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Preliminary Data Summary for the Drum Reconditioning Industry

PRELIMINARY DATA SUMMARY

FOR THE

DRUM RECONDITIONING INDUSTRY

Office of Water Regulations and Standards
Office of Water
United States Environmental Protection Agency
Washington, DC

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PREFACE

This is one of a series of Preliminary Data Summaries prepared by the Office of Water Regulations and Standards of the U.S. Environmental Protection Agency. The Summaries contain engineering, economic and environmental data that pertain to whether the industrial facilities in various industries discharge pollutants in their wastewaters and whether the EPA should pursue regulations to control such discharges. The summaries were prepared in order to allow EPA to respond to the mandate of section 304(m) of the Clean Water Act, which requires the Agency to develop plans to regulate industrial categories that contribute to pollution of the Nation's surface waters.

The Summaries vary in terms of the amount and nature of the data presented. This variation reflects several factors, including the overall size of the category (number of dischargers), the amount of sampling and analytical work performed by EPA in developing the Summary, the amount of relevant secondary data that exists for the various categories, whether the industry had been the subject of previous studies (by EPA or other parties), and whether or not the Agency was already committed to a regulation for the industry. With respect to the last factor, the pattern is for categories that are already the subject of regulatory activity (e.g., Pesticides, Pulp and Paper) to have relatively short Summaries. This is because the Summaries are intended primarily to assist EPA management in designating industry categories for rulemaking. Summaries for categories already subject to rulemaking were developed for comparison purposes and contain only the minimal amount of data needed to provide some perspective on the relative magnitude of the pollution problems created across the categories.

ACKNOWLEDGEMENTS

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1. FOREWORD

The Industrial Technology Division (ITD) of the U.S. Environmental Protection Agency (EPA) has conducted a study of the Drum Reconditioning Industry as a result of findings from the Domestic Sewage Study that the quantity of hazardous wastes generated and discharged to publicly-owned treatment works (POTWs) by the Drum Reconditioning Industry was unknown. The purpose of this study is to develop information to characterize the drum reconditioning industry as to the scope of the industry, its operations, its dischargers to the Nation's waters, and identification and quantification of the pollutants discharged to the Nation's waters.

The Agency collected data and information from a variety of sources. The information-gathering efforts of the Agency were coordinated with the Department of Transportation (DOT), five local governments, and the states. Pertinent trade associations were contacted and 16 sites were visited. Wastewater sampling was conducted at four sites and the data collected represent the best available for characterizing the industry. Analyses were conducted for over 400 conventional, nonconventional, priority, and Resource Conservation and Recovery Act (RCRA) pollutants.

2. SUMMARY

The following is a summary from the study of the Drum Reconditioning Industry conducted by the Industrial Technology Division (ITD) of the U.S. Environmental Protection Agency (EPA):

- The Domestic Sewage Study, conducted by EPA in response to Section 3018(a) of the Resource Conservation and Recovery Act (RCRA), concluded that the quantity of hazardous wastes generated and discharged to publicly-owned treatment works (POTWs) by the drum reconditioning industry was unknown.

- Steel and polyethylene drums are reconditioned for reuse at 450 facilities located throughout the Nation. The EPA Region with the largest number of reconditioners is Region V, with 24 percent of the Nation's facilities. New Jersey, California, and Illinois are the states with the largest numbers of reconditioners.

- The status of the industry's wastewater discharges is as follows:

Discharge Status	Number of Facilities
Direct Discharge	50
Indirect Discharge	200
Zero Discharge	200
TOTAL	450

- The industry is not expected to grow or decline significantly, hence, the waste quantities estimated in this report are reasonable projections of future waste quantities.

- Drum reconditioning facilities are registered under 28 different Standard Industrial Classification (SIC) Codes. Two-thirds of the 40 million drums that are reconditioned annually are tight-head drums that are washed with caustic solution to remove residues. The remaining are open-head drums that are burned in furnaces to remove viscous residues. The following list summarizes the major sources of drums received by reconditioners:

Drum Source	Percent
Petroleum	36
Chemicals	25
Resins and Adhesives	16
Paint and Ink	15
Other	8
TOTAL	100

- Drum reconditioning facilities may be subcategorized by drum type: either open-head or closed-head.

- The average drum reconditioner handles 427 drums daily and discharges 6.9 gallons of wastewater per reconditioned drum, or 3,000 gallons per day. Raw wastewater results from the washing and rinsing of tight-head drums or the quenching of burning residue on open-head drum surfaces.

- Industry raw wastewater is characterized by high concentrations of conventional, nonconventional, metal, and organic pollutants. The data shown below for selected parameters are representative of a typical raw wastewater sample:

Parameter	Concentration (mg/l)
BOD_5	3,710
TSS	4,710
COD	17,400
Oil and Grease	13,200
TOC	2,990
Iron	106
Lead	14
Zinc	25
2-Butanone	716
Acetone	858

- Forty-two extractable and volatile organics were detected in industry raw wastewaters and 15 had concentrations greater than 10 mg/l.

- The following pesticide/herbicide compounds were found in industry raw wastewater at levels greater than 1 mg/l: azinphos ethyl, azinphos methyl, fensolfothion, diazinon, dimethoate, leptophos, nemacur, parathion, and TEPP.

- Zero discharge is demonstrated to be a practical control technology for open-head facilities. Furnace quench water typically is reused after simple sedimentation.

- Tight-head facilities generally discharge wastewater, and nearly one-half of the dischargers do not treat wastewater.

- Wastewater treatment pollutant removal efficiencies were poor at the four plants sampled by the Agency.

- Sedimentation, oil/water separation, and air flotation are the dominant treatment technologies at tight-head plants. Reuse of treated effluent is possible; however, zero discharge is attainable only if wastestreams are segregated and water conservation measures are implemented.

- A model wastewater treatment system would include emulsion breaking technology and treated wastewater reuse. A typical facility would incur a capital cost of $154,000 and an annual operating cost of $47,000 to maintain and operate such a system.

- Approximately 124 million pounds of residue are contained in drums received by reconditioners, annually.

- Wastewater treatment sludges generated by the industry are composed mainly of oil and grease (15 percent) and suspended solids (7 percent). High concentrations of 23 organics are observed.

- Twelve dioxin/furan compounds are found in industry sludges; however, these compounds are not prevalent in raw wastewaters.

- The annualized wastewater control cost is $0.78 per drum reconditioned, which represents about 12 percent of the reconditioning fee.

- The cost-effectiveness of treating the process wastewater is $130 per pound equivalent of pollutant removed.

- Total loadings of priority pollutant inorganics from untreated wastewater are low when compared to raw waste loadings of priority inorganics from regulated BAT/PSES industries.

- Total loadings of priority pollutant organics from untreated wastewater are significant when compared to raw waste loadings from regulated industries.

- Implementation of the model cost technology would result in a net reduction of air emissions, a doubling of the volume of sludge generated from wastewater treatment systems, and a doubling of energy consumption.

3. INTRODUCTION

This section discusses regulatory authority and pertinent regulations, and provides an overview of the industry. Sources of data and information used to support conclusions also are discussed.

3.1 PURPOSE AND AUTHORITY

3.1.1 Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nations waters, Section 101 [a]." Under this statute, existing industrial dischargers were required to achieve compliance with "effluent limitations requiring the application of the best practicable control technology currently available (BPT), Section 301(b)(1)(A)." These dischargers are required to achieve "effluent limitations requiring the application of the best available technology economically achievable (BAT)...which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, Section 301(b)(2)(A). New industrial direct discharge performance standards (NSPS) are based on best available demonstrated technology, and existing and new dischargers to publicly-owned treatment works (POTWs) are subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers are to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards were made enforceable directly against indirect dischargers to POTWs.

Although Section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis, Congress intended that control requirements be based on regulations promulgated by the Administrator providing guidelines that consider the degree of effluent reduction attainable through the application of BPT and BAT. Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b), and 307(c) required promulgation of regulations for pretreatment standards. In addition to the regulations for designated industry categories, Section 307(a) of the Act required the Administrator to develop a list of toxic pollutants and promulgate effluent standards applicable to all dischargers of toxic pollutants. Categorical pretreatment standards originally were to be developed for 34 specific industrial categories and 129 pollutants. EPA subsequently exempted several industries and pollutants from regulation. Currently, categorical standards apply to 22 specific industrial categories and 126 priority pollutants. Finally, Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act. The U.S. Environmental Protection Agency, Industrial Technology Division (EPA-ITD) is responsible for developing effluent guidelines limitations and standards for the categorical industries.

3.2 REGULATORY OVERVIEW

3.2.1 Resource Conservation and Recovery Act

Congress enacted the Resource Conservation and Recovery Act (RCRA) in 1976 to define a Federal role in solid waste and resource management and recovery. The primary goals of RCRA are to: (1) protect human health and the environment from hazardous and other solid wastes; and (2) protect and preserve natural resources through the implementation of programs emphasizing resource conservation and recovery. The principal regulatory focus of RCRA is to control hazardous waste. To this end, RCRA mandates a comprehensive system to identify hazardous wastes and to track and control their movement from generation through transport, treatment, storage, and ultimate disposal. RCRA subsequently was amended in 1978, 1980, and 1984.

Hazardous waste management under RCRA has often been characterized as "cradle to grave" management. A firm generating solid wastes is required to determine if such waste is hazardous. Any generator of a hazardous waste must notify the EPA. If the generator chooses to move the waste off-site for treatment or disposal, a manifest must be maintained by the generator, transporter, and the receiving treatment, storage, or disposal facility. Any wastes shipped off-site to be treated, stored, or disposed of must be sent to an authorized hazardous waste disposal facility. Wastes managed on-site, like those shipped off-site, must be handled according to specific management and technical requirements in RCRA.

3.2.2 Domestic Sewage Exclusion

Under the Domestic Sewage Exclusion (DSE) [specified in Section 1004 [27] of RCRA and codified in 40 CFR 261.4 (a)(1)], solid or dissolved material in domestic sewage is not, by definition, a "solid waste" and, as a corollary, cannot be considered a "hazardous waste." Thus, the DSE covers:

- "Untreated sanitary wastes that pass through a sewer system"
- "Any mixture of domestic sewage and other wastes that passes through a sewer system to a POTW for treatment."

The premise behind the exclusion is that it is unnecessary to subject hazardous wastes mixed with domestic sewage to RCRA management requirements, since these DSE wastes would receive the benefits of treatment offered by POTWs and are already regulated under Clean Water Act (CWA) programs, such as the National

Pretreatment Program and the National Pollutant Discharge Elimination System (NPDES).

The exclusion allows industries to be connected to domestic sewers without having to comply with certain RCRA generator requirements, such as manifesting and reporting requirements. Moreover, POTWs receiving excluded wastes are not subject to RCRA treatment, storage, and disposal facility requirements.

EPA conducted a study in response to Section 3018(a) of RCRA. This provision required that EPA prepare:

> "...a report to the Congress concerning those substances identified or listed under section 3001 which are not regulated under this subtitle by reason of the exclusion for mixtures of domestic sewage and other wastes that pass through a sewer system to a publicly-owned treatment works. Such report shall include the types, size and number of generators which dispose of such substances in this manner, and the identification of significant generators, wastes, and waste constituents not regulated in a manner sufficient to protect human health and the environment."

The report, known as the Domestic Sewage Study (USEPA 1986a), is an evaluation of the impacts of wastes discharged to local wastewater treatment plants.

In performing this study, EPA collected information on waste discharges from 47 industrial categories and the residential sector. The evaluation concluded that the quantities of hazardous wastes generated and discharged to POTWs by the drum reconditioning industry were unknown. EPA's regulatory efforts, in the past, have focused on larger, industrial categories. The drum reconditioning industry traditionally has been considered a less significant waste source due to its small size and service-related orientation. Therefore, this industry never has been extensively reviewed, for regulatory purposes, at the national level for possible regulation under the CWA.

3.2.3 <u>Residues of Hazardous Waste in Empty Containers</u>

Any hazardous waste remaining in either an empty container or an inner liner removed from an empty container is not subject to regulation under RCRA. Empty is defined in 40 CFR 261.7 paragraph (b) as follows:

"(i) all wastes have been removed that can be removed using the practices commonly employed to remove materials from that type of container, e.g., pouring, pumping, aspirating and;

(ii) no more than 2.5 centimeters (one inch) of residue remain on the bottom of the container or inner liner, or

(iii) (a) no more than 3 percent by weight of the total capacity of the container remains in the container or inner liner if the container is less than or equal to 100 gallons in size, or; (b) no more than 0.3 percent by weight of the total capacity of the container remains in the container or inner liner if the container is greater than 100 gallons in size."

This definition does not apply to containers that have held a hazardous waste that is a compressed gas when the pressure of the container approaches atmospheric. Nor does the definition apply to a container or inner liner that has held an acute hazardous waste listed in 40 CFR Parts 261.31, 261.32, or 261.33(e), unless:

"(i) the container or inner liner has been triple rinsed using a solvent capable of removing the commercial chemical product or manufacturing intermediate;

(ii) the container or inner liner has been cleaned by another method that has been shown in scientific literature, or by tests conducted by the generator, to achieve equivalent removal; or

(iii) in the use of a container, the inner liner that prevented contact of the commercial chemical product or manufacturing chemical intermediate with the container has been removed."

Table 3-1 presents the acute hazardous wastes listed under Parts 261.31, 261.32, and 261.33(e).

3.2.4 Hazardous Materials Transportation Act

The Hazardous Materials Transportation Act of 1975 and its amendments established a program to protect the Nation adequately against the risks to life and property that are inherent in the transportation of hazardous materials in commerce. The key provisions of the Act address the definition of designated hazardous materials handling and the registration of transporters.

Through authority granted by the Act, the Department of Transportation (DOT) requires reconditioners of drums to comply with 49 CFR 173.28. Containers that are used more than once (refilled and reshipped after having been previously emptied) must be in such condition, including closure devices and cushioning materials, that they comply in all respects with the prescribed requirements for those containers. Emptied steel drums may be reused as prescribed in Part 173.28 as packaging for shipment of flammable liquids, flammable solids, oxidizing materials, addition

TABLE 3-1 ACUTE HAZARDOUS WASTES

(e) The commercial chemical products, manufacturing chemical intermediates or off-specification commercial chemical products or manufacturing chemical intermediates referred to in paragraphs (a) through (d) of this section, are identified as acute hazardous wastes (H) and are subject to be the small quantity exclusion defined in § 261.5(e).

[*Comment:* For the convenience of the regulated community the primary hazardous properties of these materials have been indicated by the letters T (Toxicity), and R (Reactivity). Absence of a letter indicates that the compound only is listed for acute toxicity.]

These wastes and their corresponding EPA Hazardous Waste Numbers are:

Hazardous waste No	Substance
P023	Acetaldehyde, chloro-
P002	Acetamide, N-(aminothioxomethyl)-
P057	Acetamide, 2-fluoro-
P058	Acetic acid, fluoro-, sodium salt
P066	Acetimidic acid, N-[(methylcarbamoyl)oxy]thio-, methyl ester
P001	3-(alpha-acetonylbenzyl)-4-hydroxycoumarin and salts
P002	1-Acetyl-2-thiourea
P003	Acrolein
P070	Aldicarb
P004	Aldrin
P005	Allyl alcohol
P006	Aluminum phosphide
P007	5-(Aminomethyl)-3-isoxazolol
P008	4-Aminopyridine
P009	Ammonium picrate (R)
P119	Ammonium vanadate
P010	Arsenic acid
P012	Arsenic (III) oxide
P011	Arsenic (V) oxide
P011	Arsenic pentoxide
P012	Arsenic trioxide
P038	Arsine, diethyl-
P054	Aziridine
P013	Barium cyanide
P024	Benzenamine, 4-chloro-
P077	Benzenamine, 4-nitro-
P028	Benzene, (chloromethyl)-
P042	1,2-Benzenediol, 4-[1-hydroxy-2-(methylamino)ethyl]-
P014	Benzenethiol
P028	Benzyl chloride
P015	Beryllium dust
P016	Bis(chloromethyl) ether
P017	Bromoacetone
P018	Brucine
P021	Calcium cyanide
P123	Camphene, octachloro-
P103	Carbamimidoselenoic acid
P022	Carbon bisulfide
P022	Carbon disulfide
P095	Carbonyl chloride
P033	Chlorine cyanide
P023	Chloroacetaldehyde
P024	p-Chloroaniline
P026	1-(o-Chlorophenyl)thiourea
P027	3-Chloropropionitrile
P029	Copper cyanides
P030	Cyanides (soluble cyanide salts), not elsewhere specified
P031	Cyanogen
P033	Cyanogen chloride
P036	Dichlorophenylarsine
P037	Dieldrin
P038	Diethylarsine
P039	O,O-Diethyl S-[2-(ethylthio)ethyl] phosphorodithioate
P041	Diethyl-p-nitrophenyl phosphate
P040	O,O-Diethyl O-pyrazinyl phosphorothioate
P043	Diisopropyl fluorophosphate
P044	Dimethoate
P045	3,3-Dimethyl-1-(methylthio)-2-butanone, O-[(methylamino)carbonyl] oxime
P071	O,O-Dimethyl O-p-nitrophenyl phosphorothioate
P082	Dimethylnitrosamine
P046	alpha, alpha-Dimethylphenethylamine
P047	4,6-Dinitro-o-cresol and salts
P034	4,6-Dinitro-o-cyclohexylphenol
P048	2,4-Dinitrophenol
P020	Dinoseb
P085	Diphosphoramide, octamethyl-
P039	Disulfoton
P049	2,4-Dithiobiuret
P109	Dithiopyrophosphoric acid, tetraethyl ester
P050	Endosulfan
P088	Endothall
P051	Endrin
P042	Epinephrine
P046	Ethanamine, 1,1-dimethyl-2-phenyl-
P084	Ethenamine, N-methyl-N-nitroso-
P101	Ethyl cyanide
P054	Ethylenimine
P097	Famphur
P056	Fluorine
P057	Fluoroacetamide
P058	Fluoroacetic acid, sodium salt
P065	Fulminic acid, mercury(II) salt (R,T)
P059	Heptachlor
P051	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,endo-1,4:5,8-dimethanonaphthalene
P037	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,exo-1,4:5,8-demethanonaphthalene
P060	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-endo, endo-dimeth- anonaphthalene
P004	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-endo,exo-dimethanonaphthalene
P060	Hexachlorohexahydro-exo,exo-dimethanonaphthalene
P062	Hexaethyl tetraphosphate
P116	Hydrazinecarbothioamide
P068	Hydrazine, methyl-
P063	Hydrocyanic acid
P063	Hydrogen cyanide
P096	Hydrogen phosphide
P064	Isocyanic acid, methyl ester
P007	3(2H)-Isoxazolone, 5-(aminomethyl)-
P092	Mercury, (acetato-O)phenyl-
P065	Mercury fulminate (R,T)
P016	Methane, oxybis(chloro-
P112	Methane, tetranitro- (R)
P118	Methanethiol, trichloro-
P059	4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-
P066	Methomyl
P067	2-Methylaziridine
P068	Methyl hydrazine
P064	Methyl isocyanate
P069	2-Methyllactonitrile
P071	Methyl parathion
P072	alpha-Naphthylthiourea
P073	Nickel carbonyl
P074	Nickel cyanide
P074	Nickel(II) cyanide
P073	Nickel tetracarbonyl
P075	Nicotine and salts
P076	Nitric oxide
P077	p-Nitroaniline
P078	Nitrogen dioxide
P076	Nitrogen(II) oxide
P078	Nitrogen(IV) oxide
P081	Nitroglycerine (R)
P082	N-Nitrosodimethylamine
P084	N-Nitrosomethylvinylamine
P050	5-Norbornene-2,3-dimethanol, 1,4,5,6,7,7-hexachloro, cyclic sulfite
P085	Octamethylpyrophosphoramide
P087	Osmium oxide
P087	Osmium tetroxide
P088	7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid
P089	Parathion
P034	Phenol, 2-cyclohexyl-4,6-dinitro-
P048	Phenol, 2,4-dinitro-
P047	Phenol, 2,4-dinitro-6-methyl-
P020	Phenol, 2,4-dinitro-6-(1-methylpropyl)-
P009	Phenol, 2,4,6-trinitro-, ammonium salt (R)
P036	Phenyl dichloroarsine
P092	Phenylmercuric acetate
P093	N-Phenylthiourea
P094	Phorate
P095	Phosgene
P096	Phosphine
P041	Phosphoric acid, diethyl p-nitrophenyl ester
P044	Phosphorodithioic acid, O,O-dimethyl S-[2-(methylamino)-2-oxoethyl]ester
P043	Phosphorofluoric acid, bis(1-methylethyl)-ester
P094	Phosphorothioic acid, O,O-diethyl S-(ethylthio)methyl ester
P089	Phosphorothioic acid, O,O-diethyl O-(p-nitrophenyl) ester
P040	Phosphorothioic acid, O,O-diethyl O- pyrazinyl ester
P097	Phosphorothioic acid, O,O-dimethyl O-[p-((dimethylamino)-sulfonyl)phenyl]ester
P110	Plumbane, tetraethyl-
P098	Potassium cyanide
P099	Potassium silver cyanide
P070	Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime
P101	Propanenitrile
P027	Propanenitrile, 3-chloro-
P069	Propanenitrile, 2-hydroxy-2-methyl-
P081	1,2,3-Propanetriol, trinitrate- (R)
P017	2-Propanone, 1-bromo-
P102	Propargyl alcohol
P003	2-Propenal
P005	2-Propen-1-ol
P067	1,2-Propylenimine
P102	2-Propyn-1-ol
P008	4-Pyridinamine
P075	Pyridine, (S)-3-(1-methyl-2-pyrrolidinyl)-, and salts
P111	Pyrophosphoric acid, tetraethyl ester
P103	Selenourea
P104	Silver cyanide
P105	Sodium azide
P106	Sodium cyanide
P107	Strontium sulfide
P108	Strychnidin-10-one, and salts
P018	Strychnidin-10-one, 2,3-dimethoxy-
P108	Strychnine and salts
P115	Sulfuric acid, thallium(I) salt
P109	Tetraethyldithiopyrophosphate
P110	Tetraethyl lead
P111	Tetraethylpyrophosphate
P112	Tetranitromethane (R)
P062	Tetraphosphoric acid, hexaethyl ester
P113	Thallic oxide
P113	Thallium(III) oxide
P114	Thallium(I) selenite
P115	Thallium(I) sulfate
P045	Thiofanox
P049	Thioimidodicarbonic diamide
P014	Thiophenol
P116	Thiosemicarbazide
P026	Thiourea, (2-chlorophenyl)-
P072	Thiourea, 1-naphthalenyl-
P093	Thiourea, phenyl-
P123	Toxaphene
P118	Trichloromethanethiol
P119	Vanadic acid, ammonium salt
P120	Vanadium pentoxide
P120	Vanadium(V) oxide
P001	Warfarin
P121	Zinc cyanide
P122	Zinc phosphide (R,T)

radioactive materials, and corrosive liquids covered by Sections 173.249 and 173.249(a), only if the following requirements, in addition to the other requirements of this section, are complied with prior to each reuse:

- Visual inspection - Drums must be cleaned thoroughly to remove all residue and foreign matter. Deterioration or defects, and parts that are weak, broken, or otherwise deteriorated, must be replaced.

- Air pressure test for leakage - The entire surface of each closed-head and open-head drum, except for its removable head and adjacent chime area, must be tested for leakage by constant internal air pressure.

- Markings - All previous markings, commodity identification markings, and labels must be removed. All drums that qualify for reuse must be marked on the body within 10 inches of the top of the work, "Tested," the month and year it was tested, and the DOT registration number of the reconditioner.

Retest of polyethylene carboy packages must have been made by or for shippers, or their authorized agents, as required by applicable provisions of the specifications of 49 CFR 178.19, before carboys that are to be offered for transportation are filled. Requirements for reconditioners of carboys are similar to those for steel drum reconditioners. However, registration with DOT is not required for carboy reconditioners.

3.3 OVERVIEW OF THE INDUSTRY

The drum reconditioning industry is not included in a specific U.S. Department of Commerce, Bureau of Census Standard Industrial Classification (SIC). DOT regulates facilities that clean or recondition steel or polyethylene drums, after having been previously emptied, for the purpose of resale or reuse. As of May 1986, 770 facilities were registered with DOT and EPA identified 337 additional facilities that were not registered with DOT. From a combined list of 1,107 facilities, EPA estimates that only 450 are actively engaged in drum reconditioning. Thirty-five DOT registrants are listed in the EPA Industrial Facilities Database (IFD) as NPDES permit holders. Two of these registrants identify their business as SIC No. 3412 - Metal Shipping Barrels, Drums, Kegs and Pails. The remaining registrants that are listed in IFD files under the numerous SIC numbers are shown in Table 3-2. Little information is available on the age of drum reconditioning facilities or on the number of employees per facility.

Data on effluent discharges from the 450 active drum reconditioners are limited, since most of the reconditioners are regulated by local pretreatment authorities that do not require extensive monitoring. EPA estimates that wastewater is directly discharged from approximately 50 facilities. POTWs receive indirect discharges from an estimated 200 facilities. The

TABLE 3-2. SIC INDUSTRY CODES FOR DOT REGISTRANTS THAT ARE LISTED IN IFD FILES

Industry Number	Description
1044	Uranium - Radium - Vanadium Ores
2041	Flour and Other Grain Mill Products
2711	Newspapers
2812	Alkalies and Chlorine
2813	Industrial Gases
2822	Synthetic Rubber
2823	Cellulosic Man-Made Fibers
2831	Biological Products
2834	Pharmaceutical Preparations
2851	Paints, Varnishes, Lacquers, Enamels and Allied Products
2869	Industrial Organic Chemicals, Not Elsewhere Classified
2911	Petroleum Refining
2999	Products of Petroleum and Coal, Not Elsewhere Classified
3111	Leather Tanning and Finishing
3412	Metal Shipping Barrels, Drums, Kegs and Pails
3471	Electroplating, Plating, Polishing, Anodizing and Coloring
3499	Fabricated Metal Products, Not Elsewhere Classified
3662	Radio and Television Transmitting, Signaling and Detection Equipment
3671	Radio and Television Receiving Type Electronic Tubes
3676	Resistors, for Electronic Applications
3679	Electronic Components, Not Elsewhere Classified
3731	Ship Building and Repairing
3822	Automatic Controls for Regulating Residential and Commercial Environments and Appliances
4952	Sewerage Systems
4961	Steam Supply
7041	Organization Hotels and Lodging Houses
7397	Commercial Testing Laboratories
8999	Services, Not Elsewhere Classified

remaining 200 active facilities are believed not to discharge process wastewater (SAIC 1987a).

3.4 DATA AND INFORMATION GATHERING

EPA sought to obtain a broad and accurate understanding of the drum reconditioning industry and to evaluate wastewater characteristics and treatment practices. This involved a review of the literature, meetings with trade associations and Federal and local agencies, site visits, and information from all facilities potentially in the drum reconditioning universe. In summary, the major sources of data and information are as follows:

- The Touhill Reports
- State and local agencies
- Department of Transportation
- Trade associations
- Facility site visits
- Other sources of information.

3.4.1 The Touhill Reports

In 1981, the EPA Office of Research and Development (ORD) completed a program to assess barrel and drum reconditioning processes (Touhill 1981a and b). The intent of the program was to provide recommendations for upgrading and optimizing drum reconditioning processes.

An industry profile was developed, which was based on the results of a questionnaire distributed by the National Barrel and Drum Association (NABADA). The status profile was intended to be indicative of average practice without reference to any specifically identified facility. In addition, the questionnaire dealt primarily with environmental and process considerations. Items concerning business, personnel, and proprietary matters were not included. NABADA received 49 responses to the 119 questionnaires that were distributed.

3.4.2 State and Local Agencies

EPA contacted state hazardous waste offices by telephone and mail to identify names of drum reconditioners. In some cases, no information was available, since some states do not regulate drum reconditioners as hazardous waste facilities. In other cases, the state's hazardous waste facility data base did not indicate the nature of an activity of a facility.

Hazardous waste agencies, for 18 states, do not track drum reconditioners. Eighty-three facility names were collected through contacts at the remaining states. Attempts were made to contact United States territories; however, information was not readily available.

In conjunction with presampling site visits, EPA contacted and met with local regulatory agencies. Permit applications, industrial user permits, and monitoring data were obtained for drum reconditioners that indirectly discharge wastewater. The following agencies provided information:

- The Metropolitan Sanitary District of Greater Chicago
- City of Detroit Water and Sewage Department
- County Sanitation District of Los Angeles County
- City of San Antonio Department of Wastewater Management
- State of Washington, Department of Ecology.

3.4.3 Department of Transportation

The Research and Special Programs Administration of DOT manages the registration of drum reconditioning facilities. A single list is updated monthly and is readily available for the production of mailing labels. Only half of the 770 registrants are believed by DOT officials to be active facilities and the remainder are thought to be brokers or drum dealers. DOT also maintains lists of new steel and polyethylene drum manufacturers.

3.4.4 Trade Associations

Membership directories and address lists were requested, by mail, from 12 associations that are active in the waste management field. Lists were received from the following five associations:

- Association of Petroleum Re-refiners
- Chemical Waste Transportation Council
- Institute of Chemical Waste Management
- National Association of Solvent Recyclers
- Spill Control Association of America.

Five other trade associations also were contacted by telephone. Based on conversations with association directors, these five associations are not believed to be pertinent to this study.

NABADA did not submit a current membership list, but did meet with EPA. During this meeting, NABADA representatives stated that the industry profile presented by Touhill (1981a) is still representative. Later, NABADA assisted the Agency in its selection of sampling candidates.

3.4.5 Facility Site Visits

EPA contacted numerous drum reconditioners to identify candidates for wastewater sampling. Site visits were conducted to locate sampling points in the facilities and to collect file information. Facilities that did not treat wastewater or did not have accessible sampling points were not selected for sampling. Presampling site visits were conducted at the following 16 facilities:

- ABC Drum and Barrel Company - Detroit, Michigan
- Acme Barrel and Drum Company - Chicago, Illinois
- Allied - Hastings Drum Company - Chicago, Illinois
- Columbus Steel Drum Company - Livonia, Michigan
- Cooper Drum Company - South Gate, California
- Dixie Drum Company - San Antonio, Texas
- Duke Refining Corporation - High Point, North Carolina
- Hansen-Sterling Drum Company - Chicago, Illinois
- Midwestern Drum Service Inc. - Venice, Illinois
- Myers Container Corporation - Emeryville, California
- Myers Container Corporation - Oakland, California
- Northwest Cooperage Company, Inc. - Seattle, Washington
- Pacific Coast Drum Company - South El Monte, California
- United Drum/Reliance - High Point, North Carolina
- United Steel Drum Company - East St. Louis, Illinois
- West Cooperage Company - Detroit, Michigan.

3.4.6 Other Sources of Information

EPA conducted a search of commonly used data bases to locate pertinent literature on the drum reconditioning industry. Titles published before 1980 were not sought. Since the publication of the Touhill reports, in 1981, no significant publications have appeared in these data bases.

Telephone books available at the Library of Congress were inspected to compile a list of drum vendors and reconditioners. Three hundred and thirty-seven facilities were identified in telephone books from 112 metropolitan areas that were not on the DOT list.

EPA did not conduct an extensive effort to verify the discharge status of drum reconditioners, since most reconditioners are believed to be indirect dischargers. Telephone contacts were made only to identify presampling trip candidates in geographically key areas.

The Chemical Engineering Branch of EPA's Office of Toxic Substances is conducting a study of the drum reconditioning industry to assess worker exposure to new chemicals and the potential for the chemical to be released to the environment.

In summary, EPA coordinated its information-gathering efforts with DOT, five local governments, and the states. Pertinent trade associations were contacted and a meeting was held with NABADA, the primary industry representative. Site visits were made to 16 facilities and a literature search was conducted. EPA believes that the conclusions presented in this report reflect the best information available.

4. DESCRIPTION OF THE INDUSTRY

This section discusses industry products and processes, as well as facility characteristics. This information is necessary to establish groupings within the industry. These groupings should reflect differences in wastewater generation, control, treatment, and discharge.

4.1 INDUSTRY PROFILE

Drum reconditioning is a general term for the cleaning or reconditioning of steel or polyethylene drums for resale or reuse. In 1985, approximately 50 million drums were reconditioned (Rich 1986). Table 4-1 presents a distribution of the types of products used in drums received by reconditioners (Touhill 1981a). Drums formerly containing oil and petroleum are the most prevalent type of drum reconditioned. Drums that previously contained paint, ink, and industrial chemicals are also significant. About 95 percent of the drums reconditioned are 55-gallon steel drums, while the remaining 5 percent are 30-gallon steel drums (Touhill 1981a). Despite increased use of plastic (polyethylene) containers, reconditioners have concluded that these containers present no serious competitive threat to the use of steel drums due to the difficulty of reconditioning and problems with disposal of spent plastic containers (Touhill 1981a). Drums are reconditioned either as a service or for resale. In 1979, about 45 percent of washed drums were offered for resale, 52 percent were laundered, and 3 percent were discarded. About 62 percent of burned drums were resold, 33 percent were laundered, and 5 percent were discarded (Touhill 1981a).

Approximately 450 drum reconditioners are active in the United States. This number is based on a revision to the number of active facilities estimated by the U.S. Environmental Protection Agency (EPA) in 1979, 250 drum reconditioners (Touhill 1981a). At that time, 429 active and inactive facilities were registered by the Department of Transportation (DOT); however, in May 1986, 770 facilities were registered. Therefore, 250 was multiplied by a ratio, 770:429, to derive approximately 450 active facilities. EPA identified 337 facilities that are not included in the May 1986 DOT registration list. Therefore, the estimate of 450 active facilities is believed to be conservative. Table 4-2 is a breakdown of the estimated 450 drum reconditioners by state. The three states with the largest numbers of drum reconditioners are New Jersey, California, and Illinois. Table 4-3 is a breakdown of estimated 450 drum reconditioners by EPA Region. Of the facilities identified, about 24 percent are located in EPA Region V. The DOT list of 770 facilities is provided in Appendix A. The list of 337 additional facilities identified by the Agency is provided in Appendix B.

There are three types of drum reconditioning facilities: (1) those that wash drums only (39 percent), (2) those that burn drums only (18 percent), and (3) those that both wash and burn drums (43

TABLE 4-1. TYPES OF PRODUCTS USED IN DRUMS RECEIVED BY RECONDITIONERS

Product	Percent
Oil and Petroleum	36.2
Industrial Chemicals	15.6
Paint and Ink	14.8
Cleaning Solvents	8.8
Resins	8.8
Adhesives	6.8
Food	6.8
Other	1.7
Pesticide	0.5

TABLE 4-2. ESTIMATED DRUM RECONDITIONERS BY STATE

State	Estimated Number of Plants
Alabama	9
Alaska	12
Arkansas	2
Arizona	8
California	33
Colorado	5
Connecticut	6
Florida	11
Georgia	13
Hawaii	2
Illinois	30
Indiana	11
Iowa	4
Kansas	7
Kentucky	10
Louisiana	9
Maine	1
Maryland	5
Massachusetts	13
Michigan	20
Minnesota	12
Mississippi	1
Missouri	19
Nebraska	2
New Hampshire	2
New Jersey	35
New Mexico	2
New York	24
Nevada	1
North Carolina	14
Ohio	24
Oklahoma	9
Oregon	5
Pennsylvania	17
Rhode Island	2
South Carolina	3
South Dakota	1
Tennessee	15
Texas	22
Utah	4
Virginia	4
Washington	7
West Virginia	2
Wisconsin	9
Wyoming	1
(District of Columbia)	1
(Puerto Rico)	1
Total	450

TABLE 4-3. ESTIMATED DRUM RECONDITIONERS BY EPA REGION

EPA Region	Estimated Number of Plants
I	24
II	60
III	29
IV	76
V	106
VI	44
VII	32
VIII	11
IX	44
X	24
Total	450

percent). Of all drums reconditioned, approximately two-thirds are the tight-head, or bung-top type, which must be washed. Theremainder are open-head drums that are burned. The average commercial tight-head plant reconditioned 700 drums in 1979, while the average commercial open-head plant reconditioned 550 drums. Combined plants washed and burned a daily total of 1,400 drums. Facilities that recondition their own drums for in-house use wash about 50 drums daily and burn very few (Touhill 1981a).

Wastewater treatment and control practices employed by drum reconditioners depend on their mode of processing. Since most washing facilities reuse caustic wash solutions, their discharges to publicly-owned treatment works (POTWs) usually consist only of rinse waters (Touhill 1981a). Many washing plants have moved to complete recycle systems. Some burning facilities discharge quench water from post-furnace drum cooling. However, the majority of burning plants are believed to recycle this cooling stream after solids are settled. There is wide variability in wastewaters, depending on the types of drums processed. The most commonly used water pollution control equipment includes screens, oil/water separators, flocculation and sedimentation tanks, filters, and dissolved air flotation units. Operating procedures such as preflushing, stream segregation, and cascading water use are important adjuncts to pollution control equipment.

4.2 RECONDITIONING PROCESSES

The type of reconditioning process strictly depends on the previous usage of a given drum. Open-head drums are used primarily for viscous materials that do not readily pour through a tight-head bung. Tight-head drums are used for liquids that flow freely, although some tight-head drums are cut into open-heads if drum residue is difficult to remove during reconditioning. For example, solvents and some petroleum products are less viscous liquids; therefore, they are stored in tight-head drums that eventually are reconditioned by washing. Open-head drums are used for high-viscosity liquids, such as paints and adhesives, and these drums are reconditioned by burning. Food products often are stored in lined, open-head drums. Liners are discarded before drums are burned.

Steel drums are processed by either washing or burning. Each processing method has several variations. Since tight-head drums are almost always washed, reconditioners frequently refer to washing facilities as "tight-head plants." Conversely, open-head drums are processed almost exclusively by burning; hence, burning operations often are referred to as "open-head plants." Figure 4-1 illustrates a typical tight-head drum. An open-head drum looks similar, except the top is replaced by a lid. The flanged lid and top chime are joined by a compression-type steel ring fitting. Neoprene or similar material gaskets are used to create a seal. The open-head drum lid sometimes does not contain bung holes. Appendix C is a copy of a DOT Information Bulletin on specifications for reconditioned steel drums.

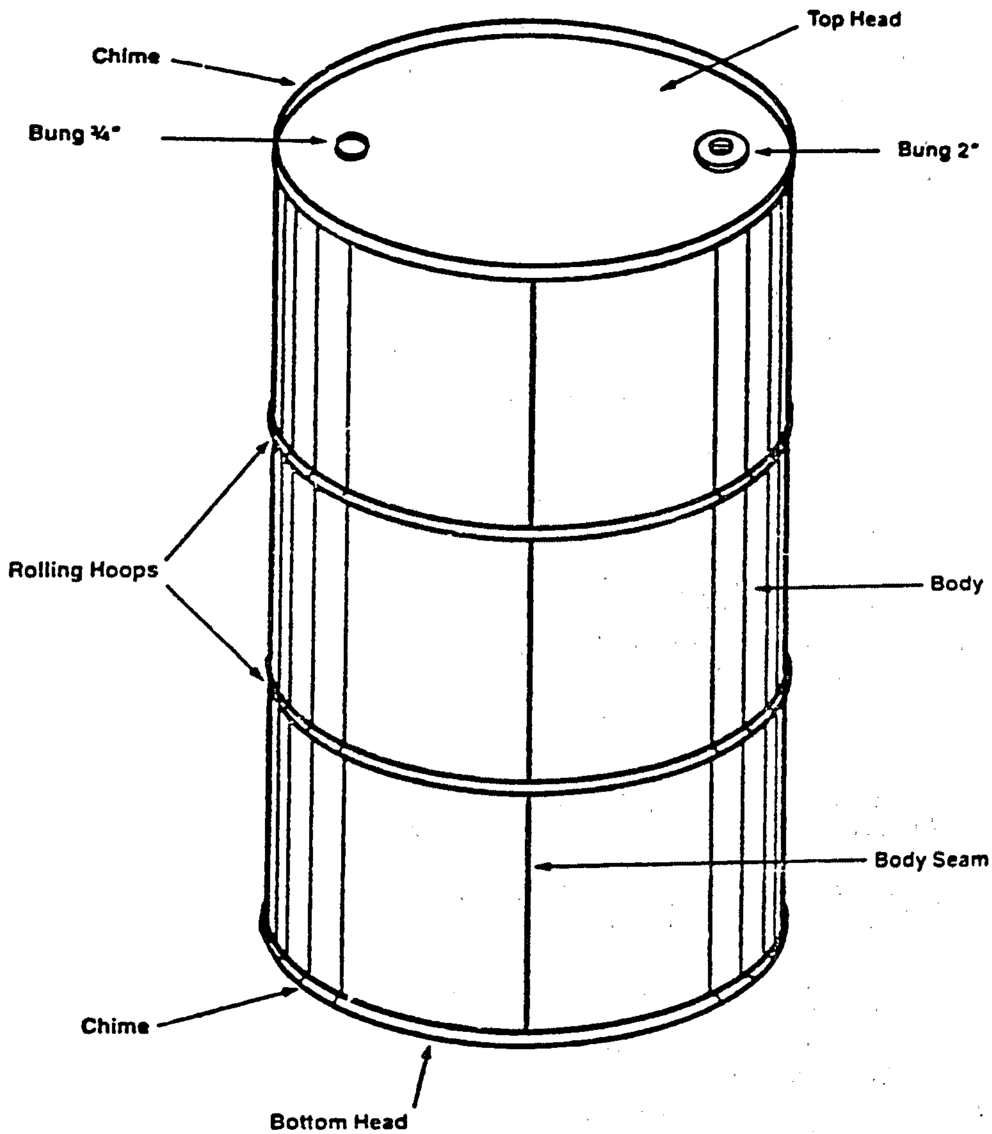

FIGURE 4-1

TYPICAL TIGHT HEAD DRUM

Touhill (1981a, 1981b) describes a large majority of drum reconditioning processes. Through site visits to 16 drum reconditioners, EPA has uncovered only one operation that was not addressed by Touhill. This includes preflushing with steam or solvents instead of caustic solutions.

4.2.1 Tight-Head Drums

Despite common usage of caustic washing, no tight-head reconditioning plants are identical (Touhill 1981a). Although many similarities exist among reconditioning plants, the maintenance or enhancement of environmental quality standards must be evaluated separately for each plant. A process diagram, which represents the general caustic washing process and its many variations, is shown in Figure 4-2.

Almost all reconditioners at washing plants perform some type of screening upon drum pickup or delivery at the reconditioning facility. Most reconditioners (more than 90 percent) will return to the shipper damaged drums, drums that are not empty, or drums that contain unacceptable materials. Many reconditioners have lists of the types of drums that they will not accept for processing. Moreover, the National Barrel and Drum Association (NABADA) and EPA have issued guidelines defining drum "emptiness." Both topics will be discussed later in this section as part of operating criteria and processing procedures.

Drums (especially oil drums) often are drained and preflushed before they enter the process lines. Some plants have oil siphons especially for oil recovery. After draining, drums receive a caustic preflush to remove the bulk of readily loosened material. Sometimes steam or, rarely, a solvent is used as a preflush agent. Prior to caustic preflushing, plant employees judge whether drums should proceed directly to a submerged caustic washer, should be chained to remove difficult adhering material, or should be converted by deheading to open-head drums, which are subsequently burned. In some cases, trained employees can detect drums that require conversion to open-head before the preflushing step. In some smaller plants, drums are transferred directly from trucks to a submerged caustic washer without draining, preflushing, and/ or chaining steps.

Most washing plants dedent drums after all caustic washing and rinsing has been completed, usually just before chime sealing and leak testing. However, some plants prefer to dedent drums immediately after draining or caustic preflushing. Presumably, dedenting is conducted at this stage so that drums can be classified earlier. Also, some reconditioners believe that it is easier to find dents as drums are rolled off of the trucks.

When the contents of a drum are difficult to remove using caustic alone, chains are inserted into the drum, along with caustic, and the drum is tumbled to dislodge adhering materials. Chaining typically occurs as a separate step prior to the submerged stripping caustic wash, or in conjunction with the submerged wash.

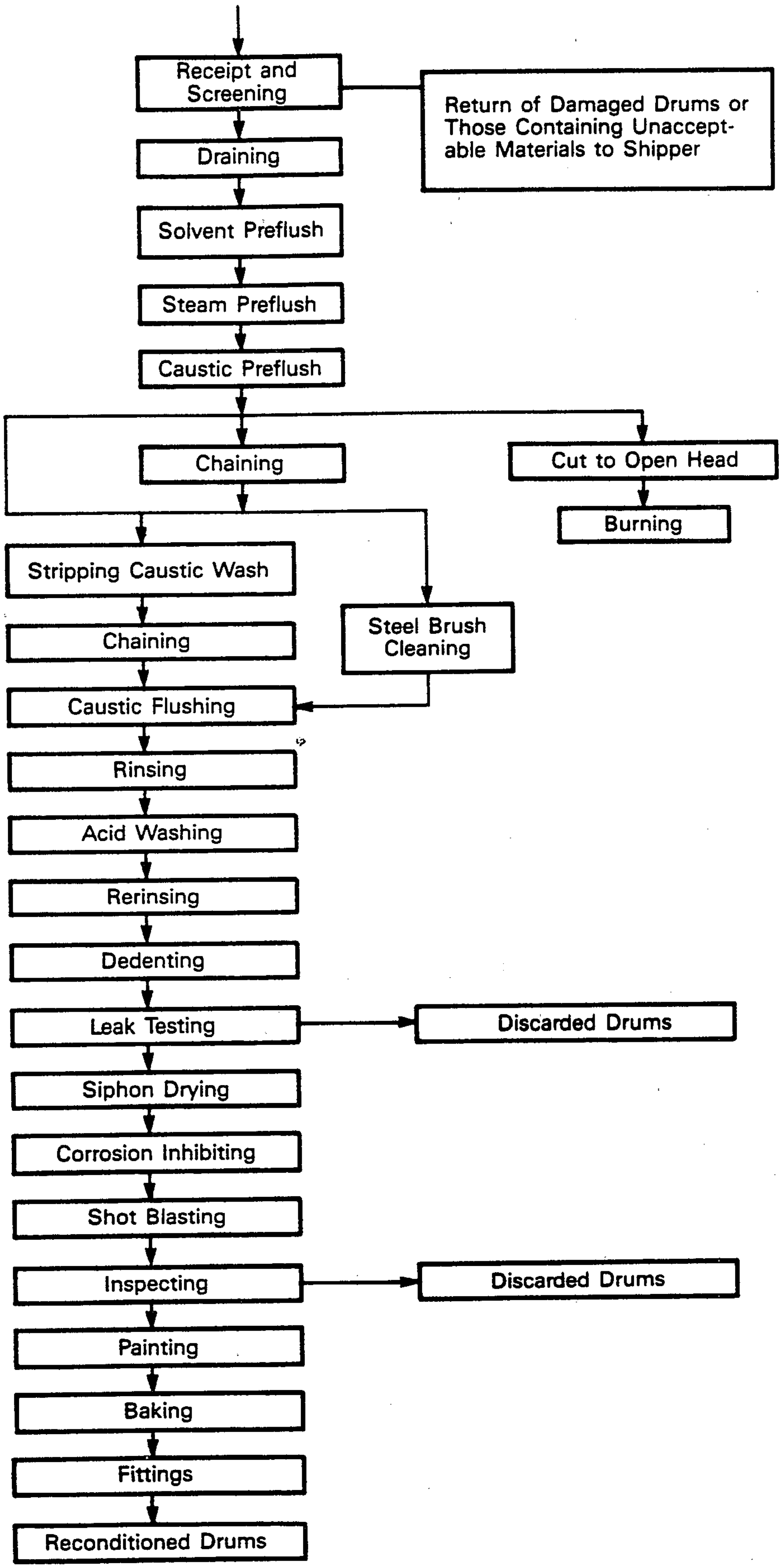

Figure 4-2. Drum Washing Process Diagram

Most often, drums that fail to be cleaned during chaining are sent for conversion to open-heads, but some washers will attempt a second chaining cycle. A few reconditioners will send chained drums to a subsequent caustic flush. Chains are usually about 0.76 meters (30 inches) long, and typically 6 to 20 pieces are used. Two kinds of chaining machines are employed. One of the more effective chaining machines rotates the drum around its vertical axis when laid on its side, and also causes horizontal rotation that permits the chain to contact both top and bottom heads as the machine moves from side to side. A second type of chaining machine performs the same process, but does not move from side to side; therefore, the drums must be moved to another machine, which stands the drum upright and again rotates about the vertical axis. In order to clean the other head, the drum would have to be turned over. In some cases, the heads are not chained. Upon completion, the chains are removed from the drums using wire hooks. Paint drums constitute the largest volume of drums that are chained. Drums containing automobile sealing compounds are thought to be among the most difficult to wash, so chaining is always used with these drums.

In most washing plants, drums are treated inside and out by submerging the drum in a hot caustic bath. Drums are set on their sides with bungs removed and are rotated as they proceed through the caustic bath. The caustic strength usually ranges between 10 and 15 percent and is heated to between 82°C (180°F) and 93°C (200°F). In larger plants, drums proceed in assembly-plant style. Typically, two receiving arms automatically lower the drums into the submerger. The drums are held in place by wheels that permit flow of the solution into the drums. One plant pumps solution over the top of the drums as they rotate to achieve better stripping. In this same plant, both preflush and submerger caustic tanks are insulated to conserve heat. In smaller plants, drums are handled batchwise, but the cleaning principle remains the same. Some plants only use hot caustic to wash the insides of the drums. Rotating steel brushes remove paint from the outsides of the drums. This procedure is not common. After caustic washing, regardless of the manner in which it was conducted, drums are rinsed. Finished drum quality improves with better rinsing; therefore, rinsewater is kept as clean as possible.

About 40 percent of washers follow the caustic rinse step with an acid wash. An acid wash is conducted primarily to remove rust spots. Re-rinsing follows the acid wash. A corrosion inhibition step is used by some washing plants. Its location in the flow train varies. Some washers prefer to siphon dry after rinsing, then dedent, chime seal, and leak test before shot blasting. Other washers chime seal and leak test after shot blasting. After the caustic and acid rinses, drums are dried using vacuum siphons.

Dedenting of tight-head drums is conducted using compressed air: 560 kPa (80 psi) pressure is used for 18 gauge drums, and 280 kPa (40 psi) for 20 gauge drums. Worker safety necessitates that the drum be shielded during dedenting. Weak drums occasionally rupture explosively upon application of compressed air.

The bottom chime is sealed on all reconditioned drums because the most frequent types of leaks are those around the bottom chime, and because handling and shipping often cause the drums to become out-of-round.

Leak testing is an operation critical to maintaining product quality control. Several methods are used, as follow:

- Leak testing is conducted by inserting an expandable plug connected to a compressed air line into the 5-cm (2-inch) bung hole. The 2-cm (3/4-inch) bung hole already has a fitting in place. After the plug is inserted, a star wheel rotates to hold the drum completely submerged for about 5 seconds while approximately 7 pounds of internal pressure are maintained within the drum.

- The drum is pressurized with an air hose in the 2-cm (3/4-inch) bung hole with the 5-cm (2-inch) bung in place. The drum then rotates under a soap spray.

- The drum is pressurized to 49 to 56 kPa (7 to 8 psi), and an air valve is closed behind an air gauge. The operator checks the gauge for a pressure drop.

- In some cases, carbon monoxide is used to pressurize the drum. If leaks are found, the drum is repaired or discarded.

During shot blasting, a small steel shot is used to abrade the drum exterior. Shot blasting serves two purposes: (1) it cleans the outside of the drum, removing residual paint, labels, or caustic; and (2) it prepares the surface for painting. Paint adheres better to rough drum surfaces. Some reconditioners use steel buffing to prepare drum surfaces for painting.

Some reconditioners preheat drums before painting in order to improve finish quality, and some facilities bake the paint. Upon inspection and placement of final fittings, the drums are ready to be shipped.

4.2.2 Open-Head Drums

The burning process for open-head drums differs significantly from the washing process, since relatively little water is used. The description of burning pertains to a continuous tunnel furnace operation, although close similarities exist between the process train at batch and continuous furnace plants (Touhill 1981a). Figure 4-3 shows a process diagram for a burning facility. Such plants have fewer unit operations than washing plants. Less variation tends to exist among burning plants than among washing facilities.

Figure 4-3

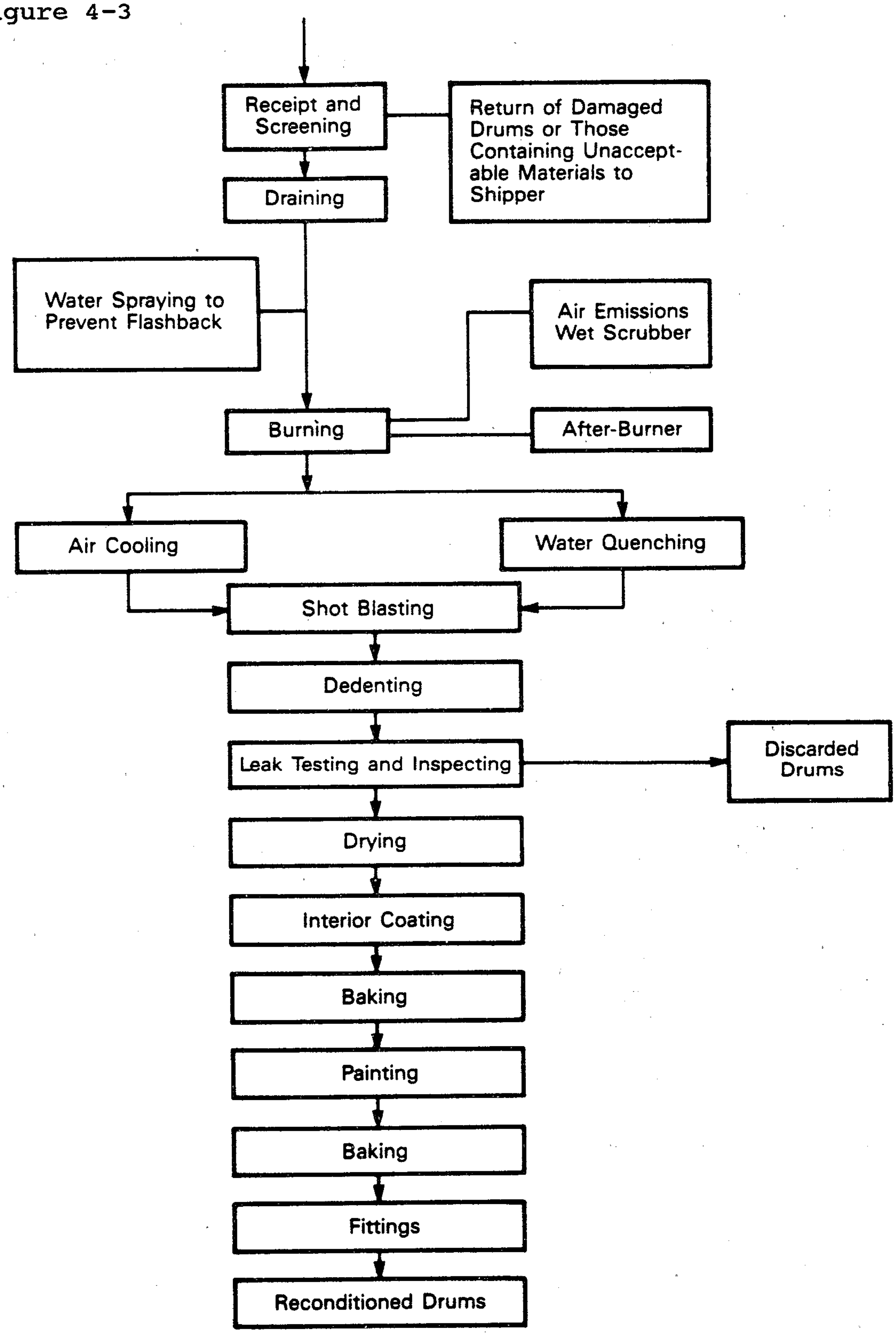

Figure 4-3. Drum Burning Process Diagram

At most plants, drums are inspected upon receipt, and those drums that contain residues beyond plant criterion for emptiness, and those that contain unacceptable materials, are returned to the shipper along with damaged drums. Some reconditioners drain the drums before burning in order to reduce temperature excursions due to materials within the drum. Other reconditioners believe that the best method of removing the residuals in the drum is to burn them directly; thus, draining before burning is avoided. Except for a few small batch incinerators, most open-head drums are burned in tunnel-type continuous furnaces. Conveyor belts move the drums through a furnace at an average rate of 6 to 8 drums per minute. During a 4-minute residence time, drum residual contents, linings, and outside paint are burned.

Some furnaces have water sprays or steam injection at the inlet opening to prevent flashbacks, and hence possible operator injury. Other furnaces contain built-in distance barriers to reduce operator exposure to flashbacks. Most burning plants have afterburners. Some afterburners plants are continuously in operation, but most are designed to operate only when an opacity detector signals that particulates are in the furnace emission. When drums exit the furnace, they are either air-cooled or water-quenched. About 40 percent of burning plants have the capability to quench, but not all use this capability all of the time. Some burning plants only operate the water quencher when burning residues remain on drum surfaces, or when there is a visible emission from the drum outlet opening.

The next two operations are shot blasting and dedenting, which can occur in either order. Shot blasting is essentially the same as for washing plants, except that burned drums (open-head) are shot blasted inside and out. In some plants, dust from shot blasting is removed by vibration, and is removed by a washing step in other plants. Dedenting is different for burning operations than in washing plants. Open-head drums are dedented mechanically with an expander dedenter. A few plants incorporate a step where a rust inhibitor is applied in water spray. This step is not conducted when the drum is intended to have an interior liner.

After shot blasting and dedenting, the bottom chime is sealed on a chime roller. The drum is then leak tested and inspected. Leak testing is similar to the testing conducted for tight-head drums, except instead of an expandable plug for a bung hole, a cap for the entire head is used. When leaks are detected, the drums are set aside for repair or discard.

After drying, drums receive an interior coating (epoxy and phenolic linings) and the outsides are painted. These finishes usually are baked on. Effective use of heat is made in some instances where the first bake for the interior coating is the preheat for the painting booth. Upon placement of the lids and rings, the drums are ready to be shipped.

4.3 INDUSTRY SUBCATEGORIZATION

The primary purpose of industry subcategorization is to establish groupings within the drum reconditioning industry such that each grouping has a uniform set of effluent limitations. This requires that the elements of each group be capable of using similar treatment technologies to achieve effluent limitations. Thus, the same wastewater treatment and control technology is applicable within a subcategory and a uniform treated effluent results from the application of a specific treatment and control technology.

The information presented in this section demonstrates that drum type is a dominant aspect that can be used to subcategorize the industry with respect to wastewater generation, control, treatment, and discharge. Drum type includes open- or tight-head drums. Drum type determines the reconditioning process selection. Reconditioning processes include burning for open-head drums and washing for either steel or plastic tight-head drums.

4.4 POTENTIAL FOR INDUSTRY GROWTH

Drum reconditioning industry growth is largely a function of local economic conditions. Drum usage, and subsequent reconditioning, reflects demand for petroleum, paint, chemical, and other products. The Agency visited three drum reconditioners in Detroit Michigan, in 1986, at a time when automotive production levels were high. Each reconditioner reported that business was good as a result of demand in the automotive industry. Conversely, the Agency contacted several reconditioners in Oklahoma and Texas who stated that business was off due to a recession in the oil industry (SAIC 1981d).

In 1985, 50 million drums were reconditioned (Rich 1986). This represents a 20 percent increase over the 1979 level of 41 million (Touhill 1981a). This increase is equivalent to a compounded growth rate of about 3 percent per year. Steel drum reconditioners, in 1979, believed that the emergence of plastic drums posed no serious threat to their industry. In recent years, plastic drums have become a more attractive alternative, since they provide a means for ultimate disposal. Plastic drums and residual contents are being incinerated in large furnaces, rather than being reconditioned. This form of incineration offers a means for ultimate hazardous waste disposal and the plastic has a high BTU content (SAIC 1987e).

4.5 SUMMARY

The following list summarizes the major points that were discussed in this section:

- Steel and polyethylene drums are reconditioned for reuse at 450 facilities located throughout the Nation. The EPA

Region with the largest number of reconditioners is Region IV, with 24 percent of the Nation's facilities. New Jersey, California, and Illinois are the states with the largest numbers of reconditioners.

- The status of the industry's wastewater discharges is as follows:

Discharge Status	Number of Facilities
Direct Discharge	50
Indirect Discharge	200
Zero Discharge	200
Total	450

- Drum reconditioning facilities are registered under 28 different SIC codes. Two-thirds of the 40 million drums reconditioned annually are tight-head drums that are washed with caustic solution to remove residues. The remaining are open-head drums that are burned in furnaces to remove viscous residues. The following list summarizes the major sources of drums received by reconditioners:

Drum Source	Percent
Petroleum	36
Chemicals	25
Resins and Adhesives	16
Paint and Ink	15
Other	8
Total	100

- Drum reconditioning facilities may be subcategorized by drum type: either open-head or closed-head.

- The industry is not expected to grow or decline significantly, hence, the waste quantities estimated in this report are reasonable projections of future waste quantities.

5. WATER USES AND WASTEWATER CHARACTERIZATION

This section describes sources, volumes, and characteristics of wastewaters that are generated by drum reconditioning processes. Summary data are presented that can be used to characterize wastewater generated at an average facility. A discussion of analytical methodology and factors affecting the recovery of pollutants and their quantification also is presented.

5.1 POLLUTANT ANALYSIS, RECOVERY, AND QUANTIFICATION

In order to fully interpret analytical data, quality assurance/quality control (QA/QC) information must first be evaluated. This is especially true for the analysis of organic pollutants. Of particular concern in organics analysis is percent recovery. For example, if 100 μg/l of a compound is reported but the percent recovery is 50 percent, the real concentration could be 200 μg/l. Conversely, if the recovery is 1,000 percent, the real concentration could be 10 μg/l. Expected recoveries for organic compounds using Contract Laboratory Protocols (CLP) are 60 to 150 percent and for pesticides the recovery is 60 to 200 percent. The percent recovery for a compound becomes increasingly important when concentrations are low (i.e., near their detection limits).

The detection limits for the various organics found in this industry sampling effort ranged from 10 to 5,000 μg/l, depending on the compound and the sample. Several reasons for the wide range in detectable limits are:

- A sample extract containing a large concentration of organics can overload the GC/MS. Consequently, the full-strength extract cannot be analyzed, making dilutions necessary and resulting in high detection limits.
- Some detection limits are high, even in "clean water." For example, the detection limit for some organics in reagent water range from 10 to 250 μg/l.
- High concentrations of a few compounds can overshadow other results. In this case, it may be necessary to use large dilutions to quantify the compounds present in high concentrations, thereby diluting those found in low concentrations. When the full-strength extract is rerun to detect and quantify the low concentration compounds, the high concentration compounds mask their presence.
- Some polar compounds (such as organic acids) are readily soluble in water, and are hard to separate and analyze with a GC. Furthermore, some polar compounds do not extract well during the extraction procedure.

Variability inherent in the methods used to analyze conventional and nonconventional pollutants must also be evaluated in order to interpret analytical data. For example, the U.S. Environmental Protection Agency, Industrial Technology Division (EPA-ITD) analytical results for BOD_5 are only accurate to ± 30 percent within a 95 percent degree of confidence. Consequently, dissolved BOD_5, a fraction of total BOD_5, can be reported, within method accuracy limits, to be greater than total BOD. A similar circumstance exists for ammonia, which is a fraction of total Kjeldahl nitrogen. The reported levels of precision and accuracy are for analyses conducted on natural water samples, not the complex matrices found in samples collected during the study. Furthermore, precision and accuracy data are not available from EPA-ITD methods for parameters such as COD and solids.

Such analytical problems were experienced by the laboratories used during the 1986-87 sampling programs. This resulted in pollutants not being found in samples, when high concentrations of these pollutants had been found in similar wastewaters in other samples. Future ITD sampling analysis efforts will be designed to correct these problems.

5.2 WATER USAGE

5.2.1 Tight-Head Drum Processing

Water is used in most stages of the tight-head drum washing process and the degree of water usage varies among facilities. In 1979, respondents to the National Barrel and Drum Association (NABADA) questionnaire indicated that their water usage rate averaged 13.3 gallons per drum (Touhill 1981a). EPA collected usage data from 10 facilities in 1987 and calculated an average water usage rate of 10 gallons per drum. The usage rates range from 2 to 30 gallons per drum. There is no apparent correlation of water usage rate to facility size (SAIC 1987b).

5.2.2 Open-Head Drum Processing

Water is used primarily in the quenching stage of the open-head drum burning process. Water is also used in other stages, but to a much lesser degree. In 1979, respondents to the NABADA questionnaire indicated that their water usage rate averaged 10.9 gallons per drum. EPA collected usage data from two facilities in 1987 and calculated an average water usage rate of 10.6 gallons per drum. The facility usage rates were 5.2 and 16 gallons per drum, respectively (SAIC 1987b).

5.3 WASTEWATER SOURCES

5.3.1 Tight-Head Drum Processing

Wastewater generated by tight-head drum washing processes is largely the result of direct contact of water washes, rinses, and sprays with drums and their contents. The Agency estimates that approximately 15 percent of the water used in tight-head plants is lost to evaporation; therefore, 9 gallons of wastewater are generated and discharged per drum. This generation rate is the result of the comingling of numerous internal wastestreams, which may be classified as follows: caustic wash, rinse water, and combined plant discharges. Each of the three classes is described below.

- Caustic Wash - This wastestream generally is recycled for reuse after screening and sedimentation. It results from preflushing, chaining, and caustic flushing.

- Rinse Water - This wastestream usually is discharged to the sewer, but is sometimes treated and used as makeup to the caustic wash system. It results from rinsing, re-rinsing, leak testing, and siphon drying. Acid washing and corrosion inhibition wastewaters generally are recycled, but are sometimes discharged with rinse wastestreams.

- Combined Plant Discharges - This wastestream usually is discharged to the sewer, but is sometimes treated and used as makeup to the caustic wash system. It results from the combination of discharged caustic washes, rinses waters, air pollution scrubber blowdown, paint booth water curtain blowdown, boiler blowdown, cooling water, sanitary wastewater, and runoff.

5.3.2 Open-Head Drum Processing

Water quenching, or furnace quenching, is unique to the open-head process and is the primary source of wastewater. Other wastewaters generated in the open-head process are similar to those found in the combined plant discharges generated at tight-head plants. These wastewaters include air pollution scrubber blowdown, paint booth water curtain blowdown, cooling water, sanitary wastewater, and runoff. EPA estimates that most of the water used in the quenching process is lost to evaporation and an average 2.8 gallons of wastewater is generated per drum (SAIC 1987b).

5.3.3 Industry Wastewater Flow

To estimate the total mass of pollutants discharged by the drum reconditioning industry, a facility flow must be selected that is representative of industry practice. Some plants wash tight-head drums and some burn open-head drums, while other plants conduct both activities. If 50 million drums were reconditioned in 1986, then 427 drums were reconditioned daily per plant, assuming that each plant operates 260 days per year. Since two-thirds of the drums reconditioned are tight-head drums, the following flow can be estimated for an average drum plant: 2/3 x 9 gallons per tight-head drum + 1/3 x 2.8 gallons per open-head drum = 6.9 gallons per drum.

An average daily plant discharge can be calculated as the product of 427 drums times 6.9 gallons, or 3,000 gpd per facility. For the estimated 250 drum reconditioners that discharge wastewater, the total industry discharge is 0.75 million gallons per day.

5.4 WASTEWATER CHARACTERIZATION

Since most drum reconditioners accept a wide range of drum types, wastewater characteristics vary from month to month. Only a few drum reconditioners are dedicated to reconditioning a single drum type. For example, EPA visited one plant that only reconditioned petroleum drums and another that only reconditioned paint drums. Generally, however, the mix of drum types at a plant shifts with cyclic economic trends and the daily marketplace.

Data are available to characterize quantitatively drum reconditioning wastewater pollutants. Recent sampling and analysis conducted by EPA-ITD constitute the most comprehensive and representative data available. ITD sampled four facilities, which collectively represent the industry. Analyses were conducted for over 400 parameters, including conventional and nonconventional pollutants, metals, and volatile and extractable organics, dioxins/furans, and pesticides/herbicides. Less comprehensive data are available from other sources, which are compared to ITD data later in this section. In 1979, in response to the NABADA survey, wastewater analyses were compiled and reported (Touhill 1981a). In 1981, the EPA Office of Research and Development (ORD) conducted wastewater sampling and analyses at three drum reconditioning facilities as part of an impact assessment of multi-media emissions (Touhill 1981b). The results of these various data-gathering efforts are summarized below.

5.4.1 EPA-ITD Sampling Data

EPA-ITD conducted presampling site visits at 16 drum reconditioners to select candidates for its wastewater and sludge sampling program. Four facilities were selected for sampling, since they are representative of the industry in terms of plant size, types of drums reconditioned, and wastewater flow. Each of the four facilities treats wastewater prior to discharge. Capsule descriptions of each facility, identified here as Plants A, B, C, and D, are presented below.

- Plant A is a medium-sized drum washing plant that processes 900 drums per day. Drum types processed are petroleum (60 percent), solvent (30 percent), and others. No caustic wash is recycled.

All process wastewater is treated by oil/water separation prior to discharge. The sampled wastestream did not contain nonprocess wastes such as boiler blowdown and sanitary wastewater.

- Plant B is a small washing plant that reconditions 200 drums per day, 95 percent of which are paint drums. Caustic wash is recycled. All process wastewater is treated by air flotation prior to discharge. The sampled, untreated wastestream did not contain nonprocess wastewater.

- Plant C is small washing plant that reconditions 100 petroleum drums per day. Process wastewater is treated by sedimentation prior to discharge. Caustic wash is recycled after sedimentation. The sampled, untreated wastestream did not contain nonprocess wastewater.

- Plant D is a large facility that washes 3,000 drums per day and burns another 3,000 drums per day. The tight-head drums washed are petroleum, (30 percent), chemicals (30 percent), resins (20 percent), paint (10 percent), and others. The open-head drums processed are paint (80 percent), adhesives (10 percent), and others. Caustic wash is recycled after sedimentation and screening. Quench water from the burning process is comingled with wastewater from the washing operation. Quench water constitutes 26 percent of the total flow to the facility's air flotation treatment system. No nonprocess wastestreams, such as boiler blowdown or sanitary wastewater, are comingled with process wastewater. Treated process wastewater is recycled for reuse as caustic wash makeup water, since much of the caustic wash is lost to evaporation.

Plants A, B, C, and D are representative of typical industry practice with respect to wastewater flow and drum type. The respective plant flows are 13,700 gpd, 2,700 gpd, 300 gpd, and 15,000 gpd. The total flow is 32,450 gpd, or 4.5 gallons per drum. This estimate is only 35 percent less than the 6.9 gallon per drum flow estimated in Section 5.2. About 4,000 gpd, or 12 percent of the total flow, is attributable to open-head processing. As mentioned in Section 5.2, an average drum plant discharges 6.9 gallons per drum, of which 0.9 gallons, or 13 percent, is attributable to open-head processing. Since these values compare closely, EPA believes that its summarized pollutant data represent industry raw wastewater. In addition, the percentage of drum types reconditioned at Plants A, B, C, and D compare well with the industry wide distribution shown in Table 4-1.

5.4.1.1 Raw Wastewater

The facilities mentioned above were sampled for internal wastestreams, treated effluent, and wastewater treatment sludges, in addition to raw wastewater. Only raw wastewater characteristics are discussed here. Treated effluent characteristics, internal wastestreams, and sludge characteristics are discussed in Section 6. The samples were analyzed for conventional, nonconventional, and priority pollutants, as well as compounds on the ITD list of analytes. The discussion below focuses on the analytical fractions reported for all of the untreated, raw wastewater samples collected by ITD. These fractions are: (1) conventionals and nonconventionals, (2) volatile and extractable organics, (3) metals, and (4) pesticides/herbicides.

A total of nine raw wastewater samples was taken at four facilities. Two methods were used to determine mean concentrations for individual pollutants. The first method reflects the concentration of the pollutant when it is present in a sample and the calculation does not include the use of zero, or not detected values. The second method reflects an industry average level and the calculation includes the use of zero, or not detected values.

- Conventionals and Nonconventionals - Raw wastewaters sampled by EPA ITD exhibited a pH greater than 11.0 and high levels of all of the parameters listed in Table 5-1. The mean biochemical oxygen demand BOD_5 is 3,710 mg/l; total suspended solids (TSS) is 4,710 mg/l; and oil and grease is 13,200 mg/l. The high concentrations reflect the fact that about 10 gallons of water are used to wash each drum and each drum is permitted by 40 CFR 261.7 to contain up to 1 inch, about 1.6 gallons, of residue.

- Volatile and Extractable Organics - The data in Table 5-2 show that 42 extractable and volatile organic compounds were detected at the 4 plants sampled. The compounds detected at more than two plants are 1,1,1-trichloroethane, 2-butanone (MEK), 2-chloronaphthalene, benzoic acid, benzyl alcohol, biphenyl, ethylbenzene, hexanoic acid, methylene chloride, naphthalene, n-hexadecane, nitrobenzene, p-cymene, styrene, toluene, and trichloroethene. Industry mean concentrations greater than 10 mg/l appear for five of the detected pollutants. The two highest means are acetone at 858 mg/l, and 2-butanone at 716.

- Metals - The data in Table 5-3 show high levels for numerous metals in the raw wastewater. Seven of the 27 compounds are detected at levels over 10 mg/l. These are aluminum, iron, lead, magnesium, sodium, calcium, and zinc. In addition to the quantitative analyses, qualitative analyses were run to determine the presence of additional metals. Results are shown in Table 5-4. Only iodine, phosphorus, potassium, and sulfur are detected at more than one plant.

TABLE 5-1. EPA-ITD SAMPLING PROGRAM COMPARISON OF RAW WASTEWATER

Fraction: Conventionals and Nonconventionals

Sample Point: Raw Wastewater

Plant No.	A	B	B	C	D	D	D	D	D	
Episode No.	1128	1130	1130	1133	1179	1179	1179	1179	1179	
Sample No.	15339	15344	15348	15357	15713	15715	15718	15722	15725	
Sample Date	Jul 23, 1986	Aug 6, 1986	Aug 7, 1987	Sep 18, 1987	Feb 2, 1987	Feb 3, 1987	Feb 4, 1987	Feb 5, 1987	Feb 6, 1987	Mean
Parameter										
Ammonia	13	22.5	9.0	.10	6.59	16.1	5.53	2.25	11.8	9
BOD_5, Total	3900	2200	418	720	16800	7500	10900	6300	3140	3710
BOD_5 Dissolved	1980	2550	2160	480	9000	4400	4640	2790	4710	2480
Chloride	50	1500	1400	200	2800	5100	4200	3200	3400	1360
COD, Dissolved	3140	3860	4400	800	45500	26400	15100	19000	22800	8460
COD, Total	6110	3860	5400	1330	75600	38100	102000	31800	40600	17400
Dissolved Solids	8850	5710	8940	21000	29900	27200	28200	20000	18800	15500
Fluoride	30	40	15	26	89.7	59	53	37.3	29	34
Oil & Grease	3240	4810	2940	34000	12900	5600	33000	4940	2540	13200
Phenol	1.61	1.51	92	2.2	169	87.4	68.8	64.7	53.2	34
Suspended Solids	4980	1850	780	20	21800	9270	20600	5220	5710	4710
Suspended Vol. Solids	880	63	50	8	16000	4033	15500	2675	4700	2380
TKN	5	1.75	46	1.6	428	270	257	20.2	291	70
Total Cyanide	8.3	1.9	.66	6.8	.57	.48	.58	.48	.05	4
Total Organic Carbon	1520	1600	210	269	19300	8500	7200	5650	10590	2990
Total Vol. Solids	3200	3170	1175	392	29940	14280	26370	9880	10590	5990
pH	10.2	12.6	12.7	11.4	12.4	12.6	12.6	12	12	NR

NOTE: All concentrations expressed in mg/l (mg/l = milligrams per liter).
Mean = mean of plant means
NR indicates data not reported

TABLE 5-2. EPA-ITD SAMPLING PROGRAM COMPARISON OF RAW WASTEWATER

Fraction: Extractable and Volatile Organics

Sample Point: Raw Wastewater

Plant No.	A	B	B	C	D	D	D	D	D	
Episode No.	1128	1130	1130	1133	1179	1179	1179	1179	1179	
Sample No.	15339	15344	15348	15357	15713	15715	15718	15722	15725	
Sample Date	Jul 23, 1986	Aug 6, 1986	Aug 7, 1987	Sep 18, 1987	Feb 2, 1987	Feb 3, 1987	Feb 4, 1987	Feb 5, 1987	Feb 6, 1987	Mean
Parameter										
1,1,1-Trichloroethane	355	ND-100	ND-100	ND-10	36179	11825	71613	26035	ND-100	18400
1,1-Dichloroethene	ND-10	ND-100	ND-100	ND-10	25286	ND-1000	ND-100	ND-100	ND-100	25300
1,2-Dichloroethane	ND-10	ND-100	ND-100	ND-10	ND-1000	ND-1000	ND-100	315	ND-100	315
2,4-Dinitrotoluene	ND-100	ND-10	ND-10	11	ND-100	ND-100	ND-1000	ND-100	ND-100	11
2-Butanone (MEK)	534	ND-500	1361630	ND-50	987690	ND-5000	18823	ND-500	1351260	716000
2-Chloronaphthalene	4609	46	46	ND-10	ND-100	ND-100	ND-1000	ND-100	ND-100	2320
2-Methylnaphthalene	ND-10	ND-10	24	ND-10	ND-100	ND-100	ND-1000	ND-100	ND-100	24
2-Nitrophenol	ND-200	ND-20	ND-2000	ND-20	ND-200	ND-200	3256	2739	2866	2950
Acetone	ND-50	ND-500	ND-500	ND-50	498139	677250	ND-500	2046290	209456	858000
Alpha-Terpineol	4745	ND-10	ND-10	ND-10	ND-100	ND-100	ND-1000	ND-100	ND-100	475
Benzoic Acid	ND-500	ND-50	94999	230	ND-500	ND-500	ND-500	ND-500	ND-500	47600
Benzyl Alcohol	ND-10	ND-10	59	ND-10	9817	ND-100	ND-1000	ND-100	9051	4750
Biphenyl	ND-100	14	ND-10	71	1266	ND-100	1394	ND-100	ND-100	472
Bis (2-Ethylhexyl) Phthalate	ND-100	ND-10	ND-10	ND-10	5419	43747	43078	9285	5718	21400
Butyl Benzyl Phthalate	ND-100	ND-10	ND-10	ND-10	ND-100	ND-100	3281	ND-100	ND-100	3280
D-N-Butyl Phthalate	ND-100	ND-10	ND-10	ND-10	2088	ND-100	13561	ND-100	5012	6890
Diphenyl Ether	ND-100	ND-10	ND-10	ND-10	ND-100	ND-100	2457	ND-100	ND-100	2460
Ethylbenzene	221	3179	ND-100	110	186495	ND-1000	75039	7857	62143	21600
Fluorene	ND-100	ND-10	ND-10	12	ND-100	ND-100	ND-1000	ND-100	ND-100	12
Hexanoic Acid	ND-10	383	ND-10	1165	ND-100	ND-100	ND-100	ND-100	ND-100	774
Isobutyl Alcohol	ND-10	3517	ND-10	ND-10	ND-1000	ND-1000	ND-100	ND-100	ND-100	3520
Isophorone	ND-100	ND-10	ND-10	ND-10	5392	25392	3371	ND-100	22038	14000
Methylene Chloride	ND-10	ND-100	ND-100	4197	ND-1000	15443	ND-100	ND-100	ND	9820

TABLE 5-2. EPA-ITD SAMPLING PROGRAM COMPARISON OF RAW WASTEWATER (Continued)

Fraction: Extractable and Volatile Organics

Sample Point: Raw Wastewater

Plant No.	A	B	B	C	D	D	D	D	D	
Episode No.	1128	1130	1130	1133	1179	1179	1179	1179	1179	
Sample No.	15339	15344	15348	15357	15713	15715	15718	15722	15725	
Sample Date	Jul 23, 1986	Aug 6, 1986	Aug 7, 1987	Sep 18, 1987	Feb 2, 1987	Feb 3, 1987	Feb 4, 1987	Feb 5, 1987	Feb 6, 1987	Mean
Parameter										
N-Decane (N-C10)	11750	ND-10	ND-10	ND-10	ND-100	ND-100	ND-1000	ND-100	ND-100	11800
N-Docosane (N-C22)	ND-100	ND-10	ND-10	ND-10	ND-100	ND-100	ND-1000	3424	12309	7870
N-Dodecane (N-C12)	6950	ND-10	ND-10	ND-10	ND-100	ND-100	ND-1000	ND-100	ND-100	6950
N-Hexadecane (N-C16)	1066	ND-10	ND-10	ND-10	ND-100	ND-100	ND-1000	1178	ND-100	1120
N-Octacosane (N-C28)	ND-100	ND-10	ND-10	ND-10	ND-100	ND-100	ND-1000	28081	ND-100	28100
N-Octadecane (N-C18)	ND-100	ND-10	ND-10	ND-10	3983	ND-100	13354	ND-100	ND-100	8670
N-Tetradecane (N-C14)	ND-100	ND-10	ND-10	ND-10	ND-100	44127	ND-1000	5754	ND-100	24900
Naphthalene	ND-100	382	ND-10	174	8842	17954	5503	2775	ND-100	3100
Nitrobenzene	ND-100	16	ND-10	12	ND-100	ND-100	ND-1000	ND-100	ND-100	14
O-Cresol	ND-10	143	37	ND-10	ND-100	ND-100	ND-1000	ND-100	ND-100	90
P-Cymene	ND-10	72	49	83	ND-100	ND-100	1996	ND-100	ND-100	713
Phenanthrene	ND-100	ND-10	ND-10	ND-10	ND-100	ND-100	ND-1000	11577	ND-100	11600
Phenol	ND-100	ND-10	ND-10	ND-10	932	ND-100	ND-1000	ND-100	ND-100	932
Styrene	ND-100	144	98	ND-10	34620	30372	18836	ND-100	4950	11200
Tetrachloroethene	ND-10	ND-100	ND-100	ND-10	ND-1000	ND-1000	86267	ND-100	ND-100	86300
Thioxanthone	ND-20	311	ND-20	ND-20	ND-200	ND-200	ND-2000	ND-200	ND-200	311
Toluene	507	55572	262	25	107977	ND-1000	42672	6159	54123	20300
Trans-1,2-Dichloroethene	ND-10	ND-10	ND-10	ND-10	ND-1000	ND-1000	ND-100	917	ND-100	917
Trichloroethene	95	ND-100	ND-100	ND-10	ND-1000	ND-1000	4038	1278	4575	1696

Note: ND = Not detected above detection limit. Detection limit shown.
All concentrations expressed in µg/l (µg/l = micrograms per liter).
Mean is the mean of detected values. Calculation does not include not detected or zero values. For example, mean trichloroethene = [95+(4038+1278+4575)/3]/2 = 1696

TABLE 5-3. EPA-ITD SAMPLING PROGRAM COMPARISON OF RAW WASTEWATER

Fraction: Metals

Sample Point: Raw Wastewater

Plant No.	A	B	B	C	D	D	D	D	D	
Episode No.	1128	1130	1130	1133	1179	1179	1179	1179	1179	
Sample No.	15339	15344	15348	15357	15713	15715	15718	15722	15725	
Sample Date	Jul 23, 1986	Aug 6, 1986	Aug 7, 1986	Sep 18, 1986	Feb 2, 1987	Feb 3, 1987	Feb 4, 1987	Feb 5, 1987	Feb 6, 1987	Mean
Parameter										
Aluminum	7800	9900	9400	3100	90800	71700	61300	37900	36100	20000
Antimony	562	16	15	41	33600	9780	10200	6820	6140	3480
Arsenic	31	20	23	18	500	62	72	16	78	54
Barium	2600	1800	1500	89	1230	2200	1500	7510	5260	1970
Beryllium	50	ND-1	ND-1	2	7	ND-5	ND-5	ND-5	ND-5	19.7
Boron	880	34	13	480	7700	6100	7270	6320	7390	2080
Cadmium	29	7	6	7	695	285	4690	1340	883	405
Calcium	47000	26000	21000	9200	120000	77000	97000	40600	50000	39200
Chromium	6700	1000	830	630	6430	3360	4720	3420	4120	3160
Cobalt	210	140	120	68	1700	760	1170	1090	1320	404
Copper	1400	400	390	250	4810	4780	5940	2640	3240	1580
Iron	10000	46000	40000	9000	693000	201000	592000	180000	216000	106000
Lead	27000	2400	2400	3300	37600	18200	34600	16500	19300	14500
Magnesium	14000	7600	6100	3900	40400	22600	28300	11600	13800	12000
Manganese	700	2100	1800	63	5130	3250	6890	2510	2720	1700
Mercury	ND-.2	1.3	1.1	.5	41	20	28	8.5	10	7.7
Molybdenum	340	100	110	280	853	1040	1880	1540	2230	558

TABLE 5-3. EPA-ITD SAMPLING PROGRAM COMPARISON OF RAW WASTEWATER (Continued)

Fraction: Metals

Sample Point: Raw Wastewater

Plant No.	A	B	B	C	D	D	D	D	D	
Episode No.	1128	1130	1130	1133	1179	1179	1179	1179	1179	
Sample No.	15339	15344	15348	15357	15713	15715	15718	15722	15725	
Sample Date	Jul 23, 1986	Aug 6, 1986	Aug 7, 1986	Sep 18, 1986	Feb 2, 1987	Feb 3, 1987	Feb 4, 1987	Feb 5, 1987	Feb 6, 1987	Mean
Nickel	120	34	36	16	991	376	1030	363	419	201
Selenium	ND-5	25	25	11	ND-5	50	ND-5	ND-5	ND-5	28.7
Silver	ND-1	ND-1	ND-1	ND-1	18	8.4	5.7	ND-1	7.3	9.9
Sodium	1800000	1500000	1800000	9000000	8800000	9090000	9510000	7290000	6720000	5180000
Thallium	ND-10	ND-10	ND-10	ND-10	100	100	ND-10	ND-10	ND-10	100
Tin	240	120	150	230	5730	4190	6390	5620	4230	1460
Titanium	59	700	500	24	2610	860	1190	577	666	475
Vanadium	12	60	59	ND-2	82	ND-50	95	ND-50	ND-50	35.3
Yttrium	ND-10	ND-10	ND-10	ND-10	ND-50	ND-50	ND-50	ND-50	ND-50	ND
Zinc	13000	17000	18000	3300	80400	54300	108000	44300	43500	25000

Note: All concentrations expressed in µg/l (µg/l = micrograms per liter).
PPT = parts per trillion
ND = Not detected above detection limit. Detection limits shown.
Mean is the mean of nonzero values. Calculation does not include not detected or zero values. For example, mean vanadium = [12+(60+59)/2 + (82+95)/2]/3 = 35.3

TABLE 5-4. EPA-ITD SAMPLING PROGRAM COMPARISON OF PROCESS WASTEWATER

Fraction: Superscan Metals

Sample Point: Raw Wastewater

Metal	Plant Code			
	A	B	C	D
Bismuth		D		
Cerium				
Dysprosium		D		
Erbium		D		
Europium				
Gadolinium				
Gallium				
Germanium		D		
Gold				
Hafnium				
Holmium				
Indium				
Iodine	D			D
Iridium				D
Lanthanum				D
Lithium				D
Lutetium				D
Neodymium				
Niobium				
Osmium				
Palladium				
Phosphorus	D	D	D	D
Platinum				D
Potassium	D	D		D
Praseodymium				
Rhenium				
Rhodium				
Ruthenium				
Samarium				
Scandium				
Silicon				D
Strontium				D
Sulfur	D	D	D	D
Tantalum				
Tellurium				
Terbium				

TABLE 5-4. EPA-ITD SAMPLING PROGRAM COMPARISON OF PROCESS WASTEWATER (Continued)

Fraction: Superscan Metals

Sample Point: Raw Wastewater

Metal	Plant Code			
	A	B	C	D
Thorium				
Thulium				
Tungsten		D		
Uranium				
Ytterbium				
Zirconium				D

NOTE: D = detected
Blank indicates not detected

- Pesticides/Herbicides - Analyses were conducted for 99 pesticide/ herbicide parameters on samples collected from Plants A, B, and C. No pesticides or herbicides were detected. Two samples were collected at Plant D and a total of 10 parameters were detected, as shown in Table 5-5. The following compounds were detected at levels greater than 1.0 mg/l: azinphos ethyl, azinphos methyl, fensulfothion, diazinon, dimethoate, and leptophos.

5.4.1.2 Quench Water

A sample of quench water was obtained from Plant D to characterize raw wastewater generated by open-head processes. As mentioned previously, this wastewater is combined with tight-head process wastestreams at Plant D and is reflected in the data presented in Tables 5-1 through 5-5. The data discussed here are for a segregated wastewater flow of 2.7 gallons per drum. The open-head drum types reconditioned were paint (90 percent) and adhesives (10 percent). The discussion below focuses on the analytical fractions reported and comparisons are made between open- and tight-head drum reconditioning wastewaters.

- Conventional/Nonconventional Parameters - The open-head quench wastewater exhibits high levels of all of the parameters listed in Table 5-6. The levels are high and in general only slightly less than the levels reported for tight-head process wastewater. The pH level is lower at 8.2. The high levels reflect the fact that water in the open-head process is only used to extinguish burning residue on drums after incineration. Values for selected parameters are presented below to demonstrate the comparability of the tight- and open-head process wastewaters.

	Concentration (mg/l)	
	Tight-Head	Open-Head
BOD_5	3,710	2,600
COD, total	17,400	51,900
TSS	4,710	9,470
Oil and Grease	13,200	5,300
TOC	2,990	4,040

- Volatile and Extractable Organics - The data in Table 5-7 show that 14 volatile and extractable compounds were detected and 13 were measured at levels over 1.0 mg/l. Most of the compounds detected are also found in open-head process wastewater; however, 4-methyl-2-pentanone is not. The two highest measurements are for methylene chloride at 103 mg/l and 2-butanone (MEK) at 67 mg/l.

TABLE 5-5. EPA-ITD SAMPLING PROGRAM COMPARISON OF RAW WASTEWATER

Fraction: Pesticides/Herbicides

Sample Point: Raw Wastewater

Plant	D	D	
Episode No.	1179	1179	
Sample No.	15713	15718	
Sample Date	Feb. 2, 1987	Feb. 4, 1987	Mean
Parameter			
Endosulfan I	296	ND	296
Endosulfan Sulfate	ND	528	528
Heptachlor	284	ND	284
Etridazone	252	ND	252
Azinphos Ethyl	4260	ND	4260
Azinphos Methyl	6207	4689	5448
Fensulfothion	5795	7859	6827
Diazinon	ND	1035	1035
Dimethoate	ND	1500	1500
Leptophos	ND	3959	3959

Note: ND = not detected above detection limit
All concentrations expressed in μg/l (μg/l = micrograms per liter).
Mean is the mean of nonzero values. Calculation does not include not detected or zero values.

TABLE 5-6. EPA-ITD SAMPLING PROGRAM

Fraction: Conventionals and Nonconventionals

Plant Sample Point Sample No. Sample Date	D Furnace Quench 15720 Feb. 5, 1987	Raw Wastewater Mean
Parameter		
Ammonia	33	9
BOD-5, Total	2600	3710
BOD-5, Dissolved	1520	2480
Chloride	333	1360
COD, Dissolved	18000	8460
COD, Total	51900	17400
Dissolved Solids	6170	15500
Fluoride	10.8	34
Oil & Grease	5300	13200
Phenol	38.7	34
Suspended Solids	9470	4710
Suspended Vol Solids	13600	2380
TKN	564	70
Total Cyanide	.28	4
Total Organic Carbon	4040	2990
Total Vol Solids	19100	5990
pH	8.2	11

NOTE: All concentrations expressed in mg/l.
mg/l = milligrams per liter
Mean from Table 5-1

TABLE 5-7. EPA-ITD SAMPLING PROGRAM
QUENCH WATER COMPARISON TO RAW WASTEWATER

Fraction: Extractable and Volatile Organics

Plant	D	
Episode Number	1179	
Sample Point	Furnace Quench	Raw Wastewater
Sample No.	15720	Mean
Sample Date	Feb. 5, 1987	
Parameter Units		
1,1,1-Trichloroethane	16720	18400
2-Butanone (MEK)	67663	716000
4-Methyl-2-Pentanone	17787	ND
Acetone	15630	858000
Benzyl Alcohol	4636	4750
Bis (2-ethylhexyl) Phthalate	881	21400
Ethylbenzene	12130	21600
Isophorone	14437	14000
Methylene Chloride	103233	15400
Naphthalene	5345	3110
O-Cresol	2586	90
P-Cymene	1002	713
Styrene	12678	11200
Toluene	16598	20300

NOTE: All concentrations expressed in $\mu g/l$.
ug/l = micrograms per liter
Raw wastewater data are only reported here for pollutants found in quench water.
Mean from Table 5-2

- Metals - The data in Table 5-8 show that metals are found at high levels in quench water. Eight of the 27 compounds are detected at levels over 10 mg/l. These are aluminum, calcium, chromium, iron, lead, magnesium, sodium, and zinc. Except for chromium, the same is true for tight-head process wastewater. A qualitative metals analysis showed that iodine, lithium, phosphorus, potassium, silicon, strontium, and sulphur were present. These compounds also are present in drum washing wastewater.

- Pesticides/Herbicides - Two pesticide/herbicide compounds were detected. These are heptachlor at 73 μg/l and TEPP at 6,900 μg/l.

- Dioxins/Furans - In addition to the analyses above, analyses also were conducted for dioxins/furans, since these compounds are sometimes associated with high-temperature wastestreams. Of the 25 parameters analyzed for, 17 compounds were detected. Only one compound, OCDD, was detected at a level greater than 100 parts per trillion (ppt). Data for all compounds are shown in Table 5-9. No dioxin/furan analyses were conducted on raw wastewater samples.

EPA-ITD data presented here for tight- and open-head process wastewaters are representative of the industry wastestreams. In the discussion that follows, other sources of data are presented. Finally, at the end of this section, the EPA-ITD data are compared to these other sources.

5.4.2 NABADA Survey Data

Data obtained in the NABADA survey from drum reconditioners are collated in Table 5-10 (Touhill 1981a). The analyses are for a variety of wastewater types (e.g., spent caustic, rinse water, and clarified effluents), and thus are indicative only of the ranges of concentrations that might be encountered. The data demonstrate that high levels of BOD, COD, TSS, and oil and grease are present in untreated drum reconditioning wastewater. For example, COD is reported at 24,549 mg/l and oil and grease at 10,228 mg/l. Average levels greater than 10 mg/l are reported for chromium, iron, lead, and zinc.

5.4.3 EPA-ORD Sampling Data

In 1981, EPA-ORD reported the results of its sampling and analysis of three reconditioning plants, which was conducted to define pollutant levels in various wastestreams (Touhill 1981b). The three facilities selected for testing were: (1) a large drum washing plant that recycles most of its caustic washing and rinsing solutions, (2) a large burning and washing plant that recycles

TABLE 5-8. EPA-ITD SAMPLING PROGRAM
QUENCH WATER COMPARISON TO RAW WASTEWATER

Fraction: Metals

Plant	D	
Episode Number	1179	
Sample Point	Furnace Quench	Raw Wastewater
Sample No.	15720	Mean
Sample Date	Feb. 5, 1987	
Parameter		
Aluminum	47300	20000
Antimony	599	3480
Arsenic	10	54
Barium	5680	1970
Beryllium	5	19
Boron	7270	2080
Cadmium	734	405
Calcium	173000	39200
Chromium	11700	3160
Cobalt	3520	404
Copper	1150	1580
Iron	47100	106000
Lead	11300	14500
Magnesium	29800	12000
Manganese	1500	1700
Mercury	.8	7
Molybdenum	789	558
Nickel	1210	201
Selenium	25	29
Silver	1	10
Sodium	773000	5180000
Thallium	50	100
Tin	353	1460
Titanium	781	475
Vanadium	50	53
Yttrium	50	ND
Zinc	107000	25000

NOTE: All concentrations expressed in µg/l.
µg/l = micrograms per liter
ND indicates not detected above detection limits
Mean from Table 5-3.

TABLE 5-9. EPA-ITD SAMPLING PROGRAM

Fraction: Dioxins/Furans

Plant	D
Episode Number	1179
Sample Point	Furnace Quench
Sample No.	15720
Sample Date	Feb. 5, 1987

Parameter	Units	
1234678-HpCDD	ppt	14.69
1234678-HpCDF	ppt	2.04
123478-HxCDF	ppt	0.55
123678-HxCDD	ppt	0.37
123789-HxCDD	ppt	0.36
234678-HxCDF	ppt	0.54
2378-TCDF	ppt	0.21
OCDD	ppt	202.72
OCDF	ppt	10.35
Total HpCDD	ppt	26.41
Total HpCDF	ppt	6.86
Total HxCDD	ppt	3.37
Total HxCDF	ppt	2.65
Total PCDD	ppt	0.63
Total PCDF	ppt	1.01
Total TCDD	ppt	1.19
Total TCDF	ppt	7.25

NOTE: ppt = parts per trillion

TABLE 5-10. DRUM RECONDITIONING WASTEWATER DATA OBTAINED THROUGH THE NABADA SURVEY

Parameter (mg/l)	Number of Observations	Mean	Range	
			Low	High
BOD	31	4,599	10	44,133
COD	24	24,549	91.5	310,909
TSS	46	2,435	77	24,000
Phenols	21	43.8	0.044	148
Oil and grease	37	10,228	19.2	248,340
Cadmium	12	0.10	0.0002	0.90
Chromium	26	12.5	0.023	244
Copper	16	2.4	0	23.0
Iron	12	114	1.6	1,041
Lead	29	45.8	0	682
Mercury	11	1.0	0	5.9
Nickel	12	0.3	0	1.0
Zinc	33	24.0	0.1	228

caustic wash but discharges rinse water, and (3) a large washing plant that handles substantial volumes of pesticide containers. These plants are identified as Plants E, F, and G, respectively. Selected samples at each facility were each analyzed for only a limited fraction of pollutant para-meters. Table 5-11 lists the wastestreams sampled and pollutant fractions analyzed for the three plants. The facilities are described in more detail below.

- Plant E is a large drum washing plant that recycles most of its caustic washing and rinsing solutions. During the sampling period, 2,400 drums were processed each 8-hour work day. Of the containers processed, 75 percent were empty oil drums, while the remainder formerly contained paint, varnish, acrylics, and various other chemicals.

- Plant F is a large drum washing and burning plant that recycles caustic washing solutions, but does not recycle rinse water. During the 4-day sampling period at the washing facility, approximately 1,200 to 1,400 drums per day were processed. About 90 percent were empty oil drums, whereas the remainder formerly contained paints, resins, and various chemicals.

- Plant G is a facility that washes pesticide containers. During the 5-day sampling period, approximately 16,000 drums were processed. On the first day of sampling, 468 pesticide drums were washed. A total of 4,000 drums of all types were processed that day. The pesticide drums contained either parathion, diazinon, or nemacur. No pesticide drums were washed during the remaining 4 days of the sampling period. However, all composite samples were analyzed for pesticides to determine concentrations remaining in the caustic washing solution.

The analytical results were reported for the following aqueous wastestreams, which are discussed below: (1) spent caustic wash, (2) clarified caustic wash, and (3) quench water.

5.4.3.1 Spent Caustic Wash

Spent caustic wash is a concentrated internal wastestream with a high pH that is the result of the primary washing operations at a drum washing plant. Based on the data presented in Table 5-12 for Plants E, F, and G, an average COD level of 100,000 mg/l can be anticipated. The levels reported for several metals at Plant E are high, especially lead and zinc, which are 227 and 362 mg/l, respectively.

Plant G spent caustic wash was analyzed for three pesticide parameters, since 12 percent of the drums washed at that plant contained pesticides. Five samples were analyzed for diazinon, nemacur, and parathion. The average levels measured for the respective parameters were 1.1, 1.7, and 2.4 mg/l, respectively.

TABLE 5-11. EPA-ORD STUDY

Wastestream	Drum Washing Wastestreams Sampled and Parameters Measured			
	Plants Sampled for Conventional and Nonconventional Pollutants	Plants Sampled for Metals	Plants Sampled for Organics	Plants Sampled for Pesticides
Spent Caustic Wash	E,F,G	E		G
Clarified Caustic Wash	E,F	E	E,F	-
Caustic Sludge	-	E,G	E,F	-
Ash Quench Water	-	-	F	-
Furnace Ash	-	F	F	-

TABLE 5-12. EPA-ORD STUDY DATA FOR SPENT CAUSTIC WASH PLANTS E, F, AND G

COD (mg/l)

Plant	Sample 1	Sample 2	Sample 3	Average
E	94,300	124,000	-	109,150
F	41,700	386,000	-	213,850
G (Tank #1)	59,800	66,700	83,500	70,000
G (Tank #2)	29,200	30,500	35,500	31,730

Plant E (mg/l)

	Sample 1	Sample 2
Aluminum	59.0	54.2
Antimony	32.9	11.5
Arsenic	2.56	0.596
Barium	3.09	1.79
Beryllium	<0.009	<0.001
Boron	848	535
Cadmium	0.002	0.002
Chromium	0.240	0.330
Cobalt	2.55	2.95
Copper	0.520	0.500
Iron	86.1	46.1
Lead	227	23.6
Magnesium	0.690	<0.001
Manganese	5.26	1.29
Mercury	<0.001	<0.001
Molybdenum	18.9	12.5
Nickel	5.33	7.19
Phosphorus	274	189
Selenium	0.087	0.271
Silicon (%)	13.4	7.68
Strontium	0.120	0.070
Thallium	<0.01	<0.1
Tin	39.0	12.4
Titanium	1.90	3.38
Vanadium	2.34	1.88
Zinc	362	250

5.4.3.2 Clarified Caustic Wash

Caustic wash is generally clarified and reused. Sometimes polymers are added to aid clarification. The data in Table 5-13 show high levels of COD and organics in clarified caustic wash waters at Plants E and F. Plants E and F handled drums that previously contained petroleum oils, paints, or organic chemicals. The metals measured in the clarified caustic at Plant E are lower than the levels shown in Table 5-12 for its unclarified caustic wash. This is probably due to the removal of suspended solids by clarification.

5.4.3.3 Ash Quench Water

Water is used to quench burning residue and control potentially airborne ash on drums that have been burned. The organic pollutant data in Table 5-14 show high levels of ethylbenzene, 1,1,1-trichloroethane, and toluene for a quench water sample drawn from Plant F.

5.4.4 Compliance Monitoring Data

EPA-ITD, as part of its current study, visited drum reconditioners to identify suitable candidates for wastewater sampling. During its visits, compliance sampling data were collected for eight facilities. Each of the eight facilities is required to monitor periodically for pollutants specified in their publicly-owned treatment works (POTW) pretreatment permit. Therefore, all data reported here represent actual facility discharges to POTWs. Table 5-15 lists the eight facilities that supplied compliance monitoring data. Plant characteristics also are listed. The eight facilities reflect the broad range of drum types processed and include both large and small plants. However, more data are reported for washing processes than for burning processes. Half of the facilities recycle caustic wash water and five of the eight treat their wastewater prior to discharge.

Effluent monitoring data are summarized in Table 5-16. The ranges reported for most parameters are wide; however, the means and medians for BOD and COD compare closely. BOD and COD both average over 2,000 mg/l in the discharges. Values over 1,000 mg/l for TSS and oil and grease are common. The metals chromium, iron, lead, mercury, and zinc typically are measured at concentrations greater than 1.0 mg/l.

5.4.5 Comparison of Data Sources

EPA-ITD data are the most comprehensive and representative available for characterizing industry raw wastewater. Data reported from other sources confirm the high levels of conventional and nonconventional pollutants measured by EPA-ITD. Analytical data were collected by EPA-ITD for samples of untreated, raw wastewater from four facilities. Data were reported by several of the 49 NABADA survey respondents for treated and untreated

TABLE 5-13. EPA-ORD STUDY ANALYSIS DATA FOR CLARIFIED CAUSTIC WASH PLANTS E AN F

Concentration (mg/l)

	Plant E		Plant F	
	Sample 1	Sample 2	Sample 1	Sample 2
COD	20,700	22,100	514,000	511,000
Acenaphthene	-	-	<50	100
Anthracene	0.2	0.03	-	-
Aliphatics, C7-18	-	-	150,000	250,000
Phenanthrene Benzene	<0.01	<0.01	-	-
Benzenes, C3-C4	-	-	50,000	74,000
Chlorobenzene	<0.01	<0.01	-	-
2-Chlorophenol	<0.025	<0.025	-	-
Bis-(2-ethylhexyl)-Chrysene	-	-	<50	<320
1,2-Dichlorobenzene	0.02	<0.01	-	-
2,4-Dimethylphenol	1.25	0.29	-	-
Ethylbenzene	0.05	0.08	-	-
Fluoranthene	-	-	70	500
Methylene Chloride	0.02	0.01	-	-
Naphthalene	0.2	0.03	1,500	70,000
n-Nitrosodiphenylamine	1.07	-	-	-
p-chloro-m-cresol	1.52	-	-	-
Phenol	2.62	0.8	-	-
Phenols, total	18.8	14.2	340	330
Pyrene	-	-	100	20
Tetrachloroethylene	<0.01	<0.01	-	-
Silicones	-	-	200	300
Toluene	0.3	0.35	-	-
1,2,4-Trichlorobenzene	-	<0.01	-	-
1,1,1-Trichloroethane	<0.01	<0.01	-	-
Aluminum	54.1	<0.012	-	-
Antimony	10.5	4.48	-	-
Arsenic	0.630	0.494	-	-
Barium	0.970	0.015	-	-
Beryllium	<0.001	<0.001	-	-
Boron	437	55.3	-	-
Cadmium	0.220	<0.002	-	-
Calcium	4.03	14.0	-	-
Chromium	0.510	<0.004	-	-
Cobalt	1.92	0.655	-	-
Copper	0.480	0.525	-	-
Cyanides	4.70	<0.002	2.59	
0.915				
Iron	40.4	32.6	-	-
Lead	45.4	23.0	-	-
Magnesium	0.010	1.27	-	-
Manganese	0.690	<0.001	-	-
Mercury	<0.001	<0.001	-	-

TABLE 5-13. EPA-ORD STUDY ANALYSIS DATA FOR CLARIFIED CAUSTIC WASH PLANTS E AND F (Continued)

Concentration (mg/l)

	Plant E		Plant F	
	Sample 1	Sample 2	Sample 1	Sample 2
Molybdenum	9.67	8.81	-	-
Nickel	7.29	<0.036	-	-
Phosphorus	179	158	-	-
Selenium	0.146	0.037	-	-
Silicon (%)	0.394	376	-	-
Silver	0.320	<0.005	-	-
Sodium (%)	6.79	7.96	-	-
Strontium	0.020	<0.001	-	-
Thallium	<0.1	<0.1	-	-
Tin	10.8	4.62	-	-
Titanium	0.810	0.335	-	-
Vanadium	1.41	0.360	-	-
Zinc	204	2.07	-	-

TABLE 5-14. EPA-ORD STUDY
ANALYTICAL DATA FOR ASH QUENCH WATER
PLANT F

Parameter	Concentration (mg/l)
Benzene	0.04
Ethylbenzene	0.43
Chloroform	<0.01
Chloroethane	0.01
1,1-Dichloroethane	0.03
1,2-Dichloroethane	<0.01
1,1,1-Trichloroethane	0.47
1,1-Dichloroethylene	0.12
Trichloroethylene	0.01
Tetrachloroethylene	0.01
Toluene	6.39
Methylene Chloride	0.11
Trichlorofluoromethane	<0.01

TABLE 5-15. COMPLIANCE MONITORING DATA FACILITY CHARACTERISTICS

Plant	Drum Types Processed	Process Type	Process Throughput (Drums/day)	Is Caustic Wash Recycled (Yes/No)	Wastewater Treatment
A	60% Petroleum 30% Solvents 10% Other	Washing	900	No	Oil/Water Separation and Sedimentation
D	80% Paint (Open-Head) 10% Adhesives (Open-Head) 10% Other (Open-Head) 30% Petroleum (Tight-Head) 30% Chemicals (Tight-Head) 20% Resins 10% Paint (Tight-Head) 10% Other (Tight-Head)	• Burning • Washing	3,000 3,000	Yes	Sedimentation and Air Flotation
H	70% Food (Open-Head) 15% Paint (Open-Head) 15% Petroleum (Tight-Head)	• Burning• • Washing•	1,200 200	Yes	Sedimentation
I	60% Petroleum 20% Plating 10% Food 10% Soaps, disinfectants	Washing	350	No	None
J	60% Petroleum 25% Food 15% Other	Washing	300	No	None
K	65% Food, paint, adhesives, and asphalt (Open-Head) 35% Petroleum, chemicals, and paint (Tight-Head)	• Burning • Washing	1,000 425	Yes	Oil/Water Separation and Sedimentation
L	95% Petroleum 5% Other	Washing	2,000	Yes	Oil/Water Separation and Sedimentation

TABLE 5-15. COMPLIANCE MONITORING DATA FACILITY CHARACTERISTICS (Continued)

Plant	Drum Types Processed	Process Type	Process Throughput (Drums/day)	Is Caustic Wash Recycled (Yes/No)	Wastewater Treatment
M	60% Petroleum 30% Paint, resins 10% Other	Washing	2,000	No	None

TABLE 5-16. PRETREATMENT COMPLIANCE MONITORING DATA FOR EIGHT DRUM RECONDITIONERS

Parameter (mg/l)	Number of Observations	Mean	Median	Range	
				Low	High
BOD_5	63	2874	2400	7	21,000
COD	6	5599	2510.5	45	18,697
TSS	75	1807	630	10	25,750
Oil and Grease	71	3688	964	11	57,744
Phenol	33	55.4	9.450	0.051	375
Phosphorus	64	39.2	17.15	<.02	323
Cyanide	32	0.381	0.1	0.005	4.81
Arsenic	6	0.005	0.006	0.003	.007
Cadmium	62	0.04	0.02	0.00	.62
Chromium (hexavalent)	6	0.088	0.12	<.025	<.12
Chromium	61	2.03	0.69	<.02	12.8
Copper	61	0.869	0.34	0.02	6.98
Iron	14	64.8	9.	1	434
Lead	63	6.21	1.38	<.02	33
Manganese	2	0.075	0.08	0.06	.09
Mercury	47	2.123	0.400	0.0	49.8
Nickel	58	0.806	0.145	0.0	22.5
Silver	9	0.012	0.01	0.01	.02
Zinc	63	11.2	2.53	0.05	108.5

wastestreams. Compliance monitoring data were collected from eight facilities and are representative of mixed process and nonprocess wastestreams, some of which have been treated. Summary data are shown below for BOD_5, COD, TSS, oil and grease, and phenol.

	Concentration (mg/l)		
	EPA-ITD	NABADA	Compliance Monitoring
BOD_5	3,700	4,600	2,900
COD	17,000	24,500	5,600
TSS	4,700	2,400	1,800
Oil and Grease	13,000	10,000	3,700
Phenol	35	43	55

Note: EPA-ITD data are for untreated wastewater. Other data sources are for treated and untreated wastewater as well as nonprocess wastewater.

High levels also are observed for metals across the data sources, as shown below for selected parameters.

	Concentration (mg/l)		
	EPA-ITD	NABADA	Compliance Monitoring
Chromium	3	12	2
Iron	106	114	64
Lead	14	45	6
Zinc	25	24	11

Note: EPA-ITD data are for untreated wastewater. Other data sources are for treated and untreated wastewater as well as nonprocess wastewater.

Extractable and volatile organic data are only available for quench water and an internal wastestream for the purpose of comparison to EPA-ITD data. The data in Table 5-12 show that at least 12 organics were observed in caustic wash samples from 2 plants. A sample of quench water shows that 10 priority pollutants were measured, as shown in Table 5-13. EPA-ITD detected 42 extractable and volatile compounds and wide ranges of concentrations were measured. No dioxin/furan data are available for comparing quench water data sources. The three pesticides observed at Plant F reflect the large number of pesticide drums reconditioned there. No pesticides were found at 3 of the 4 plants sampled by EPA-ITD; however, 11 compounds were detected at Plant D. The presence of pesticides and herbicides is probably a site-specific phenomenon.

5.5 SUMMARY

The following list summarizes the major points that were discussed in this section:

- The average drum reconditioner handles 427 drums daily and discharges 6.9 gallons of wastewater per reconditioned drum, or 3,000 gallons per day. Raw wastewater results from the washing and rinsing of tight-head drums or the quenching of burning residue on open-head drum surfaces.

- Industry raw wastewater is characterized by high concentrations of conventional, nonconventional, metal, and organic pollutants. The data shown below for selected parameters are representative of a typical raw wastewater:

Parameter	Concentration (mg/l)
BOD_5	3,710
TSS	4,710
COD	17,400
Oil and Grease	13,200
TOC	2,900
Iron	106
Lead	14
Zinc	25
2-Butanone	716
Acetone	858

- Forty-two extractable and volatile organics wee detected in industry raw wastewaters and 15 had concentrations greater than 10 mg/l.

- The following pesticide/herbicide compounds are found in industry raw wastewaters at levels greater than 1 $\mu g/l$: azinphos ethyl, azinphos methyl, fensofothion, diazinon, dimethoate, leptophos, nemacur, parathion, and TEPP.

6. CONTROL AND TREATMENT TECHNOLOGY

This section describes the types of control and treatment technologies used in the drum reconditioning industry. The pollutant removal effectiveness of these technologies also is discussed. In addition, the control technology that allows some reconditioners to achieve zero process wastewater is discussed.

6.1 INTRODUCTION

Drum reconditioning wastewater disposal practices are related to the types of treatment provided to internal and end-of-pipe wastestreams. Results of the National Barrel and Drum Association (NABADA) survey show that 75 percent of drum reconditioners recycle caustic wash to some degree (Touhill 1981a). Approximately 20 percent of the washing plants do not reuse caustic and discharge it to publicly-owned treatment works (POTWs). Another 20 percent reuse a portion of caustic and discharge the excess. About half of the plants do not discharge caustic to the sewer, since all of the caustic is reused. Rinse waters are discharged to POTWs by half of the washing plants and about 35 percent treat and reuse rinse water. NABADA survey results from 49 facilities show that none of the plants discharge caustic to surface waters and that 3 percent discharge rinsewaters to surface waters. All reconditioners that reuse wastewater must treat it. Typical caustic wash water treatment consists of screening and/or sedimentation. Oil/water separation and air flotation also are used to treat wastewater for reuse, but these treatments are more commonly used as end-of-pipe technologies. Sixty-one percent of the NABADA survey respondents reported the use of oil/water separators. Thirty-four percent use sedimentation, and 17 percent use air flotation. Fifty-six percent use screens to remove large solids and to reduce pump failure.

6.2 IN-PLANT CONTROL MEASURES

In-plant wastewater control measures provide methods for reducing the amounts of pollutants discharged by drum reconditioning facilities. The amount of drum residue brought onto facility property can be reduced if strict management procedures are enforced in the plant receiving area. Storm water contamination can be minimized if storage areas are well-maintained. The pollutant load to the wastewater treatment system can be reduced significantly if drums are drained prior to reconditioning. Water conservation measures can reduce pollutant levels and minimize the use of chemicals used in the reconditioning processes. Wastestream segregation is probably the most effective in-plant control measure practiced by reconditioners. Each of these control measures is discussed below.

6.2.1 Receiving

Drums arrive at reconditioning plants in three different ways: (1) drums can be delivered to the plant by users (usually for laundering as a service), (2) drums can be delivered by brokers who buy the drums from various users, or (3) the reconditioner can pick up the drums at the user's plant. In the first two cases, drums are inspected by trained personnel as they are unloaded from trucks. The following types of drums are refused for reconditioning and are returned to the user or broker:

- Damaged drums.
- Drums that contain more than 1 inch of residue, unless special provision is made to handle those materials.
- Drums that contain unacceptable materials, i.e., those containing hazardous materials and/or materials that the reconditioners customarily refuse (e.g., pesticides, resins, inks, adhesives, etc.).
- Drums without bungs, rings, and lids in place. (Such drums could be accepted, but reconditioners might charge a fee for placing bungs, rings, and lids on the drum.)

When drums are picked up by the reconditioners, drivers inspect the loading of each drum and refuse to load unacceptable drums. When drums are received at burning plants, either from trucks or storage, those known to create possible smoking problems (e.g., heavy grease, undercoat, or silicone) are segregated within a separate area. This permits mixing these drums into normal processing in order to minimize the potential for visible emissions. Such spacing is common at many burning plants.

6.2.2 Storage

All drums going into yard storage should have bungs in place, and rings and lids should be on the drums. This greatly reduces the potential for pollution of stormwater run-off. Furthermore, in some cases it may be appropriate for drums having ink or other water-soluble materials spilled on the outside to be wiped with an appropriate solvent before being sent into storage. This prevents contamination of stormwater run-off.

The storage area should be constructed to minimize the amount of stormwater coming into contact with the drums. Berms and dikes could be used for this purpose. In addition, storage areas could be paved where pollutants could threaten surface water or groundwater.

Because deteriorating drums can be a source of pollution, use of "first- in, first-out" (FIFO) yard inventory methods is suggested. Categorization of drums in storage yards helps in drum recovery, leads to better housekeeping, and aids in minimizing stormwater contamination.

6.2.3 Draining

Because Resource Conservation and Recovery Act (RCRA) regulations encourage better emptying of drums at the source, the need to drain drums before processing is lessened. However, draining of empty oil drums is recommended, since partially full drums continue to be received by drum reconditioners, based on recent U.S. Environmental Protection Agency (EPA) site visits.

Draining is desirable because any residue removed reduces the load on the caustic washing solution and the sludge volumes generated in the caustic. In addition, such drainage has a higher heat value than caustic sludge. This is an important consideration if incinerator disposal is contemplated. If an oil recovery pit is used, it should be kept clean so that oil can be offered for sale to refiners, or burned as fuel in the furnace of the reconditioner.

6.2.4 Water Conservation

In 1979, about 17.5 gallons of water were used to process a drum (Touhill 1981a). The current figure for the industry is estimated to be 6.9 gallons per drum for an average facility. By instituting water conservation measures, the volume of liquid wastestreams requiring treatment will be reduced. Methods for conserving water include:

- Cascading water use (reusing water for successive lower quality needs)
- Maintaining minimum flows for rinsing, leak testing, cleanup, boilers, and compressor cooling
- Mopping up spills rather than flushing to floor drains.

Some reconditioners have stated that water conservation methods should be applied carefully because concentrating some wastes could make their treatment more difficult.

6.2.5 Wastestream Segregation

Wastestream segregation is probably the most effective in-plant control measure practiced by drum reconditioners. It is essential to segregate caustic solutions and rinse waters, so that subsequent efforts to treat and reuse the various liquid wastestreams will be possible. Data are available from two sources that can be used to evaluate the effectiveness of wastestream segregation: (1) data from the EPA Office of Research and

Development (ORD), and (2) data from the EPA Industrial Technology Division (ITD).

EPA-ORD collected and analyzed samples of caustic wash and clarified caustic wash at a reconditioning facility identified in Section 5 as Plant E. These data are shown along with the pollutant removals in Table 6-1. Caustic wash segregation and treatment resulted in an 80-percent reduction in COD and a 50-percent reduction for most metals.

EPA-ITD collected a sample of caustic wash from Plant B to compare pollutant levels observed to those levels found in rinse water. Analytical results for a recycled caustic wash sample and a raw rinse wastewater sample are compared in Tables 6-2 through 6-4. Conventional and nonconventional pollutants and metals observed in the caustic wash are one order of magnitude greater than the levels observed in rinsewater. A similar conclusion cannot be drawn for the extractable and volatile organics from the data shown in Table 6-4.

6.3 WASTEWATER TREATMENT

The three predominant wastewater treatment technologies used in the drum reconditioning industry are sedimentation, oil/water separation, and air flotation. Effluent from these treatment systems are either discharged to the sewer or reused in the facility as either caustic wash makeup or as quench water.

EPA-ITD, as part of its current study, collected influent and effluent samples from sedimentation, oil/water separation, and air flotation treatment systems at four drum reconditioning facilities. This sampling effort characterized wastewater that is discharged to the sewer and determined removal efficiencies of the treatment systems. The four facilities, Plants A, B, C, and D, were described in Section 5. The treatment systems in operation at these facilities are described in the discussions below on sedimentation, oil/water separation, and air flotation. Data are also available to characterize treatment system effluents and to determine pollutant removal efficiencies.

6.3.1 <u>Sedimentation</u>

Sedimentation treatment systems generally consist of a tank that provides several hours detention time for a wastestream. During detention, solids settle and the clarified effluent overflows from the tank. Solids are scraped or pumped from the tank and contract hauled.

Plant C uses a batch sedimentation treatment system that incorporates chemical addition. At Plant C, drums are first flushed with kerosene to remove petroleum residue. Drums are later washed with a caustic solution and then rinsed. The process wastewater is composed of 50 percent wash water and 50 percent

TABLE 6-1. COMPARISON OF CAUSTIC WASH TO CLARIFIED CAUSTIC WASH PLANT E

Parameter (mg/l)	Spent Caustic Wash Average Concentration[1]	Clarified Caustic Wash Average Concentration[1]	Percent Removal
COD	109,150	21,400	80
Aluminum	56.6	27.1	52
Antimony	44.4	7.5	83
Arsenic	1.58	0.56	65
Barium	2.44	0.49	80
Boron	692	246	64
Cadmium	0.101	0.111	0
Calcium	2.95	9.0	0
Chromium	0.29	0.257	11
Cobalt	2.75	1.29	53
Copper	0.51	0.503	1
Iron	66.1	2.35	96
Lead	125.3	34.2	73
Magnesium	0.346	0.64	0
Manganese	3.28	0.34	90
Molybdenum	15.7	9.2	41
Nickel	6.26	3.66	42
Phosphorus	232	169	27
Selenium	0.179	0.092	49
Silver	0.005	0.163	0
Strontium	0.095	0.011	88
Tin	25.7	7.71	70
Titanium	2.64	0.573	78
Vanadium	2.11	0.885	58
Zinc	306	103	66

[1] Data listed are the average result of two samples.

TABLE 6-2. EPA-ITD SAMPLING PROGRAM
COMPARISON OF CAUSTIC FLUSH TO RINSE WATER

Fraction: Conventionals and Nonconventionals

Plant	B	B
Episode Number	1130	1130
Sample Point	Caustic Flush	Raw Wastewater
Sample No.	15346	15348
Sample Date	Aug. 6, 1986	Aug. 7, 1986
Parameter		
Ammonia	175	9.0
BOD-5, Total	7200	418
BOD-5, Dissolved	9000	2160
Chloride	6800	1400
COD, Dissolved	101000	4400
COD, Total	100000	5400
Dissolved Solids	279000	8940
Fluoride	500	15
Oil & Grease	2380	2940
Phenol	1.83	92
Sulfide	.1	.1
Suspended Solids	26600	780
Suspended Vol Solids	633	50
TKN	630	46
Total Cyanide	.29	.66
Total Organic Carbon	3300	210
Total Vol Solids	55300	1175
pH	13	12.7

NOTE: All concentrations expressed in mg/l.
mg/l = milligrams per liter

TABLE 6-3. EPA-ITD SAMPLING PROGRAM
COMPARISON OF CAUSTIC FLUSH TO RINSE WATER

Fraction: Extractable and Volatile Organics

Plant	B	B
Episode Number	1130	1130
Sample Point	Caustic Flush	Raw Wastewater
Sample No.	15346	15348
Sample Date	Aug. 6, 1986	Aug. 7, 1986
Parameter		
O-Cresol	ND	37
1,1,2,2-Tetrachloroethane	35165	ND
2-Butanone (MEK)	661070	1361630
2-Chloronaphthalene	4392	46
2-Methylnaphthalene	ND	24
Alpha-Terpineol	2433	ND
Benzoic Acid	ND	94999
Benzyl Alcohol	ND	59
Ethylbenzene	16294	ND
Hexanoic Acid	42	ND
Isobutyl Alcohol	12939	ND
Naphthalene	2727	ND
P-Cymene	ND	49
Styrene	ND	98
Toluene	369160	262

NOTE: ND indicates not detected above detection limits
All concentrations expressed in µg/l.
ug/l = micrograms per liter

TABLE 6-4. EPA-ITD SAMPLING PROGRAM
COMPARISON OF CAUSTIC FLUSH TO RINSE WATER

Fraction: Metals

Sample Point:	Caustic Flush	Raw Wastewater
Plant No.	B	B
Episode No.	1130	1130
Sample No.	15346	15348
Sample Date	Aug. 6, 1986	Aug. 7, 1986
Parameter		
Aluminum	270000	9400
Antimony	326	15
Arsenic	467	23
Barium	38000	1500
Beryllium	10	1
Boron	1600	13
Cadmium	86	6
Calcium	440000	21000
Chromium	16000	830
Cobalt	2900	120
Copper	8000	390
Iron	760000	40000
Lead	90000	2400
Magnesium	120000	6100
Manganese	41000	1800
Mercury	4.0	1.1
Molybdenum	3000	110
Nickel	800	36
Selenium	325	25
Silver	13	1
Sodium	58000000	1800000
Thallium	130	10
Tin	3000	150
Titanium	13000	580
Vanadium	1600	59
Yttrium	110	10
Zinc	650000	18000

NOTE: All concentrations expressed in $\mu g/l$.
$\mu g/l$ = micrograms per liter

rinse water. The process wastewater, which has a high pH, is neutralized in a mixing tank with sulfuric acid, and then a coagulant and a flocculent are added. Separation occurs in another tank where solids settle and oils rise to the top of the tank. Oil is skimmed, solids are drawn off the bottom, and the aqueous middle layer is discharged on a batch basis.

Since wastewater is batch-treated weekly, it was impossible to obtain a matched pair of raw wastewater and treated effluent. However, the effluent data reported in Tables 6-5 through 6-7 reflect a typical discharge. The pollutant levels observed in the Plant C discharge are much lower than those presented later in this section for Plants A, B, and D. For example, no organic is present at levels greater than 1 mg/l, and the metals aluminum, lead, and zinc are present at levels less than 0.5 mg/l. These lower levels are probably due to the fact that Plant C flushes its drums with a kerosene solvent before the drums are washed. Plant C only handles petroleum drums, and the metal bearing solids usually found in paint residue are not present. Also, Plant C does not handle the wide range of chemical drums that are handled at the other plants.

6.3.2 Oil/Water Separation

Oil/water separators are designed to treat oily wastestreams without addition of chemicals. Several hours of detention are provided in a tank and floating oils are skimmed. Solids that accumulate on the tank bottom are removed periodically.

Plant A uses an oil/water separator to treat its wastewater. Drums are drained before being flushed with caustic, and then are washed and rinsed. The process wastestream consists of caustic flush, caustic wash water, and rinse water. Oil/water separation is provided in a three-chamber tank from which oil is removed weekly. The tank provides an average detention time of 2.4 hours over an 8-hour operating shift. Since the total treatment system volume is flushed more than three times during an 8-hour shift, a matched pair of raw wastewater and treated effluent was obtained.

Paired data for conventional and nonconventional pollutants, metals, and organics are shown in Tables 6-8 through 6-10. Solids and oil and grease are removed by the oil/water separator, but other conventional and nonconventional pollutants are not removed by the separator. The oil and grease removal is 76 percent and the various solids fraction removals range from 22 to 62 percent. The system provides no appreciable removals for metals or extractable and volatile organics.

6.3.3 Air Flotation

Air flotation is a wastewater treatment method that is used to break emulsions and to separate oil from water. First high pH, oily wastestreams are neutralized, then a flocculent and a coagulant are added. The mixed flow is sent to a clarifier where several hours detention are provided. At the bottom of the Table

TABLE 6-5. EPA-ITD SAMPLING PROGRAM
SEDIMENTATION EFFLUENT

Fraction: Conventionals and Nonconventionals

Sample Point:	Treated Effluent
Plant No.	C
Episode No.	1133
Sample No.	15358
Sample Date	Sep. 18, 1986
Parameter	
Ammonia	.10
BOD-5, Total	390
BOD-5, Dissolved	300
Chloride	670
COD, Dissolved	970
COD, Total	1060
Dissolved Solids	14000
Oil & Grease	9
Phenol	.05
Suspended Solids	50
Suspended Vol Solids	36
TKN	10.2
Total Cyanide	.08
Total Organic Carbon	303
Total Vol Solids	20000

NOTE: All concentrations expressed in mg/l.
mg/l = milligrams per liter

TABLE 6-6. EPA-ITD SAMPLING PROGRAM
SEDIMENTATION EFFLUENT

Fraction: Extractable and Volatile Organics

Sample Point:	Treated Effluent
Plant No.	C
Episode No.	1133
Sample No.	15358
Sample Date	Sep. 18, 1986
Parameter	
4-Chloro-3-Methylphenol	28
Acetone	880
Benzoic Acid	360
Hexanoic Acid	24
Naphthalene	30

NOTE: All concentrations expressed in $\mu g/l$.
$\mu g/l$ = micrograms per liter

TABLE 6-7. EPA-ITD SAMPLING PROGRAM
SEDIMENTATION EFFLUENT

Fraction: Metals

Sample Point:	Treated Effluent
Plant No.	C
Episode No.	1133
Sample No.	15358
Sample Date	Sep. 18, 1986
Parameter	
Aluminum	340
Antimony	50
Arsenic	170
Barium	43
Beryllium	2
Boron	370
Cadmium	5
Calcium	46000
Chromium	41
Cobalt	10
Copper	4
Iron	5800
Lead	80
Magnesium	9500
Manganese	320
Mercury	.2
Molybdenum	93
Nickel	12
Selenium	25
Silver	2
Sodium	4800000
Thallium	10
Tin	650
Titanium	10
Vanadium	100
Yttrium	10
Zinc	140

NOTE: All concentrations expressed in $\mu g/l$.
$\mu g/l$ = micrograms per liter

TABLE 6-8. EPA-ITD SAMPLING PROGRAM
OIL/WATER SEPARATOR PERFORMANCE

Fraction: Conventionals and Nonconventionals

Sample Point:	Raw Wastewater	Raw Wastewater	
Plant No.	B	B	
Episode No.	1130	1130	
Sample No.	15346	15348	Percent
Sample Date	Aug. 6, 1986	Aug. 7, 1986	Removed
Parameter			
Ammonia	13	18	0
BOD-5, Total	3900	3780	3
BOD-5, Dissolved	1980	1740	12
Chloride	50	125	0
COD, Dissolved	3140	3990	0
COD, Total	6110	7380	0
Dissolved Solids	8850	7380	17
Fluoride	30	34	0
Oil & Grease	3240	770	76
Phenol	1.61	1.13	30
Sulfide	.1	.1	0
Suspended Solids	4980	1880	62
Suspended Vol Solids	880	400	55
TKN	5	13	0
Total Cyanide	8.3	9	0
Total Organic Carbon	1520	1530	0
Total Vol Solids	3200	2500	22

NOTE: All concentrations expressed in mg/l.
mg/l = milligrams per liter

TABLE 6-9. EPA-ITD SAMPLING PROGRAM
OIL/WATER SEPARATOR PERFORMANCE

Fraction: Extractable and Volatile Organics

Sample Point:	Raw Wastewater	Treated Effluent	
Plant No.	B	B	
Episode No.	1128	1128	
Sample No.	15339	15340	Percent
Sample Date	Jul 22, 1986	Aug 23, 1986	Removed
Parameter			
1,1,1-Trichloroethane	355	590	0
2-Butanone (MEK)	534	589	0
2-Chloronaphthalene	4609	4483	3
Acetone	ND	673	0
Alpha-Terpineol	4745	4322	9
Benzoic Acid	ND	1460	0
Ethylbenzene	221	308	0
N-Decane (N-C10)	11750	ND	0
N-Decosane (N-C22)	ND	147	0
N-Dodecane (N-C12)	6950	10194	0
N-Hexadecane (N-C16)	1066	ND	0
N-Octacosane (N-C28)	ND	493	0
Toluene	507	844	0
Trichloroethene	95	95	0

NOTE: All concentrations expressed in $\mu g/l$.
$\mu g/l$ = micrograms per liter
ND indicates not detected above detection limit

TABLE 6-10. EPA-ITD SAMPLING PROGRAM
OIL/WATER SEPARATOR PERFORMANCE

Fraction: Metals

Sample Point:	Raw Wastewater	Treated Effluent	
Plant No.	A	A	
Episode No.	1128	1128	
Sample No.	15339	15340	Percent
Sample Date	Jul 23, 1986	Jul 23, 1986	Removed
Parameter			
Aluminum	7800	5900	24
Antimony	562	562	0
Arsenic	31	44	0
Barium	2600	2100	19
Beryllium	50	50	0
Boron	880	960	0
Cadmium	29	18	38
Calcium	47000	36000	23
Chromium	6700	5300	21
Cobalt	210	200	5
Copper	1400	1000	29
Iron	10000	12000	0
Lead	27000	20000	26
Magnesium	14000	12000	14
Manganese	700	480	31
Mercury	0.2	0.2	0
Molybdenum	340	640	0
Nickel	120	130	0
Selenium	5	5	0
Silver	1	1	0
Sodium	1800000	1800000	0
Thallium	10	10	0
Tin	240	220	8
Titanium	59	93	0
Vanadium	12	11	8
Yttrium	10	10	0
Zinc	13000	12000	8

NOTE: All concentrations expressed in $\mu g/l$.
$\mu g/l$ = micrograms per liter

clarifier, fine bubbles of air are dispersed into the wastewater. The air bubbles rise and become enmeshed in oil agglomerations. The air-entrained agglomerations become buoyant and rise to the top of the clarifier where they are skimmed. Two facilities were sampled by EPA-ITD that used air flotation systems, Plants B and D.

Plant B is a small drum washing plant that recycles caustic wash. The process wastewater consists of rinse water and is treated by air flotation before being discharged. The wastewater treatment system detention time is 3.5 hours. The washing operations and the wastewater treatment system operating shift last 4.5 hours; then the systems are shut down for the remaining 19.5 hours of the day. Wastewater generated during an operating shift is treated and stored in the system until being displaced on the following operating day when more wastewater is generated. Since the total treatment system volume is displaced only once per day, it was not possible to obtain a matched pair of raw wastewater and treated effluent for a given day. Therefore, sampling was conducted for 2 days. The raw wastewater sample from the first day matches better with the treated effluent sample from the second day.

Raw wastewater treated effluent and percent removal data for the Plant B air flotation system are shown in Tables 6-11 through 6-13. The pollutant removals are calculated as the percent difference between the August 6 raw wastewater sample and the August 7 treated wastewater, since wastewater in the treatment system is not displaced until the following day. No or low pollutant removals are calculated for the majority of parameters measured. These observations may be the result of lag time in the system. However, suspended solids and volatile solids removals are reasonable at 85 and 76 percent, respectively. P-cymene and toluene removals are also good at 81 and 99 percent, respectively.

Plant D is a large drum washing and burning plant that recycles caustic wash. The process wastewater consists of washing process rinses and miscellaneous wastestreams (74 percent) and quench water from the burning process (26 percent). Receiving area drainage is a component of the process wastewater. The combined process wastewater is treated by air flotation and the effluent is reused as makeup to caustic wash. The system detention time is approximately 1 hour. Daily paired raw wastewater and treated effluent samples were obtained for a 5-day sampling episode.

Raw wastewater, treated effluent, and percent removal data for the Plant D air flotation system are shown in Tables 6-14 through 6-17. Pollutant removals are calculated on a daily basis, since the system detention time is only 1 hour. The average percent removed is the mean of positive and zero removal. Pollutant removals for COD, oil and grease, and the various solids samples range between 45 and 63 percent. Positive removals are reported for most of the metals. The average removal calculated was 36 percent and the highest removal calculated was 77 percent. Positive average removals are calculated for all of the extractable

TABLE 6-11. EPA-ITD SAMPLING PROGRAM
AIR FLOTATION PERFORMANCE - PLANT B

Fraction: Conventionals and Nonconventionals

Sample Point:		Raw Wastewater	Treated Wastewater	Raw Wastewater	Treated Wastewater	
Plant No.		B	B	B	B	
Episode No.		1130	1130	1130	1130	
Sample No.		15344	15345	15348	15349	Percent
Sample Date		Aug 6, 1986	Aug 6, 1986	Aug 7, 1986	Aug 7, 1986	Removed
Parameter	**Units**					
Ammonia	mg/l	22.5	10.25	9.0	8.8	61
BOD-5, Total	mg/l	2200	1980	418	1860	15
BOD-5, Dissolved	mg/l	2550	2700	2160	2100	18
Chloride	mg/l	1500	1500	1400	800	47
COD, Dissolved	mg/l	3860	2772	4400	2300	40
COD, Total	mg/l	3860	3190	5400	2400	38
Dissolved Solids	mg/l	5710	6600	8940	6370	0
Fluoride	mg/l	40	NR	15	31	22
Oil & Grease	mg/l	4810	2450	2940	4950	0
Phenol	mg/l	1.51	.50	92	.58	62
Sulfide	mg/l	.1	.1	.1	.1	0
Suspended Solids	mg/l	1850	72	780	264	86
Suspended Vol Solids	mg/l	63	14	50	206	0
TKN	mg/l	1.75	6.7	46	40	0
Total Cyanide	mg/l	1.9	.60	.66	.58	69
Total Organic Carbon	mg/l	1600	1100	210	900	44
Total Vol Solids	mg/l	3170	926	1175	740	77
pH		12.6	5.8	12.7	5.9	53

Note: NR indicates no data reported
mg/l = milligrams per liter
Percent removed = percent difference between 15344 and 15349

TABLE 6-12. EPA-ITD SAMPLING PROGRAM
AIR FLOTATION PERFORMANCE - PLANT B

Fraction: Extractable and Volatile Organics

Sample Point:	Raw Wastewater	Treated Wastewater	Raw Wastewater	Treated Wastewater
Plant No.	B	B	B	B
Episode No.	1130	1130	1130	1130
Sample No.	15344	15345	15348	15349
Sample Date	Aug 6, 1986	Aug 6, 1986	Aug 7, 1986	Aug 7, 1986
Parameter				
2-Butanone (MEK)	ND	ND	1361630	1001760
2-Chloronaphthalene	46	ND	46	48
2-Methylnaphthalene	ND	11	24	16
2-Nitrophenol	ND	64	ND	45
4-Nitrophenol	ND	100	ND	ND
Acetone	ND	ND	ND	1845
Benzene	ND	ND	ND	182
Benzoic Acid	ND	ND	94999	ND
Benzyl Alcohol	ND	ND	59	ND
Biphenyl	14	ND	ND	ND
Chlorobenzene	ND	ND	ND	56
Ethylbenzene	3179	1217	ND	2319
Hexanoic Acid	383	24	ND	ND
Isobutyl Alcohol	3517	ND	ND	ND
Methylene Chloride	ND	ND	ND	500
Naphthalene	382	ND	ND	ND
Nitrobenzene	16	ND	ND	ND
o-Cresol	143	ND	ND	ND
P-Cymene	72	ND	37	ND
Styrene	ND	ND	49	14
Thoxanthone	311	98	61	
Toluene	55572	ND	ND	ND
		86987	262	799

NOTE: ND indicates not detected above detection limit.
All concentrations expressed in µg/l.
µg/l = micrograms per liter.

TABLE 6-13. EPA-ITD SAMPLING PROGRAM AIR FLOTATION PERFORMANCE - PLANT B

Fraction: Metals					
Sample Point:	Raw Wastewater	Treated Wastewater	Raw Wastewater	Treated Wastewater	
Plant No.	B	B	B	B	
Episode No.	1130	1130	1130	1130	
Sample No.	15344	15345	15348	15349	Percent
Sample Date	Aug 6, 1986	Aug 6, 1986	Aug 7, 1986	Aug 7, 1986	Removed
Parameter					
Aluminum	9900	9900	9400	27000	0
Antimony	16	50	15	50	0
Arsenic	20	5	23	5	75
Barium	1800	180	1500	410	77
Beryllium	1	1	1	1	0
Boron	34	16	13	27	21
Cadmium	7	5	6	5	29
Calcium	26000	26000	21000	22000	15
Chromium	1000	120	830	230	77
Cobalt	140	51	120	62	56
Copper	400	57	390	110	72
Iron	46000	4300	40000	15000	67
Lead	2400	79	2400	510	79
Magnesium	7600	2900	6100	3600	53
Manganese	2100	840	1800	980	53
Mercury	1.3	0.2	1.1	.34	74
Molybdenum	100	90	110	83	17
Nickel	34	170	36	150	0
Selenium	25	5	25	5	80
Silver	1	1	1	1	0
Sodium	1500000	1600000	1800000	1600000	0
Thallium	10	10	10	10	0
Tin	120	130	150	130	0
Titanium	700	26	580	200	71
Vanadium	60	19	59	31	48
Yttrium	10	10	10	10	0
Zinc	17000	14000	18000	13000	24

NOTE: All concentrations expressed in µg/l.
µg/l = micrograms per liter
Percent removed = percent difference between 15344 and 15349

TABLE 6-14. EPA-ITD SAMPLING PROGRAM AIR FLOTATION PERFORMANCE - PLANT D

Fraction: Conventionals and Nonconventionals

Sample Point:	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	
Plant No.	D	D	D	D	D	D	D	D	D	D	
Episode No.	1179	1179	1179	1179	1179	1179	1179	1179	1179	1179	
Sample No.	15713	15714	15715	15716	15718	15719	15722	15723	15725	15726	
Sample Date	Feb 2, 1987	Feb 2, 1987	Feb 3, 1987	Feb 3, 1987	Feb 4, 1987	Feb 4, 1987	Feb 5, 1987	Feb 5, 1987	Feb 6, 1987	Feb 6, 1987	Average Percent Removed
Parameter											
Ammonia	6.59	6.22	16.1	14.4	5.53	5.62	2.25	2.5	11.8	13.8	3
BOD-5, Total	16800	9600	7500	4190	10900	4370	6300	4170	3140	2310	41
BOD-5, Dissolved	9000	6600	4400	3500	4640	2760	2790	3240	4710	1820	30
Chloride	2800	8000	5100	10800	4200	8800	3200	7400	3400	9100	0
COD, Dissolved	45500	22100	26400	14900	15100	6890	19000	15000	22800	12500	43
COD, Total	75600	40600	38100	18500	102000	16500	31800	22300	40600	9210	58
Dissolved Solids	29900	26500	27200	23400	28200	18500	20000	21800	18800	20800	12
Fluoride	89.7	.1	59	.1	53	.14	37.3	.52	29	.01	99
Oil & Grease	12900	19850	5600	252	33000	1480	4940	4800	2540	900	52
Phenol	169	347	87.4	44.5	68.8	58.4	64.7	71.5	53.2	23.4	24
Suspended Solids	21800	6730	9270	3220	20600	2920	5220	3000	5710	6140	53
Suspended Vol Solids	16000	5940	4033	3120	15500	2070	2675	1400	4700	210	63
TKN	428	370	270	282	257	153	20.2	190	291	201	17
Total Cyanide	.57	.55	.48	.32	.58	.50	.48	.58	.05	.43	10
Total Organic Carbon	19300	14500	8500	4600	7200	4380	5650	4290	5690	3640	34
Total Vol Solids	29940	12290	14280	20690	26370	5440	9880	7000	10590	4420	45

NOTE: All concentrations expressed in mg/l.
mg/l = milligrams per liter
Average percent removed = mean of positive and zero removals

TABLE 6-15. EPA-ITD SAMPLING PROGRAM AIR FLOTATION PERFORMANCE - PLANT D

Fraction: Extractable and Volatile Organics

Sample Point:	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	
Plant No.	D	D	D	D	D	D	D	D	D	D	
Episode No.	1179	1179	1179	1179	1179	1179	1179	1179	1179	1179	
Sample No.	15713	15714	15715	15716	15718	15719	15722	15723	15725	15726	Average Percent Removed
Sample Date	Feb 2, 1987	Feb 2, 1987	Feb 3, 1987	Feb 3, 1987	Feb 4, 1987	Feb 4, 1987	Feb 5, 1987	Feb 5, 1987	Feb 6, 1987	Feb 6, 1987	
Parameter											
1,1,1-Trichloroethane	36179	4099	11825	2721	71613	6780	26035	14953	ND	1893	58
1,1-Dichloroethene	25286	1007	ND	ND	ND	ND	ND	1225	ND	ND	48
1,2-Dichloroethane	ND	ND	ND	631	ND	ND	315	194	ND	ND	19
1,2-Diphenylhydrazine	ND	ND	ND	ND	ND	ND	ND	2451	ND	ND	0
2-Butanone (MEK)	987690	174905	ND	ND	18823	19097	ND	ND	1351260	108185	58
2-Chloronaphthalene	ND	ND	ND	ND	ND	ND	ND	44272	ND	ND	0
2-Hexanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	171	0
2-Nitrophenol	ND	ND	ND	5359	3256	3379	2739	2082	2866	ND	31
4-Chloro-2-nitroaniline	ND	ND	ND	ND	ND	2505	ND	ND	ND	ND	0
Acetone	498139	147138	677250	ND	ND	ND	2046290	103907	209456	ND	91
Acrolein	ND	ND	ND	ND	ND	ND	ND	1783	ND	1441	0
Benzyl Alcohol	9817	2788	ND	ND	ND	4146	ND	ND	9051	ND	57
Biphenyl	1266	ND	ND	ND	1394	ND	ND	ND	ND	ND	100
Bis(2-ethylhexyl) phthalate	5419	ND	43747	3462	43078	6603	9285	ND	5718	800	93
Butyl Benzyl Phthalate	ND	ND	ND	ND	3281	ND	ND	2675	ND	ND	50
Di-N-Butyl Phthalate	2088	ND	ND	ND	13561	2736	ND	ND	5012	1095	86
Diphenyl Ether	ND	ND	ND	ND	2457	ND	ND	ND	ND	ND	100
Ethylbenzene	186495	4518	ND	ND	75039	3014	7857	4532	62143	6715	81
Isophorone	5392	3489	25392	3822	3371	ND	ND	3081	22038	ND	64
Methacrylonitrile	ND	ND	ND	ND	ND	25	ND	ND	ND	ND	0
Methylene Chloride	ND	ND	15443	8161	ND	ND	ND	ND	ND	1870	24
N,N-Dimethylformamine	ND	ND	ND	ND	ND	2690	ND	ND	ND	ND	0
N-Decane (N-C10)	ND	ND	ND	ND	ND	2577	ND	1551	ND	ND	0
N-Docosane (N-C22)	ND	ND	ND	4905	ND	ND	3424	6312	12309	ND	33

TABLE 6-15. EPA-ITD SAMPLING PROGRAM AIR FLOTATION PERFORMANCE - PLANT D (Continued)

Fraction: Extractable and Volatile Organics

Sample Point:	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	
Plant No.	D	D	D	D	D	D	D	D	D	D	
Episode No.	1179	1179	1179	1179	1179	1179	1179	1179	1179	1179	
Sample No.	15713	15714	15715	15716	15718	15719	15722	15723	15725	15726	
Sample Date	Feb 2, 1987	Feb 2, 1987	Feb 3, 1987	Feb 3, 1987	Feb 4, 1987	Feb 4, 1987	Feb 5, 1987	Feb 5, 1987	Feb 6, 1987	Feb 6, 1987	Average Percent Removed
Parameter											
N-Hexacosane (N-C26)	ND	ND	ND	ND	ND	ND	ND	ND	ND	805	0
N-Hexadecane (N-C16)	ND	ND	ND	2642	ND	160	1178	ND	ND	ND	33
N-Octacosane (N-C28)	ND	ND	ND	ND	ND	ND	28081	ND	ND	2068	50
N-Octadecane (N-C18)	3983	ND	ND	ND	13354	ND	ND	ND	ND	320	67
N-Tetradecane (N-C14)	ND	ND	44127	4924	ND	ND	5754	4657	ND	990	36
Naphthalene	8842	ND	17954	2119	5503	1823	2775	ND	ND	318	71
P-Cymene	ND	ND	ND	ND	1996	ND	ND	ND	ND	ND	100
Phenanthrene	ND	ND	ND	ND	ND	ND	11577	ND	ND	ND	100
Phenol	932	ND	ND	ND	ND	1127	ND	ND	ND	ND	50
Styrene	34620	7379	30372	5193	18836	6395	ND	3248	4950	ND	66
Tetrachloroethene	ND	ND	ND	ND	86267	2776	ND	5331	ND	1869	32
Toluene	107977	7487	ND	ND	42672	1940	6159	4248	54123	ND	80
Trans-1,2-Dichloro-ethene	ND	ND	ND	ND	ND	ND	917	ND	ND	ND	100
Trichloroethene	ND	ND	ND	151	4038	104	1278	199	4575	156	70
Vinyl Acetate	ND	1249	ND	ND	ND	ND	ND	ND	ND	ND	0

NOTE: All concentrations expressed in µg/l.
µg/l = micrograms per liter
ND indicates not detected above detection limits
Average percent removed = mean of positive and zero removals. ND assumed equal to zero

TABLE 6-16. EPA-ITD SAMPLING PROGRAM AIR FLOTATION PERFORMANCE - PLANT D

Fraction: Metals

Sample Point:	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	Raw	Treated	
Plant No.	D	D	D	D	D	D	D	D	D	D	
Episode No.	1179	1179	1179	1179	1179	1179	1179	1179	1179	1179	Average
Sample No.	15713	15714	15715	15716	15718	15719	15722	15723	15725	15726	Percent
Sample Date	Feb 2, 1987	Feb 2, 1987	Feb 3, 1987	Feb 3, 1987	Feb 4, 1987	Feb 4, 1987	Feb 5, 1987	Feb 5, 1987	Feb 6, 1987	Feb 6, 1987	Removed
Parameter											
Aluminum	90800	91500	71700	64700	61300	57400	37900	75700	36100	150000	3
Antimony	33600	30100	9780	8980	10200	4140	6820	5640	6140	4650	24
Arsenic	500	103	62	100	72	100	16	19	78	19	31
Barium	1230	170	2200	2680	1500	1930	7510	2930	5260	599	47
Beryllium	7	5	5	5	5	5	5	5	5	5	6
Boron	7700	4870	6100	6170	7270	3960	6320	6640	7390	5650	21
Cadmium	695	138	285	229	4690	1170	1340	1270	883	909	36
Calcium	120000	52700	77000	72400	97000	46200	40600	46900	50000	43600	25
Chromium	6430	2490	3360	1570	4720	1060	3420	1160	4120	977	67
Cobalt	1700	448	760	500	1170	410	1090	582	1320	587	55
Copper	4810	1540	4780	3020	5940	1610	2640	1270	3240	1350	58
Iron	693000	74900	201000	84500	529000	96600	180000	88600	216000	43000	72
Lead	37600	8730	18200	5380	34600	4760	16500	4970	19300	3050	78
Magnesium	40400	20600	22600	22700	28300	13100	11600	12600	13800	11600	24
Manganese	5130	1810	3250	2470	6890	1840	2510	2290	2720	1980	40
Mercury	41	27	20	11	28	.5	8.5	3.8 10	.65		
Molybdenum	853	362	1040	705	1880	830	1540	1170	2230	1030	45
Nickel	991	161	376	286	1030	319	363	287	419	280	46
Selenium	5	5	50	50	5	125	5	5	5	25	0
Silver	18	63	8.40	5.7	14.6 1	9.2	7.3 1	17			
Sodium	8800000	8690000	9090000	8190000	9510000	6100000	7290000	7130000	6720000	6730000	10
Thallium	100	100	100	50	50	100	50	50	50	50	10
Tin	5730	692	4190	1220	6390	2180	5620	2550	4230	495	74
Titanium	2610	578	860	434	1190	289	577	287	666	175	65
Vanadium	82	50	50	50	95	50	50	50	50	58	17
Yttrium	50	50	50	50	50	50	50	50	50	50	0
Zinc	80400	23200	54300	37400	108000	27900	44300	30600	43500	17900	53

NOTE: All concentrations expressed in µg/l (µg/l = micrograms per liter).
Average percent removed = mean of positive and zero removals

TABLE 6-17. EPA-ITD SAMPLING PROGRAM
AIR FLOTATION PERFORMANCE - PLANT D

Fraction: Pesticides/Herbicides

Plant No.	D	D	D	D	
Episode No.	1179	1179	1179	1179	Average
Sample No.	15713	15714	15718	15719	Percent
Sample Point	Raw	Treated	Raw	Treated	Removed
Sample Date	2/02/87	2/02/87	2/04/87	2/04/87	
Parameter					
Dichloran	ND	ND	ND	282	0
Endosulfan I	296	ND	ND	ND	99
Endosulfan Sulfate	ND	ND	528	951	0
Heptachlor	284	1738	ND	ND	0
Etridazone	252	ND	ND	ND	99
Isodrin	ND	2829	ND	ND	0
Trifluralin	ND	ND	ND	322	0
Azinphos Ethyl	4260	ND	ND	ND	99
Azinphos Methyl	6207	50466	4689	3769	9
Fensulfothion	5795	ND	7859	4148	74
Phosmet	ND	30972	ND	ND	0
Diazinon	ND	ND	1035	ND	99
Dimethoate	ND	ND	1500	ND	99
Leptophos	ND	ND	3959	ND	99
TEPP	ND	ND	ND	2323	0

NOTE: ND indicates not detected
All concentrations expressed in $\mu g/l$ ($\mu g/l$ = micrograms per liter).
Average percent removed = mean of positive and zero removals. ND assumed equal to zero.

and volatile organics found in the raw wastewater and the mean of the averages is 63 percent. However, 10 compounds are detected in treated effluents that were not detected in the raw wastewater. Eight pesticides/herbicides are removed, however, five compounds are found in the treated effluent that are not found in the raw wastewater.

EPA-ITD sampled four wastewater treatment systems that are representative of the wastewater treatment technologies used in the industry: sedimentation, oil/water separation, and air flotation. Poor removals were observed, which is probably due to poor operational control during the sampling episodes rather than being indicative of industry-wide practice. Therefore, few positive conclusions can be drawn regarding treatment system performance for this industry.

6.4 ZERO DISCHARGE TECHNOLOGY

EPA observed that zero discharge is achieved by a significant number of the facilities that were visited. During routine operations, no discharge of process wastewater from the facilities occurs. Although discharges are likely during system shutdowns for maintenance or when wastewater treatment systems are upset and bypassed. Discharges are also likely during periods of high rainfall when extraordinarily high volumes of contaminated storm water may be generated. Five of the 16 facilities visited by EPA generate significant volumes of wastewater and also achieve zero discharge. All drum reconditioners are prohibited from discharging process wastewater in the Chicago Metropolitan Sanitation District (MSD). EPA identified 19 facilities that are potentially active in the city of Chicago (Appendices A and B). Information is available on Plant D and four more facilities identified below as Plants N, O, P, and Q. The methods used to achieve zero discharge are described below for each facility.

- Plant D - 15,000 gpd are generated as a result of the washing and burning of 6,000 drums. The process wastewater is treated by air flotation and reused as makeup to caustic wash and intermediate rinses and as furnace quench. Most of the wastewater is lost from the system through evaporation at the furnace or from the hot caustic wash. City water used as final rinse is the source of makeup to the total system. Solids are removed by screening and as air flotation sludge.

- Plant N - This facility washes 700 tight-head drums and burns 500 open-head drums. Process wastewater is treated by air flotation and then reused as an intermediate rinse or as furnace quench.

- Plant O - About 1,000 open- and tight-head drums are reconditioned daily. Open-head drums are not burned, but are instead shot blasted. Hence, no wastewater is generated. Wastewater is generated by tight-head washing processes and is treated by air flotation. The treated wastewater is reused as an intermediate rinse or as caustic makeup.

- Plant P - 1,500 open-head drums are burned daily. Quench water is treated by sedimentation only before being reused. Because of high evaporation losses, the quench water supply is made up by wastewater trucked in from Plant Q.

- Plant Q - This tight-head plant washes 600 drums daily. Sedimentation and oil/water skimming are provided to the process wastewater. Some wastewater is reused on-site as caustic makeup and the remainder is trucked to Plant P.

6.5 RESIDUALS GENERATION AND DISPOSAL

Nonaqueous liquid wastes and solids are generated in several plant areas. Liquid residues are sometimes dumped into process wastewater floor drains, but are usually contract hauled. Petroleum residues are sometimes sold for use in fuel blends. Oil and grease removed from oil/water separators is also sold for the same purpose. Solids generated include wastewater treatment sludges and furnace ash.

Limited data do not allow a precise estimate of the total volume of sludge and ash disposed of by the industry. Data from three plants that use air flotation show that approximately 0.7 kilograms, or 0.17 gallons of air flotation sludge are generated per drum reconditioned. Two of the three plants comingle ash quench with washing wastestreams; therefore, the 0.7 kilogram estimate reflects both tight- and open-head wastestreams. Caustic wash sediments are also comingled with the wastestreams. The Agency believes that this estimate is the best available for estimating the total mass of solids disposed of by the industry (SAIC 1987c).

NABADA (Touhill 1981a) reports that 51.2 percent of the industry used air flotation or flocculation/sedimentation. Therefore, the annual industry solids generation rate is 18 million kilograms (51.2 percent x 0.7 kilogram per drum x 50,000,000 drums), or 153,000 pounds daily, if 260 working days per year are assumed. Facilities that do not use air flotation or sedimentation are assumed to dispose of solids through their wastewater discharge. The high levels of solids observed in raw wastewaters support this assumption.

Data collected by EPA-ITD and EPA-ORD are presented below for caustic clarifier sludges, furnace ash, and air flotation sludges. EPA ITD collected air flotation sludge samples at Plants B and D. A sedimentation sludge sample was collected at Plant C. EPA-ORD collected caustic clarifier sludge samples at Plants E and F and a furnace ash sample was obtained from Plant G.

6.5.1 EPA-ITD Data

The data collected by EPA-ITD are the best available for estimating the characteristics of sludge disposed of by the industry. Sludges at three plants were sampled. Plant B used air flotation to treat tight-head process wastewater generated by paint drum reconditioning facilities. Plant C used sedimentation to remove solids from the washing and stripping of petroleum drums. Two samples were obtained from Plant D where air flotation is used to treat wastewaters generated by tight- and open-head processing. A wide range of drum types are processed at Plant D and the furnace quench constitutes 27 percent of the treatment system influent. Sludge analyses were conducted for conventional and nonconventional pollutants, metals, extractable and volatile organics, and dioxins/furans. Analytical results are summarized below.

- Conventional and Nonconventional - The data in Table 6-18 show that sludges are composed mainly of oil and grease (22 percent) and suspended solids (8 percent), which are mostly volatile solids.

- Extractable and Volatile Organics - The data in Table 6-19 show detected values. Only a few conclusions can be drawn about the presence of organics in the four sludge samples, since detection limits in many cases are greater than 1 mg/l. 2-Butanone (MEK), biphenyl, bis(2-ethylhexyl)phthalate, ethylbenzene, napthalene, and toluene were found in samples at two of the three plants. No single compound is found at all three sites and no site-specific patterns are evident.

- Metals - Industry mean concentrations are shown in Table 6-20. Iron, sodium, and aluminum constitute 2.8, 3.6, and 2.2 percent, respectively, of the typical industry sludge. Zinc and lead, the primary wastewater constituents, are observed at levels up to 0.3 and 0.8 percent, respectively.

- Dioxins/Furans - Twelve compound were detected in the four samples shown in Table 6-21. Most of these are associated with Plant D. This facility is the only one of the sampled plants that generated furnace quench. No dioxin/furans were found in raw wastewaters from the other plants. Seventeen compounds were found in the furnace quench sample. These compounds are the likely result of the low temperature drum burning operation which operates in the range of 600°F to 1,800°F.

Sludge samples also were analyzed using the Toxicity Characteristic Leaching Procedure (TCLP). The TCLP is designed to determine the mobility of both organic and inorganic contaminants present in liquid, solid, and multiphasic wastes. The solid phase of sludges are subject to extraction with an acid. The extract is mixed with the aqueous phase and the mixed liquid is then analyzed. The analytical results are used to determine compliance with

TABLE 6-18. EPA-ITD SAMPLING PROGRAM SEDIMENTATION AND AIR FLOTATION SLUDGES

Fraction: Conventionals and Nonconventionals

Sample Point:	Sludge	Sludge	Sludge	Sludge
Plant No.	B	C	D	D
Episode No.	1130	1130	1130	1130
Sample No.	15347	15359	15721	15724
Sample Date	Aug 6, 1986	Sep 10, 1986	Feb 4, 1987	Feb 5, 1987
Parameter				
Ammonia	68	NR	9.52	33.1
BOD-5, Total	2280	6600	160000	100000
BOD-5, Dissolved	1800	1440	26600	18400
Chloride	2800	1000	66700	26500
COD, Dissolved	2300	1430	112000	77900
COD, Total	84000	339000	1190000	1090000
Dissolved Solids	784	18000	20000	15400
Fluoride	500	570	.95	2.79
Oil & Grease	167	21000	51000	827000
Phenol	.37	4.96	914	870
Sulfide	1	7.4	NR	NR
Suspended Solids	58000	53050	84600	118000
Suspended VOL Solids	23000	37875	16600	103100
TKN	330	NR	950	897
Total Cyanide	284	120	6.09	1.91
Total Organic Carbon	330	4000	5.5	227000
Total VOL Solids	33000	21000	77460	124330

NOTE: All concentrations expressed in mg/kg (mg/kg = milligrams per kilogram, wet basis).
NR indicates not reported

TABLE 6-19. EPA-ITD SAMPLING PROGRAM SEDIMENTATION AND AIR FLOTATION SLUDGES

Fraction: Extractable and Volatile Organics				
Sample Point:	Sludge	Sludge	Sludge	Sludge
Plant No.	B	C	D	D
Episode No.	1130	1133	1179	1179
Sample No.	15347	15359	15721	15724
Sample Date	Aug 7, 1986	Sep 18, 1986	Feb 4, 1987	Feb 5, 1987
Parameter				
1,1,1-Trichloroethane	ND-10	NR	15710	4140
2-Butanone (MEK)	164278	NR	1938	ND-50
Acetone	ND-50	NR	20785	9507
Acrolein	ND-50	NR	ND-50	160
Biphenyl	ND-33333	3829	414	ND-3333
Bis(2-Ethylhexyl)Phthlate	ND-33333	3115	2502	ND-3333
Di-N-Butyl Phthlate	ND-33333	ND-333	2416	4257
Ethyl Methacrylate	ND-10	NR	ND-10	33
Ethylbenzene	1981	NR	17900	133057
Fluorene	ND-33333	2109	ND-333	ND-3333
Isophorone	ND-33333	ND-333	889	ND-3333
N-Docosane (N-C22)	ND-33333	ND-333	6741	ND-3333
N-Hexadecane (N-C16)	ND-33333	127003	ND-333	ND-3333
N-Octadecane (N-C18)	ND-33333	ND-333	2494	ND-3333
N-Tetradecane (N-C14)	ND-33333	ND-333	2271	ND-3333
Naphthalene	ND-33333	5425	1692	ND-3333
P-Cymene	ND-33333	5380	ND-333	ND-3333
Phenanthrene	ND-33333	1754	ND-333	ND-3333
Pyrene	ND-33333	478	ND-333	ND-3333
Styrene	ND-33333	ND-333	5120	ND-3333
Tetrachloroethene	ND-10	NR	174	ND-10
Toluene	1257	NR	12954	ND-10
Trichloroethene	ND-10	NR	1571	695

Note: All concentrations expressed in µg/l (µg/l = micrograms per liter).
ND indicates not detected. Detection limit shown.
NR indicates not reported.

TABLE 6-20. EPA-ITD SAMPLING PROGRAM SEDIMENTATION AND AIR FLOTATION SLUDGES

Fraction: Metals				
Sample Point:	Sludge	Sludge	Sludge	Sludge
Plant No.	B	C	D	D
Episode No.	1130	1133	1179	1179
Sample No.	15347	15359	15721	15724
Sample Date	Aug 7, 1986	Sep 18, 1986	Feb 4, 1987	Feb 5, 1987
Parameter				
Aluminum	57800	17400	8230	2756
Antimony	33	30	187	51
Arsenic	48	221	7	2.3
Barium	678	535	790	343
Beryllium	8	4	1	0.3
Boron	154	74	66	16
Cadmium	16	393	65	27
Calcium	2260	20600	19	5
Chromium	428	1680	159	59
Cobalt	77	74	28	20
Copper	204	383	211	62
Iron	26300	60100	17798	7149
Lead	1010	8380	1194	482
Magnesium	2110	2590	218	79
Manganese	713	74	107	47
Mercury	2	.7	2.7	0.6
Molybdenum	155	157	180	42
Nickel	163	30	167	50
Selenium	33	15	3.6	0.8
Silver	2	.8	6.5	1.6
Sodium	29000	53400	54244	9181
Thallium	33	15	4	0.9
Tin	155	143	4015	1692
Titanium	337	112	78	27
Vanadium	95	37	24	6
Yttrium	80	37	2	0.4
Zinc	2150	3260	1776	730

NOTE: All concentrations expressed in mg/kg (mg/kg = milligrams per kilogram, wet basis).

TABLE 6-21. EPA-ITD SAMPLING PROGRAM SEDIMENTATION AND AIR FLOTATION SLUDGES

Fraction: Dioxins/Furans

Sample Point:	Sludge	Sludge	Sludge	Sludge
Plant No.	B	C	D	D
Episode No.	1130	1133	1179	1179
Sample No.	15347	15359	15721	15724
Sample Date	Aug 7, 1986	Sep 18, 1986	Feb 4, 1987	Feb 5, 1987
Parameter				
1234678-HpCDD	ND	226.11	260.89	496.799
1234678-HpCDF	ND	ND	114.55	ND
123478-HxCDF	ND	ND	40.10	ND
234678-HxCDF	ND	ND	44.31	ND
OCDD	ND	41954.20	2774.67	5619.11
OCDF	143.73	ND	ND	330.89
Total HpCDD	ND	4044.62	537.35	1002.79
Total HpCDF	ND	112.99	187.33	171.61
Total HxCDD	ND	ND	168.52	138.87
Total HxCDF	ND	ND	139.62	ND
Total PCDF	ND	ND	92.46	ND
Total TCDF	ND	ND	37.06	32.67

NOTE: All concentrations expressed in ppt (ppt = parts per trillion).
ND indicates not detected above detection limits

treatment standards for solvent waste disposed of on land. Results are shown in Tables 6-22 and 6-23. Sludge from Plants B and D fail to meet the BDAT standards for the land disposal of spent solvents (EPA 1986b).

6.5.2 EPA-ORD Data

6.5.2.1 Caustic Clarifier Sludges

Samples of the sludge resulting from the clarification of caustic are shown in Table 6-24 for Plants E and F. The sample from Plant E contained floating oil and emulsions. The level of organics measured in Plant E sludge is considerably higher than the level measured in the clarified effluent. The organics probably have been absorbed by oil and emulsions that constitute the sludge. The sludge from Plant F was scraped from the sides of the clarifier. This sample was probably high in oils and greases that adhered to the clarifier walls. The high hydrocarbons levels measured reflect the fact that 95 percent of the drums serviced at Plant F contained petroleum.

The metals levels measured in Plant E sludge are generally lower than those measured in clarified effluent. This suggests either poor removals or the use of analytical protocol, which did not appropriately account for the solids. Metals data are also listed in Table 6-24 for plants that supplied data in response to the NABADA survey. The data are the average of sludges from several plants and show significantly higher levels than the data from Plant E.

Table 6-25 shows metals data for dried caustic sludge samples from Plant G that contain about 30 percent water. If a solids level of 1 percent were assumed for the undried sludge, then the data would be representative of a sludge that had been concentrated about 70 times. An extrapolation of the data with the use of a divisor of 70 would yield metals levels that are lower than those reported by NABADA respondents.

6.5.2.2 Furnace Ash

Ash removed from the surfaces of burned open-head drums is likely to contain high amounts of metal as well as incompletely combusted organics. In Table 6-26, hydrocarbons and extractable organics are shown to be present in an ash sample collected from Plant B.

6.6 SUMMARY

The following list summarizes the major points that were discussed in this section:

- o Zero discharge is demonstrated to be a practical control technology for open-head facilities. Furnace quench water typically is reused after simple sedimentation.

TABLE 6-22. EPA-ITD SAMPLING PROGRAM TOXICITY CHARACTERISTIC LEACHING PROCEDURE

Fraction: Extractable and Volatile Organics				
Sample Point:	Sludge	Sludge	Sludge	Sludge
Plant No.	B	C	D	D
Episode No.	1130	1133	1179	1179
Sample No.	15347	15359	15721	15724
Sample Date	Aug 7, 1986	Sep 18, 1986	Feb 4, 1987	Feb 5, 1987
Parameter				
1,1,1-Trichloroethane	ND-10	NR	7527	669
1,1-Dichloroethene	ND-10	NR	144	ND-10
2-Butanone (MEK)	109078	NR	611	670
2-Chloronaphthalene	47	ND-10	ND-10	ND-100
Acetone	ND-50	NR	16067	1038
Acetophenone	ND-10	NR	18	ND-100
Acrolein	ND-50	NR	197	87
Alpha-Terpineol	28	54	ND-10	ND-100
Bis(2-Ethylhexyl) Phthalate	ND-10	ND-10	128	ND-100
Di-N-Butyl Phthalate	ND-10	ND-10	115	ND-100
Ethylbenzene	642	NR	1965	1419
Hexanoic Acid	162	NR	ND-100	ND-10
Isobutyl Alcohol	ND-10	NR	ND-10	80
Isophorone	ND-10	ND-10	38	ND-100
Methylene Chloride	117	NR	ND-10	82
N-Dodecane (N-C12)	ND-10	ND-10	377	ND-100
N-Eicosane (N-C20)	ND-10	ND-10	162	342
N-Hexacosane (N-C26)	ND-10	ND-10	593	ND-100
N-Octadecane (N-C18)	ND-10	ND-10	38	ND-100
Naphthalene	63	21	76	ND-100
P-Cymene	ND-10	ND-10	15	ND-100
Styrene	ND-10	ND-10	ND-10	172
Tetrachloroethene	ND-10	NR	1712	ND-10
Thioxanthone	379	NR	ND-20	ND-200
Toluene	1518	NR	2396	ND-10
Trichloroethene	ND-10	NR	167	82

NOTE: All concentrations expressed in µg/l (µg/l = micrograms per liter).
ND indicates not detected. Detection limit shown.
NR indicates not reported

TABLE 6-23. EPA-ITD SAMPLING PROGRAM
TOXICITY CHARACTERISTIC LEACHING PROCEDURE

Fraction: Metals				
Sample Point:	Sludge	Sludge	Sludge	Sludge
Plant No.	B	C	D	D
Episode No.	1130	1133	1179	1179
Sample No.	15347	15359	15721	15724
Sample Date	Aug 7, 1986	Sep 18, 1986	Feb 4, 1987	Feb 5, 1987
Parameter				
Aluminum	147000	7000	17686	17266
Antimony	20	20	250	213
Arsenic	220	20	4	3
Barium	534	183	1126	2159
Beryllium	5	5	25	25
Boron	260	731	20	20
Cadmium	44	17	224	435
Calcium	4550	118000	5232	6265
Chromium	390	355	118	144
Cobalt	50	286	35	30
Copper	120	25	202	220
Iron	1230	120000	1124	858
Lead	2120	200	1400	1465
Magnesium	732	5920	1440	1583
Manganese	425	1060	314	462
Mercury	.2	.6	.2	.2
Molybdenum	100	100	260	260
Nickel	78	91	95	83
Selenium	200	100	4	4
Silver	20	20	0.6	0.6
Sodium	1640000	2360000	1490960	1992204
Thallium	20	20	4.2	4.2
Tin	100	125	316	299
Titanium	10	50	7	7
Vanadium	50	50	24	24
Yttrium	50	50	4	4
Zinc	10500	1930	7186	11079

NOTE: All concentrations expressed in $\mu g/l$ ($\mu g/l$ = micrograms per liter).

TABLE 6-24. ANALYTICAL DATA FOR CAUSTIC CLARIFIER SLUDGES PLANTS E AND F

Parameter	Concentration (mg/l)		
	Plant E	Plant F	Other Data*
Acenaphthalene	--	165	--
Acenaphthalenes, C1	--	135	--
Acenaphthalenes, C2	--	25	--
Acenaphthene	7.6	--	--
Aliphatics, C7-C18	--	12,500	--
Anthracene/phenanthrene	50	--	--
Benzenes, C3-C4	--	1,625	--
Bis-(2-ethylhexyl)-Phthalate	--	13	--
2-chlorophenol	14	--	--
Chrysene/benzo(a)anthracene	5.4	--	--
Dicyclohexylamine	59	--	--
Diethyl phthalate	--	13	--
Fluoranthrene	5.5	--	--
Fluorene	12	--	--
Isopropyl diphenyl amine	17	--	--
Naphthalene	47	360	--
Naphthalenes, C1	--	330	--
Naphthalenes, C2	--	335	--
n-nitrosodiphenylamine	1,200	--	--
Pyrene	5	--	--
Silicones	--	4,350	--
Aluminum	11.0	--	--
Antimony	3.77	--	--
Arsenic	0.076	--	1.6
Barium	0.520	--	651
Beryllium	0.060	--	--
Boron	23.1	--	--
Cadmium	1.16	--	9.6
Calcium	50.8	--	1,687
Chromium	0.880	--	199
Cobalt	0.960	--	--
Copper	0.990	--	2,393
Cyanides	--	--	10
Iron	8.98	--	24,922
Lead	4.28	--	4,554
Magnesium	21.7	--	--
Manganese	1.21	--	290
Mercury	0.178	--	0.48
Molybdenum	3.41	--	--
Nickel	0.48	--	29.2
Phosphorus	36.7	--	7,500
Selenium	0.023	--	30.5
Silicon	22.9	--	5,325
Silver	<0.005	--	2.3
Sodium	23,400	--	8,455
Strontium	0.250	--	--

TABLE 6-24. ANALYTICAL DATA FOR CAUSTIC CLARIFIER SLUDGES PLANTS E AND F (Continued)

Parameter	Concentration (mg/l)		
	Plant A	Plant B	Other Data*
Thallium	<0.1	--	--
Tin	<0.015	--	--
Titanium	0.230	--	--
Vanadium	1.41	--	--
Zinc	1.44	--	6,791

* Other data refers to data submitted by several drum reconditioners in response to a NABADA survey.

TABLE 6-25. ANALYTICAL DATA FOR DRIED CAUSTIC SLUDGE PLANT G

	Sample 1	Sample 2	Sample 3
Moisture Content, wt.%	27.66	14.63	45.20
	Concentration, mg/kg		
Aluminum	8,500	12,700	7,800
Antimony	889	975	828
Arsenic	6.6	11.7*	6.8
Barium	3,100	4,900	3,000
Beryllium	1.94	1.90	<1
Boron	378	539	405
Cadmium	65.2	95.2	73.6
Calcium	23,000	33,400	22,800
Chromium	1,500	2,300	1,400
Cobalt	209	548	293
Copper	990	1,900	919
Iron	81,500	134,000	80,000
Lead	5,900	10,300	5,800
Magnesium	3,600	6,200	3,800
Manganese	779	1,200	771
Mercury	3.1	1.7	3.5
Molybdenum	269	202	60.1
Nickel	1,900	2,100	1,600
Phosphorus	4,200	5,600	4,000
Selenium	1.0	1.3	1.4
Silicon	1,600	1,600	1,400
Silver	231	230	198
Sodium	55,600	87,600	58,800
Strontium	127	194	126
Thallium	<10	<10	<10*
Tin	265	320	227
Titanium	1,300	6,800	1,800
Vanadium	290	341	289
Zinc	1,900	3,300	2,000

* Average values for two analyses.

TABLE 6-26. ANALYTICAL DATA FOR FURNACE ASH PLANT F

Parameter	Concentration mg/kg ash
Aluminum	9,700
Antimony	105
Arsenic	9.2
Barium	9,460
Beryllium	<2
Boron	78.7
Cadmium	11
Calcium	7,840
Chromium	1,250
Cobalt	24.5
Copper	1,880
Iron	5,330
Lead	8,740
Magnesium	1,110
Manganese	35.9
Mercury	2.8
Molybdenum	320
Nickel	79.6
Phosphorus	606
Selenium	1.0
Silicon	156
Silver	<30
Sodium	1,450
Strontium	953
Thallium	<98.0
Tin	199
Titanium	426
Vanadium	98.3
Zinc	700
C7-C25 Aliphatics	4,200
Anthracene	40
C1 Anthracene	30
C2 Anthracene	50
C3-C4 Benzene	900
Bis (ethylhexyl) phthalate	170
Butyl benzyl phthalate	5
Diisobutyrate	100
Fluoranthene	10
Naphthalene	90
C^5 phenol	60
Pyrene	30
Silicones	10

- Tight-head facilities generally discharge wastewater and nearly half of the dischargers do not treat wastewater.

- Wastewater treatment pollutant removal efficiencies were poor at the four plants sampled by the Agency.

- Sedimentation, oil/water separation, and air flotation are the dominant treatment technologies at tight-head plants. Reuse of treated effluent is possible; however, zero discharge is only attainable if wastestreams are segregated and water conservation measures are implemented.

- Approximately 124 million pounds of residue are contained in drums received by reconditioners, annually.

- Wastewater treatment sludges generated by the industry are composed mainly of oil and grease (22 percent) and suspended solids (8 percent). High concentrations of 23 organics are observed.

7. COST OF WASTEWATER CONTROL AND TREATMENT

The purpose of this section is to describe appropriate technology and costs for controlling industry wastewater discharges. An economic assessment of possible regulations affecting the solvent recovery industry is presented.

7.1 INTRODUCTION

This section provides cost estimates for installing and operating wastewater treatment technology that is currently in-place in the drum reconditioning industry. In 1979, about half of the respondees to the National Barrel and Drum Association (NABADA) survey responded that they treat process wastewater prior to discharge. In this study, 13 out of 16 plants contacted provide wastewater treatment prior to discharge. However, as demonstrated in Section 6, the pollutant removal efficiencies of currently installed equipment are low. Therefore, a U.S. Environmental Protection Agency (EPA) decision to regulate the drum reconditioning industry will likely result in a significant investment in equipment and personnel.

7.2 MODEL TREATMENT SYSTEM

Physical/chemical treatment is the prevailing technology in the drum reconditioning industry. This technology takes the forms of sedimentation, oil/water separation, and air flotation. These technologies and related costs have been studied by the Industrial Technology Division (ITD) of EPA for numerous other industries. The Final Development Document for Effluent Limitations Guidelines and Standards for the Metal Finishing Point Source Category report costs for an emulsion breaking system that can be used as a model for estimating physical/chemical treatment costs for the drum reconditioning industry (EPA 1983).

Emulsion breaking is a demonstrated zero discharge technology for the drum reconditioning industry. The Agency visited three washing facilities that use air flotation, a variation of emulsion breaking, to achieve zero discharge. Each plant reconditions a variety of drum types that total between 500 and 3,000 drums daily per facility. Treated wastewater is used as makeup to caustic wash and as a intermediate stage rinse water.

Open-head drum reconditioners also have achieved zero discharge of process wastewater through the use of physical/chemical treatment. EPA visited a facility that recycles quench water after it is treated by sedimentation. Minor process wastestreams, such as paint booth water curtain overflow, also are treated and recycled. Because of evaporation losses in the quench process, the makeup water supply is supplemented with tap water. Two other drum burning plants discharge their quench water to emulsion breaking treatment systems that are employed to achieve zero discharge of their combined open- and tight-head wastewaters.

The model emulsion breaking system is identified as treatment system - Option 1 for the Metal Finishing Category. The system was designed to treat raw wastewater with oil and grease and toxic organic levels in excess of those observed in drum reconditioning wastewaters. Figures 7-1 and 7-2 are capital cost and operating cost curves, respectively, for the model system. All costs are reported in 1979 dollars, and a detailed discussion is presented in Appendix D.

Wastewater flows found in the drum reconditioning industry range from 100 to 20,000 gallons per day; therefore, the cost curves shown in Figures 7-1 and 7-2 are appropriate for the drum reconditioning industry. An average drum washing plant discharges 3,000 gallons of wastewater per day. In terms of 1979 dollars, an average plant that installs batch mode treatment would incur a capital cost of $70,000 and an annual operating expense of $25,000. Based on the use of cost indices, these costs would be $97,000 and $35,000, respectively, in 1985 (Engineering News Record 1985). A wastewater recycle system would add $13,000 to the capital cost (Means 1986). The cost of land and retrofit of existing process could add 20 percent to capital costs. The cost of collecting volatile organic carbon air emissions and venting to an existing control device would also increase costs 20 percent (EPA 1985). Sludge residuals would average about 2.5 percent of the wastewater volume or 75 gallons per day. The annual sludge disposal costs would average $2,000 if sludge is generated 270 days per year and the sludge is assumed to be nonhazardous since drum residuals are excluded from the RCRA definition of hazardous wastes ($5,000 = 270 x 75 x 25c/). Discharge compliance monitoring costs would be $2,000 per year. In summary, the total system capital cost would be $154,000 (154,000 = 97,000 + 13,000 for recycle + 22,000 for land and retrofit + 22,000 for emissions control). The total system operating cost would be $47,000 (47,000 = 35,000 + 5,000 for emissions control + 5,000 for sludge disposal + 2,000 for compliance monitoring).

7.3 ECONOMIC ASSESSMENT AND COST-EFFECTIVENESS

This subsection presents a preliminary economic assessment of possible regulations affecting the drum reconditioning industry. The first part of the subsection describes the treatment technology and costs analyzed, and presents the results of the economic impact analysis. The second part of the subsection provides an analysis of the cost-effectiveness of the treatment option.

7.3.1 Economic Assessment

This preliminary assessment of the possible economic impacts is based on an analysis of model plants. The impacts are measured by comparing unit control costs to service fees and drum value.

The Agency has determined, tentatively, that the model end-of-pipe treatment system for the drum reconditioning industry is air flotation. For a typical plant reconditioning 427 drums per

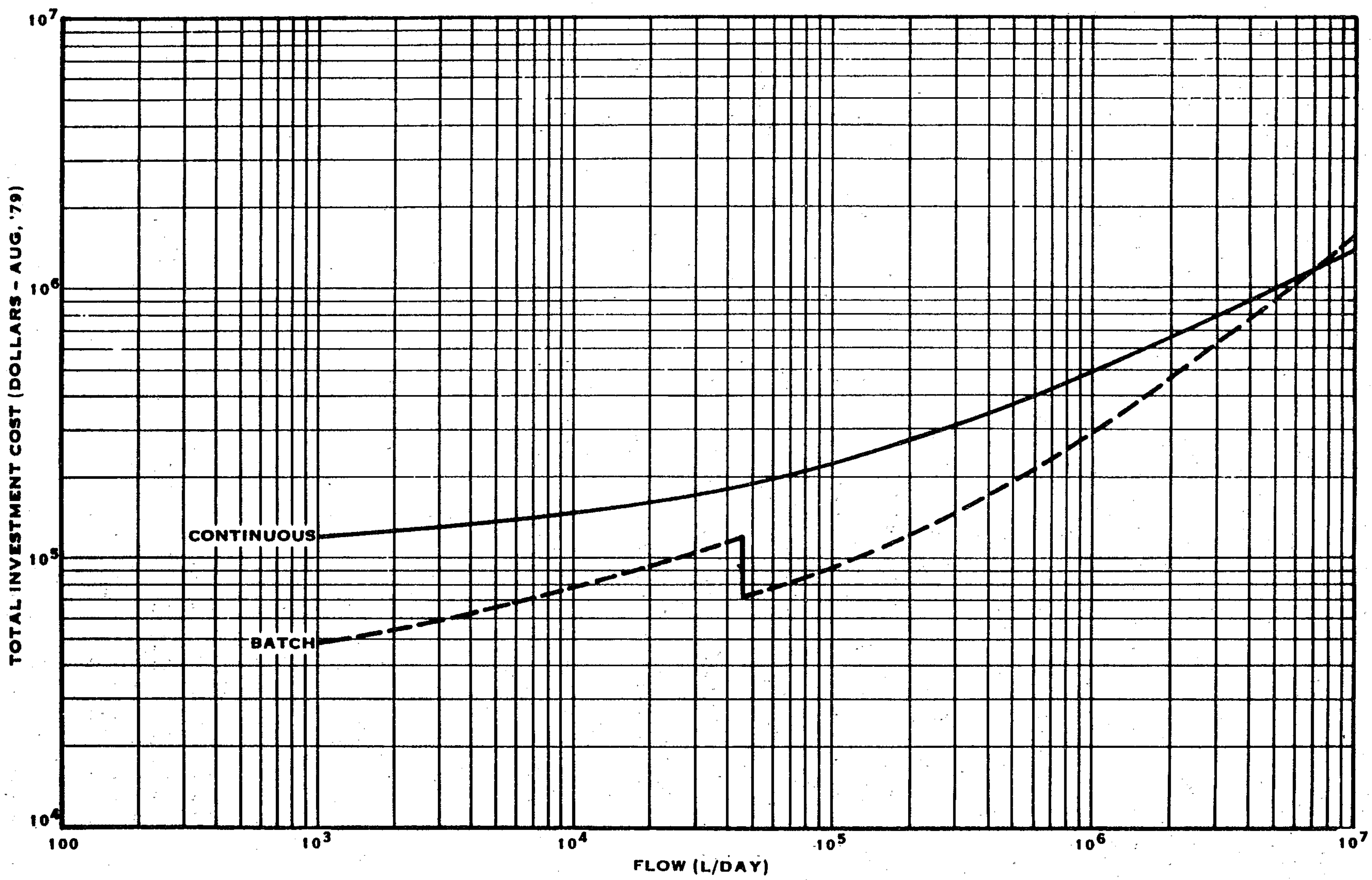

FIGURE 7-1. TOTAL INVESTMENT COSTS VS. FLOW RATE FOR OPTION 1 TREATMENT SYSTEM, CASE 6 (U.S. EPA 1983

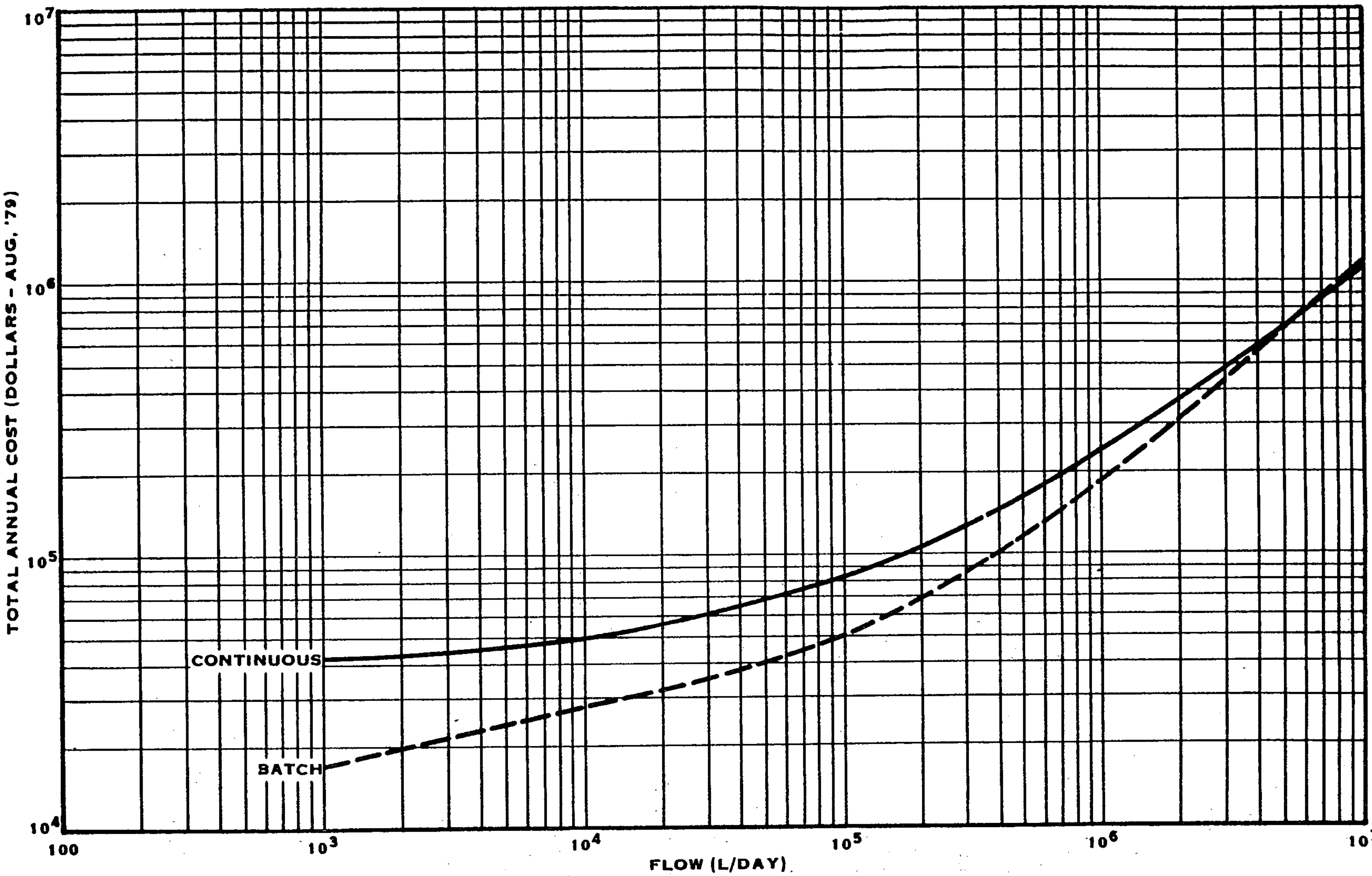

FIGURE 7-2. TOTAL ANNUAL COST VS. FLOW RATE FOR OPTION 1 TREATMENT SYSTEM, CASE 6 (U.S. EPA 1983)

day, this control option would result in a capital cost of $154,000 and an annual operating and maintenance cost of $47,000. If capital costs are annualized using a capital recovery factor of 0.26, the total annualized cost is $87,000.

For the model plant processing 427 drums per day and operating 260 days per year, the annualized control cost is about $0.78 per drum served. Based on the Agency data (SAIC 1986), laundry/service fees are about $6.50 per drum. Therefore, control costs are about 12 percent of the service fee. A second impact measure compares the control cost to the price of a reconditioned drum. Since the price is about $12.00, control costs are about 6.5 percent of the price of a reconditioned drum. Table 7-1 summarizes the calculations. By either measure, the impact of this control option is very low.

7.3.2 Cost-Effectiveness

Cost-effectiveness is defined as the incremental annualized cost of a pollution control option in an industry, or an industry subcategory, per incremental pound equivalent of pollutant removed by that control option. The analysis accounts for differences in toxicity among the pollutants with toxic weighing factors (TWF). The methodology for calculating cost effectiveness follows that used by EPA-ITD in studies of the Organic Chemicals, Plastics, and Synthetic Fibers Industry. Because concentration data are not always available for many priority and nonpriority pollutants, incremental removal may be underestimated for this preliminary cost-effectiveness calculation.

The control technology consists of sedimentation, oil/water separation, and air flotation followed by partially recycling treated wastewater. In passing through a publicly-owned treatment works (POTW) or any treatment system using an aeration operation, a volatile chemical can be either volatilized to the air, decomposed, removed in sludge, or discharged via outfalls. In this calculation, it is assumed that the volatilized portion of VOCs is captured and removed.

Table 7-2 shows the data used and the step-by-step calculation. For 250 drum reconditioners generating wastewater, each producing 3,000 gallons per day, the annual wastewater flow is 195 million gallons. The pounds equivalent (PE) removed for each pollutant is calculated on the basis of flow, concentration of that pollutant, and removal efficiencies. As described in Chapter 5, the Agency estimated the concentration of each pollutant based on sample data. Method I concentrations are appropriate for the cost effectiveness analysis and are used in this document. Total loadings for each pollutant are calculated by applying the Method I concentrations and the proportion of sample plants with detectable levels of the pollutant (labeled probability on the table) to the total number of plants. In total, 166,551 pound equivalents of priority pollutants are removed. The annualized cost per plant is $87,040, or $21.76 million for 250 plants. Therefore, the cost-effectiveness of this treatment option is $131

TABLE 7-1. IMPACT ON DRUM RECONDITIONING INDUSTRY

	Totals	Cost Impact Measure
Annualized Cost	$87,000	
Capacity	427 drums per day	$0.78/drum
Laundry/Service Fee	$6.50*/drum	12% of service fee
Reconditioned Drum Price	$12.00*/drum	6.5% of drum price

TABLE 7-2 COST-EFFECTIVENESS CALCULATION FOR DRUM RECONDITIONING WASTEWATER TREATMENT

Number of plants (N)	250
Wastewater flow (gpd) @ each plant (q)	3,000
Number of days/year in operation (d)	260
Annual flow (mgy) for all plants = N x q x d	195

Pollutant	TWF	Observed sample Probability	Observed sample conc. (ppb)	Raw waste Expected conc. (ppb)	Raw waste conc. wtd.	R	Wastewater treatment system effluent (ppb)	Wastewater treatment system conc. wtd.	Wastewater treatment system annual (lb)	Wastewater treatment system removal (PE)
1,1,1-TCA	0.000300	0.5	18384	9192	3	0.6	3677	1	8969	3
1,1-Dichloroethene	16.970000	0.25	25286	6322	107276	0.46	3414	57929	4729	80253
1,2-Dichloroethane	0.596000	0.25	315	79	47	0.19	64	38	24	15
2-Chloronaphthalene	0.350000	0.5	2323	1162	407	0	1162	407	0	0
2-Nitrophenol	0.001700	0.25	2953	738	1	0.08	679	1	96	0
Acetone	0.000000	0.25	857784	214446	0	0.91	19300	0	317366	0
Bis(2-eh) phthalate	2.186700	0.25	21449	5362	11726	0.93	375	821	8110	17735
Butyl benzyl phthal	0.025400	25	3281	82025	2083	0.5	41013	1042	66699	1694
D-N-Butyl phthalate	0.000165	0.25	6887	1722	0	0.86	241	0	2408	0
Ethylbenzene	0.004000	1	21598	21598	86	0.81	4104	16	28451	114
Isophorone	0.000010	0.25	14048	3512	0	0.64	1264	0	3655	0
Methylene chloride	2.947000	0.5	9820	4910	14470	0.24	3732	10997	1916	5648
Naphthalene	0.009030	0.75	3108	2331	21	0.71	676	6	2692	24
Phenanthrene	0.028100	0.25	11577	2894	81	1	0	0	4707	132
phenol	0.002190	0.25	932	233	1	0.5	117	0	189	0
Tetrachloroethene	0.707000	0.25	86267	21567	15248	0.32	14665	10368	11224	7935
Toluene	0.000400	1	20295	20295	8	0.8	4059	2	26405	11
T-1,2-Dichloroethen	0.000500	0.25	917	229	0	1	0	0	373	0
Trichloroethene	0.207000	0.5	1135	568	117	0.7	170	35	646	134
Endosulfan I	100.035000	0.25	296	74	7403	1	0	0	120	12039
Endosulfan sulfate	100.035000	0.25	528	132	13205	0	132	13205	0	0
Heptachlor	3438.600000	0.25	284	71	244141	0	71	244141	0	0
Sum (organic)				399,461	416,323		98,914	339,009	488,780	125,736
Antimony	0.003620	1	3481	3481	13	0.24	2646	10	1359	5
Arsenic	32.029000	1	54	54	1730	0.31	37	1193	27	872
Cadmium	5.090000	1	405	405	2061	0.36	259	1319	237	1207
Chromium	0.026700	1	3163	3163	84	0.67	1044	28	3446	92
Copper	0.467000	1	1581	1581	738	0.58	664	310	1491	696
Lead	1.750000	1	14485	14485	25349	0.78	3187	5577	18374	32155
Nickel	0.114000	1	201	201	23	0.46	109	12	150	17
Zinc	0.119000	1	24975	24975	2972	0.53	11738	1397	21527	2562
Beryllium	5.840000	0.5	20	10	58	0.06	9	55	1	6
Mercury	505.026000	0.75	8	6	3030	0.65	2	1061	6	3203
Sum (metals)				48,361	36,059		19,695	10,962	46,620	40,815
Organics plus metals				447,822	452,382		118,608	349,970	535,400	166,551
Annualized costs for all plants										21,760,000
CE ($/PE)										130.65

@ each plant: investment ($)	110,000
land costs (20% of above) ($)	22,000
O&M cost ($/y)	35,000
monitoring cost ($/y)	5,000
annualized cost ($) including 20% of investment & O&M for capturing VOCs.	87,040

per pound equivalent. The high cost-effectiveness value probably is a result of the fact that the control technology, while effective for removing conventional and nonconventional pollutants, is not specifically known for removing priority pollutants.

7.4 SUMMARY

- A model wastewater treatment system would include emulsion breaking technology and treated wastewater reuse. A typical facility would incur a capital cost of $154,000 and an annual operating cost of $47,000 to maintain and operate such a system.

- The annualized wastewater control cost is $0.78 per drum reconditioned which represents about 12 percent of the reconditioning fee.

- The cost-effectiveness of treating the process wastewater is $131 per pound equivalent of pollutant removed.

8. ENVIRONMENTAL ASSESSMENT

The purpose of this section is to present the results of environmental impacts analysis. The methodology used to estimate human health and aquatic life water quality impacts is described and results are discussed. Non-water quality impacts on emissions to the air, solid waste generation, and energy usage are also discussed.

8.1 METHODOLOGY USED TO ESTIMATE HUMAN HEALTH AND AQUATIC LIFE WATER QUALITY IMPACTS

An environmental assessment of water quality impacts was performed for both direct and indirect wastewater dischargers. Average plant raw waste concentrations and discharge flows for this industry/subcategory were used to project impacts on receiving streams. Water quality impacts for treated effluents were not performed because of the lack of pollutant-specific data.

8.1.1 Direct Discharge Analysis

The following analyses were performed for direct dischargers: (1) criteria comparisons, (2) stream flows with potential impacts, and (3) loading comparisons. The raw waste concentrations from wastestreams were compared to available water quality criteria (acute and chronic aquatic life criteria/ toxicity levels); human health criteria (ingesting water and organisms), including criteria for carcinogenicity protection or toxicity protection; and existing or proposed drinking water standards. A value greater than one indicates a criteria exceedance. The numerical values associated with these exceedances (exceedance factors) represent instream dilutions needed to eliminate projected water quality impacts.

Because actual receiving streams flow data were not available for this industry/subcategory, the stream flows with potential impacts also were projected using stream dilution factors and average plant flows.

Specific pollutant loadings were calculated based on the raw waste concentrations and total industry/subcategory flow and summed. The pollutant loadings were grouped into four categories: (1) total priority organics, (2) total nonpriority organics, (3) total priority inorganics, and (4) total nonpriority inorganics. The total priority organics and inorganics were compared to the total raw waste pollutant loadings from regulated BAT industries to evaluate the significance of pollutant loadings from the i- ndustry/ subcategory considered in this document.

8.1.2 Indirect Discharge Analysis

The following analyses were performed for indirect dischargers: (1) criteria comparisons using a POTW model and stream dilution analysis, (2) impacts to POTWs, and (3) loading comparisons.

A simplified POTW model and stream dilution analysis were performed to project receiving stream impacts from indirect dischargers. Actual receiving stream flow and POTW flow data were not available for this industry/ subcategory. In order to project receiving stream impacts, a statistical analysis was performed on the EPA's In-House Software (IHS) Industrial Facilities Discharge File and GAGE File to determine a POTW plant flow and a POTW receiving stream flow for use in the analyses. The 25th, 50th, and 75th percentile flows for POTWs with industrial indirect dischargers were 0.35, 1.1, and 3.0 million gallons per day (MGD), respectively. For this study, a 1.0 MGD plant flow is used. This is approximately the 50th percentile (median) flow and representative of the typical POTW plant flow. Twenty-one POTWs receiving industrial discharge had a plant flow of 1.1 MGD. The median receiving stream flow for the 21 POTWs was 12 MGD at low flow conditions and was used in the analysis to determine the diluted POTW effluent concentration.

Potential water quality impacts on receiving streams were determined using criteria comparisons. The POTW effluent pollutant concentrations calculated using Equation 1 were compared to acute aquatic criteria/toxicity levels to determine impacts in the mixing zone.

<u>Equation 1</u>:

$$\text{POTW Effluent } (\mu g/l) = \text{POTW Influent } (\mu g/l) \times (1 - \text{Treatment Removal Efficiency})$$

A calculated instream diluted POTW effluent concentration using Equation 2 was compared to chronic aquatic life criteria/toxicity levels, human health criteria, and drinking water standards.

<u>Equation 2</u>:

$$\text{In-Stream Diluted POTW Effluent}(\mu g/l) = \frac{\text{POTW Effluent}(\mu g/l) \times \text{POTW Flow(MGD)}}{\text{POTW Receiving Stream Flow(MGD)}}$$

Impacts on POTW operations were calculated in terms of inhibition of POTW processes and contamination of POTW sludges. Inhibition of POTW operations were determined by comparing POTW influent levels (Equation 3) with inhibition levels, when available.

<u>Equation 3</u>:

$$\text{POTW Influent } (\mu g/l) = \text{Average Plant Concentration} \times \frac{\text{Total Industry Flow (MGD)}}{\text{POTW Flow(MGD)}}$$

Contamination of sludge (thereby limiting its use) was evaluated by comparing projected pollutant concentrations in sludge (Equation 4) with sludge contamination levels, when available.

Equation 4:

Pollutant Concentration in Sludge (mg/kg) =
POTW Influent(μg/l) x Partition Factor x
Tmt. Removal Efficiency x 5.96 x Conversion Factors

The partition factor is a measure of the tendency for the pollutant to partition in sludge when it is removed from wastewater. For metals, this factor was assumed to be one. For predicting sludge generation, the model assumed the Metcalf and Eddy rule of thumb that 1,400 pounds of sludge is generated for every million gallons of wastewater processed which results in a sludge generation factor of 5.96.

To evaluate the significance of pollutant loadings from untreated indirect discharges, loading comparisons from indirect dischargers were performed using the same approach as with the direct dischargers. The total raw waste priority pollutant organic and inorganic loadings were compared to the total raw waste pollutant loadings from regulated industries with Pretreatment Standards for Existing Sources (PSES).

8.2 RESULTS OF ENVIRONMENTAL ASSESSMENT

8.2.1 Direct Dischargers

8.2.1.1 Raw Wastewater

Because of the high concentration for the majority of detected pollutants, projected water quality impacts from direct discharges of untreated (raw) wastewaters are significant for small to medium receiving streams (with stream flows up to 16,000 MGD), even at small average plant discharge flows (3,000). Of 77 detected pollutants, 59 were at levels that may be harmful to human health and/or aquatic life:

- 28 pollutants (including 10 carcinogens) have projected human health impacts for streams with less than 3,000 MGD flow;

- 29 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 36,300;

- 51 pollutants have projected long-term (chronic) aquatic life impacts for streams with less that 16,000 MGD flow; and

- 17 pollutants have projected drinking water impacts for streams with less than 11 MGD flow.

8.2.1.2 Treated Wastewater

Potential water quality impacts from the direct discharge of treated wastewater were projected for small and medium streams (with stream flows up to 15,000 MGD). Of the 77 detected pollutants, 52 were at levels that may be harmful to human health and/or aquatic life:

- 22 pollutants (including 10 carcinogens) have projected human health impacts for streams with less than 3,000 MGD flow;

- 19 pollutants have projected short-term (acute) aquatic life impacts in mixing zones of receiving streams with exceedance factors ranging from 1 to 33,000;

- 41 pollutants have projected long-term (chronic) aquatic life impacts for streams with less that 15,000 MGD flow; and

- 14 pollutants have projected drinking water impacts for streams with less than 6 MGD flow.

8.2.1.3 Pollutant Loadings (lbs/day)

	Raw Wastewater	Treated Wastewater
Priority organics:	316	140
Non-priority organics:	2,207	584
Priority inorganics:	66	29
Non-priority inorganics:	184	79
	2,773	832

Total direct discharge loadings of priority pollutants from raw wastewater are comparable to regulated industries raw loadings as follows:

- Organic loadings of 316 lbs/day compare with the leather tanning raw waste loadings, ranked in the lower half of raw waste loadings from regulated industries; and

- Inorganic loadings of 66 lbs/day ar low and are less that any raw waste loadings from regulated industries.

Total direct discharge loadings of priority pollutants from treated wastewater are comparable to regulated industries with BAT loadings as follows:

- Organic loadings of 140 lbs/day compare with coal mining and metal finishing industries, ranked in middle, in terms of loadings, of BAT-regulated industries;

- Inorganic loadings of 29 lbs/day compare with the porcelain enameling industry, ranked in the lower fourth of BAT-regulated industries.

8.2.2 Indirect Dischargers

8.2.2.1 Raw Wastewater

Indirect discharges of raw wastewaters (projected based on a model 1 MGD POTW) are expected to inhibit POTW treatment for one pollutant but not cause any sludge contamination; however, raw wastewater may cause POTWs to exceed human health criteria in receiving streams for 4 pollutants (all carcinogens), and aquatic life criteria/toxicity levels, both acute and chronic, for 7 and 6 pollutants, respectively.

8.2.2.2 Treated Wastewater

Potential water quality and POTW impacts from indirect discharge of treated wastewater (projected based on a model 1 MGD POTW) are expected to inhibit POTW treatment for one pollutant but not cause andy sludge contamination; however, treated wastewater may cause POTWs to exceed human health criteria in receiving streams for 4 pollutants (all carcinogens) and aquatic life criteria/toxicity levels, both acute and chronic, for 3 pollutants.

8.2.2.3 Pollutant Loadings (lbs/day)

	Raw Wastewater	Treated Wastewater
Priority organics:	1,263	559
Non-priority organics:	8,828	2,338
Priority inorganics:	263	117
Non-priority inorganics:	737	316
	11,091	3,330

Total indirect discharge loadings of priority pollutants from raw wastewater are comparable to regulated industries raw loadings as follows:

- Organic loadings of 1,263 lbs/day compare with the raw waste loadings from the electronic component industry, ranked in the lower half of raw waste loadings from regulated industries; and

- Inorganic loadings of 263 lbs/day are low and compare with the plastic molding and forming, ranked in the lower half of raw waste loadings from regulated industries.

Total direct discharge loadings of priority pollutants from treated wastewater are comparable to regulated industries with PSES loadings as follows:

- Organic loadings of 559 lbs/day compare with the leather tanning industry, ranked in middle of PSES-regulated industries; and

- Inorganic loadings of 117 lbs/day also compare with the middle of the PSES-regulated industries.

8.3 NON-WATER QUALITY ENVIRONMENTAL IMPACTS

The elimination or reduction of one form of pollution may create or aggravate other environmental problems. Therefore, Sections 304(b) and 306 of the CWA require EPA to consider non-water quality environmental impacts of certain regulations. In compliance with these provisions, EPA has considered the effect of possible regulations on air pollution, solid waste generation, and energy consumption. The non-water quality environmental impacts associated with this regulation are described below.

8.3.1 Air Pollution

Implementation of the model cost technology, air flotation, would result in a net reduction of air emissions. This conclusion is based on information developed during a study of dissolved air flotation (DAF) systems used in the petroleum refining industry (USEPA 1985). Installation of fixed roofs on DAF systems was shown to result in a 69 percent reduction in volatile organic carbon (VOC) emissions compared with uncovered systems. Collection of VOC emissions and venting to a control device was shown to result in 95 percent reduction. Similar percent reductions are potentially achievable in the drum reconditioning industry, although data are not available to accurately estimate the VOC mass potentially reduced.

8.3.2 Solid Waste

EPA considered the effect that implementation of the model control technology could have on the production of solid waste, including hazardous waste defined under Section 3001 of the Resource Conservation and Recovery Act (RCRA). EPA estimates that increases in total solid waste of 9,700 metric tons of sludge per year, including hazardous waste, resulting from implementation of the model technology, will double current levels (SAIC 1987). The Agency included sludge incineration in the estimated engineering costs of compliance for any incremental sludge generated by the model treatment systems. Therefore, the net residual solid waste, in the form of ash, will be negligible.

8.3.3 Energy Requirements

EPA estimated that implementation of the model control technology would double energy consumption from present industry use, since only half of the industry is believed to have any technology currently in place. With the exception of sludge incineration, the estimated increased energy consumption is 250 barrels of No. 2 fuel per year (SAIC 1987). The energy consumption associated with incineration is assumed to be small, since air flotation sludges are composed of oil, greases, and other organics that have high-energy values.

Such sludges can be used in fuel blends in existing furnaces, and therefore, disposal costs are minimal.

8.4 SUMMARY

The following list summarizes the major points that were discussed in this section:

- Total loadings of priority pollutant inorganics from untreated wastewater are low when compared to raw waste loadings of priority inorganics from regulated BAT/PSES industries.
- Total loadings of priority pollutant organics from untreated wastewater are significant when compared to raw waste loadings from regulated industries.
- Implementation of the model cost technology would result in a net reduction of air emissions, a doubling of the volume of sludge generated from wastewater treatment systems, and a doubling of energy consumption.

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