	1a	1b	2a	3a	3b	4a	4b
Metals and inorganics							
Antimony	4.50		4.50	4.50	4 50	4 50	4 50
Arsenic	4.50		4 50	9 10	13 6	13 6	72 6
Cadmium	4.50		4.50	4.50	4.50	4.50	4 50
Chromium	13.6	213	227	227	13 6	13 6	227
Copper	81.7	948	1,030	1,030	86.2	10,300	10,300
Cyanide						31 8	
Lead	36.3	2,720	2,760	2,760	40 8	40 8	2,800
Mercury						227	
Nickel	27 2	40 8	680	72 6	27 2	27 2	72 6
Silver	254	821	1,080	1,080	254	254	1,080
Thallium	18.1	13.6	34.9	29 2	22 7	22 7	77 1
Zinc	245	662	54.4	54.4	245	5,210	907
Phthalates							
Bis(2-ethylhexyl) phthalate	54.4	40 8	54 4	90 7	54 4	54 4	90 7
Di-n-butyl phthalate		136	136	147	4 5	4 5	145
Phenols							
2-Chlorophenol					4 5	295	31 8
Pentachlorophenol	9.1	90 7	182	68.1	77.1	77 1	123
Phenol	72.6	608	681	685	268	13,600	2,210
2,4,6-Trichlorophenol		68 1	68 1	68 1			68 1
p-Chloro-m-cresol		27.2	27.2	27.2			27 2
Aromatics							
Chlorobenzene		222	222	222			222
Polycyclic aromatic hydrocarbons							
Phenanthrene/trichloroethylene		245	245	245			245
Halogenated aliphatics							
1,1-Dichloroethylene	27 2	5,070	1,090	1,090	27 2	27.2	1,100
1,2-Trans-dichloroethylene		141	141	141			141
Trichloromethane		90.7	90 7	90 7			90 7
Methylene chloride	49 9	81.7	13.2	13.2	54 4	54 4	154
Chloroethylene		504	504	504			504
Trichloroethylene[a]							
Tetrachloroethylene						45 4	4 50
Pesticides and metabolites							
γ-BHC		22.7	22.7	22.7			22 7

Blanks indicate no data available

[a]See phenanthrene

TABLE 18-9. CONCENTRATIONS OF TOXIC POLLUTANTS IN LARGE FACILITY PREDOMINANT SUBCATEGORY COMBINATION RAW WASTEWATERS [2] (mg/day)

Toxic pollutant	Subcategory combination					
	1a	1b	2a	2b	3a	3b
Metals and inorganics						
Antimony	86.2	13.6	99.8	86.2	99.8	86.2
Arsenic	86.2	13.6	99.8	86.2	3,980	12,800
Cadmium	86.2	13.6	99.8	86.2	99.8	86.2
Chromium	436	159	203	166	203	435
Copper	2,700	6,190	9,800	16,700	9,850	5,100
Cyanide						
Lead	1,130	2,230	21,600	27,100	21,500	5,730
Mercury						
Nickel	957	.313	1,270	2,650	1,320	1,050
Silver	8,360	6,130	14,500	59,000	1,450	8,970
Thallium	521	86.2	608	521	608	666
Zinc	811	4,950	13,000	46,200	13,400	8,000
Phthalates						
Bis(2-ethyhexyl) phthalate	1,740	290	2,030	1,740	2,030	1,740
Di-n-butyl phthalate		1,029	1,029	10,916	3,061	3,675
Phenols						
2-Chlorophenol						4,260
Pentachlorophenol	341	59.0	403	344	29,900	43,200
Phenol	2,436	4,559	7,000	46,600	8,390	201,000
2,4,6-Trichlorophenol		508	508	5,420	508	
p-Chloro-m-cresol						
Aromatics						
Benzene					1,276	182
Chlorobenzene		1,670	1,670	11,300	1,670	
Polycyclic aromatic hydrocarbons						
Phenanthrene/trichloroethylene	1,830	1,830	19,400	2,190	531	
Halogenated aliphatics						
1,1-Dichloroethylene	957	7,710	8,940	957	8,940	957
1,2-Trans-dichloroethylene		1,040	1,040		1,040	
Trichloromethane		680	680	3,840	680	
Methylene chloride	1,660	621	2,280	1,660	2,280	4,100
Chloroethylene		3,750	3,750		3,750	
Trichloroethylene[a]						
Tetrachloroethylene						653
Pesticides and metabolites						
γ-BHC		163	163	1,700	163	

Blanks indicate no data available.

[a]See phenanthrene.

TABLE 18-9 (continued)

Toxic pollutant	Subcategory combination 4a	4b	5a	6a	7a	9a	9b
Metals and inorganics							
Antimony	86.2	99.8	86..2	99.8	99.8	99.8	99.8
Arsenic	12,800	10,400	4,340	4,350	8,240	9,750	9,800
Cadmium	86.2	99.8	86.2	99.8	99.8	99.8	99.8
Chromium	435	2,030	147,000	148,000	153,000	137,000	153,000
Copper	83,600	12,500	147,000	154,000	99,000	176,000	112,000
Cyanide	235		277	277	3,500	15,000	14,700
Lead	5,730	17,800	49,100	69,500	69,500	85,400	111,000
Mercury	1,760		1,760	1,760		1,760	
Nickel	1,050	1,330	54,500	54,700	65,300	63,600	65,300
Silver	8,970	15,200	59,300	65,500	65,500	15,000	65,600
Thallium	666	7,810	4,230	4,320	4,320	5,380	5,380
Zinc	8,200	13,100	104,000	109,000	984,000	999,000	999,000
Phthalates							
Bis(2-ethyhexyl) phthalate	1,740	2,030	1,740	2,030	4,300	2,030	2,030
Di-n-butyl phthalate	3,645	2,373	11,500	12,600	19,700	9,006	19,922
Phenols							
2-Chlorophenol	6,480	4,990	2,220	2,220		2,950	73.1
Pentachlorophenol	43,212	16,060	344.8	403.8	84,800	87,100	87,100
Phenol	303,280	238,000	194,000	199,000	100,000	206,000	148,000
2,4,6-Trichlorophenol		508.2	5,420	5,920	5,920	508.2	5,920
p-Chloro-m-cresol							
Aromatics							
Benzene	182	72.6	177	177	540	558	558
Chlorobenzene		1,690	15,800	17,500	17,500	2,080	180
Polycyclic aromatic hydrocarbons							
Phenanthrene/trichloroethylene	531	2,040	19,900	21,700	22,800	3,430	22,800
Halogenated aliphatics							
1,1-Dichloroethylene	957	8,940	24,000	32,000	32,000	50,200	50,200
1,2-Trans-dichloroethylene		1,040		1,040	1,040	3,440	3,440
Trichloromethane		681	3,540	4,220	4,220	147	5,000
Methylene chloride	5,650	5,380	3,030	3,650	2,280	4,880	3,580
Chloroethylene		3,750		3,750	3,750	12,500	12,500
Trichloroethylene[a]							
Tetrachloroethylene	989	762	336	336		445	109
Pesticides and metabolites							
γ-BHC		163	1,700	1,860	1,860	163	1,860

[a]See phenanthrene.

TABLE 18-10. POLLUTANTS FOUND IN THE DIRECT DISCHARGES FOR SIX ESTABLISHMENTS HAVING NPDES PERMITS [2]

Wastewater flow, m^3/day: Establishment I, 3,290; Establishment II, 2,650; Establishment III, 5,220; Establishment IV, 87.1; Establishment V, 2,600; Establishment VI, 2,610; total, 16,500

Pollutant	Establishment number						Total discharge, kg/day	Average concentration, µg/L
	I	II	III	IV	V	VI		
	Concentration, kg/day							
Conventional pollutants								
BOD_5	6.13	6.13	12.3	0.045	2.63	6.13	33.3	2,000
TSS	6.13	6.13	12.3	0.091	0.091	6.13	31.5	1,900
Oil and grease	2.65	2.63	5.30	0.045	0.045	2.63	13.2	800
Toxic pollutants								
Chromium	0.156	0.158	0.311	0.002	0.047	0.156	0.830	50
Copper	0.088	0.065	0.113	0.001	0.017	0.057	0.310	19
Cyanide		0.001					0.001	0.1
Lead	0.023	0.023	0.046	0.0002	0.007	0.023	0.122	7.4
Nickel	0.061	0.065	0.122	0.001	0.018	0.061	0.328	20
Zinc	0.023	0.355	0.045	0.0002	0.007	0.023	0.453	28
Di-n-butyl phthalate	0.001	0.002	0.002	0.000	0.00002	0.001	0.006	0.3
Pentachlorophenol		0.020					0.020	1.2
Phenol	0.054	0.055	0.108	0.001	0.016	0.054	0.289	18
Benzene	0.0002	0.0002	0.0004	0.0000	0.0000	0.0002	0.001	0.1
Phenanthrene/trichloroethylene	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.2
1,1-Dichloroethylene	0.028	0.028	0.055	0.0002	0.008	0.028	0.147	8.9

Blanks indicate no data available.

II.18.4 POLLUTANT REMOVABILITY

Pollutants released in the process waters from the soap and detergent industry are generally of a nontoxic nature and can be pretreated, removed, or ultimately disposed of under normal controlled conditions. Treatment techniques currently in use to recover or remove wastewater pollutants at these facilities are standard, well-established processes.

The industry's wastewater pollutants can be greatly reduced by lower process water usage and/or the recycling of process water. In addition, significant recovery of marketable soap products, fats, glycerine, organic surface active agents, etc., can be realized by lower water use, particularly through process redesign or replacement. For example, by changing operating techniques associated with barometric condensers or by replacing such condensers with surface condesers, water use in most processes can be lowered and the amount of organics released to the sewer can be reduced. These organics can be recovered to be purified for a possible profit. In the manufacture of liquid detergents, installation of additional water recycle piping and tankage and the use of air (rather than water) to blow out filling lines can substantially reduce water use and minimize loss of the finished product.

Table 18-11 presents treatment methods for the removal or elimination of pollutants found in wastewaters from soap and detergent manufacture. Important features and details of the various treatment methods and abatement systems can be readily found in the literature. As seen in this table, organics (especially those of a toxic nature) can be treated primarily by bioconversion processes and activated carbon adsorption systems. The remainder of the major pollutants can be treated by filtration, sedimentation or clarifying processes, and other treatment techniques. As an example, coagulation and sedimentation of the wastewaters can help remove insoluble precipitate residuals chracteristic of soap manufacturing processes. The relative efficiency of removal of pollutants for these various processes is given in Table 18-12, which shows that for most pollutant treatment processes, removability efficiency can be as high as 90-95%. The efficiency achieved is governed by operating parameters of the various processes and by the types and amounts of pollutants in the wastewater.

TABLE 18-11. TREATMENT METHODS USED IN ELIMINATION OF POLLUTANTS [1]

Pollutants	Treatments
Free and emulsified oils and greases	1. Gravity separation 2. Coagulation and sedimentation 3. Carbon adsorption 4. Mixed media filtration 5. Flotation
Suspended solids	1. Plain sedimentation 2. Coagulation-sedimentation 3. Mixed media filtration
Dispersed organics	1. Bioconversion 2. Carbon adsorption
Dissolved solids (inorganic)	1. Reverse osmosis 2. Ion exchange 3. Sedimentation 4. Evaporation
Unacceptable acidity or alkalinity	1. Neutralization
Sludge obtained from or produced in process	1. Digestion 2. Incineration 3. Lagooning 4. Thickening 5. Centrifuging 6. Wet oxidation 7. Vacuum filtration

TABLE 18-12. RELATIVE EFFICIENCY OF SEVERAL METHODS USED IN REMOVING POLLUTANTS [1]

Pollutant and method	Removal efficiency
Oil and grease	
API type separation	Up to 90% of free oils and greases; variable on emulsified oil
Carbon adsorption	Up to 95% of both free and emulsified oils
Flotation	Without the addition of solid phase, alum or iron, 70-80% of both free and emulsified oil; with the addition of chemicals, 90%
Mixed media filtration	Up to 95% of free oils, efficiency in removing emulsified oils unknown
Coagulation-sedimentation with iron, alum or solid phase (bentonite etc)	Up to 95% of free oil; up to 90% of emulsified oil
Suspended solids	
Mixed media filtration	70-80%
Coagulation-sedimentation	50-80%
Chemical oxygen demand	
Bioconversions (with final clarifier)	60-95% or more
Carbon adsorption	Up to 90%
Residual suspended solids	
Sand or mixed media filtration	50-95%
Dissolved solids	
Ion exchange or reverse osmosis	Up to 99%

II.18.5 REFERENCES

1. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Soap and Detergent Manufacturing Point Source Category. EPA-440/1-74-018a, U.S. Environmental Protection Agency, Washington, D.C., April 1974.

2. Project Recommendations for the Soap and Detergent Manufacturing Industry (SIC 2841) BAT/Toxics Study. U.S. Environmental Protection Agency, Washington, D.C., November 1979.

3. Economic Analysis of Effluent Guidelines for the Soap and Detergent Industry. EPA-230/2-73-026 (PB 256 313), U.S. Environmental Protection Agency, Washington, D.C., July 1976.

II.19 STEAM ELECTRIC POWER GENERATING

II.19.1 INDUSTRY DESCRIPTION

II.19.1.1 General Description [1-4]

The steam electric power generation industry is defined as those establishments primarily engaged in the steam generation of electrical energy for sale. It is more commonly termed the steam electric utility industry and includes both fossil-fueled and nuclear plants. It does not include steam electric power plants in industrial, commercial, or other facilities. The industry falls under two Standard Industrial Classification (SIC) Codes, SIC 4911 and SIC 4931.

Of the 1,068 steam electric power generating plants in operation in 1977, 22% were built after 1971. These plants (57% of which are 500 MW or larger in size) represent about 40% of existing capacity. Plants built before 1960 represent 41% of the total number of existing plants and account for 18% of total capacity. In the operation of a power plant, combustion of fossil fuels--coal, oil, or gas--supplies heat to produce steam that is used to generate mechanical energy in a turbine. This energy is subsequently converted by a generator to electricity. Nuclear fuels, presently uranium, are used in a similar cycle except that the heat is supplied by atomic fusion.

Wastewaters at steam electric power plants arise from a number of sources and operations, most of which are process related. Continuous discharges result from such sources as cooling water systems, ash handling systems, pollution control (SO_2) systems, and boiler blowdown. Regular intermittent wastewaters are produced from such processes as regeneration of water from treatment systems. Wastewaters from maintenance cleaning are usually generated on an irregular, infrequent basis. Drainage from coal and ash piles depends primarily on the amount of rainfall rather than plant operating parameters. Finally, there are a number of miscellaneous activities that can generate wastewater streams. The discharge frequency for these varies from plant to plant. Some or all of the various types of wastewater streams occur at almost all of the plant sites in the industry. However, most plants do not have distinct and separate discharge points for each source of wastewater; rather, they combine certain streams prior to final discharge.

Table 19-1 presents industry summary data for the Steam Electric Power Generating (utility) point source category in terms of the number of subcategories and number of dischargers.

TABLE 19-1. INDUSTRY SUMMARY [1-5]

Industry: Steam Electric Power Generating
Total Number of Subcategories: 8 (6 have subdivisions, totaling 25)
Number of Subcategories Studied: 8
Number of Dischargers in Industry:[a]
· Direct: 1,050
· Indirect: 100
· Zero: 10

[a]1,068 as of spring 1977.

Current BPT regulations for the Steam Electronic Power Industry are presented in Table 19-2. "Small units" are defined by the EPA as generating units of less than 25-MW capacity. "Old units" are defined as generating units of 500-MW or greater rated net generating capacity which were first placed into service on or before January 1, 1970, as well as any generating unit of less than 500-MW capacity first placed in service on or before Janutary 1, 1974. The term "10-year, 24-hour rainfall event" refers to a rainfall event with a probable recurrence interval of once in 10 years as defined by the National Weather Service.

II.19.1.2 Subcategory Descriptions [1, 3, 4]

Subcategories for the steam electric utility point source category, as shown in Table 19-3, consist of different sources of wastewater streams within a plant. This approach is a departure from the usual method of subcategorizing an industry according to different types of plants, products, or production processes. The breakdown in Table 19-3 into divisions and subdivisions is based on similarities in wastewater characteristics throughout the industry. Descriptions of the eight broad subcategories are given in this section.

Condenser Cooling System

The condenser cooling system condenses spent steam (from expansion in the turbine generator to produce electricity) so it may be recycled to the boiler or discharged. Once-through or recirculating systems may be used.

TABLE 19-2. CURRENT BPT REGULATIONS FOR THE STEAM ELECTRIC POWER INDUSTRY [6]

Effluent characteristic	Daily maximum	30-day maximum
Generating, Small, and Old Unit Subcategories		
Low volume waste sources and ash transport water		
TSS, mg/L	100	30
Oil and grease, mg/L	20	15
Metal cleaning wastes and boiler blowdown		
TSS, mg/L	100	30
Oil and grease, mg/L	20	15
Copper (total), mg/L	1.0	1.0
Iron (total), mg/L	1.0	1.0
Once-through cooling water and cooling tower blowdown		
Free available chlorine, mg/L	0.5	0.2
pH range (except once-through cooling water)	6.0 - 9.0	6.0 - 9.0
Polychlorinated biphenyl compounds (PCB's)	No discharge	
Area Runoff Subcategory		
Material storage and construction runoff (except 10-year, 24-hour rainfall events)[a]		
TSS, mg/L	50	50
pH (range)	6.0 - 9.0	6.0 - 9.0

[a] Any untreated overflow from facilities designed, constructed, and operated to treat the volume of material storage runoff and construction runoff which is associated with a 10-year, 24-hour rainfall event is not subject to BPT regulation.

TABLE 19-3. STEAM ELECTRIC POWER GENERATING SUBCATEGORIES [1]

1. Condenser Cooling System
   - Once-through
   - Recirculating (primarily cooling tower blowdown)

2. Water Treatment
   - Clarification
   - Softening
   - Ion exchange
   - Evaporation
   - Filtration
   - Other treatment

3. Boiler or Steam Generator Blowdown

4. Maintenance Cleaning
   - Boiler or steam generator tubes
   - Boiler fireside
   - Air preheater
   - Miscellaneous small equipment
   - Stack
   - Cooling tower basin

5. Ash Handling
   - Oil-fired plants
     - Fly ash
     - Bottom ash
   - Coal-fired plants
     - Fly ash
     - Bottom ash

6. Drainage
   - Coal pile
   - Contaminated floor and yard drains
   - Ash pile

7. Air Pollution (SO_2) Control Devices

8. Miscellaneous Waste Streams
   - Sanitary wastes
   - Plant laboratory and sampling systems
   - Intake screen backwash
   - Closed cooling water systems
   - Low level radiation wastes
   - Construction activity

A once-through system withdraws water from a water source, such as an ocean, a river, or a groundwater source, and then discharges the water after passage through the condenser system. Approximately 67% of the steam electric power plants use this method. Chlorine or hypochlorite is usually added to minimize the biofouling of heat transfer surfaces.

Recirculating systems recycle cooling water to the condenser cooling system and may include one or more of the following: evaporative cooling towers (wet); dry cooling towers (closed); hybrid cooling towers (wet and dry combination); cooling lakes and ponds; and spray lakes and ponds. Approximately 33% of the steam electric power plants use this method. A bleed stream (blowdown) generally must be provided, especially for evaporative cooling towers, to control dissolved solids buildup. Chemicals are added to recirculating water for corrosion, scaling, or biofouling control.

Water Treatment

Boiler feedwater is treated for the removal of suspended and dissolved solids to prevent scale formation. The basic treatment processes used are clarification, filtration, lime/lime soda softening, ion exchange, reverse osmosis, and evaporation (excluding reverse osmosis). The principal chemical additives used in water treatment are phosphate, caustic soda, lime, and alum. These treatment methods are associated with wastewater discharges.

Boiler or Steam Generator Blowdown

As a result of evaporation, total dissolved solids build up in the boiler water. To maintain such solids within allowable limits for boiler operation, a controlled amount of boiler water (blowdown) is intermittently bled off. Approximately 69% of steam electric power plants practice boiler blowdown. Power plant boilers are of either the once-through or the drum-type design. Once-through designs are used almost exclusively in high pressure supercritical boilers and have no wastewater streams associated with their operation. Drum-type boilers operate at subcritical conditions where the steam they generate is in equilibrium with boiler water. Boiler blowdown is usually of high quality; it may even be of higher quality than the intake water.

Maintenance Cleaning

As a result of combusion processes in the boiler, residues accumulate on the boiler sections and on the air preheater. To maintain efficient heat transfer rates, these accumulated residues are removed periodically.

The insides of boiler or steam generator tubes are often cleaned with a water wash to which a variety of chemicals may be added depending on the type of deposit, type of metal, type of boiler, prior experience, etc. The waste stream usually contains heavy metals.

Boiler firesides are commonly washed by spraying high pressure water against hot boiler tubes. Waste streams contain dissolved and suspended solids. Acid wastes are common in boilers using high sulfur fuel.

Air preheaters are periodically water washed to remove deposits. Waste streams are high in suspended and dissolved solids, such as sulfates, hardness, and heavy metals. Use of high sulfur fuels will add sulfur oxides to deposits, causing acidic effluents.

The buildup of solids on and/or in miscellaneous small equipment (condensate coolers, hydrogen coolers, air compressor coolers, etc.) and cooling tower basins, and soot buildup in stacks require periodic washings that produce waste streams.

Ash Handling

Ash is produced as a result of fossil fuel combustion in the boiler. The ash may be carried in the flue gas (fly ash) and removed by a collection device, then transported (sometimes by water) to a disposal site. Bottom ash, which collects in the boiler bottom, must also be removed and disposed, sometimes by use of water.

Oil-fired boilers generate less ash than coal-fired ones; however, the ash is high in vanadium, sodium, and sulfur. Ash produced from coal firing varies in composition depending on the coal grade.

Wastewater streams may result from water transport of fly ash, water removal of bottom ash, and water transport of bottom ash.

Drainage

For coal-fired units, a coal supply of approximately 90 days is usually maintained near the site. The piles are usually not enclosed, so the coal comes into contact with moisture and air which can oxidize metal sulfides to sulfuric acid. Precipitation then results in acidic coal pile runoff with minerals and metals in the stream.

Floor and yard drains within a power plant may become contaminated with dust, fly ash, coal dust or oil, detergent, etc., and may be a source of wastewater.

Fly ash or bottom ash stored in an unenclosed pile will produce contaminated runoff caused by precipitation.

Air Pollution (SO_2) Control Devices

Depending upon the fossil fuel sulfur content, an SO_2 scrubber may be required to remove sulfur emissions in the flue gases. Such operations result in liquid waste streams.

Miscellaneous Waste Streams

Besides the major waste streams previously discussed, there are miscellaneous waste streams in a steam electric power plant such as sanitary wastes, plant laboratory and sampling systems, backwashes of the intake screen, closed cooling water systems, low level radiation wastes (nuclear only), and runoff from construction activity.

Table 19-4 indicates the occurrence of each subcategory of the steam electric utility industry according to the four major fuel types.

II.19.2 WASTEWATER CHARACTERIZATION

Wastewater produced by a steam electric power plant can result from a number of operations at the site. Some wastewaters are discharged more or less continuously as long as the plant is operating. Others are produced intermittently, but on a fairly regular basis such as daily or weekly, and are still associated with the production of electrical energy. Other intermittent wastewaters, produced at less frequent intervals, are generally associated with either the shutdown or startup of a boiler or generating unit. Additional wastewaters exist that are essentially unrelated to production but depend on meteorological or other factors. Figure 19-1 presents a typical flow diagram for fossil-fueled steam electric power plants. Wastewater flowrates for the steam electric power generating industry are shown in Table 19-5. The following sections present data available on these waste streams.

II.19.2.1 Condenser Cooling System Wastewater

Wastewater generated from once-through condenser cooling systems will vary widely depending on the quality of the source. Biocides such as chlorine and hypochlorite are usually added to systems of this type to minimize biological growth within the condenser.

Wastewater from a recirculating condenser system (primarily cooling tower blowdown) will depend on the amount of dissolved solids allowable in the system and on the various chemical additives

TABLE 19-4. OCCURRENCE OF SUBCATEGORIES BY FUEL TYPE [1]

Process of operation	Nuclear	Coal	Oil	Gas
1. Condenser Cooling System				
Once-through	X	X	X	X
Recirculating	X	X	X	X
2. Water Treatment				
Clarification	X	X	X	X
Softening	X	X	X	X
Ion exchange	X	X	X	X
Evaporation	X	X	X	X
Filtration	X	X	X	X
Other treatment	X	X	X	X
3. Boiler or Steam Generator				
Blowdown	X	X	X	X
4. Maintenance Cleaning				
Boiler or generator tubes	X	X	X	X
Boiler fireside		X	X	X
Air preheater		X	X	X
Miscellaneous small equipment		X	X	X
Stack		X	X	X
Cooling tower basin	X	X	X	X
5. Ash Handling				
Bottom ash		X	-[a]	
Fly ash		X	X	
6. Drainage				
Coal pile		X		
Floor and yard drains		X	X	X
7. Air Pollution (SO_2) Control Devices		X	X	
8. Miscellaneous Streams				
Sanitary wastes	X	X	X	X
Plant laboratory and sampling systems	X	X	X	X
Intake screen backwash	X	X	X	X
Closed cooling water systems	X	X	X	X
Low level radiation wastes	X			
Construction activity				

[a]Bottom ash may be formed for heavier oils.

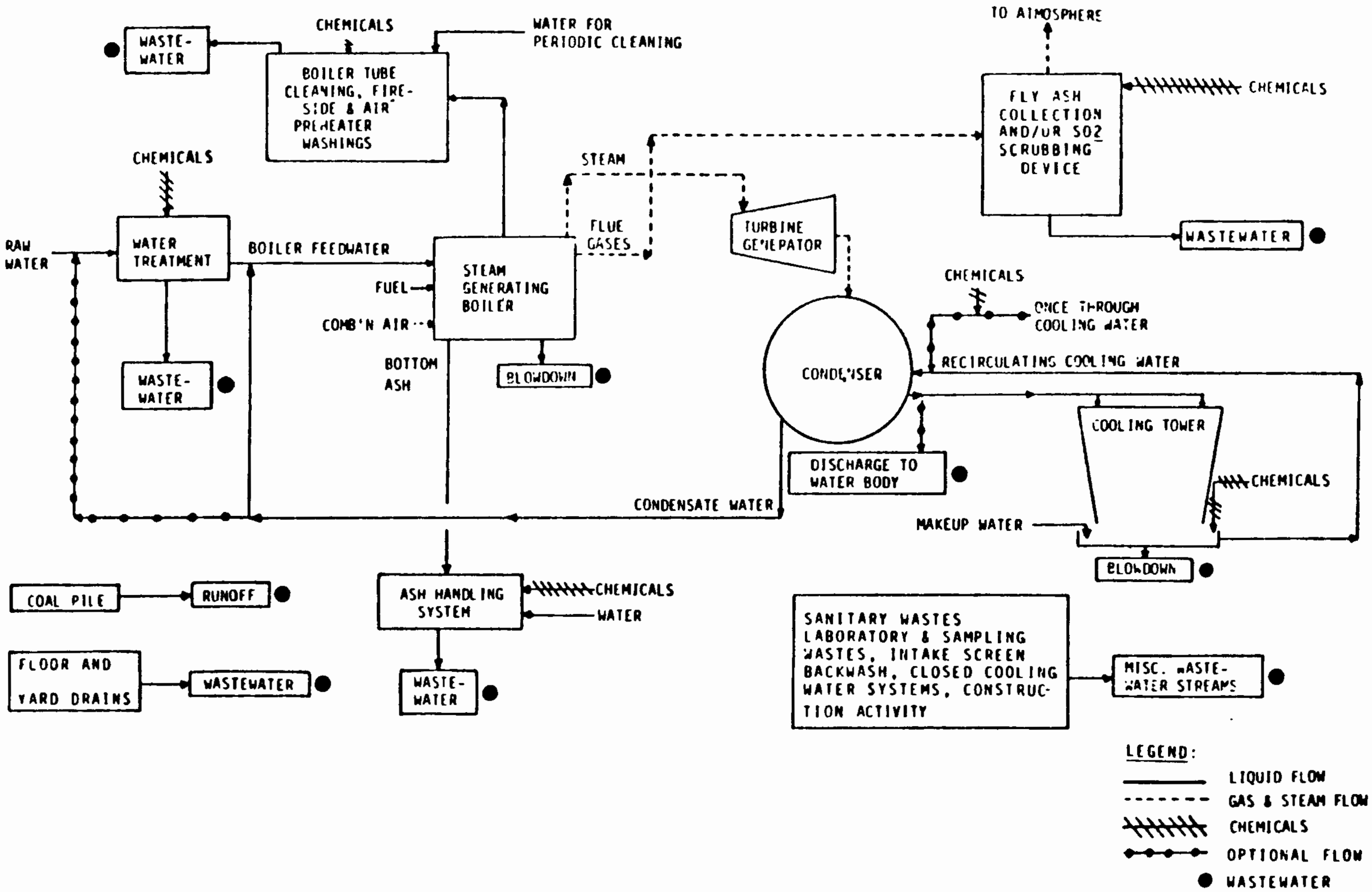

Figure 19-1. Fossil-fueled steam-electric power plant - typical flow diagram.

TABLE 19-5. WASTEWATER FLOWRATES [1, 4]

Waste stream	Number of plants	Flowrate, m^3/d (gpd) Range		Median		Frequency	Remarks
1 Condenser cooling water							
Once-through	-	-		-		-	-
Recirculating	5	53 1,100	(14,000 - 280,000)	240	(63,000)	-	Blowdown depends on water quality and varies from 2 to 20 concentrations
2 Water treatment							
Clarification							
Coal	88	0.026 - 2,300	(7 - 60,000)	102	(27,000)		
Gas	26	0 038 - 4,500	(10 - 1,200,000)	210	(58,000)		
Oil	14	0.076 - 380	(20 - 100,000)	75	(20,000)		
Softening						-	-
Coal	37	0.11 - 190	(29 - 50,000)	99	(26,000)		
Gas	40	0.057 - 3,400	(15 - 900,000)	117	(31,000)		
Oil	15	0.28 - 840	(75 - 220,000)	60	(16,000)		
Ion exchange						52-365 cycles/yr	Extremely variable depending
Coal	104	0.055 - 400	(14 - 100,000)	35	(9,300)		
Gas	86	0.026 - 620	(7 - 160,000)	42	(11,000)		
Oil	42	0.061 - 500	(16 - 130,000)	73	(19,000)		
Evaporation						300-365 cycles/yr	Extremely variable depending
Coal	104	0.0076 - 3,600	(2 - 960,000)	110	(29,000)		
Gas	83	0.030 - 810	(8 - 220,000)	52	(13,000)		
Oil	57	0.057 - 60,000	(15 - 15,000,000)	1,200	(320,000)		
Filtration						-	-
Coal	155	0.0061 - 1,100	(1.6 - 300,000)	97	(25,000)		
Gas	58	0.15 - 360	(40 - 94,000)	30	(7,800)		
Oil	58	0.11 - 950	(20 - 250,000)	95	(25,000)		
Reverse osmosis						-	-
Coal	3	0.011 - 120	(3 - 32,000)	40	(11,000)		
Gas	11	1.76 - 360	(470 - 95,000)	69	(18,000)		
3. Boiler blowdown						25-365 cycles/yr	-
Coal	231	0.00042 - 2,500	(0.11 - 650,000)	130	(33,000)		
Gas	189	0.015 - 2,600	(4 - 700,000)	73	(19,000)		
Oil	148	0.010 - 14,000	(2.7 - 3,800,000)	250	(66,000)		
4. Maintenance (chemical) cleaning							
Boiler tubes	7	570 - 19,000	(150,000 - 4,900,000)	870	(230,000)	Once/7-100 mo	-
Boiler fireside						2-8 yr	-
Coal	42	0.010 - 77	(2.7 - 20,000)	10	(2,700)		
Gas	40	0.0011 - 10	(0.3 - 2,700)	1.9	(510)		
Oil	81	0.052 - 130	(14 - 36,000)	13	(3,400)		

(continued)

TABLE 19-5 (continued).

Waste stream	Number of plants	Flowrate, m^3/d (gpd) Range		Median		Frequency	Remarks
4 Maintenance (chemical) cleaning (continued)							
Air preheater						4-12 yr	-
Coal (total)	148	0.010 - 590	(2.7 - 160,000)	41	(11,000)		
Gas (total)	56	0.0010 - 37	(0.27 - 9,900)	3.7	(980)		
Oil (total)	110	0.0053 - 2,000	(1.4 - 530,000)	40	(11,000)		
Coal, 25-MW capacity	3	0.021 - 0 21	(5.5 - 55)	0 091	(25)		
Coal, 100-MW capacity	16	0 021 - 10	(5.5 - 2,700)	2.9	(760)		
Coal, 500-MW capacity	54	0.010 - 180	(2.7 - 47,000)	17	(4,600)		
Gas, 25-MW capacity	8	0.016 - 0.25	(4.1 - 66)	0.095	(25.2)		
Gas, 100-MW capacity	12	0.0010 - 4.5	(0 27 - 1,200)	0.91	(240)		
Gas, 500-MW capacity	23	0 0020 - 26	(0.56 - 6,800)	4.2	(1,100)		
Oil, 25-MW capacity	13	0.026 - 37	(6.8 - 9,900)	7.7	(2,000)		
Oil, 25-MW capacity	7	0 0051 - 1.6	(1.4 - 410)	0.29	(77)		
Oil, 100-MW capacity	8	0.45 - 39	(120 - 10,000)	7 0	(1,900)		
Oil, 500-MW capacity	52	0.017 - 140	(4.6 - 38,000)	11	(3,000)		
Oil, 500-MW capacity	43	0.11 - 2,000	(20 - 530,000)	88	(23,000)		
Miscellaneous small equipment	-	-		-		-	-
Stack	-	-		-		-	Cleaned infrequently
Cooling tower basin	-	-		-		-	Cleaned infrequently
5. Ash handling							
Coal	24	1,800 - 78,000	(480,000 - 21,000,000)	18,000	(4,700,000)		
Coal and gas	5	1,900 - 98,000	(500,000 - 26,000,000)	33,000	(8,700,000)		
Coal and oil	4	19 - 2,700	(4,900 - 720,000)	2,600	(690,000)		
Coal, oil, and gas	2	20,000 - 53,000	(5,200,000 - 14,000,000)	36,000	(9,600,000)		
6. Drainage							
Coal pile	4	3.1 - 360	(810 - 96,000)	15	(3,900)	-	Flow dependent upon frequency, duration, and intensity of rainfall
Floor and yard drains	3	5.5 - 14	(1,400 - 3,600)	5.5	(1,400)	-	Flow dependent upon frequency and duration of cleaning and storm-water runoff
Ash pile	-	-		-		-	-
7. Air pollution control devices							
Five gas scrubber blowdown							
Coal (total)	13	27 - 57,000	(7,000 - 15,000,000)	6,500	(1,700,000)	-	-
Scrubber solids pond overflow						-	-
Coal (total)	7	0.95 - 8,700	(250 - 2,300,000)	3,200	(840,000)		
Coal, 25-MW capacity	1			8,700	(2,300,000)		
Coal, 100-MW capacity	1			0.95	(250)		
Coal, 500-MW capacity	1			77	(20,300)		
Coal, 500-MW capacity	4	27 - 6,200	(7,000 - 1,700,000)	3,200	(850,000)		
8 Miscellaneous waste streams							
Sanitary wastes	-	-		-		-	Estimated flow 25-35 gal/capita day
Plant laboratory and sampling	-	-		-		-	Nominal, variable flow
Intake screen backwash	-	-		-		-	Guideline requires collection and removal of debris; flow data not significant
Closed cooling systems	-	-		0.019	(5)	-	-
Low level radiation wastes	-	-		-		-	Variable, depending on treatment technology, leakage, etc.
Construction activity	-	-		-		-	Flow dependent on rainfall

used to control corrosion, sealing, and biological growth. The fill material in natural draft cooling towers is normally asbestos cement. Erosion of this fill material can result in the discharge of asbestos from cooling water blowdown. Table 19-6 lists the toxic pollutants observed in condenser cooling system wastewater.

II.19.2.2 Water Treatment Wastewater

Removal of dissolved and suspended salts from boiler feedwater to prevent or reduce scaling may be accomplished by clarification, softening, ion exchange, evaporation, filtration, or other treatment.

Clarification agglomerates suspended solids and removes them from water by settling. Chemicals such as aluminum sulfate, ferrous sulfate, ferric sulfate, sodium aluminate, polyelectrolytes, and others are used as additives. Wastewater streams from clarifiers usually contain 3,000 mg/L to 15,000 mg/L total solids (of which 75% to 80% are suspended solids and the remainder dissolved solids), 30 mg/L to 100 mg/L BOD, 500 mg/L to 10,000 mg/L COD, and pH of 5 to 9.

Softening removes hardness using chemical precipitation. The two major chemicals used are calcium hydroxide and sodium carbonate.

Ion exchange removes mineral salts in one step using an organic resin which periodically must be regenerated. The pH of the wastewater will vary depending on the type of system and resins used. The neutralized wastewater is high in total dissolved solids.

Evaporator wastewater, with a pH range of 6 to 9, contains concentrated salts from the feedwater.

Filtration is used after several other water treatment operations and requires periodic backflushing.

Reverse osmosis is a process used by some plants to remove dissolved salts. Concentrated salt solution (brine) is discouraged as a waste.

Table 9-7 presents pollutant concentrations observed in water treatment wastewater streams.

II.19.2.3. Boiler or Steam Generator Blowdown Wastewater

Boiler blowdown is generally of fairly high quality because the boiler feedwater must be maintained at high quality [2]. Boiler blowdown having a high pH may contain a high dissolved solids

TABLE 19-6. CONDENSER COOLING SYSTEM - INTAKE AND RAW WASTEWATER POLLUTANT CONCENTRATIONS [1]

	Once through cooling water systems[a]						Recirculating cooling water system[b,c]					
	Intake			Discharge			Intake			Discharge		
	Number of plants	Concentration[d]		Number of plants	Concentration[d]		Number of plants	Concentration[d]		Number of plants	Concentration[d]	
Pollutant		Range	Median		Range	Median		Range	Median		Range	Median
Metals												
Antimony	3	<5 - 7	<5	3	<5 - 10	<5	2	4 - 7	6	3	BDL - 7	5
Arsenic							3	BDL - 3	1	3	4 - 35	7
Asbestos							18	BDL - 140,000	BDL	14	BDL - 160,000,000	BDL
Beryllium	3		<5	3		<5	2	BDL - <10		4	BDL - <10	3.4
Cadmium	3	<5 - <10	<5	3	<5 - 30	<5	7	BDL - 100	8	8	BDL - 200	3
Chromium	3	<5 - 39	24	3	<5 - 17	8	8	BDL - 439	70	8	2 - 555	52
Copper	3	6 - 22	16	3	5 - 24	20	8	9 - 700	32	8	34 - 3,800	56
Cyanide	3	<20 - 20	<20	3	<20 - 20					6	BDL - <20	<20
Lead	3	<5 - 19	8	3	<5 - 14	<5	7	6 - 500	20	7	BDL - 800	<20
Mercury	3	0.21 - 0.42	0.23	3	0.17 - 0.42	0.34				3		BDL
Nickel	3	<5 - 29	7	3	<5 - 26	25	7	1.5 - 200	5	8	4 - 200	18
Selenium	3	11 - 35	20	3	<5 - 28	18				3		BDL
Silver	3	<5 - 12	<5	3		<5	6	BDL - 40	1.3	6	0.7 - 80	3
Thallium	3		<5	3	<5 - 13	<5	1		BDL	3	BDL - 8	BDL
Zinc	3	<5 - 42	5	3	<5 - 26	<5	6	15 - <600	62	6	26 - 780	248
Phenol (total)	3	<10 - <100	30	3	<10 - <100	50						
Phthalates												
Bis(2-ethylhexyl) phthalate	1		10	4	12 - 35	31	1		21	5	<10 - 36	22
Butyl benzyl phthalate				1		10						
Di-n-butyl phthalate	3	<10 - 38	23	5	23 - 44	26	4	30 - 40	37	5	<10 - 48	10
Diethyl phthalate				2	10 - 11	11						
Di-n-octyl phthalate				1		10						
Phenols												
2,4-Dichlorophenol							2		<25			
2,4-Dinitrophenol							1		<25			
Pentachlorophenol							2		<25			
Phenol	4	5 - 15	10	4	5 - 18	7	3	7 - 16	12	3	8 - 20	8
2,4,6-Trichlorophenol	1		28	1		<25	3		<25	1		35
Aromatics												
Benzene										1		45
1,2-Dichlorobenzene	1		18	2	10 - 30	20	3	<10 - 18	<10	3	<10 - 26	20
1,3-Dichlorobenzene	1		18	2	10 - 30	20	3	<10 - 18	<10	3	<10 - 26	20
1,4-Dichlorobenzene	1		18	2	10 - 30	20	3	<10 - 18	<10	3	<10 - 26	20
1,2,4-Trichlorobenzene				1		10						
Polycyclic aromatic hydrocarbons												
2-Chloronaphthalene				1		10						
Halogenated aliphatics												
Bromoform	1		<10	1	97 - 580	340	1		BDL	2	13 - 150	82
Chlofodibromomethane							1		BDL	1		59
1,2-Dichloroethane	1		72	1		44						
1,1-Dichloroethylene				1		16						
1,2-Trans-dichloroethylene				1		11						
Methylene chloride	1		240	6	2,000 - 9,400	<3,000	1		74	6	65 - 9,400	<1,600
Tetrachloroethylene				1		78						
1,1,1-Trichloroethane				1		12				2	13 - 26	18

Note: Blanks indicate no data available.

[a] Metals concentrations are screening data; verification results not available. Organics derived from verification data.

[b] Cooling tower blowdown

TABLE 19-7. UTILITY BOILERS - RAW WASTEWATER POLLUTION CONCENTRATIONS [3, 4]

Parameter	Clarification discharge	Softening[a] discharge			Ion exchange[b] discharge			
	Mean	Number of plants	Range	Median	Number of plants	Range	Median	Mean
Toxic pollutants, μg/L								
Antimony								
Arsenic								
Asbestos								
Beryllium								
Cadmium								
Chromium		3	90 - 110	100	5	20 - 200	70	
Copper		3	60 - 150	120	5	20 - 1,300	20	
Cyanide		3	5 - 14	5	3	<5 - 5	5	
Lead								
Mercury								
Nickel		3	70 - 250	90	5	30 - 200	30	
Selenium								
Silver								
Thallium								
Zinc		3	90 - 320	120	4	20 - 210	50	
Phthalates, μg/L								
Bis(2-ethylhexyl) phthalate								
Phenols, μg/L								
2-Chlorophenol								
2,4-Dichlorophenol								
Phenol								
Aromatics, μg/L								
Benzene								
1,3-Dichlorobenzene								
Ethylbenzene								
Toluene								
Halogenated aliphatics, μg/L								
Chloroform								
Methylene chloride								
Nontoxic pollutants, μg/L								
Aluminum								
Barium								
Calcium								
Iron	350,000	3	440 - 10,000	9,000	3	20 - 9,500	1,000	
Magnesium								
Manganese								
Phosphorus								
Potassium								
Sodium								3,100
Tin								

TABLE 19-7 (continued).

Parameter	Clarification discharge Mean	Softening[a] discharge Number of plants	Range	Median	Ion exchange[b] discharge Number of plants	Range	Median	Mean
Conventional parameters[e]								
Ammonia								46
BOD_5		3	1.8 - 48	10	3	1.0 - 6.0	1.0	
Bromide					3	0.03 - 1.5	1.0	
Chloride								1,700
COD		3	37 - 560	200	3	2.0 - 14	9.8	
Flow[h]	320	3	7,500 - 17,000	16,000	4	4,300 - 23,000	8,200	
Fluoride								
Oil and grease		3	1.0	1.0	5	1.0 - 13	1.0	
pH[g]								
Phenols								
Silica								
Sulfate								2,100
TDS		3	190 - 23,000	1,000	3	0.16 - 4,000	170	
TOC								
TSS	25,000	3	40 - 9,400	1,800	4	1.0 - 31	23	

Parameter	Evaporation[c] discharge Number of plants	Range	Median	Mean	Filtration discharge[d] Number of plants	Range	Median	Other treatment-reverse osmosis discharge[d] Number of plants	Range	Median
Toxic pollutants, µg/L										
Antimony					1		(<5,000) <5,000	1		(<5,000)<5,000
Arsenic					1		(<13,000) 14,000	1		(<5,000)<5,000
Asbestos[f]					1		(0) 0	1		(0) 0
Beryllium					1		(<5,000) <5,000	1		(<5,000)<5,000
Cadmium					1		(<5,000) <5,000	1		(<5,000)<5,000
Chromium	2	200 - 80		50	1		(<5,000) 21,000	1		(<5,000)<5,000
Copper	2	20 - 2,600		1,300	1		(<5,000) 40,000	1		(10,000)30,000
Cyanide	2	6 - 28		17	1		(<20,000) 30,000	1		(20,000)30,000
Lead					1		(<5,000) 20,000	1		(<5,000)<5,000
Mercury					1		(0.390) 390	1		(530) 550
Nickel	2		30		1		(<5,000) 28,000	1		(<5,000)<5,000
Selenium					1		(20,000) 12,000	1		(13,000)58,000
Silver					1		(<5,000) <5,000	1		(9,000)<5,000
Thallium					1		(<5,000) <5,000	1		(<5,000)<5,000
Zinc	2	110 - 440	280		1		(<5,000) 41,000	1		(13,000)14,000
Phthalates, µg/L										
Bis(2-ethylhexyl) phthalate					1		(1) <1	1		(1) <1
Phenols, µg/L										
2-Chlorophenol								1		(<1) 27
2,4-Dichlorophenol					1		(<1) 243			
Phenol					1		(253) 13	1		(50) 1

TABLE 19-7 (continued).

Parameter	Evaporation[c] discharge: Number of plants	Range	Median	Mean	Filtration discharge[d]: Number of plants	Range	Median	Other treatment-reverse osmosis discharge[d]: Number of plants	Range	Median
Aromatics, µg/L										
Benzene								1		(3) 2
1,3-Dichlorobenzene								1		(<1) 1
Ethylbenzene								1		(<1) 3
Toluene					1		(<1) 150	1		(<1) 46
Halogenated aliphatics, µg/L										
Chloroform					1		(3) 5.2	1		(<1) 23
Methylene chloride					1		(3) 1.4	1		(1) <1
Nontoxic pollutants, µg/L										
Aluminum										
Barium										
Calcium										
Iron	2	220 - 380	300							
Magnesium										
Manganese										
Phosphorus										
Potassium										
Sodium										
Tin										
Conventional parameters[e]										
Ammonia										
BOD_5	2	5.1 - 15	10							
Bromide										
Chloride				190						
COD	2	21 - 76	48							
Flow[h]			41,000							
Fluoride										
Oil and grease	2	1.0 - 1.9	1.5							
pH[g]										
Phenols					1		(50) 20	1		(10) 20
Silica										
Sulfate				79						
TDS	2	2,200 - 2,500	2,400							
TOC										
TSS	2	15 - 93	54							

Note: Blanks indicate no data available.

[a]Lime softener blowdown.

[b]Demineralizer regeneration.

[c]Evaporator blowdown.

[d]Intake concentrations in parentheses.

[e]Values in mg/L except as noted.

[f]Values in fibers/liter.

[g]Values in pH units.

[h]Values in m^3/d.

concentration depending on boiler pressure. Blowdown from boilers treated with phosphate will contain hydroxide alkalinity while those treated with hydrazine will contain ammonia and, depending on boiler pressure, sulfite. Table 19-8 presents raw waste concentrations for boiler blowdown wastewater streams.

TABLE 19-8. BOILER OR STEAM GENERATOR BLOWDOWN - RAW WASTEWATER POLLUTION CONCENTRATIONS [4]

Parameter	Boiler blowdown discharge		
	Number of plants	Range	Median
Toxic pollutants, µg/L			
Antimony			
Arsenic			
Asbestos[a]			
Beryllium			
Cadmium			
Chromium	4		20
Copper	4	20 - .190	40
Cyanide	2	5 - 14	10
Lead			
Mercury			
Nickel	4		30
Selenium			
Silver			
Thallium			
Zinc	4	10 - 50	20
Conventional parameters, mg/L			
BOD_5	2	11 - 12	11
COD	2	2.0 - 157	80
Iron	4	0.03 - 1.4	0.06
Oil and grease	2	1.0 - 15	7.9
pH[b]	4	9.0 - 12	10
TDS	2	120 - 1,410	760
TSS	4	2.7 - 31	7.6

Note: Blanks indicate no data available.
[a]Values in fibers/liter.

[b]Values in pH units.

II.19.2.4 Maintenance Cleaning Wastewater

Boiler tubes must be cleaned occasionally to remove accumulations of scale. Cleaning mixtures used for this purpose include alkaline chelating rinses, proprietary chelating rinses, organic solvents, acid cleaning mixtures, and alkaline mixtures with oxidizing agents for copper removal. Wastes from these cleaning operations will contain iron, copper, zinc, nickel, chromium, hardness, and phosphates. In addition to these constituents, wastes from alkaline cleaning mixtures will contain ammonium ions, oxidizing agents, and high alkalinity; wastes from acid cleaning mixtures will contain fluorides, high acidity, and organic compounds; wastes from alkaline chelating rinses will contain high alkalinity and organic compounds; and wastes from most proprietary processes will be alkaline and will contain organic and ammonium compounds. Pollutants observed in selected boiler tube wastewater streams are presented in Table 19-9.

Table 19-10 presents pollutant concentrations observed for boiler fireside and air preheater wastewater streams. No data were available to describe wastewater streams generated by stack, cooling tower basin, and small equipment cleaning.

II.19.2.5 Ash Handling Wastewater

Ash handling is the conveyance of accumulated waste products to a disposal system. Table 19-11 presents pollutant concentrations observed in ash handling wastewater during a verification study of ash pond overflows.

II.19.2.6 Drainage Wastewaters

Rainfall can become a wastewater stream after running through coal piles, floor and yard drains, or ash piles. Table 19-12 presents data on coal pile runoff and floor and yard drains. Data on ash pile wastewater streams are not available.

II.19.2.7 Air Pollution (SO_2) Control Wastewater

Wastewater characteristics of streams from air pollution control devices will depend on the type of process used. Existing flue gas desulfurization (FGD) processes may be divided into two categories: nonregenerable (throwaway) and regenerable. Nonregenerable FGD processes include lime, limestone, lime/limestone combinations, and double alkaline systems. Magnesium oxide and Wellman-Lord are the regenerable processes. Tables 19-13 and 19-14 present pollutant concentrations for selected nonregenerable FGD wastewater streams. There are no wastewater or sludge streams associated with the Wellman-Lord process. No data are available to describe magnesium oxide wastewater streams.

TABLE 19-9. MAINTENANCE CLEANING-BOILER OR GENERATOR TUBE WASH SOLUTIONS-RAW WASTEWATER POLLUTANT CONCENTRATIONS [1]

Parameter	Ammoniated citric acid discharge			Ammoniated EDTA discharge		
	Number of operations[a]	Range	Median	Number of operations	Range	Median
Toxic pollutants, µg/L[b]						
Antimony						
Arsenic						
Asbestos[c]						
Beryllium						
Cadmium						
Chromium				3	10,000 - 27,000	12,000
Copper	4	8,000 - 220,000	20,000	7	170 - 12,000,000	120,000
Cyanide						
Lead						
Mercury						
Nickel	1		130,000	3	12,000 - 140,000	
Selenium						
Silver						
Thallium						
Zinc	1		390,000	3	79,000 - 140,000	120,000
Nontoxic pollutants, µg/L						
Aluminum				1		31,000
Barium						
Calcium				2	21,000 - 45,000	33,000
Iron	3	8,300,000 - 11,000,000	9,800,000	7	2,300,000 - 8,300,000	6,900,000
Manganese				2	50,000 - 73,000	61,000
Magnesium				2	11,000 - 21,000	16,000
Phosphorus	1		200,000	1		260,000
Potassium						
Sodium				1		370,000
Tin						
Conventional parameters, mg/L[b]						
pH				7	8.8 - 10	9.2
TDS				2	60,000 - 74,000	67,000
TSS				1		24
BOD_5						
COD						
TOC						
Oil and grease				1		41
Phenols						
NH_3-N				1		5,200
Org-N						
NO_2+NO_3-N						
Silica	1		40	1		94
Bromide						
Chloride						
Fluoride						
Sulfate						

(continued)

TABLE 19-9 (continued)

Parameter	Ammoniacal sodium bromate discharge: Number of operations[a]	Range	Median	Hydrochloric acid without copper complexer discharge: Number of operations	Range	Median
Toxic pollutants, µg/L[b]						
Antimony						
Arsenic	3	<5 - 310,000	48	6	8 - 60	33
Asbestos[c]						
Beryllium	2	10	<10	4	<10	<10
Cadmium	3	<1 - <20	<1	6	<1 - 100	21
Chromium	4	ND - <50	<5	6	<5 - 8,800	1,300
Copper	6	100,000 - 790,000		7	690 - 47,000	13,000
Cyanide						
Lead	3	<10 - 100	<10	5	<10 - 5,200	860
Mercury	3	<.02 - 15,000	<.02	4	<2	<2
Nickel	5	ND - 260,000	520	7	770 - 300,000	160,000
Selenium	3	<2 - 24,000	<2	4	<2 - <4	<2
Silver	2	<10 - 20	20	4	20 - 70	30
Thallium						
Zinc	5	0.050 - 1,000	500	7	940 - 170,000	20,000
Nontoxic pollutants, µg/L						
Aluminum	2	200	<200	4	6,500 - 8,200	6,800
Barium	2	100	<100	4	<100 - 400	200
Calcium	3	ND -3,000	400	6	16,000 - 74,000	59,000
Iron	5	ND - 4,900	1,700	7	1,100,000 - 4,200,000	2,800,000
Manganese	3	10 - 40	30	6	6,900 - 29,000	21,000
Magnesium	3	ND - 2,900	670	4	5,700 - 8,800	7,600
Phosphorus	2	10,000 - 30,000	20,000	6	1,200 - 50,000	40,000
Potassium	2	70,000 - 220,000	150,000	4	1,400 - 2,300	1,700
Sodium	3	3,700 - 59,000	15,000	4	31,000 - 74,000	45,000
Tin	2	<1,000		4	<1,000 - 7,300	1,900
Conventional parameters, mg/L[b]						
pH	2	10 - 11	10	6	0.5 - 3.3	0.7
TDS	3	340 - 1,400	1,000			
TSS	3	8 - 77	71	6	8 - 120	34
BOD_5						
COD				6	1,200 - 9,900	1,500
TOC	2	24 - 120	72	6	90 - 4,600	230
Oil and grease				6	<5 - 23	16
Phenols	2	<5	<5	6	0.020 - 0.070	0.043
NH_3-N				6	80 - 330	190
Org-N	2	700 - 2,000	1,000	6	0.06 - 870	108
NO_2+NO_3-N	2	<10 - 40	25	4	<0.01 - 0.07	<0.01
Silica	2	0.04 - 0.51	0.27	5	19 - 240	66
Bromide	2	7.2 - 14	11			
Chloride	2	<5 - 52	28			
Fluoride	1		60			
Sulfate	2	1.5 - 6.1	3.8	4	<1 - 10	<1

(continued)

TABLE 19-9 (continued)

Parameter	Hydrochloric acid with copper complexer discharge			Hydroxyacetic/formic acid discharge		
	Number of operations	Range	Median	Number of operations	Range	Median
Toxic pollutants, µg/L[b]						
Antimony						
Arsenic						
Asbestos[c]						
Beryllium						
Cadmium						
Chromium	1		17,000			
Copper	6	20,000 - 960,000	370,000	1		2,000
Cyanide						
Lead						
Mercury						
Nickel	5	3,000 - 500,000	270,000	1		5,00
Selenium						
Silver						
Thallium						
Zinc	4	10,000 - 840,000	410,000	1		8,000
Nontoxic pollutants, µg/L						
Aluminum						
Barium						
Calcium	2	67,000 - 980,000	520,000			
Iron	6	1,900,000 - 6,500,000	3,900,000	4	2,900,00 - 8,800,00	4,600,000
Manganese	1		8,200			
Magnesium						
Phosphorus	2	100,000 - 300,000	200,000			
Potassium						
Sodium	1		9,200			
Tin						
Conventional parameters, mg/L[b]						
pH[d]						
TDS	1		2,400			
TSS						
BOD_5						
COD						
TOC						
Oil and grease						
Phenols						
NH_3-N						
Org-N						
NO_2+NO_3-N						
Silica	2	30 - 280	160			
Bromide						
Chloride						
Fluoride						
Sulfate						

Note: Blanks indicate no data available

[a]Number of independent boiler chemical cleaning operations.

[b]Except as noted.

[c]Values in Fibers/liter.

[d]Values in pHunits.

TABLE 19-10. MAINTENANCE CLEANING - BOILER FIRESIDE AND AIR PREHEATER [1]

Parameter	Boiler fireside wash[a] Concentration Maximum	Boiler fireside wash[a] Concentration Mean	Boiler fireside wash[a] Mean loading, kg/cleaning	Boiler fireside wash[a] Mean loading, (lb/cleaning)	Air preheater wash water[a] Number of operations	Air preheater wash water[a] Concentration Range	Air preheater wash water[a] Concentration Median	Air preheater and fireside wash[b] concentration Intake	Air preheater and fireside wash[b] concentration Discharge
Toxic pollutants, μg/L									
Antimony									
Arsenic									
Beryllium								6	
Cadmium								6	20
Chromium (total)	15,000	1,500	6.8	(15)	3	1,000 - 1,500	1,300	10	200
$Chromium^{+6}$	<1,000	20	0.09	(0.2)					
Copper	250,000	6,000	27	(60)				7	200
Cyanide									
Lead								03	600
Mercury									
Nickel	900,000	70,000	317	(700)	3	18,000 - 25,000	21,000	BDL	100
Selenium									
Silver									
Thallium									
Zinc	40,000	4,000	18	(40)	3	1,100 - 1,400	1,200	BDL	900
Nontoxic pollutants, μg/L									
Aluminum	21,000	2,000	9	(20)					
Calcium					3	29,000 - 38,000	34,000		
Iron	14,000,000	2,500,000	11,000	(25,000)					
Magnesium					3	260,000 - 330,000	330,000		
Manganese	40,000	3,500	16	(35)					
Sodium					3	360,000 - 380,000	370,000		
Conventional parameters, mg/L									
pH[c]					3	3.2 - 3.5	3.5		
TDS	50,000	5,000	23,000	(50,000)	3	606 - 750	730		
TSS	25,000	250	1,100	(2,500)	3	29 - 83	34		
COD					3	50 - 70	60		
Chloride					3	17 - 27	19		
Sulfate	10,000	1,000	4,500	(10,000)	3	1,900 - 2,700	2,300		
Oil and grease	BDL	BDL	BDL		3	0.25 - 8.5	0.25		
Total hardness, as $CaCO_3$					3	1,400 - 1,600	1,500		

Note: Blanks indicate data not available.

[a]Data from one plant.

[b]Verification data.

[c]Values in pH units.

TABLE 19-11. ASH HANDLING - INTAKE, INFLUENT, AND EFFLUENT POLLUTANT CONCENTRATIONS [1]

	Bottom Ash[a,b]								
	Influent			Effluent			Intake		
Pollutant	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants	Range	Median
Metals, µg/L									
Antimony				3	5 - 7	6	3	3 - 7	4
Arsenic				3	BDL - 74	9	2	BDL - 3	
Asbestos[c]									
Beryllium	6	2 - 30	6	5	BDL - 2.5	<1.0	2	BDL - <1	
Cadmium	6	8 - 100	45	5	BDL - 10	2	4	BDL - 40	2
Chromium	6	60 - 900	200	8	BDL - 1,000	9	6	BDL - 2,000	9
Copper	6	50 - 200	100	8	13 - 80	26	7	<6 - 700	16
Cyanide				8	BDL - 22	<20	2	4 - 5	5
Lead	6	50 - 1,000	200	8	BDL - 30	13	4	9 - 20	13
Mercury				6	BDL - 1.5	<0.5	1		<0.5
Nickel	6	20 - 500	95	8	2.5 - 490	14	8	BDL - 1,000	9
Selenium				3	3 - 42	8	3	BDL - 2	2
Silver	3	2 - 20	8	4	0.5 - 6	3.3	4	BDL - 1.6	1.2
Thallium				3	BDL - 9	BDL	1		BDL
Zinc	6	100 - 900	500	8	BDL - 300	<60	6	15 - 70	57
Phthalates, µg/L									
Bis(2-ethylhexyl) phthalate				6	21 - 309	22	2	<10 - 21	16
Butyl benzyl phthalate				1		10	1		<10
Di-n-butyl phthalate	1		65	3	31 - 46	36	4	<10 - 33	<10
Diethyl phthalate							1		<10
Di-n-octyl phthalate							1		<10
Phenols, µg/L									
2,4-Dichlorophenol				1		83	3		<25
2,4-Dinitrophenol				1		50	3		<25
Pentachlorophenol				1		51			
Phenol				5	6 - 40	14	5	6 - 36	12
2,4,6-Trichlorophenol							2	<25 - 28	27
Aromatics, µg/L									
1,2-Dichlorobenzene				2	64 - 65	65	3		<10
1,3-Dichlorobenzene	1		35	2	64 - 65	65	3		<10
1,4-Dichlorobenzene				2	64 - 65	65	3		<10
1,2,4-Trichlorobenzene							1		<10
Polycyclic aromatic hydrocarbons, µg/L									
Acenaphthylene	1		16				1		<10
2-Chloronaphthalene				1		52			
Halogenated aliphatics, µg/L									
1,2-Dichloroethane				1		27			
Methylene chloride	1		5,400	6	300 - 9,400	>1,800	1		48

(continued)

TABLE 19-11 (continued).

	Fly Ash[a]								
	Influent			Effluent			Intake		
Pollutant	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants	Range	Median
Metals[c]									
Antimony									
Arsenic									
Asbestos									
Beryllium	2	30 - 400	215						
Cadmium	2	80 - 200	140	1		90	1		<2
Chromium	2	400 - 2,000	1,200	2	9 - 49	29	2	12 - 2,000	1,000
Copper	2	400 - 2,000	1,200	2	12 - 19	16	2	13 - 90	52
Cyanide									
Lead	2		4,000	2	23 - 70	47	1		15
Mercury				2		<0.5			
Nickel	2	400 - 2,000	1,200	2	32 - 75	54	2	<5 - 1,000	520
Selenium									
Silver	2	10 - 100	55						
Thallium									
Zinc	2	8,000 - 10,000	9,000	2	<60 - 1,200	630	2		<60
Phthalates, µg/L									
Bis(2-ethylhexyl) phthalate				2	17 - 25	21			
Butyl benzyl phthalate									
Di-n-butyl phthalate	1		46	2	7 - 48	28	2	<10 - 42	26
Diethyl phthalate									
Di-n-octyl phthalate									
Phenols, µg/L									
2,4-Dichlorophenol									
2,4-Dinitrophenol									
Pentachlorophenol									
Phenol				1		35	1		38
2,4,6-Trichlorophenol									
Aromatics, µg/L									
1,2-Dichlorobenzene				1		41	1		<10
1,3-Dichlorobenzene				1		41	1		<10
1,4-Dichlorobenzene				1		41	1		<10
1,2,4-Trichlorobenzene									
Polycyclic aromatic hydrocarbons, µg/L									
Acenaphthylene									
2-Chloronaphthalene									
Halogenated aliphatics, µg/L									
1,2-Dichloroethane									
Methylene chloride				2	>140 - >9,400	>4,800			

Note: Blanks indicate no data available.

[a]Verification data.

[b]Coal-fueled plants only.

[c]Values in fibers/liter.

TABLE 19-12. DRAINAGE - RAW WASTEWATER POLLUTION CONCENTRATIONS [2]

Parameter	Coal pile drainage discharge[a]: Number of plants	Coal pile drainage discharge[a]: Range	Coal pile drainage discharge[a]: Median	Floor and yard drains, Discharge: Number of plants	Floor and yard drains, Discharge: Range	Floor and yard drains, Discharge: Median	Floor and yard drains, Intake: Number of plants	Floor and yard drains, Intake: Range	Floor and yard drains, Intake: Median
Toxic pollutants, μg/L[b]									
Antimony									
Arsenic									
Asbestos[c]									
Beryllium	(1)		(4)						
Cadmium	(1)		(10)						
Chromium	6 (1)	ND - 17,000	1,800 (200)	1		20	1		20
Copper	4 (1)	1,600 - 3,400	1,700 (10)				1		55
Cyanide									
Lead	(1)		(900)						
Mercury									
Nickel									
Selenium									
Silver									
Thallium									
Zinc	7 (1)	6 - 23,000	1,600 (1,000)	1		10	3	4 - 10	4
Nontoxic pollutants, mg/L									
Aluminum	2	830 - 1,200							
Barium									
Calcium									
Iron	9	60 - 93,000,000	900				1		40
Manganese									30
Magnesium	2	89,000 - 170,000					3		1,000
Phosphorus									
Potassium									
Sodium	3	160,000 - 1,300,000	1,300,000				3	4,000 - 5,000	4,000
Tin									
Conventional parameters[b]									
pH[d]	9	2.1 - 7.8	3	3	Low - Neutral				
TDS	7	250 - 44,000	5,800	3	75 - 180	180	3	70 - 180	180
TSS	7	22 - 3,300	610	3	0 - 5	5	3	0 - 5	0
BOD_5	4	0 - 10	1.5	3	2 - 4	4	3	2 - 4	4
COD	5	85 - 1,100	1,100	3	2 - 4	4	3	2 - 4	4
Bromide									
Chloride	4	3.6 - 480	13	3	8 - 10	10	3	8 - 10	10
Fluoride									
Sulfate	8	130 - 22,000	3,046	1		1.3	3	0.5 - 1.3	0.5
Ammonia	5	0 - 1.8	0.35	3	0.01 - 0.07	0.07	3	0.01 - 0.07	0.07
Nitrate	5	0.3 - 2.3	1.8	3	0.5 - 2	0.5	3	0.5 - 2.1	0.5
Alkalinity, as CaCO	8	0 - 82	10.2	3	14 - 35	35	3	14 - 35	35
Acidity, as $CaCO_3$	5	8.7 - 27,000	10.3						
Total hardness	4	130 - 1,900	620				3	7 - 29	29
Oil and grease				1		5	3	1 - 4	4
Phenols				1		0.001	3		1
Flow[e]				3	5.5 - 14	5.5			

[a]Verification data in parentheses.
bExcept as noted.
[c]Values in fibers/liter.
[d]Values in pH units.
[e]Values in m^3/d.

Note: Blanks indicate no data available.

II.19.2.8 Miscellaneous Waste Streams

The amount of sanitary wastewater depends on the number of people at the plant, which depends on the size, age, and type of plant. Such water is very similar to municipal wastewater except that it does not normally contain laundry or kitchen wastes. Table 19-15 presents estimated pollutant concentrations for sanitary wastewater streams on a per capita basis.

Wastewater from laboratories varies depending on the use of the facilities and type of power plant.

Characteristics of wastewater from backwash of the intake screen depend on the debris in the source water.

Closed cooling water systems have blowdown with a 1 mg/L to 2 mg/L settleable solids content.

Low level radioactive wastewaters contain boron. The concentration and flow discharged depends on the type of water system at the reactor.

Construction activity will generate wastewaters whose types and amounts depend on the size and nature of the activity. Table 19-16 presents pollutant concentrations associated with construction activity at a number of selected sites.

II.19.3 PLANT SPECIFIC DESCRIPTION [1, 4]

Tables 19-17 through 19-26 present pollutant data for selected steam electric power plants. As data for all subcategories were not available for all plants, individual plants were chosen to represent as many subcategories as possible. Verification data were used unless otherwise noted. Analyses of verification samples were performed by Richardson, Radian, GSRI, and Chicago. Detection limits for these contractors are listed below:

Richardson	Limit, μg/L
Acid extractables	25
Base-neutral compounds	10
Phenols	5

Richardson and Chicago	Limit, μg/L
Zinc	60
Antimony	25
Arsenic	25
Selenium	25
Cyanide	20
Lead	20
Thallium	10
Copper	6

TABLE 19-13. AIR POLLUTION CONTROL DEVICES - NONREGENERABLE FLUE GAS DESULFURIZATION (FGD) PROCESSES - RAW WASTEWATER POLLUTANT CONCENTRATIONS [1]

Parameter	Mist eliminator wash water (wet limestone) discharge concentration, Flowrate, L/min/m²			Bleed stream (wet lime/limestone)[a] discharge concentration range	Sludges - lime/limestone and double-alkali system[b] discharge	
	40.7	20.35	10.18		Concentration range	Loading range, mg/kg
Toxic pollutants, μg/L						
Antimony				90 - 2,300		
Arsenic	2	2	10	<4 - 300	4 - 1,800	0.6 - 52
Beryllium	10	<10	<10	<2 - 140	2 - 180	0.05 - 6
Cadmium	42	13	31	4 - 110	4 - 110	0.08 - 4
Chromium	<50	<50	<50	10 - 500	15 - 500	10 - 250
Copper	20	20	30	<2 - 200	2 - 560	8 - 76
Cyanide	<10	<10	<10			
Lead	33	11	16	10 - 400	10 - 520	0.23 - 21
Mercury	<0.2	<0.2	<0.2	0.4 - 70	0.4 - 70	0.001 - 5
Nickel	<50	<50	<50	50 - 1,500		
Selenium	12	24		<1 - 2,200	0.6 - 2,700	2 - 17
Silver	<10	<10	<10	10 - 600		
Zinc	70	20	140	10 - 350	10 - 590	45 - 430
Nontoxic pollutants, μg/L						
Aluminum	<200	<200	<200	30 - 300	30 - 2,000	
Barium	<100	<100	<100			
Boron				8,000 - 46,000		
Calcium	220,000	440,000	430,000	520,000 - 3,000,000	180,000 - 2,600,000	105,000 - 270,000
Cobalt				1,000 - 700		
Iron	5,800	70	5,500	200 - 8,100		
Manganese	160	140	370	90 - 2,500		
Magnesium	6,500	8,300	18,000	3,000 - 2,700,000	4,000 - 2,800,000	
Molybdenum				910 - 6,300		
Potassium	2,200	3,000	2,600	5,900 - 32,000	5,900 - 100,000	
Sodium	8,100	8,800	11,000	14,000 - 2,400,000	10,000 - 28,000,000	0 - 48,000
Tin				3,100 - 3,500		
Vanadium				1 - 670		
Conventional parameters, mg/L[c]						
pH[d]	3.1		2.7	3.04 - 11	4.3 - 12.7	
TDS	1,000	1,900	2,200	3,200 - 15,000	2,800 - 92,000	
COD				60 - 390	1 - 390	
Alkalinity, as $CaCO_3$	580	1,100	1,100	41 - 150		
Acidity, as $CaCO_3$	64		150			
Conductance	1,300	1,600	2,700	3 - 15		
Turbidity	<1	<1	2	<3 - <10		
Silica				0.2 - 3.3		
Fluoride				0.07 - 10	0.6 - 58	
Chloride	24	40	120	420 - 4,800	420 - 33,000	0 - 9,000
Sulfate	700	1,000	1,200	720 - 10,000	600 - 35,000	35,000 - 470,000
Sulfite				0.8 - 3,500	0.9 - 3,500	1,600 - 300,000
Ammonia	0.21	0.25	0.34			
Phosphate	0.11	0.03	0.03	0.03 - 0.41		

Note: Blanks indicate no data available

[a] Data from three plants.

[b] Data from seven plants burning coal and using lime, limestone, or double-alkali absorbents.

[c] Except as noted

[d] Values in pH units.

[e] Values in μmhos/cm.

[f] Values in JTU.

TABLE 19-14. POLLUTION CONTROL DEVICES - NONREGENERABLE FGD PROCESSES - SETTLING POND INFLUENT AND TREATED EFFLUENT MEDIAN CONCENTRATIONS [1][a]

Parameter	Pond A Input liquor	Pond A Supernate	Pond B Input liquor	Pond B Supernate	Pond C Input liquor	Pond C Supernate	Pond D Input liquor	Pond D Supernate
Toxic pollutants, μg/L								
Arsenic	24	5		5		6	240	70
Lead	10	16		20		26	260	10
Mercury	0.5	0.0002		1		0.2	0.1	0.2
Selenium	2	2		21		3		
Nontoxic pollutants, μg/L								
Boron	16,000	5,500		60,000		300	90,000[b]	43,000
Calcium	2,000,000	880,000	1,400,000[b]	1,700,000	2,600	470,000	1,300,000	910,000
Magnesium	210,000		390,000[b]	900	240	1,700	260,000	96,000
Sodium	68	20,000	38,000[b]	34,000	60			
Conventional parameters, mg/L[c]								
pH[d]	8.2	8.0	7.1[b]	9.6	8.1[b]	11	8.2	8.4
TDS	7,110	2,800	6,100[b]	2,200	9,000[b]	1,600	5,900	3,400
TSS	16[b]	9		8		9		98
COD	20[b]	37		43		19		19
Alkalinity, as $CaCO_3$	81[b]	49		190		100		97
Conductivity[e]	10.0	3.2	5.4[b]	8.3	8.2[b]	2.4	5.2	3.9
Chloride	3,604	630	2,400	1,500	4,200	500	1,800	980
Sulfate	1,400	1,100	1,700[b]	900	1,600[b]	200	2,300	1,000
Sulfite	32	0.8[b]	120[b]	70	80[b]	0.85[b]		

[a]Analyses of input liquors to four disposal ponds and subsequent supernates at one plant. All four disposal ponds were filled with effluents representing a cross section of lime or limestone scrubber effluent conditions.

[b]Median derived from less than three plants.

[c]Values in mg/L except as noted.

[d]Values in pH units.

[e]Values in μmhos/cm.

TABLE 19-15. MISCELLANEOUS WASTE STREAMS - SANITARY WASTES - RAW WASTEWATER POLLUTANT CONCENTRATIONS [3]

Location	Flow, m^3/d (gpd)	BOD_5, g (lb)	TSS, g (lb)
Office-administrative (per capita)	0.095 (25)	30 (0.071)	70 (0.15)
Plant (per capita)	0.13 (35)	40 (0.09)	85 (0.19)

TABLE 19-16. MISCELLANEOUS WASTE STREAMS - CONSTRUCTION ACTIVITY - RAW WASTEWATER POLLUTANT CONCENTRATIONS [1]

Location	Number of days	Median pH	Median turbulence, JTU	Median TSS, mg/L
Bellefonte Construction Monitoring				
Drainage ditch, foot of Barge Dock Road	11	7.5		36
	12		25	
West drainage ditch culvert at project entrance road	30	7.6		
	36		25	25
East drainage ditch culvert at project entrance road	38	7.8		
	46		80	75
Settling pond effluent, Town Creek 2.9	33	7.8		
	40		37	
	39			30
Settling pond effluent, Town Creek 3.0	5	7.1	10	6
Drainage ditch, foot of Bellefonte Road	11	7.40		
	13		11	
	12			15
Intake cofferdam pump discharge	3	7.6		
	6		130	120
Permanent pond influent, east ditch[a]	12		1,100	1,700
Permanent pond influent, west ditch[a]	12		150	170
Permanent pond influent, southwest ditch[a]	6		16	20
Construction pond influent, permanent pond effluent[a]	12		29	32
Construction pond influent, berm ditch[a]	8		270	400
Construction pond effluent[a]	12		60	62
Hartsville Construction Monitoring				
Corley Branch 0.03	13	7.6	9.8	15
Mouth of unnamed tributary at CRM 283.52	13	7.6	14	16
Mouth of unnamed tributary at CRM 284.8	9	7.5	31	38
Mouth of unnamed tributary at Dixon Creek 0.46	4	8.0	16	13
Mouth of unnamed tributary at Dixon Creek 1.06	4	7.8		
	5		23	26

[a]pH data not available.

TABLE 19-17. WASTEWATER CHARACTERIZATION, PLANT 0630 [1] (μg/L)

Fuel: Oil and gas
Capacity: 169 MW

Pollutant	Cooling tower intake[a]	Cooling tower effluent[a]	Reverse osmosis intake[a]	Reverse osmosis effluent[a]
Metals				
Antimony	<5	6	<5	<5
Arsenic	<5	13	<5	<5
Beryllium	<5	<5	<5	<5
Cadmium	10	25	<5	<5
Chromium	37	75	<5	<5
Copper	25	150	10	30
Cyanide	130	360	20	30
Lead	<5	17	<5	<5
Mercury	0.41	0.91	0.53	0.55
Nickel	8	100	<5	<5
Selenium	<5	23	13	58
Silver	9	32	9	<5
Thallium	<5	<5	<5	<5
Zinc	41	67	13	14
Phenol (total)	20	40	10	20
Phenols				
2-Chlorophenol	<1	<1	<1	27
2,4-Dichlorophenol	<1	<1	<1	240
Phenol	30	15	255	13
Aromatics				
Toluene	<1	<1	<1	150
Halogenated aliphatics				
Chloroform	<1	<1	3	5.2
Methylene chloride	15	21	3	1.4

Note: All unlisted organics were found in concentrations of less than 1 μg/L.

[a]Screening data: Values for organics are blank adjusted (composite sample concentration minus blank concentration). Metals concentrations are from grab samples.

TABLE 19-18. WASTEWATER CHARACTERIZATION, PLANT 1226 [1] (µg/L)

Water source. Wells .
Fuel: Bituminous coal, oil, and gas
Capacity: 1,229 MW

Pollutant	Cooling tower blowdown[a]							Ash pond overflow - bottom ash[a]							
	Radian		Richardson		GSR1	Chicago (total)		Radian		Richardson		GSR1	Chicago (total)		Chicago influent (total)
Metals															
Antimony	7	(7)						7	(7)						
Arsenic	4	(3)						9	(3)						
Beryllium	BDL							BDL							9
Cadmium	1.8	(2.1)						2	(2)						8
Chromium	5	(7)	28			20	(7)	6	(7)				10	(7)	300
Copper	47	(12)	6	(10)		50	(10)	14	(12)	18	(10)		10	(10)	100
Cyanide	BDL		BDL					BDL		BDL					
Lead	3	(10)						4	(10)	9	(12)				200
Mercury	BDL		BDL					BDL		BDL					
Nickel	6	(1.5)						5.5	(1.5)		(27)				100
Selenium	BDL							8	(BDL)						
Silver	0.7	(1.3)						0.5	(1.3)						8
Thallium	BDL							BDL							
Zinc	26	(9)	50			BDL	(70)	7	(9)				BDL	(70)	700
Phthalates															
Bis(2-ethylhexyl) phthalate					22[b]							21[c]			
Di-n-butyl phthalate					10										
Phenols															
2,4-Dinitrophenol										50	(<10)				
Phenol			8	(12)						17	(12)				
Halogenated aliphatics															
Bromoform	150	(BDL)													
Chlorodibromomethane	59	(BDL)													
Methylene chloride					>1,800							300			
1,1,1-Trichloroethane												27			

[a] Intake values given in parentheses.

[b] Mixture of butyl benzyl and bis(2-ethylhexyl) phthalate.

[c] Combined with di-n-octyl phthalate.

Note: Blanks indicate no data available.
Note: All unlisted organics were found in concentrations of less than 1 µg/L.

TABLE 19-19. WASTEWATER CHARACTERIZATION, PLANT 1720 [1] (μg/L)

Fuel: Oil and gas
Capacity: 1,269 MW

Pollutant	Once-through fresh[a]	Fresh intake water[a]	Cooling discharge	Filtration plant effluent[a]	Water treatment wastes
Metals					
Antimony	7	<5	<5	<5	7
Arsenic	18	13	25	14	<5
Beryllium	<5	<5	<5	<5	<5
Cadmium	<5	<5	<5	5	<5
Chromium	24	<5	17	21	24
Copper	16	<5	20	40	506
Cyanide	20	<20	20	30	<20
Lead	8	<5	14	20	5
Mercury	0.42	0.39	0.42	0.39	0.42
Nickel	29	<5	26	28	9
Selenium	20	20	18	12	25
Silver	<5	<5	<5	<5	37
Thallium	<5	<5	<5	<5	5
Zinc	42	<5	36	41	<5
Phenols (total)	30	50	50	20	40
Phthalates					
Bis(2-ethylhexyl) phthalate	15	1	<1	<1	<1
Phenols					
Phenol	30	50	<1	<1	<1
Aromatics					
Benzene	<1	3	1	2	3
1,3-Dichlorobenzene	<1	<1	<1	1	<1
Ethylbenzene	20	<1	2	3	2
Toluene	26	<1	22	46	55
Halogenated aliphatics					
Chloroform	<1	7	14	23	8
1,2-*Trans*-dichloroethylene	<1	<1	<1	<1	2
Methylene chloride	630	1	24	<1	120
Tetrachloroethylene	<1	<1	3	<1	<1
1,1,1-Trichloroethane	2	1	2	2	1
Trichloroethylene	2	<1	2	<1	<1
Trichlorofluoromethane	40	<1	<1	<1	<1

[a]Screening data: Values for organics are blank adjusted (composite sample concentration minus blank concentration)metals concentrations are from grab samples.

Note: All unlisted organics were found in concentrations of less than 1 μg/L.

TABLE 19-20. WASTEWATER CHARACTERIZATION, PLANT 1741 [1] (μg/L)

Water source: River
Fuel: Bituminous coal and oil
Capacity: 99 MW

Pollutant	Ash pond overflow[a]								Coal pile runoff		
	Fly ash				Bottom ash						
	Richardson	GSR1	Chicago (total)	Chicago influent (total)	Richardson	GSR1	Chicago (total)	Chicago influent (total)	Richardson	GSR1	Chicago (total)
Metals											
Antimony											
Arsenic											
Beryllium				30			BDL	2			4
Cadmium			90 (BDL)	200			10 (BDL)	10			10
Chromium	12 (5)		6 (4,000)	400	9 (5)		BDL (4,000)	60			200
Copper	15		9 (90)	400	35		10 (90)	50			10
Cyanide					BDL						
Lead	120 (9)		BDL (20)	4,000	14 (9)		BDL (20)	50			30
Mercury	BDL										
Nickel	100 (79)		50 (2,000)	400	15 (79)		BDL (2,000)	20			900
Selenium											
Silver				10							
Thallium											
Zinc	1,400		1,000 (BDL)	10,000			70 (BDL)	100			1,000
Phthalates											
Bis(2-ethylhexyl) phthalate		25				309				12[b]	
Di-n-butyl phthalate	40 (<10)	13			26 (<10)	46			32		
Phenols											
2,4-Dichlorophenol					83 (<25)						
Pentachlorophenol					51 (<25)						
Aromatics											
1,2-Dichlorobenzene[c]	41 (<10)				65 (<10)				20		
1,3-Dichlorobenzene[c]	41 (<10)				65 (<10)				20		
1,4-Dichlorobenzene[c]	41 (<10)				65 (<10)				20		
Halogenated aliphatics											
Chloroform										17	
1,2-*Trans*-dichloroethylene										53[d]	
Methylene chloride		>9,400								>3,900	

[a]Intake values given in parentheses.

[b]Combined with di-n-octyl phthalate.

[c]Richardson did not distinguish between 1,2-, 1,3-, and 1,4-dichlorobenzene compounds.

[d]Combination of both *cis* and *trans* forms.

Note: Blanks indicate no data available.
Note: All unlisted organics were found in concentrations of less than 1 μg/L.

TABLE 19-21. WASTEWATER CHARACTERIZATION, PLANT 3306 [1]

Parameter	Fireside wash			
	Concentration, µg/L[a]		Average loading, kg/cleaning (lb/cleaning)	
	Maximum	Average		
Toxic pollutants				
Chromium (total)	15,000	1,500	6.8	(15)
Chromium+6	<1,000	20	0.09	(0.2)
Copper	250,000	6,000	27	(60)
Nickel	900,000	70	320	(700)
Zinc	40,000	4,000	18	(40)
Nontoxic pollutants				
Aluminum	21,000	2,000	9	(20)
Iron	14,000,000	2,500,000	11,000	(25,000)
Manganese	40,000	3,500	16	(35)
Conventional parameters				
TDS	50,000	5,000	23,000	(50,000)
TSS	25,000	250	1,135	(2,500)
Sulfate	10,000	1,000	4,500	(10,000)
Oil and grease		Virtually absent		

[a]Except conventionals, which are given in mg/L

TABLE 19-22. WASTEWATER CHARACTERIZATION, PLANT 3404 [1] (µg/L)

Water source: Wells
Fuel Bituminous coal and oil
apac:ty: 475.6 MW

Pollutant	Fresh intake water[a]	Saline intake water	Cooling tower blowdown[a]	Treatment plant effluent	Ash pond effluent	Slag tank overflow
Metals						
Antimony	<5	11	14	8	12	13
Arsenic	<5	<5	8	9	14	8
Beryllium	<5	<5	<5	<5	<5	<5
Cadmium	<10	15	40	10	13	25
Chromium	<5	16	23	22	20	16
Copper	<5	25	13	30	29	23
Cyanide	<20	<20	<20	<20	<20	<20
Lead	<5	5	<5	8	5	<5
Mercury	0.23	0.34	0.58	0.47	0.32	0.47
Nickel	<5	21	29	80	33	21
Selenium	5	55	87	55	42	48
Silver	<5	40	64	35	19	41
Thallium	<5	<5	9	5	<5	6
Zinc	12	<5	<5	10	8	5
Phenol (total)	10	36	<10	20	20	70
Phthalates						
Bis(2-ethylhexyl) phthalate	<1	11	62	18	9	16
Phenols						
Phenol	<1	<1	<1	1	1	1
Aromatics						
Benzene	2	1	<1	<1	1	1
1,4-Dichlorobenzene	<1	<1	1	<1	<1	<1
Toluene	<1	3	3	5	3	4
Halogenated aliphatics						
Bromoform	<1	<1	4	26	<1	<1
Chlorodibromomethane	1	<1	3	1	<1	<1
Chloroform	47	3	1	1	<1	3
Dichlorobromomethane	17	<1	<1	<1	<1	<1
1,1-Dichloroethylene	<1	1	2	1	1	1
Methylene chloride	<1	20	<1	3	4	1
Trichlorofluoromethane	<1	<1	1	<1	<1	<1

[a]Screening data: Values for organics are blank adjusted (composite sample concentration minus blank concentration). Metals concentrations are from grab samples.

Note: Blanks indicate no data available.
Note: All unlisted organics were found in concentrations of less than 1 µg/L.

TABLE 19-23. WASTEWATER CHARACTERIZATION, PLANT 3410 [1]

Parameter	Air preheater Range	Air preheater Median
Toxic pollutants, μg/L		
Chromium	1,000 - 1,500	1,300
Nickel	18,000 - 25,000	21, 000
Zinc	1,100 - 1,500	1,200
Nontoxic pollutants, μg/L		
Calcium	29,000 - 38,000	34,000
Iron	340,000 - 520,000	460,000
Magnesium	260,000 - 330,000	330,000
Sodium	360,000 - 380,000	370,000
Conventional parameters, mg/L[a]		
TDS	610 - 750	730
TSS	29 - 83	34
COD	50 - 70	60
pH[b]	3.2 - 3.5	3.3
Oil and grease	0.25 - 8.5	0.25
Total hardness, as $CaCO_3$	1,400 - 1,600	1,500
Conductance[c]	2,700 - 3,200	2,700
Chloride	17 - 27	19
Sulfate	1,900 - 2,700	2,500

[a]Except as noted.

[b]Values in pH units.

[c]Values in μmhos/cm.

TABLE 19-24. WASTEWATER CHARACTERIZATION, PLANT 4222 [1] (μg/L)

Water source: River
Fuel: Bituminous coal
Capacity: 1,500 MW

Pollutant	River water intake[a]	Det. basin effluent[a]	Ash sluice wastes	Storm water effluent	POTW water intake
Metals					
Antimony	<5	29	48	<5	<5
Arsenic	<5	160	120	<5	12
Beryllium	<5	20	100	<5	<5
Cadmium	<5	<5	10	<5	<5
Chromium	<5	11	196	<5	<5
Copper	16	6	300	6	6
Cyanide	<20	<20	<20	<20	<20
Lead	<5	<5	240	<5	<5
Mercury	0.26	0.21	0.62	0.29	0.36
Nickel	6	8	250	21	8
Selenium	<5	32	<5	5	5
Silver	<5	<5	<5	<5	<5
Thallium	<5	<5	29	<5	<5
Zinc	14	10	400	10	23
Phenol (total)	<100	260	<100	<100	<100
Phthalates					
Bis(2-ethylhexyl) phthalate	1	<1			
Halogenated aliphatics					
Methylene chloride	<1	5			
Trichlorofluoromethane	<1	2			

[a]Screening data: Values for organics are blank adjusted (composite sample concentrations minus blank concentration). Metals concentrations are from grab samples.

Note: Blanks indicate no data available.
Note: All unlisted organics were found in concentrations of less than 1 μg/L.

TABLE 19-25. WASTEWATER CHARACTERIZATION, PLANT 6387 [4]

Parameter	Lime softner blowdown Sample 1	Lime softner blowdown Sample 2	Evaporator blowdown	Ash transport blowdown	Combined discharge to POTW
Conventional and Nonconventional pollutants, mg/L					
BOD_5	1.8	10	15	1.2	8.4
COD	200	560	76	290	49
TDS	1,000	23,000	2,200	1,900	
TSS	9,400	44	93	1,700	240
TS	10,000	23,000	2,300	3,500	1,700
Oil and grease	1.0	1.0	1.0	1.0	<1.0
Phosphate			6.2	0.02	
Surfactants					0.024
Flow[a]	17	7.6	41	45	520
Toxic pollutants, µg/L					
Chromium (total)	110	100	20	120	20
Chromium $^{+6}$	4	7	5	9	6
Copper	150	120	20	200	20
Cyanide	14	5	6	112	6
Nickel	90	90	110	80	70
Zinc	320	90	110	80	70
Nontoxic pollutants, µg/L					
Iron	10,000	440	380	6,200	640

Note: Blanks indicate data not available.

[a]Values in m^3/d.

TABLE 19-26. WASTEWATER CHARACTERIZATION, PLANT 8392 [4]

Parameter	Demineralizer regeneration concentration, µg/L	Boiler blowdown Concentration, µg/L[a]	Boiler blowdown Loading, g/MWh	Combined discharge to POTW Concentration, µg/L[a]	Combined discharge to POTW Loading, g/MWh
Toxic pollutants					
Chromium (total)	20	20	0.0001	8,100	6.1
Chromium^{+6}	5	9	-[b]	8,000	6.0
Copper	20	60	0.0003	40	0.03
Cyanide	5	14	-[b]	5	<0.005
Nickel	30	30		<30	<0.03
Zinc	20	20	0.0001	2,600	2.0
Nontoxic pollutants					
Iron	70	80	0.0004	710	0.54
Conventional parameters					
TDS	170	120	0.61	16	12
TSS	1.0	6.9	0.036	<1.0	<1.0
TS	170	125.0	0.65	16	12
BOD_5	1.0	11	0.06	20	15
COD	2.0	2.0		12	8.9
Oil and grease	1.0	1.0		1.2	0.91
Bromide	1.0				
Phosphate	0.05	20	0.1		
Surfactants	0.011				
Flow		1.7[c]		240[c]	0.76[d]

[a]Except conventional parameters, which are given in mg/L (unless otherwise noted).

[b]Negligible.

[c]Values in m^3/d.

[d]Value in m^3/MWh.

Note: Blanks indicate no data available.

Richardson and Chicago	Limit, µg/L
Chromium	5
Nickel	5
Cadmium	2
Beryllium	1
Silver	1
Mercury	0.5

GSR1	Limit, µg/L
All tested pollutants	10

Detection limits for Radian were not available. Richardson analyzed the indicated metals only. Arsenic, thallium, antimony, selenium, and mercury were not analyzed in Chicago metal samples.

II.19.4 POLLUTANT REMOVABILITY [1, 3, 4]

Wastewater effluents discharged to publicy owned treatment facilities are sometimes treated by end-of-process physical or chemical systems to remove pollutants potentially hazardous to the POTW or which may be treated inadequately in the POTW. Such treatment methods are numerous, but they generally fall into one of three broad categories in accordance with their process objectives. These include pH control, removal of dissolved materials, and separation of phases.

Table 19-27 lists potential treatment methods and Table 19-28 provides a similar list of solid/liquid separation processes. Available technologies and efficiencies removal for major pollutants are listed in Table 19-29. Most of the processes listed in these tables are in use for treatment of steam electric or other industrial or municipal wastewaters.

Three specific plants were cited in Reference 1 in terms of pollutant removability. Specifics for these three plants are presented in Tables 19-30 through 19-35.

II.19.5 REFERENCES

1. Draft Technical Report for Revision of Steam Electric Effluent Limitations Guidelines. U.S. Environmental Protection Agency, Washington, D.C., September 1978. 607 pp.

2. Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Steam Electric Power Generating Point Source Category. EPA-440/1-73/029, U.S. Environmental Protection Agency, Washington, D.C., March 1974. 677 pp.

3. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Steam Electric Power Generating Point Source Category. EPA-440/1-74/029-a, U.S. Environmental Protection Agency, Washington, D.C., October 1974. 842 pp.

4. Supplement for Pretreatment to the Development Document for the Steam Electric Power Generating Point Source Category. EPA-440/1-77/084, U.S. Environmental Protection Agency, Washington, D.C., April 1977. 244 pp.

5. NRDC Consent Decree Industry Summary - Steam Electric Power Generating Industry.

6. Environmental Protection Agency Effluent Guidelines and Standards for Steam Electric Power Generating. 40 CFR 423; 39 FR 36186, October 8, 1974, effective November 7, 1974; 40 FR 7095, February 19, 1975; 40 FR 23987, June 4, 1975; 42 FR 15690, March 23, 1977; 43 FR 43025, September 22, 1978; 43 FR 44848, September 29, 1978.

TABLE 19-27. END-OF-PIPE TREATMENT TECHNOLOGIES [4]

Method	Objectives	Chemicals or equipment used	Process requirements	Efficiency of removal	Demonstration status
Neutralization	pH adjustment, usually to within the range of 6 to 9	Acid or base as required, usually sulfuric acid or lime			Practiced extensively by industry
Chemical reduction	Reduction of hexavalent chromium to trivalent chromium	Sulfur dioxide, sodium bilsufite, sodium metabisulfite, ferrous salts	pH range of 2 to 3	99.7% (removal to <1 mg/L)	Practiced extensively by industry
Precipitation	Removal of ions by forming insoluble salts	Lime, hydrogen sulfide, organic precipitants, soda ash	Optimum pH depends on the ions to be removed	Copper - 96.6% (removal to <1 mg/L) nickel - 91.7% chromium - 98.8% (removal to 0.006 mg/L) zinc - 99.7% (removal to 0.5-2.5 mg/L) phosphate - 93.6% iron (removal to 0.3 mg/L)	Practiced extensively by industry
Ion exchange	Removal of ions by sorption on surface of a solid matrix	Synthetic cation and anion exchange resins	May require pH adjustment	Cyanide - 99% chromium - 98% (removal to 0.01 mg/L) copper - 95% (removal to 0.03 mg/L) iron - 100% cadmium - 92% nickel - 100% zinc - 75% (removal to 20 mg/L) phosphate - 90% sulfate - 97% aluminum - 98%	Used primarily in water treatment operation for production of boiler feedwater
Liquid/liquid extraction	Removal of soluble organics or chemically charged pollutants	Immiscible solvents that may contain chelating agents	May require pH adjustment	Phenol - 99% chromium - 99% nickel - 99% zinc - 99% fluoride - 68% iron - 99% molybdenum - 90%	Process is not highly developed for industrial use (except phenol extraction)

(continued)

TABLE 27 (continued)

Method	Objectives	Chemicals or equipment used	Process requirements	Efficiency of removal	Demonstration status
Disinfection	Destruction of microorganisms	Chlorine, hypochlorite salts, phenol, phenol derivatives, ozone, salts of heavy metals, chlorine dioxide	May require pH adjustment		Disinfection by chlorine is practiced extensively by industry
Adsorption	Removal of sorbable contaminants	Activated carbon, synthetic sorbents	May require pH adjustment	Depends on the nature of pollutants and composition of waste	Practiced extensively by industry
Chemical oxidation	Destruction of cyanides	Chlorine, hypochlorite salts, ozone, hydrogen peroxide	pH = 9.5-10 (first step), pH = 8 (second step)	99.6%	Practiced extensively by industry
Distillation	Separation of dissolved matter by evaporation of the water	Multistage flash distillation, multiple-effect long-tube vertical evaporation, submerged tube evaporation, vapor compression	May require pH adjustment	100%	Practiced only to a moderate extent by industry, primarily the submerged tube type unit
Reverse osmosis	Separation of dissolved matter by filtration through a semipermeable membrane	Tubular membrane hollow fiber modules, spiral-wound flat sheet membrane		TDS - 93%	Very limited use in industrial wastewater treatment
Electrodialysis	Removal of dissolved polar compounds	Solute is exchanged between two liquids through a selective semipermeable membrane in response to differences in chemical potential between two liquids		TDS - 62-96%	Not practiced by industry
Freezing	Separation of solute from liquid by crystallizing the solvent	Direct refrigeration, indirect refrigeration		>99.5%	Unproven method in waste treatment application

TABLE 19-28. SOLID/LIQUID SEPARATION SYSTEMS [4]

Unit operation	Process objectives	Methods or units used	Retention time	Chemicals used	Efficiency of removal	Demonstration status
Skimming	Removal of floating solids or liquid wastes from the water		1-15 min	None	70-90%	Practiced extensively by industry
Clarification	Removal of suspended solids by settling	Settling ponds, clarifiers	45 min	Coagulants, coagulant aids, pH adjustment	To 15 mg/L	Practiced extensively by industry
Flotation	Separation of suspended solids by flotation followed by skimming	Froth flotation, dispersed air flotation, dissolved air flotation, gravity flotation, vacuum flotation	20-30 min	Aluminum and ferric salts, activated silica organic polymers	90-99%	Practiced extensively by industry
Microstraining	Removal of suspended solids by passing the wastewater through a microscreen		N/A	None	70-80% (23 µm) 50-60% (3 µm)	Practiced only to a moderate extent, primarily in municipal wastewater treatment plants
Filtration	Removal of suspended solids by filtration through a bed of sand and gravel	Multimedia bed, mixed media bed	N/A	None	50-99%	Practiced extensively primarily in water treatment plant
Screening	Removal of large solid matter by passing through screens	Coarse screens, bar screens,	N/A	None	50-99%	Practiced extensively by industry
Thickening	Concentration of sludge by removing water	Gravity thickening, air flotation thickening	N/A	None	Depends on the nature of sludge	Practiced extensively by industry

(continued)

TABLE 19-28 (continued).

Unit operation	Process objectives	Methods or units used	Retention time	Chemicals used	Efficiency of removal	Demonstration status
Pressure filtration	Separation of solid from liquid by passing through a semipermeable membrane under pressure	Plate and frame pressure filter	1-3 hr	None	To 50-75% moisture content	Practiced by industry for sludge dewatering
Heat drying	Reduce the water content of sludge	Flash drying, spray drying, rotary kiln drying multiple hearth drying	N/A	None	To 8% moisture	Rotary kilns are used by industry to small extent
Ultrafiltration	Separation of macro-molecules of suspended matter from the waste by filtration through a semi-permeable membrane under pressure		N/A	None	Total solid removal of 95% and above	Used by industry primarily to treat oily waste
Sandbed drying	Removal of moisture from sludge by evaporation and drainage through sand	Covered beds, uncovered beds	Filtration 1-2 days	None	As filter 15-20%	Practiced extensively by industry
Vacuum filtration	Solid liquid separation by vacuum	Rotary vacuum filter	1-5 minutes	None	Produces 30% solid in in filter cake	Practiced extensively by industry
Centrifugation	Liquid/solid separation by centrifugal force	Disc centrifuge, basket centrifuge, conveyor type centrifuge	N/A	None	Moisture is reduced to 65-70%	Practiced by industry for sludge dewatering
Emulsion breaking	Separation between emulsified oil and water		2-8 hr	Aluminum salts, iron salts, pH adjustment (1-4)	>99%	Practiced extensively by industry

TABLE 19-29. CHEMICAL WASTES CONTROL AND TREATMENT TECHNOLOGY [3]

Pollutant/parameter	Control and/or treatment technology	Effluent reduction achievable	Industry usage
pH	Neutralization with chemicals	Neutral pH	Common
Dissolved solids	1. Concentration and evaporation	Complete removal	Not generally in use - desalinization technology
	2. Reverse osmosis	50-95%	Not in use - desalinization technology
	3. Distillation	60-90%	Not in use - desalinization technology
Suspended solids	1. Sedimentation	90-95%	Extensive
	2 Chemical coagulation and precipitation	95-99%	Moderate
	3. Filtration	95% (removal to 2-10 µg/L)	Not generally practiced-water treatment technology
BOD/COD, Sanitary wastes	Biological treatment	Neutral pH and >95% removal	Limited usage
COD, Water treatment, chemical cleaning	1. Chemical oxidation	85-95%	Limited usage
	2. Aeration	85-95%	Not practiced
	3. Biological treatment	85-95%	Not practiced
Phosphate, Blowdown, chemical cleaning, floor and yard drains, plant laboratory and sampling	1. Chemical coagulation and and precipitation		Not generally practiced-water treatment technology
	2. Deep well disposal	Ultimate disposal	Not practiced
Iron, Water treatment, chemical cleaning, coal ash handling, coal pile drainage	1 Oxidation, chemical coagulation and precipitation	Removal to 0.1 mg/L	Limited usage
	2 Deep well disposal	Ultimate disposal	Not practiced
Copper, Once-through condenser cooling	1 Replace condenser tubes with stainless steel or titanium	Elimination of discharge	Done in several plants where tubes have erroded or corroded-not done for environmental reasons
Copper, Blowdown, chemical cleaning	1. Chemical coagulation and precipitation	Removal to 0.1 mg/L	Limited usage
	2 Ion exchange	Removal to 0.1 mg/L	Not practiced
	3. Deep well disposal	Ultimate disposal	Not practiced
Mercury, Coal ash handling and coal pile drainage	1 Reduction and precipitation	Removal to 0.3 mg/L	Limited usage
	2. Ion exchange	Removal to 0.1 mg/L	Not practiced
	3. Adsorption	Removal to 50 µg/L	Not practiced
Vanadium, Chemical cleaning	1. H_2S treatment and precipitation	Removal of low concentrations difficult to achieve	Not practiced
	2. Ion exchange		Not practiced

(continued)

TABLE 19-29 (continued).

Pollutant/parameter	Control and/or treatment technology	Effluent reduction achievable	Industry usage
Vanadium, Oil ash handling	1. Convert to dry collection	Ultimate disposal	Practiced in several plants
	2. Total recycle with blowdown and precipitation	Complete recycle of liquid	Not generally practiced
Chlorine, Once-through condenser cooling	1. Control of residual Cl_2 with automatic instrumentation	Control to 0.2 mg/L	Limited usage in the industry-Technology from sewage treatment practiced in some plants-all systems are not capable of being converted to mechanical cleaning
	2. Utilize mechanical cleaning	Eliminates Cl_2 discharge	
Chlorine, Recirculating	1. Control of residual Cl_2 with automatic instrumentation	Control to 0.2 mg/L	Limited usage in the industry
	2. Reduction of Cl_2 with sodium bisulfite	Below detectable limits	Being installed in a new nuclear facility; however excess $NaHSO_3$ is discharged
Aluminum/zinc, Water treatment, chemical cleaning, coal ash handling, coal pile drainage	1. Chemical precipitation	Removal to 1.0 mg/L	Limited usage
	2. Ion exchange	Removal to 0.1 mg/L	
	3. Deep well disposal	Ultimate disposal	Not practiced
Oil, Chemical cleaning, ash handling, floor and yard drains	1. Oil-water separator (sedimentation with skimming)	Removal to 15 mg/L	Common usage
	2. Air flotation	Removal to 10 mg/L	Limited usage
Phenols, Ash handling, coal pile drainage, floor and yard drains	1. Biological treatment	Removal to 1 mg/L	Not practiced
	2. Ozone treatment	Removal to <0.01 mg/L	Not practiced
	3. Activated carbon	Removal to <0.01	Not practiced
Sulfate/sulfite, Water treatment, chemical cleaning, ash handling, coal pile drainage, SO_2 removal	Ion exchange (sulfate) Oxidation and ion exchange (sulfite)	75-95%	Not practiced
Ammonia, Water treatment, blowdown, chemical cleaning, closed cooling water systems	1 Stripping	50-90%	Not practiced; several installations in sewage treatment
	2. Biological nitrification	Removal to 2 mg/L	Not practiced for these waste streams
	3. Ion exchange	80-95%	Not practiced
Oxidizing agents, Chemical cleaning	Neutralization with reducing agent and precipitation where necessary	Neutral pH and >95% removal	Limited usage
Fluoride, Chemical cleaning	Chemical precipitation	Removal to 1 mg/L	Limited usage
Boron, Low level radwastes	Ion exchange	Removal to 1 mg/L	Not generally practiced-radioactive material would concentrate on ion exchange resin requiring inclusion in solid radwaste disposal system

TABLE 19-30. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW AND TREATED WASTEWATER, PLANT 1226 [1]

	Reverse osmosis						Chemical precipitation, Lime					
	Cooling tower blowdown			Ash pond effluent			Cooling tower blowdown			Ash pond effluent		
	Concentration, µg/L			Concentration, µg/L			Concentration, µg/L			Concentration, µg/L		
Toxic pollutant	Inlet	Outlet	Percent removal	Inlet	Outlet	Percent removal	Inlet	Outlet	Percent removal	Inlet	Outlet	Percent removal
Metals and inorganics												
Antimony	7	10	0[a]	7	BDL	100[b]	7	4	43	7	10	0[a]
Arsenic	4	1	75	9	<1	>89	4	3	25	9	1	89
Beryllium	<0.5	<0.5	-[c]	<0.5	<0.5	-[c]	<0.5	0.9	-[a]	<0.5	<0.5	-[c]
Cadmium	1.8	2.5	0[a]	2.0	1.3	35	1.8	3.0	0[a]	2.0	2.0	0[a]
Chromium	5	<2	60	6	<2	>67	4	9	0[a]	6	11	0[a]
Copper	47	10	79	14	10	29	47	18	62	14	10	29
Cyanide	5	1	80	<1	8	0[a]						
Lead	3	<3	>0	4	<3	>25	3	5	0[a]	4	<3	>25
Mercury	0.2	0.3	0[a]	<0.2	<0.2	-[c]	0.2	0.7	0[a]	<0.2	0.3	0[a]
Nickel	6.0	3.0	50	5.5	5.0	9	6.0	2.9	52	5.5	6.0	0[a]
Selenium	<2	<2	-[c]	8	2	75	<2	<2	-[c]	8	8	0
Silver	0.7	0.6	14	0.5	<0.2	>60	0.7	0.9	0[a]	0.5	0.4	20
Thallium	<1	<1	-[c]	<1	<1	-[c]	<1	<1	-[c]	<1	<1	-[c]
Zinc	27	<2	>92	7	<2	>57	26	2	92	7	2	57
Ethers												
4-Chlorophenol	<1											
Phthalates												
Bis(2-ethylhexyl) phthalate[d]	3.2	1.2	63									
Butyl benzyl phthalate		<1										
Di-n-butyl phthalate	5.0	11.3	0[a]		9.9							
Diethyl phthalate	<1	<1	-[c]									
Dimethyl phthalate	6.1	<1	>84	2 3	5.5	0[a]						
Phenols												
Phenol	1.7	NA	-[c]	2.0	NA	-[c]						
Aromatics												
Benzene	3.8				1.9							
1,3-Dichlorobenzene	<1											
Ethylbenzene		<1										
Toluene				<1								
1,2,4-Trichlorobenzene[e]	4.6											
Polycyclic aromatic hydrocarbons												
Acenapthene	1.1	<1	>9	<1	<1	-[c]						
Acenaphthylene	<1	<1	-[c]	<1	1.6	0[a]						
Anthracene[f]		1.5			<1							
Benz(a)anthracene[d]	3.2	1.2	63									
Benzo(b)fluoranthene[g]	2.9			<1								
Benzo(k)fluoranthene[g]	2.9			<1								
2-Chloronaphthalene	2.1											
Chrysene[d]	3.2	1.2	63									
Fluoranthene		<1			2.7							
Fluorene		<1		<1								
Indeno(1,2,3-cd)pyrene												
Naphthalene		<1			1.4							
Phenanthrene[f]		1.5			<1							
Pyrene					<1							

TABLE 19-30 (continued).

	Reverse osmosis						Chemical precipitation, Lime					
	Cooling tower blowdown			Ash pond effluent			Cooling tower blowdown			Ash pond effluent		
	Concentration, µg/L			Concentration, µg/L			Concentration, µg/L			Concentration, µg/L		
Toxic pollutant	Inlet	Outlet	Percent removal	Inlet	Outlet	Percent removal	Inlet	Outlet	Percent removal	Inlet	Outlet	Percent removal
Halogenated aliphatics												
Bromoform	150	ND	100	<1	<1	-[c]						
Chlorodibromomethane	59	ND	100	<1	<1	-[c]						
Hexachlorobutadiene[e]	4.6											
Hexachlorocyclopentadiene	<1	<1	-[c]	<1	<1	-[c]						
Tetrachloroethylene	<2	1.3	0[a]	<1	<1	-[c]						
1,1,1-Trichloroethane	ND	<1	0[a]									
Trichloroethylene	ND	<1	0[a]									
Pesticides and metabolites												
Aldrin	<1											
α-BHC[h]	<1			<1	<1	-[c]						
γ-BHC[h]	<1			<1	<1	-[c]						
4,4'-DDT	<1											
Endosulfan sulfate[i]	<1											
Endrin aldehyde[i]	<1											
Heptachlor epoxide	<1				<1							
	Chemical precipitation, Lime + Fe^{+2}						Activated carbon					
Metals and inorganics												
Antimony	7	9	0[a]	7	9	0[a]						
Arsenic	4	3	25	9	3	67						
Beryllium	<0.5	<0.5	-[c]	<0.5	<0.5	-[c]						
Cadmium	1.8	1.6	11	2.0	3.2	0[a]						
Chromium	5	3	40	6	4	33						
Copper	47	4	91	14	7	50						
Cyanide												
Lead	3	<3	>0	4	<3	>25						
Mercury	0.2	0.2	0	<0.2	0.6	0[a]						
Nickel	6.0	6.0	0	5.5	9.0	0[a]						
Selenium	<2	<2	-[c]	8	7	12						
Silver	0.7	0.4	43	0.5	0.4	20						
Thallium	<1	<1	-[c]	<1	<1	-[c]						
Zinc	26	2	92	7	6	14						
Ethers												
4-Chlorophenol							<1					
Phthalates												
Bis(2-ethylhexyl) phthalate[d]							3.2	<1	69	<1	<1	-[c]
Butyl benzyl phthalate												
Di-n-butyl phthalate							5.0	6.8	0[a]			
Diethyl phthalate							<1	ND	100		<1	-
Dimethyl phthalate							6.1	ND	100	2.3	1.5	35
Phenols												
Phenol							1.7	NA	-[c]	2.0	NA	-[c]

(continued)

TABLE 19-30 (continued).

Toxic pollutant	Chemical precipitation, Lime + Fe: Cooling tower blowdown, Concentration, µg/L, Inlet	Outlet	Percent removal	Ash pond effluent, Concentration, µg/L, Inlet	Outlet	Percent removal	Lime: Cooling tower blowdown, Concentration, µg/L, Inlet	Outlet	Percent removal	Ash pond effluent, Concentration, µg/L, Inlet	Outlet	Percent removal
Aromatics												
Benzene							3.8					
1,3-Dichlorobenzene							<1					
Ethylbenzene											2.3	
Toluene										<1		
1,2,4-Trichlorobenzene[e]							4.6					
Polycyclic aromatic hydrocarbons												
Acenapthene							1.1			<1		
Acenaphthylene							<1	<1	-[c]	<1		
Anthracene[f]												
Benz(a)anthracene[d]							3.2	<1	69	<1	<1	-[c]
Benzo(b)fluoranthene[g]							2.9	5.9	0[a]	<1	1.2	0[a]
Benzo(k)fluoranthene[g]							2.9	5.9	0[a]	<1	1.2	0[a]
2-Chloronaphthalene							2.1					
Chrysene[d]							3.2	<1	69	<1	<1	-[c]
Fluoranthene								<1		1.0		
Fluorene										<1		
Indeno(1,2,3-cd)pyrene											2.1	
Naphthalene							<1					
Phenanthrene[f]												
Pyrene							<1			7.1	<1	>86
Halogenated aliphatics												
Bromoform							150	ND	100	<1	ND	100
Chlorodibromomethane							59	ND	100	<1	<1	-[c]
Chloroform							<1	ND	100			
1,2-Dichloroethane								<1				
Hexachlorobutadiene[e]												
Hexachlorocyclopentadiene							<1			<1		
Tetrachloroethylene							<2			<1		
1,1,1-Trichloroethane											<1	
Trichloroethylene											<1	
Pesticides and metabolites												
Aldrin							<1					
δ-BHC[h]							<1					
γ-BHC[h]							<1					
4,4'-DDT							<1					
Endosulfan sulfate[i]							<1					
Endrin aldehyde[i]							<1					
Heptachlor epoxide							<1					

[a] Negative removal.

[b] Effluent concentration below detectable limits.

[c] Indeterminate.

[d] Combination of bis(2-ethylhexyl) phthalate, benz(a)anthracene, and chrysene.

[e] Combination of 1,2,4-trichlorobenzene and hexachlorobutadiene.

[f] Combination of phenanthrene and anthracene.

[g] Combination of benzo(b)fluoranthene and benzo(k)fluoranthene.

[h] Combination of δ-BHC and γ-BHC.

[i] Combination of endosulfan sulfate and endrin aldehyde.

TABLE 19-31. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN RAW AND TREATED WASTEWATER, PLANT 1226 [1]

Pollutant	Cooling tower blowdown: Concentration Inlet	Cooling tower blowdown: Concentration Outlet	Cooling tower blowdown: Percent removal	Ash pond effluent: Concentration Inlet	Ash pond effluent: Concentration Outlet	Ash pond effluent: Percent removal
	Reverse osmosis					
TOC, mg/L	<20	<20	-[a]	<20	<20	-[a]
pH	6.8			9.1		
Methoxyclor, μg/L	1.1					
Vanadium, μg/L	27	58	0[b]	78	14	82
	Chemical precipitation: Lime					
TOC, mg/L	<20	<20	-[a]	<20	<20	-[a]
pH	11.5			11.5		
Methoxyclor, μg/L						
Vanadium, μg/L	27	6	78	78	78	0
	Chemical precipitation: Lime + Fe^{+2}					
TOC, mg/L	<20	<20	-[a]	<20	<20	-[a]
pH						
Methoxyclor, μg/L	1.1					
Vanadium, μg/L	27	12	56	78	82	0[b]

[a]Indeterminate.

[b]Negative removal.

TABLE 19-32. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW AND TREATED WASTEWATER, PLANT 5409 [1]

	Reverse osmosis						Chemical precipitation Lime					
	Cooling tower blowdown			Ash pond effluent			Cooling tower blowdown			Ash pond effluent		
	Concentration, µg/L		Percent	Concentration, µg/L		Percent	Concentration, µg/L		Percent	Concentration, µg/L		Percent
Toxic pollutant	Inlet	Outlet	removal	Inlet	Outlet	removal	Inlet	Outlet	removal	Inlet	Outlet	removal
Metals and inorganics												
Antimony	<1	<1	-[a]	5	2.5	50	<1	4	0[b]	5	4	20
Arsenic	<1	<1	-[a]	74	<1	>99	<1	2.5	0[b]	74	<1	>99
Beryllium	3.4	<0.5	>85	<0.5	<0.5	-[a]	3.4	0.8	76	<0.5	<0.5	-[a]
Cadmium	0.8	<0.5	>37	<0.5	<0.5	-[a]	0.8	<0.5	>38	<0.5	<0.5	-[a]
Chromium	37	<2	>94	<2	<2	-[a]	37	8.8	76	<2	<2	-[a]
Copper	620	51	92	26	9	65	620	70	89	26	12	54
Cyanide	5	24	0[b]	13	10	23						
Lead	70	<3	>96	<3	6.5	0[b]	70	<3	>96	<3	<3	-[a]
Mercury	0.5	<0.2	>60	<0.2	<0.2	-[a]	0.5	<0.2	>60	<0.2	<0.2	-[a]
Nickel	4.0	3.6	10	2.5	1.5	40	4	2.3	43	2.5	2.2	12
Selenium	<2	<2	-[a]	42	6.1	85	<2	2.3	0[b]	42	52	0[b]
Silver	14	1.1	92	1	1	0	14	7.8	44	1	1.1	0[b]
Thallium	8	4	50	9	1	89	8	<1	>88	9	8	11
Zinc	61	<2	>97	11	2	92	61	<2	>97	11	<2	>82
Phthalates												
Bis(2-ethylhexyl) phthalate[c]	3.4	2	41	<1	<1	-[a]						
Di-n-butyl phthalate	10	ND	100	12								
Diethyl phthalate	2.7	<1	>63	<1								
Dimethyl phthalate	11	4.7	56	6.7								
Phenols												
Phenol	4.1	NA	-[a]	4.1	NA	-[a]						
Aromatics												
Benzene	1.5	<1	>33	1.0	<1	>0						
Ethylbenzene					1.7							
Toluene					3.3							
1,2,4-Trichlorobenzene[d]				<1								
Polycyclic aromatic hydrocarbons												
Acenapthene	1.7	<1	>41	1.0								
Acenaphthylene	<1	<1	-[a]	<1								
Anthracene	6.2											
Benz(a)anthracene[c]	3.4	2	41	<1	<1	-[a]						
Benzo(b)fluoranthene[e]	2.8	ND	100									
Benzo(k)fluoranthene[e]	2.8	ND	100									
2-Chloronaphthalene	<1	1.4	-[a]									
Chrysene[c]	3.4	2	41	<1	<1	-[a]						
Fluoranthene	5.5	7.4	0[b]	<1	<1	-[a]						
Fluorene	<1	<1	-[a]	<1								
Naphthalene	<1											
Phenanthrene	6.2											
Pyrene	3.5	<1	>71		<1							

(continued)

TABLE 19-32 (continued).

Toxic pollutant	Reverse osmosis: Cooling tower blowdown: Concentration, µg/L Inlet	Outlet	Percent removal	Reverse osmosis: Ash pond effluent: Concentration, µg/L Inlet	Outlet	Percent removal	Chemical precipitation, Lime: Cooling tower blowdown: Concentration, µg/L Inlet	Outlet	Percent removal	Chemical precipitation, Lime: Ash pond effluent: Concentration, µg/L Inlet	Outlet	Percent removal
Halogenated aliphatics												
Chlorodibromomethane	<1											
Chloroform	2.4	<1	>58	<1								
Hexachlorobutadiene[d]				<1								
Hexachlorocyclopentadiene	<1	<1	-[a]									
Trichloroethylene	<1	ND	100									
Pesticides and metabolites												
Aldrin				<1								
β-BHC[f]		1.1										
δ-BHC[g]					<1							
γ-BHC[g]					<1							
4,4'-DDD		<1										
4,4'-DDT				<1								
β-Endosulfan		<1										
Endrin	<1			<1								
Heptachlor[f]		1.1										
	Chemical precipitation, Lime + Fe^{+2}						Activated carbon					
Metals and inorganics												
Antimony	<1.0	<1.0	-[a]	5.0	3.5	30						
Arsenic	<1.0	<1.0	-[a]	74	<1.0	>99						
Beryllium	3.4	<0.5	>85	<0.5	<0.5	-[a]						
Cadmium	0.8	0.5	37	<0.5	<0.5	-[a]						
Chromium	37	<2.0	>95	<2.0	<2.0	-[a]						
Copper	620	48	92	26	18	31						
Cyanide												
Lead	70	<3	>96	<3.0	<3.0	-[a]						
Mercury	0.5	<0.2	>60	<0.2	<0.2	-[a]						
Nickel	4.0	3.6	10	2.5	2.0	20						
Selenium	<2.0	<2.0	-[a]	42	32	24						
Silver	14	1.0	93	1.0	1.1	0[b]						
Thallium	8.0	1.0	>88	9.0	7.0	22						
Zinc	61	<2	>97	11	<2.0	>82						
Phthalates												
Bis(2-ethylhexyl) phthalate[c]												
Di-n-butyl phthalate												
Diethyl phthalate												
Dimethyl phthalate												
Phenols												
Phenol												

(continued)

TABLE 19-32 (continued).

Toxic pollutant	Chemical precipitation, Lime + Fe^{+2}: Cooling tower blowdown, Concentration, µg/L, Inlet	Outlet	Percent removal	Ash pond effluent, Concentration, µg/L, Inlet	Outlet	Percent removal	Activated carbon: Cooling tower blowdown, Concentration, µg/L, Inlet	Outlet	Percent removal	Ash pond effluent, Concentration, µg/L, Inlet	Outlet	Percent removal
Aromatics												
Benzene	1.5	<1	>33	1.0	<1	>0						
1,4-Dichlorobenzene		1.8										
Ethylbenzene												
Toluene												
1,2,4-Trichlorobenzene[d]												
Polycyclic aromatic hydrocarbons												
Acenapthene												
Acenaphthylene												
Anthracene												
Benz(a)anthracene[c]												
Benzo(b)fluoranthene[e]												
Benzo(k)fluoranthene[e]												
2-Chloronaphthalene	<1											
Chrysene[c]												
Fluoranthene												
Fluorene												
Naphthalene												
Phenanthrene												
Pyrene												
Halogenated aliphatics												
Chlorodibromomethane	<1	ND										
Chloroform	2.4	<1	>58	<1								
Hexachlorobutadiene[d]												
Hexachlorocyclopentadiene	<1			<1								
Trichloroethylene	<1	ND	100									
Pesticides and metabolites												
Aldrin				<1								
β-BHC[f]												
δ-BHC[g]		<1										
γ-BHC[g]		<1										
4,4'-DDD												
4,4'-DDT				<1								
β-Endosulfan												
Endrin	<1			<1								
Heptachlor[f]												

[a]Interdeterminate.

[b]Negative removal.

[c]Combination of bis(2-ethylhexyl) phthalate, benz(a)anthracene, and chrysene.

[d]Combination of 1,2,4-trichlorobenzene and hexachlorobutadiene.

[e]Combination of benzo(b)fluoranthene and benzo(k)fluoranthene.

[f]Combination of heptachlor and β-BHC.

[g]Combination of δ-BHC and γ-BHC.

TABLE 19-33. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN RAW AND TREATED WASTEWATER, PLANT 5409 [1]

Pollutant	Reverse osmosis					
	Cooling tower blowdown			Ash pond effluent		
	Concentration		Percent removal	Concentration		Percent removal
	Inlet	Outlet		Inlet	Outlet	
TOC, mg/L	21	<20	>5	<20	<20	-[a]
pH	6.8			6.7		
Vanadium, μg/L	11	16	0[b]	31	21	32
	Chemical precipitation					
	Lime					
TOC, mg/L	21	<20	>5	<20	<20	-[a]
pH						
Vanadium, μg/L	11	6	45	31	19	39
	Chemical precipitation					
	Lime + Fe^{+2}					
TOC, mg/L	21	NA		<20	NA	
pH						
Vanadium, μg/L	11	46	0[b]	31	19	39

[a]Indeterminate.

[b]Negative removal.

TABLE 19-34. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN RAW AND TREATED WASTEWATER, PLANT 5604 [1]

	Reverse osmosis						Chemical precipitation, Lime					
	Cooling tower blowdown			Ash pond effluent			Cooling tower blowdown			Ash pond effluent		
	Concentration, µg/L		Percent removal	Concentration, µg/L		Percent removal	Concentration, µg/L		Percent removal	Concentration, µg/L		Percent removal
Toxic pollutant	Inlet	Outlet		Inlet	Outlet		Inlet	Outlet		Inlet	Outlet	
Metals and inorganics												
Antimony	5	2	60	6	3	50	5	3	40	6	5	14
Arsenic	7	49	0[a]	<1	<1	-[b]	7	<1	>86	<1	1	0[a]
Beryllium	<0.5	<0.5	-[b]	2.5	5	0[a]	<0.5	<0.5	-[b]	2.5	0.5	<80
Cadmium	<0.5	2	0[a]	1	<1	>0	<0.5	<0.5	-[b]	1	0.5	<50
Chromium	2	2	0	4	<1	>75	2	<2	>0	4	2	50
Copper	180	32	82	80	9	89	180	48	73	80	23	71
Cyanide	3	6	0[a]	22	4	82						
Lead	<3	20	0[a]	<3	<1	67	<3	<3	-[b]	<3	3	0[a]
Mercury	<0.2	<1	0[a]	<0.2	<1	0[a]	<0.2	<0.2	-[b]	<0.2	0.2	0[a]
Nickel	6	<1	>83	9.5	<1	>89	6	12	0[a]	9.5	0.5	<95
Selenium	<2	<1	50	3	<1	>67	<2	<2		3	3	0
Silver	3	4	0[a]	5.5	2	64	3	4	0[a]	5.5	5	9
Thallium	<1	<1	-[b]	<1	2	0[a]	<1	<1	-[b]	<1	1	0[a]
Zinc	780	3	99	300	53	82	780	140	82	300	31	90
Phthalates												
Bis(2-ethylhexyl) phthalate[c]	1.3	<1	>23	1.0	2.1	0[a]						
Butyl benzyl phthalate												
Di-n-butyl phthalate	2.9	ND	100	1.6	<1	>38						
Diethyl phthalate		<1		4.9	<1	>80						
Dimethyl phthalate	<1	2.5	0[a]		<1							
Phenols												
Phenol	2.4	NA			NA							
Aromatics												
Benzene	<1			2.0	1.4	30						
Ethylbenzene		2.6			2.1							
Toluene	24	20	15	3.5	2.8	20						
Polycyclic aromatic hydrocarbons												
Acenapthene	<1				<1							
Acenaphthylene	<1	<1			<1							
Anthracene	<1	<1	-[b]									
Benz(a)anthracene[c]	1.3	<1	>23	1.0	2.1	0[a]						
Benzo(b)fluoranthene[d]	7.8	12	0[a]									
Benzo(k)fluoranthene[d]	7.8	12	0[a]									
Chrysene[c]	1.3	<1	>23	1.0	2.1	0[a]						
Fluoranthene	2.7	<1	>63		8.9							
Fluorene	1	<1	>0		<1							
Indeno(1,2,3-cd)pyrene	18.8											
Phenanthrene	<1	<1	-[b]									
Pyrene	4.8	3.9	19									
Halogenated aliphatics												
Chloroform		<1		<1	ND	100						
Pesticides and metabolites												
β-BHC[e]		<1										
Heptachlor[e]		<1										

(continued)

TABLE 19-34 (continued).

Toxic pollutant	Chemical precipitation, Lime + Fe^{+2}: Cooling tower blowdown, Concentration, µg/L, Inlet	Outlet	Percent removal	Chemical precipitation, Lime + Fe^{+2}: Ash pond effluent, Concentration, µg/L, Inlet	Outlet	Percent removal	Activated carbon: Cooling tower blowdown, Concentration, µg/L, Inlet	Outlet	Percent removal	Activated carbon: Ash pond effluent, Concentration, µg/L, Inlet	Outlet	Percent removal
Metals and inorganics												
Antimony	5	5	0	6	30	0[a]						
Arsenic	7	<1	>86	<1	<1	-[b]						
Beryllium	<0.5	<0.5	-[b]	2.5	0.5	80						
Cadmium	<0.5	<0.5	-[b]	1	<0.5	>50						
Chromium	2	<2	>0	4	2	50						
Copper	180	26	86	80	23	80						
Cyanide												
Lead	<3	<3	-[b]	<3	<3	-[b]						
Mercury	<0 2	<0.2	-[b]	<0.2	<0.2	-[b]						
Nickel	6	3	50	9.5	<0.5	>95						
Selenium	<2	<2	-[b]	3	3	0						
Silver	3	10	0[a]	5.5	5	9						
Thallium	<1	<1	-[b]	<1	<1	-[b]						
Zinc	780	36	95	300	25	92						
Phthalates												
Bis(2-ethylhexyl) phthalate[c]							1.3	1.2	7.7	1.0	<1	>0
Butyl benzyl phthalate								1.9			2.4	
Di-n-butyl phthalate							2.9	4.2	0[a]	1.6	<1	>38
Diethyl phthalate								7.5		4.9	<1	>80
Dimethyl phthalate							<1				<1	
Phenols												
Phenol							2.4	NA			NA	
Aromatics												
Benzene												
1,4-Dichlorobenzene												
Ethylbenzene							<1	<1	-[b]	2.0	<1	>50
Toluene							24	3.3	>86	3.5	5.3	0[a]
Polycyclic aromatic hydrocarbons												
Acenapthene							<1					
Acenaphthylene							<1					
Anthracene							<1					
Benz(a)anthracene[c]							1.3	1.2	7.7	1.0	<1	>0
Benzo(b)fluoranthene[d]							7.8	3.7	52			
Benzo(k)fluoranthene[d]							7.8	3.7	52			
Chrysene[c]							1.3	1.2	7.7	1.0	<1	>0
Fluoranthene							2.7	1 1	59		6 9	
Fluorene							<1			<1		
Indeno(1,2,3-cd)pyrene							19				2.0	
Phenanthrene							<1					
Pyrene							4.8	1.5	69		<1	
Halogenated aliphatics												
Chloroform										<1	ND	100
Pesticides and metabolites												
β-BHC[e]												
Heptachlor[e]												

[a]Negative removal

[b]Indeterminate

[c]Combination of bis(2-ethylhexyl) phthalate, benz(a)anthracene, and chrysene

[d]Combination of benzo(b)fluoranthene and benzo(k)fluoranthene.

[e]Combination of β-BHC and heptachlor.

TABLE 19-35. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN RAW AND TREATED WASTEWATER, PLANT 5604 [1]

Pollutant	Cooling tower blowdown			Ash pond effluent		
	Concentration		Percent	Concentration		Percent
	Inlet	Outlet	removal	Inlet	Outlet	removal
	Reverse osmosis					
TOC, mg/L	14			7.6		
TSS, mg/L						
pH	6.9			5.6		
Vanadium, μg/L	24	22	8	27	5	81
	Chemical precipitation, Lime					
TOC, mg/L	14			7.6		
TSS, mg/L	42			15		
pH						
Vanadium, μg/L	24	77	0[a]	27	17	37
	Chemical precipitation, Lime + Fe^{+2}					
TOC, mg/L	14			7.6		
TSS, mg/L	42			15		
pH						
Vanadium, μg/L						

[a]Negative removal.

II.20 TEXTILE MILLS

II.20.1 INDUSTRY DESCRIPTION [1]

II.20.1.1 General Description

The United States textile industries are covered by 2 of the 20 major groups of manufacturing industries in the Standard Industrial Classification (SIC). They are Textile Mill Products, Major Group 22, and Apparel and Other Textile Mill Products, Major Group 23. The Textile Mill Products group includes 30 separate industries that manufacture approximately 90 classes of products. The Apparel and Other Textile Products group includes 33 separate industries that manufacture some 70 classes of products.

Major Group 22 facilities are principally engaged in receiving and preparing fibers; transforming these materials into yarn, thread, or webbing; converting the yarn and web into fabric or related products; and finishing these materials at various stages of the production. Many produce a final consumer product such as thread, yarn, bolt fabric, hosiery, towels, sheets, carpet, etc., while the rest produce a transitional product for use by other establishments in Major Groups 22 and 23.

The facilities in Major Group 23, Apparel and Other Textile Mill Products, are principally engaged in receiving woven or knitted fabric for cutting, sewing, and packaging. Some of the products manufactured are dry cleaned and some undergo auxiliary processing to prepare them for the consumer. In general, all processing is dry and little or no discharge results.

The exact number of wet processing mills and the total number of mills in the textile industry are difficult to establish because of the relatively large numbers involved, the dynamic state of the industry, and differing classification criteria. The number of wet processing mills is estimated to be approximately 2,000, and the total mills between 5,000 and 7,500. Nearly 80% of the facilities are located in the Mid-Atlantic and Southern regions. The remaining 20% are distributed about equally between the New England region and the North Central and Western regions. Some industries, particularly yarn manufacturing, weaving, and carpet manufacturing, are heavily concentrated in a few southeastern states.

Facilities in the textile industry are engaged in various processing operations required to transform fiber -- the industry's basic raw material -- into yarn, fabric, or other finished textile products. Approximately 70% of the facilities are believed to perform manufacturing operations that require no process water and an additional 10% are believed to use only small quantities of process water. In contrast, the remaining 20% of the facilities that scour wool fibers, clean and condition other natural and man-made fibers, and dye or finish various textile products generally require large quantities of process water.

Depending on the primary fiber type (wool, cotton, or man-made), a variety of production processes, some completely dry in terms of water requirements and some resulting in wastewater discharge, are used to manufacture the various products of this industry. In general, most of the dry- or low water use-processing operations (spinning, tufting, knitting, weaving, slashing, adhesive processing, and functional finishing) precede the wet processing operations in the manufacturing sequence.

Most high water use textile manufacturing processes occur during the conventional finishing of fiber and fabric products. The most significant are desizing, scouring, mercerizing, bleaching, dyeing, and printing. In the case of wool products, the distinct nature of this fiber often makes additional wet processing necessary prior to conventional finishing. Additional specific processes for wool include raw wool scouring, carbonizing, and fulling.

It is not uncommon for two or more wet process operations to occur sequentially in a single batch unit or on a continuous range. For example, it is not unusual for desizing, scouring, and mercerizing operations to be placed in tandem with the continuous bleaching range to enable cotton to be finished more efficiently. It should be understood that a variety of wet finishing situations of this type may occur, depending upon factors such as processes employed, type and quality of materials and product, and original mill and equipment design.

Table 20-1 presents industry summary data for the Textile Mills point source category in terms of the number of subcategories, number of dischargers, pollutants and toxics found in significant quantities, total number of toxic pollutants detected, and candidate treatment and control technologies [1], [2].

II.20.1.2 Subcategory Descriptions

Based on similarities in raw materials, final products, manufacturing processes, and waste characteristics, the following subcategories of the textile industry were established:

1. Wool Scouring
2. Wool Finishing
3. Low Water Use Processing
4. Woven Fabric Finishing
    a. Simple Processing
    b. Complex Processing
    c. Complex Processing Plus Desizing
5. Knit Fabric Finishing
    a. Simple Processing
    b. Complex Processing
    c. Hosiery Products
6. Carpet Finishing
7. Stock and Yarn Finishing
8. Nonwoven Manufacturing
9. Felted Fabric Processing

TABLE 20-1. INDUSTRY SUMMARY [1], [2]

Industry: Textile Mills
Total Number of Subcategories: 13
Number of Subcategories Studied: 9

Number of Dischargers in Industry: 1,165

- Direct: 239
- Indirect: 926
- Zero: 0

Pollutants and Toxics Found in Significant Quantities:

- 11 Heavy metals
- Cyanide
- Total phenol

Number of Toxic Pollutants Detected in:

- Raw wastewater: 58
- Treated effluent: 46

Candidate Treatment and Control Technologies:

- Chemical coagulation
- Multimedia filtration
- Coagulation plus filtration

Subcategory 1 - Wool Scouring

This subcategory covers facilities that scour natural impurities from raw wool and other animal hair fibers as the majority of their processing. Wool scouring is conveniently separated from other segments of the textile industry because wool and other animal hair fibers require extensive preliminary cleaning.

Wool scouring, the first treatment performed on wool, is employed to remove the impurities peculiar to wool fibers. These impurities are present in great quantities and variety in raw wool and include natural wool grease and sweat, and acquired impurities such as dirt, feces, and vegetable matter. Disinfectants and insecticides applied in sheep dips for therapeutic purposes may also be present. Practically all of the natural and acquired impurities in wool are removed in the scouring process.

Two methods of wool scouring, solvent and detergent scouring, are practiced. In the United States, the latter is used almost exclusively. In the detergent process the wool is raked through a series of 1,500- to 3,000-gallon scouring bowls known as a "scouring train." Unless the first bowl is used as a steeping or desuinting bowl, the first two bowls contain varying concentrations of either soap and alkali, or nonionic detergents of the ethylene oxide condensate class. The soap-alkali scouring baths are generally characterized by a temperature of 32°C to 40°C (115°F to 130°F) and a pH of 9.5 to 10.5; neutral detergent baths normally have a pH of 6.5 to 7.5 and a temperature of 43°C to 57°C (135°F to 160°F). The last two bowls of the scouring train are for rinsing, and a counterflow arrangement is almost always employed using the relatively clean waters from these bowls in preceding bowls.

Scouring emulsifies the dirt and grease and produces a brown, gritty, turbid waste that is often covered with a greasy scum. It has been estimated that for every pound of fibers obtained, 1.5 lb of waste impurities are produced. Since the wool grease present in the scour liquor is not readily biodegradable and is of commercial value, grease recovery is usually practiced. In the most typical recovery process, the scour liquor is first piped to a separation tank where settling of grit and dirt occurs. The supernatant from the tank is then centrifuged (one or more stages) into high density, medium density, and low density streams. The high density stream consists mainly of dirt and grit, and is discharged as waste. The medium density stream is recycled to the wool scouring train. The low density stream contains concentrated grease that is normally refined further to produce lanolin. Acid-cracking, utilizing sulfuric acid and heat, is an alternative method of grease recovery, but it is not widely practiced at this time.

Subcategory 2 - Wool Finishing

This subcategory covers facilities that finish fabric, a majority of which is wool, other animal hair fiber, or blends containing primarily wool or other animal hair fibers, by employing any of the following processing operations on at least 5% of their total production: carbonizing, fulling, bleaching, scouring (not including raw wool scouring), dyeing, and application of functional finish chemicals. Mills that primarily finish stock or yarn of wool, other animal hair fibers, or blends containing primarily wool or other animal hair fibers and that perform carbonizing are included in this subcategory, and wool stock or yarn mills that do not perform carbonizing and scouring are covered under Subcategory 7, Stock and Yarn Finishing. Wool finishing is differentiated from other finishing categories because of the manufacturing processes (principally carbonizing and fulling) and dyes and other chemicals associated with wool operations. As a result, wool finishing operations generate high volume wastes with pH fluctuations and oil and grease.

Processes comprising a typical wool finishing operation include carbonizing, fulling, fabric scouring, and dyeing. Carbonizing removes burrs and other vegetable matter from loose wool or woven wool goods. These cellulosic impurities may be degraded to hydrocellulose, without damaging the wool, when acted upon by acids. It is important to remove these impurities from the wool to prevent unequal absorption of dyes.

The first operation in carbonization is acid impregnation. Typically this consists of soaking the wool in a 4% to 7% solution of sulfuric acid for a period of 2 to 3 hr. The excess acid is squeezed out and the wool is baked to oxidize the cellulosic contaminants to gases and a solid carbon residue. The charred material, primarily hydrocellulose, is crushed between pressure rollers so that it may be shaken out by mechanical agitation. Some solid waste is generated, but, with the exception of an occasional dump of contaminated acid bath, no liquid waste results. However, after the residue has been shaken out, the acid must be removed. This is achieved by preliminary rinsing to remove most of the acid followed by neutralization with sodium carbonate solution. A final rinse is then used to remove the alkalinity. As a result, the overall water requirements for the carbonization of wool are substantial.

Fulling gives woven woolen cloth a thick, compact, and substantial feel, finish, and appearance. To accomplish it, the cloth is mechanically worked in fulling machines in the presence of heat, moisture, and sometimes pressure. This allows the fibers to felt together, which causes shrinkage, increases the weight, and obscures the woven threads of the cloth.

There are two common methods of fulling, alkali and acid. In alkali fulling, soap or detergent is used to provide the needed lubrication and moisture for proper felting action. The soap or detergent is usually mixed with sodium carbonate and a sequestering agent in a concentrated solution. In acid fulling, which may be used to prevent bleeding of color, an aqueous solution of sulfuric acid, hydrogen peroxide, and small amounts of metallic catalysts (chromium, copper, and cobalt) is used.

Fabric scouring is employed to remove natural and acquired impurities from the fabric. Either light or heavy scouring of wool goods may be performed during wool finishing to remove the acquired impurities.

Dyeing is the most complex of all the wet process operations. It is performed essentially for aesthetic reasons in that it does not contribute to the basic structural integrity, wearability, or durability of the final product. In short, the function of dyeing is to anchor dyestuff molecules to textile fibers by a variety of processes.

Subcategory 3 - Low Water Use Processing

Low water use processing operations include establishments primarily engaged in manufacturing greige goods, laminating or coating fabrics, texturizing yarn, tufting and backing carpet, producing tire cord fabric, and similar activities in which either cleanup is the primary water use or process water requirements are small, or both.

While there are a large number of facilities of these types, the process-related wastewater generated and discharged from each is, for the most part, comparatively small.

Subcategory 4 - Woven Fabric Finishing

This subcategory covers facilities that primarily finish fabric, a majority of which is woven, by employing any of the following processing operations on at least 5% of their production: desizing, scouring, bleaching, mercerizing, dyeing, printing, and application of functional finish chemicals. Integrated mills that finish a majority of woven fabric along with greige manufacturing or other finishing operations such as yarn dyeing are included in this subcategory, and total finishing production should be applied to the applicable Woven Fabric Finishing effluent limitations to calculate discharge allowances. Denim finishing mills are also included in this category. Woven fabric composed primarily of wool is covered under Subcategory 2 - Wool Finishing.

A wide variety of processes are used in finishing woven fabric, and in terms of cumulative flow this subcategory is the largest.

Desizing is a major contributor to the BOD load in woven fabric finishing. This results in a major difference in waste characteristics between woven and knit fabric finishing, and is responsible for differences in the waste characteristics within the Woven Fabric Finishing subcategory as well. In addition, the number of processes performed at a particular mill may vary from merely scouring or bleaching to all of those previously listed. The following subdivisions describe the process differences.

Simple Processing. This Woven Fabric Finishing subdivision covers facilities that perform fiber preparation, desizing, scouring, functional finishing, and/or one of the following processes applied to more than 5% of total production: bleaching, dyeing, or printing. This subdivision includes all Woven Fabric Finishing mills that do not qualify under either the Complex Processing or Complex Processing Plus Desizing subdivisions.

Complex Processing. This Woven Fabric Finishing subdivision covers facilities that perform fiber preparation, desizing of less than 50% of their total production, scouring, mercerizing, functional finishing, and more than one of the following, each applied to more than 5% of total production: bleaching, dyeing, and printing.

Complex Processing Plus Desizing. This Woven Fabric Finishing subdivision covers facilities that perform fiber preparation, desizing of greater than 50% of their total production, scouring, mercerizing, functional finishing, and more than one of the following, each applied to more than 5% of total production: bleaching, dyeing, and printing.

Subcategory 5 - Knit Fabric Finishing

This subcategory covers facilities that primarily finish fabric made of cotton and/or synthetic fibers, a majority of which is knit, by employing any of the following processing operations on at least 5% of their production: scouring, bleaching, dyeing, printing, and application of lubricants, antistatic agents, and functional finish chemicals. Integrated mills that finish a majority of knit fabric along with greige manufacturing or other finishing operations such as yarn dyeing are included in this subcategory. Total finishing production should be applied to the applicable Knit Fabric Finishing effuent limitations to calculate discharge allowances.

Basic knit fabric finishing operations are similar to those in the Woven Fabric Finishing subcategory and may include scouring, bleaching, dyeing, printing, and application of lubricants, antistatic agents, and functional finish chemicals. Knitting is performed in conjunction with finishing at most of these facilities. Desizing is not required in knit fabric finishing and mercerizing is uncommon in practice. The generally lower waste loads of the subcategory can be attributed to the absence of these processes.

As with woven fabric finishing, the number of processes performed at a mill may vary considerably. In addition, hosiery manufacture is distinct in terms of manufacturing and raw wastewater characteristics. Consequently, internal subdivision is required for this subcategory.

Simple Processing. This Knit Fabric Finishing subdivision covers facilities that perform fiber preparation, scouring, functional finishing, and/or one of the following processes applied to more than 5% of total production: bleaching, dyeing, or printing. This subdivision includes all Knit Fabric Finishing mills that do not qualify under either the Complex Processing or Hosiery Products subdivisions.

Complex Processing. This Knit Fabric Finishing subdivision covers facilities that perform fiber preparation, scouring, functional finishing, and/or more than one of the following processes each applied to more than 5% of total production: bleaching, dyeing, or printing.

Hosiery Products. This Knit Fabric Finishing subdivision covers facilities that are engaged primarily in dyeing or finishing hosiery of any type. Compared to other Knit Fabric Finishing facilities, Hosiery Finishing mills are generally much smaller (in terms of wet production), more frequently employ batch processing, and more often consist of only one major wet processing operation. All of these factors contribute to their lower water use and much smaller average wastewater discharge.

Subcategory 6 - Carpet Finishing

This subcategory covers facilities that primarily finish textile-based floor covering products, of which carpet is the primary element, by employing any of the following processing operations on at least 5% of their production: scouring, bleaching, dyeing, printing, and application of functional finish chemicals.

Integrated mills that finish a majority of carpet along with tufting or backing operations or other finishing operations such as yarn dyeing are included in this subcategory, and total finishing production should be applied to the applicable Carpet Finishing effluent limitations to calculate discharge allowances. Mills that only perform carpet tufting and/or backing are covered under Subcategory 3 - Low Water Use Processing. Carpet Finishing is a distinct segment of the textile industry because of the lower degree of processing required and the typically weaker wastes that result.

Subcategory 7 - Stock and Yarn Finishing

This subcategory covers facilities that primarily finish stock, yarn, or thread of cotton and/or synthetic fibers by employing any of the following processing operation on at least 5% of their production: scouring, bleaching, mercerizing, dyeing, or application of functional finish chemicals. Facilities finishing stock, yarn, or thread principally of wool also are covered if they do not perform carbonizing as needed for coverage under Subcategory 2 - Wool Finishing. Denim finishing is included under Subcategory 4 - Woven Fabric Finishing.

Typical stock and yarn finishing may include scouring, bleaching, mercerizing, dyeing, or functional finishing. As a result of process differences, the water usage and pollutant loadings of this subcategory are lower than those found in most other subcategories.

Subcategory 8 - Nonwoven Manufacturing

This subcategory covers facilities that primarily manufacture nonwoven textile products of wool, cotton, or synthetics, singly or as blends, by mechanical, thermal, and/or adhesive bonding procedures. Nonwoven products produced by fulling and felting processes are covered in Subcategory 9 - Felted Fabric Processing.

The Nonwoven Manufacturing subcategory includes a variety of products and processing methods. The processing is dry (mechanical and thermal bonding) or low water use (adhesive bonding) with the major influence on process-related waste characteristics resulting from the cleanup of bonding mix tanks and application equipment. Typical processing operations include carding, web formation, wetting, bonding (padding or dipping with latex acrylic or polyvinyl acetate resins) and application of functional finish chemicals. Pigments for coloring the goods are usually added to the bonding materials.

Subcategory 9 - Felted Fabric Processing

This subcategory covers facilities that primarily manufacture nonwoven products by employing fulling and felting operations as a means of achieving fiber bonding. Wool, rayon, and blends of wool, rayon, and polyester are typically used to process felts. Felting is accomplished by subjecting the web or mat to moisture, chemicals (detergents), and mechanical action. Wastewater is generated during rinsing steps that are required to prevent rancidity and spoilage of the fibers.

II.20.2 WASTEWATER CHARACTERIZATON [1]

Wastewater characteristics for the textile industry, in general, reflect the products and the methods employed to manufacture them. Because there is such a diversity in products, in processing, in raw materials, and in process control, there is a wide range in the characteristics. The variation extends vertically within each subcategory, as well as horizontally among the subcategories. Nonprocess-related variables such as raw water quality and discharge of nonprocess-related wastes (sanitary, boiler blowdown, cooling water, etc.) contribute to this lack of uniformity.

II.20.2.1 Subcategory 1 - Wool Scouring

Wool scouring waste contains significant quantities of natural oils, fats, suint, and adventitious dirt that, even after in-process grease recovery steps, cause the characteristics to be distinctly different from those of the other subcategories. These materials are collectively responsible for high concentrations and quantities of BOD_5, COD, TSS, and oil and grease. Since the natural fat is technically a wax, it is not readily biodegradable and must be removed by physical or chemical treatment. Wastewater from the wool scouring process is usually brown, thickly turbid, and noticeably greasy. It is strongly alkaline and very putrescible.

II.20.2.2 Subcategory 2 - Wool Finishing

Wool finishing wastes are typically high volume, low concentration wastes (for the conventional pollutant parameters) that, in terms of mass loadings, contribute large quantities of conventional pollutants per unit of production. The nonconventional pollutants (sulfide and color) and the toxic pollutants that have been historically monitored (phenol and chromium) are both high in concentration and quantity. These conditions can be attributed to the numerous steps required in processing and finishing wool yarn and wool fabric and to the wide variety of chemicals used.

II.20.2.3 Subcategory 3 - Low Water Use Processing

Low water use processing refers, almost exclusively, to facilities that perform weaving or adhesive-related processing. Regardless of mill size, process-related wastewaters from both types of mills are typically very low in volume. The only mills with large flows are those engaged in water-jet weaving and mills discharging large volumes of cooling or other nonprocess water. Where process-related wastewater is a large portion of the total discharge, the wastewater characteristics are determined primarily by the slashing process (conventional weaving), the weaving process (water-jet weaving mills), or the dipping, padding, or saturating process (adhesive-related mills).

II.20.2.4 Subcategory 4 - Woven Fabric Finishing

The wastewater generated from the finishing of woven fabric is represented by a rather broad range in concentration and mass quantity for the conventional pollutant parameters. The internal subdivisions of this subcategory (Simple Processing, Complex Processing, Complex Processing Plus Desizing) group the estimated 336 mills into 3 reasonably distinct segments.

The differences between the three subdivisions are a function of the complexity of the wet processing. Mills classified in the Complex Processing subdivision perform simple processing plus one or more additional major wet processing steps. Mills classified in the Complex Processing Plus Desizing subdivision perform complex processing plus desizing on the majority of their production. The typical water use and waste mass loading values are progressively greater for each subsequent subdivision and generally reflect an increase in the same basic pollutant parameters.

II.20.2.5 Subcategory 5 - Knit Fabric Finishing

The wastewater generated from the finishing of knit fabric are, like those from the finishing of woven fabric, represented by a rather broad range in concentration and mass quantity for the conventional pollutant parameters. The typical waste is not generally as great in terms of concentration as woven fabric finishing waste, and the variability from mill to mill is also somewhat less.

II.20.2.6 Subcategory 6 - Carpet Finishing

The wastewater volume from carpet mills is typically quite large, although water use (gal/lb of product) is low relative to other subcategories. This is due to the specialized nature of carpet manufacturing and the heavy weight of carpet relative to other textile products. The wet processing employed by a carpet mill can include various combinations of the following operations: scouring, bleaching, dyeing, printing, functional finishing, and backing. Wastes from dyeing and printing are the major contributors to the high flows at these mills, but these processes do not lead to extreme levels of conventional and nonconventional pollutants. Scouring and bleaching are performed very little at carpet finishing mills. Functional finishing and carpet backing make small contributions to the total flow; the latter often results in a latex waste that should be segregated from the rest of the waste discharge for separate treatment.

II.20.2.7 Subcategory 7 - Stock and Yarn Finishing

The volume of wastewater discharged by Stock and Yarn Finishing facilities is comparable to that from mills in other finishing subcategories. The wastes generated are generally not as strong as those found in the other subcategories, and depend substantially on whether natural fibers, blends, or synthetic fibers alone are processed.

II.20.2.8 Subcategory 8 - Nonwoven Manufacturing

The nature of nonwoven manufacturing is such that a typical facility has relatively small hydraulic and pollutant loadings. The wastewater may contain latex and numerous other contaminants. At a few facilities, special manufacturing operations or activities common to other subcategories might be performed with resultant higher water use.

II.20.2.9 Subcategory 9 - Felted Fabric Processing

Felted fabric processing typically results in high volume wastes of a generally dilute nature. The wet processing operations may include felting, dyeing, and functional finishing. The rinses that follow felting (fulling) and dyeing, if employed, result in considerable water use and contribute most of the pollutants. Functional finishing may also make minor contributions to the waste load.

Table 20-2 presents the toxic pollutants found in detectable concentrations for plant water supply, raw wastewater, and secondary effluents. Tables 20-3 and 20-4 present the conventional and classical pollutant raw wastewater concentrations and pollutant loadings, respectively, by subcategory. Values in parentheses indicate the median of field sampling results. The remaining values are generated from historical data and from three or more plants.

II.20.3 PLANT SPECIFIC DESCRIPTION [3]

Tables 20-5 through 20-9 present toxic pollutant and classical pollutant data for five textile mills.

TABLE 20-2. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN TEXTILL MILL WASTEWATER [1]

	Concentrations observed, µg/L								
	Water supply			Raw wastewater			Secondary effluent		
Toxic pollutant	Number of plants	Median	Maximum	Number of plants	Median	Maximum	Number of plants	Median	Maximum
Metals and inorganics									
Antimony	6	<5	48	23	7	170	16	4.5	680
Arsenic	4	<5	<5	14	10	200	8	39	160
Asbestos	-[a]	-	-	-	-	-	-	-	-
Beryllium	4	<5	<5	5	<5	40	5	<5	<5
Cadmium	5	<10	<10	22	<5	46	15	6	13
Chromium	5	<5	<5	37	14	880	27	20	1,800
Copper	6	10	47	40	40	2,400	28	32	290
Cyanide	4	11	22	10	8.0	39	5	12	980
Lead	6	<5	45	26	35	750	16	46	120
Mercury	4	0.2	0.8	10	0.6	4	7	0.4	0.7
Nickel	6	<5	47	32	54	300	18	70	150
Selenium	6	<5	23	10	35	740	4	47	97
Silver	6	<5	17	26	32	130	15	25	140
Thallium	4	3	3	5	3	9	4	3	18
Zinc	12	60	4,540	45	190	7,900	30	200	38,000
Phthalates									
Bis(2-ethylhexyl) phthalate	6	8.2	39	27	26	860	23	18	231
Butyl benzyl phthalate				2	42	73			
Di-n-butyl phthalate	1		1.6	7	16	67	1		3.6
Diethyl phthalate	3	2.1	5.5	10	6.0	86	4	1.5	9.4
Dimethyl phthalate				4	12	14	1		1.0
Nitrogen compounds									
Acrylonitrile				1		1,600	1		400
1,2-Diphenylhydrazine				1		22			
N-nitrosodiphenylamine				3	15	72			
N-nitroso-di-n-propylamine							2	10	19
Phenols									
2-Chlorophenol				1		78	1		5.9
2,4-Dichlorophenol				2	26	41			
2,4-Dimethylphenol							1		8.0
2-Nitrophenol							1		4.1
4-Nitrophenol							1		<10
Pentachlorophenol				11	52	940	2	12	15
Phenol	5	10	36	25	55	4,900	7	14	50
2,4,6-Trichlorophenol				4	20	27	1		19
Cresols									
-Chloro- -cresol				1		170	1		32

[a]Dashes indicate pollutant not analyzed for.

(continued)

TABLE 20-2 (continued)

Toxic pollutant	Concentrations observed, µg/L: Water supply: Number of plants	Water supply: Median	Water supply: Maximum	Raw wastewater: Number of plants	Raw wastewater: Median	Raw wastewater: Maximum	Secondary effluent: Number of plants	Secondary effluent: Median	Secondary effluent: Maximum
Monocyclic aromatics									
Benzene	2	<4	<5	10	<5	200	4	<5	64
Chlorobenzene				5	25	300	1		3.5
1,2-Dichlorobenzene				7	2.0	290	4	10	20
1,4-Dichlorobenzene				2	110	215	2	0.8	1.5
2,6-Dinitrotoluene				1		54			
Ethylbenzene				20	54	2,840	8	63	3,000
Hexachlorobenzene				2	1.3	2			
Toluene	4	0.8	2.4	25	26	620	16	14	1,400
1,2,4-Trichlorobenzene				8	410	2,700	4	610	1,580
Polycyclic aromatics									
Acenaphthene				3	8.7	12	1		0.5
Anthracene	3	0.2	0.4	1		0.1	1		4.4
Benzo(b)fluoranthene				1		<10			
Benzo(k)fluoranthene				1		<10			
Fluorene	2	0.2	0.4	1		15			
Naphthalene				19	44	110	5	22	255
Pyrene				1		0.9	4	0.2	0.3
Polychlorinated biphenyls and related compounds									
2-Chloronaphthalene				1		<10			
Halogenated aliphatics									
Chloroform	6	39	1,360	11	48	640	6	8.5	58
Dichlorobromomethane	2	<5	<5	1		6.6			
1,1-Dichloroethane				1		14			
1,2-Dichloroethane				1		<5			
1,1-Dichloroethylene				1		<5			
1,2-Dichloropropane				1		100			
1,3-Dichloropropane	1		0.8						
Methyl chloride				1		<5			
Methylene chloride	2	<5	<5	3	47	110	3	<5	<5
Tetrachloroethylene				7	<5	2,100	2	11	17
1,1,1-Trichloroethane	1		<5	4	7.8	17	1		<5
Trichloroethylene				10	47	840	4	4.9	87
Trichlorofluoromethane				3	90	2,140			
Vinyl chloride				1		11			
Pesticides and metabolites									
4,4'-DDT							1		0.5
Dieldrin							1		0.2
TCDD	-[a]	-	-	-	-	-	-	-	-

[a]Dashes indicate pollutant not analyzed for.

TABLE 20-3. RAW WASTEWATER POLLUTANT CONCENTRATIONS BY SUBCATEGORY[a] [1]

Characteristic	Subcategory 1			Subcategory 2			Subcategory 3		
	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants	Range	Median
Flow, gpd	11	1×10^4-7.5×10^5	7.0×10^4	15	5.0×10^4-4.2×10^6	5.0×10^5	13	6.1×10^3-2.8×10^5	6.1×10^4
BOD_5, mg/L	9	310-6,680	2,270	10	66-750	170	13	37-2,550	290
COD, mg/L	4	1,140-17,800	7,030	7	280-2,000	590	8	115-2,960	690
TSS, mg/L	8	120-13,200	3,310	10	17-245	62	12	10-530	185
Sulfide, μg/L			(500)[a]			(3,500)			
Oil and grease, mg/L	7	80-5,000	580	1		(70)			(80)
Phenol, μg/L				2	50-155	(102)	1		91
Chromium, μg/L			(120)			(500)			(4)
Color, APHA units			(2,200)			(1,500)			(10)
	Subcategory 4a			Subcategory 4b			Subcategory 4c		
Flow, gpd	48	1.5×10^4-5.5×10^6	1.7×10^5	39	1.1×10^4-7.6×10^6	4.0×10^5	51	9×10^3-5.5×10^6	1.7×10^5
BOD_5, mg/L	32	19-2,050	270	23	83-2,160	350	36	125-2,600	420
COD, mg/L	28	200-5,020	900	12	240-5,140	1,060	29	370-2,780	1,240
TSS, mg/L	26	16-2,440	62	18	40-870	110	28	1-,1260	150
Sulfide, μg/L	6	25-580	72	3	100-120	100			(1,700)
Oil and grease, mg/L	11	6-1,440	69	6	34-160	46	5	5-100	68
Phenol, μg/L	10	10-600	49	6	10-600	54	5	14-1,220	150
Chromium, μg/L	16	1-530	38	7	19-1,180	110	11	14-12,500	100
Color, APHA units	9	20-10,000	800			(1,400)			(1,900)
	Subcategory 5a			Subcategory 5b			Subcategory 5c		
Flow, gpd	71	2.9×10^3-2.8×10^6	5.6×10^5	35	3.0×10^4-3.5×10^6	6.4×10^5	57	1.1×10^3-4.1×10^5	6.0×10^4
BOD_5, mg/L	35	60-1,860	210	19	120-920	270	39	38-790	320
COD, mg/L	29	340-19,400	870	11	545-3,150	790	27	450-4,980	1,370
TSS, mg/L	32	21-2,160	53	19	18-740	60	29	9-180	82
Sulfide, μg/L	3	20-7,100	55	4	50-1,470	155	4	10-8,000	560
Oil and grease, mg/L	9	14-455	83	6	6-110	52	13	15-275	99
Phenol, μg/L	9	1-1,680	110	5	72-230	100	10	26-580	62
Chromium, μg/L	13	13-600	78	8	10-180	80	17	10-1,200	80
Color, APHA units	9	170-1,460	400	7	37-940	750	8	40-1,060	450

[a]Parentheses indicate value is median of field sampling results.

(continued)

TABLE 20-3 (continued)

Characteristic	Subcategory 6 Number of plants	Subcategory 6 Range	Subcategory 6 Median	Subcategory 7 Number of plants	Subcategory 7 Range	Subcategory 7 Median	Subcategory 8 Number of plants	Subcategory 8 Range	Subcategory 8 Median
Flow, gpd	37	2.0×10^4-1.8×10^6	4.2×10^5	116	1.2×10^4-2.6×10^6	2.5×10^5	11	2.9×10^3-4.0×10^5	1.5×10^5
BOD_5, mg/L	10	190-565	440	62	43-1,630	185	4	55-380	200
COD, mg/L	14	280-2,120	1,190	46	140-4,760	680	4	230-2,090	550
TSS, mg/L	12	37-210	67	59	2-4,200	38	4	68-285	120
Sulfide, μg/L	4	10-450	175	9	1-4,440	200			(1,200)
Oil and grease, mg/L	5	3-93	18	18	1-180	21	3	8-160	28
Phenol, μg/L	7	1-1,140	130	12	3-620	170	3	70-1,100	575
Chromium, μg/L	7	4-300	30	25	4-1,600	100	2	60-500	275
Color, APHA units	4	65-1,900	490	11	57-3,000	570			(200)

Characteristic	Subcategory 9 Number of plants	Subcategory 9 Range	Subcategory 9 Median
Flow, gpd	11	1.4×10^4-5×10^5	1.0×10^5
BOD_5, mg/L	4	64-630	180
COD, mg/L	3	205-3,940	2,360
TSS, mg/L	4	59-180	78
Oil and grease, mg/L			(60)
Phenol, μg/L			(40)
Chromium, μg/L	3	10-370	50
Color, APHA units			(90)

[a] Parentheses indicate value is median of field sampling results.

TABLE 20-4. RAW WASTEWATER POLLUTANT LOADINGS BY SUBCATEGORY [1]

Characteristic	Subcategory 1			Subcategory 2			Subcategory 3		
	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants	Range	Median
BOD_5, kg/Mg	9	3.8-210	42	10	22-140	60	13	0.2-22	2.3
COD, kg/Mg	4	20-750	130	7	97-445	200	8	2.7-26	14.5
TSS, kg/Mg	8	1.9-240	43	10	9.5-97	17	12	0.3-4	1.6
Sulfide, g/Mg							1		3.8
Oil and grease, kg/Mg	7	1.3-62	10	1		7.8	1		
Phenol, g/Mg				2	11-75	43	1		2.3
Chromium, g/Mg				2	66-160	110	2	1.5-3.4	2.4
	Subcategory 4a			Subcategory 4b			Subcategory 4c		
BOD_5, kg/Mg	32	3.8-215	23	23	3.6-96	33	36	5.9-190	45
COD, kg/Mg	28	12-440	92	12	10-388	110	29	48-900	120
TSS, kg/Mg	26	0.8-220	8	18	2-62	9.6	28	0.2-84	15
Sulfide, g/Mg	6	0.6-130	7.6	3	7.8-20	12.5	2	15.7-290	155
Oil and grease, kg/Mg	11	0.6-150	9.1	6	2.2-14	3.8	5	0.4-15	4.1
Phenol, g/Mg	10	1.8-51	8.2	4	0.9-25	7.7	6	0.9-150	13
Chromium, g/Mg	16	0.1-44	4.3	7	2.4-49	2.6	11	0.6-1,520	21
	Subcategory 5a			Subcategory 5b			Subcategory 5c		
BOD_5, kg/Mg	35	4.4-85	28	19	8.0-140	22	39	1.6-140	26
COD, kg/Mg	29	18-380	81	11	49-500	115	27	26-630	89
TSS, kg/Mg	32	2.9-42	6.3	19	1.3-110	6.9	29	0.3-24	6.7
Sulfide, g/Mg	3	3.1-770	13	4	8.3-110	14	4	2.0-400	100
Oil and grease, kg/Mg	9	0.5-46	4	6	0.4-18	3.5	13	1.4-28	6.6
Phenol, g/Mg	9	0.1-400	8.7	5	3.4-37	12	10	1.8-150	4.2
Chromium, g/Mg	13	0.6-85	7.8	8	1.4-35	4.7	17	0.4-270	6.4
	Subcategory 6			Subcategory 7			Subcategory 8		
BOD_5, kg/Mg	10	14-41	26	62	0.8-110	21	4	15-310	6.7
COD, kg/Mg	14	22-135	82	46	2.5-380	63	4	64-380	38
TSS, kg/Mg	12	1.6-9.3	4.7	59	0.1-480	4.6	4	16-120	64
Sulfide, g/Mg	4	0.8-22	9.4	9	0.6-170	28	1		117
Oil and grease, kg/Mg	5	0.2-9.4	1.1	18	0.1-22	1.6	3	2.4-130	11.2
Phenol, g/Mg	7	0.1-59	11	12	0.5-83	15.0	3	16-500	247
Chromium, g/Mg	7	0.2-12	3.4	25	0.8-360	12.0	2	11.7-139	75.4
	Subcategory 9								
BOD_5, kg/Mg	4	3.3-16	70						
COD, kg/Mg	3	10-99	186						
TSS, kg/Mg	4	0.2-15	2.2						
Sulfide, g/Mg	1	15	0.5						
Oil and grease, kg/Mg	1		3.4						
Phenol, g/Mg	1		0.2						
Chromium, g/Mg	3	0.4-16	0.5						

TABLE 20-5. WASTEWATER CHARACTERIZATION, PLANT 100 [3]

Category: Textile Mills
Wastewater treatment description: Neutralization, aeration, clarification, carbon/sand filtration, chlorine contact
Influent flowrate, gpd: 960,000 av (650,000 to 1,400,000 range during sampling)

Pollutant	Pollutant concentration, μg/L			
	Intake water	Raw wastewater	Clarifier effluent	Filter effluent
Toxic pollutants				
Acrylonitrile			<100	<100
Benzene			<1	<1
Benzidine	0.4			
1,2,4-Trichlorobenzene		270	40	11
Hexachlorobenzene	1.3			
Bis(chloromethyl) ether		59		
2,4,6-Trichlorophenol		16	<5	<5
p-Chloro-*m*-cresol		29	5	3
Chloroform			<5	<5
1,2-Dichlorobenzene		-[a]	3	3
1,3-Dichlorobenzene		-[a]		
1,4-Dichlorobenzene		-[a]		
2,4-Dichlorophenol		20		
1,2-Dichloropropane		56		
2,4-Dimethylphenol		190		
Ethylbenzene	2.8	5.9	<0.3	<0.3
Methylene chloride	7.4	8.7		
Naphthalene	0.3	18	9	2.8
N-nitrosodi-n-propylamine			<5	<5
Pentachlorophenol			18	12
Phenol		1.6	<5	<5
Bis(2-ethylhexyl) phthalate		425	100	75
Di-n-butyl phthalate	1.8	24		
Diethyl phthalate	0.9			
Dimethyl phthalate		18		
Anthracene	0.4			
Fluorene	0.06	1.0		
Tetrachloroethylene	0.6	310	<0.8	3.8
Toluene	2.1	2.8	13	<0.5
Trichloroethylene		10	-	-
Antimony (total)	<10	160	160	160
Arsenic (total)	<1	19	4	4
Asbestos (fibrous)	NA[b]	NA	NA	NA
Beryllium (total)	<0.04	<0.04	<0.04	<0.04
Cadmium (total)	2.9	<2	<2	<2
Chromium (total)	<4	34	76	34

(continued)

TABLE 20-5 (continued)

Pollutant	Pollutant concentration, μg/L			
	Intake water	Raw wastewater	Clarifier effluent	Filter effluent
Toxic pollutants (continued)				
Copper (total)	63	49	120	51
Cyanide (total)	<2	<2	<2	<2
Lead (total)	<22	<22	<22	<22
Mercury (total)	<0.5	<0.5		
Nickel (total)	<36	<36	<36	45
Selenium (total)	1	<1		
Silver (total)	<5	<5	<5	13
Thallium (total)	<50	<50		
Zinc (total)	420	490	250	240
TCDD	NA	NA	NA	NA
	Pollutant concentration, units as specified			
Criteria pollutants				
BOD, mg/L	NA	NA	NA	NA
COD, mg/L	15	230	130	130
TSS, mg/L		25	130	74
Oil and grease, mg/L	NA	NA	NA	NA
Total phenols, mg/L	0.002	0.81	0.02	0.018
Sulfide, mg/L	<0.003	0.044	0.006	0.009
Color (ADMI @ pH 7.6)	<5	130	110	110
pH, pH units	7.3	6.9	7.6	7.6
Other pollutants				
Color (ADMI @ original pH)	<5	130	120	110

Note: Blanks indicate that concentrations were below detection limit.

[a]Total of 56 μg/L.

[b]Not analyzed.

TABLE 20-6. WASTEWATER CHARACTERIZATION, PLANT 200 [3]

Category: Textile Mills
Wastewater treatment description: Lime and ferric chloride reactors, polyelectrolyte addition, primary clarification, aeration, secondary clarification, chlorination, multimedia pressure filter
Influent flowrate, gpd: 440,000 av (90,000 to 840,000 range during sampling)

Pollutant	Pollutant concentration, µg/L				
	Intake water	Raw wastewater	Primary clarifier effluent	Secondary clarifier effluent	Filter effluent
Toxic pollutants					
Acrylonitrile	0.4	0.8	<100	<100	<100
Benzene			1	<1	<1
1,2,4-Trichlorobenzene			<2	<2	<2
1,1,1-Trichloroethane		9.3			
2,4,6-Trichlorophenol			<5	<5	<5
p-Chloro-*m*-cresol			<5	<5	<5
Chloroform	360	26	285	<5	<5
1,2-Dichlorobenzene			<0.5	<0.5	<0.5
Ethylbenzene	6.0	0.5	4.1	<0.3	<0.3
Fluoranthene	0.2	0.2			
Methyl chloride	9.0	7.0			
Naphthalene			30	3.8	<1
N-nitrosodi-n-propylamine			<5	<5	<5
Pentachlorophenol				<5	1.2
Phenol		14	11	<5	<5
Bis(2-ethylhexyl) phthalate		550	13	31	33
Butyl benzyl phthalate	0.8				
Di-n-butyl phthalate	8.0	3.5			
Diethyl phthalate	5.0	1.8			
Anthracene		1.2			
Fluorene	0.4				
Pyrene	0.3	0.1			
Tetrachloroethylene				<0.8	<0.8
Toluene	1.9	19	6.4	0.8	<0.5
Trichloroethylene	3.2			<1	<1
Antimony (total)	<10	130	33	<10	51
Arsenic (total)	<1	5			
Asbestos (fibrous)	NA[a]	NA	NA	NA	NA
Beryllium (total)	<0.04	<0.04	<0.04	<0.04	1.5
Cadmium (total)	<2	3.1	<2	<2	4.8
Chromium (total)	<4	3,170	130	9.4	20
Copper (total)	<4	1,460	330	30	46
Cyanide (total)	<2	<2	<2	14	18
Lead (total)	<22	460	39	<22	81

(continued)

TABLE 20-6 (continued)

Pollutant	Pollutant concentration, µg/L				
	Intake water	Raw wastewater	Primary clarifier effluent	Secondary clarifier effluent	Filter effluent
Toxic pollutants (continued)					
Mercury (total)	<1	<1			
Nickel (total)	<36	230	180	150	220
Selenium (total)	<1	<1			
Silver (total)	<5	22	10	<5	10
Thallium (total)	<50	<50			
Zinc (total)	45	1,040	460	51	150
TCDD	NA	NA	NA	NA	NA
	Pollutant concentration, units as specified				
Criteria pollutants					
BOD, mg/L	NA	NA	NA	NA	NA
COD, mg/L	15	4,530	1,000	110	96
TSS, mg/L	5	885	40	10	7
Oil and grease, mg/L	NA	NA	NA	NA	NA
Total phenols, mg/L	<0.002	0.19	0.030	<0.002	0.002
Sulfide, mg/L	0.059	0.45	0.098	0.02	<0.003
Color (ADMI @ pH 7.6)	5	30	35	30	13
pH, pH units	7.4	5.5	5.3	8.2	8.0
Other pollutants					
Color (ADMI @ original pH)	5	31	90	15	13

Note: Blanks indicate that concentrations were below detection limit.

[a]Not analyzed.

TABLE 20-7. WASTEWATER CHARACTERIZATION, PLANT 400 [3]

Category: Textile Mills
Wastewater treatment description: Holding basin, aeration basins, clarification, sand filtration, chlorine contact
Influent flowrate, gpd: 260,000av (230,000 to 320,000 range during sampling)

Pollutant	Pollutant concentration, µg/L			
	Intake water	Holding pond effluent	Secondary clarifier effluent	Filter effluent
Toxic pollutants				
Acrolein				120
Acrylonitrile		200	<100	<100
Benzene		90	<1	<1
1,2,4-Trichlorobenzene			<2	<2
2,4,6-Trichlorophenol			<5	<5
p-Chloro-*m*-cresol			<5	<5
Chloroform			<5	77
1,2-Dichlorobenzene			<0.5	<0.5
Ethylbenzene		2.1	<0.3	<0.3
Methylene chloride	22	30		
Naphthalene			<1	<1
N-nitrosodi-n-propylamine			<5	<5
Pentachlorophenol			<5	<5
Phenol		0.9	<5	<5
Bis(2-ethylhexyl) phthalate		110		
Pyrene		8.7		
Tetrachloroethylene			<0.8	<0.8
Toluene	4.8	3.7	<0.5	<0.5
Trichloroethylene		4.8	39	59
Antimony (total)	<10	190	84	81
Arsenic (total)	<1	1		
Asbestos (fibrous)	NA[a]	NA	NA	NA
Beryllium (total)	<0.04	<0.04	<0.04	<0.04
Cadmium (total)	<2	5.3	<2	<2
Chromium (total)	<4	<4	<4	<4
Copper (total)	11	17	8	6
Cyanide (total)	<5	<5	<5	<5
Lead (total)	<22	99	40	71
Mercury (total)	<0.2	<0.2		
Nickel (total)	<36	69	20	54
Selenium (total)	<1	3		
Silver (total)	<5	19	16	12
Thallium (total)	<50	<50	<50	

[a]Not analyzed.

(continued)

TABLE 20-7 (continued)

Pollutant	Pollutant concentration, units as specified			
	Intake water	Holding pond effluent	Secondary clarifier effluent	Filter effluent
Toxic pollutants (continued)				
Zinc (total)	33	340	58	71
TCDD	NA[a]	NA	NA	NA
Criteria pollutants				
BOD, mg/L	NA	NA	NA	NA
COD, mg/L	6.3	1,740	190	130
TSS, mg/L	12	200	50	35
Oil and grease, mg/L	NA	NA	NA	NA
Total phenols, mg/L	0.011	0.034	0.007	0.006
Sulfide, mg/L	<0.003	0.050	0.012	<0.003
Color (ADMI @ pH 7.6)	8	160	79	73
pH	8.0	7.2	7.6	7.6
Other pollutants				
Color (ADMI @ original pH)	50	160	83	74

Note: Blanks indicate that concentrations were below detection limit

[a]Not analyzed.

TABLE 20-8. WASTEWATER CHARACTERIZATION, PLANT 500 [3]

Category: Textile Mills
Wastewater treatment description: Holding basin, aerated lagoon, clarifier, dissolved air flotation, chlorine contact, polishing pond
Influent flowrate, gpd: 276,000 (252,000 to 288,000 range during sampling)

Pollutant	Pollutant concentration, µg/L			
	Intake water	Raw wastewater	Secondary clarifier effluent	DAF effluent
Toxic pollutants				
Acrylonitrile			<100	<100
Benzene	0.3	0.3	<1	<100
1,2,4-Trichlorobenzene			<2	<2
1,1,1-Trichloroethane		2.8		
1,1,2,2-Tetrachloroethane		21		
2,4,6-Trichlorophenol			<5	<5
p-Chloro-*m*-cresol			<5	<5
Chloroform				21
1,2-Dichlorobenzene			<0.5	<0.5
1,2-*Trans*-dichloroethylene		4.5		
2,4-Dimethylphenol		20		
Ethylbenzene	1.1		<0.3	<0.3
Methylene chloride	11	82		
Naphthalene		210	<1	<1
N-nitrosodi-n-propylamine			<5	<5
Pentachlorophenol		2.1	<5	<5
Phenol			<5	<5
Bis(2-ethylhexyl) phthalate			<0.5	
Butyl benzyl phthalate	1.6	160		
Di-n-butyl phthalate	0.6	3.0		
Diethyl phthalate		150		
Acenaphthylene		4,400		
Anthracene	0.05			
Tetrachloroethylene	1.8	890	320	220
Toluene	7.3	2.9	2.0	1.2
Trichloroethylene	0.6	3.1	24	2.8
Antimony (total)	24	515	450	375
Arsenic (total)	2	4		
Beryllium (total)	<0.04	<0.04	<0.04	<0.04
Asbestos (fibrous)	NA[a]	NA	NA	NA
Cadmium (total)	2	<2	<2	<2
Chromium (total)	6	4	6	<4
Copper (total)	46	44	14	<4

[a]Not analyzed

(continued)

TABLE 20-8 (continued)

Pollutant	Pollutant concentration, μg/L			
	Intake water	Raw wastewater	Secondary clarifier effluent	DAF effluent
Toxic pollutants (continued)				
Cyanide (total)	<2	12	<2	<2
Lead (total)	53	62	46	25
Mercury (total)	<1	<1		
Nickel (total)	130	130	150	110
Selenium (total)	<2	<2		
Silver (total)	14	11	16	15
Thallium (total)	<50	<50		
Zinc (total)	19	75	54	45
TCDD	NA	NA	NA	NA
	Pollutant concentration, units as specified			
Criteria pollutants				
BOD, mg/L	NA	NA	NA	NA
COD, mg/L	8.0	2,380	480	150
TSS, mg/L	6	100	26	8
Oil and grease, mg/L	NA	NA	NA	NA
Total phenols, mg/L	0.006	0.048	0.021	0.10
Sulfide, mg/L	<0.003	<0.003	<0.003	<0.003
Color (ADMI @ pH 7.6)	280	120	82	49
pH, pH units	7.6	7.9	7.7	7.3
Other pollutants				
Color (ADMI @ original pH)	280	140	81	48

Note: Blanks indicates that concentrations were below detection limit.
[a]Not analyzed.

TABLE 20-9. WASTEWATER CHARACTERIZATION, PLANT 700 [3]

Category: Textile Mills
Wastewater treatment description: Aerated equalization, ferric chloride addition, flocculation, clarification
Influent flowrate, gpd: 467,000 av (400,000 to 525,000 range during sampling)

Pollutant	Pollutant concentration, µg/L			
	Intake water	Aeration effluent	Clarifier effluent	Filter effluent
Toxic pollutants				
Acrylonitrile			<100	<100
Benzene		0.2	<1	<1
Chlorobenzene	0.2	0.4		
1,2,4-Trichlorobenzene			17	19
1,1,2,2-Tetrachloroethane		0.1		
2,4,6-Trichlorophenol		8.5	7.4	11
p-Chloro-*m*-cresol			<5	<5
Chloroform		1.0	<5	55
2-Chlorophenol		10		
2,4-Dimethylphenol		2.3		
Ethylbenzene	0.3	0.3	0.3	0.3
Methylene chloride	6.3	4.0		
Naphthalene		5.5	38	38
4-Nitrophenol		240		
N-nitrosodi-n-propylamine			20	69
Pentachlorophenol			<5	
Phenol			49	
Di-n-butyl phthalate	2.6	33		
Di-n-octyl phthalate	1.7			
Diethyl phthalate	0.1	5.1		
Anthracene	0.2			
Phenanthrene		1.4		
Tetrachloroethylene		0.2	24	<0.8
Toluene	0.7	1.6	2	1.6
Trichloroethylene	0.4	0.3	15	23
Antimony (total)	36	200	67	60
Arsenic (total)	<1	3		
Asbestos (fibrous)	NA[a]	NA	NA	NA
Beryllium (total)	<0.04	<0.04	<0.04	<0.04
Cadmium (total)	<3	4	7	6
Chromium (total)	8	23	19	14
Copper (total)	48	40	8.3	7.7
Cyanide (total)	<5	<5	<5	<5
Lead (total)	55	63	71	63
Mercury (total)	<1	<1		
Nickel (total)	150	150	140	150

(continued)

TABLE 20-9 (continued)

Pollutant	Pollutant concentration, µg/L			
	Intake water	Aeration effluent	Clarifier effluent	Filter effluent
Toxic pollutants (continued)				
Selenium (total)	2	3		
Silver (total)	43	51	45	49
Thallium (total)	<50	<50		
Zinc (total)	270	140	640	45
TCDD	NA	NA	NA	NA
	Pollutant concentration, units as specified			
Criteria pollutants				
BOD, mg/L	NA[a]	NA	NA	NA
COD, mg/L	21	740	530	420
TSS, mg/L	8	58	50	18
Oil and grease, mg/L	NA	NA	NA	NA
Total phenols, mg/L	0.013	0.069	0.084	0.096
Sulfide, mg/L	<0.003	0.420	0.086	<0.003
Color (ADMI @ pH 7.6)	10	110	92	68
pH, pH units	8.2	7.45	7.0	6.4
Other pollutants				
Color (ADMI @ original pH)	14	140	94	67

Note: Blanks indicate that concentrations were below detection limit.

[a]Not analyzed.

II.20.4 POLLUTANT REMOVABILITY [1]

This section addresses current treatment technologies and pollutant removability associated with the Textile Industry.

II.20.4.1 Industry Application of Wastewater Treatment

The following is a summary of methods and removal efficiencies for systems for which data were obtained.

(1) Aerated lagoons (see Table 20-10)

Used by: Direct dischargers - 33
Indirect dischargers - 12

(2) Activated sludge (see Table 20-11)

Used by: Direct dischargers - 94
Indirect dischargers - 11

(3) Stabilization lagoons (see Table 20-12)

Used by: Direct dischargers - 44
Indirect dischargers - 17

(4) Polishing ponds

Subcategory 7, one plant sampled (see Table 20-13)
Subcategory 9, one plant sampled (see Table 20-14)

(5) Coagulation, chemical or polymer (see Table 20-15)

Used by: Direct dischargers - 16
Indirect dischargers - 15
Zero dischargers - 3

TABLE 20-10. EFFECTIVENESS OF AERATED LAGOONS [1]

Subcategory	Discharge	hp/Mgal[a]	Detention time, hr	BOD, mg/L		COD, mg/L		TSS, mg/L	
				Inf	Eff	Inf	Eff	Inf	Eff
4c	Direct	45	60	370	94	835	810	-	89
4a	Indirect	400	24	69	69	640	580	54	68
4c	Indirect	780	86	1,740	160	-	-	560	600
5a	Indirect	150	18	390	190	1,760	1,220	-	-
7	Direct	25	75	110	14	-	-	21	12
7	Direct	1,000	0.5	250	250	560	430	-	110

[a]Mgal = Million gallons.

TABLE 20-11. EFFECTIVENESS OF ACTIVATED SLUDGE [1]

Subcategory	Discharge	hp/Mgal[a]	Detention time, hr[b]	BOD, mg/L		COD, mg/L		TSS, mg/L	
				Inf	Eff	Inf	Eff	Inf	Eff
1	Direct	160	99	1,560	125	16,200	2,600	3,970	1,230
4c	Direct	120	110	475	19	-	-	-	91
4a	Direct	60	24	130	22	472	310	34	38
4c	Direct	41	75	270	24	840	340	-	27
4c	Direct	58	130	400	8	-	250	80	8
4c	Direct	250	97	330	23	2,970	590	-	44
4c	Direct	80	78	640	105	1,240	660	170	180
4a	Direct	60	120	180	9	470	160	26	18
4b	Direct	90	80	250	5	-	-	220	48
5b	Direct	60	48	270	45	690	350	28	55
5a	Direct	74	82	190	19	340	160	97	63
5a	Direct	40	420	200	13	745	230	49	62
5b	Direct	75	110	180	5	-	120	18	18
5b	Direct	160	76	1,100	11	-	260	280	45
6	Direct	44	130	210	29	610	230	93	50
7	Direct	80	33	150	6	500	126	36	27
7	Indirect	500	44	1,630	230	4,760	1,840	140	195
7	Indirect	80	50	125	5	-	160	46	21

aMgal = Million gallons.

[b]Calculated based on average flow and basin volume available for the year 1976.

TABLE 20-12. EFFECTIVENESS OF STABILIZATION LAGOONS [1]

Subcategory	Discharge	Effluent concentration, mg/L[a] BOD	COD	TSS
4c	Direct	53	175	14
4c	Direct	35	115	35
4b	Indirect	480	2,190	18
5b	Indirect	325	810	40
5b	Indirect	145	-	-
5a	Indirect	140	860	-
5c	Indirect	210	550	-
7	Indirect	230	630	59
7	Indirect	110	790	945
8	Direct	17	-	29
8	Indirect	79	-	180

[a]Influent data were not presented.

TABLE 20-13. EFFECTIVENESS OF A POLISHING POND, SUBCATEGORY 7 [1]

Conventional and nonconventional pollutant treatability		
Pollutant	Influent	Effluent
COD, mg/L	78	140
TSS, mg/L	37	28
Phenols, μg/L	36	51
Sulfide, μg/L	2	ND[a]
Color, ADMI	210	220
Priority pollutant treatabilty		
Priority pollutant	Influent, μg/L	Effluent, μg/L
Trichlorofluoromethane	48	ND
Bis(2-ethylhexyl) phthalate	40	11
Lead	36	ND
Zinc	865	120

[a]Not detected.

TABLE 20-14. EFFECTIVENESS OF A POLISHING POND, SUBCATEGORY 9 [1]

Conventional and nonconventional pollutant treatability		
Parameter	Influent	Effluent
COD, mg/L	550	260
TSS, mg/L	91	22
Phenols, μg/L	52	28
Sulfide, μg/L	ND[a]	ND
Color, ADMI	280	300

Priority pollutant treatability		
Priority pollutant	Influent, μg/L	Effluent, μg/L
Naphthalene	56	ND[a]
Bis(2-ethylhexyl) phthalate	18	ND
Chromium	35	ND
Copper	ND	18
Selenium	32	18
Zinc	45	100

[a]Not detected.

TABLE 20-15. EFFECTIVENESS OF COAGULATION [1]

Subcategory	Coagulants	Treatment step	BOD, mg/L Inf	BOD, mg/L Eff	COD, mg/L Inf	COD, mg/L Eff	TSS, mg/L Inf	TSS, mg/L Eff
		Direct dischargers						
2	Alum, polymer	Secondary clarifier	150	11	900	-	175	64
4b	Alum	Secondary clarifier	83	14	310	150	43	35
4b[a]	-	Flotation unit	-	51	-	480	-	190
4c	-	Secondary clarifier	200	51	845	660	82	140
4c	Polymer	Secondary clarifier	-	7	850	160	-	54
4c[a]	Ferric chloride, lime	Coag/floc raw waste	-	4	1,400	99	170	30
4c[a]	-	-	760	12	1,600	250	420	99
5a	-	Coag/floc secondary	330	24	1,265	210	-	40
5a	Polymer	Secondary clarifier	-	24	-	270	-	65
5a	Polymer	Injection prefiltration	280	5	930	200	41	7
7	Alum, polymer	Secondary clarifier	330	20	1,570	480	26	23
7	Chlorinated copperas, lime	Secondary clarifier	60	15	330	130	31	11
8	-	Flotation postbiological	-	6	-	-	-	14
		Indirect dischargers						
2	Lime	Coag/floc raw waste	-	-	1,330	560	-	560
4a[a]	Lime, alum	Flotation	-	250	-	400	-	30
4c[a]	Ferric chloride	Coag/clarify print waste	-	420	-	695	-	120
4a[b]	Aluminum chloride	Flotation print waste	-	340	-	885	-	210
4a[a]	Alum	Coag/clarify print waste	320	130	1,980	260	460	72
		Recycle plant						
4a	Alum	Flotation	300	10	-	1,550	-	5

[a]Fabric printing is a signficant portion of production.
[b]Latex and PVC coating operations.

II.20.4.2 Other Methods and Industry Applications

Other full-scale treatment methods that have been cited in the literature, but for which no data were presented, include: screening, neutralization, equalization, biological processes, and biological beds.

II.20.5 REFERENCES

1. Technical Study Report BATEA-NSPS-PSES-PSNS - Textile Mills Point Source Category (draft contractor's report). Contracts 68-01-3289 and 68-01-3884, U.S. Environmental Protection Agency, Washington, D.C., November 1978.

2. NRDC Consent Decree Industry Summary - Textile Mills.

3. MRC internal sampling data on file at Effluent Guidelines Division of EPA, 1978.

II.21 TIMBER PRODUCTS PROCESSING

II.21.1 INDUSTRY DESCRIPTION [1]

II.21.1.1 General Description

The Timber Products Processing Industry encompasses manufacturers and processors who use forest materials to produce their goods and merchandise. The Environmental Protection Agency recognizes 15 distinct subcategories of manufacturers and/or processors engaged in utilization of timber. This section addresses three major subsections of the entire industry, (encompassing five subcategories): wood preserving, both steaming and Boulton processes; insulation board manufacturing; and both S1S and S2S hardboard manufacturing.

Table 21-1 presents industry summary data for the Timber Products Processing point source category in terms of the number of subcategories and number of dischargers [1, 2].

II.21.1.2 Subcategory Descriptions

This section presents general descriptions and process descriptions for the following five subcategories of the Timber Products Processing point source category: wood preserving (steaming and Boulton processes), insulation board manufacturing, and hardboard manufacturing (S1S and S2S). The remaining ten subcategories have been classified as Paragraph 8 exclusions and will not be discussed in this report.

Wood Preserving

According to information from the American Wood Preserver's Association there are approximately 300 companies, with a total employment of about 11,000, engaged in wood preserving in the United States. Fifty percent of the industry capacity is controlled by 10 companies. Over three-quarters of the plants are concentrated in two distinct regions. One area extends from east Texas to Maryland and corresponds roughly to the natural range of the Southern pines, the major species utilized. The second, smaller area is located along the Pacific Coast, where Douglas fir and western red cedar are the predominant species.

The three most prevalent types of preservatives used in wood preserving are creosote, pentachlorophenol (PCP), and various

TABLE 21-1. INDUSTRY SUMMARY [1, 2]

Industry: Timber Products Processing
Total Number of Subcategories: 15
Number of Subcategories Studied: 5

Number of Dischargers in Industry:

- Direct: 15
- Indirect: 49
- Zero: 363

formulations of water-soluble inorganic chemicals, the most common of which are the salts of copper, chromium, and arsenic. Fire retardants are formulations of salts, the principal ones being borates, phosphates, and ammonium compounds. Eighty percent of the plants in the United States use at least two of the three types of preservatives. Many plants treat with one or two preservatives plus a fire retardant.

The wood preserving process consists of two basic steps: (1) preconditioning the wood to reduce its natural moisture content and to increase the permeability, and (2) impregnating the wood with the desired preservatives.

The preconditioning step may be performed by one of several methods including (1) seasoning or drying wood in large, open yards; (2) kiln drying; (3) steaming the wood at elevated pressure in a retort followed by application of a vacuum; (4) heating the stock in a preservative bath under reduced pressure in a retort (Boulton process); or (5) vapor drying, heating of the unseasoned wood in a solvent to prepare it for preservative treatment. All of these preconditioning methods have as their objective the reduction of moisture content of the unseasoned stock to a point where the requisite amount of preservative can be retained in the wood.

Conventional steam conditioning (open steaming) is a process in which unseasoned or partially seasoned stock is subjected to direct steam impingement at an elevated pressure in a retort. The maximum permissible temperature is set by industry standards at 118°C and the duration of the steaming cycle is limited by these standards to no more than 20 hours. Steam condensate that forms in the retort exits through traps and is conducted to oil-water separators for removal of free oils. Removal of emulsified oils requires further treatment.

In closed steaming, a widely used variation of conventional steam conditioning, the steam needed for conditioning is generated *in-situ* by covering the coils in the retort with water from a reservoir and heating the water by passing process steam through the coils. The water is returned to the reservoir after oil separation and reused during the next steaming cycle. There is a slight increase in volume of water in the storage tank after each cycle due to water exuded from the wood. A small blowdown from the storage tank is necessary to account for this excess water and also to control the level of wood sugars in the water.

Modified closed steaming is a variation of the steam conditioning process in which steam condensate is allowed to accumulate in the retort during the steaming operation until it covers the heating coils. At that point, direct steaming is discontinued and the remaining steam required for the cycle is generated within the retort by utilizing the heating coils. Upon completing the steaming cycle, the water in the cylinder is discarded after recovery of oils.

Preconditioning is accomplished in the Boulton process by heating the stock in a preservative bath under reduced pressure in the retort. The preservative serves as a heat transfer medium. After the cylinder temperature has been raised to operating temperature, a vacuum is drawn, and water removed in vapor form from the wood passes through a condenser to an oil-water separator where low-boiling fractions of the preservative are removed. The Boulton cycle may have a duraction of 48 hours or longer for large poles and piling, a fact that accounts for the lower production per retort day as compared to plants that steam condition.

The vapor-drying process consists of exposing wood in a closed vessel to vapors from any one of many organic chemicals that are immiscible with water and have a narrow boiling range.

Table 21-2 presents a summary of information pertaining to the wood preserving category.

Insulation Board Manufacturing

Insulation board is a form of fiberboard, which in turn is a broad generic term applied to sheet materials constructed from ligno-cellulosic fibers. Insulation board is a "noncompressed" fiberboard, which is differentiated from "compressed" fiberboards, such as hardboard, on the basis of density. Densities of insulation board range from about 0.15 to 0.50 g/cm^3 (9.5 to 31 lb/ft^3).

There are 18 insulation board plants in the United States with a combined annual production capacity of over 330 million square meters (3,600 million square feet) on a 13-mm (0.5-in.) basis. Sixteen of the plants use wood as a raw material for some or all

TABLE 21-2. WOOD PRESERVING SUBCATEGORY SUMMARY [1, 2]

Number of Dischargers[a]:

	Boulton	Steaming	Inorganic salt	Nonpressure
• Direct:	0	10	1	0
• Indirect:	11	23	5	0
• Zero:	24	57	56	23

Pollutants and Toxics Found in Significant Quantities:

Pentachlorophenol	Arsenic
Phenol	BOD
2,4-Dimethylphenol	TSS
2,4-Dichlorophenol	COD
Copper	Oil and grease
Chromium	Phenols (standard methods)

Number of Toxic Pollutants Found in:

- Raw wastewater: 39
- Treated effluent: 39

Candidate Treatment and Control Technologies:

Primary oil water separation
Secondary oil water separation
Biological treatment
Reuse and recycle
Evaporation

[a]Those plants responding to questionnaires for industry study.

of their production. One plant uses bagasse exclusively, and one plant uses waste paper exclusively for raw material. Four plants use mineral wool, a nonwood-based product, as a raw material for part of their insulation board production. Production of mineral wood board is classified under SIC 3296 and is not within the scope of this section. Five plants produce hardboard products as well as insulation board at the same facility.

Insulation board can be formed from a variety of raw materials including wood from softwood and hardwood species, mineral fiber, waste paper, bagasse, and other fibrous materials. In this section, only those processes employing wood as raw materials are considered. Plants utilizing wood may receive it as roundwood, fractionated wood, and/or whole tree chips. Fractionated wood can be in the form of chips, sawdust, or planer shavings.

At the time of this compilation only limited data were available on this subcategory. Available data are contained in the tables in Section II.21.2. Table 21-3 summarizes information pertaining to the insulation board manufacturing subcategory.

TABLE 21-3. INSULATION BOARD MANUFACTURING SUBCATEGORY SUMMARY [1, 2]

Number of Dischargers:[a]

- Direct: 8[b]
- Indirect: 6
- Zero: 2

Pollutants and Toxics Found in Significant Quantities:

Copper
Chromium
Arsenic
BOD
TSS

Number of Toxic Pollutants Found in:

- Raw wastewater: 17
- Treated effluent: 13

Candidate Treatment and Control Technologies:

Biological treatment
Reuse and recycle
Evaporation

[a]Those plants responding to questionnaires for industry study.

[b]Includes three self-contained dischargers-spray irrigation.

Hardboard Manufacturing

Hardboard is a form of fiberboard, which is a broad generic term applied to sheet materials constructed from ligno-cellulosic fibers. Hardboard is a "compressed" fiberboard, with a density over 0.50 g/cm^3 (31 lb/ft^3). The thickness of hardboard products ranges between 2 and 13 mm (nominal 1/12 to 7/16 in.).

Production of hardboard by the wet process method is accomplished by thermo-mechanical fiberization of the wood furnish. One plant produces wet-dry hardboard using primarily mechanical refining.

Dilution of the wood fiber with fresh or process water then allows forming of a wet mat of a desired thickness on a forming machine. This wet mat is then pressed either wet or after drying. Chemical additives help the overall strength and uniformity of the product. The uses of manufactured products are many and varied, requiring different processes and control measures. The quality and type of board are important in the end use of the product.

Hardboard which is pressed wet immediately following forming of the wet-lap is called wet-wet or smooth-one-side (S1S) hardboard; that which is pressed after the wet-lap has been dried is called wet-dry or smooth-two-side (S2S) hardboard.

There are 16 wet process hardboard plants in the United States, representing an annual production in excess of 1.5 million metric tons per year. Seven of the plants produce only SIS hardboard. Nine plants produce S2S hardboard. Of these nine, five plants also produce insulation board, while three plants also produce SIS hardboard.

Table 21-4 presents a summary of pertinent information pertaining to the hardboard manufacturing subcategory.

TABLE 21-4. HARDBOARD MANUFACTURING SUBCATEGORY SUMMARY [1, 2]

Number of Dischargers:[a]

- Direct: 12
- Indirect: 2
- Zero: 2

Pollutants and Toxics Found in Significant Quantities:

Copper
Chromium
Arsenic
BOD
TSS

Number of Toxic Pollutants Found in:

- Raw wastewater: 23
- Treated effluent: 17

Candidate Treatment and Control Technologies:

Biological treatment
Reuse and recycle
Evaporation

[a]Those plants responding to questionnaires for industry study.

II.21.2 WASTEWATER CHARACTERIZATION [1]

II.21.2.1 Wood Preserving

The quantity of wastewater generated by a wood preserving plant is a function of the method of conditioning used, the moisture content of the wood being treated, and the amount of rainwater draining toward the treating cylinder. Most wood preserving plants treat stock having a wide range of moisture contents. Although most plants will predominantly use one of the major conditioning methods, many plants will use a combination of several conditioning methods, and the actual quantity of wastewater generated by a specific plant may vary considerably. The average wastewater volume from 14 Boulton plants is reported to be 21,210 L/d (5,600 gal/d) or 139 L/m^3 (1.03 gal/ft^3). The average wastewater volume for eight closed loop steaming plants is 5,200 L/d (1,370 gal/d) or 60.0 L/m^3 (0.45 gal/ft^3). The average wastewater volume for 10 plants which treat significant amounts of dry stock is 13,300 L/d (3,510 gal/d) or 121 L/m^3 (0.91 gal/ft^3). Additionally the average wastewater volume for 13 open steaming plants is 24,700 L/d (8,810 gal/d) or 324 L/m^3 (2.43 gal/ft^3).

Table 21-5 presents concentrations of toxic pollutants found in the raw wastewater (for both steaming and Boulton processes) and treated effluent (for steaming and Boulton processes combined). Table 21-6 similarly presents toxic pollutant loadings in kg/m^3 of product derived from the concentrations given in Table 21-5 for the wood preserving subcategory. Conventional pollutant concentrations are shown in Table 21-7 and corresponding pollutant loads in Table 21-8.

II.21.2.2 Insulation Board Manufacturing

Insulation board plants responding to the data collection portfolio reported fresh water usage rates ranging from 95 to 5,700 liters per day for process water (0.025 to 1.5 MGD). One insulation board plant, Plant 543, which also produces hardboard in approximately equal amounts, uses over 15 million liters per day (4 MGD) of fresh water for process water.

Water becomes contaminated during the production of insulation board primarily through contact with the wood during fiber prepaparation and forming operations, and the vast majority of pollutants are fine wood fibers and soluble wood sugars and extractives.

More specifically potential sources of wastewater in an insulation board plant include:

TABLE 21-5. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN STEAMING AND BOULTON SUBCATEGORY WASTEWATER [1] (μg/L)

	Raw wastewater						Treated effluent		
	Steaming process			Boulton process			Steaming and Boulton process		
Toxic pollutant	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants	Range	Median
Metals and inorganics									
Antimony	8	BDL - 47	1.5				7	BDL - 14	1
Arsenic	12	BDL - 14,200	24				11	BDL - 6,980	29
Beryllium	8	BDL - 19	BDL				7	BDL - 13	BDL
Cadmium	8	BDL - 10	1				7	BDL - 7	~0.5
Chromium	11	BDL - 13,900	23				11	1 - 6,600	22.5
Copper	12	8 - 3,910	165				11	18 - 4,000	92
Lead	8	1 - 91	12.5				7	BDL - 37	4
Mercury	8	BDL - 3.7	~0.1				7	BDL - 2	~0.05
Nickel	8	3 - 210	24				7	2 - 150	14.5
Selenium	8	BDL - 53	1				7	BDL - 39	1
Silver	8	BDL - 6	BDL				7	BDL - 4	BDL
Thallium	8	BDL - 10	1				7	BDL - 7	BDL
Zinc	8	119 - 78,200	360				8	47 - 41,000	252
Phthalates									
Bis(2-ethylhexyl) phthalate	5	BDL - 437	126	3	BDL - 1,460	433	7	BDL - 305	9
Phenols									
2-Chlorophenol	5	BDL - 42	15	1		BDL	5	BDL - 4	BDL
2,4-Dimethylphenol	5	BDL - 6,600	1,300	1		BDL	5	BDL - 140	BDL
Pentachlorophenol	12	BDL - 306,000	23,600	2	BDL - 27,000	10	17	32 - 134,000	5,300
Phenol	5	1,400 - 87,000	16,000	1		71	5	BDL - 16,000	15
2,4,6-Trichlorophenol	5	BDL - 533	252	1		BDL	5	BDL - 5	BDL
Monocyclic aromatics									
Benzene	4	3 - 2,800	1,050	1		BDL	5	BDL - 33	10
Ethylbenzene	4	37 - 2,100	380	1		BDL	5	BDL - 20	BDL
Toluene	4	27 - 3,200	500	1		BDL	5	BDL - 140	23
Polycyclic aromatic hydrocarbons									
Acenaphthene	5	1,060 - 55,000	1,700	3	BDL - 2,830	-[a]	7	BDL - 18,000	90
Acenaphthylene	5	BDL - 1,210	933	3	BDL - 2,060	-[a]	7	BDL - 190	4
Anthracene/phenanthrene	5	195 - 39,000	6,720	3	BDL - 1,510	920	7	BDL - 37,000	59
Benzo(a)anthracene	5	BDL - 7,700	157				7	BDL - 3,400	BDL
Benzo(a)pyrene	5	BDL - 2,700	7	3	BDL	BDL	7	BDL - 290	BDL
Benzo(b)fluoranthene	5	BDL - 1,680	BDL	3	BDL	BDL	7	BDL - 2,500	BDL
Benzo(ghi) perylene	5	BDL - 315	BDL	3	BDL	BDL	7	BDL - 63	BDL
Benzo(k)fluoranthene	5	BDL - 3,900	17	3	BDL	BDL	7	BDL - 210	BDL
Chrysene	5	BDL - 4,700	98	1	BDL - 18	-[a]	7	BDL - 19,000	BDL
Dibenzo(ah)anthracene	5	BDL - 430	-[a]	3	BDL	BDL	7	BDL	BDL
Fluoranthene	5	633 - 35,000	1,600	3	BDL - 282	-[a]	7	BDL - 17,000	106
Fluorene	5	820 - 48,000	2,310	3	BDL - 824	-[a]	7	BDL - 16,000	36
Indeno(1,2,3-cd)pyrene	5	BDL - 5,500	BDL	3	BDL	BDL	7	BDL - 110	BDL
Naphthalene	5	464 - 45,000	3,470	3	BDL - 3,140	-[c]	7	BDL - 36,000	33
Pyrene	5	360 - 22,000	1,100	3	BDL - 194	-[c]	7	BDL - 9,400	77
Halogenated aliphatics									
Methyl chloride	4	BDL - 702	77	1		2,600	5	13 - 1,900	140
Methylene chloride	4	BDL - 20	-[c]	1		9	5	BDL - 23	BDL

[a] Includes plants treating with organic preservatives only plus those treating with both organic and inorganic preservatives; steaming and/or Boulton process or both.

[b] See also conventional pollutants.

[c] Detected in one sample only.

TABLE 21-6. TOXIC POLLUTANT LOADINGS FOUND IN STEAMING AND BOULTON SUBCATEGORY WASTEWATER [1]
[lb/ft³ (kg/m³)]

	Raw wastewater						Treated effluent		
	Steaming process			Boulton process			Steaming and Boulton process		
Toxic pollutant[a]	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants		Median
Metals and inorganics									
Antimony	8	<0.01 - 0.82	0.01				11	<0.01 - 0.27	<0.02
		(<0.16 - 13.2)	(0.16)					(<0.2 - 4.3)	(<0.3)
Arsenic	12	<0.01 - 246	0.2				11	<0.01 - 135	0.32
		(<0.16 - 3,960)	(3.2)					(<0.2 - 2,170)	(0.5)
Beryllium	8	<0.01 - 0.01	<0.01				7	<0.01 - 0.1	<0.01
		(<0.16 - 0.16)	(<0.16)					(<0.2 - 1.6)	(<0.16)
Cadmium	8	<0.01 - 0.03	<0.01				7	<0.01 - 0.06	<0.01
		(<0.16 - 0.48)	(<0.16)					(<0.2 - 1.0)	(<0.2)
Chromium	11	<0.01 - 116	0.4				11	0.01 - 29.1	0.58
		(<0.16 - 1,870)	(6.4)					(0.2 - 468)	(9.3)
Copper	12	0.06 - 9.59	1.5				11	0.17 - 7.42	1.71
		(1.0 - 154)	(24.2)					(2.7 - 119)	(27.5)
Lead	8	0.01 - 1.6	0.07				7	<0.01 - 0.72	0.9
		(0.16 - 25.8)	(1.1)					(<0.2 - 11.6)	(1.4)
Mercury	8	<0.01 - 0.03	<0.01				7	<0.01 - 0.03	<0.01
		(<0.16 - 0.48)	(<0.16)					(<2 - 0.5)	(<0.16)
Nickel	8	0.02 - 5.97	0.13				7	0.01 - 1.21	0.34
		(0.32 - 96.1)	(2.09)					(2 - 19.5)	(5.5)
Selenium	8	<0.01 - 0.35	0.03				7	<0.01 - 0.26	0.01
		(<0.16 - 5.6)	(0.48)					(2 - 4.2)	(<0.16)
Silver	8	<0.01 - 0.03	<0.01				7	<0.01 - 0.03	<0.01
		(<0.16 - 0.48)	(<0.16)					(<2 - 0.5)	(<0.16)
Thallium	8	<0.01 - 0.13	0.01				7	<0.01 - 0.05	0.01
		(<0.16 - 2.09)	(0.16)					(<2 - 0.8)	(<0.16)
Zinc	8	0.66 - 652	3.38				7	0.72 - 205	3.06
		(10.6 - 10,500)	(54.4)					(11.6 - 3,300	(49.3)
Phthalates									
Bis(2-ethylhexyl) phthalate	5	<0.1 - 6.4	1.4	3	<0.1 - 17.1	10.8	7	<0.01 - 1	<0.01
		(<1.6 - 103)	(22.5)		(<1.6 - 275)	(174)		(<0.2 - 16.1)	(<0.2)
Phenols									
2-Chlorophenol	3	BDL - 0.7	0.3	1		BDL	5	<0.1	<0.1
		(BDL - 11.3)	(4.8)					(<2)	(<2)
2,4-Dimethylphenol	3	2.3 - 107	24.3	1		BDL	5	<0.1 - 2.7	<0.1
		(37.0 - 1,720)	(391)					(<0.2 - 43.5)	(<2)
Pentachlorophenol	15	<0.1 - 1,970	214	3	<0.1 - 179	<0.1	10	0.3 - 2,440	44.6
		(<1.6 - 31,700)	(3,440)		(8.1 - 2,880)	(2,930)		4.8 - 39,300)	(718)
Phenol	3	311 - 425	321	1	6.6		5	<0.1 - 123	<0.1
		(5,010 - 6,840)	(5,170)			(106)		(<2 - 1,980)	(<2)
2,4,6-Trichlorophenol	3	BDL - 10.4	4.4	1		BDL	5		
		(BDL - 167)	(70.8)						

(continued)

TABLE 21-6 (continued)

Toxic pollutant[a]	Raw wastewater: Steaming process: Number of plants	Steaming process: Range	Steaming process: Median	Boulton process: Number of plants	Boulton process: Range	Boulton process: Median	Treated effluent: Steaming and Boulton process: Number of plants	Steaming and Boulton process: Range	Steaming and Boulton process: Median
Monocyclic aromatics									
Benzene	3	10.3 - 31.5	18.3	1		<0.1	5	<0.1 - 0.6	0.1
		(165 - 506)	(294)			(1.6)		(<2 - 9.7)	(2)
Ethylbenzene	3	7.4 - 15.1	7.7	1		<0.1	5	<0.1 - 0.2	<0.1
		(119 - 243)	(124)			(<1.6)		(<2 - 3.2)	(<2)
Toluene	3	9.7 - 49.5	11.8	1		<0.1	5	<0.1 - 2.1	0.3
		(156 - 797)	(190)			(<1.6)		(<2 - 33.8)	(4.8)
Polycyclic aromatic hydrocarbons									
Acenaphthene	5	8.3 - 75.9	33.0	3	<0.1 - 33.1	<0.1	7	<0.01 - 13.8	0.1
		(134 - 1,220)	(531)		(<1.6 - 533)	(<1.6)		(<0.2 - 222)	(1.6)
Acenapthalene	5	0.1 - 23.2	9.2	3	<0.1 - 24.1	<0.1	7	<0.01 - 0.6	0.01
		(1.6 - 374)	(148)		(<1.6 - 388)	(<1.6)		(<0.2 - 9.7)	(0.2)
Anthracene/phenanthrene	5	13.5 - 200	94.7	3	<0.1 - 17.7	6.1	7	<0.01 - 28.5	0.09
		(217 - 3,220)	(1,530)		1.6 - 285)	(98.2)		(0.2 - 459)	(1.4)
Benzo(a)anthracene	5	<0.1 - 27.3	3.0	3	<0.1 - 0.4	<0.1	7	<0.01	<0.01
		(<1.6 - 440)	(48.3)		(<1.6 - 6.4)	(<3.6)		(<0.2)	(<0.2)
Benzo(a)pyrene	5	BDL - 23.5	0.1	3	<0.1	<0.1	7	<0.01 - 0.6	<0.01
		(BDL - 378)	(1.6)		(<1.6)	(<1.6)		(<0.2 - 9.7)	(<0.2)
Benzo(b)fluoranthene	5	BDL - 29.3	0.2	3	<0.1	<0.1	7	<0.01 - 1.9	<0.01
		(BDL - 472)	(3.2)		(<1.6)	(<1.6)		(<0.2 - 31.9)	(<0.2)
Benzo(ghi) perylene	5	0.1 - 5.5	<0.1	3	<0.1	<0.1	7	<0.01 - 0.1	<0.01
		(<1.6 - 88.6)	(<1.6)		(<1.6)	(<1.6)		(<0.2 - 1.6)	(<0.2)
Benzo(k)fluoranthene	5	BDL - 29.3	0.2	3	<0.1	<0.1	7	<0.01 - 0.4	<0.01
		(BDL - 472)	(3.2)		(<1.6)	(<1.6)		(<0.2 - 6.4)	(<0.2)
Chrysene	5	<0.1 - 24.9	3.1	3	<0.1 - 0.2	<0.1	7	<0.01 - 1.5	<0.01
		(<1.6 - 401)	(49.9)		(<1.6 - 3.2)	(<1.6)		(<0.2 - 24.2)	(<0.2)
Dibenzo(ah)anthracene	5	<0.1 - 1.6	<0.1	3	<0.1	<0.1	7	<0.01	<0.01
		(<1.6 - 25.8)	(1.6)		(<1.6)	(<1.6)		(<0.2)	(<0.2)
Fluoranthene	5	4.9 - 112	20.3	3	<0.1 - 3.3	<0.1	7	<0.01 - 13.1	<0.08
		(78.9 - 1,800)	(327)		(<1.6 - 53.1)	(1.6)		(<0.2 - 211)	(1.3)
Fluorene	5	6.4 - 61.1	29.1	3	<0.1 - 9.6	<0.1	7	<0.01 - 12.3	0.06
		(103.0 - 984)	(469)		(<1.6 - 155)	(<1.6)		(<0.2 - 198)	(1.0)
Indeno(1,2,3-cd)pyrene	5	<0.1 - 20.3	0.1	3	<0.1	<0.1	7	<0.01 - 0.2	<0.01
		(<1.6 - 327)	(1.6)		(<1.6)	(<1.6)		(<0.2 - 3.2)	(<0.2)
Naphthalene	5	4.1 - 540	17.2	3	<0.1 - 36.8	<0.1	7	<0.01 - 27.7	<0.1
		66.0 - 8,690	(277)		(<1.6 - 593)	(<1.6)		(<0.2 - 446)	(1.6)
Pyrene	5	2.8 - 84.4	16.1	3	<0.1 - 2.3	<0.1	7	0.01 - 7.2	0.05
		(45.1 - 1,360)	(259)		(<1.6 - 37.0)	(1.6)		(<0.2 - 116)	(0.8)
Halogenated aliphatics									
Methyl chloride	1	1 - 12.2	1.5	1		17.2	5	0.3 - 12.6	2.7
		(16.1 - 196)	(24.2)			277		(4.8 - 203)	(43.5)
Methylene chloride	3	<0.1 - 0.1	-	1		<0.1	5	<0.1 - 0.3	<0.1
		(<1.6 - 1.6)				(<1.6)		(<2 - 4.8)	(<2)

[a]Includes plants treating with organic preservatives only plus those treating with both organic and inorganic preservatives. Steaming and/or Boulton process or both.

TABLE 21-7. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN STEAMING AND BOULTON SUBCATEGORY WASTEWATER [1] (mg/L)

	Raw wastewater						Treated effluent		
	Steaming process			Boulton process			Steaming and Boulton process		
Pollutant	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants	Range	Median
Phenols	15	0.640 - 501	53.6	3	BDL - 1,270	184	17	0.048 - 680	18.9
PCP	15	BDL - 306	23.6	3	BDL - 27	0.01	14	0.032 - 134	5.8
Oil and grease	15	11 - 1,900	627	3	12.3 - 1,360	39.4	17	9.3 - 1,220	52.3
COD	15	1,360 - 15,700	6,730	3	520 - 7,320	3,700	17	100 - 10,600	2,290
TSS				1	81				

TABLE 21-8. LOADINGS OF CONVENTIONAL POLLUTANTS FOUND IN STEAMING AND BOULTON SUBCATEGORY WASTEWATER [1] [lb/1,000 ft^3 (kg/1,000 m^3)]

	Raw wastewater						Treated effluent		
	Steaming process			Boulton process			Steaming and Boulton process		
Pollutant	Number of plants	Range	Median	Number of plants	Range	Median	Number of plants	Range	Median
Phenols	15	0.011 - 11.4 (0.1771 - 184)	1.06 (17.1)	3	<0.0001 - 14.9 (<0.0016 - 240)	1.53 (24.6)	17	0.0003 - 6.92 (0.0048 - 111)	0.385 (6.20)
PCP	15	<0.0001 - 1.97 (<0.0016 - 31.7)	0.214 (3.44)	3	<0.0001 - 0.179 (<0.0016 - 2.88)	0.0001 (0.0016)	14	0.0004 - 2.44 (0.0064 - 39.3)	0.0336 (0.541)
Oil and grease	15	0.0627 - 30.4 (1.01 - 489)	7.72 (124)	3	0.0718 - 38.6 (1.16 - 621)	0.461 (7.42)	17	0.0626 - 13.5 (1.01 - 217)	0.706 (11.4)
COD	15	(10.2 - 283) (164 - 4,560)	47.7 (768)	3	3.44 - 208 (55.4 - 3,350)	21.6 (348)	17	0.821 - 162 (13.2 - 2,610)	23.8 (383)
TSS				1		0.537 (8.65)			

Chip wash water
Process whitewater generated during fiber preparation (refining and washing)
Process whitewater generated during forming
Wastewater generated during miscellaneous operations (dryer washing, finishing, housekeeping, etc.)

Reference 1 considers an average unit flow for Plant 97, which is 8.3 L/kg (2,000 gal/ton) to be representative of an insulation board, mechanical refining plant which produces a full line of insulation board products and which practices internal recycling to the extent practicable.

Table 21-9 presents concentrations of toxic pollutants found in insulation board manufacturing raw wastewater. Table 21-10 similarly presents toxic pollutant metals loading for this subcategory.

II.21.2.3 Hardboard Manufacturing

Production of hardboard by wet process requires significant amounts of water. Plants responding to the data collection portfolio reported fresh water usage rates for process water ranging from approximately 190 thousand to 19 million liters per day (0.05 to 5 MGD). One plant, 543, which produces both hardboard and insulation board in approximately equal amounts, reported fresh water use of over 15 million liters per day (4 MGD).

Water becomes contaminated during the production of hardboard primarily through contact with the wood raw material during the fiber preparation, forming, and--in the case of S1S hardboard--pressing operations. The vast majority of pollutants consist of fine wood fibers, soluble wood sugars, and extractives. Additives not retained in the board also add to the pollutant load.

The water used to process and transport the wood from the fiber preparation stage through mat formation is referred to as process whitewater. Process whitewater produced by the dewatering of stock at any stage of the process is usually recycled to be used as stock dilution water. However, due to the buildup of suspended solids and dissolved organic material which can cause undesirable effects in the board, there may be a need to bleed off a quantity of excess process whitewater.

More specifically, potential wastewater sources in the production of wet process hardboard include:

TABLE 21-9. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN INSULATION BOARD SUBCATEGORY RAW WASTEWATER [1] (μg/L)

Toxic pollutant	Number of plants	Range	Median
Metals and inorganics			
Antimony	4	0.67 - 3	1.46
Arsenic	4	1.6 - 3.3	2.5
Beryllium	4	0.5 - 0.83	0.5
Cadmium	4	0.5 - 1.0	0.565
Chromium	4	1.3 - 11	4.9
Copper	4	200 - 450	310
Lead	4	1.3 - 21	3.3
Mercury	4	1 - 7.5	5.8
Nickel	4	8.8 - 240	58.5
Selenium	4	3.3 - 5.0	4.5
Silver	4	0.5 - 0.6	0.5
Thallium	4	0.5 - 0.83	0.7
Zinc	4	250 - 720	534
Halogenated aliphatics			
Chloroform[a]	3	BDL-20	BDL
Phenols			
Phenol	3	BDL-40	BDL
Monocyclic aromatics[b]			
Benzene	3	BDL-70	40
Toluene	3	BDL-60	40

[a]One sample of raw wastewater contained 20 μg/L of chloroform. Plant intake water contained 10 μg/L of chloroform.

[b]Plant 97 intake water contained 50 μg/L and 30 μg/L of benzene and toluene, respectively.

TABLE 21-10. LOADINGS OF TOXIC POLLUTANT METALS FOUND IN INSULATION BOARD SUBCATEGORY RAW WASTEWATER [1]
[lb/10^6 ton (kg/10^6 Mg)]

Toxic pollutant	Range		Median
Metals and inorganics			
Antimony	4.2 - 49	(2.1 - 25)	157
Arsenic	25 - 120	(13 - 60)	44
Beryllium	8.3 - 20	(4.2 - 10)	12.5
Cadmium	5.6 - 20	(2.8 - 10)	13.5
Chromium	11 - 840	(5.5 - 470)	175
Copper	82 - 7,200	(41 - 3,600)	4,150
Lead	11 - 340	(6 - 170)	81.5
Mercury	41 - 1,600	(21 - 80)	62
Nickel	180 - 1,700	(90 - 850)	1,040
Selenium	14 - 27	(7 - 14)	70
Silver	4.2 - 20	(2.1 - 10)	10.4
Thallium	5.6 - 33	(2.8 - 17)	10.6
Zinc	5,900 - 12,000	(3,000 - 6,000)	9,200

Chip wash water
Process whitewater generated during fiber preparation (refining and washing)
Process whitewater generated during forming
Hot press squeezeout water
Wastewater generated during miscellaneous operations (dryer washing, finishing, housekeeping, etc.)

A unit flow of 12 L/kg (2,800 gal/ton) is considered to be representative in Reference 1 of an S1S hardboard plant which produces a full line of hardboard products and which practices internal recycling to the extent practicable. A unit flow of 24.6 L/kg (5,900 gal/ton) is considered to be representative in Reference 1 of an S2S hardboard manufacturing plant which produces a full line of hardboard products and practices internal recycling to the extent possible.

Available data analyses list primarily metals and inorganics as toxic pollutants; no base/neutrals data are presented. Table 21-11 presents concentrations and pollutant loadings for toxic pollutants found in hardboard manufacturing raw wastewater. Table 21-12 similarly presents concentrations and loadings for conventional pollutants.

II.21.3 PLANT SPECIFIC DESCRIPTIONS

Due to the nature of available plant specific data, only subcategory wastewater characteristics could be derived, and plant specific wastewater characterization information is not presented.

II.21.4 POLLUTANT REMOVABILITY

The following sections address the current level of in-place treatment technology and the raw and treated effluent loads and percent reduction for several pollutants and several plants. Information is organized with respect to the aforementioned subcategories [wood preserving including steaming and Boulton processes, insulation board manufacturing, and hardboard manufacturing (S1S and S2S)].

II.21.4.1 Wood Preserving

Tables 21-13 through 21-17 present the current level of in-place treatment technology for Boulton-no dischargers, Boulton-indirect dischargers, steaming-no dischargers, steaming-direct dischargers, and steaming-indirect dischargers, respectively.

Tables 21-18 through 21-20 present average raw and treated waste loads and percent removal for COD, phenols, oil and grease, and pentachlorophenol for plants with less than BPT technology in place, current pretreatment technology in place, and current BPT technology in place.

TABLE 21-11. CONCENTRATIONS AND LOADINGS OF TOXIC POLLUTNATS FOUND IN HARDBOARD MANUFACTURING SUBCATEGORY RAW WASTEWATER]1]

Toxic pollutant	Number of plants	Concentration, µg/L Range	Concentration, µg/L Median	Loading, lb/ton (kg/Mg) Range	Loading, lb/ton (kg/Mg) Median
Metals and inorganics					
Antimony	6	0.5 - 8	2.65	17 - 200 (9 - 100)	99 (52)
Arsenic	6	1 - 1.3	1.2	23 - 51 (12 - 26)	31 (15.5)
Beryllium	6	0.5 - 0.67	0.5	1 - 25 (0.5 - 13)	14.5 (7.5)
Cadmium	6	0.5 - 5	0.5	13 - 120 (7 - 60)	35.5 (18)
Chromium	6	1 - 420	52.5	34 - 11,000 (17 - 5,500)	475 (240)
Copper	6	33 - 530	355	880 - 27,000 (440 - 14,000)	7,150 (3,600)
Lead	6	2 - 55	4	40 - 1,500 (20 - 750)	102 (51)
Mercury	6	0.05 - 18	1.35	2.5 - 620 (1.2 - 310)	28 (14.5)
Nickel	6	3.3 - 270	7.5	110 - 4,700 (55 - 2,400)	190 (100)
Selenium	6	0.8 - 3.8	2.15	35 - 110 (18 - 55)	46.5 (23.5)
Silver	6	0.5 - 7	0.585	10 - 350 (5 - 180)	17 (9)
Thallium	6	0.5 - 1.5	0.585	10 - 26 (5-13)	21 (11)
Zinc	6	190 - 2,300	665	5,000 - 48,000 (2,500 - 24,000)	15,500 (8,000)
Phenols					
Phenol	2	BDL - 680[b]			
	3	BDL - 300	BDL[c]		
Monocyclic aromatics					
Benzene	2	BDL - 80[b]			
	3	BDL - 90	BDL[c]		
Ethylbenzene	2	BDL - 20[b]			
Toluene	2	15 - 70[b]			
Halogenated aliphatics					
Chloroform	2	BDL - 20[b]	BDL[c]		
1,1,1-Trichloroethane	3	BDL - 90	BDL[c]		
Pesticides and metabolites[d]					
Aldrin			<0.001		
BBC's			0.015		
Chlordane			<0.001		
Heptachlor			<0.001		

[a]S1S and S2S combined for metals - no observed difference.

[b]S1S type hardboard; no loading data.

[c]S2S type hardboard; no loading data.

[d]S1S and S2S processes combined; number of plants was not specified.

TABLE 21-12. CONCENTRATIONS AND LOADINGS OF CONVENTIONAL POLLUTANTS FOUND IN HARDBOARD MANUFACTURING SUBCATEGORY RAW WASTEWATER[a] [1]

Pollutant	Untreated wastewater concentration, mg/L Range	Untreated wastewater concentration, mg/L Median	Untreated wastewater loading, lb/ton (kg/Mg) Range	Untreated wastewater loading, lb/ton (kg/Mg) Median
BOD_5			3.77 - 232 (1.89 - 116)	74.7 (37.4)
Total phenols	BDL - 8.9	0.335	0.006 - 0.086 (0.003 - 0.043)	0.019 (0.009)

TABLE 21-13. CURRENT LEVEL OF IN-PLACE TECHNOLOGY, BOULTON, NO DISCHARGERS[a] [1]

	Number of plants	Percent
Primary oil separation	20	83
Oil separation by DAF	1	4
Evaporation ponds	15	63
Spray or soil irrigation	1	4
Cooling tower evaporation	4	17
Thermal evaporation	1	4
Effluent recycle to boilers or condensers	4	17
No discharge	2	8

[a]Plants may use more than one technology.

TABLE 21-14. CURRENT LEVEL OF IN-PLACE TECHNOLOGY, BOULTON, INDIRECT DISCHARGERS[a] [1]

	Number of plants	Percent
Primary oil separation	11	100
Chemical flocculation and/ or oil absorbent media	4	36
Biological treatment	2	18

[a]Plants may use more than one technology.

TABLE 21-15. CURRENT LEVEL OF IN-PLACE TECHNOLOGY, STEAMING, NO DISCHARGERS[a] [1]

	Number of plants	Percent
Gravity oil-water separation	44	77
Chemical flocculation or oil absorptive media	5	8.8
Sand filtration	8	14
Oxidation lagoon	3	5
Aerated lagoon	10	17
Spray irrigation	9	16
Holding basin	22	39
Thermal evaporation	2	3.5
Solar evaporation pond	20	35
Spray assisted solar evaporation	17	30
Effluent recycle to boiler or condenser	10	17

[a]Some plants use more than one technology.

TABLE 21-16. CURRENT LEVEL OF IN-PLACE TECHNOLOGY, STEAMING, DIRECT DISCHARGERS[a] [1]

	Number of plants	Percent
Gravity oil-water separation	10	100
Chemical flocculation or oil absorptive media	3	30
Sand filtration	2	20
Oxidation lagoon	2	20
Aerated lagoon	2	20
Spray irrigation	1	10
Holding basin	2	20
Solar evaporation pond	5	50
Spray assisted solar evaporation	2	20
Effluent recycle to boiler or condenser	2	20

[a]Some plants use more than one technology.

TABLE 21-17. CURRENT LEVEL OF IN-PLACE TECHNOLOGY, STEAMING, INDIRECT DISCHARGERS[a] [1]

	Number of plants	Percent
Gravity oil-water separation	23	100
Chemical flocculation or oil absorptive media	7	30
Sand filtration	3	13
Oxidation lagoon	1	4
Aerated lagoon	2	9
Holding basin	17	74
Spray assisted solar evaporation	2	9
Effluent recycle to boiler or condenser	2	9

[a]Some plants use more than one technology.

TABLE 12-18. WOOD PRESERVING CONVENTIONAL POLLUTANT DATA AVERAGES FOR PLANTS WITH LESS THAN EQUIVALENT OF BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, lb/1,000 ft^3		Percent removal
		Raw	Treated	
COD	3	92.8	31.2	66.4
Phenols	3	1.77	1.01	42.9
Oil and grease	3	8.71	1.75	79.9
Pentachlorophenol	3	0.498	0.151	69.7

TABLE 21-19. WOOD PRESERVING CONVENTIONAL POLLUTANT DATA AVERAGES FOR PLANTS WITH CURRENT PRETREATMENT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, lb/1,000 ft^3		Percent removal
		Raw	Treated	
COD	10	80.7	41.5	48.6
Phenols	10	3.11	2.03	34.7
Oil and grease	10	7.82	0.908	88.4
Pentachlorophenol	7	<0.294	0.0716	<75.6

TABLE 21-20. WOOD PRESERVING CONVENTIONAL POLLUTANT DATA AVERAGES FOR PLANTS WITH LESS THAN THE EQUIVALENT OF BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, lb/1,000 ft^3		Percent removal
		Raw	Treated	
COD	6	31.3	6.00	80.8
Phenols	6	2.41	0.0061	99.7
Oil and grease	6	4.32	<0.821	>81.0
Pentachlorophenol	5	<0.268	0.0135	<95.0

Table 21-21 presents average raw and treated waste loads and percent removals of methylene chloride, trichloromethylene, benzene, ethylbenzene, and toluene for plants with current BPT technology in place. Tables 21-22 and 21-23 present similar data for base/neutral toxic pollutants for current pretreatment technology and current BPT technology in place.

Tables 21-24 and 21-25 present similar data for wood preserving phenols for plants with current pretreatment technology in place and current BPT technology in place.

Additionally, Tables 21-26 through 21-30 present average metals raw and treated waste loads and removals in a similar manner for the wood preserving subcategory.

II.21.4.2 Insulation Board Manufacturing

Table 21-31 summarizes the current level of in-place treatment technology for six plants. Tables 21-32 through 21-37 present treated effluent characteristics and various average raw and treated waste characteristics and removals for the insulation board manufacturing subcategory.

II.21.4.3 Hardboard Manufacturing

Table 21-38 summarizes the current level of in-place treatment technology for 13 hardboard manufacturing plants. Tables 21-39 through 21-45 present treated effluent characteristics and various raw and treated waste characteristics and removals for the hardboard manufacturing subcategory.

TABLE 21-21. WOOD PRESERVING VOLATILE ORGANIC ANALYSIS DATA FOR PLANTS WITH CURRENT BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, lb/1,000 ft³ Raw	Treated	Percent removal
Methylene chloride	3	0.0049	0.0043	12.2
Trichloromethylene	3	<0.0001	<0.0002	
Benzene	3	>0.0200	<0.0003	>98.5
Ethylbenzene	3	0.101	<0.0001	>99.9
Toluene	3	0.0237	<0.0009	96.2

TABLE 21-22. WOOD PRESERVING BASE NEUTRALS DATA AVERAGES FOR PLANTS WITH CURRENT TREATMENT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, lb/10⁶ ft³ Raw	Treated	Percent removal
Fluoranthene	3	<5.7	<0.3	<94.7
Benzo(b)fluoranthene	3	<0.1	<0.1	-[a]
Benzo(k)fluoranthene	3	<0.1	<0.1	-[a]
Pyrene	3	<3.8	<0.1	97.4
Benzo(a)pyrene	3	<0.1	<0.1	-[a]
Indeno(1,2,3-cd)pyrene	3	<0.1	<0.1	-[a]
Benzo(ghi)perylene	3	<0.1	<0.1	-[a]
Phenanthrene/anthracene	3	32.4	0.8	97.5
Benz(a)anthracene	3	<0.6	<0.1	83.3
Dibenz(ah)anthracene	3	<0.1	<0.1	-[a]
Naphthalene	3	<13.7	<7.2	47.4
Acenaphthene	3	<15.8	<0.8	94.9
Acenaphthylene	3	<11.7	<1.0	91.5
Fluorene	3	<11.6	<0.3	97.4
Chrysene	3	<0.3	<0.1	66.7
Bis(2-ethylhexyl) phthalate	3	<6.2	<1.0	83.9

[a] Negligible removal.

TABLE 21-23. WOOD PRESERVING BASE NEUTRALS DATA AVERAGES FOR PLANTS WITH CURRENT BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, $lb/10^6\ ft^3$		Percent removal
		Raw	Treated	
Fluoranthene	4	53.0	8.8	85.4
Benzo(b)fluoranthene	4	<9.1	<1.4	85.7
Benzo(k)fluoranthene	4	12.7	<1.5	>89.7
Pyrene	4	39.5	3.2	93.0
Benzo(a)pyrene	4	<10.5	<1.8	83.9
Indeno(1,2,3-cd)pyrene	4	<7.3	<1.0	89.6
Benzo(ghi)perylene	4	<1.5	<0.4	78.9
Phenanthrene/anthracene	4	121	<7.1	>94.0
Benz(a)anthracene	4	<12.9	<2.4	86.0
Dibenz(ah)anthracene	4	<0.5	<0.1	83.3
Naphthalene	4	>186	<0.4	>99.8
Acenaphthene	4	43.6	2.2	95.3
Acenaphthylene	4	4.9	<0.2	>97.0
Fluorene	4	34.4	<1.5	>95.9
Chrysene	4	<11.2	<1.5	83.1
Bis(2-ethylhexyl) phthalate	4	<0.2	<0.1	66.7

[a]Negligible removal.

TABLE 21-24. WOOD PRESERVING PHENOLS DATA AVERAGES FOR PLANTS WITH CURRENT PRETREATMENT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, $lb/10^3\ ft^3$		Percent removal
		Raw	Treated	
Phenols	2	6.6	0.2	97.1
2-Chlorophenol	2	<0.1	<0.1	-[a]
2,4-Dimethylphenol	2	<0.1	<0.1	-[a]
2,4,6-Trichlorophenol	2	<0.1	<0.1	-[a]
Pentachlorophenol	7	419	69.7	83.4

[a]Negligible removal.

TABLE 21-25. WOOD PRESERVING PHENOLS DATA AVERAGES FOR PLANTS WITH CURRENT BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, $lb/10^3\ ft^3$		Percent removal
		Raw	Treated	
Phenols	3	352	<0.2	>99.9
2-Chlorophenol	3	<0.4	<0.1	75.0
2,4-Dimethylphenol	3	44.5	<1.0	>97.8
2,4,6-Trichlorophenol	3	<5.0	<0.1	98.0
Pentachlorophenol	5	73.6	13.5	97.6

TABLE 21-26. WOOD PRESERVING METALS DATA, ORGANIC PRESERVATIONS ONLY, AVERAGES FOR PLANTS WITH CURRENT PRETREATMENT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, lb/10^6 ft^3 Raw	Treated	Percent removal
Antimony	2	<0.01	0.02	-[a]
Arsenic	2	0.03	0.05	-[a]
Beryllium	2	<0.01	<0.01	-[b]
Cadmium	2	<0.01	<0.01	-[b]
Chromium	2	0.01	0.09	-[a]
Copper	2	1.37	0.97	29.2
Lead	2	0.08	0.02	75.0
Mercury	2	<0.01	<0.01	-[b]
Nickel	2	0.05	0.01	-[a]
Selenium	2	0.01	0.05	-[a]
Silver	2	<0.01	<0.01	-[b]
Thallium	2	0.01	0.02	-[a]
Zinc	2	3.38	9.99	

[a]Negative removal.

[b]Negligible removal.

TABLE 21-27. WOOD PRESERVING METALS DATA, ORGANIC PRESERVATIONS ONLY, AVERAGES FOR PLANTS WITH CURRENT BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Number of plants	Waste load, lb/10^6 ft^3 Raw	Treated	Percent removal
Antimony	4	0.22	<0.08	>63.6
Arsenic	4	61.6	34	44.8
Beryllium	4	<0.01	<0.01	-[a]
Cadmium	4	<0.01	<0.02	-[b]
Chromium	4	0.12	0.1	16.7
Copper	4	0.48	0.35	27.1
Lead	4	0.43	<0.21	>51.2
Mercury	4	<0.01	<0.01	-[a]
Nickel	4	0.10	0.1	-[a]
Selenium	4	0.02	0.02	-[a]
Silver	4	<0.01	<0.01	-[a]
Thallium	4	<0.01	<0.01	-[a]
Zinc	4	1.63	0.96	41.1

[a]Negative removal.

[b]Negligible removal.

TABLE 21-28. WOOD PRESERVING METALS DATA, ORGANIC AND INORGANIC PRESERVATIVES. AVERAGES FOR PLANTS WITH LESS THAN CURRENT BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Waste load, $lb/10^6\ ft^3$ Raw	Waste load, $lb/10^6\ ft^3$ Treated	Percent removal
Arsenic	0.43	0.44	-[a]
Chromium	0.53	0.56	-[a]
Copper	1.67	1.71	-[a]

[a]Negative removal.

TABLE 21-29. WOOD PRESERVING METALS DATA, ORGANIC AND INORGANIC PRESERVATIVES, AVERAGES FOR PLANTS WITH CURRENT PRETREATMENT TECHNOLOGY IN-PLACE [1]

Pollutant	Waste load, $lb/10^6\ ft^3$ Raw	Waste load, $lb/10^6\ ft^3$ Treated	Percent removal
Antimony	<0.05	<0.03	40.0
Arsenic	<0.30	<0.60	-[a]
Beryllium	<0.01	<0.01	-[b]
Cadmium	<0.02	<0.03	-[a]
Chromium	<7.28	<6.34	12.9
Copper	3.9	2.64	32.3
Lead	0.03	0.05	-[a]
Mercury	<0.01	<0.01	-[b]
Nickel	0.62	0.67	-[a]
Selenium	0.19	0.14	26.3
Silver	0.02	<0.01	>50.0
Thallium	<0.01	<0.01	-[b]
Zinc	60.1	56.1	6.7

[a]Negative removal.

[b]Negligible removal.

TABLE 21-30. WOOD PRESERVING METALS DATA, ORGANIC AND INORGANIC PRESERVATIVES, AVERAGES FOR PLANTS WITH CURRENT BPT TECHNOLOGY IN-PLACE [1]

Pollutant	Waste load, $lb/10^6\ ft^3$ Raw	Waste load, $lb/10^6\ ft^3$ Treated	Percent removal
Antimony	<0.01	<0.01	-[a]
Arsenic	2.53	2.5	-[a]
Beryllium	<0.01	<0.01	-[a]
Cadmium	0.02	0.1	-[b]
Chromium	0.45	0.95	-[b]
Copper	1.5	1.8	-[b]
Lead	0.31	0.3	-[a]
Mercury	0.03	0.01	66.7
Nickel	1.94	0.34	82.5
Selenium	<0.01	<0.01	-[a]
Silver	<0.01	<0.01	-[a]
Thallium	<0.01	<0.01	-[a]
Zinc	2.33	3.06	-[b]

[a]Negligible removal.

[b]Negative removal.

TABLE 21-31. IN-PLACE TREATMENT TECHNOLOGY AT SIX INSULATION BOARD MANUFACTURING PLANTS [1]

Plant number	Product/process	Treatment system
125	Structural/decorative insulation board, thermomechanical	Clarifier, aerated lagoon
373	Insulation board/ hardboard, thermomechanical	Oxygen-activated sludge system, clarifier
531	Mechanical process insulation board	Aerated lagoon, evaporation pond, self-contained discharger (irrigation)
555	Structural/decorative insulation board, mechanical process	Clarifier, activated sludge
931	Structural/decorative insulation board, mechanical process	Floc clarifier, aerated lagoon, discharge to POTW
1071	Insulation board/S2S hardboard, thermomechanical	Settling ponds, aerated lagoon, oxidation pond

TABLE 21-32. INSULATION BOARD THERMOMECHANICAL REFINING TREATED EFFLUENT CHARACTERISTICS (ANNUAL AVERAGE) [1]

Plant	Production		Flow		BOD		TSS	
number	Mg/d	tons/d	1,000 L/Mg	1,000 gal/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
125[a]	139	153	1.88	0.45	2.03	4.06	1.71	3.42
	145	160	1.75	0.419	1.94	3.87	1.13	2.26
373[b]	605	665[c]	51.3	12.3	4.06	8.12	12.3	24.5
1071	359	395[c]	21.9	5.26	2.15	4.31	0.94	1.88

[a]First line of data lists 1976 average annual daily data; second line lists 1977 average annual data, except as noted.

[b]Data are taken before paper wastewater is added.

[c]Includes both insulation board and hardboard production.

TABLE 21-33. INSULATION BOARD MECHANICAL REFINING ANNUAL AVERAGE RAW AND TREATED WASTE CHARACTERISTICS [1]

Plant	BOD, kg/Mg (lb/ton)			TSS, kg/Mg (lb/ton)		
number	Raw waste	Treated effluent	Percent reduction	Raw waste	Treated effluent	Percent reduction
931[a]	4.33 (8.67)	1.05 (2.10)	76	0.71 (1.42)	1.15 (2.30)	-[b]
555[c]	20.8 (41.6)	0.28 (0.56)	99	45.2 (90.5)	2.64 (5.29)	94
	20.9 (41.8)	0.28 (0.56)	99	31.4 (62.9)	1.46 (2.91)	95
531	1.27 (2.54)	0.07 (0.14)	94	0.46 (0.923)	0.16 (0.32)	65

[a]Raw waste loads were calculated from 1977 verification sampling data.

[b]Negative removal.

[c]First line of data lists 1976 average annual daily data, second line lists 1977 average annual daily data.

TABLE 21-34. INSULATION BOARD THERMOMECHANICAL REFINING ANNUAL AVERAGE RAW AND TREATED WASTE CHARACTERISTICS [1]

Plant number	BOD, kg/Mg (lb/ton)			TSS, kg/Mg (lb/ton)		
	Raw waste	Treated effluent	Percent reduction	Raw waste	Treated effluent	Percent reduction
125[a]	17.0 (34.1)[b] 23.5 (47.0)[b]	2.03 (4.06) 1.94 (3.87)	88 92	42.8 (85.7)[b] 38.6 (77.3)[b]	1.71 (3.42) 1.13 (2.26)	96 97
373	29.8 (59.5)	4.06 (8.12)	86	28.6 (57.1)	12.3 (24.5)	57
1071	43.2 (86.3)	2.15 (4.31)	95	--	0.94 (1.88)	--

[a]First line of data lists 1976 average annual daily data, second line lists 1977 average annual daily data.

[b]Data obtained during 1977 and 1978 verification sampling programs.

TABLE 21-35. RAW AND TREATED EFFLUENT LOADS AND PERCENT REDUCTION FOR TOTAL PHENOLS, INSULATION BOARD[a] [1]

Plant number	Raw waste load kg/Mg	Raw waste load lb/ton	Treated waste load kg/Mg	Treated waste load lb/ton	Percent reduction
555	0.00095 0.007	0.0019 0.014	0.00010 0.00012	0.00021 0.00025	89 98
231	0.0024 0.009	0.0048 0.018	-- --	-- --	-- --
931	0.00040	0.00079	0.00008	0.00015	81
125	0.0022 0.0055	0.0045 0.011	0.00014 0.00065	0.00029 0.0013	94 88

[a]Total phenols concentration data obtained during 1977 and 1978 verification sampling programs. Average annual daily waste flow and production data for 1976 and 1977 supplied by plants in response to data collection portfolio were used to calculate waste loads.

TABLE 21-36. RAW AND TREATED EFFLUENT LOADINGS AND PERCENT REDUCTIONS FOR INSULATION BOARD METALS [1]

Pollutant	Plant 931 Waste load, kg/10⁶ Mg (lb/10⁶ ton) Raw	Plant 931 Treated	Plant 931 Percent reduction	Plant 231 Waste load, kg/10⁶ Mg (lb/10⁶ ton) Raw	Plant 231 Treated	Plant 231 Percent reduction	Plant 125 Waste load, kg/10⁶ Mg (lb/10⁶ ton) Raw	Plant 125 Treated	Plant 125 Percent reduction	Plant 555 Waste load, kg/10⁶ Mg (lb/10⁶ ton) Raw	Plant 555 Treated	Plant 555 Percent reduction
Antimony	2.1 (4.2)	18 (35)	-[a]	25 (49)	21 (42)	14	(27)	2.8 (5.6)	79	22 (44)	48 (95)	-[a]
Arsenic	13 (25)	6 (11)	56	27 (54)	13 (26)	52	60 (120)	6 (12)	90	17 (34)	20 (40)	-[a]
Beryllium	4.2 (8.3)	2.1 (4.2)	49	7 14	12 (24)	-[a]	10 (20)	1 (1.0)	90	5.5 (11)	6 (11)	-[a]
Cadmium	2.8 (5.6)	3.5 (6.9)	-[a]	8 (16)	13 (26)	-[a]	10 (20)	1 (1.0)	90	5.5 (11)	6 (11)	-[a]
Chromium	6 (11)	22 (44)	-[a]	60 (120)	20 (40)	-[a]	470 (940)	6 (11)	98	120 (220)	90 (170)	26
Copper	1,900 (3,700)	900 (1,900)	51	2,300 (4,600)	20 (40)	13	41 (82)	180 (350)	-[a]	360 (7,200)	1,200 (23,000)	68
Lead	6 (11)	6 (11)	-[b]	170 (34)	21 (41)	-[a]	27 (53)	3.8 (7.5)	85	55 (11)	18 (16)	85
Mercury	2.1 (4.2)	0.4 (0.8)	80	41 (82)	13 (26)	-[a]	21 (41)	1.9 (3.8)	91	80 (160)	0.7 (1.3)	99
Nickel	800 (1,600)	600 (1,100)	31	850 (1,700)	9 (18)	5	250 (490)	13 (26)	94	90 (180)	37 (74)	58
Selenium	14 (27)	7 (13)	52	35 (70)	25 (49)	30	70 (140)	4.4 (8.7)	93	35 (7)	32 (63)	10
Silver	2.1 (4.2)	2.1 (4.2)	-[b]	4.9 (9.8)	17 (33)	-[a]	10 (20)	1.3 (2.5)	88	5 (11)	7 (13)	-[a]
Thallium	2.8 (5.6)	8 (15)	-[a]	4.1 (8.2)	4.1 (8.2)	-[b]	17 (33)	1.3 (2.5)	92	6.5 (13)	8 (16)	-[a]
Zinc	3,000 (5,000)	1,400 (2,800)	44	4,200 (8,400)	4,700 (9,500)	-[a]	5,000 (10,000)	170 (330)	96	6,000 (12,000)	800 (1,600)	86

[a]Negative removal.

TABLE 21-37. INSULATION BOARD TOXIC POLLUTANT DATA, ORGANICS [1]

	Average concentration, µg/L				
	Raw wastewater			Treated effluent	
Pollutant	Plant 231	Plant 555	Plant 125	Plant 555	Plant 125[a]
Chloroform	20	BDL[b]	BDL	BDL	BDL
Benzene	70	40[c]	BDL	BDL	BDL
Toluene	40	40[c]	BDL	BDL	BDL
Phenol	BDL	40	BDL	BDL	BDL

[a]One treated effluent sample contained 40 µg/L of trichlorofluoromethane.

[b]One sample of raw wastewater contained 20 µg/L of chloroform. Plant intake water contained 10 µg/L of chloroform.

[c]Plant intake water contained 50 µg/L and 30 µg/L of benzene and toluene, respectively.

TABLE 21-38. IN-PLACE TREATMENT TECHNOLOGY AT 13 HARDBOARD MANUFACTURING PLANTS [1]

Plant number	Product	Treatment system
24	S1S, S2S	Activated sludge, aerated lagoon
28	S1S	Lime neutralization, discharge to POTW
42	S1S, S2S	Activated sludge, humus ponds, aerated lagoons, settling pond
64	S1S	Settling ponds
248	S2S	Kinecs air pond, Infilco aero accelerators, aerated lagoons, facultative lagoon
262	S1S	Settling pond, aerated lagoon
373	S2S	Not specified
428	S1S, S2S	Settling pond, aerated lagoon
444	S1S	Settling ponds, aerated lagoon
606	S1S	Settling ponds, activated sludge, aerated lagoon
824	S1S	Aerated lagoons, settling ponds
888	S1S	Settling ponds, activated sludge, aerated lagoon; no discharge
1071	S2S	Clairfier, aerated lagoon, oxidation ponds

TABLE 21-39. S1S HARDBOARD TREATED EFFLUENT CHARACTERISTICS (ANNUAL AVERAGE)[a] [1]

Plant number	Production		Flow		BOD		TSS	
	Mg/d	tons/d	1,000 L/Mg	1,000 gal/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
444	88.7	97.5	46.6	11.2[b]	9.00	18.0[b]	17.1	34.1[b]
606	194	213	7.38	1.78	5.05	10.1	4.05	8.10
	194	213	9.35	2.24	9.35	18.7	8.50	17.0
824	117	129	8.84	2.12	6.85	13.7	10.1	20.2
	115	127	15.2	3.65	3.06	6.13	10.2	20.4
888[c]	91.9	101	--	--	--	--	--	--
42	343	377	4.16	1.00	0.13	0.26	0.12	0.24
24	1,450	1,590	9.40	2.26	0.97	1.93	1.14	2.27
64[d]	111	122	4.24	1.02	18.5	36.9	1.59	3.18
	111	122	0.62	0.15	5.10	10.2	0.59	1.17
262	67.0	73.8	21.4	5.14	5.85	11.7	13.8	27.6
	64.1	70.7	17.2	4.12	5.35	10.7	12.2	24.5

[a] First line of data lists 1976 average annual daily data; second line lists 1977 average annual data, except as noted.

[b] Hardboard and paper waste streams are comingled.

[c] All of the treated effluent is recycled.

[d] Second line lists data from October 1976 through February 1977.

TABLE 21-40. S2S HARDBOARD ANNUAL AVERAGE RAW AND TREATED WASTE CHARACTERISTICS [1]

Plant number	Production		Flow		BOD, kg/Mg (lb/ton)			TSS, kg/Mg (lb/ton)		
	Mg/d	(tons/d)	1,000 L/Mg	(1,000 gal/ton)	Raw waste	Treated effluent	Percent reduction	Raw waste	Treated effluent	Percent reduction
248[a]	210	(231)	18.3	(4.39)	66.5 (133)	4.44 (8.88)	93	--	--	--
	218	(240)	21.6	(5.17)	62.0 (124)	2.54 (5.07)	96	11.7 (23.4)	5.05 (10.1)	57
1071	359	(395[b])	21.9	(5.26)	43.2 (86.3)	2.15 (4.31)	95	--	0.4 (1.88)	--
373	605	(665[b])	51.3	(12.3)	29.8 (59.5)	4.06 (8.12)	86	28.6 (57.1)	12.3 (24.5)	57
428	611	(343)	25.8	(6.18)	116 (232)	20.8 (41.5)	82	20.0 (40.0)	43.8 (87.6)	-[b]

[a] First line of data lists 1976 average annual daily data, second line lists 1977 average annual daily data.

[b] Negative removal.

TABLE 21-41. S1S HARDBOARD ANNUAL AVERAGE RAW AND TREATED WASTE CHARACTERISTICS[a] [1]

	BOD, kg/Mg (lb/ton)			TSS, kg/Mg (lb/ton)		
Plant number	Raw waste	Treated effluent	Percent reduction	Raw waste	Treated effluent	Percent reduction
444[b]	32.7 (65.4)	9.00 (18.0)	72	6.90 (13.8)	17.1 (34.1)	-[c]
606	29.3 (58.6)	5.05 (10.1)	83	12.4 (24.8)	4.05 (8.10)	67
	25.4 (50.7)	9.35 (18.7)	63	12.8 (25.7)	8.50 (17.0)	34
824	35.6 (71.2)	6.85 (13.7)	81	22.5 (44.9)	10.1 (20.2)	55
	33.8 (67.7)	3.06 (6.13)	91	13.0 (25.9)	10.2 (20.4)	21
262	37.4 (74.8)	5.85 (11.7)	84	12.6 (25.2)	13.8 (27.6)	-[c]
	42.0 (84.0)	5.35 (10.7)	87	6.45 (12.9)	12.2 (24.5)	-[c]
42	1.89 (3.77)[d]	0.13 (0.26)	93	0.56 (1.15)[d]	0.12 (0.24)	79
24	21.9 (43.8)[e]	0.97 (1.93)	96	5.85 (11.7)[e]	1.14 (2.27)	81

[a] First line of data lists 1976 average annual daily data, second line lists 1977 average annual daily data.

[b] Hardboard and paper waste streams are comingled.

[c] Negative removal.

[d] Raw waste loads shown are for combined weak and strong wastewater streams.

[e] Raw waste load taken after primary clarification, pH adjustment, and nutrient addition.

TABLE 21-42. RAW AND TREATED EFFLUENT LOADS AND PERCENT REDUCTION FOR TOTAL PHENOLS, HARDBOARD[a] [1]

Plant number	Raw waste load		Treated waste load[a]		Percent reduction
	kg/Mg	lb/ton	kg/Mg	lb/ton	
262[b]	0.005	0.01	0.00030	0.00059	94
	0.0010	0.021	0.00020	0.00040	98
42	0.01	0.02	0.00015	0.0003	98
24	0.003	0.006	--	--	--
824[b]	0.055	0.11	0.00046	0.00092	99
	0.031	0.062	0.065	0.13	-[c]
28	--	--	0.003	0.006	--
22	0.0015	0.003	0.0028	0.0055	-[c]
428[b,d]	--	--	0.0005	0.001	--
	0.10	0.21	0.00095	0.0019	99

[a]Total phenols concentration data obtained during 1977 and 1978 verification sampling programs. Average annual daily waste flow and production data supplied by plants in response to data collection portfolio were used to calculate waste loads.

[b]First line lists 1976 data, second line lists 1977 data.

[c]Negative removal.

[d]1976 historical data supplied by plant in response to data collection portfolio.

TABLE 21-43. RAW AND TREATED EFFLUENT LOADINGS AND PERCENT REDUCTIONS FOR HARDBOARD METALS [1]

Pollutant	Plant 824: Waste load, kg/10⁶ Mg (lb/10⁶ ton)		Plant 824	Plant 248: Waste load, kg/10⁶ Mg (lb/10⁶ ton)		Plant 248	Plant 42: Waste load, kg/10⁶ Mg (lb/10⁶ ton)		Plant 42
	Raw	Treated	Percent reduction	Raw	Treated	Percent reduction	Raw	Treated	Percent reduction
Antimony	200 (400)	8.5 (17)	96	80 (150)	9 (18)	89	80 (150)	10 (20)	87
Arsenic	12 (23)	20 (40)	-[a]	26 (51)	24 (48)	8	16 (32)	17 (14)	56
Beryllium	6 (12)	4.5 (9)	25	13 (25)	9 (18)	31	8 (16)	2.8 (5.6)	65
Cadmium	290 (570)	4.5 (9)	98	60 (120)	37 (74)	38	7 (13)	8 (16)	-[a]
Chromium	290 (580)	6 (11)	98	190 (370)	43 (85)	77	100 (190)	24 (47)	76
Copper	3,900 (7,800)	1,400 (2,800)	64	14,000 (27,000)	9,000 (17,000)	36	440 (880)	17 (33)	96
Lead	60 (120)	20 (40)	67	120 (240)	37 (74)	69	800 (1,500)	33 (65)	96
Mercury	18 (35)	18 (35)	-[b]	1.3 (2.5)	37 (74)	-[a]	27 (05.3)	1.1 (2.2)	59
Nickel	2,400 (4,700)	200 (4,700)	92	1,800 (3,500)	330 (660)	82	800 (1,500)	24 (47)	97
Selenium	18 (35)	6 (12)	33	20 (40)	19 (37)	8	50 (100)	20 (39)	60
Silver	6 (12)	0.5 (1)	92	180 (350)	85 (170)	53	7 (13)	33 (66)	53
Thallium	13 (26)	7 (14)	46	13 (25)	13 (25)	-[b]	13 (26)	23 (45)	82
Zinc	9,000 (17,000)	2,500 (4,900)	72	4,800 (9,600)	800 (1,600)	83	3,000 (5,000)	260 (520)	91

(continued)

TABLE 21-43 (continued)

Pollutant	Plant 824 Waste load, kg/10⁶ Mg (lb/10⁶ ton) Raw	Plant 824 Treated	Plant 824 Percent reduction	Plant 248 Waste load, kg/10⁶ Mg (lb/10⁶ ton) Raw	Plant 248 Treated	Plant 248 Percent reduction	Plant 42 Waste load, kg/10⁶ Mg (lb/10⁶ ton) Raw	Plant 42 Treated	Plant 42 Percent reduction
Antimony	24 (48)			9 (17)	9 (17)	-[b]	100 (200)	11 (23)	89
Arsenic	14 (27)			17 (34)	17 (34)	-[b]	15 (31)	0.4 (0.9)	97
Beryllium	15 (10)			9 (17)	9 (17)	-[b]	7 (13)	4.8 (9.6)	31
Cadmium	15 (10)			9 (17)	9 (17)	-[b]	7 (13)	4.8 (9.6)	31
Chromium	90 (170)			17 (34)	35 (69)	-[a]	6,000 (11,000)	820 (160)	86
Copper	1,100 (2,100)			9,000 (17,000)	4,000 (7,900)	56	3,300 (6,500)	4.8 (96)	99
Lead	20 (40)			35 (69)	26 (52)	26	42 (83)	36 (71)	14
Mercury	11 (21)			310 (62)	70 (140)	77	22 (43)	0.4 (0.7)	98
Nickel	60 (120)			60 (110)	35 (69)	42	120 (230)	60 (110)	50
Selenium	24 (48)			60 (110)	47 (93)	15	23 (45)	19 (38)	17
Silver	5 (10)			9 (17)	9 (17)	-[b]	9 (17)	60 (110)	-[a]
Thallium	5 (10)			9 (17)	9 (17)	-[b]	9 (17)	8 (16)	11
Zinc	24,000 (48,000)			14,000 (27,000)	6,000 (13,000)	53	7,000 (14,000)	1,900 (3,800)	73

[a]Negative removal.

[b]Negligible removal.

TABLE 21-44. S1S HARDBOARD SUBCATEGORY TOXIC POLLUTANT DATA, ORGANICS [1]

	Average concentration, μg/L			
	Raw wastewater		Treated effluent	
Pollutant	Plant 262[a]	Plant 824	Plant 262	Plant 824
Chloroform	BDL	20	BDL	BDL
Benzene	BDL	80	10	80
Ethylbenzene	20	BDL	BDL	BDL
Toluene	15	70	BDL	70
Phenol	BDL	680	BDL	20

[a]Plant 262 intake water contained 10 μg/L toluene and 97 μg/L phenol.

TABLE 21-45. S2S HARDBOARD SUBCATEGORY TOXIC POLLUTANT DATA, ORGANICS [1]

	Average concentration, μg/L					
	Raw wastewater			Treated effluent		
Pollutant	Plant 248	Plant 428	Plant 663	Plant 248	Plant 428	Plant 663
Chloroform	BDL	20	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	BDL	BDL	90	BDL	BDL	BDL
Benzene	BDL	90[a]	BDL	BDL	40	BDL
Toluene	BDL	60[a]	10	100[b]	30	BDL
Phenol	BDL	300	BDL	BDL	BDL	BDL

[a]Plant intake water was measured at 120 μg/L benzene and 80 μg/L toluene.

[b]Plant reported a minor solvent spill in final settling pond prior to sampling.

II.21.5 REFERENCES

1. Revised Technical Review of the Best Available Technology, Best Demonstrated Technology, and Pretreatment Technology for the Timber Products Processing Point Source Category (draft contractors report). Contract 68-01-4827, U.S. Environmental Protection Agency, Washington, D.C., October 1978.

2. NRDC Consent Decree Industry Summary - Timber Products Processing.

II.22 PUBLICLY OWNED TREATMENT WORKS (POTW'S)

II.22.1 INDUSTRY DESCRIPTION [1]

II.22.1.1 General Description

Publicly owned treatment works (POTW's), although not a true industry, are discussed in this manual to support the evaluation of industrial treatment facilities and practices. POTW's often treat a variety of wastes including treated and untreated industrial wastewater. Discharge at these facilities is normally directly to a stream or lake. This section presents the results of a pilot study of two selected POTW's. These two POTW's are the initial effort to study 40 POTW's to determine the fate of toxic pollutants entering POTW's, sponsored by the U.S. Environmental Protection Agency, Effluent Guidelines Division. At this time, only the two plants discussed here have been sampled and analyzed. Descriptions of these facilities are included in the plant-specific description section of this report.

II.22.1.2 Subcategory Description

No subcategories are currently defined for POTW's.

II.22.2 WASTEWATER CHARACTERIZATION

POTW's do not generate wastewater to be treated. Instead, the wastewater that is treated in the POTW originates from several sources. The pollutant loading from these sources varies considerably depending on the percentage of industrial and municipal flow rates and loadings. Because of this variability each POTW will have influent characteristics unique to that facility. This section presents raw influent wastewater characterization data on two individual POTW's.

POTW A accepts a large proportion of its influent total flow from industrial sources, yielding a higher incidence of toxic pollutants than POTW B. In all, 52 organic toxic pollutants and nine toxic metals were found in the influent to this facility. Eighteen organic toxic pollutants were measured above the minimum detection limit and seven toxic metals were found in higher concentrations than in POTW B. POTW A generally had higher concentrations than POTW B of both toxic and conventional (BOD, COD, TSS, etc) pollutants. Only a small percentage of industrial wastewater is mixed with the predominantly municipal influent at POTW B. Thirty-three toxic organic pollutants were detected and only five of these were detected above the minimum quantifiable limit. Nine metallic toxic pollutants were found. Only zinc had a higher concentration in POTW B than in POTW A.

Tables 22-1 through 22-4 presents an initial screening study of raw wastewater characterization data for these two facilities.

TABLE 22-1. CONCENTRATONS OF CONVENTIONAL POLLUTANTS FOUND IN THE RAW WASTEWATER ENTERING POTW A [1]

Pollutant	Number of: Samples analyzed	Number of: Times detected above min.	Concentration, mg/L: Average	Median	Minimum	Maximum
BOD_5	27	27	220	180	80	450
COD	26	26	430	440	180	630
TOC	27	27	210	240	39	340
TSS	27	27	180	130	77	560
Total phenols	83	82	< 0.130	0.050	<0.006	5.20
Oil and grease	78	78	49	40	18	340

II.22.3 PLANT-SPECIFIC DESCRIPTIONS

Plant A has a design capacity of 4.5 x 10^5 m^3/d (120 MGD) with approximately 70% of its organic loading and 30% of its flow contributed by industry. Plant B has a design capacity of 5.7 x 10^4 m^3/d (15 MGD) with approximately 2% industrial flow. The following paragraphs describe these facilities in greater detail.

Plant A

The design capacity of Plant A is 1.1 x 10^6 m^3/d (300 MGD) primary flow and 4.5 x 10^5 m^3/d (120 MGD) secondary flow. Under normal dry weather conditions, the flow through this system varies between 85% and 90% of its secondary capacity. During the first week of sampling at the plant, the flow averaged only 3.4 x 10^5 m^3/d (91.0 MGD).

The original primary treatment facility was constructed in 1924, and most of the sewers are as old or older than the primary system. It is estimated that the collection system is 60% separate sewers and 40% combined sewers.

TABLE 22-2. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE RAW WASTEWATER ENTERING POTW A [1]

Toxic Pollutant	Number of: Samples analyzed	Number of: Times detected	Number of: Detected above min.	Concentration, µg/L: Average	Concentration, µg/L: Median	Concentration, µg/L: Minimum	Concentration, µg/L: Maximum
Metals and inorganics							
Antimony	23		0	1 - 50	<50	<50	<50
Arsenic	23		0	1 - 50	<50	<50	<50
Beryllium	23		0	1 - 2	<2	<2	<2
Cadmium	23		21	<12	9	<2	40
Chromium	23		23	450	370	63	1400
Copper	23		23	190	150	35	860
Cyanide	84		57	120 - 130	24	10	1300
Lead	23		16	55 - 61	41	20	220
Mercury	23		15	0.0 - 0.3	0.3	0.2	0.8
Nickel	23		22	<98	66	<10	350
Selenium	23		0	1 - 50	<50	<50	<50
Silver	23		18	<8	9	<2	18
Thallium	23		0	1 - 50	<50	<50	<50
Zinc	23		23	260	260	23	500
Ethers							
Bis(2-chloroethoxy)methane	28	2	0	0 - 1	ND	ND	<10
Phthalates							
Bis(2-ethylhexyl) phthalate	28	26	14	25 - 29	5	ND	250
Butyl benzyl phthalate	28	11	1	1 - 4	ND	ND	12
Di-n-butyl phthalate	28	19	14	1 - 8	<10	ND	44
Diethyl phthalate	28	17	0	1 - 6	<10	ND	<10
Di-n-octyl phthalate	28	1	0	0 - 1	ND	ND	<10
Dimethyl phthalate	28	11	0	1 - 3	ND	ND	<10
Phenols							
Pentachlorophenol	28	7	0	1 - 2	ND	ND	<10
Phenol	28	27	9	13 - 19	<10	ND	200
2,4,6-Trichlorophenol	28	1	0	0 - 1	ND	ND	<10
p-Chloro-*m*-cresol	28	1	0	0 - 1	ND	ND	<10
Aromatics							
Benzene	82	81	45	290	37	ND	5600
Chlorobenzene	82	9	0	0 - 1	ND	ND	<10
1,2-Dichlorobenzene	28	15	0	1 - 5	<10	ND	<10
1,3-Dichlorobenzene	28	6	0	1 - 2	ND	ND	<10
1,4-Dichlorobenzene	28	14	0	1 - 5	<5	ND	10
Ethylbenzene	82	75	28	21 - 27	<10	ND	890
Hexachlorobenzene	28	1	0	0 - 1	ND	ND	<10
Toluene	82	81	56	35 - 38	13	ND	440
1,2,4-Trichlorobenzene	28	1	0	0 - 1	ND	ND	<10
Polycyclic aromatic hydrocarbons							
Acenaphthene	28	2	0	0 - 1	ND	ND	<10
Acenaphthylene	28	1	0	0 - 1	ND	ND	<10
Anthracene	28	21	0	1 - 7	<10	ND	<10
Chrysene	28	5	0	0 - 1	ND	ND	<10
Fluoranthene	28	8	0	1 - 2	ND	ND	<10
Flourene	28	8	0	1 - 2	ND	ND	<10
Indeno(1,2,3-cd)pyrene	28	2	0	0 - 1	ND	ND	<10
Naphthalene	28	23	1	1 - 8	<10	ND	13
Phenanthrene	28	21	0	1 - 7	<10	ND	<10
Pyrene	28	10	1	3 - 6	ND	ND	84
Halogenated aliphatics							
Bromoform	82	1	0	0 - 1	ND	ND	<10
Carbon tetrachloride	82	6	1	0 - 1	ND	ND	39
Chlorodibromomethane	82	1	0	0 - 1	ND	ND	<10
Chloroform	82	79	67	43 - 44	21	ND	440
Dichlorobromomethane	82	1	0	0 - 1	ND	ND	<10
1,1-Dichloroethane	82	19	0	1 - 2	ND	ND	<10
1,2-Dichloroethane	82	1	0	0 - 1	ND	ND	<10
1,1-Dichloroethylene	82	60	5	1 - 7	<10	ND	15
1,2-*Trans*-dichloroethylene	82	69	18	4 - 11	<10	ND	64
Hexachlorobutadiene	28	1	0	0 - 1	ND	ND	<10
Methylene chloride	82	82	20	8 - 16	<10	<10	100
Tetrachloroethylene	82	81	58	47 - 50	16	ND	1500
1,1,1-Trichloroethane	87	71	45	15 - 18	10	ND	220
1,1,2-Trichloroethane	82	3	1	<3	ND	ND	270
Trichloroethylene	82	81	49	28 - 32	11	ND	440
Trichlorofluoromethane	82	2	0	0 - 1	ND	ND	<10

Note: Pollutants not detected in any sample are not listed.

TABLE 22-3. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN THE RAW WASTEWATER ENTERING POTW B [1]

Pollutant	Number of: Samples analyzed	Number of: Times detected above min.	Concentration, mg/L: Average	Median	Minimum	Maximum
BOD_5	7	7	95	96	73	130
COD	7	7	180	180	150	230
TOC	7	7	70	69	61	82
TSS	7	7	97	87	55	230
Total phenols	42	40	<0.020	0.012	<0.001	0.160
Oil and grease	40	40	24	26	5	48

TABLE 22-4. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN THE RAW WASTEWATER ENTERING POTW B [1]

Toxic Pollutant	Number of: Samples analyzed	Times detected	Detected above min.	Concentration, µg/L: Average	Median	Minimum	Maximum
Metals and inorganics							
Antimony	7		0	1 - 50	<50	<50	<50
Arsenic	7		0	1 - 50	<50	<50	<50
Beryllium	7		0	1 - 2	<2	<2	<2
Cadmium	7		6	<4	4	<2	9
Chromium	7		7	71	67	12	130
Copper	7		7	54	55	39	72
Cyanide	41		34	77 - 78	66	<10	240
Lead	7		2	16 - 30	<20	<20	79
Mercury	7		5	0.0 - 0.3	0.2	<0.2	0.4
Nickel	7		7	30	31	11	48
Selenium	7		0	1 - 50	<50	<50	<50
Silver	7		2	1 - 2	<2	<2	6
Thallium	7		0	1 - 50	<50	<50	<50
Zinc	7		7	280	300	110	440
Phthalates							
Bis(2-ethylhexyl) phthalate	6	6	3	8 - 14	1	<10	19
Butyl benzyl phthalate	6	6	0	1 - 10	<10	<10	<10
Di-n-butyl phthalate	6	5	0	1 - 8	<10	ND	<10
Diethyl phthalate	6	5	0	1 - 8	<10	ND	<10
Dimethyl phthalate	6	3	0	1 - 5	<5	ND	<10
Di-n-octyl phthalate	6	4	0	1 - 6	<10	ND	<10
Phenols							
Pentachlorophenol	6	1	0	0 - 1	ND	ND	<10
Phenol	6	4	0	1 - 6	<10	ND	<10
Aromatics							
Benzene	42	31	4	7 - 14	<10	ND	260
Chlorobenzene	42	2	0	0 - 1	ND	ND	<10
1,2-Dichlorobenzene	6	5	0	1 - 8	<10	ND	<10
1,3-Dichlorobenzene	6	1	0	0 - 1	ND	ND	<10
1,4-Dichlorobenzene	6	1	0	0 - 1	ND	ND	<10
2,6-Dinitrotoluene	6	1	0	0 - 1	ND	ND	<10
Ethylbenzene	42	18	0	1 - 4	ND	ND	<10
Toluene	42	32	1	1 - 8	<10	ND	37
Polycyclic aromatic hydrocarbons							
Anthracene	6	3	0	1 - 5	<5	ND	<10
Fluoranthene	6	3	0	1 - 5	<5	ND	<10
Naphthalene	6	4	0	1 - 6	<10	ND	<10
Phenanthrene	6	3	0	1 - 5	<5	ND	<10
Pyrene	6	3	0	1 - 5	<5	ND	<10
Halogenated aliphatics							
Chlorodibromomethane	42	3	0	0 - 1	ND	ND	<10
Chloroform	42	40	0	1 - 9	<10	ND	<10
Dichlorobromomethane	42	4	0	0 - 1	ND	ND	<10
1,1-Dichloroethane	42	2	0	0 - 1	ND	ND	<10
1,2-Dichloroethane	42	2	0	0 - 1	ND	ND	13
1,1-Dichloroethylene	42	16	0	1 - 3	ND	ND	<10
1,2-Dichloropropane	42	1	0	0 - 1	ND	ND	<10
Methylene chloride	42	39	5	6 - 14	<10	ND	180
Tetrachloroethylene	42	41	0	1 - 9	<10	ND	<10
1,1,2-Trichloroethane	42	14	0	1 - 3	ND	ND	<10
Pesticides and metabolites							
Isophorone	6	1	0	0 - 1	ND	ND	<10

Note: Pollutants not detected in any sample are not listed.

Sludge handling at this POTW involves primary sludge thickening by gravity thickeners, secondary sludge thickening by dissolved air flotation (DAF), vacuum filtration, and incineration. During the sampling period at Plant A, the primary sludge flow averaged 1.2×10^3 m^3/d (325,000 gal/d) and the secondary (waste activated) sludge flow averaged 5.7×10^3 m^3/d (1.5 MGD).

Industrial contributions to the flow are primarily from several major industries: pharmaceutical manufacture, petrochemicals, plating operations, and automotive foundries. Also contributing to Plant A's sewage collection system are some coking operations and some food processing plants.

The treatment unit operations at this conventional activated sludge POTW begin with gravity flow from the drainage area to the bar screens and grit chambers, from which lift pumps elevate the wastewater for gravity flow through the rest of the plant. After the lift pumps, the wastewater passes through pre-aeration, primary settling, and clarification, and then proceeds into the aeration chambers. After aeration, clarification, and chlorination, the wastewater is discharged to a local stream.

Tables 22-5 and 22-6 present conventional and toxic pollutant data for the influent and final effluent streams of this facility. Data are also presented for the effluent prior to chlorination, and for the primary and secondary sludges.

TABLE 22-5. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS, FOUND IN PUBLICLY OWNED TREATMENT WORKS (POTW), PLANT A[a] [1]

	Concentration, mg/L				Concentration, mg/L		
Pollutant	Influent	Effluent pre-Cl_2[b]	Final Effluent	Percent removal	Primary sludge	Secondary sludge	Combined sludge
BOD_5	200	22	13	94	20,000	6,000	6,700
COD	420	69	68	84	58,000	6,700	18,000
TOC	260	55	65	75	24,000	2,700	8,200
TSS	140	10	20	86	47,000	6,300	1,800
Total phenols	0.18		0.013	92	0.670	<0.037	-
Oil and grease	53	-	4 - 6	89 - 92	9,100	<480	-

Note: Pollutants not detected in any sample are not listed.
[a]Week 1 average results.
[b]Prechlorination

Plant B

The design capacity of Plant B is 5.7×10^4 m^3/d (15 MGD), but under normal operations between 3.0×10^4 m^3/d and 3.7×10^4 m^3/d (8 and 10 MGD) receive secondary treatment. During the sampling period of this pilot study the influent flow to the facility

TABLE 22-6. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN PUBLICLY OWNED TREATMENT WORKS (POTW), PLANT A[a] [1]

Toxic pollutant	Concentration range, μg/L			Percent removal range	Concentration, μg/L		
	Influent	Effluent pre-Cl_2[b]	Final effluent		Primary sludge	Secondary sludge	Combined sludge
Metals and inorganics							
Antimony	0 - 50	<50	0 - 50		150	<22	66
Arsenic	0 - 50	<50	0 - 50		1,300	63	180
Beryllium	0 - 2	<2	0 - 2		37	10	<12
Cadmium	12	<4	4 - 5	60 - 65	1,200	340	600
Chromium	440	42	46	90	15,000	18,000	18,000
Copper	190	13	27	86	77,000	9,000	24,000
Cyanide	18	-	3 - 11	15 - 83	630	<75	-
Lead	56	<20	0 - 20	58 - 100	47,000	1,600	11,000
Mercury	0.3	<0.4	0.4	24	<3.1	<2.6	<2.7
Nickel	98	50	40	59	13,000	3,300	3,200
Selenium	0 - 50	<50	0 - 50		10	23	<12
Silver	8	<2	0 - 2	74 - 100	25	180	82
Thallium	0 - 50	<50	0 - 50		2	<1	<1
Zinc	252	42	90	64	150,000	13,000	48,000
Ethers							
Bis(2-chloroethoxy)methane	0 - 1	ND	ND		ND	ND	ND
Phthalates							
Bis(2-ethylhexyl) phthalate	32 -36	<19	11 - 16	50 - 69	2,200	42	1,200
Butyl benzyl phthalate	1 - 4	ND	0 - 4		1	ND	ND
Di-n-butyl phthalate	2 - 9	<3	0 - 6		ND	ND	ND
Diethyl phthalate	0 - 6	ND	0 - 3		ND	ND	ND
Dimethyl phthalate	0 - 4	ND	0 - 1		ND	ND	ND
Di-n-octyl phthalate	ND	ND	0 - 1		ND	ND	ND
Nitrogen compounds							
Acrylonitrile	ND	ND	ND		ND	3	
3,3'-Dichlorobenzidine	ND	ND	0 - 1		ND	ND	ND
Phenols							
2-Chlorophenol	ND	ND	0 - 1		ND	ND	ND
2,4-Dimethylphenol	ND	<3	0 - 1		ND	ND	ND
Pentachlorophenol	0 - 3	<7	0 - 1		93	110	15
Phenol	13 - 19	<10	18 - 23	0 - 5	94	68	33
2,4,6-Trichlorophenol	ND	ND	ND		ND	ND	
p-Chloro-*m*-cresol	ND	ND	ND		ND	ND	ND

(continued)

TABLE 22-6 (continued)

Toxic pollutant	Concentration range, µg/L: Influent	Concentration range, µg/L: Effluent pre-Cl_2[b]	Concentration range, µg/L: Final effluent	Percent removal range	Concentration, µg/L: Primary sludge	Concentration, µg/L: Secondary sludge	Concentration, µg/L: Combined sludge
Aromatics							
Benzene	5 - 13	<1	0 - 5		170	10	-
Chlorobenzene	0 - 2	ND	ND		ND	ND	-
1,2-Dichlorobenzene	0 - 4	ND	0 - 1		ND	ND	ND
1,3-Dichlorobenzene	0 - 4	ND	0 - 1		ND	ND	ND
1,4-Dichlorobenzene	0 - 4	ND	0 - 3		ND	ND	ND
Ethylbenzene	30 - 36	ND	0 - 7	77 - 99	280	<4	-
Hexachlorobenzene	ND	ND	ND		ND	ND	ND
Nitrobenzene	ND	ND	ND		ND	ND	ND
Toluene	18 - 23	<10	0 - 9	51 - 100	280	2	-
1,2,4-Trichlorobenzene	ND	ND	ND		ND	ND	ND
Polycyclic aromatic hydrocarbons							
Acenaphthene	0 - 1	ND	ND		170	ND	75
Acenaphthylene	ND	ND	ND		ND	ND	ND
Anthracene	0 - 7	ND	0 - 4		1,600	4	840
Fluoranthene	0 - 3	ND	0 - 4		ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	ND	0 - 1		ND	8	ND
Naphthalene	1 - 8	ND	0 - 4		200	4	<23
Phenanthrene	0 - 7	ND	0 - 4	1,600	4	840	
Pyrene	0 - 3	ND	0 - 6		760	ND	350
Halogenated aliphatics							
Carbon tetrachloride	1 - 2	ND	ND	100	11	6	-
Chlorodibromomethane	ND	ND	ND		17	29	-
Chloroform	49 - 50	<28	15 - 21	57 - 70	ND	ND	-
Dichlorobromomethane	ND	ND	0 - 2		57	56	-
1,1-Dichloroethane	0 - 2	ND	ND		11	ND	-
1,2-Dichloroethane	ND	ND	ND		ND	ND	-
1,1-Dichloroethylene	1 - 8	<5	0 - 7		9	ND	-
1,2-*Trans*-dichloroethylene	0 - 8	ND	0 - 2		23	ND	-
1,2-Dichloropropane	ND	ND	ND		ND	ND	-
Hexachlorobutadiene	ND	ND	ND		ND	ND	ND
Methylene chloride	6 - 14	<10	1 - 10	0 - 91	220	250	-
Tetrachloroethylene	53 - 57	<10	1 - 9	83 - 98	290	7	-
1,1,1-Trichloroethane	17 - 20	<10	0 - 7	59 - 100	24	ND	-
Trichloroethylene	24 - 29	<9	0 - 9	65 - 100	280	<1	-
Trichlorofluoromethane	ND	ND	0 - 1		ND	ND	-

Note: Blanks indicate sufficient data are not available.

[a]Week 1 average results.

[b]Priority pollutant not detected in any sample are not listed.

averaged 3.0×10^4 m^3/d (8.09 MGD). This 18-year old treatment facility (updated and expanded most recently in 1973) is designed for a discharge with an effluent quality of not more than 10 mg/L biochemical oxygen demand (BOD) and 12 mg/L of suspended solids. The average BOD and total suspended solids discharges during the week of sampling were 25 mg/L and 19 mg/L, respectively.

The treatment unit operations utilized at this conventional activated sludge facility are as follows. Wastewater flows from the sewer system to a diversion chamber from which it is pumped to a height which allows gravity flow to the rest of the plant. The wastewater then passes through parallel detritus tanks (grit chambers), communitors, preaeration chambers and into the primary settling tank. After primary settling, wastewater flows to the aeration tanks, secondary settling, and chlorination, and, then is discharged.

The primary sludge flow at this POTW is pumped to holding tanks where it is combined with the thickened (via DAF) waste-activated sludge. From this point, the combined sludge passes to the sludge conditioning facilities where it is heated and pressurized prior to vacuum filtration. The decant from the sludge conditioning system and the filtrate is either returned to the sludge conditioning building, or bled to the head of the aeration tanks. The filter cake is incinerated and the resulting ash is slurried to a diked lagoon on the plant property.

During the sampling period, the primary sludge flow averaged 110 m^3/d (29,400 gal/d).

The sewer system for Plant B consists primarily of combined sewers. Four main trunk lines cover the far sections of the 7.61×10^6 m^2 (29.4 mi^2) drainage area. The sewer lines are mostly concrete construction and average 20 years in age, with some lines over 50 years old. The age of the sewer lines accounts for the estimate that as much as 40% to 50% of the total flow to the POTW can be attributed to infiltration in the subsystems and interceptors, according to the facilities plan, completed under the authority of Section 201 of the Clean Water Act (PL 95-217). The industrial contribution to the wastewater flow to Plant B can be considered minimal. The areawide waste treatment management plan under Section 208 of the Clean Water Act lists the zoning breakdown of the drainage area as 96.6% residential, 1.0% retail business and offices, and 2.4% industrial. The industries associated with this drainage area are grain elevators, oil and fuel terminals, machine tool and metalworking companies, box and insulation companies, and one major chemical facility with its own National Pollutant Discharge Elimination System (NPDES) discharge permit. With such a small industrial flow, Plant B is considered to give a general approximation of a typical residential treatment facility.

Tables 22-7 and 22-8 present conventional and toxic pollutant data for the influent, final effluent, prechlorination effluent, and sludge streams for this facility.

TABLE 22-7. CONCENTRATIONS OF CONVENTIONAL POLLUTANTS FOUND IN PUBLICLY OWNED TREATMENT WORKS (POTW), PLANT B[a] [1]

	Concentration, mg/L					Concentration, mg/L		
Pollutant	Tap water	Influent	Effluent pre-cl[b]	Final effluent	Percent removal	Secondary sludge	Combined sludge	DAF blanket
BOD_5	<10	95	20	25	74	8,500		
COD	<1	180	52	57	69		32,000	
TOC	22	70	29	33	53		12,000	
TSS	3	97	12	19	80		22,000	
Total phenols	0.006	0.020		<0.004	84	0.008	0.460	2.800
Oil and grease	7	24		<8	67	<250	3,500	11,000

[a]Week 1 average
[b]Prechlorination

II.22.4 POLLUTANT REMOVABILITY

Wastewater treatment at POTW's can significantly reduce the concentration of pollutant parameters in the influent to the facility. In the sampling at Plant A, BOD was reduced from an average influent concentration of 200 mg/L to 13 mg/L (94% removal) and the TSS level was reduced from 140 mg/L to 20 mg/L (86% removal). Chromium and copper were reduced to less than 50 µg/L (90% and 86% removal, respectively). Cadmium, nickel, and zinc were removed to a lesser extent (59% to 65% removal). Nine organic toxic pollutants were detected in the influent at an average concentration over 10 µg/L. Eight of the nine were reduced by a minimum of 50%. Only phenol at the levels measured was not effectively removed.

Plant B achieves typical removals of BOD and TSS (74% and 80% removal, respectively). Toxic metals, already in low concentrations, were often reduced below their detection limit. Cadmium, copper, and zinc levels were reduced to between 69% and 81%. Lead and nickel were removed less effectively. Organic toxic pollutants at Plant B occurred at low levels and removal efficiencies are not meaningful.

Removal percentages for these facilities are given in Tables 22-4 through 22-7 in the plant-specific description section.

TABLE 22-8. CONCENTRATIONS OF TOXIC POLLUTANTS FOUND IN PUBLICLY OWNED TREATMENT WORKS (POTW), PLANT B[a] [1]

Toxic pollutant	Concentration, µg/L				Percent removal	Concentration, µg/L		
	Tap water	Influent	Effluent pre-Cl[b]	Final effluent		Secondary sludge	Combined sludge	DAF blanket
Metals and inorganics								
Antimony	<50	0 - 50	<50	<50			39	
Arsenic	<50	0 - 50	<50	<50			150	
Beryllium	<2.0	<2.0	<2.0	<2.0		890.0	<12.0	890.0
Cadmium	<2.0	4 - 5	<2	<2	55 - 100		310	
Chromium	<5	71	26	22	69		8,100	
Copper	6	54	11	10	81		11,000	
Cyanide	<10	77 - 78		<140		340	1,700	2,900
Lead	<20	16 - 30	<23	<20			7,400	
Mercury	<0.2	<0.3	<0.2	<0.2	5 - 100		5.1	
Nickel	<10	30	21	20	33		3,100	
Selenium	<50	0 - 50	<50	<50			<28	
Silver	<2	1 - 3	<7	<2	0 - 84		<79	
Thallium	<50	0 - 50	<50	<50			<2	<50
Zinc	7	280	83	52	81		<27,000	
Phthalates								
Bis(2-ethylhexyl) phthalate	<10	9 - 14	<11	<9			1,500	
Butyl benzyl phthalate	<10	0 - 10	<3	<5			ND	
Di-n-butyl phthalate	<10	0 - 8	<6	<6			ND	
Diethyl phthalate	<10	0 - 8	<3	<3			ND	
Dimethyl phthalate	ND	0 - 5	<1	<3			ND	
Di-n-octyl phthalate	ND	0 - 7	<1	<1			ND	
Nitrogen compounds								
Acrylonitrile	ND	ND	ND	ND	ND	ND	41	ND
3,3'-Dichlorobenzidine	ND	ND	ND	<1			ND	
Phenols								
2-Nitrophenol	ND	ND	<8	<4			ND	
4-Nitrophenol	ND	ND	<34	<14			ND	
Pentachlorophenol	ND	0 - 2	<4	<1			ND	
Phenol	<10	0 - 7	<9	<9			4	
Aromatics								
Benzene	ND	7 - 14	<1	<4	44 - 84	<5	33	10
1,2-Dichlorobenzene	<10	0 - 8	<1	<4			ND	
1,3-Dichlorobenzene	ND	0 - 2	<3	<5			ND	
1,4-Dichlorobenzene	ND	0 - 2	ND	ND			ND	
2,6-Dinitrotoluene	ND	0 - 2	ND	ND			ND	
Ethylbenzene	ND	0 - 4	<0.5	<1		5	2	10
Toluene	<10	1 - 8	<5	<7		25	340	230
Polycyclic aromatic hydrocarbons								
Acenaphthylene	ND	ND	<1	<3			ND	
Anthracene	ND	0 - 5	ND	ND			91	
Chrysene	ND	ND	ND	<1			8	
Fluoranthene	ND	0 - 5	ND	ND			ND	
Naphthalene	ND	0 - 7	<1	<4			91	
Phenanthrene	ND	0 - 5	ND	ND			91	
Pyrene	ND	0 - 5	ND	ND			45	
Halogenated aliphatics								
Bromoform	<10	ND	ND	ND	ND	ND	ND	ND
Chlorodibromomethane	20	0 - 1	<2	<3		ND	9	ND
Chloroform	75	0 - 10	<10	<10	0 - 91	ND	ND	ND
Dichlorobromomethane	ND	0 - 1	<2	<3		35	74	35
1,2-Dichloroethane	ND	0 - 1	<2	<2		ND	ND	ND
1,1-Dichloroethylene	ND	0 - 4	<2	<3		ND	ND	ND
1,1-*Trans*-dichloroethylene	ND	ND	<0.5	ND	ND	ND	ND	ND
Methylene chloride	30	6 - 14	<9	<10		180	250	250
1,1,1-Trichloroethane	ND	0 - 2	<1	<0.5		ND	ND	ND
Trichloroethylene	ND	<0 - 3	<0.5	0.5		ND	ND	ND
Pesticides and metabolites								
Isophorone	ND	0 - 2	ND	ND			ND	

Note: Blanks indicate sufficient data are not available; priority pollutants not detected in any sample are not listed.

[a]Week 1 average.

[b]Prechlorination.

II.22.5 REFERENCES

1. Fate of Priority Pllutants in Publicly Owned Treatment Works - Pilot Study. EPA-440/1-79-300, U.S. Environmental Protection Agency, Washington, D.C., October 1979.

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