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DEVELOPMENT DOCUMENT

FOR

EFFLUENT LIMITATIONS GUIDELINES
NEW SOURCE PERFORMANCE STANDARDS

AND

PRETREATMENT STANDARDS

FOR THE

METAL MOLDING AND CASTING
(FOUNDRIES)
POINT SOURCE CATEGORY
VOLUME I

Anne M. Gorsuch
Administrator

Steven Schatzow
Director
Office of Water Regulations and Standards

Jeffery Denit, Director
Effluent Guidelines Division

Ernst Hall
Chief, Metals and Machinery Branch

John G. Williams
Project Officer

November 1982

Effluent Guidelines Division
Office of Water Regulations and Standards
U. S. Environmental Protection Agency
Washington, D.C. 20460

TABLE OF CONTENTS

SECTION	SUBJECT	PAGE
I.	SUMMARY AND CONCLUSIONS	1
II.	RECOMMENDATIONS	9
III.	INTRODUCTION	23
	Legal Authority	23
	Background - The Clean Water Act	23
	General Description of the Metal Molding and Casting Industry	25
	Plant Data Collection	30
	Profile of Plant Data	33
	Description of Metal Molding and Casting Industry Processes	34
	Anticipated Industry Growth	46
	Profile of Plants in the Metal Molding and Casting Point Source Category	47
	Additional Data Collection Activities	52
IV.	INDUSTRY SUBCATEGORIZATION	111
	Introduction	111
	Selected Subcategories	112
	Subcategory Definitions	115
	Subcategorization Basis	121
	Production Normalizing Parameters	
V.	WATER USE AND WASTE CHARACTERIZATION	127
	Introduction	
	Information Collection	128
	Production Profile	129
	Process Wastewater Flow	129
	Selection of Plants for Sampling	130
	Water Use and Waste Characteristics	135
	Incoming Water Analysis	135
	Raw Waste Analysis	135
	Effluent Analysis	135
	Aluminum Casting Subcategory	136
	Copper Casting Subcategory	144
	Iron and Steel (Ferrous) Casting Subcategory	147
	Lead Casting Subcategory	164
	Magnesium Casting Subcategory	166
	Zinc Casting Subcategory	167
VI.	SELECTION OF POLLUTANTS	287
	Pollutants Not Detected in Raw	287

TABLE OF CONTENTS (Continued)

SECTION	SUBJECT	PAGE
	Wastewaters	
	Pollutants Detected in Raw Wastewaters Below Quantifiable Limits	287
	Pollutants Present in Raw Wastewaters	287
	Regulation of Specific Pollutants	
	Aluminum Casting Subcategory	377
	Copper Casting Subcategory	389
	Ferrous Casting Subcategory	396
	Lead Casting Subcategory	409
	Magnesium Casting Subcategory	411
	Zinc Casting Subcategory	416
	Summary	
VII.	CONTROL AND TREATMENT TECHNOLOGY	441
	Introduction	441
	End-of-Pipe Treatment Technologies	441
	Major Technologies	442
	Emulsion Breaking	442
	Oxidation By Potassium Permanganate	450
	Chemical Precipitation	451
	Granular Bed Filtration	462
	Pressure Filtration	466
	Settling	468
	Skimming	471
	Major Technology Effectiveness	476
	Minor Technologies	496
	Carbon Adsorption	492
	Centrifugation	498
	Coalescing	500
	Evaporation	502
	Flotation	505
	Gravity Sludge Thickening	507
	Sludge Bed Drying	509
	Ultrafiltration	511
	Vacuum Filtration	515
	In-Plant Technology	516
VIII.	COST, ENERGY, AND NON-WATER QUALITY IMPACTS	543
	Introduction	543
	Sampled Plant Treatment Costs	543
	Development of Cost Models	544
	Basis for Model Cost Estimates	546
	Model Cost Estimates	547
	Cost, Energy, and Non-Water Quality Impacts Summary	547

TABLE OF CONTENTS (Continued)

SECTION	SUBJECT	PAGE
IX.	EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE	799
	Introduction	799
	Factors Considered	799
	Approach To BPT Development	800
	Identification of Proposed BPT	810
	Aluminum Casting Subcategory	810
	Copper Casting Subcategory	822
	Ferrous Casting Subcategory	824
	Lead Casting Subcategory	831
	Magnesium Casting Subcategory	835
	Zinc Casting Subcategory	838
	Analysis of BPT Discharge Options	843
	Review	843
	Cost Comparison of BPT Options	844
	Comparison of Discharge Loads Between BPT Options	846
	Major Assumptions of BPT Options Analysis	847
X.	EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE	921
	Introduction	921
	Development of BAT	921
	Identification of BAT	922
XI.	BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY	965
XII.	EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF NEW SOURCE PERFORMANCE STANDARDS	967
	Introduction	967
	Identification of NSPS	967
	Rationale for NSPS	968
	NSPS Effluent Levels	968
	Selection of NSPS Alternatives	968
XIII.	PRETREATMENT STANDARDS FOR DISCHARGERS TO PUBLICLY OWNED TREATMENT WORKS	989
	Introduction	989
	General Pretreatment Standards	989
	Categorical Pretreatment Standards	989

TABLE OF CONTENTS (Continued)

SECTION	SUBJECT	PAGE
	Identification of Pretreatment	991
	Rationale For PSES and PSNS	
	PSES and PSNS Effluent Levels	994
	Selection of PSES and PSNS Alternative	993
XIV.	ACKNOWLEDGEMENTS	1015
XV.	REFERENCES	1017
XVI.	GLOSSARY	1019

TABLES

NUMBER	TITLE	PAGE
III-1	Foundry Shipments in the United States	54
III-2	Penton Foundry Census Information	55
III-3	Distribution of Additional 1000 Foundry Plant Surveys	56
III-4 thru III-8	General Summary Tables - Aluminum Casting Subcategory	57 61
III-9 and III-10	General Summary Tables - Copper and Copper Alloy Casting Subcategory	62 63
III-11 thru III-15	General Summary Tables - Ferrous Casting Subcategory	64 84
III-16 and III-17	General Summary Tables - Lead Casting Subcategory	86 87
III-18 and III-19	General Summary Tables - Magnesium Casting Subcategory	88 89
III-20 and III-21	General Summary Tables - Zinc Casting Subcategory	90 92
III-22	Operating Modes, Control and Treatment Technologies and Disposal Methods	93
III-23	Ferrous Mold Cooling Casting Quench Operations	97
III-24	Distribution of Plants	98
III-25	Percentage of Active "Wet" Operations Within Each Employee Group	99
V-1	Annual Production of Plants Which Generate Process Wastewaters	171
V-2 thru V-7	Metals Casting Industry Discharge Summaries	172 180
V-8	Active Foundry Operations; Discharge Mode	181

TABLES (Continued)

NUMBER	TITLE	PAGE
	Profile	
V-9	List of Toxic Pollutants	182
V-10	Conventional and Nonconventional Pollutants	186
V-11	Plant Assessment of the Known or Believed Presence of Toxic Pollutants in Foundry Raw Process Wastewaters	187
V-12	Toxic Pollutants Considered to be Present in Foundry Process Wastewaters	192
V-13	Inorganic Toxic Pollutants Selected for Sampling and Analysis During Verification Plant Visits	195
V-14	Types and Amounts of Binders Used in Foundries	196
V-15 thru V-19	Characteristics of Aluminum Process Wastewaters	197 201
V-20 and V-21	Characteristics of Copper Process Wastewaters	203 204
V-22 thru V-26	Characteristics of Ferrous Process Wastewaters	205 222
V-27	Characteristics of Lead Process Wastewaters	224
V-28 and V-29	Characteristics of Magnesium Process Wastewaters	225 226
V-30 and V-31	Characteristics of Zinc Process Watewaters	227 228
V-32 thru V-37	Raw Wastewater Analyzed Data Profile Profile	229 244
VI-1	Toxic Pollutants Not Detected in the Metal Molding and Casting Industry	427

TABLES (Continued)

NUMBER	TITLE	PAGE
VI-2	Toxic Pollutants Detected Below Quantifiable Limits in the Metal Molding and Casting Category	428
VI-3	Toxic Pollutants Present in the Metal Molding and Casting Category	429
VI-4	Toxic Pollutant Disposition; Metal Molding and Casting Category	431
VI-5	Conventional and Non-conventional Pollutant Disposition; Metal Molding and Casting Industry	436
VI-6	Toxic, Conventional and Non-Conventional Pollutants Considered for Regulation in the Metal Molding and Casting Category	437

TABLES (Continued)

NUMBER	TITLE	PAGE
VII-1	Emulsion Breaking Performance Data	445
VII-2	Emulsion Breaking Performance Data; Toxic Organic Pollutants	446
VII-3	Effect of pH Control on Metals Removal	454
VII-4	Effectiveness of NaOH for Metals Removal	454
VII-5	Effectiveness of Lime and NaOH for Metals Removal	456
VII-6	Theoretical Solubilities of Hydroxides and Sulfides of Selected Metals in Pure Water	457
VII-7	Sampling Data from Sulfide Precipitation-Sedimentation Systems	457
VII-8	Sulfide Precipitation-Sedimentation Performance	459
VII-9	Ferrite Co-Precipitation Performance	460
VII-10	Multimedia Filter Performance	465
VII-11	Performance of Selected Settling Systems	470
VII-12	Skimming Performance	473
VII-13	Trace Organic Removal by Skimming; API Plus Belt Skimmers	475
VII-14	Combined Metals Data Effluent Values	483
VII-15	L&S Performance; Additional Pollutants	485
VII-16	Combined Metals Data Set - Untreated Wastewater	486
VII-17	Maximum Pollutant Level in Untreated Wastewater	486
VII-18, 19 and 20	Precipitation-Sedimentation-Filtration (LS&F) Performance	488 490

TABLES (Continued)

NUMBER	TITLE	PAGE
VII-21	Summary of Treatment Effectiveness	494
VII-22	Activated Carbon Performance (Mercury)	497
VII-23	Treatability Rating of Priority Pollutants Utilizing Carbon Adsorption	512
VII-24	Classes of Organic Compounds Adsorbed on Carbon	513
VII-25	Ultrafiltration Performance	514
VIII-1 thru VIII-5	Effluent Treatment Costs	553 557
VIII-6 thru VIII-10	Foundry Operations Control and Treatment Technology; Aluminum Foundries	558 587
VIII-11 and VIII-12	Foundry Operations Control and Treatment Technology; Copper and Copper Alloy Foundries	592 594
VIII-13 thru VIII-17	Foundry Operations Control and Treatment Technology; Ferrous Foundries	597 613
VIII-18 and VIII-19	Foundry Operations Control and Treatment Technology; Lead Foundries	621 625
VIII-20 and VIII-21	Foundry Operations Control and Treatment Technology; Magnesium Foundries	628 630
VIII-22 and VIII-23	Foundry Operations Control and Treatment Technology; Zinc Foundries	632 635
VIII-24 thru VIII-34	Model Cost Data - Aluminum Foundries	648 659
VIII-35 and VIII-36	Model Cost Data - Copper and Copper Alloy Foundries	660 661
VIII-37 thru VIII-84	Model Cost Data - Ferrous Foundries	662 738
VIII-85 thru	Model Cost Data - Lead Foundries	740

TABLES (Continued)

NUMBER	TITLE	PAGE
VIII-87		742
VIII-88 and VIII-89	Model Cost Data - Magnesium Foundries	743 744
VIII-90 thru VIII-94	Model Cost Data - Zinc Foundries	745 749
VIII-95	Procedure for Determining Industry Wide Treatment Costs for Each Process	750
VIII-96 thru VIII-98	Metals Casting Industry; Wastewater Treatment Cost Summary; Aluminum Subcategory	751 753
VIII-99 thru VIII-101	Metals Casting Industry; Wastewater Treatment Cost Summary; Copper Subcategory	754 756
VIII-102 thru VIII-113	Metals Casting Industry; Wastewater Treatment Cost Summary; Ferrous Subcategory	757 768
VIII-114	Metals Casting Industry; Wastewater Treatment Cost Summary; Lead Subcategory	769
VIII-115	Metals Casting Industry; Wastewater Treatment Cost Summary; Magnesium Subcategory	770
VIII-116 thru VIII-118	Metals Casting Industry; Wastewater Treatment Cost Summary; Zinc Subcategory	771 773
VIII-119 thru VIII-126	Statistical Estimates of Foundry Operations Operations	774 787
VIII-127	Energy Requirements Due to Water Pollution Control	788
VIII-128	Solid and Liquid Waste Generation Due to Water Pollution Control	791

TABLES (Continued)

NUMBER	TITLE	PAGE
IX-1	Pollutants Selected for Regulation at BPT	850
IX-2	Operations with Recycle Systems Installed	853
IX-3	Zero Discharge Operation Data Summary	854
IX-4	Process Segments in Which the Proposed BPT Limitations are No Discharge of Process Wastewater Pollutants	860
IX-5	Summary of Treatment In-Place	861
IX-6	Comparison of BPT Model Costs; Selected BPT Models vs. Discharge Options	862
IX-7	Dragout Tank Effluent Quality	864
IX-8	BPT and Discharge Option Monitoring Cost Criteria	865
IX-9	Comparison of BPT Model Waste Loads; Selected BPT Models vs Discharge Options	866
IX-10	Comparison of Metals Casting Industry Pollutant Waste Loads; Direct Dischargers	868
IX-11	Toxic Organic Pollutants not Treated by the BPT Discharge Alternative Treatment Technologies	869
IX-12	Expected Compliance Strategy; Selected BPT Treatment Models vs Discharge Options	870
IX-13	Differences in Cost Between Complete Recycle and Partial Recycle	871
IX-14	Comparison of Metals Casting Industry Treatment Costs and Total Pollutant Waste Loads; Proposed BPT Levels of Treatment vs Discharge Options	872
IX-15	Alternative Effluent Limitations; 90% Recycle Discharge Alternative	873

TABLES (Continued)

NUMBER	TITLE	PAGE
IX-16	Alternative Effluent Limitations; 50% Recycle Discharge Alternative	883
X-1	Raw Wastewater and Treated Effluent Pollutant Loads; Direct and Zero Discharge Operations	937
X-2	Alternative Effluent Limitations; 90% Recycle Discharge Alternative	940
X-3	Alternative Effluent Limitations; 50% Recycle Discharge Alternative	946

FIGURES

NUMBER	TITLE	PAGE
III-1	Product Flow Diagram	100
III-2 thru III-9	Process Flow Diagrams	101 thru 108
III-10	Cast Metals Production at Five-Year Intervals	109
III-11	Ferrous Foundry Trends in the United States	110
V-1 thru V-40	Wastewater Treatment System Water Flow Diagrams (Sampled Plants)	246 thru 285
VII-1	Comparative Solubilities of Metal Hydroxides and Sulfide as a Function of pH	519
VII-2	Effluent Zinc Concentration vs Minimum Effluent pH	520
VII-3	Lead Solubility in Three Alkalies	521
VII-4	Granular Bed Filtration	522
VII-5	Pressure Filtration	523
VII-6	Representative Types of Sedimentation	524
VII-7 thru VII-15	Hydroxide Precipitation Sedimentation Effectiveness	525 thru 533
VII-16	Activated Carbon Adsorption Column	534
VII-17	Centrifugation	535
VII-18	Types of Evaporation Equipment	536
VII-19	Dissolved Air Flotation	537
VII-20	Gravity Thickening	538

FIGURES (Continued)

NUMBER	TITLE	PAGE
VII-21	Sludge Drying Bed	539
VII-22	Simplified Ultrafiltration Flow Schematic	540
VII-23	Vacuum Filtration	541
VIII-1	Aluminum Foundries Die Casting and Casting Quench; BPT Co-Treatment Model	794
VIII-2	Ferrous Foundries Dust Collection and Slag Quench; BPT Co-Treatment Model	795
VIII-3	Ferrous Foundries Dust Collection and Sand Washing; BPT Co-Treatment Model	796
VIII-4	Ferrous Foundries Slag Quench and Melting Furnace Scrubber; BPT Co-Treatment Model	797
IX-1 thru IX-5	Aluminum Casting Operations; BPT Model Treatment System	892 896
IX-6 and IX-7	Copper and Copper Alloy Casting Operations; BPT Model TReatment System	897 898
IX-8 thru IX-13	Ferrous Casting Operations; BPT Model Treatment System	899 904
IX-14 thru IX-16	Lead Casting Operations; BPT Model Treatment System	905 907
IX-17 and IX-18	Magnesium Casting Operations; BPT Model Treatment System	908 909
IX-19 and IX-20	Zinc Casting Operations; BPT Model Treatment System	910 911
IX-21 and IX-22	Discharge Options; Wastewater Flow Diagrams	912 913
IX-23	Metal Molding and Casting Alternative BPT Analysis; BPT Costs	914
IX-24	Ferrous Subcategory; Dust Collection Operations - Discharge Alternative	915

FIGURES (Continued)

NUMBER	TITLE	PAGE
	Treatment Model	
IX-25 thru IX-28	Metal Molding and Casting; Alternative BPT Analyses	916 919
X-1 thru X-7	Aluminum Casting Operations; BAT Alternatives	952 958
X-8 and X-9	Lead Casting Operations; BAT Alternatives	959 960
X-10 thru X-12	Zinc Casting Operations; BAT Alternatives	961 963
XII-1 thru XII-10	Aluminum Casting Operations; NSPS Alternatives	972 981
XII-11 thru XII-13	Lead Casting Operations; NSPS Alternatives	982 984
XII-14 thru XII-17	Zinc Casting Operations; NSPS Alternatives	985 988
XIII-1 thru XIII-10	Aluminum Casting Operations; PSES and PSNS Alternatives	997 1006
XIII-11 thru XIII-13	Lead Casting Operations; PSES and PSNS Alternatives	1007 1009
XIII-14 thru XIII-17	Zinc Casting Operations; PSES and PSNS Alternatives	1010 1013

SECTION I

SUMMARY AND CONCLUSIONS

Pursuant to Sections 301, 304, 306, 307, and 501 of the Clean Water Act and the Settlement Agreement in Natural Resources Defense Council v. Train 8 ERC 2120 (D.D.C. 1976) modified 12 ERC 1833 (D.D.C. 1979), EPA has collected and analyzed data for plants in the Metal Molding and Casting Point Source Category. There are no existing effluent limitations or performance standards for this industry. This document and the administrative record provide the technical basis for proposing effluent limitations guidelines for existing direct dischargers, pretreatment standards for new and existing indirect dischargers, and standards of performance for new source direct dischargers.

This category is made up of three thousand six hundred (3600) plants employing people. Nine hundred sixty five (965) of these plants use wet processing methods which can generate wastewaters. Of the 965 plants, 287 discharge directly to rivers, lakes, or streams; 327 discharge to publicly owned treatment works (POTW); and 351 achieve zero discharge of process wastewaters.

The Agency developed a data collection portfolio (DCP) to collect information regarding plant size, age, productin, the number of employees, the production processes used, the quantities of process wastewaters generated and discharged, wastewater treatment facilities in-place, and disposal practices at plants practicing metal molding and casting. Using the Penton "Metal Casting Industry Directory" as a basis, the Agency selected, using statistical survey methods, 1269 plants for receipt of DCPS. Responses were received from 960 plants In order to characterize the industry, statistical weights, based upon the statistical survey methods, were applied to each item in the plant survey data. The Agency conducted a telephone survey in mid-1981 to update the plant information and data.

In addition to the DCP distribution described above, DCPS were sent to all of the plants (226) identified as producers of lead castings. These plants are primarily involved in the manufacture of batteries. Ten of the respondents indicated that process wastewaters are generated in metal molding and casting activities.

EPA sampled the raw and untreated process wastewaters at 40 plants. Nineteen of these plants were visited during a previous study of this industry, and the remainder were visited as part of current guidelines development efforts. In the previous Agency study, analyses were performed for the conventional and for

selected non-conventional and toxic metal pollutants. In the current industry study, analyses were performed for the conventional, toxic metal, and toxic organic pollutants and for selected non-conventional pollutants. In each subcategory, wastewater samples were collected from the metal molding and casting processes and from associated process wastewater generating equipment (i.e., scrubbers).

In developing the subcategorization and process segmentation scheme, the Agency examined the following factors:

1. Type of metal cast
2. Manufacturing process
3. Air pollution sources and control devices
4. Water use
5. Process wastewater characteristics
6. Raw materials
7. Process chemicals
8. Wastewater treatability
9. Plant size (production and number of employees)
10. Plant age
11. Geographic location
12. Non-water quality impacts; solid waste generation and disposal; and energy requirements

The type of metal cast is the principal factor affecting the Agency's subcategorization scheme. Differences in the physical and chemical properties of the various types of metal cast result in a diversity of manufacturing processes, raw materials, process chemical use, sources of air pollution, water use, and process wastewater characteristics. Accordingly, the six subcategories reflect the six types of base metal. EPA has determined that differences in alloys of the same bases metal were not significant enough to warrant subcategorization by alloy.

The subcategories were further divided into nineteen process segments to allow for dissimilar manufacturing processes and ancillary operations among the different subcategories.

Following are the subcategories of the metal molding and casting point source category:

Subpart	Subcategory
A. Aluminum Casting	1. Investment Casting
	2. Melting Furnace Scrubber
	3. Casting Quench
	4. Die Casting
	5. Die Lube

B.	Copper Casting	1. Dust Collection Scrubber 2. Mold Cooling and Casting Quench
C.	Iron & Steel (Ferrous) Casting	1. Dust Collection Scrubber 2. Melting Furnace Scrubber 3. Slag Quench 4. Mold Cooling and Casting Quench 5. Sand Washing
D.	Lead Casting	1. Continuous Strip Casting 2. Melting Furnace Scrubber 3. Grid Casting Scrubber
E.	Magnesium Casting	1. Grinding Scrubber 2. Dust Collection Scrubber
F.	Zinc Casting	1. Die Casting and Casting Quench 2. Melting Furnace Scrubber

The Agency reviewed the raw wastewater characteristics data and process information to select those pollutants which would be considered for specific regulation. These pollutnts follow:

Antimony	Fluoride
Arsenic	Iron
Cadmium	Manganese
Chromium	Phenols (4AAP)
Copper	Sulfide
Lead	Oil and Grease
Nickel	Total suspended solids
Zinc	Specific toxic organic pollutants
Ammonia (N)	

The Agency studied various end-of-pipe technologies to treat the assorted process wastewaters generated in this point source category. These technologies include:

Sedimentation
Chemical precipitation and sedimentation
Flocculation
Neutralization
Multimedia filtration
Vacuum filtration
Chemical emulsion breaking
Evaporative cooling
Oxidation by potassium permangauate
Activated Carbon Adsorption

EPA also studied in-plant control and wastewater recycle. The use of wastewater recycle was reported extensively in the plant survey data and was observed in many of the sampled plants.

Model treatment system costs were prepared for each level of treatment considered in each process segment. Using these model costs, the information provided in the DCPs and in the update survey, and the statistical survey methods employed, the Agency estimated the cost impact of the proposed regulation on the industry. The Agency estimated, for each process segment, the number of potential closures, the number of employees affected, and the impact on price and balance of trade. These results are reported in the economic impact analysis.

EPA is proposing BPT limitations for 18 process segments. For one process segment, lead continuous strip casting, there are no direct dischargers; therefore EPA is not proposing BPT limitations for this process segment.

EPA is proposing no discharge of process wastewater pollutants for 14 process segments (the 9 process segments of the iron and steel, the copper and the magnesium casting subcategories and 5 process segments associated with the other 4 subcategories). These five process segments are: the aluminum casting quench, the aluminum die lub, the lead melting furnace scrubber, the lead grid casting scrubber, and the zinc casting quench process.

EPA is proposing BPT discharge limitations for the remaining 4 process segments based on treatment followed by a discharge. The 4 process segments are: aluminum investment casting, aluminum melting furnace scrubber, aluminum die casting, and zinc melting furnace scrubber. Generally, the treatment provided in these segments consists of chemical precipitation, sedimentation, oil removal, and/or partial recycle.

For the fourteen process segments for which the Agency is proposing complete recycle of process wastewaters at BPT, the Agency considered two less stringent treatment alternatives. These options call for partial recycle and treatment of the wastewater not recycled. Both discharge alternatives are designed to be compatible with existing in-place treatment technologies and are based upon solids and metals removal technologies currently used by foundries (i.e., lime addition followed by clarification). The options differ by the extent of partial recycle after simple sedimentation. One option is based upon 90 percent recycle and the other is based upon 50 percent recycle. Oil skimming devices are included for both options, as required, for oil removal.

After comparing complete recycle with the two discharge options, the Agency concluded that 100 percent recycle is preferable, based upon the extent to which 100% recycle is practiced and upon cost and pollutant removal considerations. However, comments are solicited on these and similar treatment technologies. Further analysis, based upon comments, may show that one of these options is an appropriate basis for BPT limitations in the final regulation.

For 14 process segments, the BPT levle of treatment achieves complete recycle. As this is the best available technology, BAT is equal to BPT for these process segments.

There are no direct dischargers in the lead continuous strip process segment. Therefore, no BAT limitations are proposed for this process segment. In the aluminum investment casting and the aluminum melting furnace scrubber process segments exclusions, provided in paragraph 8 of the Revised Settlement Agreement, preclude the proposal of BAT effluent limitations. In these process segments, the toxic organic and toxic metal pollutants were either not detected or detected below treatable levels.

The proposed BPT limitations for the aluminum die casting process segment are based upon hydroxide precipitation-sedimentation, filtration and chemical emulsion breaking with 85 percent recycle of process wastewater. EPA is proposing BAT limitations based on the BPT technology with recycle increased to 95 percent.

EPA is using complete recycle as the basis for porposed BAT effluent limitations in the zinc melting furnace scrubber process segment. Complete recycle has been demonstrated, and high recycle rates are common, in this process.

The basis for new source performance standards is to be the best available demonstrated technology (BDT). New plants have the opportunity to design the best and most efficient metal molding and casting processes and wastewater treatmetn technologies.

The 90% and 50% recycle options considered as possible bases for BPT were rejected for the reasons set forth above in the BPT discussion. Complete recycle is economically achievable and will remove substantial quantities of toxic pollutants. A number of process segments would discharge toxic organic pollutants (principally phenolic compounds) if complete recycle were not the basis for BAT. Neither the 90% nor the 50% recycle options were based upon technologies that would treat these toxic organic pollutants. If a discharge option were selected for BAT and these pollutants required treatment, the total cost of these options would far exceed the cost of complete recycle.

EPA is proposing NSPS for all 19 process segments of all six subcategories. This number includes the 18 process segments for which BPT and BAT limitations are proposed plus the lead continuous strip casting process segment, (in which there are no existing direct dischargers). For the 15 process segments where the proposed BPT and BAT limitations are complete recycle, pollutant discharges have been reduced to the maximum extent possible. The Agency has selected NSPS technology that is equivalent to BPT/BAT technology for these 15 process segments. BAT technology achieves no discharge of process wastewater pollutants and is demonstrated in the industry.

In the aluminum investment casting and the aluminum melting furnace scrubber process segments, EPA has selected the equivalent of BPT as the bases for the proposed NSPS. Complete recycle has not been demonstrated in these process segments and cannot be readily transferred.

In the aluminum die casting process segment, the proposed NSPS are equivalent to the proposed BAT limitations, with the addition of standards for TSS, oil and grease, and pH. The treatment technologies and associated pollutant removal capabilities have been demonstrated in this process segment.

The proposed NSPS for the lead continuous strip casting process segment are based upon lime precipitation, sedimentation, and filtration. Filtration is used to improve lead removal performance. these technologies are in use and well demonstrated in this process segment.

EPA is proposing PSES for the 19 process segments of all six subcategories. For the 13 process segments where the proposed BAT limitations are based upon complete recycle the Agency has selected the equivalent of BAT as the basis for the proposed PSES. EPA is proposing PSES equivalent to BAT for aluminum die casting. For lead continuous strip casting EPA is porposing PSES based on the hydroxide precipitation, sedimentation, and filter technologies as demonstrated by 4 of the 5 continuous strip casting plants. For the aluminum investment casting and the aluminum melting furnace scrubber process segments, EPA is not proposing PSES because the levels of total suspended solids and oil and grease discharged from these processes are considered compatible with treatment by POTWs. For the two process segments of the magnesium subcategory there are no indirect dischargers therefore EPA is not proposing PSES.

For the 13 process segments for which the Agency is proposing complete recycle of process wastewater as the basis for PSES, the

Agency considered two less stringent treatment alternatives. These are the same alternatives as were considered for BPT. The Agency is proposing PSES based upon complete recycle rather than on either of the other treatment alternatives because complete recycle is achievable and will result in additional pollutant removals. PSES, like BAT, should represent the best existing performance in the industrial category or subcategory. As was the case for BPT it will be typically less expensive to implement 100 percent recycle after simple sedimentation than to install and operate technology that would achieve lower recycle but would treat the wastewaters not recycled.

EPA is proposing PSNS for 17 of the 19 process segments in all six subcategories. For the 15 process segments in which the proposed BAT/NSPS/PSES limitations and standards are no discharge of process wastewater pollutants, the Agency is proposing the equivalent of BAT/NSPS/PSES as the basis for porposed PSNS. EPA is proposing PSNS equivalent to BAT for the aluminum die casting segment. For the lead continuous strip casting segment EPA is proposing PSNS equivalent to PSES.

For the aluminum investment casting and the aluminum melting furnace scrubber process segments, EPA is not proposing PSNS because the levels of total suspended solids and oil and grease discharged from these processes are considered compatible with treatment by POTWs.

SECTION II

RECOMMENDATIONS

EPA has divided the metal molding and casting category into nineteen process segments for the purpose of developing proposed effluent limitations and standards. segments for the purpose of developing proposed effluent limitations and standards. These process segments are:

Subpart	Subcategory/Segment
A.	Aluminum Casting Subcategory
	1. Investment Casting Operations
	2. Melting Furnace Scrubber Operations
	3. Casting Quench Operations
	4. Die Casting Operations
	5. Die Lube Operations
B.	Copper Casting Subcategory
	1. Dust Collection Operations
	2. Mold Cooling and Casting Quench Operations
C.	Ferrous Casting Subcategory
	1. Dust Collection Operations
	2. Melting Furnace Scrubber Operations
	3. Slag Quenching Operations
	4. Mold Cooling and Casting Quench Operations
	5. Sand Washing Operations
D.	Lead Casting
	1. Continuous Strip Casting
	2. Melting Furnace Scrubber
	3. Grid Casting
E.	Magnesium Casting Subcategory
	1. Grinding Scrubber Operations
	2. Dust Collection Operations
F.	Zinc Casting Subcategory
	1. Die Casting and Casting Quench Operations
	2. Melting Furnace Scrubber Operations

Following are the proposed effluent limitations and standards for each of the process segments.

A. Aluminum Casting Subcategory

1. Investment Casting Operations

(a) Proposed BPT Effluent Limitations

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
TSS	1.103	0.538
Oil and Grease	0.538	0.323
pH	Within the range of 7.5 to 10	

(b) Proposed New Source Performance Standards

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
TSS	1.103	0.538
Oil and Grease	0.538	0.323
pH	Within the range of 7.5 to 10	

2. Melting Furnace Scrubber Operations

(a) Proposed BPT Effluent Limitations

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
TSS	0.0166	0.00809
Oil and Grease	0.00809	0.00486
pH	Within the range of 7.5 to 10.0	

(b) Proposed New Source Performance Standards

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
TSS	0.0166	0.00809
Oil and Grease	0.00809	0.00486
pH	Within the range of 7.5 to 10	

3. Casting Quench Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Source

No discharge of process wastewater pollutants to a POTW.

4. Die Casting Operations

(a) Proposed BPT Effluent Limitations

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
Lead	0.0000726	0.0000653
Zinc	0.000740	0.000305
Phenols (4AAP)	0.000322	0.000161
TSS	0.0109	0.00799
Oil and Grease	0.00726	0.00726
pH	Within the range of 7.5 to 10	

(b) Proposed BAT Effluent Limitations

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
Acenaphthene	0.0000092	0.0000046
2,4,6-trichlorophenol	0.0000305	0.0000152
Parachlorometacresol	0.0000281	0.0000140
Chloroform	0.0000668	0.0000334
Phenol	0.0000063	0.0000031
Butyl benzyl phthalate	0.000104	0.0000518
Chrysene	0.0000019	0.0000010
Tetrachloroethylene	0.0000261	0.0000131
Lead	0.0000242	0.0000218
Zinc	0.000247	0.000102
Phenols(4AAP)	0.000107	0.0000537

(c) Proposed New Source Performance Standards

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
Acenaphthene	0.0000092	0.0000046
2,4,6-trichlorophenol	0.0000305	0.0000152
Parachlorometacresol	0.0000281	0.0000140
Chloroform	0.0000668	0.0000334
Phenol	0.0000063	0.0000031
Buty benzyl phthalate	0.000104	0.0000518
Chrysene	0.0000019	0.0000010
Tetrachloroethylene	0.0000261	0.0000131
Lead	0.0000242	0.0000218
Zinc	0.000247	0.000102
Phenols(4AAP)	0.000107	0.0000537
TSS	0.00363	0.00266
Oil and Grease	0.00242	0.00242
pH	Within the range of 7.5 to 10	

(d) Proposed Pretreatment Standards for Existing and New Sources

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
Acenaphthene	0.0000092	0.0000046
2,4,6-trichlorophenol	0.0000305	0.0000152
Parachlorometacresol	0.0000281	0.0000140
Chloroform	0.0000668	0.0000334
Phenol	0.0000063	0.0000031
Butyl benzyl phthalate	0.000104	0.0000518
Chrysene	0.0000019	0.0000010
Tetrachloroethylene	0.0000261	0.0000131
Lead	0.0000242	0.0000218
Zinc	0.000247	0.000102
Phenols(4AAP)	0.000107	0.0000537

5. Die Lube Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

B. Copper Casting Subcategory

1. Dust Collection Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

2. Mold Cooling and Casting Quench Operations
Quench Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

C. Ferrous Casting Subcategory

1. Dust Collection Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

2. Melting Furnace Scrubber Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

3. Slag Quenching Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

4. Mold Cooling and Casting Quench Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatmennt Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

5. Sand Washing Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

D. Lead Casting Subcategory

1. Continuous Strip Casting Operations

(a) Proposed New Source Performance Standards

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
TSS	0.00340	0.00250
Oil and Grease	0.00227	0.00227
Lead	0.0000227	0.0000204
pH	Within the range of 7.5 to 10	

(b) Proposed Pretreatment Standards for Existing and New Sources

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
Lead	0.0000227	0.0000204

2. Melting Furnace Scrubber Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

3. Grid Casting Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

E. Magnesium Casting Subcategory

1. Grinding Scrubber Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for New Sources

No discharge of process wastewater pollutants to a POTW.

2. Dust Collection Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for New Sources

No discharge of process wastewater pollutants to a POTW.

F. Zinc Casting Subcategory

1. Die Casting and Casting Quench Operations

(a) Proposed BPT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(b) Proposed BAT Effluent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

2. Melting Furnace Scrubber Operations.

(a) Proposed BPT Effluent Limitations

Pollutant or Pollutant Property	Maximum for Any One Day (kg/kkg)	Maximum for Monthly Average (kg/kkg)
Zinc	0.00419	0.00176
Phenols (4AAP)	0.0315	0.0157
TSS	0.129	0.0630
Oil and grease	0.0630	0.0378
pH	Within the range of 7.5 to 10	

(b) Proposed BAT Effuent Limitations

No discharge of process wastewater pollutants to navigable waters.

(c) Proposed New Source Performance Standards

No discharge of process wastewater pollutants to navigable waters.

(d) Proposed Pretreatment Standards for Existing and New Sources

No discharge of process wastewater pollutants to a POTW.

SECTION III

INTRODUCTION

LEGAL AUTHORITY

This report is a technical background document prepared to support effluent limitations and standards under authority of Sections 301, 304, 306, 307, and 501 of the Federal Water Pollution Control Act, as amended (the Clean Water Act or the Act). These effluent limitations and standards are in partial fulfillment of the Settlement Agreement in Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified March 9, 1979. This document also fulfills the requirements of Sections 304(b) and 304(c) of the Act. These sections require the Administrator, after consultation with appropriate Federal and State agencies and other interested persons, to issue information on the processes, procedures, or operating methods which result in the elimination or reduction of the discharge of pollutants through the application of the best practicable control technology currently available (BPT), the best available technology economically achievable (BAT), and through the implementation of new source performance standards (NSPS), and pretreatment standards for new and existing sources (PSNS and PSES).

BACKGROUND - The 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 Nation's waters. By July 1, 1977, existing industrial dischargers were required to achieve effluent limitations requiring the application of the best practicable control technology currently available (BPT), Section 301(b)(1)(A); and by July 1, 1984, these dischargers were required to achieve effluent limitations requiring the application of the best available technology economically achievable (BAT), Section 301(b)(2)(A). BAT will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants. New industrial direct dischargers were required to comply with Section 306 new source performance standards (NSPS), based on best available demonstrated technology; and new and existing sources which introduce pollutants into publicly owned treatment works (POTWs) were subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers were 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 any owner or operator of any source which introduces pollutants into POTWs (indirect dischargers).

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, for the most part, control requirements would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Section 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 these regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic 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 EPA was unable to promulgate many of these regulations by the dates contained in the Act. In 1976, EPA was sued by several environmental groups, and in settlement of this lawsuit, EPA and the plaintiffs executed a Settlement Agreement, which was approved by the Court. This Agreement required EPA to develop a program and adhere to a schedule for promulgating for 21 major industries BAT effluent limitations, pretreatment standards, and new source performance standards for 65 toxic pollutants and classes of pollutants. (See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified March 9, 1979.)

The Clean Water Act amendments of 1977 incorporated several of the basic elements of the Settlement Agreement program for priority pollutant control. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now require the achievement by July 1, 1984, of effluent limitations requiring application of BAT for toxic pollutants, including the 65 toxic pollutants and classes of pollutants which Congress declared toxic under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant control. Moreover, to strengthen the toxic pollutant control program, Congress added Section 304(e) to the Act, authorizing the Administrator to prescribe best management practices (BMPs) to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

GENERAL DESCRIPTION OF THE METAL MOLDING AND CASTING INDUSTRY

The unique feature of the foundry industry is the pouring or injection of molten metal into a mold, with the cavity of the mold representing, within close tolerances, the final dimensions of the product. One of the major advantages of this process is that intricate metal shapes, which are not easily obtainable by any other method of fabrication, can be produced. Another advantage is the rapid translation of a projected design into a finished article. New articles are easily standardized and duplicated by the casting method.

The foundry industry ranks fifth among all manufacturing industries based on "Value added by Manufacture" according to data issued by the United States Department of Commerce in 1970 (Survey of Manufacturers, SIC 29-30). As of 1978, there were over 3,600 commercial foundries in the United States employing approximately 300,000 workers and producing over 17 million metric tons/year (19 million tons/year) of cast products. In the estimated number of foundries the Agency does not count art studios, trade schools, coinage mints, and other such establishments as commercial foundries.

The product flow of the typical foundry operation is shown in Figure III-1. In all types of foundries, raw materials are assembled and stored in various material bins. From these bins, a "furnace charge" is selected by using various amounts of the desired materials. This material is "charged" into a melting furnace and through a heating process, the metal is made molten. Simultaneously, molds are prepared. This process begins by forming a pattern (usually of wood) to the approximate final shape of the product. This pattern is usually made in two pieces that will eventually match to form a single piece, although patterns may consist of 3 or more pieces. Each part of the pattern is used to form a cavity in a moist sand media, and the two portions of the mold (called "cope" and "drag") are matched together to form a complete cavity in the sand media. An entrance hole (called a "sprue") provides the proper path of molten metal introduction into the cavity. The mold is then ready to receive the molten metal. In die casting operations the mold cavity is formed in metallic die blocks which are locked together to make a complete cavity.

The molten metal is now "tapped" from the furnace into the ladle. The ladle and molds are moved to a pouring area and the metal is poured into the molds. The molds are then moved to a cooling area where the molten metal solidifies into the shape of the pattern. When sufficiently cooled, the sand is removed by a process known as "shake out." By violent shaking, the sand

surrounding the metal is loosened, falls away, and is returned to the sand storage area.

The cast metal object (casting) is further processed by removing excess metal, and cleaned by various methods that complete the removal of the sand from its surface. In the case of die casting, where no sand is used, the cast object is removed from the die casting machine after cooling sufficiently to retain its shape. The casting is either further cooled by a water bath or is allowed to air cool on a runout or cooling table. Depending on the final use of the casting, further processing by heat treatment, quenching, machining, chemical treatment, electroplating, painting, or coating may take place. Following inspection, the casting is ready for shipment.

Foundry Metal Description

Many of the cast metals have unique properties which influence the way they are melted and processed and, subsequently, affect the process wastewater characteristics. A brief description of these metals, foundry equipment, and processes is presented to identify sources of process wastewaters.

Aluminum

Aluminum is a light silver-white metal 2.7 times denser than water. It is soft but possesses good tensile strength. It melts at 660°C (1200°F) and is easily cast, extruded, and pressed. An aluminum structure weighs half as much as a steel structure of comparable strength. Until 1886 aluminum was a rarity. Then the economic Hall process was developed to extract metallic aluminum from its oxide "alumina". Today aluminum is the second most widely used metal after iron. Table III-1 indicates that in 1977 over 0.9 million metric tons) (1 million tons of aluminum castings were shipped in the United States. Aluminum may be cast in a variety of ways. A drawing depicting the process and water flow in a typical aluminum investment operation is presented in Figure III-2. Figure III-3 shows the process arrangement and water flow schematic for a typical aluminum die casting operation.

Copper

Copper is a red, ductile nonferrous metal, second only to aluminum in importance of nonferrous metals. It melts at 1083°C (1982°F) and has excellent corrosion resistance. It is the metal which heralded the Bronze Age (3,000 B.C.) and is occasionally found in a metallic state in nature. Brass and bronze, which are mixtures of copper, tin, lead, and zinc, are two of the most

important copper alloys. Other copper alloys include manganese, nickel, silicon, and beryllium. Table III-1 provides a recent history of copper shipment tonnages. Copper and its alloys may also be cast in a variety of ways as depicted in Figure III-4. Figure III-4 also shows the process and process wastewater flow schematic typical of a copper casting operation.

Ferrous

Iron is the world's most widely used metal. When alloyed with carbon, it has a wide range of useful engineering properties. Alloys of iron include: gray, ductile, malleable, and steel. Tonnages shipped are presented in Table III-1. Figure III-5 displays typical processes and process wastewater flow schematic for ferrous foundries.

Gray Iron is the most popular of the cast irons. It is characterized by the presence of most of the contained carbon as flakes of free graphite in the as-cast iron. Gray iron is classified into ten classes based on the minimum tensile strength of a cast bar. The tensile strength is affected by the amount of free graphite present as well as the size, shape, and distribution of the graphite flakes. Flake size, shape, and distribution are strongly influenced by metallurgical factors in the melting of the iron and its subsequent treatment while molten and by solidification rates and cooling in the mold.

Ductile Iron (also known as nodular iron, spherulitic iron, etc.) is similar to gray iron with respect to carbon, silicon and iron content, and in the type of melting equipment, handling temperatures, and general metallurgy. The important difference between ductile and gray iron is that the graphite separates as spheroids or nodules (instead of flakes as in gray iron) under the influence of a few hundredths of a percent of magnesium in the composition. The presence of minute quantities of sulfur, lead, titanium, and aluminum can interfere with, and prevent, the nodulizing effect of magnesium. Molten ductile iron must be purer than molten gray iron, however, a small quantity of cerium added with the magnesium minimizes the effects of impurities which inhibit nodule formation and make it possible to produce ductile iron from the same raw materials used for high grade gray iron manufacture.

The general procedure for manufacturing ductile iron is similar to that of gray iron, but with more precise control of composition and pouring temperature. Prior to pouring metal into the molds (and in some cases during pouring), the metal is innoculated with the correct percent of magnesium, usually in a

carrier alloy, to promote the development of spheroids of graphite on cooling.

While the development of ductile iron dates back to the 1920's, only within the last 20 years has it become an important engineering material. This can be noted from Table III-1 which shows its increasing use.

Malleable Iron is produced from base metal in the following ranges of composition:

	Percent		
Carbon	2.00	to	3.00
Silicon	1.00	to	1.80
Manganese	0.20	to	0.50
Sulfur	0.02	to	0.17
Phosphorus	0.01	to	0.10
Boron	0.0005	to	0.0050
Aluminum	0.0005	to	0.0150

Low tonnage foundries use batch-type furnaces (e.g., electric arc induction, or reverberatory). The tapping temperature of the iron is 1500°C-1600°C (2,700 - 2,900°F) depending on the fluidity required. In large tonnage shops needing a continuous supply of molten malleable iron, electric furnaces or duplexing systems are employed. Cupola furnaces are common in some malleable shops, especially for the production of pipe fittings. After the iron casting solidifies, the metal is a brittle white iron. Malleable iron castings are produced from this white iron by heat treating processes which convert the as-cast structure to a "temper carbon" grain structure in a matrix of ferrite. This is an annealing process requiring proper furnace temperature/time cycles and a controlled atmosphere.

Steel - The making and pouring of steel for sand castings is similar to the casting of steel into ingots. One major difference from steel mill practice is the higher tapping temperature needed to attain the correct fluidity needed to pour the steel into molds. The melting furnaces in foundries are generally of the same type as those for steel mills but are smaller. Only a thoroughly "killed" steel is used for foundry products. Molding practices are similar to those of gray iron operations, however, precautions are required for the higher pouring temperatures 1800°C (3,200°F). Mold coatings or washes are used to give a better finish and are generally made of more refractory-like materials to resist metal penetration.

Lead

Lead is a heavy, gray, soft metal of low tensile strength weighing 11,340 kg/cu m (710 lb/ft^3). The melting point for lead is 327.4°C (621°F). Its softness and ductility makes lead of little use as a load bearing metal, however, its outstanding resistance to corrosion warrants its use in many applications.

Most lead production results from the remelting of the metal. Lead is cast into grids used in the manufacture of lead acid storage batteries. For battery manufacture, lead is cast in a grid casting machine or by the continuous strip casting method.

Magnesium

Magnesium is a silver-white metal weighing 1751 kg/cu m (108 lbs/ft^3). On an equal weight basis, magnesium is equal to or stronger than any other common metal. It can be melted in the same types of furnaces used for aluminum or zinc. However, due to the nature of molten magnesium, care must be exercised in selecting refractories and other materials which the molten metal may contact.

Magnesium furnaces are usually of the stationary or tilting crucible type and heated by gas, oil, or coreless electric induction units. The crucibles are made of low carbon steel with nickel and copper contents below 0.10 percent. Magnesium is usually alloyed with aluminum, zinc, manganese, or rare earth metals for foundry work.

Most magnesium is cast in sand molds. The practice for sand casting of magnesium alloys differs from most other metals in the precautionary measures required to prevent metal-mold reactions. Inhibitors such as sulfur, boric acid, potassium fluoroborate, and ammonium fluorosilicate are mixed with the sand to prevent these reactions. Molding sands for magnesium alloys must have high permeability to permit the free flow of mold gases to the atmosphere.

Table III-1 indicates the growth of magnesium foundry production. A general process schematic is presented in Figure III-6.

Zinc

Zinc, which is less dense than iron, is a bluish-white metal with a hexagonal close-spaced crystal structure. Zinc melts at 420°C (788°F) and boils at a temperature of 907°C (1665°F). Its low melting temperature, very small grain size and adequate strength makes zinc and zinc alloys well suited for die casting. Die

casting is the process most often used to shape zinc products. Zinc alloy compositions consist of 0.25 percent copper, 4 percent aluminum, 0.005 to 0.08 percent magnesium and traces of lead, cadmium, tin, and iron. Furnaces used in melting and alloying zinc are usually the pot type, although immersion tube and induction furnaces are also used. A furnace should hold five to seven times the amount used in one hour. Good temperature control is a necessity for both melting and holding furnaces. Table III-1 indicates the decreasing shipments of zinc castings. A zinc casting process schematic is presented in Figure III-7.

PLANT DATA COLLECTION

A preliminary review of the data which existed at the start of this study indicated the need for more extensive plant data. The needed data were collected through the use of a mail survey and a sampling program.

Development of the Data Collection Portfolio

After the review and analysis of existing data, a draft data collection portfolio was developed. The portfolio was designed to collect information about all types of plants engaged in metal molding and casting. Information was solicited about plant size, age, historical production, number of employees, land availability, water usage, manufacturing processes, raw material and process chemical usage, air pollution control techniques which result in a process wastewater, wastewater treatment technologies, the known or believed presence or absence of toxic pollutants in the plant's raw and treated process wastewaters, and other pertinent factors.

During the review of the existing data, 15 trade associations and interest groups associated with metal molding and casting activities were identified. Representatives of these 15 groups were invited to meet with EPA, to review the draft data collection portfolio, and to offer comments.

Comments received from these groups were reviewed and, where appropriate, were incorporated into the final data collection portfolio. In addition to this input, EPA remained in communication with many of the trade associations throughout the entire study in order to utilize their knowledge of foundry practices.

Survey Design

The Penton "Metal Casting Industry Directory", which identifies 4,400 metal molding and casting activity operations, was used as

the primary basis for the survey. Initially, a survey of all 4,400 plants was considered. However, the Penton information provided sufficient detail (e.g., metal cast and employee group) to design a statistically based survey. After reviewing existing treatment process and in-process control trends, 71 companies and corporations with 269 plants were selected to receive the data collection portfolio (DCP).

In order to collect data from a wide variety of plants, the Penton information was partitioned into 36 cells (a matrix of 9 metal types by 4 employee groups), as shown in Table III-2. The 9 metal types are: ductile iron, gray iron, malleable iron, steel, brass and bronze, aluminum, magnesium, zinc, and a final group designated as "other metals". The employee groups are: under 10 employees, 10 to 49 employees, 50 to 249 employees, and 250 or more employees. This survey provided a basis for assessing the potential economic impacts of effluent limitations and standards on plants in each employee group.

After reviewing information available in the Penton casting industry directory and other data, it was considered necessary to solicit data from 1,000 additional plants. Therefore, a total of 1269 plants were surveyed via DCP questionnaire (approximately 29 percent of the total plant population identified in the Penton census).

To ensure that those plants, which appear to be relatively few in number (i.e., cell populations no larger than 70 individual plants), were not missed in the random selection process, 394 plants, falling into cells with populations no greater than 70, were selected from the sampling frame of 1,000 plants.

Using a computer, 606 plants (the remainder of the group of 1,000) were randomly selected from the Penton file. Table III-3 displays the distribution by metal type and employee group of the plants selected to receive a survey questionnaire. The total number of entries on Table III-3 exceeds 1,000, since entries for plants which cast more than one metal type appear once for each type of metal cast.

Randomly selected plants had equal probabilities of being selected for inclusion in the survey. The probability that a plant would be selected was calculated using the following equation.

$$P = (1000 - L) / (4404 - K - L)$$

where L = number of plants occupying cells with populations no larger than 70

K = number of specific plants surveyed due to the need for specific technical information

Therefore $P = (1000 - 394) / (4404 - 269 - 394)$

$P = 0.162$

The weight assigned to each plant surveyed with P = 0.162 was therefore, 1/P or 6.17. In estimating plant populations, based upon the survey design, plants surveyed with "p" probability are designated as "P" plants. Likewise, plants surveyed due to the need for technical information are designated as "K" plants while plants surveyed with corresponding cell populations no larger than 70 are designated as "L" plants. In addition to weighting the survey responses, corrections to the weighting factors were made to account for plants which failed to respond to the survey. Since it was anticipated that plants with more employees would have a different response ratio (the number of survey responses vs. the number of surveys mailed) than plants with fewer employees, the correction for non-response was made for each specific employee group. Therefore, four different non-response correction factors were developed.

Distribution of the Plant Survey

Using a mailing list of plants developed according to the plant selection process described above, information requests were sent to the selected recipients.

In addition to the distribution of plant surveys described above, Metal Molding and Casting DCPs were mailed to another type of plant. These plants were identified from the preliminary data review as being engaged in the casting of lead. These plants are primarily involved in battery manufacture. All of the plants identified as casting lead were mailed DCPs. Two hundred twenty-six surveys were sent to companies believed to have plants engaged in the casting of lead.

Processing of Survey Responses

Upon receipt of the survey responses, the data were reviewed, organized and prepared for computer entry. Tables III-4 through III-21 provide summaries of the plant survey data. Also, Table III-22 identifies the operating modes and control and treatment technologies applicable to wastewaters from this industry. That table gives the key to symbols appearing on Tables III-4 through III-21. In determining recycle and discharge rates, all data (block diagrams and various data entries) in the DCP were used to confirm the information provided in the summary tables. In

several instances, state environmental offices were contacted to confirm information presented in the DCPs for certain plants.

Additional Information Collected

The plant survey information also provided the identity of a number of engineering firms which design and install foundry air and water pollution control equipment which operate with no process wastewater discharges. These firms provided operation and maintenance information on these systems and installation lists of user foundries. Thirty-six foundries were subsequently contacted by phone, and information pertinent to the operation and maintenance of this complete recycle equipment was obtained.

PROFILE OF PLANT DATA

The DCP survey data were used to develop a technical profile of the plants within the foundry point source category. The profile data provide information such as plant frequency distribution, the types of metals cast, employee groupings, manufacturing processes, air pollution sources, and water use. A discussion of the profile development follows.

Industry Profile Development

Based upon the data received, each plant was classified as either "wet", "dry", "not a foundry" or "non-deliverable". "Wet" plants generate process wastewaters from metal molding and casting operations or from air pollution control facilities associated with these operations. "Dry" plants do not generate process wastewaters from the operations described above, although noncontact cooling waters may be used at these plants. Those respondents which indicated that the company was no longer in business, the casting manufacturing facility no longer existed, or that the company was not engaged in commercial metal molding and casting operations were identified as "not a foundry". The data request was identified as "non-deliverable" if the Postal Service could not deliver the material at the indicated address.

Realizing that the plant survey was statistically based, estimates (based upon the design of the survey and the responses received) were made for the total plant population. These estimates were determined in the following manner. A 9 x 4 matrix (9 metal types by 4 employee groups) was developed for each of the four classifications noted above. DCP information about the metal cast and the number of employees was compared with the Penton information and, where necessary, adjustments in cell populations were made to reflect the plant DCP data. An additional fifth matrix was developed which presented the

frequency distribution of plants which had not responded even after a second data solicitation was mailed.

Each of the five matrices was then further broken down into 3 discrete subparts which identified plants within the matrix by the way in which the plants were surveyed (i.e., plants previously designated as either K, L, or P plants).

At this level of detail, the appropriate statistical weights and correction factors for nonresponse plants could be applied. Nonresponse correction factors were determined for each employee group. Estimates were then made of the total number of plants generating a metal molding and casting process wastewater, the total number of plants which do not generate process wastewaters, and the total number of plants not engaged in metal molding and casting. The statistical weights were further applied to determine plant populations in each process segment and discharge mode (i.e., direct or POTW), and to determine industry productions and wastewater volumes.

For the lead casting subcategory, technical information was obtained concurrently with the battery manufacturing technical data solication. A survey of the entire lead casting subcategory was conducted.

DESCRIPTION OF METAL MOLDING AND CASTING INDUSTRY PROCESSES

After reviewing the data provided in the responses to the DCP questionnaires, the Agency developed a list of the metal molding and casting industry operations which generate process wastewaters. The data presented in the plant survey responses indicate that the major sources of wastewaters and wastewater pollutants are the air pollution control devices used in conjunction with metal molding and casting processes. Following are descriptions of the wastewater generating operations noted in the plant survey data base.

Melting Equipment

Scrubbers are used to remove the fumes, gases, and particulates from melting furnace emmissions. As a result, these scrubbers generate process wastewaters which are contaminated with the pollutants carried by the furnace emissions. The following melting equipment descriptions are provided as a basis for discussion of the various types of scrubbers used in melting furnace operations.

Cupola Furnace

The cupola furnace is a vertical shaft furnace consisting of a cylindrical steel shell, lined with refractories and equipped with a wind box and tuyeres for the admission of air. A charging opening is provided at an upper level for the introduction of melting stock and fuel. Holes and spouts for the removal of molten metal and slag are located near the bottom of the furnace.

Air for combustion is forced into the cupola through tuyeres located above the slag well. The products of combustion, i.e., particles of coke, ash, metal, sulfur dioxide, carbon monoxide, carbon dioxide, etc., and smoke comprise the cupola emissions. Air pollution emission standards require that these emissions be controlled. Wastewaters are generated in this process as a result of using water as the medium for scrubbing furnace gases.

The cupola has been the standard melting furnace for gray iron. Figures III-8 and III-9 illustrate cupola furnace systems.

Electric Arc Furnaces

An electric arc furnace is essentially a refractory lined hearth in which material can be melted by heat from electric arcs. The molten metal has a large surface area in relation to its depth, permitting bulky charge material to be handled. This large surface area to depth ratio is effective in slag to metal reactions as the slag and metal are at the same temperature. Arc furnaces are not generally used for nonferrous metals as the high operational temperatures of the arc tend to vaporize the lower melting temperature metals. Arc furnaces are operated in a batch fashion with tap-to-tap times of 1-1/2 to 2 hours. Power, in the range of 551-662 kwh/metric ton (500-600 kwh/ton), is introduced through three carbon electrodes. These electrodes are consumed in the process of passing the electric current through the scrap and metal into the molten batch. They oxidize at a rate of 5 to 8 kg per metric ton of hot metal (10.5 to 17 lbs/ton).

The waste products from the process are smoke, slag, carbon monoxide and dioxide gases, and oxides of iron emitted as submicron fumes. Dry type air pollution control equipment such as baghouses are generally used to control electric arc furnace emissions.

Induction Furnaces

Induction melting furnaces have been used for many years to produce nonferrous metals. Innovations in the power application area during the last 20 years have enabled these furnaces to be

competitive with cupolas and arc furnaces in gray iron and steel production. This type of furnace has some very desirable features. There is little or no contamination of the metal bath, no electrodes are necessary, composition can be accurately controlled, good stirring is inherent, and while no combustion occurs, the temperature obtainable is theoretically unlimited.

There are two types of induction furnaces: (a) coreless, in which a simple crucible is surrounded by a water-cooled copper coil carrying alternating current, and (b) core or channel, in which the molten metal is channeled through one leg of a transformer core. The induction furnace provides good furnace atmosphere control, since no fuel is introduced into the crucible. As long as clean materials such as castings and clean metal scrap are used, no air pollution control equipment is necessary. If contaminated scrap is charged or magnesium is added to manufacture ductile iron, air pollution control devices are required to collect the fumes that are generated.

Reverberatory Furnace

A reverberatory furnace operates by radiating heat from the burner flame, roof, and walls onto the material to be heated. This type of furnace was developed particularly for melting solids and for refining and heating the resulting liquids. It is generally one of the least expensive methods of melting since the flames come into direct contact with the solids and molten metal. A reverberatory furnace usually consists of a shallow refractory-lined hearth for holding the charged metal. It is enclosed by vertical side and end walls, and covered with a low arched roof of refractories. Combustion of fuel occurs directly above the charge and the molten bath. The wall and roof receive heat from the flame and combustion products and radiate heat to the molten bath. The transfer of heat occurs almost solely by radiation. There are many shapes of reverberatory furnaces, with the most common type being the open hearth style used in steel manufacture. However, the cost of pollution control equipment, as well as inefficiencies in handling the metal, have caused this type of furnace to become obsolete in steel and gray iron manufacture. Reverberatory furnaces are widely used in nonferrous production.

The products of combustion from reverberatory furnaces are conducted to a stack and exhausted to the atmosphere. Contaminants such as smoke, carbon monoxide and dioxide, sulfur dioxide, and metal oxides must be removed from the exhaust gases. These become process wastewater pollutants when scrubbers are used to clean the combustion gases.

Crucible Furnace

Crucible furnaces, which are used to melt metals having melting points below 1900°C (2,500°F), are constructed of a refractory material such as a clay-graphite mixture or silicon carbide, and are made in various shapes and sizes. The crucible is set on a pedestal and surrounded by a refractory shell with a combustion chamber between the crucible and the shell. The crucible is usually sealed or shielded from the burner gases to prevent contamination of the molten metal.

There are three general types of crucible furnaces; tilting, pit, and stationary. All have one or more gas or oil burners mounted near the bottom of the unit. The crucible is heated by radiation and contact with the hot gases. The exhaust gases contain only products of hydrocarbon combustion and generally are not controlled.

Fume Scrubbing Equipment

The preceding discussion on the various types of melting units used in the remelting of metal describes the source of the fumes, particulates, smoke, and other waste products that are the major contaminants of process wastewater when scrubbers are used to control the furnace emissions. Generally, venturi scrubbers are used to clean these furnace emissions but other methods are used.

The methods of cleaning the wastewaters produced will be described in later sections of this report.

Fabric Media (Baghouse)

The collection of particulate matter is achieved by entrapment of the particles in the fabric of a filter cloth that is placed across a flowing gas stream. These dust particles are removed from the cloth by shaking or back flushing the fabric with air. Filtration does not remove gaseous contaminants from the furnace exhaust. These gaseous contaminants include: carbon monoxide, phenols, carbon dioxide, hydrogen, chloride, hydrogen, sulfide, nitrogen and its oxides, ammonia, hydrogen, and water vapor. The quantities of these contaminants depend on the type of fuel, furnace efficiency, and infiltration of air into the gas stream. Baghouse particulate removal methods have been developed to a high degree of efficiency (97-99 percent removal of particulate matter). These methods, coupled with the recuperation of heat and the ignition of the combustible gases, have received considerable attention from industry.

The cloth filter media (baghouse) has a temperature limit of approximately 121°C (250°F). These gases can be cooled to this temperature by long runs of duct work between the furnace and the baghouse. The ductwork acts as a radiator to cool the gases. These systems are dry operations and, as such, produce no process wastewaters.

Other installations have quench towers between the furnace and the baghouses or electrostatic precipitator. This method of operation cools the hot gases by evaporating water sprayed into the quench tower prior to their entry into the baghouses or precipitators. This quench chamber usually is arranged to provide a sharp reversal in the direction of the gas stream and a sudden reduction in flow velocity. These features, coupled with the cooling effect achieved by the evaporation of the water, cause the larger dust particles to be deposited at the bottom of the chamber. The gases then flow to the filter chamber. The deposited dust is removed periodically.

In addition to a gas temperature reduction, this water spray absorbs many of the gaseous contaminants listed above.

Wet Scrubbers

Washing Coolers: Several general designs of washing coolers are used, however, all provide some means of securing a long retention time to keep the gases in contact with the scrubbing liquor. In general, these units consist of a large cylindrical vessel with the gases entering tangentially at the bottom and exiting through the top center. Several levels of sprays bring the scrubbing liquor into contact with the rising gases. The bottom is usually conical with a large pipe outlet to return the dirty liquor to a settling area.

Another type of scrubber known as the bulk bed washer, or packed tower, contains water sprayed gravel beds. The gases enter in a downward or tangential direction which results in a preliminary dust removal capability (due to inertia). The gases then flow upward through a wetted gravel bed. At the upper surface of this bed, the gas velocity creates a turbulent water zone that brings the finest dust particles into contact with the water. The scrubbing liquid is sprayed above this gravel bed and continually washes it. The liquid is then removed at the bottom and is recirculated and/or discharged. Above the spray heads is a droplet catcher that removes the droplets from the rising gas stream. This scrubbing method requires approximately 10 in. (water) of pressure drop and is not effective on particles smaller than 1 micron.

Figure III-8 illustrates this method, as well as a method of recovering some of the heat from the gas stream.

Wet Cap: The "wet cap" method is an attempt to reduce the particulate emissions by passing the waste gases through a water stream or water curtain. This method, operated with a low pressure drop, could be added to existing cupolas with only minor changes to equipment and operations. Figure III-9 depicts this method.

Venturi Scrubber: This scrubber consists primarily of a Venturi tube fitted with spray nozzles at the throat. The dust-laden gases flow axially into the throat where they are accelerated to 61 m/sec (200 ft/sec). Water is sprayed into this throat by a ring of nozzles. This produces a dense mist-like water curtain. The water droplets in this curtain combine with the dust particles. In the subsequent diffuser, the velocity is reduced and inertia is used to separate the droplets from the gas stream. Venturi scrubbers require 15-100 in. (water) of pressure drop across the gas stream. They are very effective on particulate matter in the range of 1 micron and readily adsorb many furnace gases, thus adding many pollutants to the process wastewaters.

Venturi scrubbers are operated in conjunction with sedimentation and recirculation systems.

Dust Scrubbing Equipment

Foundries that use sand as a molding media have the problem of collecting and controlling the dusts produced in handling and using this sand. Sand, as used in foundry molding, is mixed with one or more materials that coat the sand grains and act as a binder to hold the sand into the form of the pattern. These binders are a major source of organic pollutants in foundry operations. Fumes and odors result from the pouring of hot metal into molds, while the cleaning of the casting to remove traces of sand, gates, runners, heads, mold flashings and mismatch also produces dust and fumes which are removed from the work place. Many of these dusts are collected on fabric media in a "baghouse." In many instances, it is more economical or more efficient to remove these airborne particles by entrapping them in a spray or mist. These types of "wet collectors" will be examined as they are currently used in the foundry industry.

Spray Chambers

The simplest type of wet scrubber is a chamber in which spray nozzles are placed. The gas stream velocity decreases as it

enters the chamber where the particles are wetted by the spray, settle, and are collected at the bottom of the chamber.

Cyclone-Type Scrubbers

Cyclone-type scrubbers feature a tangential inlet to a cylindrical body. Water is injected through spray nozzles which break the water into many droplets. These droplets contact the particles and increase their inertial action with the result that the particulates impinge on the vessel sides where they are flushed to the bottom. The clean gases then exit through the top of the scrubber. Baffles in this exit collect and aid in the removal of the water droplets from the gas stream.

Orifice-Type Scrubbers

Orifice-type scrubbers utilize the velocity of the gas stream to provide liquid contact. The flow of gases through a restricted passage partially filled with water causes the dispersion of the water into many droplets that intimately contact and wet the airborne dusts and absorb some of the gaseous contaminants. While the amount of water in motion is large, most of the water can be recirculated without pumps.

Mechanical-Centrifugal Scrubbers

A spray of water at the inlet of a fan becomes a mechanical-centrifugal collector. The collection efficiency is enhanced by the entrapment of dusts on the droplet surface and the impingement of the droplets on the rotating blades. The spray also flushes the blades of the collected dusts. However, this spray can substantially increase corrosion and wear on the fan.

Another type of mechanical collector uses a rotating element to generate a spray of water droplets into a dust laden gas stream. The wetted particles flush to the collection pan where they can settle while the water is recirculated.

Venturi Scrubbers

Venturi scrubbers have been described in the section on melting furnace scrubbers. They are also used in dust collection systems. In some cases there is a single large Venturi in the dust laden air stream with low pressure water added at the Venturi throat. The extreme turbulence breaks the water into a fine spray where it impacts and wets the dust particles.

Other applications are similar to orifice-type scrubbers but with the Venturi's shape replacing the orifices. These Venturi's are

located at the water line and, consequently, water is drawn into the Venturi throat where it is broken into a fine spray by the turbulent air. The spray droplets wet the dust particles and are impinged against baffle plates where they drain to the reservoir.

Packed Towers

This device is similar to the bulk bed washer described in the melting scrubber section. The dust laden gases pass through a bed of granular or fibrous collection material while liquid is flushed over the surface of the collection material to keep it wet and clean, and to prevent re-entrainment of the particles. Collection efficiency depends on the length of time the gas stream is in contact with the collecting surfaces. The collecting material should have a large ratio of area to weight and be of a shape that resists close packing. Coke, broken rock, glass spheres, rashig rings, and tellirets are materials that are often used as tower packing materials.

A cone-shaped bottom aids in removing settled dust particles from the liquid, while mist eliminators located in the exit gas-stream reduce the loss of the flushing liquor. Recirculation of the liquor is usually practiced.

Wet Filters

A wet filter consists of a spray chamber with filter pads composed of glass fibers, knitted wire mesh, or other fibrous materials. The dust is collected on the spray pads by virtue of the dust laden gas stream being drawn through the pads. Sprays directed against the pads wash the dusts away. The water drains to a reservoir where it is settled or clarified and then recirculated or discharged.

Casting Methods

Foundries use several methods of casting molten metal into its final shape. None of these methods involve intimate contact between the molten metal and water as the explosive forces, developed by the rapid generation of steam when water comes into contact with molten metal, cannot be controlled.

Sand Casting

Green Sand Castings: This is the most widely used molding method. It utilizes a mold made of compressed, moist sand. The term "green" denotes the presence of moisture in the molding sand and that the mold is not dried or baked. This method is usually

the most expedient, but is generally not suitable for large or very heavy castings.

Dry Sand Casting: Most large and very heavy castings are made in dry sand molds. The mold surfaces are given a refractory coating and are dried before the mold is closed for pouring. This hardens the mold and provides the necessary strength to contain large amounts of metal. Molds which are hardened by the CO_2 process may also be considered in this category. Such molds are not dried, but are made from an essentially moisture free sand mixture which contains sodium silicate. The mold is rapidly hardened by the reaction of carbon dioxide gas with the silicate. The process can also be used for making cores. It is advantageous in reducing manufacturing time, but is not practical for some types of work.

Shell Mold Castings: This method is of recent development and utilizes the unique process of making molds by forming thin shells of a resin-bonded sand over a hot pattern. It is suitable for small and some medium-sized castings. Shell molding provides improved accuracy and surface finish, thus allowing greater detail and less drift than would normally be acceptable in green sand molding. Metal patterns of special construction are necessary. The process is of particular advantage when it provides savings in machining and finishing. The shell process has also been very effectively applied in making cores which may be used with any of the molding methods.

Core Mold Casting: Castings of unusual complexity (such as the thin and deep fins of an air-cooled engine cylinder) may be produced in a mold made of the type of sand commonly used for cores. This sand has almost free-flowing properties when it is packed around the pattern, and it will fill crevices and reproduce detail. After baking, the mold becomes strong enough to resist the forces of flowing molten metal. Core sand molds may be used when complexity requires more than one parting line in a casting. Core sand sections may be used to form a complex external portion of a casting in either a green or dry sand mold, just as cores are used to form internal surfaces.

Permanent Mold Castings: Iron castings, within limits as to size, complexity, and properties, can be produced in large numbers from mechanically operated permanent iron molds. This mechanized, high-production process is mainly used for castings of suitable shape, of less than 11.4 kg (25 pounds) in weight, and with 0.48 cm (3/16") minimum wall thickness. Cores are formed with conventional sand or shell cores.

Ceramic Mold Casting: Certain highly specialized castings requiring an unusually fine finish, precise detail, and close tolerances are produced in molds made of fired ceramics. This is comparable to the plaster-mold process which is used for nonferrous alloys. Pattern equipment is generally of a "core-box" type, and may be made of metal or plaster. In some applications, backdraft or undercuts are allowed by making part of the pattern of a flexible material. When the mold can be assembled from a number of pieces, castings of several hundred pounds in weight and several feet in a major dimension can be made to relatively close tolerances.

Centrifugal Casting Operations

Centrifugal casting utilizes the force of gravity, but centrifugal force may be used. True centrifugal casting is a means for producing a cavity in the casting without the use of a core. The production of pipe by this process is well known, but the method is also used for making many other cylindrical castings from engine cylinder liners to large process rolls.

Investment Casting Operations

Investment casting uses a mold that is produced by surrounding an expendable pattern with a ceramic slurry which hardens at room temperature. The pattern is usually wax or plastic and is melted or burned out leaving a cavity, with very close tolerances, in the refractory material. Investment casting is also known as the "lost wax" or "precision casting" process.

In sand casting, the pattern is usually wood or metal, and it makes an impression or cavity in the sand. In investment casting, a metal die is used to produce the wax patterns. These, in turn, produce the ceramic mold. Ceramic cores, which are expendable, are used when needed.

The wax is melted out and all moisture in the ceramic backup material eliminated in an autoclave where temperature can be closely controlled. Metal is poured into the molds and allowed to cool. The mold is then pushed from its container and the ceramic is broken away. Final cleaning, a source of process wastewater, is accomplished by high pressure water jets in a hydroblast cabinet. The casting is then sent to the finishing department where heads and gates are removed.

Die Casting

In most die casting operations the major sources of wastewaters are the die casting machine hydraulic oil leakage, mold cooling

water leakage, casting quenches, and mold lubricant spray. These wastewaters collect around the machine base and are contaminated by dirt, and oil and grease from various fittings.

In some operations (see Figure III-3) where the casting quench tank is located beneath the machine, these waters drain into the quench tank. Other plants segregate their process wastewater streams.

Die Lubes

In die casting, the application of lubricants to the die cavity is a necessary and often critical process. Lubricants prevent a casting from sticking to the die, and also provide a better finish to the casting. The correct lubricant will permit metal to flow into cavities that will not otherwise fill properly. A secondary function of a lubricant is the cooling of the die.

Selection of a lubricant is based upon the melting temperature of the metal, operating temperature of the die surface, and the alloy being cast. No single lubricant will be suitable for all die casting applications. In fact, two or three different lubricants are sometimes needed to achieve increased productivity.

When molten metal contacts an oil type lubricant, some of the lubricant decomposes and leaves a powder of carbonaceous materials on the die surface. This can be removed from the die surface with an air jet. When the correct lubricant is used, enough of it remains on the die for the production of several more castings.

Moving die parts, such as ejectors and cores, must be treated with a high temperature lubricant to prevent seizure. Oil suspensions of graphite are usually used. Many of these compounds are carefully developed for specific machines and represent a considerable expense. The placement, recovery and reclamation of these materials is an important phase of the die casting operation. Several plants have segregated their waste streams and employ die lubricant recovery processes.

Casting Quenches

In some instances certain metal grain structures, obtainable only through sudden thermal changes, are desired in a casting. In these cases, the operator will quench the casting in a water bath. This water bath may be plain water or may contain an additive to promote some special condition. The additive is a very minor part of the bath.

Non-ferrous foundries quench their castings more frequently than ferrous froundries. This is due to a desire to cool and solidify the casting quickly more than to promote a grain structure change. Nonferrous foundries are predominantly die casters. A quench operation immediately after ejection of a die cast part, will solidify the metal quickly, reduce the machine cycle time, and increase production. Many aluminum die casting plants have replaced the quench with a runout table on which the castings air cool. Depending upon the configuration of the casting, zinc die cast material may sag and not retain the desired specifications if air cooled. Therefore, the trend to eliminate quenching and its associated water pollution problems has not been as prevalent in zinc die casting operations as it has in aluminum die casting operations.

Mold Cooling

Where permanent molds are used in the casting process, it is often necessary to force cool the molds with water sprayed or flushed over the mold. This water becomes a process wastewater and contains contaminating materials picked up from the molds. The centrifugal casting of pipe is an example of mold cooling. Only large foundries are engaged in this casting method as indicated by Table III-23.

Slag Quench

Most melting operations produce a slag or dross. This is generally is mixture of non-metallic fluxes introduced with the "charge" to act as a scavenger to remove the impurities from the molten metal. This slag is removed from the molten metal and cooled for disposal or for reclamation of metal. In ferrous foundries the amount of slag produced requires disposal on a large scale. Where the slag is continuously produced (i.e., in a cupola operation), the slag is quenched in a water stream to rapidly cool and fragmentize it to an easily handled bulk material. The quench water is a process wastewater.

In nonferrous foundries the slags generated are considerably smaller in volume and mass than those generated in ferrous foundries and are handled without producing a process wastewater.

Sand Washing

In the many plants which use sand as a molding media, the reclaiming and reuse of the sand is a major operation. Three methods of reclaiming sand are in general use; dry, wet, and thermal.

The dry method has several sub-methods which generally include screening, lump breaking, and cooling before reuse. These processes usually produce a dust from the handling of the sand, but no process wastewaters result unless a wet dust collecter is used.

The wet method has several variations. Generally, a slurry is made of sand and water. Agitating or stirring this slurry causes the sand grains to scrub against each other and remove the particles of burnt clay, chemical binders, sugar, wood fiber, etc., which may adhere to the sand grains. The slurry is pumped to a classifier for separation of the fine materials. The sand is then dried.

The thermal method involves heating the sand to 649-816°C (1200-1500°F) in air to remove carbonaceous material. Some clay may also be removed by abrasion of the sand grains as they travel through the process. The thermal reclamation process does not produce a process wastewater.

The wash water used in wet reclamation contains considerable contaminants in the form of fine silicate material, spent clay, and other pollutants. To economize on water use, this water can be clarified and returned to the sand washing system. Several examples of water reclamation from wet sand reclamation processes are found in the plant survey response.

Magnesium Grinding Scrubbers

Finely divided particles of magnesium can react violently in air. It is mandatory that magnesium dusts be wetted to prevent this reaction. Therefore, all dusts produced in cleaning, sawing, grinding or machining of magnesium are collected in a scrubber. The water spray coats the dust laden gas stream and wets the magnesium particles eliminating the fire hazard.

Scrubbers on grinding or sawing dusts can be of several types as previously described. Where practicable, the dusts from such metal working operations can be salvaged and remelted.

ANTICIPATED INDUSTRY GROWTH

During 1956 through 1976, annual castings production ranged primarily between 13.6 and 18.1 million metric tons (15 and 20 million tons). Ferrous castings have accounted for about 90 percent of the total tonnage produced annually since 1956, and nonferrous casting production has remained close to 10 percent.

Table III-1 presents information on foundry shipments in the United States.

Contrasting trends, however, are evident among the ferrous and nonferrous metal types (as can be seen in Figure III-10) which presents production at 5-year intervals over the 1956-76 period. For example, within the ferrous castings group, the trend of ductile iron production has been sharply upward, while production for gray iron, malleable iron, and steel in 1976 was lower than 20 years earlier. Similarly, among the nonferrous metals, aluminum has registered a significant long-term gain, whereas the trends for the others are relatively mixed.

Figure III-11 shows that the number of smaller iron foundries has decreased dramatically, while large and medium size iron foundries have increased in number. In addition, as noted in Table III-1, and as observed from conversations with plant personnel, there is a trend toward a decreasing percentage of zinc casting shipments compared to total foundry shipments and to aluminum shipments. It appears that zinc casting production will decrease in favor of the production of lighter weight aluminum castings. However, zinc casting plants will remain in operation for some time.

PROFILE OF PLANTS IN THE METAL MOLDING AND CASTING POINT SOURCE CATEGORY

The profile of the Metal Molding and Casting Industry is based upon the technical data furnished to the Agency by plants engaged in metal molding and casting operations. Regulations applicable to plants casting nickel, tin, and titanium are not being proposed because these operations do not generate process wastewaters.

The profile of the industry is organized into the following seven topics (the discussion of each topic follows):

1. Wet and dry plant frequency distribution and analysis
2. Process wastewater flow profile
3. Production profile
4. Process wastewater discharge mode profile
5. Frequency distribution profile of toxic pollutants
6. Production equipment age vs. treatment equipment age

7. Analysis of the land available for treatment equipment installation

Wet and Dry Frequency Distribution and Analysis

Analysis of the survey data reflective of 1976 indicated that an estimated 3600 plants manufactured castings applicable to this point source category. One thousand nineteen (1019), or 28 percent, operated manufacturing processes which resulted in the generation of a process wastewater. Based upon the update survey the agency conducted in 1981, it is estimated that of those 1019 plants, 965 are currently producing a process wastewater. These plants are considered to be wet plants. Some plants either closed or changed manufacturing processes or air pollution control devices from those with process wastewaters to other equipment which did not produce a process wastewater. Of the 965 plants with process wastewaters, 287 plants discharge process wastewaters to navigable waters, 327 plants introduce process wastewaters into Publicly Owned Treatment Works (POTWs), and 351 plants do not discharge process wastewaters.

The distribution of plants by major metal cast and employee group is presented in Table III-24. Following is a summary of the data presented in this table.

Type of Metal Cast	Percent of the Plants Casting This Metal That Have a Process Wastewater*
Aluminum	11.6
Copper	11.0
Iron and Steel	47.1
Lead	7.1
Magnesium	58.3
Zinc	21.7

* Based upon 1980 operations.

Table III-24 also indicates that 72 percent of the plants in the category do not generate process wastewaters, while 28 percent of the plants generate process wastewaters as a result of metal molding and casting activities.

Table III-25 presents the percentage of "wet" operations in each employee group in each subcategory. This table indicates that smaller foundry operations, as distinguished by the number of employees, usually do not generate a process wastewater. This trend is illustrated below.

Percent of Active Plants, in

Employee Group	Each Group that are Dry
<10	98.7
10-49	84.0
50-249	51.4
>250	22.5

The main reason for the trend noted above is the different air pollution requirements for plants of various sizes. The small foundries still in operation are generally job shops that do not require large capacity production equipment. As a result, the air pollution impact from these shops is much smaller than large production foundries, and for economic reasons, baghouses (as opposed to scrubbers which generate wastewaters) are preferred for emission control. In addition, most sand handling activities in small shops are performed by hand, and subsequently do not produce the large volume of dust associated with mechanical sand handling equipment. Therefore, many of the small foundries have not installed wet air pollution control devices to control air emissions for sand handling operations. These factors have led to the predominance of dry operations for small metal molding and casting operations.

Process Wastewater Flow Profile

An estimated 420 billion liters (111 billion gallons) of process wastewater is generated each year in the manufacture of castings. Approximately 279 billion liters (73.6 billion gallons) of process wastewater or 66 percent is recycled to some extent. Approximately 94.9 billion liters (25.1 billion gallons) of the total process wastewater flow is discharged to navigable waters while 8.5 billion liters (2.2 billion gallons) are introduced into POTWs. Of the 279 billion liters (73.6 billion gallons) of process wastewater recycled each year, 168 billion liters (44.3 billion gallons) are recycled in operations which have no discharge.

The subcategories (ranked in decreasing volume of process wastewater) are: ferrous casting, zinc casting, copper casting, aluminum casting, lead casting, and magnesium casting. Process wastewaters discharged to navigable waters from plants engaged in the molding and casting of iron and steel account for 98 percent of the total direct discharge volume for the category. Likewise, 91 percent of the total volume of process wastewaters introduced into POTWs results from the casting of ferrous metals. More specific details of the process wastewater flow profile are presented in Section V.

Production Profile

For the purposes of this document, the term production is used to express the amount of metal poured and not the weight of finished castings produced by, or shipped from, those plants within the Metal Molding and Casting Point Source Category.

An estimated 55.2 million metric tons (60.8 million tons) of metal are poured annually in plants which generate a process wastewater in their metal molding and casting processes. Approximately 29.7 million metric tons (32.8 million tons) of metal are poured annually in plants discharging process wastewaters directly to navigable waters. Ten million metric tons (11 million tons) of metal are poured annually in plants which introduce process wastewaters into POTWs. An estimated 15.4 million metric tons (17.0 million tons) of metal are poured in plants which do not discharge process wastewaters (or 28 percent of the total annual amount of metal poured). In determining the estimate for "no discharge" operations, only the weight of metal poured at plants which do not discharge process wastewaters from any metal molding and casting process was considered. For example, the weight of metal poured at a plant with one process which did not have a wastewater discharge and one process discharging to a POTW was included in the estimate for the POTW discharge group.

In addition, for those plants with a process wastewater, 65 percent of all the metal melted is poured in 25 percent of the plants. Ninety-seven percent of the metal poured in these wet operations is ferrous metal, and gray iron represents 70 percent of the total weight of all ferrous metal poured. More specific information about the production profile is presented in Section V of this document.

Process Wastewater Discharge Mode Profile

As discussed earlier, an estimated 965 operations generate process wastewaters in the metal molding and casting industry. Of this total, 287 (or 30%) of these operations discharge to navigable waters, while 327 (or 34%) of the total discharge to POTWs. In 351 out of the 965 (or 36%) metal molding and casting processes, no process wastewaters are discharged. More specific discharge mode information is presented in Section V of this document.

Production Equipment Age Versus Treatment Equipment Age

The age of a foundry has no bearing on the applicability of installing water pollution control equipment at that facility.

Some foundries, which have operated at the same location for over 100 years, replaced melting furnaces as recently as five years ago and sand handling systems as recently as ten years ago. Process wastewater treatment equipment age varies from thirty years for some equipment items to less than one year for the more recent system installations or additions to older treatment systems.

A review of the industry survey data indicates that about half of the plants in the industry summary data base installed process wastewater treatment equipment five or more years after the installation of the oldest melting furnace. In fact, nine percent of the ferrous foundries in the data base installed process wastewater treatment equipment as long as 30 years after the installation of the oldest melting furnace.

Land Availability for the Installation of Wastewater Treatment Equipment

In the survey questionnaires, the Agency requested that the plants provide information on the amount of land available for the installation of wastewater treatment equipment. The information provided by the industry was used to identify those plants which may have a shortage of land on which to erect treatment facilities.

Approximately 10 percent of all the respondents to this segment of the data collection portfolio reported that they had a limited amount of land available adjacent to the plant on which to install treatment facilities. This concern was expressed through their response to the information sought and through the description of the physical circumstances which may limit the installation of treatment equipment.

Review of the plant data from the 10 percent of the plants expressing concern over the limited availability of land indicates that these plants already have some process wastewater equipment in-place equivalent to the BPT and BAT treatment equipment identified in this document. These plants employ some form of settling technology and recycle. Thirty-three percent of those plants (those plants with information expressing concern over land availability) with settling and recycle technology already installed reported that no process wastewaters were discharged from their plants. In these cases, no additional treatment equipment is needed. The remaining plants generally employ extensive recycle.

Based upon the technical findings, the installation of additional treatment equipment or the elimination of process wastewater

discharges would not be hindered by the limited availability of land reported by plants responding to the information request. In addition, though many plants use settling ponds or lagoons for solids removal, the more space-efficient clarifiers have been included as part of the BPT and BAT model treatment systems.

ADDITIONAL DATA COLLECTION ACTIVITIES

Initially, all existing information on metal molding and casting was collected from previous EPA foundry studies, literature sources, trade journals, inquiries to EPA regional and state environmental authorities, and from raw material and equipment manufacturers and suppliers. These sources provided information on industry practices and wastewater generation, and gave direction to the effort of collecting additional data.

Previous studies - Previous federal government contracted studies of the foundry category were examined. These studies were prepared by Cyrus Wm. Rice Division of NUS Corporation under Contract No. 68-01-1507 and A. T. Kearney and Company, Inc. for the National Technical Information Service, U.S. Department of Commerce, PB-207 148. These studies provided data on the types of metals cast, plant size, geographic distribution, manufacturing processes, waste treatment technology, and raw and treated process wastewater characteristics at specific plants.

Literature Study - Published literature in the form of handbooks, engineering and technical texts, reports, trade journals, technical papers, periodicals, and promotional materials were examined. Those sources used to provide information for this study are listed in Section XIV. As previously noted, the "Metal Casting Industry Directory" (a Penton Publication) provided information on the number, size, and distribution of foundry operations in addition to other factors pertaining to plant characteristics.

Regional and State Data - EPA regional offices and state environmental agencies were contacted to obtain permit and monitoring data on specific plants. The EPA's Water Enforcement Division's "Permits Compliance System" was used as another mechanism to identify and gather additional information on foundries.

Raw Material Manufacturers and Suppliers - Manufacturers and suppliers of foundry raw materials and process chemicals, such as core binders and mold release agents, were contacted for information about the chemical compositions of their products. Since many of these materials are considered proprietary by the vendor, only generic information was obtained about these

products. From this information, predictions were made as to the possible introduction of toxic pollutants into foundry process wastewaters due to the presence of these materials in the foundry work area.

Equipment Manufacturers and Suppliers - Manufacturers and suppliers of foundry process and pollution control equipment were contacted to obtain engineering specifications and technical information on foundry manufacturing processes and air and water pollution control practices.

In addition to utilizing existing data (including data from 19 ferrous foundries sampled in 1974) and plant supplied data (submitted in the survey questionaire), a sampling program was carried out at 23 additional plants. Five aluminum casting plants; five copper casting plants; ten iron and steel casting plants; one lead casting plant; one magnesium casting plant; and four zinc casting plants were sampled. At two plants, both aluminum and zinc casting analytical data were obtained. These two plants are counted twice in the above distribution; once for aluminum casting and once for zinc casting.

Upon completion of the sampling and analysis efforts, all of the data obtained were analyzed to determine process wastewater characteristics and mass discharge rates for each sampled plant. In addition to evaluating pollutant generation and discharge rates for the sampled plants, the industry survey data were examined to determine the range of control and treatment technologies existing within the foundry category. Special attention was paid to in-process technology such as the recycle of process wastewater, the segregation of characteristically different process wastewaters and the minimization of water use. An industry update survey was conducted in mid-1981 to confirm and to update the wastewater treatment data for the industry.

TABLE III-1

FOUNDRY SHIPMENTS IN THE UNITED STATES

Year	Amount Shipped*								Total Amount Shipped**
	Gray Iron	Ductile Iron	Malleable Iron	Steel	Aluminum	Copper	Magnesium	Zinc	
1967	13,466	863	1,131	1,857	767	483	20	419	19.0
1968	14,097	1,033	1,007	1,730	794	396	21	426	19.5
1969	14,679	1,254	1,172	1,897	849	426	21	439	20.8
1970	12,338	1,607	852	1,724	753	375	17	348	18.0
1971	11,728	2,111	884	1,583	787	352	22	368	17.8
1972	13,494	1,835	960	1,609	926	381	21	400	19.6
1973	14,801	2,246	1,031	1,894	1,013	389	22.5	453	21.8
1974	14,459	2,202	914	2,090	869	337	24.3	346	21.2
1975	10,621	1,824	730	1,937	687	256	15.7	286	16.3
1976	11,935	2,243	846	1,803	921	274	19.5	345	18.4
1977	12,291	2,702	829	1,718	1,005	289	24.9	329	19.2
1978	12,524	2,868	816	1,862	995	283	22.4	274	19.6

* : Multiply by 10^3 to get actual tonnage
**: Multiply by 10^6 to get actual tonnage.

TABLE III-2

PENTON FOUNDRY CENSUS INFORMATION

	Less than 10 Employees	10-49 Employees	50-249 Employees	Greater than 250 Employees
Ductile Iron	28	127	283	98
Gray Iron	149	489	579	156
Malleable Iron	11	20	42	37
Steel	45	177	337	97
Brass & Bronze (Copper Alloy)	533	714	277	37
Aluminum	843	1,016	450	75
Magnesium	30	50	42	8
Zinc	225	289	175	39
Other Metals	150	158	59	9

TABLE III-3

DISTRIBUTION OF ADDITIONAL
1000 FOUNDRY PLANT SURVEYS

	Less than 10 Employees	10-49 Employees	50-249 Employees	Greater than 250 Employees
Ductile Iron	25	26	60	69
Gray Iron	54	104	103	79
Malleable Iron	11	18	36	22
Steel	41	30	56	33
Brass & Bronze (Copper Alloy)	119	144	69	28
Aluminum	167	200	98	52
Magnesium	28	46	36	4
Zinc	50	65	43	25
Other Metals	32	24	50	8

TABLE III-4

GENERAL SUMMARY TABLE
ALUMINUM CASTING
INVESTMENT CASTING

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
04704	1951	430.00	0.65	N/A	N/A	1.00	4,900.00	0.00	0.00	100.00	YES	97.00	FFP	1977
													FLP	1977
													TP	1977
05206	1965	76.00	0.30	N/A	N/A	1.00	12,800.00	0.00	100.00	0.00	NO	0.00	SB	N/A
06389	N/A	12.00	0.05	N/A	N/A	1.00	8,000.00	0.00	0.00	100.00	NO	0.00	NONE	N/A

TABLE III-5

GENERAL SUMMARY TABLE
ALUMINUM CASTING
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
00206	1967	2,815.50	11.30	N/A	N/A	1.00	N/A	97.00	0.00	3.00	YES	3.00	SL	1969
13562	1936	13,442.00	18.20	N/A	N/A	1.00	527.00	37.00	0.00	63.00	YES	1.80	SL	1957
17089	1960	102,511.00	125.20	N/A	N/A	3.00	2,800.00	60.00	0.00	40.00	YES	70.00	SS1	1957
													CL	1973
													F	1975
													FLA	1975
													FLP	1975
20114	1968	9,400.00	17.80	N/A	N/A	2.00	2,481.00	97.50	2.50	0.00	NO	0.00	SS	1973
22121	1971	2,265.60	6.47	N/A	N/A	1.25	13,280.00	95.00	5.00	0.00	NO	0.00	IR	N/A
													NONE	N/A

TABLE III-6

GENERAL SUMMARY TABLE
ALUMINUM CASTING
CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
00206	1967	2,815.50	11.30	N/A	N/A	1.00	221.00	0.00	0.00	100.00	YES	1.00	SL	1969
04809	1963	40.00	0.15	N/A	N/A	1.25	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
09951	1976	1,404.00	1.95	N/A	N/A	3.00	N/A	90.00	10.00	0.00	NO	0.00	NONE	N/A
10615	1950	602.50	1.68	N/A	N/A	1.50	6,866.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
11703	N/A	3,601.20	7.20	N/A	N/A	2.00	N/A	0.00	100.00	0.00	NO	0.00	NONE	N/A
13978	1969	6,812.00	7.76	N/A	N/A	3.00	N/A	0.00	0.00	100.00	NO	0.00	NONE	N/A
14401	1949	32,500.00	43.50	N/A	N/A	3.00	99.30	90.00	10.00	0.00	NO	0.00	SS	N/A
14789	1952	9,961.00	13.10	N/A	N/A	3.00	1.45	0.00	0.00	0.00	NO	0.00	H	N/A
14924	1946	587.90	2.10	N/A	N/A	1.00	232.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
19405	1960	33,350.00	42.00	N/A	N/A	3.00	19.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
26767	N/A	1,736.70	3.10	N/A	N/A	2.00	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
29697	N/A	2,810.00	3.75	N/A	N/A	3.00	888.00	0.00	100.00	0.00	NO	0.00	NONE	N/A

TABLE III-7

GENERAL SUMMARY TABLE
ALUMINUM CASTING
DIE CASTING

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
05878	N/A	18,000.00	22.50	N/A	N/A	3.00	88.90	0.00	100.00	0.00	NO	0.00	SB	1977
													SS	1977
10615	1950	602.50	1.68	N/A	N/A	1.50	2,866.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
11665	1961	22,692.00	23.70	N/A	N/A	3.00	506.00	0.00	100.00	0.00	YES	18.00	EB	1957
													FLA	1974
													GF	1974
													SS1	1957
													SS2	1974
12040	1955	32,195.00	43.00	N/A	N/A	3.00	1,300.00	0.00	0.00	100.00	YES	90.00	EB	1952
													FLP	1952
													GF	1952
													NL	1952
													SB	1952
													VF	1952
13562	1936	13,442.00	18.20	N/A	N/A	3.00	14,464.00	37.00	0.00	63.00	YES	59.60	SL	1957
													SS	1957
14401	1949	32,500.00	43.50	N/A	N/A	3.00	1,655.00	90.00	10.00	0.00	NO	0.00	NONE	N/A
15265	1960	85,790.00	102.50	N/A	N/A	3.00	1,639.00	80.00	0.00	20.00	NO	N/A	ACG	1976
													BOA	1976
													CL	1976
													CY	1976
													FDSP	1976
													FLL,	1976
													FLP	1976
17089	1960	102,511.20	125.20	N/A	N/A	3.00	1,200.00	79.00	0.00	21.00	YES	30.00	CL	1975
													FLA	1973
													FLP	1975
													FP	1973
													SS	1973
19405	1948	33,350.00	42.00	N/A	N/A	3.00	475.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
20223	1958	90,154.00	100.00	N/A	N/A	3.00	720.00	95.00	5.00	0.00	YES	50.00	FLA	1965
													FLP	1965
													GF	1965
													NC	1965
													SS	1965
													VF	1965

TABLE III-8

GENERAL SUMMARY TABLE
ALUMINUM CASTING
DIE LUBE

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
07138	1966	8,697.00	14.00	N/A	N/A	3.00	71.40	0.00	100.00	0.00	NO	0.00	UF	1974
19275	1957	57,442.00	76.60	N/A	N/A	3.00	8.70	0.00	0.00	100.00	YES	7.00	BOA	1977
													CL	1977
													FF	1977
													FLL	1971
													FLO1	1971
													GF	1957
													SL	1971
													SS	1957
19405	1948	33,350.00	42.00	N/A	N/A	3.00	14.30	0.00	100.00	0.00	NO	0.00	NONE	N/A
20147	1945	40,101.00	44.60	N/A	N/A	3.00	45.20	100.00	0.00	0.00	NO	0.00	BOT	1976
													CY	1976
													SS	1977

TABLE III-9

GENERAL SUMMARY TABLE
COPPER AND COPPER ALLOY CASTING
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
03884	1940	4,978.30	13.98	34.00	2.432	1.00	424.00	0.00	0.00	100.00	YES	2.90	SB	1972
05946	1970	2,330.00	10.00	45.00	4.500	1.00	2,027.00	100.00	0.00	0.00	NO	0.00	IR	N/A
09094	1960	4,129.40	12.00	256.00	21.333	2.00	180.00	100.00	0.00	0.00	YES	82.00	SL	N/A
12322	1960	7,580.00	21.90	25.40	1.160	1.33	15.10	0.00	0.00	100.00	YES	0.10	SB	1960
19872	1964	7,744.10	21.70	333.00	15.346	1.50	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
40011	1940	2,127.00	8.86	40.00	4.515	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A

TABLE III-10

GENERAL SUMMARY TABLE
COPPER AND COPPER ALLOY CASTING
MOLD COOLING AND CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
04951	1963	273.00	0.50	N/A	N/A	3.00	2,300.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
11740	1953	215.00	0.43	N/A	N/A	2.00	140.00	0.00	0.00	100.00	YES	0.02	CL	1953
													EB	1953
													FLO2	1953
													SB	1953
													SS	1953
12322	1960	7,580.00	21.90	N/A	N/A	1.33	817.00	0.00	0.00	100.00	YES	6.40	SS	1960
16446	1972	9,969.00	27.20	N/A	N/A	2.00	26,470.00	99.50	0.50	0.00	NO	0.00	CT	N/A
19484	1949	167.00	0.42	N/A	N/A	1.00	N/A	0.00	100.00	0.00	NO	0.00	NONE	N/A
38846	1940	5,639.80	7.50	N/A	N/A	3.00	1,280.00	0.00	0.00	100.00	YES	1.90	SL	1972

TABLE III-11

GENERAL SUMMARY TABLE
FERROUS CASTING - DUCTILE IRON
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
05417	1962	7,200.00	14.00	12.50	0.893	2.00	3,840.00	100.00	0.00	0.00	NO	0.00	IR	N/A
05941	1964	17,068.00	34.10	226.50	6.642	2.00	318.00	96.00	4.00	0.00	NO	0.00	NONE	N/A
06450	1972	1,419.00	6.00	45.00	7.500	1.00	N/A	90.00	10.00	0.00	NO	0.00	NONE	N/A
09148	1974	8,500.00	34.00	1,240.00	36.471	1.00	151.00	100.00	0.00	0.00	NO	0.00	SL	1974
10435	1967	1,068.90	4.30	40.00	9.302	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
10684	1951	213,386.00	335.00	133.00	0.397	3.00	1,805.00	N/A	0.00	N/A	YES	4.00	SL	1971
12393	1971	71,452.00	180.00	1,800.00	10.000	2.00	192.00	100.00	0.00	0.00	NO	0.00	CL	1971
14173	1943	335,000.00	447.00	507.00	1.134	3.00	61.00	N/A	0.00	N/A	YES	0.50	SL	1965
14809	1948	1,226,942.00	2,606.00	874.00	0.335	2.00	4,160.00	99.40	0.00	0.60	NO	0.00	NONE	N/A
15372	1966	14,500.00	19.30	20.00	1.036	3.00	3,600.00	100.00	0.00	0.00	NO	0.00	SB	1966
16502	1972	42,530.00	91.60	228.00	2.489	2.00	77.00	100.00	0.00	0.00	NO	0.00	IR	N/A
16612	1966	714,527.00	1,297.00	875.00	0.675	2.00	3,946.00	0.00	0.00	100.00	YES	55.00	CL	1977
													FLA	1977
													FLP	1977
													SB	1977
17018	1951	42,242.00	2,235.00	3.15	0.001	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
17370	1959	19,200.00	40.00	480.00	12.000	2.00	400.00	93.00	7.00	0.00	NO	0.00	FLP	1970
													SB	1974
18888	1965	2,000.00	8.00	54.10	6.762	1.00	N/A	90.00	10.00	0.00	NO	0.00	NONE	N/A
19733	1968	126,000.00	293.00	3,150.00	10.751	2.00	283.00	84.00	0.00	16.00	YES	75.00	CY	1968
													FLP	1968
													SCR	1968
													T	1968
													VF	1968
20784	1973	126,054.00	248.00	1,550.00	6.250	2.00	154.00	0.00	0.00	100.00	YES	73.00	FLP	1973
													SL	1973
													SS	1975
24595	1966	10,953.00	79.90	408.00	5.106	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
27743	1940	130,435.00	181.00	2,667.00	14.735	3.00	132.00	87.40	0.00	12.60	NO	0.00	FLP	1964
													SB	1966
88281	1943	18,946.00	43.00	180.00	4.186	2.00	N/A	N/A	N/A	0.00	NO	0.00	NONE	N/A

TABLE III-11

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
00396	1949	7,750.00	55.00	250.00	4.545	1.00	54.00	100.00	0.00	0.00	NO	0.00	IR	N/A
00698	1975	21,386.00	61.00	447.00	7.328	1.00	N/A	100.00	0.00	0.00	N/A	N/A	IR	N/A
00839	1966	133,516.00	213.00	1,640.00	7.700	2.00	1,014.00	100.00	0.00	0.00	NO	0.00	IR	N/A
00880	N/A	7,200.00	29.80	140.00	4.698	1.00	N/A	100.00	0.00	0.00	N/A	N/A	IR	N/A
01381	1955	14,200.00	59.00	300.00	5.085	1.00	N/A	100.00	0.00	0.00	YES	N/A	CL	N/A
													CLFL	N/A
													FLA	N/A
													FLP	N/A
													T	N/A
01644	1973	5,500.00	30.00	220.00	7.333	1.00	236.00	100.00	0.00	0.00	NO	0.00	IR	N/A
01801	1956	58,280.00	141.80	1,095.00	7.722	1.75	690.00	100.00	0.00	0.00	NO	0.00	IR	N/A
02031	1972	5,222.00	23.00	138.00	6.000	1.00	533.00	99.00	0.00	1.00	YES	40.00	DT	1975
													SL	1975
02121	1971	11,250.00	55.00	200.00	3.636	1.00	120.00	100.00	0.00	0.00	NO	0.00	IR	N/A
02195	N/A	3,948.00	16.00	160.00	10.000	1.00	165.00	100.00	0.00	0.00	NO	0.00	IR	N/A
02236	1970	3,605.00	18.00	175.00	9.722	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
02511	1942	6,440.00	27.00	140.00	5.185	1.00	48.00	100.00	0.00	0.00	NO	0.00	IR	N/A
02883	1967	9,835.00	45.00	270.00	6.000	1.00	N/A	N/A	0.00	N/A	N/A	N/A	IR	N/A
03313	1960	78,594.00	110.00	659.00	5.991	3.00	1,318.00	100.00	0.00	0.00	NO	0.00	FLP	1974
													SB	1974
													SL	1976
03646	1974	6,263.70	29.50	350.00	11.864	1.00	43.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
03760	1943	35,609.00	150.00	2,000.00	13.333	1.00	41.00	99.00	1.00	0.00	NO	0.00	SB	N/A
03913	1972	12,670.00	52.00	178.00	3.423	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
04688	1945	32,000.00	68.00	1,600.00	23.529	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
05008	1954	22,411.00	92.00	500.00	5.435	1.00	132.00	0.00	100.00	0.00	NO	0.00	FLP	1968
													SB	1970
05640	N/A	28,500.00	122.00	2,440.00	20.000	1.00	120.00	100.00	0.00	0.00	NO	0.00	SB	N/A
05659	1947	8,500.00	60.00	412.00	6.867	1.00	161.00	99.00	1.00	0.00	NO	0.00	FLP	1970
													NC	1970
													T	1970
06265	1968	81,400.00	113.00	133.00	1.177	3.00	N/A	100.00	0.00	0.00	N/A	N/A	UNK	N/A
06426	1970	2,200.00	19.40	40.00	2.062	1.00	N/A	100.00	0.00	0.00	NO	0.00	UNK	N/A
06450	1972	1,419.00	6.00	27.00	4.500	1.50	N/A	N/A	N/A	0.00	N/A	N/A	IR	N/A
06565	1968	15,275.00	69.50	53.40	0.768	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
06680	1965	12,999.00	27.40	924.00	33.723	2.00	N/A	N/A	0.00	N/A	NO	0.00	IR	N/A
06956	1955	195,100.00	488.00	164.00	0.336	3.00	1,700.00	95.00	0.00	5.00	YES	17.00	CL	1976
													FLL	1974
													FLP	1974
													SL	1976
													SS	1976
06999	1955	6,910.00	28.80	135.00	4.688	1.00	560.00	60.00	40.00	0.00	NO	0.00	NW	N/A
07298	1964	31,800.00	63.60	2,144.00	33.711	2.00	N/A	100.00	0.00	0.00	N/A	N/A	IR	N/A

TABLE III-11

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
07322	1950	17,500.00	37.50	280.00	7.467	2.00	36.00	95.00	0.00	5.00	NO	0.00	IR	N/A
07344	1966	22,008.00	45.00	365.00	8.111	2.00	270.00	98.20	0.00	1.80	NO	0.00	IR	N/A
07902	1975	17,143.00	77.00	400.00	5.195	1.00	184.00	25.00	75.00	0.00	NO	0.00	FLP	N/A
													SB	N/A
07929	1966	52,500.00	105.00	650.00	6.190	2.00	570.00	100.00	0.00	0.00	NO	0.00	SB	1973
08070	1946	14,170.00	60.00	124.00	2.067	1.00	N/A	N/A	N/A	0.00	NO	0.00	NONE	N/A
08301	N/A	1,759.00	10.50	160.00	15.238	1.00	N/A	100.00	0.00	0.00	N/A	N/A	IR	N/A
08482	1957	24,265.00	39.50	100.00	2.532	2.00	446.00	99.00	1.00	0.00	NO	0.00	SB	1967
08868	1965	41,591.00	55.00	360.00	6.545	3.00	298.00	100.00	0.00	0.00	NO	0.00	IR	N/A
09441	1967	31,421.00	65.50	820.00	12.519	2.00	N/A	N/A	0.00	N/A	NO	0.00	NONE	N/A
09593	1953	12,126.00	55.00	286.00	5.200	1.00	488.00	100.00	0.00	0.00	NO	0.00	IR	N/A
09929	1977	12,950.00	52.40	325.00	6.202	1.00	43.00	0.00	0.00	100.00	YES	29.00	CL	1977
													EB	1977
													FLP	1977
													FP	1977
													NA	1977
													NC	1977
													SS	1977
10242	N/A	723.00	2.00	10.00	5.000	1.00	N/A	N/A	0.00	N/A	NO	0.00	NONE	N/A
10600	1971	91,956.00	194.80	2,344.00	12.033	2.00	N/A	90.00	10.00	0.00	NO	0.00	NONE	N/A
10837	1963	243,125.00	496.20	8,753.50	17.641	2.00	173.00	0.00	0.00	100.00	YES	89.00	CL	1967
													FD	1978
													FLP	1967
													SL	1977
10865	1962	749,609.00	1,059.00	10,526.00	9.940	3.00	114.00	N/A	0.00	N/A	YES	83.00	CT	1970
													F	1974
													FLA	1978
													FLP	1969
													SL	1966
11111	1971	121,053.00	161.40	1,368.00	8.476	3.00	649.00	100.00	0.00	0.00	NO	0.00	SB	1967
11245	1971	10,000.00	13.90	111.00	7.986	3.00	592.00	90.20	9.80	0.00	NO	0.00	NONE	N/A
11865	1974	34,662.00	158.10	220.00	1.392	1.00	27.00	100.00	0.00	0.00	NO	0.00	IR	N/A
11964	1954	518,900.00	1,037.80	1,052.50	1.014	2.00	1,020.00	77.40	0.00	22.60	YES	30.00	CL	1964
													CLA	1978
													FLP	1978
													SB	1954
12164	1975	4,631.00	17.80	125.00	7.022	1.00	N/A	90.00	10.00	0.00	NO	0.00	NONE	N/A
13089	1971	558,391.00	920.00	1,333.00	1.449	3.00	68.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
13416	1968	217,030.00	408.00	4,800.00	11.765	2.00	436.00	100.00	0.00	0.00	YES	95.00	FLP	1974
													SB	1926
13460	1971	21,600.00	90.00	832.50	9.250	1.00	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
14069	1966	62,873.00	146.20	1,370.50	9.374	2.00	253.00	88.00	0.00	12.00	YES	38.00	SL1	1977
													SL2	1974

TABLE III-11

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
14069													SL3	1946
14104	1974	374,098.00	356.00	240.00	0.674	3.00	N/A	100.00	0.00	0.00	NO	0.00	SB1	1976
													SB2	1969
													SB3	1958
14670	1975	12,678.00	25.36	189.00	7.453	2.00	688.00	99.80	0.20	0.00	NO	0.00	NONE	N/A
15104	N/A	325,770.00	514.00	154.00	0.300	1.70	935.00	100.00	0.00	0.00	NO	0.00	FLP	1955
													SB	1955
													TP	1979
15520	1971	166,578.00	359.00	2,430.00	6.769	2.00	96.00	70.00	0.00	30.00	YES	85.00	SB	1949
15612	1953	1,121,058.00	2,061.00	1,350.00	0.655	2.00	3,619.00	0.00	0.00	100.00	YES	55.00	CL	1977
													FLA	1977
													FLP	1977
													SB	1977
17230	1968	25,011.00	96.00	384.00	4.000	1.00	139.00	100.00	0.00	0.00	NO	0.00	FLP	1977
													SB	1977
17348	1946	132,995.00	294.00	186.00	0.633	2.00	3,740.00	0.00	0.00	100.00	YES	61.00	SL	1958
													SS	1958
17380	1972	108,794.00	241.00	130.00	0.539	2.00	6,780.00	88.00	0.00	12.00	NO	0.00	CL	1972
													FLP	1972
													SCR	1972
													VF	1972
17746	1956	57,938.00	131.00	1,000.00	7.634	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
18073	1952	632,506.00	962.00	5,238.00	5.445	3.00	824.00	100.00	0.00	0.00	NO	0.00	SB	N/A
													SS	N/A
18919	1942	15,882.00	61.80	150.00	2.427	1.00	48.00	0.00	100.00	0.00	YES	10.00	CL	1976
													FLL	1975
													FLP	1975
													NA	1975
													SB	1976
													SS	1976
18941	N/A	100,380.00	385.00	125.00	0.325	1.00	252.00	66.00	0.00	34.00	NO	0.00	NONE	N/A
19347	1939	29,500.00	64.00	350.00	5.469	2.00	1,029.00	100.00	0.00	0.00	YES	48.00	CL	1959
													CT	1970
													SB	1959
19408	1955	315,707.00	607.25	4,051.70	6.672	2.00	752.00	97.00	3.00	0.00	YES	66.00	CL	1973
													FLP	1973
													VF	1966
19533	1960	11,604.00	49.40	121.60	2.462	1.00	316.00	100.00	0.00	0.00	NO	0.00	IR	N/A
19820	1946	57,778.00	123.00	48.00	0.390	2.00	450.00	100.00	0.00	0.00	NO	0.00	IR	N/A
19933	1972	70,237.00	290.00	128.00	0.441	1.00	164.00	100.00	0.00	0.00	NO	0.00	SB	1978
20112	1905	187,037.00	159.00	248.00	1.560	3.00	91.00	0.00	0.00	100.00	YES	5.60	SB	1972
													SS	1972
20208	1965	107,041.00	208.00	66.50	0.320	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A

TABLE III-11

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
20249	1966	259,733.00	477.00	1,950.00	4.088	2.00	1,329.00	100.00	0.00	0.00	NO	0.00	IR	N/A
20345	1965	188,160.00	384.00	1,154.00	3.005	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
20408	1945	19,597.00	39.00	150.00	3.846	2.00	625.00	100.00	0.00	0.00	NO	0.00	IR	N/A
20699	1900	161,819.00	133.00	623.00	4.684	3.00	N/A	N/A	0.00	N/A	YES	8.80	CL	1977
													FLP	1977
													SS	1977
													VF	1977
26777	1974	27,500.00	120.00	1,800.00	15.000	1.00	200.00	100.00	0.00	0.00	NO	0.00	IR	N/A
27500	1964	157,912.00	319.65	2,240.00	7.008	2.00	455.00	100.00	0.00	0.00	NO	0.00	FLP	1973
													SB	1973
28822	1960	54,644.00	144.00	1,160.00	8.056	2.00	368.00	99.00	1.00	0.00	NO	0.00	IR	N/A
38842	1962	162,162.00	337.50	85.00	0.252	2.00	16,840.00	90.00	0.00	10.00	YES	13.00	SL	1972
53772	1969	43,281.00	83.20	75.00	0.901	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
58823	1967	27,934.00	58.20	509.00	8.746	2.00	830.00	99.00	1.00	0.00	NO	0.00	IR	N/A
63773	1962	73,767.00	113.00	175.00	1.549	2.00	411.00	100.00	0.00	0.00	YES	1.00	SB	1977
74991	N/A	11,750.00	24.00	640.00	26.667	2.00	N/A	N/A	N/A	0.00	YES	N/A	IR	N/A
77775	1962	37,485.00	72.00	50.00	0.694	2.00	4,056.00	100.00	0.00	0.00	YES	25.00	SB	1977
94412	1969	114,133.00	237.80	1,636.00	6.880	2.00	137.00	85.00	0.00	15.00	YES	26.00	FLP	1976
													SB	1974

TABLE III-11

(CONTINUED)
GENERAL SUMMARY TABLE
FERROUS CASTING - MALLEABLE IRON
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
02243	1967	11,590.00	32.00	128.00	4.000	4.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
03049	1976	11,264.60	46.36	12.00	0.259	1.00	200.00	40.00	60.00	0.00	NO	0.00	NONE	N/A
03118	1916	17,402.00	70.00	280.00	4.000	1.00	100.00	100.00	0.00	0.00	NO	0.00	IR	N/A
03432	1975	22,600.00	45.20	343.00	7.588	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
03898	1940	20,640.00	70.00	400.00	5.714	1.50	170.00	90.00	0.00	10.00	YES	2.40	FLP	N/A
													PSP	N/A
													SL	N/A
03901	1965	30,000.00	200.00	1,500.00	7.500	1.00	144.00	100.00	0.00	0.00	NO	0.00	DT	N/A
04100	1970	12,544.00	42.00	312.00	7.429	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
05622	1970	8,591.00	21.00	300.00	14.286	2.00	N/A	95.00	0.00	5.00	YES	0.80	F	1975
													FLP	1975
													NC	1975
06123	1949	104,356.00	222.00	24.80	0.112	2.00	1,041.00	100.00	0.00	0.00	YES	25.00	FLL	1973
													FLO1	1975
													SB	1973
06773	1907	4,325.00	20.30	300.00	14.778	1.00	48.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
07472	1927	54,660.00	95.00	661.00	6.958	2.00	134.00	100.00	0.00	0.00	NO	0.00	FLP	1970
													SB	1970
08436	1968	13,241.00	27.00	160.00	5.926	2.00	N/A	100.00	0.00	0.00	NO	0.00	DT	N/A
													FLA	N/A
													FLL	N/A
													FLP	N/A
08998	1951	13,539.20	23.80	214.20	9.000	2.00	N/A	80.00	0.00	20.00	NO	0.00	NONE	N/A
09306	1971	13,602.00	34.00	319.00	9.382	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
11197	1966	44,300.00	93.50	875.00	9.358	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
12203	1955	81,600.00	109.00	600.00	5.505	3.00	738.00	100.00	0.00	0.00	NO	0.00	IR	N/A
16882*	1968	664,205.00	893.00	5,767.00	6.458	3.00	305.00	100.00*	0.00	0.00	YES	35.00	SL	1975
17331	1949	5,920.00	32.70	722.00	22.080	1.00	397.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
18797	1965	207,530.00	259.40	1,425.00	5.493	3.00	337.00	97.00	0.00	3.00	YES	58.00	CL	1976
													SL	1976
													SS	1977
23455	1946	83,539.70	191.20	882.00	4.613	2.00	231.00	99.00	1.00	0.00	NO	0.00	NONE	N/A
28488	1974	10,619.00	54.50	250.00	4.587	1.00	N/A	90.00	0.00	10.00	NO	0.00	SB	1972

*: The plant reports 100% recycle, however, additional information indicates the possibility of an intermittent blowdown (for landscaping purposes).

TABLE III-11

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - STEEL
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
01834	1957	38,700.00	42.60	240.00	5.634	2.00	1,156.00	100.00	0.00	0.00	NO	0.00	FLP	N/A
													SB	N/A
01835	1953	4,411.50	10.90	46.50	4.266	2.00	392.00	95.00	5.00	0.00	NO	0.00	DT	1940
02365	1957	16,120.00	32.00	232.00	7.250	2.00	N/A	100.00	0.00	0.00	N/A	N/A	IR	N/A
05333	1955	10,120.00	23.00	80.00	3.478	2.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
05560	1943	2,500.00	10.00	11.80	1.180	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
05643	1962	9,464.00	19.70	56.60	2.873	2.00	N/A	N/A	N/A	0.00	N/A	N/A	IR	N/A
06977	1945	23,000.00	30.00	152.00	5.067	3.00	126.00	100.00	0.00	0.00	N/A	N/A	IR	N/A
07863	1942	2,206.00	9.20	30.80	3.348	1.00	N/A	N/A	N/A	0.00	N/A	N/A	IR	N/A
10225	1914	37,000.00	44.00	367.00	8.341	3.00	190.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
10308	1968	33,192.00	46.30	177.00	3.823	3.00	N/A	90.00	10.00	0.00	NO	0.00	NONE	N/A
10629	1968	10,791.00	23.00	88.00	3.826	2.00	164.00	0.00	0.00	100.00	YES	0.20	CL	1977
													FLA	1977
													FLP	1977
													SS	1977
													T	1977
11598	1948	15,250.00	31.00	141.60	4.568	2.00	N/A	90.00	10.00	0.00	NO	0.00	IR	N/A
11635	N/A	15,438.00	19.53	258.60	13.241	3.00	223.00	0.00	0.00	100.00	NO	0.00	CL	1978
													FLA	1949
													FLP	1978
													SB	1949
14761	1959	7,024.00	14.60	50.00	3.425	2.00	58.00	100.00	0.00	0.00	NO	0.00	IR	N/A
15654	1954	125,000.00	173.60	80.00	0.461	3.00	130.00	100.00	0.00	0.00	YES	2.50	SB	1972
15873	1958	5,985.00	12.50	182.50	14.600	2.00	112.80	100.00	0.00	0.00	NO	0.00	IR	N/A
17015	1977	11,700.00	114.70	350.00	3.051	2.00	309.00	100.00	0.00	0.00	NO	0.00	IR	N/A
20007	1969	46,778.00	192.00	1,500.00	7.813	1.00	67.00	N/A	N/A	0.00	YES	N/A	CL	N/A
													FLP	N/A
20009	1969	72,341.00	105.00	110.70	1.054	3.00	N/A	N/A	N/A	0.00	NO	0.00	NONE	N/A
24566	1971	38,106.00	82.50	800.00	9.697	2.00	N/A	90.00	0.00	10.00	YES	3.80	FL03	1975
													FLP	1975
													SL	1975

TABLE III-12

GENERAL SUMMARY TABLE
FERROUS CASTING - DUCTILE IRON
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
07438	1954	4,410.00	21.00	N/A	N/A	1.00	2,000.00	100.00	0.00	0.00	NO	0.00	IR	N/A
08944	1956	74,200.00	327.00	N/A	N/A	1.00	201.00	40.00	0.00	60.00	YES	3.00	NA	1970
													SB	1970
													SS	1970
09148	1974	8,500.00	34.00	N/A	N/A	1.00	1,524.00	100.00	0.00	0.00	YES	22.00	SL	1974
10684	1951	213,386.00	335.00	N/A	N/A	3.00	5,731.00	0.00	0.00	100.00	NO	0.00	CL	1971
													FLP	1971
													SCR	1971
													SL	1971
													SS	1971
													T	1971
													VF	1971
12393	1976	71,452.00	180.00	N/A	N/A	2.00	2,400.00	100.00	0.00	0.00	YES	82.00	CL	1971
													FLP	1971
14173	1943	335,000.00	447.00	N/A	N/A	3.00	3,812.00	N/A	0.00	N/A	NO	0.00	FLL	1977
													FLP	1977
													SB	1977
													SL	1978
14254	N/A	11,973.00	82.60	N/A	N/A	1.00	5,230.00	80.00	20.00	0.00	NO	0.00	NC	1973
													SB	1973
14444	1970	70,498.00	329.00	N/A	N/A	1.00	978.00	43.00	0.00	57.00	YES	43.00	CL	1974
													FLL	1974
													FLP	1974
													SS	1974
													VF	1974
14809	1964	1,226,942.00	2,606.00	N/A	N/A	2.00	2,100.00	99.40	0.00	0.60	YES	57.00	SL1	1948
													SL2	1968
15555	1962	73,968.00	296.00	N/A	N/A	1.00	819.00	70.00	0.00	30.00	YES	60.00	FLL	1978
													FLP	1978
													SB	1978
													VF	1978
16612	1966	714,527.00	1,297.00	N/A	N/A	2.00	2,035.00	0.00	0.00	100.00	YES	42.00	CL	1966
													FLA	1966
													FLP	1966
													SS	1966
18947	1974	114,107.00	423.00	N/A	N/A	2.00	149.00	100.00	0.00	0.00	NO	0.00	NONE	N/A
30160	1972	26,965.00	115.00	N/A	N/A	1.00	626.00	100.00	0.00	0.00	NO	0.00	SL	1972

TABLE III-12

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
00000	1948	3,724.00	16.00	N/A	N/A	1.00	450.00	N/A	0.00	N/A	NO	0.00	IR	N/A
00396	1949	7,750.00	55.00	N/A	N/A	1.00	2,600.00	100.00	0.00	0.00	NO	0.00	IR	N/A
00749	1975	86,421.00	157.00	N/A	N/A	2.37	2,599.00	90.00	10.00	0.00	YES	40.00	CL	1973
													FLL	1973
													FLP	1973
													SB	1973
													SL	1973
01381	1955	14,200.00	59.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	YES	N/A	CL	N/A
													CY	N/A
													FLA	N/A
													FLP	N/A
01801	1956	58,280.00	141.80	N/A	N/A	1.75	2,031.00	100.00	0.00	0.00	NO	0.00	T	N/A
01942	1972	32,385.00	115.70	N/A	N/A	1.00	1,556.00	100.00	0.00	0.00	NO	0.00	IR	N/A
													FLP	1972
													NC	1972
02031	1972	5,222.00	23.00	N/A	N/A	1.00	4,876.00	99.00	0.00	1.00	YES	60.00	SB	1972
02121	1971	11,250.00	55.00	N/A	N/A	1.00	2,182.00	95.00	5.00	0.00	YES	40.00	SL	1973
02195	N/A	3,948.00	16.00	N/A	N/A	1.00	9,000.00	100.00	0.00	0.00	NO	0.00	NC	1971
02236	1970	3,605.00	18.00	N/A	N/A	1.00	3,653.00	100.00	0.00	0.00	NO	0.00	SB	1971
02418	1930	1,300.00	5.20	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	SB	1970
03313	1973	78,594.00	100.00	0.00	0.000	3.00	1,903.00	81.00	0.00	19.00	YES	75.00	IR	N/A
													IR	N/A
													FLP	1974
03399	1976	2,700.00	11.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	SB	1974
03646	1974	6,263.70	29.50	N/A	N/A	1.00	6,834.00	86.00	14.00	0.00	NO	0.00	SL	1974
03868	1946	1,723.50	8.00	N/A	N/A	1.00	3,000.00	100.00	0.00	0.00	NO	0.00	IR	N/A
03913	1972	12,670.00	52.00	N/A	N/A	1.00	3,323.00	100.00	0.00	0.00	NO	0.00	SB	1974
04577	1936	16,800.00	70.00	N/A	N/A	1.00	3,000.00	99.90	0.10	0.00	NO	0.00	IR	N/A
													SB	N/A
													FLP	1971
04955	1952	6,003.00	25.00	N/A	N/A	1.00	300.00	100.00	0.00	0.00	NO	0.00	NC	1971
05008	1954	22,411.00	92.00	N/A	N/A	1.00	2,217.00	99.00	1.00	0.00	NO	0.00	SB	1971
													NONE	N/A
													FLP	1964
													PSP	1964
													SB	1964
05533	1960	57,123.00	115.00	N/A	N/A	2.00	3,130.00	40.00	0.00	60.00	NO	0.00	SSP	1964
05594	1970	15,742.00	67.30	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	SB	1974
													SL	1974
													DT	1971
													FLP	1971
													NC	1971

TABLE III-12

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
05640	N/A	28,500.00	122.00	N/A	N/A	1.00	2,295.00	100.00	0.00	0.00	NO	0.00	SB	N/A
05658	1947	8,500.00	60.00	N/A	N/A	1.00	1,440.00	100.00	0.00	0.00	NO	0.00	DT	N/A
													UNK	N/A
05691	1964	132,324.00	403.40	N/A	N/A	2.00	286.00	100.00	0.00	0.00	NO	0.00	SB	1964
													SL	1964
06213	1948	24,820.00	52.00	N/A	N/A	2.00	2,538.00	100.00	0.00	0.00	NO	0.00	SB	1963
													UNK	1968
06265	1968	81,400.00	113.00	N/A	N/A	3.00	5,522.00	100.00	0.00	0.00	YES	N/A		
06343	1962	37,790.00	72.70	N/A	N/A	2.00	4,952.00	100.00	0.00	0.00	NO	0.00	IR	N/A
06426	1970	2,200.00	19.40	N/A	N/A	1.00	3,943.00	100.00	0.00	0.00	NO	0.00	IR	N/A
06956	1959	195,100.00	488.00	N/A	N/A	3.00	1,900.00	95.00	0.00	5.00	YES	52.00	CL	1974
													FLL	1974
													FLP	1974
													SL	1974
07170	1952	200.00	4.00	N/A	N/A	1.00	2,880.00	100.00	0.00	0.00	NO	0.00	IR	N/A
07225	1947	375.00	1.50	N/A	N/A	1.00	960.00	100.00	0.00	0.00	N/A	N/A	IR	N/A
07234	1964	2,750.00	11.00	N/A	N/A	1.00	5,236.00	100.00	0.00	0.00	N/A	N/A	IR	N/A
07524	N/A	1,470.00	6.00	N/A	N/A	1.00	1,800.00	100.00	0.00	0.00	N/A	N/A	IR	N/A
08092	1924	1,775.00	15.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
08496	N/A	4,550.00	33.20	N/A	N/A	1.00	2,458.00	66.70	0.00	33.30	N/A	N/A	IR	N/A
08828	1955	4,996.60	22.60	N/A	N/A	1.00	159.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
09151	1958	15,000.00	30.00	N/A	N/A	2.00	N/A	100.00	0.00	0.00	N/A	N/A	IR	N/A
09183	1964	7,646.00	N/A	0.00	N/A	1.00	1,883.00	100.00	0.00	0.00	N/A	N/A	NC	1974
													SB	1974
09441	1967	31,421.00	65.50	N/A	N/A	2.00	536.00	100.00	0.00	0.00	NO	0.00	IR	N/A
09593	1953	12,126.00	55.00	N/A	N/A	1.00	1,676.00	N/A	0.00	N/A	NO	0.00	IR	N/A
09925	1938	1,000.00	4.00	N/A	N/A	1.00	2,700.00	50.00	50.00	0.00	NO	0.00	PSP	1972
10865	1965	749,609.00	1,058.80	N/A	N/A	3.00	1,632.00	N/A	0.00	N/A	YES	10.00	DT	1969
													FLA	1978
													FLL	1974
													FLP	1974
													FP	1978
													SB	1966
													SL	1970
11964	1963	518,900.00	1,037.80	N/A	N/A	2.00	1,041.00	95.00	0.00	5.00	YES	0.70	CL	1964
													CLA	1978
													FLP	1978
													SB	1954
13416	1968	217,030.00	408.00	N/A	N/A	2.00	4,400.00	98.00	0.00	2.00	NO	0.00	FLP	1975
													NC	1975
													SB	1975
													SS	1975
													T	1975

TABLE III-12

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
14069	1966	62,873.00	146.20	N/A	N/A	2.00	2,052.00	88.00	0.00	12.00	YES	33.00	SL1	1946
													SL2	1974
													SL3	1977
14670	1975	12,678.00	25.40	N/A	N/A	2.00	5,906.00	99.00	1.00	0.00	NO	0.00	DT	1973
													SB	1973
15520	1971	166,578.00	359.00	N/A	N/A	2.00	401.00	95.00	5.00	0.00	NO	0.00	CL	1971
													FLA	1971
													FLP	1971
													SS	1971
													VF	1971
16612	1952	1,121,058.00	2,061.00	N/A	N/A	2.00	960.00	0.00	0.00	100.00	NO	0.00	CL	1966
													DR	1966
													FLP	1966
17230	1968	25,011.00	91.60	N/A	N/A	1.00	4,913.00	100.00	0.00	0.00	NO	0.00	FLP	1977
													NC	1977
													SB	1977
18073	1952	632,506.00	962.00	N/A	N/A	3.00	2,694.00	100.00	0.00	0.00	YES	N/A	SB	1952
													SL	1952
													SS	1952
19347	1939	29,500.00	64.00	N/A	N/A	2.00	6,000.00	100.00	0.00	0.00	YES	25.00	CL	1959
													NC	1959
													SL	1959
19408	1955	315,707.00	607.00	N/A	N/A	2.00	2,141.00	N/A	N/A	0.00	NO	0.00	SB	N/A
19533	1960	11,604.00	49.00	N/A	N/A	1.00	3,673.00	70.00	30.00	0.00	YES	20.00	SB	N/A
19820	1946	57,778.00	123.00	N/A	N/A	2.00	6,572.00	100.00	0.00	0.00	YES	N/A	SB	1976
													SL	1976
20249	1974	259,733.00	477.00	N/A	N/A	2.00	1,610.00	N/A	N/A	0.00	NO	0.00	NONE	N/A
20345	1965	188,160.00	384.00	N/A	N/A	2.00	425.00	77.00	23.00	0.00	YES	43.00	CL	1965
23454	1960	3,684.00	14.60	N/A	N/A	1.00	9,555.00	96.00	0.00	4.00	NO	0.00	FLP	1970
28822	1960	54,644.00	114.00	N/A	N/A	2.00	3,032.00	100.00	0.00	0.00	NO	0.00	IR	N/A
53772	1969	43,281.00	83.20	N/A	N/A	2.00	N/A	N/A	N/A	0.00	NO	0.00	IR	N/A
58823	1967	27,934.00	58.20	N/A	N/A	2.00	7,093.00	100.00	0.00	0.00	NO	0.00	IR	N/A
63773	1974	73,767.00	113.00	N/A	N/A	2.00	3,186.00	100.00	0.00	0.00	NO	0.00	IR	N/A
74991	N/A	11,750.00	24.00	N/A	N/A	2.00	500.00	0.00	100.00	0.00	YES	12.00	IR	N/A
77775	1963	37,485.00	72.00	N/A	N/A	2.00	7,222.00	100.00	0.00	0.00	NO	0.00	IR	N/A
94412	1977	114,133.00	237.80	N/A	N/A	2.00	1,794.00	81.00	0.00	19.00	YES	50.00	FLP	1974
													SL	1974

TABLE III-12

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - MALLEABLE IRON
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
03898	1940	20,640.00	70.00	N/A	N/A	1.50	2,400.00	97.00	0.00	3.00	YES	97.00	FLP	1971
													SB	1971
													SL	1971
03901	1976	30,000.00	200.00	N/A	N/A	1.00	1,350.00	100.00	0.00	0.00	NO	0.00	SB	N/A
07472	1927	54,660.00	95.00	N/A	N/A	2.00	2,284.00	100.00	0.00	0.00	YES	69.00	SL	1967
08436	1973	13,241.00	27.00	N/A	N/A	2.00	N/A	100.00	0.00	0.00	YES	N/A	DT	1968
													FLA	1968
													FLL	1968
													FLP	1968
													SL	1968
23455	1974	83,539.70	191.20	N/A	N/A	2.00	3,163.00	99.70	0.30	0.00	NO	0.00	IR	N/A

TABLE III-13

GENERAL SUMMARY TABLE
FERROUS CASTING - DUCTILE IRON
SLAG QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
10684	1951	213,386.00	335.00	N/A	N/A	3.00	5,731.00	0.00	0.00	100.00	NO	0.00	CLA	N/A
													SB	N/A
14173	1943	335,000.00	447.00	N/A	N/A	3.00	805.00	N/A	0.00	N/A	NO	0.00	FLL	1972
													FLP	1972
14444	1970	70,498.00	329.00	N/A	N/A	1.00	540.00	88.00	0.00	12.00	NO	0.00	SB	1972
14809	1964	1,226,942.00	2,606.00	N/A	N/A	2.00	1,234.00	99.40	0.60	0.00	YES	29.00	SB	N/A
15555	1962	73,968.00	296.00	N/A	N/A	1.00	997.00	75.00	0.00	25.00	NO	0.00	SB1	1948
16612	1966	714,527.00	1,297.00	N/A	N/A	2.00	1,943.00	0.00	0.00	100.00	YES	N/A	SB2	1968
													SB	1978
													CL	1966
													FLA	1966
													FLP	1966
16666	1966	109,187.00	237.00	N/A	N/A	2.00	60.80	100.00	0.00	0.00	NO	0.00	SB	1966
17018	N/A	42,242.00	233.50	N/A	N/A	1.00	N/A	N/A	N/A	0.00	NO	0.00	SB	N/A
18947	N/A	114,107.00	423.00	N/A	N/A	2.00	236.00	100.00	0.00	0.00	YES	10.00	SB	N/A
													NA	N/A
													SB	N/A
20784	1977	126,054.00	248.00	N/A	N/A	2.00	581.00	39.00	0.00	61.00	NO	0.00	SL	N/A
													FLP	1973
													SB	1973
													SL	1973
24595	1966	10,953.00	79.90	N/A	N/A	1.00	935.00	0.00	100.00	0.00	NO	0.00	SS	1973
27743	1956	130,435.00	181.00	N/A	N/A	3.00	N/A	N/A	0.00	N/A	NO	0.00	NONE	N/A
30160	N/A	26,965.00	115.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	UNK	N/A
													SB	N/A

TABLE III-13

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
SLAG QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
00749	1975	86,421.00	157.00	N/A	N/A	2.37	183.00	90.00	10.00	0.00	NO	100.00	FLA	1974
													FLP	1974
													SB	1974
01801	1956	58,280.00	141.80	N/A	N/A	1.75	28.00	0.00	0.00	100.00	NO	0.00	DT	N/A
													SB	N/A
01942	1972	32,385.00	155.70	N/A	N/A	1.00	1,287.00	100.00	0.00	0.00	NO	0.00	FLP	1972
													NC	1972
													SB	1972
02031	1972	5,222.00	23.00	N/A	N/A	1.00	274.00	0.00	0.00	100.00	YES	75.00	SL	1975
02121	1971	11,250.00	55.00	N/A	N/A	1.00	873.00	95.00	5.00	0.00	NO	0.00	NC	1971
													SB	1971
02195	N/A	3,948.00	16.00	N/A	N/A	1.00	1,650.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
02236	1974	3,605.00	18.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
03313	1973	78,594.00	110.00	N/A	N/A	3.00	436.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
03646	1974	6,263.70	29.50	N/A	N/A	1.00	1,007.00	0.00	100.00	0.00	NO	0.00	SB	1974
04577	1936	16,800.00	70.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	ES	N/A
04688	1945	32,000.00	68.00	N/A	N/A	2.00	1,162.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
05533	1960	57,123.00	115.00	N/A	N/A	2.00	2,713.00	40.00	0.00	60.00	YES	56.00	PSP	1951
													SB	1972
													SL1	1951
													SL2	1951
05658	1967	8,500.00	60.00	N/A	N/A	1.00	2.40	0.00	100.00	0.00	NO	0.00	DT	N/A
													SB	N/A
05691	1964	132,324.00	201.70	N/A	N/A	2.00	2,280.00	100.00	0.00	0.00	NO	0.00	SB	N/A
06213	1948	24,820.00	52.00	N/A	N/A	2.00	3,173.00	0.00	0.00	100.00	NO	0.00	DT	N/A
													SB	N/A
06565	1968	15,275.00	69.50	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	SB	N/A
06956	1956	195,100.00	488.00	N/A	N/A	3.00	860.00	95.00	0.00	5.00	YES	24.00	CL	1974
													FLL	1974
													FLP	1974
													SL	1974
07322	1975	17,500.00	37.50	N/A	N/A	2.00	256.00	95.00	0.00	5.00	YES	10.00	FLA	1976
													FLP	1976
													SL	1976
08070	1946	14,170.00	60.00	N/A	N/A	1.00	16.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
08663	1972	11,177.00	31.00	N/A	N/A	2.00	N/A	100.00	0.00	0.00	YES	N/A	DT	N/A
													SB	N/A
08828	1955	4,996.00	22.60	N/A	N/A	1.00	160.00	57.00	43.00	0.00	NO	0.00	UNK	N/A
09441	1978	31,421.00	65.50	N/A	N/A	2.00	1,088.00	100.00	0.00	0.00	NO	0.00	SL	1955
10865	1965	749,609.00	1,058.80	N/A	N/A	3.00	290.00	0.00	0.00	100.00	YES	2.00	FLL	1979
													FLP	1969
													SB	1966
													SL1	1974

TABLE III-13

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
SLAG QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
10865														
11865	1974	34,622.00	158.00	N/A	N/A	1.00	607.00	75.00	0.00	25.00	YES	N/A	SL2	1978
													CL	1976
													DT	1976
													FDS	1976
													FLP	1976
11964	1965	518,900.00	1,037.80	N/A	N/A	2.00	925.00	77.40	0.00	22.60	YES	15.00	SB	1976
													CL	1964
													FLP	1965
13416	1968	217,030.00	408.00	N/A	N/A	2.00	4,235.00	100.00	0.00	0.00	NO	0.00	SB	1954
													DT	N/A
14069	1966	62,873.00	146.00	N/A	N/A	2.00	378.00	90.00	0.00	10.00	YES	5.80	SB	N/A
													SL	1946
16612	1962	1,121,058.00	2,061.00	N/A	N/A	2.00	N/A	0.00	0.00	100.00	YES	N/A	SS	1974
													CL	1966
													DT	1966
													FLP	1965
17348	1946	132,995.00	294.00	N/A	N/A	2.00	327.00	0.00	0.00	100.00	YES	10.00	SB	1966
													CL	1958
													FLP	1958
													SCR	1958
													SS	1958
17746	1956	57,938.00	131.00	N/A	N/A	2.00	229.00	100.00	0.00	0.00	YES	30.00	VF	1958
													CL	1976
													CT	1976
													FD	1976
18919	1964	15,882.00	61.80	N/A	N/A	1.00	777.00	100.00	0.00	0.00	NO	0.00	FLP	1976
19347	1974	29,500.00	64.00	N/A	N/A	2.00	1,500.00	100.00	0.00	0.00	YES	16.00	SB	N/A
													CL	1959
													CT	1970
19408	1968	315,707.00	607.00	N/A	N/A	2.00	275.00	N/A	N/A	0.00	NO	0.00	SL	1970
19820	1946	57,778.00	123.00	N/A	N/A	2.00	468.00	100.00	0.00	0.00	YES	6.00	SB	N/A
													SB	1976
20112	1966	187,037.00	211.00	N/A	N/A	3.00	895.00	0.00	0.00	100.00	YES	47.00	SL	1976
20249	1974	259,733.00	477.00	N/A	N/A	2.00	N/A	N/A	N/A	0.00	NO	0.00	NONE	N/A
20345	1965	188,160.00	384.00	N/A	N/A	2.00	300.00	62.00	38.00	0.00	YES	15.00	CL	N/A
20699	1954	161,819.00	211.00	N/A	N/A	3.00	620.00	90.00	0.00	10.00	YES	3.00		
27500	1964	157,912.00	319.65	N/A	N/A	2.00	1,652.00	100.00	0.00	0.00	NO	0.00	DT	1969
													SB	1969
53772	1971	43,281.00	83.20	N/A	N/A	2.00	N/A	0.00	100.00	0.00	NO	0.00	UNK	N/A
63773	1974	73,767.00	113.00	N/A	N/A	2.00	N/A	0.00	100.00	0.00	NO	0.00	NONE	N/A
74991	0	11,750.00	24.00	N/A	N/A	2.00	600.00	0.00	100.00	0.00	YES	15.00	DR	1967
94412	1977	114,133.00	237.80	N/A	N/A	2.00	1,067.00	70.00	0.00	30.00	YES	30.00	FLP	1976
													SB	1974
													SL	1976

TABLE III-13

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - MALLEABLE IRON
SLAG QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
03901	1976	30,000.00	2,000.00	N/A	N/A	1.00	1,350.00	100.00	0.00	0.00	NO	0.00	DT	N/A
													SB	N/A
04222	N/A	80,435.00	40.20	N/A	N/A	1.00	N/A	50.00	50.00	0.00	NO	0.00	NONE	N/A
05538	N/A	2,100.00	9.50	N/A	N/A	1.00	378.90	0.00	100.00	0.00	NO	0.00	NONE	N/A
06773	1964	4,235.00	20.30	N/A	N/A	1.00	259.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
07472	1927	54,660.00	95.00	N/A	N/A	2.00	1,026.00	100.00	0.00	0.00	YES	31.00	SL	1967
23455	1974	83,539.70	191.20	N/A	N/A	2.00	753.00	0.00	0.00	100.00	NO	0.00	NONE	N/A

TABLE III-14

GENERAL SUMMARY TABLE
FERROUS CASTING - DUCTILE IRON
MOLD COOLING AND CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
08944	1956	74,200.00	327.00	N/A	N/A	1.00	1,376.00	80.00	0.00	20.00	YES	23.00	NA	1970
													SL	1970
14173	1943	335,000.00	447.00	N/A	N/A	3.00	N/A	N/A	0.00	N/A	YES	N/A	SS	1970
14444	1970	70,498.00	329.00	N/A	N/A	1.00	350.00	64.00	0.00	36.00	YES	21.00	SL	1965
													CL	1974
													FLL	1974
													FLP	1974
14580	1973	125,499.00	229.00	N/A	N/A	2.00	4,377.00	85.00	0.00	15.00	YES	60.00	SS	1974
													CSB	1970
													SB	1970
15555	1962	73,968.00	296.00	N/A	N/A	1.00	190.00	14.00	86.00	0.00	YES	46.00	SS	1970
													FLL	1978
													FLP	1978
													SB	1978
16502	1972	42,530.00	91.60	N/A	N/A	2.00	157.00	0.00	0.00	100.00	NO	0.00	VF	1978
17018	1951	42,242.00	223.50	N/A	N/A	1.00	N/A	N/A	N/A	0.00	YES	48.00	NONE	N/A
													NA	1972
18947	1974	114,107.00	212.00	N/A	N/A	2.00	9,434.00	100.00	0.00	0.00	NO	0.00	SB	1965
19733	1968	126,000.00	293.00	N/A	N/A	2.00	328.00	0.00	0.00	100.00	YES	5.00	CSB	N/A
													FLP	1968
													T	1968
													VF	1968

TABLE III-14

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
MOLD COOLING AND CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
03068	N/A	214,373.00	355.00	N/A	N/A	2.00	123.00	0.00	0.00	100.00	NO	0.00	CL	1978
													FLP	1978
03069	N/A	129,399.00	412.00	N/A	N/A	1.00	55.00	0.00	0.00	100.00	NO	0.00	SS	1977
05691	1964	132,324.00	403.40	N/A	N/A	2.00	553.00	0.00	100.00	0.00	YES	19.00	SB	1964
09151	1958	15,000.00	30.00	N/A	N/A	2.00	N/A	0.00	0.00	100.00	N/A	N/A	NONE	N/A
11865	1974	34,622.00	158.10	N/A	N/A	1.00	266.00	0.00	0.00	100.00	YES	35.00	CL	1976
													FLP	1976
15104	N/A	325,770.00	514.00	N/A	N/A	1.70	N/A	0.00	0.00	100.00	NO	0.00	NONE	N/A
17289	1962	9,719.70	11.39	N/A	N/A	3.00	588.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
17746	1956	57,938.00	131.00	N/A	N/A	2.00	534.00	100.00	0.00	0.00	YES	70.00	CL	1977
													CT	1977
													FLP	1976
20112	1905	187,037.00	210.00	N/A	N/A	3.00	120.00	0.00	0.00	100.00	YES	6.50	SL	1972
													SS	1972
20408	1945	19,597.00	39.00	N/A	N/A	2.00	N/A	100.00	0.00	0.00	NO	0.00	SB	N/A

TABLE III-14

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - STEEL
MOLD COOLING AND CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
01665	1976	9,151.60	15.20	N/A	N/A	2.00	291.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
01834	1957	38,700.00	42.60	N/A	N/A	3.00	76.00	100.00	0.00	0.00	NO	0.00	CT	N/A
02365	1951	16,120.00	32.00	N/A	N/A	2.00	N/A	N/A	N/A	0.00	N/A	N/A	NONE	N/A
02495	N/A	600.00	2.50	N/A	N/A	1.00	4.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
04265	1948	1,119.00	2.25	N/A	N/A	2.00	42.70	0.00	100.00	0.00	N/A	N/A	NONE	N/A
04890	1965	24,995.00	49.50	N/A	N/A	2.00	199.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
06937	1967	260.00	5.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	N/A	N/A	NONE	N/A
07882	1942	5,467.00	10.90	N/A	N/A	2.00	5,505.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
07898	1967	397.00	0.80	N/A	N/A	2.00	125.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
08768	N/A	6,754.00	13.30	N/A	N/A	2.00	75.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
10225	1914	37,000.00	44.00	N/A	N/A	3.00	N/A	75.00	25.00	0.00	NO	0.00	CT	N/A
10388	1968	33,192.00	46.30	N/A	N/A	3.00	583.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
11598	1948	15,250.00	31.00	N/A	N/A	2.00	145.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
11643	1970	41,478.00	70.00	N/A	N/A	3.00	8,229.00	100.00	0.00	0.00	NO	0.00	DT	1970
15654	1954	125,000.00	173.60	N/A	N/A	3.00	5,100.00	100.00	0.00	0.00	NO	0.00	CT	1972
													SB	1972
16934	1943	20,599.00	38.20	N/A	N/A	2.00	52.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
17015	1977	11,700.00	114.70	N/A	N/A	2.00	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
17017	1952	66,117.00	88.10	N/A	N/A	3.00	11.40	76.00	24.00	0.00	NO	0.00	NONE	N/A
20000	1957	66,144.00	95.44	N/A	N/A	3.00	1,320.00	99.80	0.20	0.00	YES	34.00	CT	N/A
20002	1964	62,331.20	90.00	N/A	N/A	3.00	1,493.00	99.80	0.20	0.00	YES	29.00	CT	N/A
20003	1943	19,310.70	39.90	N/A	N/A	2.00	1,170.00	0.00	0.00	100.00	NO	0.00	NONE	N/A
20007	1969	46,778.00	192.00	N/A	N/A	1.00	55.00	0.00	100.00	0.00	YES	N/A	CL	N/A
20009	1969	72,341.00	105.00	N/A	N/A	3.00	N/A	N/A	N/A	0.00	NO	0.00	NONE	N/A
20011	1961	75,346.00	107.30	N/A	N/A	3.00	2,237.00	99.80	0.20	0.00	YES	42.00	CT	N/A
20719	1942	4,108.00	11.30	N/A	N/A	1.50	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
21175	1948	4,450.00	12.40	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
24566	1971	38,106.00	82.48	N/A	N/A	2.00	1,164.00	100.00	0.00	0.00	YES	N/A	SL	N/A
28634	1951	15,796.00	30.37	N/A	N/A	2.00	1,391.00	0.00	0.00	100.00	NO	0.00	NONE	N/A

TABLE III-14

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - MALLEABLE IRON
MOLD COOLING AND CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
06123	1949	104,356.00	222.03	N/A	N/A	2.00	113.00	100.00	0.00	0.00	YES	2.50	SB	1973

TABLE III-15

GENERAL SUMMARY TABLE
FERROUS CASTING - GRAY IRON
SAND WASHING AND RECLAIM

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
01381	1955	14,200.00	59.00	75.00	1.271	1.00	N/A	100.00	0.00	0.00	YES	N/A	CL	N/A
													CY1	N/A
													CY2	N/A
													FLP	N/A
07902	1975	17,143.00	77.00	40.00	0.519	1.00	N/A	N/A	N/A	0.00	NO	0.00	SB	N/A
11964	1965	518,900.00	1,037.80	903.00	0.870	2.00	3,085.00	77.50	0.00	22.50	YES	41.00	UNK	N/A
													CL	1964
													FLA	1964
15520	1971	166,578.00	359.00	2,404.00	6.696	2.00	198.00	81.00	19.00	0.00	NO	0.00	FLP	1964
													SB	1954
17348	1946	132,995.00	294.00	120.00	0.408	2.00	3,040.00	0.00	0.00	100.00	YES	32.00	CY	1971
20699	1954	161,819.00	133.00	25.00	0.188	2.00	1,402.00	0.00	0.00	100.00	YES	6.60	SB	1971
													SL	1969
													CL	1977
													FLP	1977
													SS	1977
													VF	1977

TABLE III-15

(CONTINUED)

GENERAL SUMMARY TABLE
FERROUS CASTING - STEEL
SAND WASHING AND RECLAIM

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
20007	1969	46,778.00	192.00	285.00	1.484	1.00	N/A	N/A	N/A	0.00	YES	N/A	CL	N/A
													FLP	N/A
20009	1969	72,341.00	105.00	83.00	0.790	3.00	1,565.00	56.00	44.00	0.00	YES	80.00	SL	1950
24566	1971	38,106.00	82.50	50.00	0.606	2.00	1,461.00	0.00	0.00	100.00	YES	96.00	FL03	1975
													FLP	1975
													SL	1975

TABLE III-16

GENERAL SUMMARY TABLE
LEAD CASTING
CONTINUOUS STRIP

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
10062	1954	17,038.00	28.00	N/A	N/A	2.00	49.70	0.00	100.00	0.00	YES	1.30	E	1977
													FP	1977
10145	1975	4,438.00	19.00	N/A	N/A	2.00	84.40	85.50	14.50	0.00	YES	4.90	NO3	1977
													E	1977
10169	1975	8,605.00	15.00	N/A	N/A	2.00	42.00	100.00	0.00	0.00	YES	9.80	FP	1977
													NO3	1977
													E	1977
													FP	1977
													NO3	1977
10175	1954	11,508.00	17.70	N/A	N/A	2.00	N/A	0.00	100.00	0.00	YES	N/A	SB1	1977
													SB2	1977
													E	1976
													FP	1976
10181	1946	12,125.00	23.00	N/A	N/A	2.00	41.70	0.00	100.00	0.00	YES	0.50	NO3	1976
													SB	1976
													E	1977
													NO3	1977
													SB	1977

TABLE III-17

GENERAL SUMMARY TABLE
LEAD CASTING
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
10038	N/A	570.00	2.30	N/A	N/A	1.00	217.00	99.00	1.00	0.00	YES	8.80	SL	1976
10041	1971	5,606.00	7.50	N/A	N/A	3.00	133.00	100.00	0.00	0.00	NO	0.00	IR	1971
10131	1971	5,896.00	12.00	N/A	N/A	2.00	3,200.00	100.00	0.00	0.00	NO	0.00	IR	1971
10137	1975	6,864.00	9.00	N/A	N/A	3.00	6.00	100.00	0.00	0.00	NO	0.00	IR	1975
10142	1972	5,457.00	7.30	N/A	N/A	3.00	137.00	100.00	0.00	0.00	NO	0.00	IR	1972

TABLE III-18

GENERAL SUMMARY TABLE
MAGNESIUM CASTING
GRINDING SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
05244	1975	49.70	0.20	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	IR	N/A
08146	1940	192.00	0.82	N/A	N/A	1.00	1,600.00	0.00	0.00	100.00	NO	0.00	NONE	N/A

TABLE III-19

GENERAL SUMMARY TABLE
MAGNESIUM CASTING
DUST COLLECTION

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
08146	1940	192.00	0.82	100.00	121.951	1.00	22.00	0.00	0.00	100.00	NO	0.00	NONE	N/A

TABLE III-20

GENERAL SUMMARY TABLE
ZINC CASTING
CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
01334	1964	6,000.00	15.00	N/A	N/A	2.00	N/A	100.00	0.00	0.00	YES	N/A	NONE	N/A
01707	1975	2,500.00	3.40	N/A	N/A	3.00	706.00	0.00	0.00	100.00	NO	0.00	FLL	1976
													FP	1976
													NL	1976
													SB	1976
													SS	1976
02589	1970	500.00	1.00	N/A	N/A	2.00	500.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
04525	1959	330.00	1.40	N/A	N/A	1.00	N/A	0.00	100.00	0.00	NO	0.00	NONE	N/A
04622	1956	10,671.00	22.20	N/A	N/A	2.00	93.00	0.00	0.00	100.00	NO	0.00	H	N/A
05091	1956	360.00	0.75	N/A	N/A	2.00	533.00	0.00	100.00	0.00	NO	0.00	NONE	N/A
05117	1940	48,500.00	61.50	N/A	N/A	3.00	546.00	30.00	0.00	70.00	YES	8.00	CL	1972
													EB	1972
													FLL	1972
													FLP	1972
													NL	1972
													SS	1972
													T	1972
													VF	1972
05947	1970	3,600.00	14.00	N/A	N/A	1.00	N/A	100.00	0.00	0.00	NO	0.00	CT	N/A
													SB	N/A
06606	1946	6,000.00	6.41	N/A	N/A	3.00	N/A	0.00	100.00	0.00	NO	0.00	NONE	N/A
08724	1952	2,268.00	2.90	N/A	N/A	3.00	5.50	0.00	100.00	0.00	YES	0.01	NONE	N/A
09105	N/A	8,030.30	10.30	N/A	N/A	3.00	N/A	N/A	N/A	0.00	NO	0.00	NONE	N/A
09707	1956	586.00	1.40	N/A	N/A	1.50	N/A	80.00	20.00	0.00	YES	N/A	NONE	N/A
10308	1954	13,005.00	15.63	N/A	N/A	3.00	N/A	100.00	0.00	0.00	YES	25.00	EB	1974
													FLA	1974
													FLC	1974
													FLP	1974
													GF	1974
													NC	1974
													SB	1974
													SS1	1974
													SS2	1974
10475	1955	11,000.00	25.00	N/A	N/A	2.00	N/A	100.00	0.00	0.00	NO	0.00	UNK	N/A
10640	1965	9,714.00	14.00	N/A	N/A	2.00	857.00	0.00	0.00	100.00	YES	5.00	CL	1956
													EB	1956
													FLA	1956
													FLL	1956
													FLO2	1956
													FLP	1956
													NA	1956
													NL	1956
													NW	1956

TABLE III-20

(CONTINUED)
GENERAL SUMMARY TABLE
ZINC CASTING
CASTING QUENCH

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
10640													T	1956
12060	1967	1,900.00	4.90	N/A	N/A	1.50	32.70	0.00	100.00	0.00	YES	0.01	CL	1975
													FLP	1975
13524	1956	32,396.00	43.20	N/A	N/A	3.00	66.70	0.00	100.00	0.00	YES	N/A	EB	1973
													FLA	1973
													FLP	1973
													GF	1973
													NC	1973
													SB	1973
													SS	1973
18139	1952	42,023.50	41.70	N/A	N/A	3.00	4.80	0.00	100.00	0.00	YES	0.20	SB	1977
													SS	1977
18463	N/A	8,105.20	16.89	N/A	N/A	2.00	2,152.00	0.00	100.00	0.00	YES	35.00	FLL	1970
													FLP	1953
													GF	1953
													NC	1953
													NL	1970
													NW	1953
													SL	1953
21207	1965	1,421.50	3.17	N/A	N/A	2.00	772.00	N/A	N/A	0.00	NO	0.00	NONE	N/A

TABLE III-21

GENERAL SUMMARY TABLE
ZINC CASTING
MELTING FURNACE SCRUBBERS

NEW PLANT CODE	AGE OF OLDEST FURNACE	PRODUCTION TONS/YR	PRODUCTION TONS/SHIFT	TONS OF SAND /SHIFT	TONS SAND/ TON METAL	SHIFT /DAY	APPLIED FLOW GAL/TON	PERCENT RECYCLE	PERCENT POTW DISCH	PERCENT DIRECT DISCH	CENT TRT	PERCENT OF TOTAL	TRT TECH	TRT AGE
04622	1956	10,671.00	22.20	N/A	N/A	2.00	N/A	100.00	0.00	0.00	NO	0.00	NONE	N/A
10475	1955	11,000.00	25.00	N/A	N/A	2.00	N/A	90.00	10.00	0.00	NO	0.00	NONE	N/A
10640	1965	9,714.00	14.00	N/A	N/A	2.00	24,700.00	98.30	0.00	1.70	YES	2.40	CL	1956
													EB	1956
													FLA	1956
													FLL	1956
													FLO2	1956
													FLP	1956
													NA	1956
													NL	1956
													NW	1956
													T	1956
13524	1956	32,396.00	43.20	N/A	N/A	3.00	N/A	90.00	10.00	0.00	YES	10.00	EB	1973
													FLA	1973
													FLP	1973
													GF	1973
													NC	1973
													SB	1973
													SS	1973
18139	1952	42,023.50	41.70	N/A	N/A	3.00	5,468.00	85.00	15.00	0.00	YES	27.00	CL	1977
													EB	1977
													FLP	1977
													FP	1977
													NL	1977
													S	1977
													SB	1977

TABLE III-22

OPERATING MODES, CONTROL AND TREATMENT TECHNOLOGIES AND DISPOSAL METHODS

Symbols

A. Operating Modes

1.	OT	Once-Through
2.	Rt,s,n	Recycle, where t = type waste s = stream recycled n = % recycled t: U = Untreated T = Treated
	P	Process Wastewater (s) % of raw waste flow (n)
3.	REt,n	Reuse, where t = type n = % of raw waste flow t: U = before treatment T = after treatment
4.	IR	Internal Recycle
5.	BDn	Blowdown, where n = discharge as % of raw waste flow

B. Control Technology

10.	DI	Deionization
11.	SR	Spray/Fog Rinse
12.	DR	Drag-out Recovery

C. Disposal Methods

20.	H	Haul Off-Site
21.	DW	Deep Well Injection
22.	EME	Evaporation, Multiple Effect

TABLE III-22
OPERATING MODES, CONTROL AND TREATMENT
TECHNOLOGIES AND DISPOSAL METHODS
PAGE 2

C. Disposal Methods (cont.)

23.	ES	Evaporation on Slag
24.	EVC	Evaporation, Vapor Compression Distillation

D. Treatment Technology

30.	SC	Segregated Collection
31.	E	Equalization/Blending
32.	Scr	Screening
33.	OB	Oil Collecting Baffle
34.	SS	Surface Skimming (oil, etc.)
35.	PSP	Primary Scale Pit
36.	SSP	Secondary Scale Pit
37.	EB	Emulsion Breaking
38.	A	Acidification
39.	AO	Air Oxidation
40.	GF	Gas Flotation
41.	M	Mixing
42.	Nt	Neutralization, where t = type

t: L = Lime
C = Caustic
A = Acid
W = Wastes
O = Other, footnote

43.	FLt	Flocculation, where t = type

t: L = Lime
A = Alum
P = Polymer
M = Magnetic
FC = Ferric Chloride
O = Other, footnote

TABLE III-22
OPERATING MODES, CONTROL AND TREATMENT TECHNOLOGIES AND DISPOSAL METHODS
PAGE 3

D. Treatment Technology (cont.)

44.	CY	Cyclone/Centrifuge/Classifier
45.	DT	Drag Tank
46.	CL	Clarifier
47.	T	Thickener
48.	TP	Tube/Plate Settler
49.	SLn	Settling Lagoon, where n = days of retention time
50.	VF	Vacuum Filtration (of, e.g., CL, T, or TP underflows)
51.	Ft,m,h	Filtration, where t = type m = media h = head

t	m	h
D = Deep Bed	S = Sand	G = Gravity
F = Flat Bed	O = Other, footnote	P = Pressure

52.	CLt	Chlorination, where t = type t: A = Alkaline B = Breakpoint
53.	CO	Chemical Oxidation (other than CLA or CLB)
54.	BOt	Biological Oxidation, where t = type t: An = Activated Sludge n = No. of Stages T = Trickling Filter B = Biodisc O = Other, footnote
55.	CR	Chemical Reduction (e.g., chromium)
56.	CT	Cooling Tower

TABLE III-22
OPERATING MODES, CONTROL AND TREATMENT
TECHNOLOGIES AND DISPOSAL METHODS
PAGE 4

D. Treatment Technology (cont.)

57.	ACt	Activated Carbon, where t = type t: P = Powdered G = Granular
58.	IX	Ion Exchange
59.	RO	Reverse Osmosis
60.	D	Distillation
61.	AAl	Activated Alumina
62.	OZ	Ozonation
63.	UV	Ultraviolet Radiation
64.	CNTt,n	Central Treatment, where t = type n = process flow as % of total flow t: 1 = Same Subcats. 2 = Similar Subcats. 3 = Synergistic Subcats. 4 = Cooling Water 5 = Incompatible Subcats.
65.	On	Other, where n = Footnote number
66.	SB	Settling Basin
67.	AE	Aeration
68.	PS	Precipitation with Sulfide
69.	OS	Oil Separator

TABLE III-23

FERROUS MOLD COOLING
AND CASTING QUENCH OPERATIONS

Plant Code	Employee Group	Metal	Product	Casting Process
04409	50-249	Gray Iron	-	71% Centrifugal
08944	≥250	Ductile Iron	Pipe	97% Centrifugal
11865	≥250	Gray Iron	Pipe	60% Centrifugal
14173	≥250	Ductile Iron	Pipe	86% Centrifugal
14580	≥250	Ductile Iron	Pipe	100% Centrifugal
17746	≥250	Gray Iron	Pipe	84% Centrifugal
18947	≥250	Ductile Iron	Pipe	100% Centrifugal

TABLE III-24

DISTRIBUTION OF PLANTS
METALS CASTINGS INDUSTRY

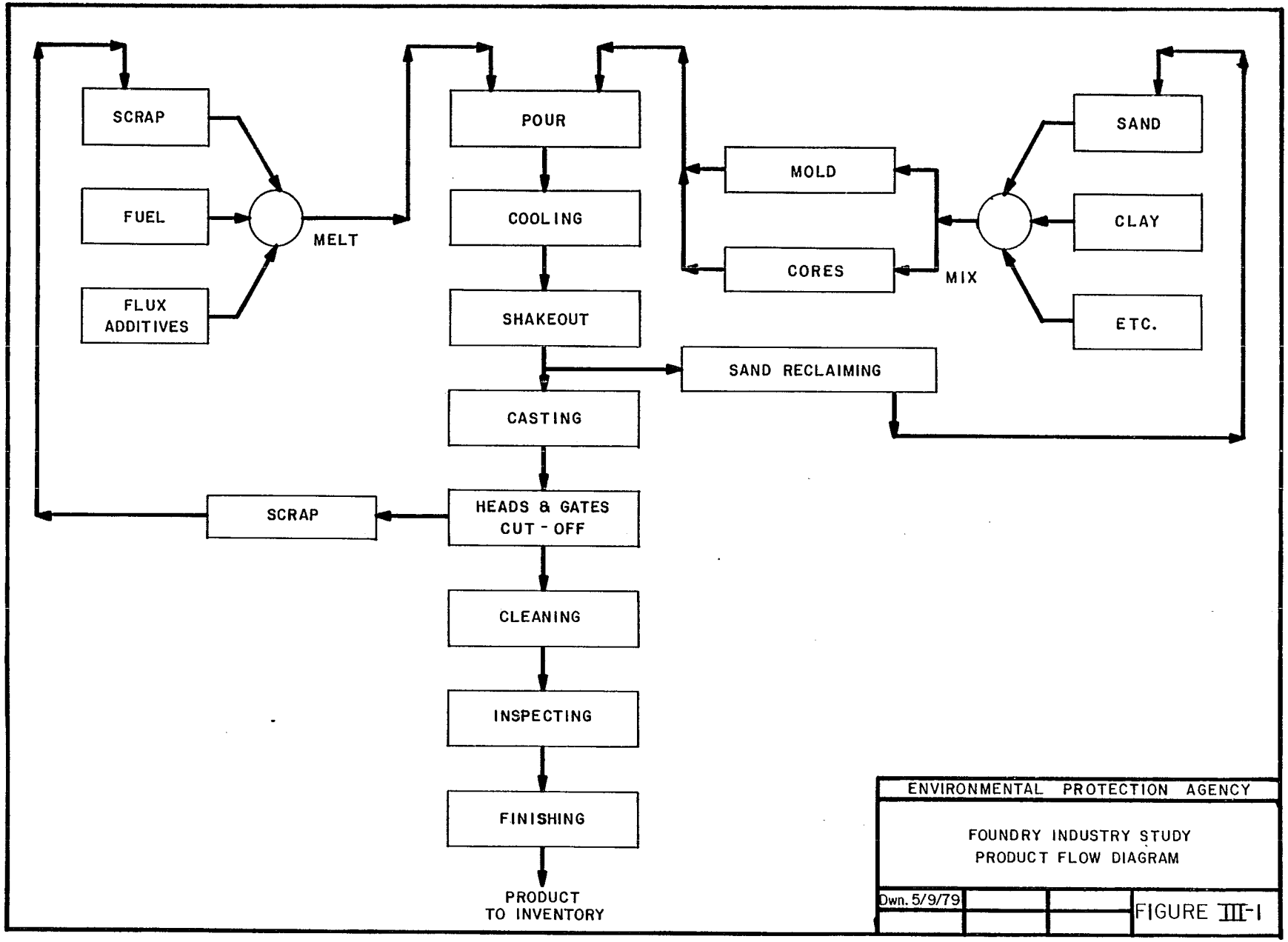
Subcategory	Less than 10 Employees		10-49 Employees		50-249 Employees		More than 250 Employees		Total	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Aluminum Casting	0	316	66 (56)	401	38 (36)	85	16 (14)	4	120 (106)	806
Copper Casting	9 (9)	217	14 (14)	352	42 (42)	65	16 (13)	0	81 (78)	634
Ferrous Casting	0	66	123 (123)	377	381 (365)	269	207 (195)	55	711 (683)	767
Lead Casting									10*	130*
Magnesium Casting	0	1	2 (2)	3	5 (5)	1	0	0	7 (7)	5
Zinc Casting	0	74	45 (45)	124	31 (31)	87	14 (5)	7	90 (81)	292
Total	9 (9)	674	250 (240)	1257	497 (479)	507	253 (227)	66	1019 (965)	2634

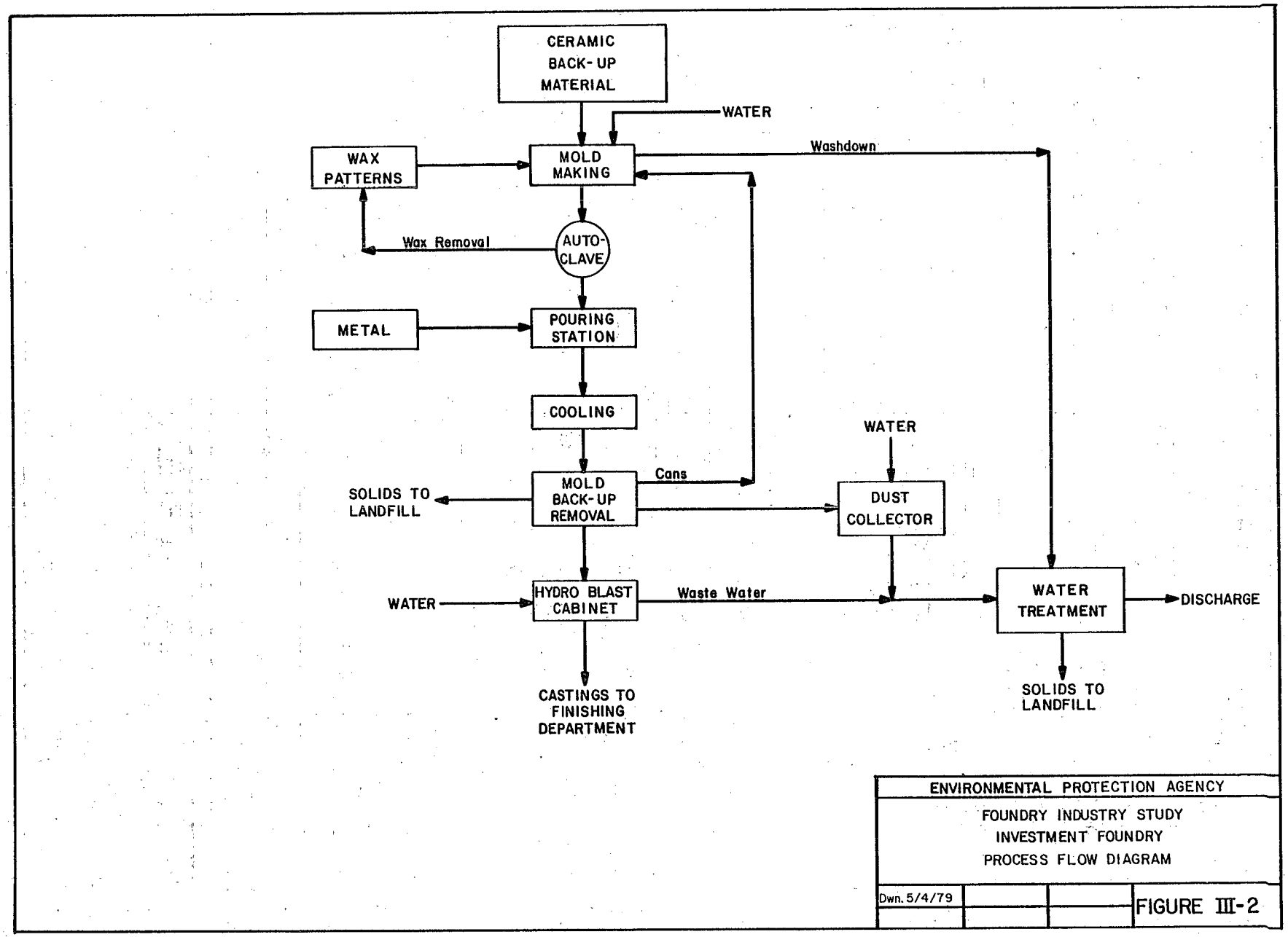
* : Lead casting data are not arrayed by employee group.
(): Numbers enclosed in parentheses represent active foundry operations.

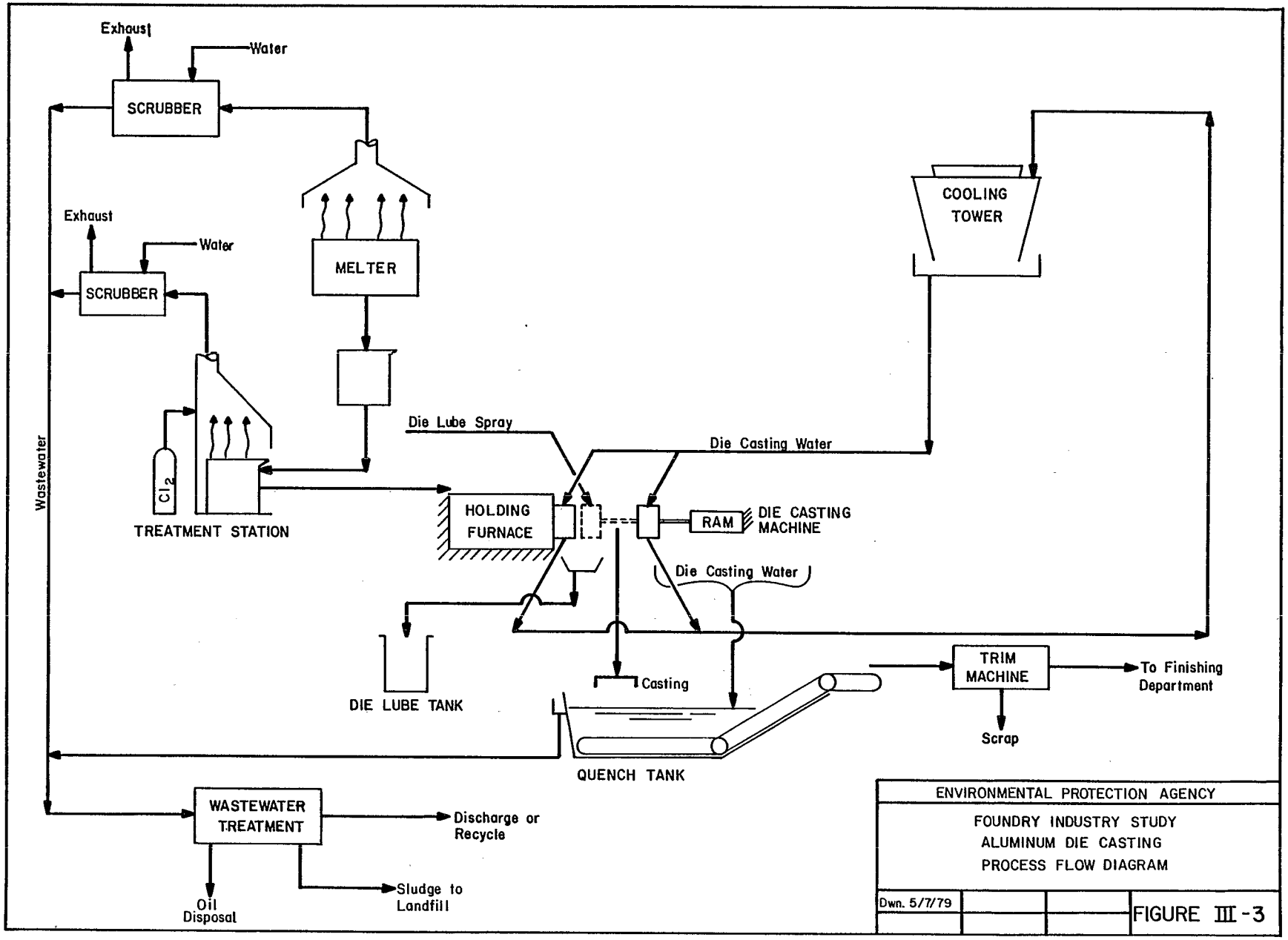
TABLE III-25

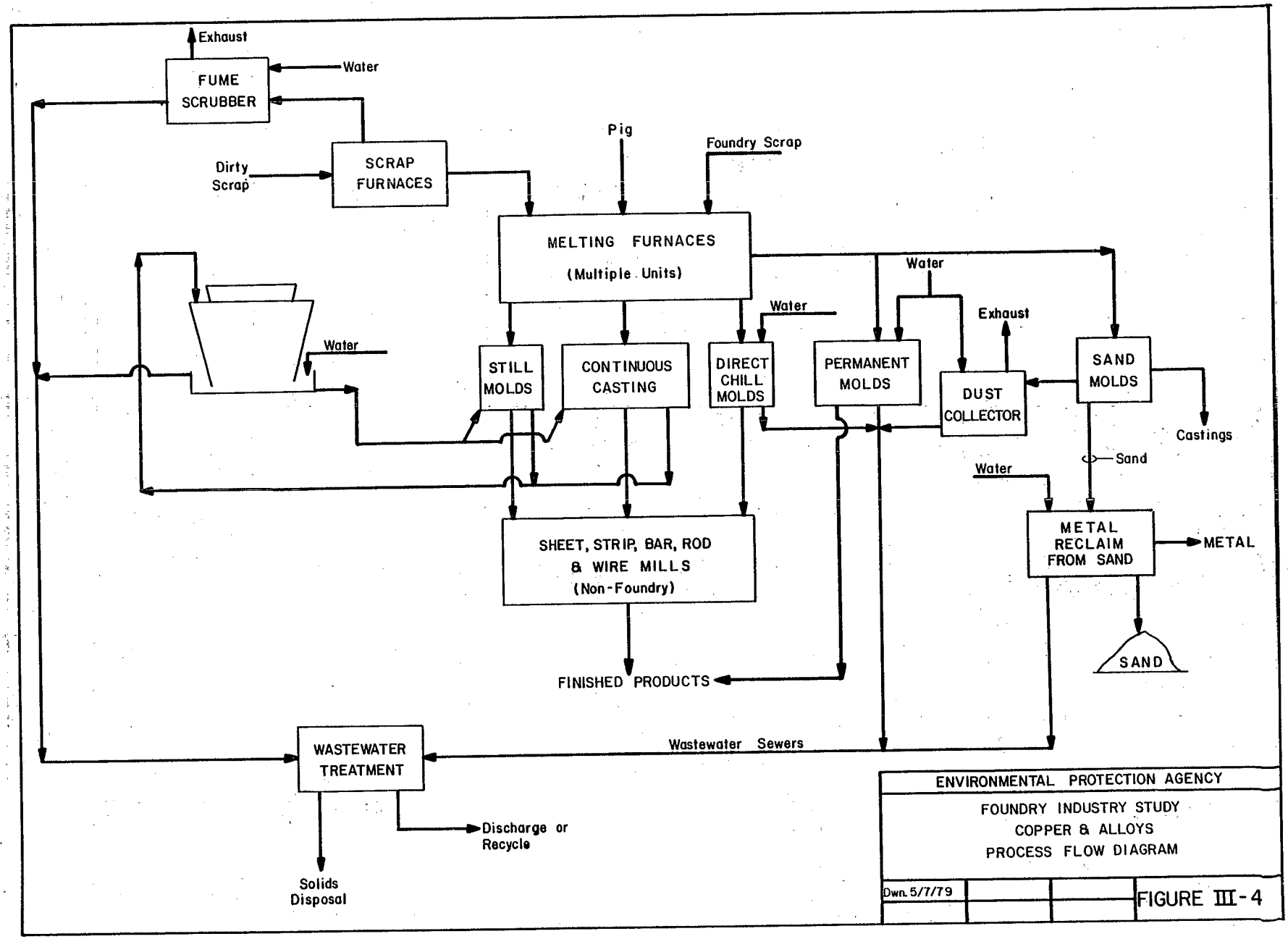
PERCENTAGE OF ACTIVE "WET" OPERATIONS
WITHIN EACH EMPLOYEE GROUP
METALS CASTING INDUSTRY

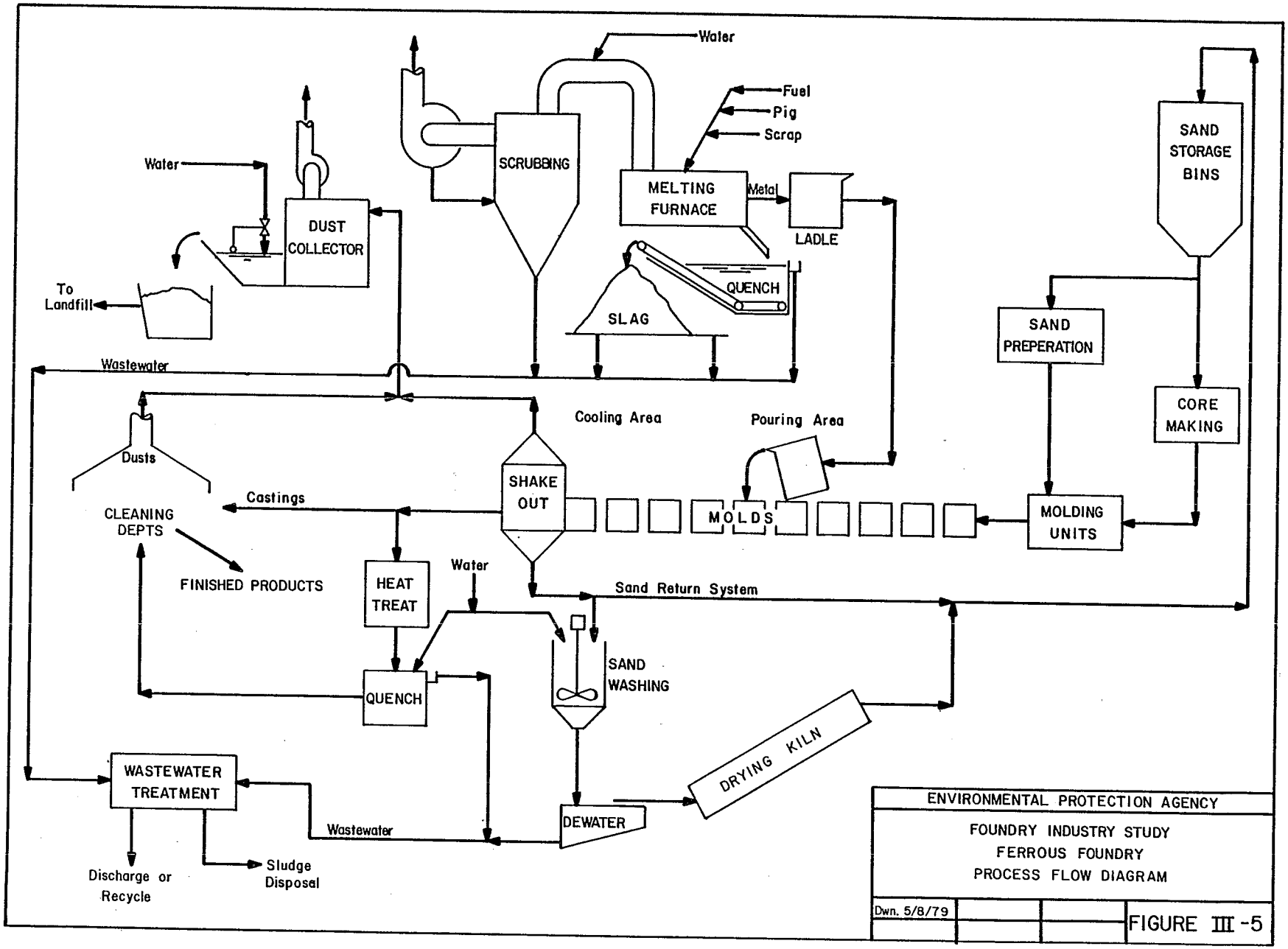
Subcategory	Less than 10 Employees	10-49 Employees	50-249 Employees	More than 250 Employees
Aluminum Casting	0	12.3%	29.8%	77.8%
Copper Casting	4.0%	3.8%	39.3%	100%
Ferrous Casting	0	24.6%	57.6%	78.0%
Magnesium Casting	0	40.0%	83.3%	-
Zinc Casting	0	26.6%	26.3%	41.7%

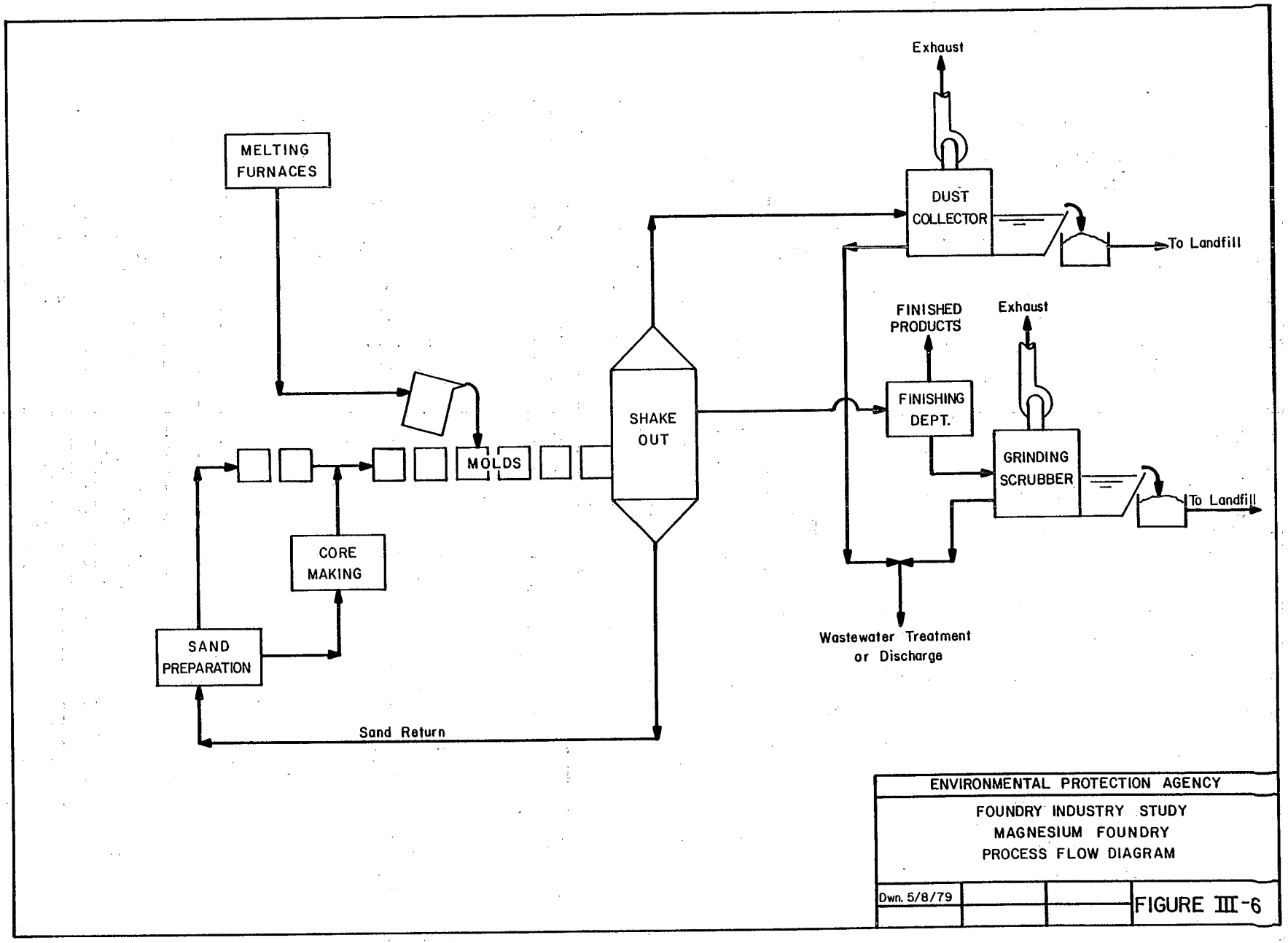

SCRAP
FUEL
FLUX ADDITIVES
MELT
POUR
COOLING
SHAKEOUT
CASTING
HEADS & GATES CUT - OFF
CLEANING
INSPECTING
FINISHING
PRODUCT TO INVENTORY
SCRAP
SAND RECLAIMING
MOLD
CORES
MIX
SAND
CLAY
ETC.
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
PRODUCT FLOW DIAGRAM
Dwn. 5/9/79
FIGURE III-1

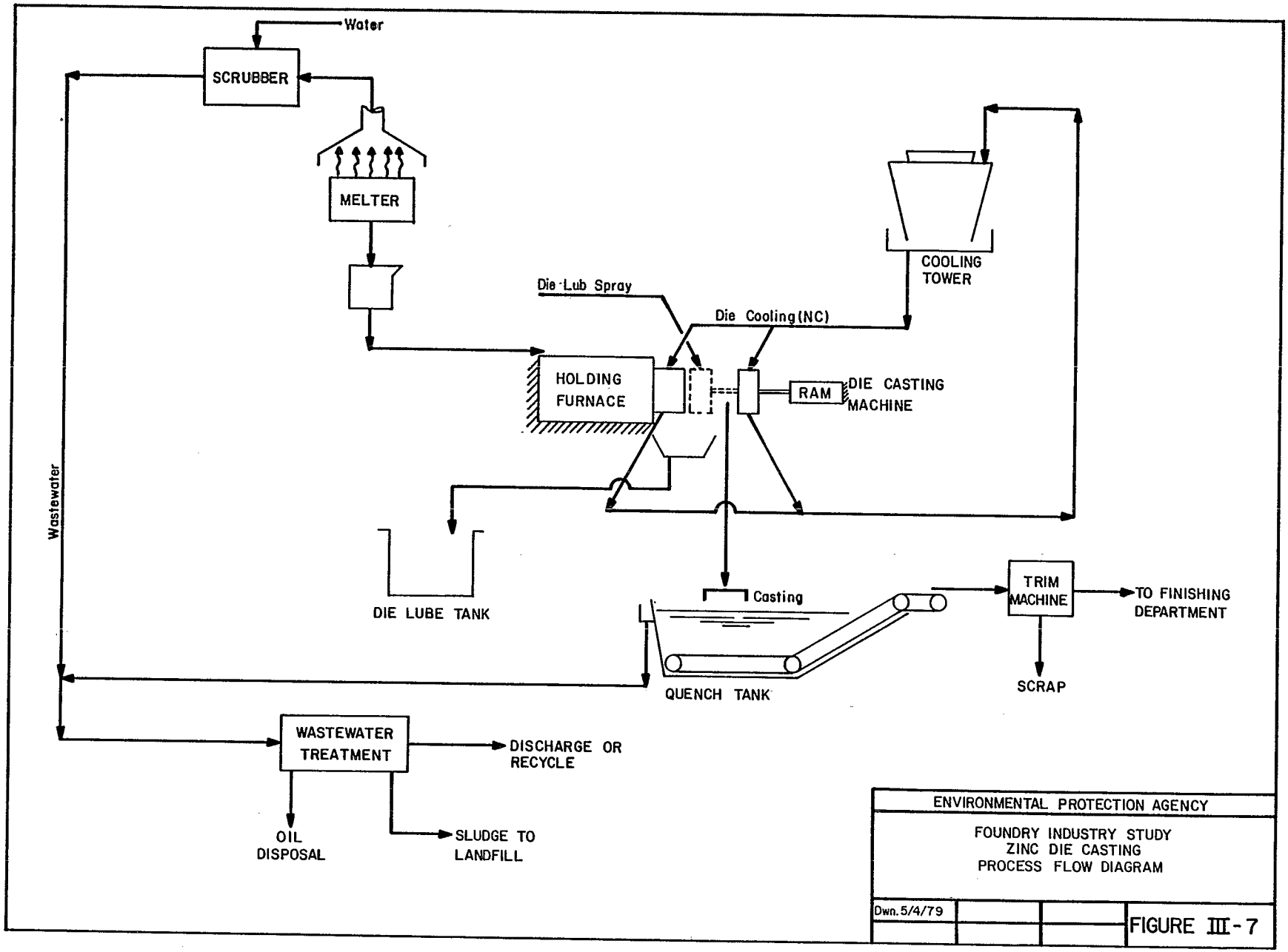

CERAMIC BACK-UP MATERIAL
WATER
WAX PATTERNS
MOLD MAKING
Washdown
Wax Removal
AUTO-CLAVE
METAL
POURING STATION
COOLING
WATER
SOLIDS TO LANDFILL
Cans
MOLD BACK-UP REMOVAL
DUST COLLECTOR
WATER
HYDRO BLAST CABINET
Waste Water
WATER TREATMENT
DISCHARGE
CASTINGS TO FINISHING DEPARTMENT
SOLIDS TO LANDFILL
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
INVESTMENT FOUNDRY
PROCESS FLOW DIAGRAM
Dwn. 5/4/79
FIGURE III-2


Exhaust
Water
SCRUBBER
Exhaust
Water
SCRUBBER
MELTER
COOLING TOWER
Wastewater
Die Lube Spray
Die Casting Water
Cl_2
TREATMENT STATION
HOLDING FURNACE
RAM
DIE CASTING MACHINE
Die Casting Water
DIE LUBE TANK
Casting
TRIM MACHINE
To Finishing Department
Scrap
QUENCH TANK
WASTEWATER TREATMENT
Discharge or Recycle
Oil Disposal
Sludge to Landfill
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
ALUMINUM DIE CASTING
PROCESS FLOW DIAGRAM
Dwn. 5/7/79
FIGURE III-3


Exhaust
FUME SCRUBBER
Water
Dirty Scrap
SCRAP FURNACES
Pig
Foundry Scrap
MELTING FURNACES
(Multiple Units)
Water
Water
Exhaust
Water
STILL MOLDS
CONTINUOUS CASTING
DIRECT CHILL MOLDS
PERMANENT MOLDS
DUST COLLECTOR
SAND MOLDS
Castings
Sand
Water
METAL RECLAIM FROM SAND
METAL
SHEET, STRIP, BAR, ROD & WIRE MILLS
(Non-Foundry)
SAND
FINISHED PRODUCTS
WASTEWATER TREATMENT
Wastewater Sewers
Discharge or Recycle
Solids Disposal
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
COPPER & ALLOYS
PROCESS FLOW DIAGRAM
Dwn. 5/7/79
FIGURE III-4


Water
Fuel
Pig
Scrap
SCRUBBING
MELTING FURNACE
Metal
LADLE
SAND STORAGE BINS
Water
DUST COLLECTOR
To Landfill
QUENCH
SLAG
SAND PREPERATION
Wastewater
CORE MAKING
Cooling Area
Pouring Area
Dusts
SHAKE OUT
Castings
CLEANING DEPTS
MOLDS
MOLDING UNITS
FINISHED PRODUCTS
HEAT TREAT
Water
Sand Return System
SAND WASHING
QUENCH
DRYING KILN
WASTEWATER TREATMENT
Wastewater
DEWATER
Discharge or Recycle
Sludge Disposal
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
FERROUS FOUNDRY
PROCESS FLOW DIAGRAM
Dwn. 5/8/79
FIGURE III-5


Exhaust
MELTING FURNACES
DUST COLLECTOR
To Landfill
FINISHED PRODUCTS
Exhaust
FINISHING DEPT.
SHAKE OUT
MOLDS
GRINDING SCRUBBER
To Landfill
CORE MAKING
SAND PREPARATION
Wastewater Treatment or Discharge
Sand Return
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
MAGNESIUM FOUNDRY
PROCESS FLOW DIAGRAM
Dwn. 5/8/79
FIGURE III-6

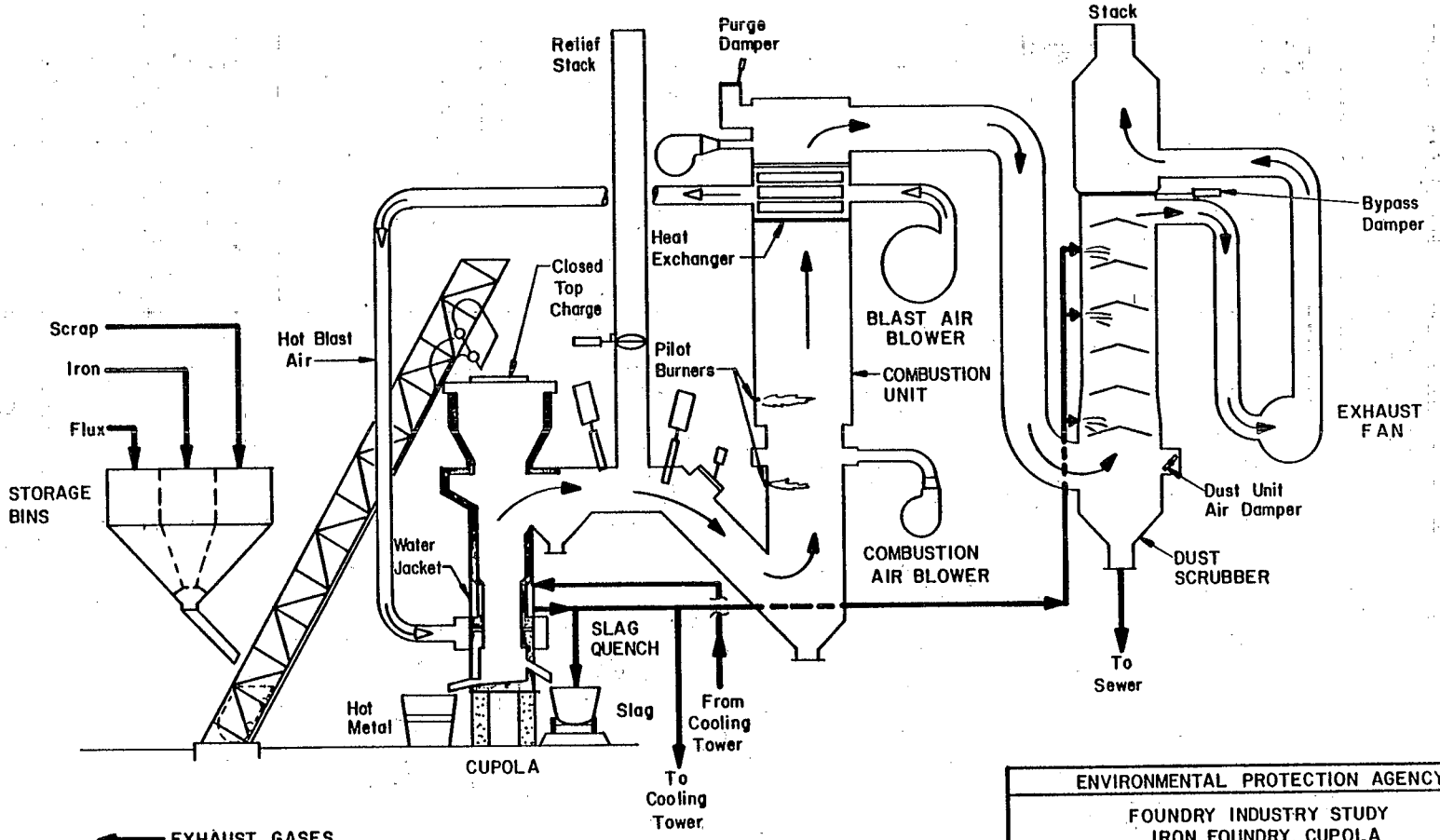


ENVIRONMENTAL PROTECTION AGENCY

FOUNDRY INDUSTRY STUDY
ZINC DIE CASTING
PROCESS FLOW DIAGRAM

Dwn. 5/4/79

FIGURE III-7

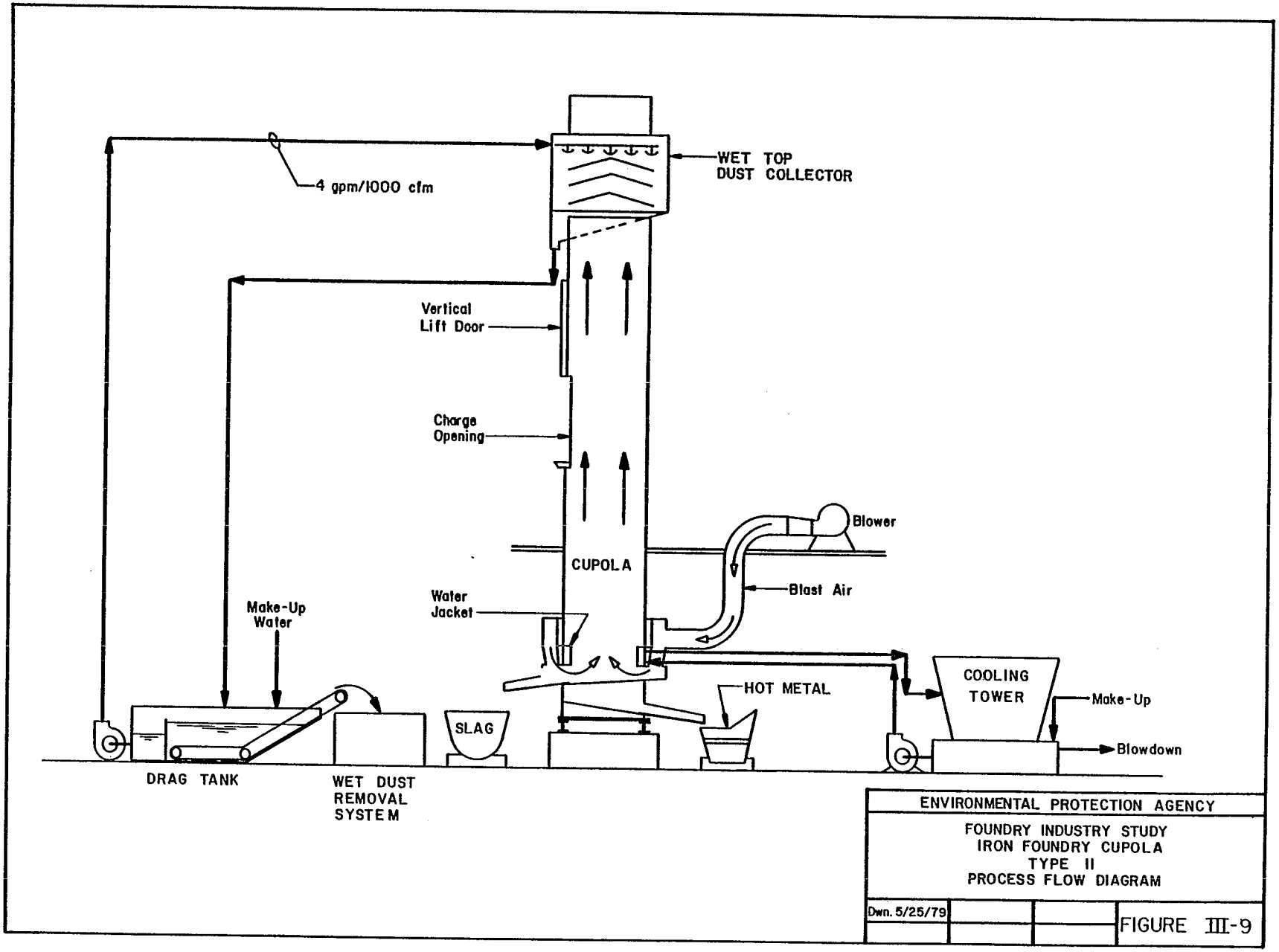


ENVIRONMENTAL PROTECTION AGENCY

FOUNDRY INDUSTRY STUDY
IRON FOUNDRY CUPOLA
TYPE III
PROCESS FLOW DIAGRAM

Dwn. 5/25/79

FIGURE III-8



ENVIRONMENTAL PROTECTION AGENCY

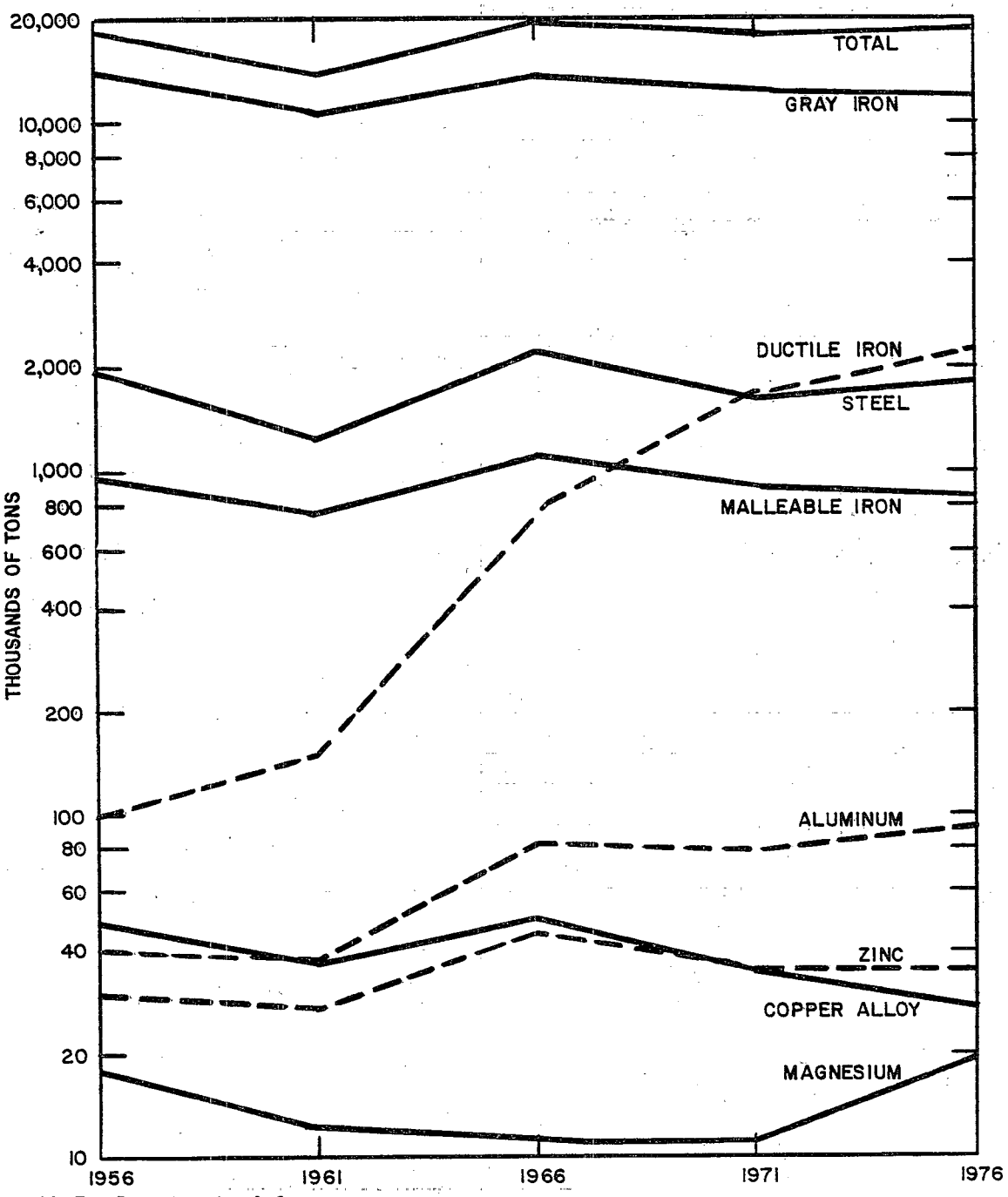
FOUNDRY INDUSTRY STUDY
IRON FOUNDRY CUPOLA
TYPE II
PROCESS FLOW DIAGRAM

Dwn. 5/25/79

FIGURE III-9

FIGURE III - 10

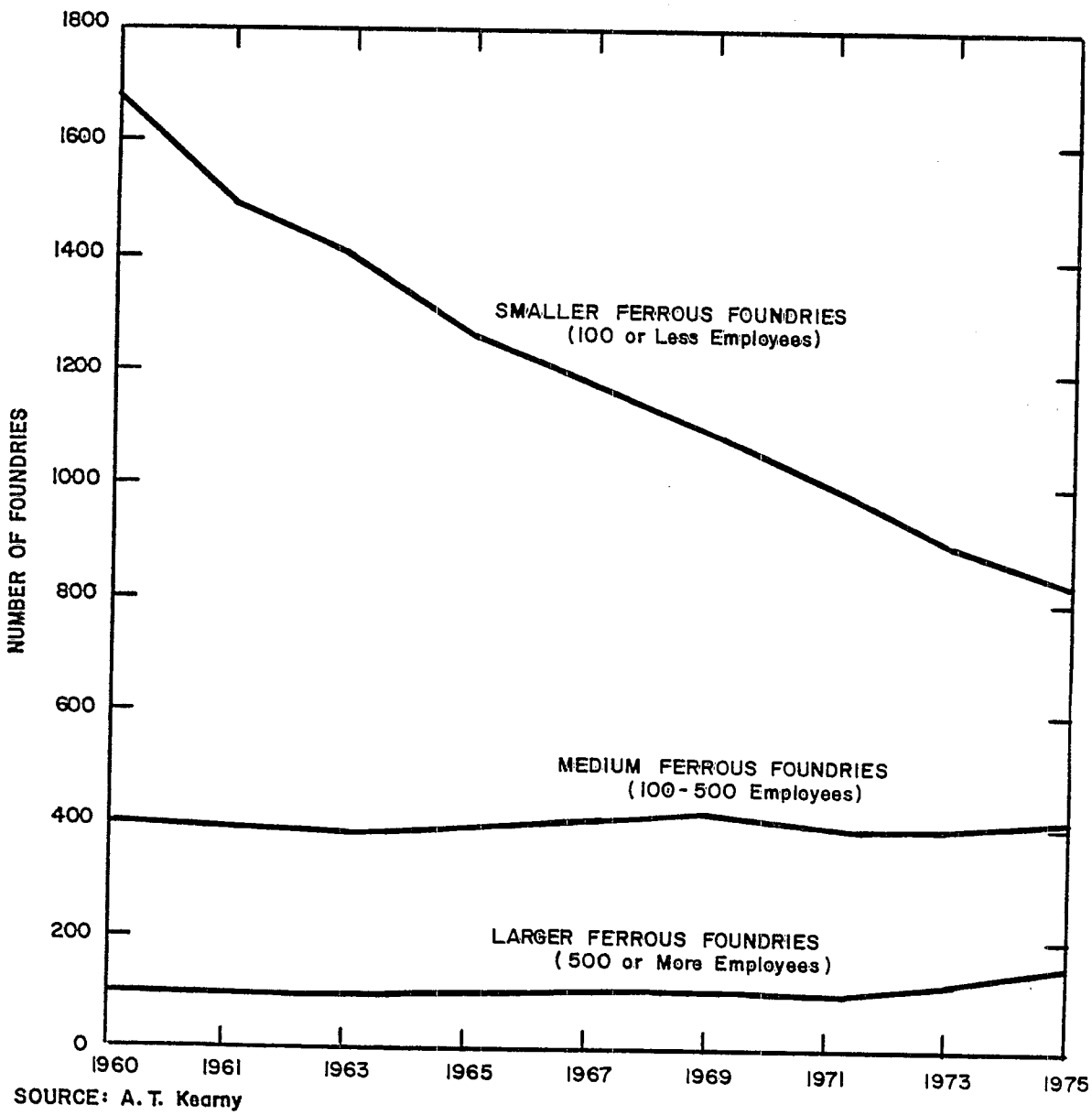
CAST METALS PRODUCTION (THOUSANDS OF TONS) AT 5-YEAR INTERVALS 1956-1976



SOURCE: Department of Commerce

FIGURE III - 11

FERROUS FOUNDRY TRENDS IN THE UNITED STATES



SOURCE: A. T. Kearny

SECTION IV

INDUSTRY SUBCATEGORIZATION

INTRODUCTION

The metal molding and casting (foundry) point source category includes a large number of plants which use a variety of metal molding and casting techniques to cast the different metals. Foundries employ different manfacturing processes (some of which require air pollution control devices) which create process wastewaters. These wastewaters have unique raw waste characteristics and require various wastewater treatment and control technologies. The metal molding and casting point source category is, therefore, not amenable to a single set of effluent limitations and standards applicable to all foundries.

This category is, however, amenable to a subcategorization scheme which provides for the grouping of foundries which: cast similar metals, employ similar manufacturing processes, have similar sources of air pollution which require control, and, as a result, generate wastewaters with similar basic characteristics. Appropriate subcategorization ensures that plants grouped into a subcategory and process group are sufficiently similar. As a result, a reasonable comparison of like plants and their treatment performances can be made. This segmentation scheme allows the application of a uniform set of effluent limitations and standards of performance for each process segment.

SELECTED SUBCATEGORIES

Based on the findings detailed in this section and supported by the discussions in Sections III, V, and VII, the subcategories and subcategory segments established for the development of effluent limitations and standards of performance are:

A. Auminum Casting
   1. Investment Casting Operations
   2. Melting Furnace Scrubber Operations
   3. Casting Quench Operations
   4. Die Casting Operations
   5. Die Lube Operations

B. Copper Casting
   1. Dust Collection Scrubber Operations
   2. Mold Cooling and Casting Quench Operations

C. Ferrous Casting
   1. Dust Collection Scrubber Operations
   2. Melting Furnace Scrubber Operations
   3. Slag Quenching Operations
   4. Mold Cooling and Casting Quench Operations
   5. Sand Washing Operations

D. Lead Casting

   1. Continuous Strip Casting Operations
   2. Melting Furnace Scrubber Operations
   3. Grid Casting Scrubber Operations

E. Magnesium Casting
   1. Grinding Scrubber Operations
   2. Dust Collection Scrubber Operations

F. Zinc Casting
   1. Die Casting and Casting Quench Operations
   2. Melting Furnace Scrubber Operations

SUBCATEGORY DEFINITIONS

Metal molding and casting is defined as the remelting of a metal, or metal alloy, to form a cast intermediate or final product by pouring or forcing the molten metal into a mold except for ingots, pigs, or other cast shapes related to primary metal smelting. The category includes the aluminum, copper, ferrous, lead, magnesium, and zinc casting subcategories. The manufacturing processes associated with the casting of each metal and which generate process wastewaters are:

Aluminum Casting

1. Investment Casting Operations - The casting of aluminum or aluminum alloys by investment casting techniques involves: mold backup, hydroblast cleaning of castings, and the collection of dusts resulting from the hydroblasting of castings and the handling of the investment material. This operation is also known as the lost wax, lost pattern, hot investment, or precision casting process.

2. Melting Furnace Scrubber Operations - Those air pollution control operations which clean dusts and fumes from melting furnace operations through the use of water or process wastewater as a cleaning medium.

3. Casting Quench Operations - Those operations in which a casting at elevated temperature is immersed in a liquid bath

for the purpose of rapidly decreasing the temperature of the casting.

4. Die Casting Operations - Those operations associated with die casting in which the various related process wastewaters are collected in a common container. The sources of these wastewaters include: die surface cooling sprays, hydraulic fluid leakage, splash over from casting quench, and leakage from non contact cooling water systems associated with the die casting equipment which subsequently becomes contaminated due to common collection with process wastewaters.

5. Die Lube Operations - Those operations associated with die casting which involve the spraying of a liquid containing mold release agents onto the die surface or die head and the subsequent segregated collection of the liquid.

Copper Casting

1. Dust Collection Scrubber Operations - Those air pollution control operations which clean dusts resulting from: sand preparation, sand molding processes, core making processes, sand handling transfer processes, the removal of sand from the casting, and other sand related dust sources through the use of water or process wastewater as a cleaning medium.

2. Mold Cooling and Casting Quench Operations - Those operations in which contact cooling water is applied to metallic molds and those operations in which a casting is immersed in a liquid bath for the purpose of rapidly decreasing the temperature of the casting.

Ferrous Casting

1. Dust Collection Scrubber Operations - Those air pollution control operations which clean dusts resulting from: sand preparation, sand molding processes, core making processes, sand handling and transfer processes, the removal of sand from the casting (including shot blasting), and other sand related dust sources, and pouring floor, pouring ladle, and transfer ladle fumes when collected in an air duct system common with sand dusts through the use of water or process wastewater as a cleaning medium.

2. Melting Furnace Scrubber Operations - Those air pollution control operations which clean dusts and fumes from: melting furnace operations pouring floor fumes,

pouring ladle or transfer ladle dusts, and fumes when collected in a air duct system common with the melting or holding furnace. These scrubbers use water or process wastewater as a cleaning medium.

3. Slag Quench Operations - Those operations in which furnace slag is cooled or sluiced with water or process wastewater.

4. Mold Cooling and Casting Quench Operations - Those operations requiring the application of cooling water directly on the casting mold and those operations in which a casting is immersed in a liquid bath for the purpose of rapidly decreasing the temperature of the casting or for imparting desired metallurgical properties.

5. Sand Washing Operations - Those operations in which spent sand is reclaimed for reuse by washing the sand to remove impurities.

Lead Casting

1. Continuous Strip Casting Operations - Those operations requiring the application of cooling water directly on the lead strip for the purpose of rapidly decreasing the temperature of the lead strip.

2. Melting Furnace Scrubber Operations - Those air pollution control operations which use water or process wastewater to clean the dusts and fumes from melting or holding furnace exhaust gases.

3. Grid Casting Scrubber Operations - Those air pollution control operations which use water or process wastewater to clean dusts and fumes resulting from grid casting operations.

Magnesium Casting

1. Grinding Scurbber Operations - Those air pollution control and fire retardant operations which clean and trap magnesium dusts resulting from the cleaning, abrading, or grinding of the casting following its removal from the mold medium.

2. Dust Collection Scrubber Operations - Those air pollution control operations which clean dusts resulting from sand preparation, sand molding processes, core making processes, sand handling and transfer processes, the removal

of sand from the casting, and other sand related dust sources through the use of water or process wastewater as a cleaning medium.

Zinc Casting

1. Die Casting and Casting Quench Operations - Those operations in which castings at elevated temperatures are immersed in a liquid bath for the purpose of rapidly decreasing the temperature of the casting.

2. Melting Furnace Scrubber Operations - Those air pollution control operations which clean the dusts and fumes from melting or holding furnace operations with the use of water or process wastewater as a cleaning medium.

SUBCATEGORIZATION BASIS

In identifying the subcategories and subcategory process segments for the metal molding and casting point source category, the following factors were considered:

1. Type of metal cast
2. Manufacturing process
3. Air pollution sources
4. Water use
5. Process wastewater characteristics
6. Raw materials
7. Process chemicals
8. Wastewater treatability
9. Plant size
10. Plant age
11. Geographic location

The type of metal cast and the manufacturing process form the basic framework for the selected subcategories. Many of the other factors provided additional support for the subcategorization scheme. These other factors, including process wastewater characteristics, helped to delineate the final subcategories and are reflected in the subcategories and subcategory process segments developed.

Rationale for Subcategorization - Factors Considered

Type of Metal Cast

The type of metal cast forms the principal basis for subcategorization of the category. Metals differ in physical and chemical properties.

The inherent differences in the physical and chemical properties of the various types of metals cast result in a diversity of manufacturing processes, process chemical use, sources of air pollution, water use, and process wastewater characteristics. As seen in the technical findings of this study, the type of metal cast affects the kinds and quantities of toxic metal and toxic organic pollutants present in foundry process wastewaters. The different casting techniques used with the various cast metals require the use of different process chemicals. The binders, or chemical additives used in sand casting, are substantially different from those process chemicals used as mold release agents in die casting operations.

Examination of the analytical data indicated that differences in alloys of the same base metal were not of sufficient magnitude to subcategorize by alloy. This is most apparent in the ferrous casting subcategory, where variations in raw waste characteristics, manufacturing processes, process chemicals, etc., among gray iron, malleable, ductile, and steel foundries were not significant enough to support subcategorization by alloy.

Subcategorization based upon waste characteristics was considered. However, a review of each of the remaining factors reveals that the type of metal cast, the manufacturing process, and the subsequent air pollution control device or process chemical used, affects the process wastewater characteristics of plants in the foundry category. Subcategorization by metal type, therefore, inherently considers process wastewater characteristics and other pertinent factors.

In those instances where a plant casts more than one metal, the manufacturing processes, equipment, and pollutant sources are usually segregated by metal type. A specific melting furnace, for example, melts only one metal to avoid cross contamination with another metal. Manufacturing processes are generally designed to handle only one metal type without extensive overhaul or rebuilding. Many of these manufacturing processes (die casting for example) require the use of special process chemicals designed for very specific applications.

As would be expected, there is a close relationship between the type of metal cast (and the subcategories derived from them) and factors such as manufacturing processes, process chemicals, raw materials, process wastewater characteristics, and air pollution sources as described below.

Manufacturing Process

The subcategories developed on the basis of metal type were further segmented to allow for dissimilar manufacturing processes. This segmentation takes into account the differences in water use and the dissimilar process wastewater characteristics.

Many manufacturing processes are unique to the type of metal cast. The data indicate that slag quenching is only associated with the melting of ferrous metals. The other manufacturing operations depend on the type of metal being processed. A cupola furnace is a unique source of air pollution with characteristic emissions generally controlled by wet air pollution control devices. Casting techniques also differ depending on the metal. Aluminum and zinc castings are frequently produced by die casting methods while ferrous metals are not.

Not all manufacturing processes generate a process wastewater. Consideration of manufacturing process helped to distinguish between those processes which generate a process wastewater and those which do not. Examination of the data reveals that a manufacturing process may generate process wastewater in one of two ways: water which is used directly in the manufacturing process, or water which is used in an air pollution control device associated with the manufacturing process. The industry survey data indicate that approximately 80% of all foundry wastewaters are generated by air pollution control devices.

Manufacturing Processes

The manufacturing processes which generate a process wastewater directly are: 1) for aluminum casting - the investment casting, casting quench, die casting, and die lube processes; 2) for copper casting - the mold cooling and casting quench process; 3) for ferrous casting - the slag quenching, casting quench and mold cooling, and sand washing processes; and 4) for zinc casting - the die casting and casting quench process.

Though some manufacturing processes exhibit significant differences depending upon the type of metal cast, other manufacturing processes, similar in design and function, are associated with the casting of different metals. For example, aluminum and zinc castings may be formed through a similar die casting process. Where similar manufacturing processes associated with different metals were encountered, process chemical usage and process wastewater characteristics were examined to identify any additional basis of support for a

subcategorization scheme based upon the type of metal cast and the manufacturing process.

The consideration of the type of metal cast and the associated manufacturing processes helped to identify the sources of process wastewaters and to group the data, by manufacturing process, for further analysis. In instances where process wastewater streams are not generated as the result of direct contact with the manufacturing process and where different metals are processed on similar manufacturing units, other factors were considered.

Air Pollution Sources

Certain manufacturing processes are characteristic sources of air pollution. Where required, air pollution control devices have been installed to control air emissions from various manufacturing processes. The design of these devices may be either of the "dry" or "wet" type. An example of a "dry" type control device is a bag house. Such dry devices are discussed in Section III. "Wet" air pollution control devices are referred to as scrubbers, and these devices produce process wastewater.

Those manufacturing processes which generate a process wastewater from scrubbers are: for aluminum casting; the melting furnace scrubber process, for copper casting; the dust collection scrubber process, for ferrous casting; 1) the dust collection scrubber process, and 2) the melting furnace scrubber process; for lead; 1) the melting furnace scrubber process and 2) the grid casting scrubber process, for magnesium casting; 1) the dust collection scrubber, and 2) the grinding scrubber process; and, for zinc casting; 1) the melting furnace scrubber process.

Since wet air pollution control equipment is unique to certain manufacturing processes, these operations are differentiated from other manufacturing operations and from other process wastewater sources as previously described. Consideration of air pollution sources and the associated control devices helped to further substantiate the manufacturing process segments for each subcategory.

Process Water Usage

The decision to use water as part of a manufacturing process or as an air pollution control medium depends on many factors. The volume of water used is primarily dependent upon the manufacturing process, air pollution control device, the cost and availability of water, and most significantly, plant water management practices. Manufacturing processes and air pollution control are implicitly reflected in the subcategories and process

segments developed. Plant water management practices vary from plant to plant, therefore, process water usage was not considered to be an appropriate basis for subcategorization or segmentation. However, process water usage is an integral part of the wastewater treatment models and limitations developed.

Process Wastewater Characteristics

In addition to supporting subcategorization by metal type, consideration of wastewater characteristics helped to differentiate between similar manufacturing operations used to cast different metals. The analytical data for the wastewater samples indicate that the type and quantity of pollutants differ among similar manufacturing processes. While aluminum and zinc are cast on similar die cast equipment, zinc was found at 40 times the concentration in zinc casting quench solutions than aluminum casting quench solutions. More toxic organic pollutants were detected in aluminum casting quench solutions than in zinc casting quench solutions.

Raw Materials

Raw material composition was found to significantly influence wastewater characteristics. This effect is primarily the result of the type of metal being cast. The production of a zinc casting for example, initially begins with the use of a zinc raw material in the charge to the melting furnace.

Because of this, raw material usage is implicitly considered in a subcategorization scheme based on the type of metal cast.

Process Chemicals

The major process chemicals used in the manufacture of castings fall into two general classes; those associated with sand casting, and those associated with die casting. This distinction helped to further substantiate the subcategorization scheme. The process chemicals associated with sand casting techniques include sand and core binders and related chemical additives. Several of these process chemicals contain toxic pollutants or chemicals which when exposed to hot metal temperatures may break down to toxic pollutant materials.

Analysis of plant data indicates the use of a wide variety of sand casting materials. At least 14 different chemical types of sand additives are commercially available. On-site visits to many plants indicated that more than one type of sand additive is often used simultaneously within the plant, and that changes in the use of the various products occur periodically.

The process chemicals associated with die casting include die lubricants, die coatings and quench solution additives. Twenty-eight manufacturers or suppliers of these process chemicals have been identified. These materials are used to prevent castings from adhering to the die and to provide a casting with improved surface characteristics. Many different products are frequently tried until a satisfactory lubricant or coating is found. A correctly chosen lubricant will allow metal to flow into cavities that otherwise may not be filled.

Due to the wide variety of process chemicals and the frequent changeover of these products, the type of process chemical used was not found to be a primary basis for subcategorization. However, the type of process chemical used was a supportive factor in the subcategorization and segmentation scheme developed.

Process Wastewater Treatability

Treatment systems are designed to treat specific types of pollutants which are characteristic of various process wastewaters. Some process wastewaters will be predominantly oily in nature, while other process wastewater streams will be free of oil but will contain toxic metals. The treatment applications identified at plants during the development of this report encompass systems ranging from no treatment to relatively extensive treatment. The wastewater treatment systems range from once-through systems discharging to POTWs or navigable waters, to 100 percent recycle systems. Since process wastewater characteristics differ among waste streams from various manufacturing processes, the different process segments implicitly consider the various treatment technologies and capabilities involved in handling the different process wastewaters. Thus, wastewater treatability does not substantiate the need for further segmentation.

Plant Size

Plant size can be evaluated by several methods: number of employees, production, or process wastewater flow. Evaluation of the production and employee group information confirmed an expected trend. Larger foundries (based upon the number of employees) generally had greater productions. However, this trend did not have any effect on the subcategorization scheme for the industry.

No identifiable relationship between size and process wastewater characteristics was found. Nor did the number of employees or production have a quantifiable relationship with the volume of

process wastewaters produced. No discernable pattern appeared when plant water usage rates were compared with plant production rates and the employee groups. However, the employee groupings have been retained and used as a means of providing convenient BPT, BAT, and PSES model sizes for further economic evaluation.

Plant Age

Referring to the Plant Summary data presented in Sections III and V it can be seen that the provision of wastewater treatment, up to complete recycle, is not related to plant age. As an example, plants which have been in operation for over 30 years installed treatment and recycle facilities as recently as six years ago. In other instances, treatment and recycle facilities have been in use at some plants for over 35 years. The Agency has, therefore, concluded that age is not an appropriate basis for further subcategorization or subdivision.

Geographic Location

Plants engaged in metal molding and casting are located in all of the industrial regions of the United States. None of the available data indicate that the location of a plant affects the type of metal cast, the manufacturing process employed, or other process wastewater characteristics. The only pattern noticed is that the plants are generally located near the areas which will use their products, whether they are used by other corporate entities or are sold to the end users. Therefore, geographic location is not considered as an appropriate factor in establishing subcategories.

Summary

The primary factor affecting the wastewater characteristics of plants is the type of metal cast. An additional important factor is the type of manufacturing process used to form the desired casting. These two factors form the basis for subcategorization of the metal molding and casting point source category. In addition, other factors such as process chemical usage and air pollution sources, helped to support the subcategorization scheme.

PRODUCTION NORMALIZING PARAMETER

Having selected the appropriate subcategorization scheme, the next step involved the development of a quantitative parameter on which to base limitations and standards. Since pollutant measurements are expressed as mg/l, concentration is the obvious first consideration for limitations. However, while the

concentration of a pollutant is an intensive property of the wastewater, it is not an intensive property of pollution. A plant which dilutes its wastewater would have an advantage in meeting concentration limitations over plants which conserve water. Thus, a plant with good water conservation practices might be penalized by a concentration based limitation. In order to preclude the possibility of dilution, the concentration of pollutants in the discharge must be multiplied by the discharge flow rate to provide a mass discharge level for each pollutant. Since the mass discharge relates to the level of production, the mass discharge level requires still another parameter to account for differences in the actual production levels from plant to plant. Such a parameter must establish an effluent discharge rate relationship that changes in proportion to the level of production activity. The following discussions deal with the selection of this production normalizing parameter and the application of this parameter to effluent limitations.

Selection of Production Normalizing Parameter

The level of production activity in a plant can be expressed quantitatively as the amount of metal poured, the amount of process chemicals consumed, the weight of castings shipped, or the number of employees. In addition, in those instances where sand is used as the mold medium, the amount of sand used can be an indicator of production activity.

The technical findings indicate that the use of two production normalizing parameters is appropriate. These two parameters are the weight of metal poured, and the weight of sand used in molds and cores. These two production normalizing parameters are more closely associated with the level of production activity relative to pollutant load than any other parameters which could be considered.

An outline of the rationale used in selecting these two parameters, as well as in eliminating other parameters from consideration follows.

Weight of Metal Poured

The weight of metal poured readily lends itself as a reasonable production normalizing parameter for many of the subcategories and subcategory segments.

In those instances where a furnace scrubber is used to control furnace emissions, the pollutants become waterborne contaminants during the furnace emission cleaning process. The emissions result from the melting and heating of the raw materials which

make up the furnace charge. On first consideration, it would appear to be appropriate to base the production normalizing parameter on furnace charge. However, the composition of the furnace charge varies from plant to plant. This is particularly prevalent in the ferrous casting subcategory. The ratios of coke, scrap, iron, limestone, etc., vary widely among plants which produce the same quantity of iron or steel. Therefore, it would be impractical to apply a production normalizing parameter on such a variable basis as furnace charge.

The use of the weight of metal poured provides a consistent and uniform parameter for applying effluent limitations to a wide variety of plants. In addition to its application to furnace scrubbers, its use with all the other manufacturing subcategory segments (except for those segments associated with sand usage) is technically reasonable and provides a uniform basis for applying limitations.

Weight of Sand

In those instances where sand is used as the mold medium, consideration of the mechanisms by which pollutants are conveyed from the manufacturing process to the process wastewater leads to the selection of the weight of sand as a production normalizing parameter. Those subcategories are: copper casting; dust collection scrubber process, ferrous casting; dust collection and sand washing processes and, magnesium casting; dust collection scrubber process.

The processes associated with sand usage, such as mold and core making, casting shakeout, and sand handling equipment, generate dusts and fumes. The contaminated air is cleaned by scrubbers. Therefore, contaminants in the air are transferred to the water. The volume of air passing through the scrubbers remains at a constant rate, while the mass of pollutant material in the air stream changes with varying levels of production activity (i.e., the amount of sand in use). To account for these changes in production activity, the amount of sand used leads to the selection of the weight of sand as a production normalizing parameter for dust collection scrubber processes.

In sand washing operations, sand comes into intimate contact with water, and, as a result the water is contaminated with pollutants. The amount of sand washed affects the process wastewater characteristics and leads to the selection of the weight of sand washed as a production normalizing parameter for the sand washing subcategory segment.

Surface Area of Casting

Surface area was considered as a possible production normalizing parameter for those manufacturing processes involving quenching, since pollutants enter the quench water through intimate contact with the casting. However, surface area of a casting is a randomly changing variable dependent upon the shape and design of the castings being manufactured. Therefore, surface area was not selected as a practical production normalizing parameter.

Number of Employees

As previously indicated, the number of employees does not necessarily reflect the production rate at any plant. For these reasons, the number of employees does not constitute an appropriate production normalizing parameter.

Weight of Final Product

The weight of final product is a readily available production record, but its application as a production normalizing parameter has a significant drawback.

The weight of the casting in final product form may vary substantially from the casting's initial weight. Casting weight is at a maximum when the casting is first formed (i.e., immediately after the pouring of the molten metal into the mold). At this point, the casting has the gates, sprues, and risers attached, and the total weight of all the castings produced per unit time closely equates with the total amount of metal poured during that unit of time

The major reduction in weight occurs after the metal molding and casting and supportive process steps (sand preparation, mold and core making, sand washing, etc.) have occurred. This weight reduction is due to the removal of the gates, sprues, and risers. Weight loss can be as little as 5 percent or as much as 70 percent of the initial total casting weight, depending upon the type of metal cast, the casting shape, and the volume of the gates, sprues, and risers in the mold required to allow adequate flow of the molten metal into the mold.

Additional weight changes can occur when metal is removed during the machining of the casting or, for example, when weight is added during the electroplating or the painting of the casting.

For the reasons stated above, the weight of the final product was not found to be a suitable production normalizing parameter.

Process Chemicals Consumed

For the reasons stated in the discussion of the factors considered for subcategorization, the variability of process chemicals consumed diminishes its usefulness as an appropriate production normalizing parameter.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

INTRODUCTION

This section presents data which characterize the wastewater streams originating in the various foundry operations. The wastewater characterizations are based upon the field sampling programs conducted in association with this study (1977-1978) and a previous study (1974).

Process water usage plays a major role in the determination of pollutant loads and, in turn, the estimation of pollutant removal costs. The Agency evaluated published information, DCP responses and the sampled plant analytical data to evaluate process water use; to estimate pollutant loads; to obtain total wastewater volumes; and to identify the treatment technologies in use in the foundry industry.

The water use rates pertain only to metal molding and casting process and air pollution control equipment wastewaters and not to nonprocess or noncontact cooling waters. Process wastewater is defined as that water which, during manufacturing or processing, comes into direct contact with the processes, products, exit gases, raw materials, or by-products associated with foundry operations. The process wastewaters become contaminated with the various pollutants characteristic of the manufacturing process or wet air pollution control device (scrubber) associated with a manufacturing process. Thus, process wastewaters from metal molding and casting operations would include those wastes generated during: the melting or remelting of the cast metal; the preparation of cores and molds and related activities such as sand transfer, sandwashing, etc.; the pouring or injection of metal into molds; the removal of the casting from the mold; the removal or cleaning of the mold medium from the mold; and the removal of gates, sprues, and risers from the casting. For example, casting quench process wastewaters are considered to be foundry related wastewaters. However, wastewaters generated during the plating of these castings are non-foundry process wastewaters. Noncontact cooling water is defined as that cooling water which does not come into direct contact with the processes, products, by-products or raw materials. Non-process water is defined as that water which is used in non-process operations, such as for utility requirements. However, when noncontact cooling or non-process waters are mixed with process wastewaters, either by design or through leaks, spills, etc., the total volume of the discharge is considered to be process wastewater.

INFORMATION COLLECTION

EPA collected information describing the metal molding and casting industry from a number of sources. Some information was found within existing Agency data from a previous study of ferrous foundry operations performed by EPA, and from foundry permits for operations which discharge to surface waters. The Agency also reviewed published literature for the purpose of obtaining as much pertinent information as possible. In addition to the data provided in the information requests sent to a number of foundries and to several chemical suppliers, technical information was provided by industry representatives and trade associations throughout the course of this study. The sampling program provided the greatest amount of specific plant and process data. Finally, further comments and information were provided by plants commenting on the Contractor's Draft Technical Report (EPA 440/1-80/070a).

A previous Agency study of ferrous casting operations was used to supplement the plant information and analytical data base developed for this study. Although this earlier study was not published, it presented treatment and analytical data from a number of ferrous casting operations. This information was incorporated with the ferrous foundry treatment capability and analytical data bases developed during this current study.

National Pollutant Discharge Elimination System (NPDES) permits for metal molding and casting plants having a direct discharge were obtained from the appropriate Regional EPA or state offices. In many cases, these permits covered other wastewater streams and noncontact cooling waters in addition to the foundry wastewaters. In some instances these permits did not specify the point of origin of the discharge streams, and it was not possible to determine if noncontact cooling waters or other wastewaters were mixed with foundry wastewaters prior to discharge. For these reasons, only minimal use (other than confirming some other observations) of this analytical data was made during this study.

The Agency conducted a literature search to obtain as much pertinent published information as possible. Information was gathered on: the processes employed in the metal molding and casting industry; the purpose and theory of each process; the chemicals used; the methods of reducing water consumption; and the methods of treating foundry industry wastewaters. Some of this information is presented in this section and in Sections III and VII.

Industry and trade association representatives provided information throughout the course of this study. Wastewater

treatment system capabilities, new industry developments which may impact regulatory decisions and options, and many other industry aspects and topics were provided to or discussed with the Agency.

In addition to the data requests sent to a large number of foundry operations, product data was requested from some of the chemical suppliers. The data provided by the chemical suppliers pertains to proprietary products. It is considered to be confidential and does not appear in this document. However, this data was used by the Agency as a guide in predicting which pollutants could be expected to be found in foundry process wastewaters. The requested company data is presented and discussed later in this section. The sampling program is also described later in this section.

Comments on the Contractor's Draft Technical Report were incorporated in this report where applicable. These comments covered topics ranging from general manufacturing processes to the problems involved in wastewater treatment and their relation to foundry operations.

PRODUCTION PROFILE

Table V-1 presents for each subcategory; the estimated weight of metal poured annually, the weight of metal poured in plants which discharge their process wastewater to navigable waters, the weight of metal poured in plants which discharge their process wastewater to POTWs, and the weight of metal poured in wet process plants which do not discharge process wastewaters.

PROCESS WASTEWATER FLOW

Estimates, by process segment and employee group of the total annual process wastewater flows within the metal molding and casting point source category are presented in Tables V-2 through V-7. These estimates are based upon the process wastewater flows reported by plants responding to the data collection survey in conjunction with the statistical weights (the relationship of each plant to the industry as a whole) of the respondents. The "Applied Flow" column indicates the volume of process wastewaters flowing through or associated with the manufacturing processes, or through the air pollution control devices associated with the manufacturing processes. The "Recycle Flow" column indicates the volume of process wastewater which is recycled back to the process, while the column marked "Flow at 100 percent Recycle" indicates the volume of process wastewater which is recycled in those operations with no process wastewater discharges.

Table V-8 summarizes by subcategory the distribution of foundry operations according to discharge mode, i.e., direct discharge, indirect discharge to POTW's, or zero discharge.

SELECTION OF PLANTS FOR SAMPLING

In order to characterize foundry process wastewaters, assess treatment capabilities, develop model treatment systems, and develop the proposed limitations and standards, it was necessary to visit selected foundries. At these sites, detailed operational data (including treatment costs and water use and wastewater generation rates) were obtained, and wastewater samples were collected. The information presented in the DCPs served as the primary basis for selecting plants for engineering and sampling visits. The specific criteria used to select these plants included:

1. The metal cast
2. The foundry processes which generate wastewaters
3. The type of air pollution control devices installed, i.e., scrubbers or "dry" type collectors such as bag houses
4. The type of process wastewater treatment equipment in place
5. The in-process control technologies which reduce the volume of process wastewaters
6. The degree to which process wastewater is recycled or reused.

Sampling Program and Pollutant Analysis

During this study, sampling programs were conducted at 23 plants for the purpose of obtaining samples on which analyses would be performed for conventional, nonconventional, and toxic pollutants. Prior to any plant visit, all available data, i.e., plant layout, production sequence, and wastewater treatment facilities in use were reviewed. This information was usually furnished with the plant's DCP. However, in some instances, it was necessary to solicit additional details. Following is a list of the plants sampled during this phase (1977-1979) of this study.

SAMPLED PLANTS

Aluminum Casting	Copper Casting
04704	04736
10308*	06809
12040*	09094
17089	19872
18139*	
20147	

Ferrous Casting		
00001	51026	55217
00002	51115	56123
06956	51473	56771
07170	52491	56789
07929	52881	57100
15520	53219	57775
15654	53642	58589
20009	54321	59101
50315	55122	59212

Lead Casting	Magnesium Casting	Zinc Casting
10145	08146	04622
		10308*
		12040*
		18139*

*These plants cast both aluminum and zinc.

Generally, two separate visits were made by the EPA project officer and the contractor to each plant selected as a sampling site. During the first visit, an engineering reconnaissance visit, sample point locations which represented the most appropriate flow measurement locations were identified, and any questions about plant operations were resolved, so that the sampling team leader could become sufficiently familiar with the plant to conduct a technically sound sampling survey. The information collected during the engineering reconnaissance visit, together with the previously obtained information about the plant, was organized into a detailed sampling plan.

During the second visit to the plant, the actual sampling was conducted. In addition to the wastewater sampling and flow measurement tasks performed during the sampling visits, specific technical information was also obtained for each sampled plant. This technical information included production and raw material usage, during the period of sampling, and routine maintenance procedures and equipment. Also, during the sampling visits, existing or potential problems and preventive maintenance procedures associated with the use of extensive recycle systems were discussed with plant personnel.

Additional engineering visits (no samples were collected during these visits) were made at three plants for the purpose of obtaining technical information. During a previous EPA study of the foundry industry, samples were collected at 19 foundries. Therefore, the total number of foundries visited is forty-three, of which forty were sampled.

Analyses of the samples collected at the visited plants were performed in accordance with EPA protocols. These protocols are detailed in "Screening and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants," March 1977 revised April 1977, U.S. EPA (short form of title: "Screening Protocol").

A major goal of this study was the characterization of foundry process wastewaters with respect to toxic pollutants. These efforts were conducted in response to the 1976 Settlement Agreement. A complete list of the toxic pollutants, as developed from the Settlement Agreement and in the Clean Water Act, is presented in Table V-9. Analyses were also performed for a number of other pollutants, some of which result from foundry processes. These pollutants are identified on Table V-10. Analyses for several of these pollutants, i.e., total solids, temperature, calcium hardness, alkalinity, acidity, and pH, were performed so that Langelier Saturation Indices could be determined for various high recycle rate systems. The Langelier Saturation Index provided data which were used to assess the scaling or corrosion problems that can be associated with wastewater recycle systems.

In a two-phase sampling and analysis program, EPA checked for the presence and quantities in foundry wastewaters of the toxic pollutants designated in the Clean Water Act. In addition to the 129 toxic pollutants, EPA sampled for several other conventional and nonconventional pollutants (such as total suspended solids, oil and grease, pH, iron, ammonia, cyanide, and nontoxic phenols).

EPA derived data in a field sampling program designed to determine the concentrations of pollutants in foundry wastewaters. Sampled plants were selected to be representative of the manufacturing processes, the prevalent mix of production among plants, and the in-place treatment technologies found in the industry. EPA obtained and analyzed samples from 40 facilities. Before visiting a plant, EPA reviewed available plant specific data on manufacturing processes and wastewater treatment. The Agency selected representative points to sample the raw wastewater leaving the manufacturing process or air pollution control device prior to treatment and to sample the final treated effluent. The Agency prepared, reviewed, and approved a detailed sampling plan showing the selected sample points and the overall sampling procedure.

Under the sampling plan, the Agency conducted the sampling in the following manner: sampling visits were made during three consecutive days of plant operation. Raw wastewater samples were collected before treatment. Treated effluent samples were collected following application of in-place treatment technologies. EPA also sampled plant intake water to determine the presence of pollutants prior to contamination by manufacturing processes.

This first phase of the sampling program detected and quantified waste constituents included in the list of 129 toxic pollutants. Wherever possible, each sample of an individual raw waste stream, or a treated effluent was collected by an automatic, time-series compositor over three consecutive 8 to 24 hour sampling and operational periods. Where automatic compositing was not possible, grab samples were collected and composited manually. The second phase of the sampling program confirmed the presence and further quantified the concentrations and waste loadings of the toxic pollutants found during the first phase of the program.

Metals analyses were performed by the flame and flameless atomic adsorption methods. The flameless method was used for mercury analyses.

Analyses for cyanide and cyanide amenable to chlorination were performed using methods promulgated by the Agency under Section 304(h) of the Act (304(h) methods).

Analysis for asbestos fibers included transmission electron microscopy with selected area diffraction. Analysis results were reported as chrysotile fiber count.

Analyses for conventional pollutants (TSS, pH, and oil and grease) and nonconventional pollutants (ammonia, fluoride, and iron, etc.) were performed by 304(h) methods.

EPA employed the analytical methods for the toxic organic pollutants that are described in the sampling and analytical protocol. This protocol is set forth in "Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants", revised April, 1977.

Analysis for total phenols was performed using the 4-aminoantipyrine (4AAP) method.

During both phases of this study, all samples were analyzed for all toxic organic pollutants, while Phase II toxic metals analyses were done selectively depending on the screening results of Phase I. Screening visits were conducted first to generally characterize the wastewater quality of foundry operations. For these visits, analyses were performed for all toxic metals (refer to Table V-9). After evaluating the screening program analytical data and the data presented in Tables V-11 and V-12, those toxic metal pollutants found below the level of treatability or below quantifiable levels in a particular foundry process were eliminated from further analytical or regulatory consideration. There are no data presented in Tables V-11 and V-12 for the casting quench and mold cooling process segment of the ferrous subcategory, because no toxic metal pollutants were found, or believed to be present, in significant concentrations. Table V-11 presents a summary of the plant assessments (as noted in the DCP responses) of the known or believed presence of toxic pollutants in each subcategory. Table V-12 presents a summary of the toxic pollutants expected, on the basis of an engineering assessment, to be present in each subcategory's process wastewaters. Refer to Section VI for a discussion of the factors used to evaluate the environmental significance of the various pollutants.

After the data gathered during the screening program were evaluated, subsequent analyses were performed for those toxic metals which warranted further verification in each subcategory. The toxic metal pollutants selected for verification analyses are presented in Table V-13.

As a number of toxic organic pollutants were suspected to be present or detected (refer to the above data) in each of the four analytical classes of toxic organic pollutants, it was determined that it would be more practical, from an analytical standpoint, to perform analyses for all toxic organics for all samples

collected. Published information pertinent to raw materials and process chemicals used in the casting manufacturing processes indicated that many toxic organic pollutants could be present in these materials. Table V-14 presents a summary of the annual consumption of process chemicals in the form of additives or binders, as noted in the plant DCP responses. Information on the raw materials used in the metal molding and casting processes is presented in the glossary.

WATER USE AND WASTE CHARACTERISTICS

Incoming Water Analysis

Incoming water samples were collected for each sampled plant and analyzed for various pollutants as previously discussed. Overall, these analyses revealed few pollutants at concentrations above the minimum quantifiable limit of the specific analytical method or at concentration levels significant enough to affect the anticipated design of a waste treatment system. Where incoming (i.e., makeup) water concentrations of regulated pollutants are of a significant level, the environmental impact will be assessed on a case-by-case level by the respective regulatory authorities.

Raw Waste Analysis

The analytical data base generated as a result of the sampling effort is presented in Supplement B to the Technical Development Document. After reviewing the analytical data, those pollutants which could be considered for regulation in each subcategory were identified. Upon a further review (detailed in Section VI) of the information obtained as a result of this evaluation, lists of those pollutants to be considered for regulation for each process were developed. The sampled plant analytical data (both raw and treated wastewater) presented in this section (Tables V-15 through V-31) refer to these selected pollutants. Tables V-32 through V-37 present profiles of the raw wastewater analytical data obtained as a result of the sampling programs in each subcategory. For definitions of the various control and treatment technology codes used in Tables V-15 through V-31, refer to Table III-21.

Effluent Analysis

Samples of the final plant effluents were taken for every day of sampling. Since a number of plants had two or more effluent discharges, samples were taken of each effluent. For those sampled plants which did not have an effluent discharge (i.e., no

discharge of process wastewater to a surface water or to a municipal treatment plant), samples of treated recycled wastewater were collected. Where sampled plants had more than one completely recycled stream, each recycle stream was sampled.

Aluminum Foundries

An estimated 3.94 billion liters (1.04 billion gallons) of process wastewater are generated each year in the casting of aluminum. Fifty-six percent of this wastewater is recycled, while 38 percent is discharged to navigable waters, and 6 percent is discharged to POTWs

Investment Casting Process

An estimated 45.32 million liters (11.97 million gallons) of process wastewater are generated each year by investment casting processes. This represents 1.2 percent of the total process wastewater flow at plants within the aluminum casting subcategory. Twenty-nine percent of this flow is discharged to navigable waters, while 71 percent is discharged to POTWs. Plant survey responses indicated applied flow rates ranging from a low of 20,400 l/kkg (4,900 gal/ton) to a high of 53,290 l/kkg (12,800 gal/ton).

A general process and water flow diagram of a representative aluminum investment casting operation is presented in Figure III-4. The process wastewater in this operation results from several processes. The processes are mold backup, hydroblast (of castings), and dust collection (used in conjunction with hydroblasting and the handling of the investment material and castings). The major impact on the waste loads results from the use of the investment material. The type of wax used in mold formation and the hydroblast process also impact wastewater quality.

A review of the three respondents employing this process indicated that in two of the plants, the process wastewaters receive treatment via settling (the other plant's discharge is untreated). The three plants discharge all process wastewaters to either a POTW or to navigable waters without recycle. The most extensive treatment system was installed in 1977, and this plant was visited and analytical data was obtained. Treatment components at this plant include polymer addition to promote floc formation with a subsequent settling stage for solids removal.

Plant 04704, Figure V-1, generates process wastewaters from mold back-up, hydroblast casting cleaning, and dust collection, which are co-treated. Polymer is added to aid settling in a Lamella plate separator. The Lamella sludge is filtered through a paper filter, with the filtrate being returned to the head of the treatment system. The treated effluent is discharged to the river.

Table V-15 presents the raw waste and treated effluent concentrations and waste loads from this plant.

Melting Furnace Scrubber Process

An estimated 1254 million liters (331 million gallons) of process wastewater are generated annually by melting furnace scrubber operations. This represents 31.8 percent of the total process wastewater flow at plants within the aluminum casting subcategory. Approximately 60 percent of this flow is recycled, while 40 percent is discharged to navigable waters. Plant survey responses indicated a range of applied flow rates from 2,194 l/kkg (527 gal/ton) to 55,290 l/kkg (13,280 gal/ton). Recycle rates varied from 37 percent to a high of 97.5 percent.

A general process and water flow diagram of a representative aluminum foundry melting operation and its scrubber system is presented in Figure III-5.

The quality and cleanliness of the material charged in the furnace influences the emissions from the furnace. Generally, aluminum furnaces which melt high quality material do not require "wet" air pollution control devices (e.g., afterburners may be used). However, when dirty, oily scrap is used, the furnace emissions are often controlled through the use of scrubbers. The process wastewater from these scrubbers may be either recirculated within the scrubber equipment package (which includes a settling chamber) or discharged to an external treatment system and then recycled back to the scrubber.

A review of the five respondents using melting furnace gas scrubbing equipment indicates that process wastewaters are handled in a variety of ways, although they are generated in the same manner. Table III-4 describes the treatment systems used with this process. All of the surveyed plants employ some degree of process wastewater recycle, however some systems employ an "internal" (within the scrubber equipment package) recycle, while other plants recycle their process wastewaters externally after passing through various treatment stages. Two of the plants

employ internal recycle systems, with the blowdowns of each system being introduced untreated to a POTW. These two plants are among the three plants with the highest recycle rates (95 percent and 97.5 percent). The process wastewater treatment systems used at the three remaining plants provide for recycle of externally treated process wastewaters, with the blowdown being discharged to a receiving stream. The treatment systems at these plants incorporate basically some type of settling operation, with one plant providing more extensive treatment.

Plant 17089, Figure V-2, produces die casting and casting quench process wastewaters which are skimmed of oil and then co-treated with melting furnace scrubber process wastewaters. At the time of sampling, the treatment consisted of alum and polymer additions in a flash mix tank followed by clarification, pressure filtration, recycle, and discharge. The clarifier underflow was thickened and dewatered in a centrifuge before being dried in a basin. Sixty-five percent of the treated process wastewater was reused in the plant, while the remainder was discharged to navigable waters. Since the completion of the sampling vist, this plant has added an activated carbon adsorption system.

Plant 18139, Figure V-3, generates process wastewater from a Venturi scrubber on the aluminum melting furnaces. The process wastewater is recirculated through a settling tank. Overflow from the settling tank is mixed with process wastewaters from the zinc melting furnace and aluminum and zinc casting quenches. The mixed process wastewater passes through a settling basin, an oil separator and storage tanks before discharge.

Table V-16 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program.

Casting Quench Process

An estimated 104.57 million liters (27.63 million gallons) of process wastewater are generated each year by casting quench operations. This represents 2.66 percent of the total process wastewater flow at plants within the aluminum casting subcategory. Forty-eight percent of this flow is recycled, 10 percent is discharged to navigable waters, and 42 percent is discharged to POTWs. Plant survey responses indicated a range of applied flow rates from 6.05 l/kkg (1.45 gal/ton) to 28,590 l/kkg (6,866 gal/ton). Recycle rates varied from 0 to 100 percent. In some instances no applied flow could be assigned to a process, since the castings were quenched in a tank with no discharge or

only very infrequent dumps. In these instances, the operations were considered to be 100 percent recycle, since the same quench solution is continuously reused.

A general process and water flow diagram of a representative aluminum foundry casting quench operation is presented in Figure III-5. The process wastewaters considered in association with this operation are those wastewaters which are discharged from the casting quench tanks. Raw waste loads will depend on the duration of the quenching cycle, the degree of quench recycle, the quench solution additives used, and the contamination of the quench solutions with wastes from other sources (hydraulic oil leaks, etc.). The major impact on the raw waste loads, however, is due to the nature of the quenching solution and the contamination of the quench solutions with wastes from other sources.

A review of the twelve plant responses with casting quench operations indicates that all process wastewaters are generated in the same manner, although they are handled in a variety of ways. The treatment schemes range from untreated discharges to POTWs to complete recycle systems. Refer to Table III-5 for descriptions of the treatment schemes used in this subcategory segment. All plants use some form of settling, even if this is only accomplished in the quench tank itself. However, the quantity of castings quenched, the process wastewater flow through the quench tank, and the size of the quench tank are factors which may necessitate the need for a separate settling stage to remove solids.

Of the twelve plants with casting quench operations indicated in their responses, two plants employed 100 percent recycle and two plants employed a 90 percent recycle rate. The blowdowns of the two 90 percent recycle plants as well as the discharges of four other plants (with no recycle) are introduced untreated to POTWs. Of the three direct discharge plants, one has treatment via a settling lagoon, and the other two provide no treatment. The process wastewaters of one plant are removed by a contract hauler. Settling is indicated as the only treatment provided for casting quench process wastewaters.

Plant 10308, Figure V-4, generates zinc die casting quench wastes, aluminum die casting quench wastes, cutting and machining coolant wastes, and impregnating wastes which are co-treated in a batch-type system. The zinc casting quench waste is actually the effluent from a system which recycles the quench tank contents through a settling and skimming operation and back to the quench tanks. The zinc casting quench wastes represent approximately 25 percent of the total treatment volume. After undergoing a

sulfuric acid and alum emulsion break, neutralization, flocculation and solids separation, the treated effluent is discharged to a land locked swamp.

Plant 17089, Figure V-2, produces die casting and casting quench process wastewaters which are skimmed of oil and then co-treated with melting scrubber process wastewaters. The treatment consists of alum and polymer additions in a flash mix tank followed by clarification, pressure filtration, recycle, and discharge. Clarifier underflow is thickened and dewatered in a centrifuge before being dried in a basin. Sixty-seven percent of the treated water is reused in the plant, and the remainder is discharged.

Plant 18139, Figure V-3, has a number of die casting machines and associated quench tanks which are emptied on a scheduled basis. The schedule results in the emptying of one 1135.5 liter (300 gallon) quench tank each operational day. Each quench tank is emptied approximately once a month. The quench tank discharge mixes with melting furnace scrubber discharges, zinc casting quench tank flows, and other non-foundry flows prior to settling and skimming. The treated process wastewaters are discharged to a POTW.

Table V-17 summarizes the raw waste and treated effluent concentrations and waste loads observed at these two plants during the sampling program.

Die Casting Process

An estimated 2.52 billion liters (0.665 billion gallons) of process wastewater are generated each year by die casting operations. This represents 64.0 percent of the total process wastewater flow at plants within the aluminum casting subcategory. An estimated 56.4 percent of this flow is recycled, while 37.5 percent is discharged to navigable waters, and 6.1 percent is discharged to POTWs. Plant survey responses indicated a range of applied flow rates varying from 371 l/kkg (88.9 gal/ton) to 60,358 l/kkg (14,464 gal/ton). Recycle rates varied from 0 to 90 percent.

A general process and water flow diagram of a representative aluminum foundry die casting operation is depicted in Figure III-5. The various sources of wastewaters in the die casting operations are contact mold cooling water, die surface cooling sprays, casting machine hydraulic cooling systems using water, and leakage from various noncontact cooling systems which are

subsequently contaminated with hydraulic oils, lubricants, etc. Depending upon the degree of maintenance performed on the various die casting systems, the major source of process wastewaters could vary from surface cooling sprays, in the case of a well maintained operation, to contaminated leakages in the case of systems which receive only cursory maintenance. Preventive maintenance can affect the volume and contaminants of die casting process wastewater. Refer to Table III-6 for process wastewater source and treatment information.

Of the ten plants with die casting operations identified in their responses, five recycle systems, at 37%, 79%, 80%, 90%, and 95%, are indicated. Six of these ten plants discharge to POTWs. One of these plants employs emulsion breaking, skimming, alum feed, flotation and additional skimming. Of the remaining five POTW dischargers, three plants provide no process wastewater treatment, and two plants provide only settling.

The four plants discharging to navigable waters provide more extensive treatment than the POTW dischargers.

Of the seven plants employing some type of process wastewater treatment system, the following technologies are used:

a. Settling and skimming (7 plants): Primary solids and tramp oil removal is achieved with settling and skimming. In some instances, recycle follows.

b. Emulsion breaking (5 plants): Using alum or sulfuric acid or both, the emulsified oils are broken out of the emulsion and are then removed as scum.

c. pH adjustment, flocculation and clarification (4 plants): Lime, polymer, alum and other chemicals are used to adjust waste pH and promote floc formation, after which the floc is allowed to settle in a clarifier. This step provides for metals removal, some oil removal, and enhanced solids removal compared to settling tanks.

d. Filtration (2 plants): Two plants use filters to provide additional TSS and particulate pollutant removal.

Plant 17089, Figure V-2, produces die casting and casting quench wastes which are skimmed of oil and then co-treated with melting scrubber wastewaters. The treatment consists of alum and polymer additions in a flash mix tank followed by clarification, pressure filtration, recycle, and discharge. Clarifier underflow is thickened and dewatered in a centrifuge before being dried in a

basin. Sixty-five percent of the treated water is reused in the plant, and the remainder is discharged.

Plant 12040, Figure V-5, produces aluminum and zinc die casting process wastewaters which are co-treated. After collection in a receiving tank where oil is skimmed, they are batch treated by emulsion breaking, flocculation and settling before discharge. The released oil is returned to the receiving tank for skimming, and the settled wastes are vacuum filtered and dried before being land filled. Filtrate water is returned to the receiving tank.

Table V-18 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program.

Die Lube Process

An estimated 14.62 million liters (3.86 million gallons) of process wastewater are generated each year in die lube operations. This represents 0.37 percent of the total process wastewater flow at plants within the aluminum casting subcategory. Fifty-two percent of this flow is recycled, while 14.5 percent is discharged to navigable waters, and 33 percent is discharged to POTWs. Plant survey responses indicated a range of applied flow rates varying from a low of 36.3 l/kkg (8.7 gal/ton) to a high of 270 l/kkg (71. Plant survey responses indicated the use of either complete or no recycle.

A general process and water flow diagram of a representative die casting operation employing a die lube system is presented in Figure III-5.

The die lube operation involves the spraying of a lubricating solution onto the die surface prior to casting. These solutions are emulsions which contain certain "casting release" agents which permit the casting to fall away or be removed readily from the dies.

A review of the four plants with die lube operations identified in their survey responses indicate that the process wastewaters are generated in the same manner, although the process wastewaters are treated in distinctly different ways. Refer to Table III-7 for descriptions of the various treatment systems. A 100 percent recycle system is in operation at one plant and was observed during a sampling visit, while the other three plants discharged all die lube process wastewaters. The more extensive treatment systems were installed after 1971.

Of the three foundries with process wastewater discharges, one plant provided no treatment prior to its discharge to a POTW, another plant discharged the permeate from an ultrafiltration unit to a POTW, and the remaining plant provided treatment in a central facility prior to a direct discharge. This central facility (die lube flow represented only 7 percent of total central treatment facility flow) provided various chemical additions, biological treatment, and clarification. The 100 percent recycle plant used skimming, cyclonic separation, and a paper filter to treat its process wastewater and recover die lubricants.

The various technologies in use at the three plants with process wastewater treatment systems are as follows:

a. Ultrafiltration Unit: hydraulic pressure is used to drive the aqueous phase of the die lube wastes through a semi-permeable membrane. Higher molecular weight organics remain behind that membrane. Some lower molecular weight organics pass through with the aqueous phase.

b. Cyclonic Separator, Skimming, Paper Filter: This system is used in conjunction with a complete recycle operation to provide for suspended solids removal, tramp oil removal, and recovery of process chemicals.

c. Flotation, skimming, addition of ferric chloride and lime, lagoon, trickling filter, activated sludge, and clarifier. Note: Die lube flow is only seven percent of the total plant process wastewater flow to the treatment system.

Plant 20147, Figure V-6, indicated that the sources of die lube process wastewaters are: 1) excess die lube sprayed on the dies for additional cooling, 2) leakage from die cooling (noncontact cooling water which becomes mixed with process wastewater), 3) leakage from hydraulic system cooling water (noncontact cooling water which passes through a heat exchanger to cool the hydraulic oil and becomes mixed with process wastewater), and 4) hydraulic oil leakage.

Process wastewater is controlled in three ways. On each shift, maintenance personnel inspect each die casting machine for leaks. Where necessary, repairs are made during the shift to reduce the process wastewater flow. Under the die of each machine, a pan collects excess die lube which drips from the die. A portable pump and tank is wheeled to each machine during each shift to collect the die lube collected in the pans. In addition, on the floor around each die casting machine, a dam contains the process wastewater from various leaks. Die lubricant which does not

collect in the pan is also contained by the dam. The process wastewater collected in this manner flows to storage tanks through a floor drain.

Stratification of the process wastewater into three layers occurs in the storage tanks. Tramp oil floats to the top and is removed by a belt collector. The tramp oil is collected, stored, and removed by a contractor. The middle layer, comprised of die lubricant, is removed to a second tank. From this second tank, the die lubricant passes through a cyclonic filter. The die lubricant removed through the top of the cyclone passes through a paper filter and then is stored, until it is reused on the die casting machines. The material removed from the bottom of the cyclone is stored, until it is removed by a contract hauler.

Die lubricants collected in the pans beneath the dies are removed to the reconstruction area of the plant, where the used die lubricant passes through a paper filter, is mixed with new lubricant and water to bring it up to specification, and is stored until needed on the die casting machines.

Table V-19 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program.

Copper Foundries

An estimated 7.20 billion liters (1.90 billion gallons) of process wastewater result each year by the casting of copper and copper alloys. Approximately 98.2 percent of this water is recycled, while 1.4 percent is discharged to navigable waters, and 0.4 percent is discharged to POTWs. Complete recycle is practiced at plants which generate 74.3 percent of the wastewater in this subcategory. Three manufacturing processes use water in the copper casting subcategory.

Dust Collection Process

An estimated 814 million liters (215 million gallons) of process wastewater result each year by dust collection operations. This represents 11.3 percent of the total process wastewater flow at plants within the copper casting subcategory. Of this total flow, 97.0 percent is recycled, while 3.0 percent is discharged to navigable waters. None of the DCP respondents indicated that process wastewaters from this process were discharged to POTWs. Plant survey data indicate a range of applied flow rates varying from 63 l/kkg (15.1 gal/ton) to 8,440 l/kkg (2,027 gal/ton). The recycle rates indicated in the plant survey data were either 0 or 100 percent.

A general process and water flow diagram of a typical copper foundry dust collection system is presented in Figure III-6.

Copper foundry dust collection operations use scrubbers to remove airborne particulates. The dust collection systems under consideration herein are used to remove the airborn particulates generated as a result of molding sand handling operations, mold making and casting shake out. The major pollutant load from this process results from the casting sand itself and the binders and process chemicals used in the molding and casting processes.

A review of the six plant responses with dust collection operations indicates that all process wastewaters are generated in the same manner and are handled in the same manner, i.e., all of the treatment systems employ some type of settling step. Refer to Table III-8 for descriptions of the treatment systems employed in this subcategory segment. Of the six plants using this process, four plants employ 100 percent recycle systems, and two discharge all dust collector process wastewaters. Of the 100 percent recycle plants, three have "internal" recycle systems, while one plant recycles all dust collector process wastewaters through a settling lagoon. The internal recycle systems recirculate process wastewater within the scrubber equipment package as designed by the scrubber manufacturer. The two plants with discharges provide settling prior to the discharge of all dust collector process wastewaters to receiving streams.

Settling to achieve solids removal is the only treatment technology identified in the survey responses. Plant 19872, Figure V-7, was observed during the sampling program. This plant uses a dust collector scrubber with an internal recycle rate of 100 percent. Settled sludge is removed by a dragout mechanism for disposal. Specific, representative raw wastewater and treated effluent samples could not be obtained at this plant.

Plant 09094, Figure V-8, produces process wastewater from three internal recycle dust collectors. The process wastewaters are collected and treated in a series of three lagoons to provide solids removal. The lagoon effluent is recycled back to the scrubbers. Discharge from the ponds was eliminated in 1977 when the ponds were dammed. Additional water from the lagoons is used to sluice the sludge from the settling chambers of the three scrubbers to the first pond.

Table V-20 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program.

Mold Cooling and Casting Quench Process

An estimated 6.39 billion liters (1.69 billion gallons) of process wastewater are generated each year by mold cooling and casting quench operations. This represents 88.7 percent of the total process wastewater flow at plants within the copper casting subcategory. Approximately 98.3 percent of this flow is recycled, while 1.18 percent is discharged to navigable waters and 0.48 percent is discharged to POTWs. Plant survey responses indicated a range of applied flow rates varying from 583 l/kkg (140 gal/ton) to 110,200 l/kkg (26,470 gal/ton). All plants, except one, had discharge rates of 100 percent of the applied flow. The exception, which had the largest applied flow rate (at least eleven times greater than the next lowest applied flow rate), had a recycle rate of 99.5 percent.

A general process and water flow diagram of a representative copper foundry dust collection system is presented in Figure III-6.

Copper casting foundries generate process wastewaters as a result of cooling operations requiring contact cooling water for molds and quenches for castings as they are formed. The major pollutant load from these operations is the particles of copper and alloying materials which are represented as suspended solids. These particles settle primarily in the cooling and quench tanks, where periodically the solids are removed and reclaimed.

Review of the responses of the surveyed plants with mold cooling and casting quench operations indicates that all process wastewaters are generated in the same manner, although the wastes are handled in a variety of ways. Refer to Table III-9 for descriptions of the treatment systems employed at these plants. Process wastewater handling schemes varied from untreated discharges to POTWs to settling and cooling. Settling operations were dated to 1960.

Of the six plants identified in the survey with this process, two plants discharge all of their mold cooling and casting quench process wastewaters untreated to POTWs, three plants provide settling prior to the discharge of all of their process wastewaters to a receiving stream, and the process wastewaters of one plant are discharged to a POTW following extensive recycle. The recycle plant installed cooling towers in its recycle loops.

Of the four plants using some type of process wastewater treatment system, the various technologies employed are as follows:

a. Settling: To provide solids removal.

b. Settling, Recycle and Cooling Tower: Settling is used in the system with a high recycle rate to provide solids removal. Cooling is needed to maintain the proper heat removal capabilities in the system.

Plant 04736, Figure V-9, uses a mold cooling and casting quench operation. This process operates with a higher degree of recycle, with make-up via a float valve. An auxilliary holding tank is installed to maintain a water balance in this system.

Plant 06809, Figure V-10, recycles its mold cooling and casting quench wastewaters through a cooling tower. An overflow from the hot wells serves as a blowdown from this recycle system. This blowdown undergoes treatment (sedimentation and skimming) in a central treatment system. The mold cooling and casting quench wastewaters comprise 3 percent of the total flow to the central lagoon.

Table V-21 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program.

Iron and Steel (Ferrous) Foundries:

An estimated 399.1 billion liters (105.4 billion gallons) of process wastewater is generated each year by the casting of ferrous metals. Seventy-five percent is recycled, 23.3 percent is discharged to navigable waters, and 1.9 percent is discharged to POTWs. An estimated 39.2 percent of this flow is recycled at 100 percent.

Dust Collection Process

An estimated 208.9 billion liters (55.2 billion gallons) of process wastewater is generated each year in dust collection operations. This represents approximately 52.3 percent of the total process wastewater flow at plants within the ferrous casting subcategory. Approximately 78.7 percent of this process segment's flow is recycled, while 20.1 percent is introduced into navigable waters and 1.2 percent is discharged to POTWs. An estimated 45 percent of this flow is recycled at 100 percent. Plant survey responses indicated a range of applied flow rates varying from 171 l/kkg (27 gal/ton) to 96,200 l/kkg (16,840 gal/ton). Recycle rates varied from 0 to 100 percent.

Figure III-7 presents a general process and water flow diagram of a representative ferrous foundry dust collection operation.

Ferrous foundry dust collection systems use the various types of scrubbers, described in Section III, to remove airborne gases and particulates. These dust collection systems are used to remove the airborne contaminants generated as a result of sand handling operations, mold and core making, and mold and casting shakeout. The major pollutant load results from the casting sand itself and the binders and process chemicals used in the molding and casting processes. Test data from dust collection systems were obtained during the sampling programs conducted during 1974 and 1978.

A review of the 147 plant responses with dust collection operations indicates that all process wastewaters are generated in the same manner and are treated in essentially the same manner, i.e., all treatment systems are primarily settling operations. Refer to Table III-10 for descriptions of the treatment systems used in this process. Recycle rates vary from 0 to 100 percent. Recycle systems involved both "internal" (within the scrubber equipment package) and "external" (through separate waste treatment) recycle of the process wastewaters.

Of the 147 responses indicating the presence of dust collection scrubbers, 73 plants indicated that 100 percent of the process wastewaters associated with their dust collection operation are recycled. Of these 73 plants, 47 plants indicated 100 percent "internal" recycle within the scrubber equipment package, and 26 plants indicated 100 percent recycle of process wastewater with external treatment provided.

Seventy-four plants recycle the dust collection process wastewater at less than 100 percent. Thirty-five of these plants discharge the recycle overflow untreated; 24 untreated discharges go to POTWs, and 11 untreated discharges go to navigable waters. Of the 39 other plants discharging treated process wastewaters, 11 discharge to POTWS, and 28 discharge to navigable waters.

Sixteen plants discharge all of their process wastewater without any recycle. Nine plants provide treatment prior to direct discharge, and one plant discharges untreated process wastewaters to navigable waters. Two plants provide treatment prior to discharge to POTWs, and 4 plants discharge untreated process wastewaters to POTWs.

The various treatment technologies indicated in the plant data are:

a. "Internal" Recycle: Settling for solids removal is provided within a manufacturer's scrubber equipment package. Sludge is removed via an endless chain conveyor fitted with scoops to move the sludge from the settling chamber to an appropriate receptor outside the scrubber.

b. Settling With or Without Chemical Addition and Skimming: Solids removal is accomplished in a variety of ways. These methods include lagoons, clarifiers, tanks, and dragout chambers. Polymer or other chemicals may be added to enhance solids removal. Skimming is provided for surface scum removal.

Plant 55122, Figure V-11, was sampled during the 1974 sampling program. Dust collector process wastewaters from casting cooling, core room, molding and cleaning departments are collected and recirculated from a central sump. Ninety percent of the process wastewater is recirculated, while 10 percent is discharged to a receiving stream. A sidestream treatment system consists of a cyclone separator, with the underflow screen dewatered and solids disposed to landfill, while the screen drains to the central sump. The cyclone overflow goes to a thickener where polymer is added. The thickener underflow is vacuum filtered, the solids are disposed of at a landfill, and the filtrate is returned to the thickener.

Plant 59101, Figure V-12, has a series of 12 bulk bed washer type scrubbers in the foundry for the cleaning of molding and cleaning dusts. The process wastewater from these units is pumped to a collection sump and then to a lagoon. No dust scrubber process wastewater is recycled externally.

This plant also has a sand washing system to reclaim sand for reuse. The process wastewater from this operation also is sent to the lagoons. The lagoons are arranged to give maximum use of the land area. The inlet to the first lagoon is arranged so that the heavy solids can be removed readily. The lagoon overflow is discharged to a receiving stream.

Plant 57775, Figure V-13, has a process wastewater from a dust scrubber. The process wastewater flows to a drag tank, where solids separation occurs, and sludge is removed. At the time of the plant visit in 1974, 88 percent of the dust collection process wastewater was recycled. Since that time, the dust collection process wastewater has been combined with the melting furnace scrubber process wastewater recirculation system, and 100 percent recycle of all process wastewater has been achieved. At the time of sampling, a raw wastewater sample could not be

obtained; therefore, only effluent analytical data are presented for this plant in Table V-22.

Plant 54219, Figure V-13, has a scrubber which cleans molding and cleaning dusts. The process wastewaters from the scrubber drain to a drag tank, where a flocculant is added, and solids are removed. Ninety-eight percent of the process wastewater is recycled to the collector, while the overflow goes to the sanitary sewer.

Plant 55217, Figure V-15, has a wet dust collector system. Scrubber process wastewater flows to a large lagoon. From the lagoon, process wastewater is recirculated back to the dust collection scrubbers. This recirculation system is common with the melting furnace scrubber recirculation system. There is no discharge from this common system. All process wastewater is recirculated.

Plant 67100, Figure V-15, has four scrubbers to clean dusts from sand mixing, mold shakeout, and shot blast cleaning operations. They are mechanical-centrifugal type collectors. After settling, a portion of the wastewater is recycled back to the dust collector, while the remainder is discharged to the municipal sanitary treatment plant.

Plant 56771, Figure V-17, produces dusts from the molding area, core room shakeout and cleaning areas. These dusts are cleaned by means of a scrubber. The process wastewater is settled in a drag tank, where chemical additions aid settling. A portion of the process wastewater is recycled, while the remaining process wastewater flow was discharged to a POTW prior to 1974. Since then the discharge has been eliminated.

Plant 15520, Figure V-18, is a large foundry with a complex water balance. Dust collection scrubber process wastewaters, slag quench process wastewaters, and sand washing process wastewaters are settled and recycled with make-up from noncontact cooling water. As water balance upsets occur, overflow is periodically discharged to a POTW.

Plant 20009, Figure V-19, has four wet dust collectors which are operated with an overflow to a POTW. A sand reclaim process washes the sand for sand recovery. The waste products are settled in a series of four lagoons. Settled sludge from the ponds is removed to landfill. Forty percent of the lagoon water is discharged by overflow to a POTW , and 60 percent of the process wastewater flow is recycled.

Plant 07929, Figure V-20, has operated nine dust collection scrubbers at 100 percent recycle of process wastewater since 1973. These nine scrubbers remove airborne particulates generated in the casting shakeout area, core room mullers, pouring casting cooling lines, sand handling and transfer system, and the molding floor and molding line areas. Western bentonite clay is used in the foundry sand. A two compartment settling concrete tank was installed in 1973. Only one settling compartment is used at a time, and, as necessary, the compartments are switched to allow for sludge removal. The solids are landfilled on company property. An inertial grit separator was installed in 1978. Prior to the installation of the grit separator, the scrubbers would become fouled approximately once per month. The fouling was believed by plant personnel to be caused by bentonite clay. The cleaning of all the scrubbers required a maintenance effort of three men for three 8-hour shifts. At the time of the installation of the grit separator, a maintenance program employing a 1,000 psi pump and hand held cleaning wand was initiated to clean the scrubbers on a routine basis. All scrubber cleaning is performed one weekend per month by one maintenance man and a helper.

Plant 51115, Figure V-21, has two interconnected 100 percent recycle process wastewater systems. The treatment system was originally installed in 1959. Prior to 1976, process wastewater was discharged to a navigable water. In 1976 this discharge was eliminated, when 100 percent recycle of the process wastewater was achieved. Three scrubbers which clean dusts from the core room and shakeout area are in operation at this foundry. Process wastewaters from the sand washer and the dust scrubbers flow by gravity to a collection tank. Water in the collection tank flows via gravity to the grit building where alum, polymer, and flocculant aids are added. Solids are removed in a drag tank. Wastewater from the drag tank flows to a settling basin, where it is pumped as needed to the dust collectors and sand washing equipment. Problems were encountered with the 100 percent recycle system immediately after closing the loop. These problems were: 1) the determination of the correct amount of polymer addition required for optimum settling took a number of weeks; 2) during this transition period plugging of the scrubbers occurred; and 3) a larger than normal amount of solids collected in the settling basin. However, after the correct amount of polymer addition was determined and the proper water balance was achieved throughout the system, these problems were eliminated.

Plant 50315, Figure V-22, generates process wastewater from scrubbers which clean dusts from sand molding operations. The process wastewater drains to a lagoon for settling. One hundred percent of this process wastewater has been recycled back to the dust collection scrubbers since 1974.

Plant 59212, Figure V-23, generates dust collector, slag quench and melting scrubber process wastewaters, which are then collected in a drag tank. Chemical additions to aid settling are made, and the water is recirculated.

Solids are removed by the drag conveyor, and overflow wastewaters drain to a second settling tank. Two settling ponds have been added since 1974. Treated wastewaters are discharged to a POTW.

Plant 53642, Figure V-24, has a scrubber system for the cleaning of dusts collected in the molding, core room, pouring, cooling, and cleaning areas. The process wastewater flows to a primary settling tank and then is pumped to a cyclone separator. The cyclone underflow flows to a classifier for dewatering and removal of solids, with the settled wastewaters being returned to the primary tank. The upflow from the cyclones goes to a second tank for recycle, with a blowdown (10 percent) to a thickener. Alum and polymer are added at the thickener. The underflow goes to a vacuum filter. The filter cake goes to a landfill, and the filtrate is returned to the thickener. The thickener overflow is available for reuse or discharge to the river.

Plant 06956, Figure V-25, generates wastewaters from dust collection, melting furnace scrubber, and slag quenching operations. These wastewaters are combined for treatment. The wastewaters are first treated in a clarifier with polymer added to enhance solids removal and lime added for pH control. The clarifier effluent flows to a lagoon from which a portion of the treated wastewaters are recycled to the processes listed above. The lagoon not only provides system holding capacity but also provides additional solids removal capability. Clarifier sludge is transported to a landfill disposal site. The overall recycle rate of this combined system is 95%; the remainder is discharged to a receiving stream.

Table V-22 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling programs.

Melting Furnace Scrubber Process

An estimated 118.7 billion liters (31.4 billion gallons) of process wastewater are generated each year in melting furnace scrubber operations. This represents 30 percent of the total process wastewater flow at plants within the ferrous casting subcategory. Approximately 79 percent of this flow is recycled, while 19.6 percent is discharged to navigable waters, and 1.0 percent is discharged to POTWs. An estimated 41.8 percent of this flow is recycled at 100 percent. Plant survey responses indicated a range of applied flow rates from 620 l/kkg (149 gal/ton) to 39,780 l/kkg (9,555 gal/ton).

A general process and water flow diagram of a representative ferrous foundry melting furnace scrubber operation is presented in Figure III-7.

The major pollutant load is due to the amount, type and cleanliness of scrap and metal used in the furnace charge and the various by-products associated with the melting process.

A review of the 82 plants responses with furnace scrubber operations indicates that the process wastewaters are not only generated in a similar manner, but also are treated in essentially the same manner. Refer to Table III-11 for descriptions of the treatment systems used by plants in this subcategory segment. Recycle rates may vary from 0 to 100 percent, and recycle systems employ both "internal" and "external" treatment systems.

Of the 82 plant responses indicating the use of a melting furnace scrubber system, 42 plants have 100 percent recycle systems. Of these 42 plants, 20 have "internal" recycle systems and 22 provide external treatment for the recycled process wastewaters. Another 40 plants employ recycle systems with recycle rates less than 100 percent. Of these 40 plants, 4 plants have untreated discharges to POTWs, 13 plants discharge treated process wastewaters to a POTW, 19 plants discharge treated process wastewaters to a receiving stream, and four plants discharge untreated process wastewaters to a receiving stream. The above mentioned untreated discharges are typically internal recycle system blowdowns.

The various treatment technologies indicated in the plant data are:

a. Internal Recycle: These systems provide solids removal via some type of settling operaton. In some instances various

chemicals are added to provide pH adjustment and enhanced solids removal.

b. External Recycle, Settling With or Without Chemical Addition: These systems use lagoons, settling tanks, dragout chambers, or clarifiers to accomplish solids removal. Various chemicals are added for the purposes of pH adjustment and enhanced solids removal.

Note that both the internal and external treatment systems use essentially the same treatment process.

Plant 06956, Figure V-25, generates wastewaters from melting furnace scrubber, slag quenching, and dust collection operations. These wastewaters are combined for treatment. The wastewaters are first treated in a clarifier with polymer addition to enhance solids removal and lime addition for pH control. The clarifier effluent flows to a lagoon from which a portion of the treated wastewaters are recycled to the processes listed above. The lagoon not only provides system holding capacity but also provides additional solids removal capability. Clarifier sludge is transported to a landfill disposal site. A portion of the wastewater flow is discharged from the lagoon. The recycle rate of the combined treatment system is 95 percent.

Plant 52491, Figure V-26, has a Venturi scrubber for control of cupola emissions. The process wastewater is collected in a settling tank where caustic is added. The overflow is recycled to the Venturi scrubber. This flow is adjusted to give a slight surplus of return water in the settling tank. This surplus is discharged to the city sewer. The settling tank is dumped daily to a dewater box. After additional settling in the dewater box, the water is returned to the settling tank and the solids are landfilled.

Plant 57775, Figure V-13, produces process wastewaters from a melting furnace scrubber system which are treated in a drag tank by addition of caustic and polymer. Solids are landfilled and the process wastewater is recycled. At the time of the sampling in 1973, some overflow from the drag tank drained to the sanitary sewer. However, since collection of plant data in 1973, this plant has closed the loop on the melting furnace scrubber system, i.e., no process wastewater is now discharged.

Plant 53219, Figure V-14, has a Venturi scrubber and a separator on the cupola. The separator has a conical bottom that collects heavy solids. Caustic is added to the separator via a pump. Water is pumped from the separator to the process, and an overflow from the separator discharges to the sanitary sewer.

The separator is drained, at the end of the cupola run, to a dewatering tank, and the solids are sent to a landfill.

Plant 56789, Figure V-27, operates a cupola Venturi scrubber. The scrubber process wastewater drains to a classifier tank where caustic and polyelectrolytes are added. The underflow goes to a drag tank where solids are settled and removed. The drag tank overflow is recycled to the classifier and the excess is drained to a transfer tank. Wastewater in the overflow transfer tank is pumped to a storage tank. Caustic is added at the overflow tank for corrosion control. All process wastewater from the melting furnace scrubber has been recycled since 1974.

Plant 58589 Figure V-28, has a melting furnace scrubber process wastewater which is collected in a separator, and then pumped to a large sump. After settling overnight, the contents of the sump are siphoned to a second sump. Water from this second sump is recycled to the quench chamber scrubber the next day. This plant recycles all of its melting furnace process wastewaters. Solids are removed from the first sump on a bi-monthly basis.

Plant 56123, Figure V-29, collects melting furnace scrubber process wastewaters in a drag tank where caustic is added and heavy solids are removed. The overflow from this tank goes to a filtrate tank where a portion of the process wastewater is recycled to the furnace scrubber. A sidestream from this filtrate tank passes through cyclone classifiers and then to pressure sand filters. From the sand filters the treated process wastewater returns to the filtrate tank. The filter backwash is blown down to a surge tank and then to a floc tank where chemical additions are made. The floc tank overflows to a clarifier. The clarifier underflow is delivered to a landfill, and the overflow is discharged to municipal sanitary sewers.

Plant 55217, Figure V-15, generates process wastewaters from the melting furnace scrubber on a triplex cupola arrangement. The process wastewaters are collected in a slurry tank. Caustic is added, and the wastewater is pumped to a large lagoon that is shared with another plant. Since 1974, all process wastewater from the melting furnace scrubber has been recycled.

Plant 50315, Figure V-22, and Plant 55217 share settling lagoons. The process wastewater from the melting furnace scrubbers flows to the lagoon and is recycled from the lagoon to the cupola emission system. Since 1974, all process wastewater from the melting furnace scrubber has been recycled.

Plant 54321, Figure V-30, generates melting furnace scrubber process wastewaters and slag quench process wastewaters which are

drained to a drag tank. A classifier removes solids continuously from a sidestream, while the settled material is removed continuously by the drag conveyor. Hydrated lime is added to control corrosion. Pumps recycle water from the drag tank to the quencher and Venturi scrubber on the melting furnace. Since the collection of plant data in 1974, this plant has closed the loop on the recycle of process wastewater from the melting furnace scrubber. There is no process wastewater discharge from this system.

Plant 56771, Figure V-17, has a system similar to plant 54321 with the addition of an aftercooler and a cooling tower. These two units reduce stack temperature and carryover. And like plant 59321, this plant has closed the loop on the recycle of process wastewater from the melting furnace scrubber.

Plant 52881, Figure V-31, has a system that is a duplicate of the treatment system used at Plant 54321. As at Plant 54321, this plant has closed the loop on the furnace scrubber recycle system.

Plant 59212, Figure V-23, generates melting furnace scrubber process wastewaters, together with dust scrubber and slag quench process wastewaters which are collected in a drag tank. Chemicals are added to the drag tank to aid settling. Process wastewater from the drag tank is recirculated to the mist eliminator. Process wastewater from the mist eliminator is pumped through two cyclones, with the clarified process wastewater going to the furnace scrubber and returning through the mist eliminator to the cyclones. The cyclone underflow is drained to the drag tank. Solids are removed in the drag tank by a drag conveyor. Overflow from the drag tank drains to a second settling tank. Process wastewater from the second settling tank discharges to a POTW.

Plant 00001, Figure V-32, operates a cupola furnace with an emission control system similar to plant 07170. The settled particulates are discharged to a landfill daily. Settling is aided by a cyclone and a classifier in the system, as well as chemicals that are added during operation. The particulates settle to the bottom of the cyclone due to inertial action. These are piped to the classifier, where further settlement collects them at the bottom of the cone. After the cupola is shut down, this sludge is dumped to a tote bucket. The recirculating pumps are operated for a short period to cool the system and to move any particulates in the system into the classifier. After settling overnight, the classifier cone sediment is again dumped to the tote bucket. This system operates with the recycle of all process wastewater. However, due to the nature of this system's operations, discrete raw

wastewater and treated effluent quality and load values could not be determined.

Plant 00002, Figure V-33, is similar to Plant 00001 with an added feature of energy recuperation before the Venturi scrubber to reclaim heat from the furnace exhaust gas stream. The Venturi, separato the equipment, hydraulic cyclone and classifier are similar to Plant 00001. The methods of operation are also similar. Again, this system recycles all of its process wastewater. As with plant 00001, discrete raw wastewater and treated effluent quality and load values could not be determined.

Plant 15520, Figure V-18, has a separate treatment system for melting furnace scrubber process wastewaters. The treatment system consists of chemical additions, clarification and vacuum filtering of the settled material. Clarifier overflow is recycled to a balance tank and then to the melting furnace scrubber. Noncontact cooling water is used as makeup to the melting furnace scrubber recirculating system.

Plant 07170, Figure V 34, is a small gray iron foundry which operates a melting furnace scrubber system. The melting furnace operates approximately two hours per day during which time all system process wastewaters are recycled. Caustic and polymer are added to the process wastewater system following furnace operation, and the process wastewater is allowed to settle overnight. Prior to operation of the furnace the following day, the settled solids are drained from the system to a company landfill. All process wastewaters are recirculated in this system. As with plant 00001, discrete raw wastewater and treated effluent quality and load values could not be determined.

Table V-23 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling programs.

Slag Quench Process

An estimated 43.2 billion liters (11.4 billion gallons) of process wastewater are generated each year by slag quenching operations. This represents 10.8 percent of the total process wastewater flow at plants within the ferrous casting subcategory. Approximately 43 percent of this flow is recycled, 53.4 percent is discharged to navigable waters, and 3.7 percent is discharged to POTWs. An estimated 11 percent of this process wastewater is recycled at 100 percent. Plant survey responses indicated a

range of applied flow rates varying from 10.0 l/kkg (2.4 gal/ton) to 23,860 l/kkg (5,731 gal/ton).

Figure III-7 presents a general process and water flow diagram of a representative ferrous foundry slag quenching operation.

In this operation, the slag removed during the melting operation is quenched in order to cool and thus solidify the slag. The quenched slag is subsequently removed for disposal or reuse in other applications. The pollutants in this process wastewater result from the slag quenching operation.

A review of the responses of the 63 plants with slag quenching operations indicates that the process wastewaters are not only generated in a similar manner but also are generally treated in a similar manner. Refer to Table III-12 for descriptions of the treatment systems used in this process. Degrees of process wastewater treatment vary from no treatment at all to the recycling of 100 percent of all process wastewaters. The oldest process wastewater treatment component was installed in 1948.

Of the 62 ferrous foundries with slag quenching operations indicated in the plant data, 16 plants recycle all of their process wastewater, while 7 foundries discharge all of their process wastewaters untreated to a POTW, and 4 plants discharge all of their process wastewaters untreated to receiving streams. Eleven plants treat and then discharge all of their process wastewaters to POTWs, and 24 foundries treat and then discharge all of their process wastewaters to receiving streams. Twenty-three plants have recycle systems with recycle rates less than 100 percent; 14 of these 23 facilities discharge a portion of their wastewater flow to a receiving stream, and 9 of these plants discharge a portion of their wastewater flow to a POTW.

Settling with or without chemical addition is the basic treatment system indicated in the plant data. Settling tanks, dragout tanks, or clarifiers were used as the main means of solids removal. Various chemicals (polymer, lime, caustic, etc.) are added to the process wastewaters to aid in solids removal.

Plant 51026, Figure V-35, generates slag quench, mold cooling, casting quench, dust collecting, and sand washing process wastewaters which are drained to a series of lagoons, and after 84 hours detention time are discharged to the river. The first lagoon in the series is periodically dredged with the sludge trucked to a nearby landfill. During this clean-out operation, the flow is diverted to a duplicate lagoon.

Plant 54321, Figure V-30, generates slag quench process wastewaters and melting furnace scrubber process wastewaters which, in turn, drain to a drag tank. A sidestream to a classifier removes solids continuously, as well as the continuous removal of settled material by the drag conveyor. Hydrated lime is added to control corrosion. Pumps recycle all of the process wastewater from the drag tank to the quencher and Venturi. There are insufficient data from this plant visit to characterize slag quenching wastewater quality.

Plant 56771, Figure V-17, has a slag quenching system similar to the system at Plant 54321. All process wastewater is recycled.

Plant 52881, Figure V-31, has a system that is a duplicate of the system at Plant 54321. This system also recirculates all of its process wastewater.

Plant 59212, Figure V-23, generates slag quench, dust collector, and melting furnace scrubber process wastewaters which are collected in a drag tank. Chemical additions to aid settling are made, and the water is recirculated to the mist eliminator. Drainage from the mist eliminator is pumped through two cyclones with the clarified water going to the Venturi and returning through the mist eliminator to the cyclones. The cyclone underflow is drained to the drag tank. Solids are removed by the drag conveyor, and overflow water drains to a second settling tank. Treated wastewaters are discharged to a POTW. There is insufficient data from this plant visit to characterize slag quenching wastewater quality.

Plant 15520, Figure V-18, generates slag quench water, dust collection scrubber water, and sand washing process wastewaters which are settled and recycled with makeup from noncontact cooling water. The wastewater discharge is directed to a POTW.

Plant 06956, Figure V-24, generates process wastewaters from melting furnace scrubber, slag quenching, and dust collection operations. These wastewaters are then combined for treatment. The process wastewaters are first treated in a clarifier with polymer added to enhance solids removal and lime added for pH control. The clarifier effluent flows to a lagoon, from which a portion of the treated wastewaters are recycled to the processes listed above. The lagoon not only provides system holding capacity, but also provides additional solids removal capability. Clarifier sludge is transported to a landfill disposal site. A portion of the wastewater flow is discharged from the lagoon. The recycle rate of the combined treatment system is 95 percent.

Plant 55217, Figure V-15, applies water to the slag discharge of a cupola. These wastewaters convey the solidified slag to a slag quench pit, where a conveyor mechanism removes the slag. The slag is transported to a disposal site. Slag quenching wastewaters are recycled, at a rate of 95%, from the pit to the process. The discharge from this quenching process is delivered to a large lagoon which is shared with Plant 56123. Since 1974, all process wastewater has been recycled. Plant 56123, Figure V-29, operates a slag quenching system similar to the system at Plant 55217. However, the slag quench pit discharges to an additional basin, the separation sump. From this sump, 95% of the flow is recycled to the slag quenching operation, while the remainder is discharged to a POTW. There is insufficient data from this plant visit to characterize slag quenching wastewater quality.

Table V-24 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling programs.

Casting Quench and Mold Cooling Process

An estimated 18.4 billion liters (4.87 billion gallons) of process wastewater are generated each year by casting quench and mold cooling operations. This represents 4.6 percent of the total process wastewater flow at plants within the ferrous casting subcategory. Approximately 79 percent of this flow is recycled, 12.3 percent is discharged to navigable waters, and 8.5 percent is discharged to POTWs. An estimated 46 percent of the total process wastewater flow is completely recycled. Plant survey responses indicated a range of applied flow rates varying from 17 l/kkg (4 gal/ton) to 39,280 l/kkg (9,434 gal/ton).

Figure III-7 presents a general process and water flow diagram of a representative ferrous foundry mold cooling and casting quench operation.

In this process, process wastewaters are generated as a result of operations requiring quenching and contact cooling waters. The various types of cooling and quenching operations are listed on the summary Table III-13. The mold cooling operations require contact cooling waters (those mold cooling operations indicated as using noncontact cooling waters were not included on the summary tables). Quenching of the castings takes place either subsequent to casting or to a heat treatment operation following the casting operation. The major impact on the waste loads is

the suspended solids, which consist primarily of scale-like material from the surface of the castings.

A review of the 48 plant responses with casting quench and mold cooling operations indicates that, although the process wastewaters are similar in origin, several approaches are taken for process wastewater treatment. Refer to Table III-13 for descriptions of the treatment systems employed in this subcategory segment. The degree of recycle varies from 0 to 100 percent. The oldest treatment system dates from 1964. Of the 48 foundries with casting quench and mold cooling operations indicated in their data, 11 plants employ complete recycle systems, while 10 plants discharge all of their process wastewaters to POTWs untreated, and 8 plants discharge all of the process wastewaters to a receiving stream without treatment. Ten plants provide treatment prior to discharging all of their process wastewaters to receiving streams, and 9 plants provide treatment for all of process wastewaters prior to discharge to a POTW. Fourteen foundries employ recycle systems with recycle rates less then 100 percent, with 10 of these operations discharging a portion of their process wastewater flow to a POTW and 4 operations discharging a portion of their process wastewater flow to receiving streams.

The treatment technologies noted in the plant data are as follows:

a. Settling: Solids removal is provided. In some cases recycle follows.

b. Cooling Tower and Settling: The cooling tower is used to provide a means of reducing the heat load on the system. In some cases settling is incorporated to provide solids removal as necessary. The cooling tower system is used generally on the higher recycle rate operations.

Plant 51026, Figure V-35, generates casting quench, mold cooling, slag quench, dust collecting, and sand washing wastewaters which are drained to a series of lagoons, and after 84 hours detention time are discharged to the river. The first lagoon in the series is periodically dredged, and the sludge is trucked to a nearby landfill. During this clean-out operation, the flow is diverted to a duplicate lagoon.

Plant 15654, Figure V-36, employs a heat treated casting quench operation involving the complete recycle of all process wastewaters. The treatment system utilizes a settling channel, from which solids are removed infrequently, and a cooling tower to provide for quench water cooling.

Table V-25 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program.

Sand Washing Process

An estimated 9.89 billion liters (2.61 billion gallons) of process wastewater are generated each year by sand washing operations. This represents 2.5 percent of the total process wastewater at plants within the ferrous casting subcategory. Approximately 65 percent of this flow is recycled, while 25.3 percent is discharged to navigable waters and 9.4 percent is discharged to POTWs. Though two plants have been identified which completely recycle their process wastewaters. One of these plants, which lies outside of the statistical survey framework, was sampled during the original foundry industry study. This plant recirculates (at 100 percent) 171.8 million liters (45.4 million gallons) of process wastewater per year in a combined sand washing and dust collection system. Seventy-two percent of the process wastewater comes from the sand washing operation. Plant survey responses indicated an applied flow rate range of 826 l/kkg (198 gal/ton) to 12,840 l/kkg (3,085 gal/ton).

A general process and water flow diagram of a representative sand washing and reclamation system is presented in Figure III-7.

In this operation, wastewaters are generated as a result of using water to wash the used casting sand. The waters are used to remove impurities, primarily "spent" binders and sand, from the casting sand prior to its reuse in the molding processes. The sand and binders become "spent" as a result of the heat present in the casting process. The major pollutant waste load is due to the various materials (primarily metals and binders) washed from the sand.

It should be noted that various pieces of settling and solids removal equipment are used in the sand washing process to collect and dewater the sand prior to its drying and reuse. This equipment is considered to be part of the sand washing operation rather than a part of the process wastewater treatment system. As such, process wastewater treatment equipment is applied to the discharges from the various pieces of sand washing equipment.

A review of the responses from 10 plants with sand washing and reclaiming operations indicates that the process wastewaters are not only generated in the same basic manner, but also are treated in essentially similar systems. Refer to Table III-14 for

descriptions of the treatment systems used in this process. These systems vary from 100 percent discharge to 100 percent recycle systems. The oldest treatment technology in use was installed in 1950.

Of the 10 foundries with sand washing operations indicated in the plant data, 1 plant (01381) recycles all of its process wastewater, while 4 plants treat and then discharge all of their process wastewaters to receiving streams. Five plants have recycle rates less than 100 percent, with 4 plants discharging a portion of their wastewater flow to POTWs and 1 plant discharging a portion of its process wastewater flow to a receiving stream. As noted above, one of the previously sampled plants recycles all of its process wastewaters.

Settling is the basic treatment technology observed in all plant responses. Settling tanks, clarifiers, etc. are used in order to provide solids removal. Four of the plants incorporate a polymer feed in order to enhance solids removal capabilities.

Plant 51473, Figure V-37, has a sand washing process. The sand from shakeout is conveyed to a screen. A magnetic separator removes all metallic particles from the sand. The screen oversize (3/8 in.) goes to a mixer vessel where city water is added. This is thoroughly agitated and then pumped to a slurry tank. The slurry tank meters the mix to a dewater table, where the solids are screw conveyed to a rotary dryer. The underflow from the dewater table is pumped to a settling tank. The settling tank is cleaned out on a weekly schedule, and the solids are removed to landfill. The treated effluent is discharged to a receiving stream.

Plant 51115, Figure V-21, generates dust collection and sand washing wastewaters which are collected, treated with flocculants and sent to a drag tank. The sludge from this settling operation goes to a landfill; the overflow water is drained to a settling pond for additional settling. Overflow from the settling basin goes to a pump wet well. This is pumped to a tank, where it is pumped (as needed) to the dust collectors and the sand washing equipment. This is a complete recycle system.

Plant 15520, Figure V-18, generates sand washing process wastewaters, dust collection scrubber process wastewaters, and slag quench process wastewaters which are settled and recycled. Makeup water is from noncontact cooling water. Overflow is discharged to a POTW.

Plant 20009, Figure V-19, operates a sand reclamation process. The sand washing process wastewater is settled in a series of

four lagoons. Sixty percent of the process wastewater is recycled, while 40 percent is discharged by overflow to a POTW.

Plant 51026, Figure V-35, generates sand washing, mold cooling, casting quench, slag quench, and dust collecting scrubber process wastewaters which are drained to a series of lagoons, and after 84 hours detention time are discharged to the river. The first lagoon in the series is periodically dredged with the sludge being trucked to a nearby landfill. During this clean-out operation, the flow is diverted to a duplicate lagoon.

Plant 59101, Figure V-12, has a sand washing system to reclaim sand for reuse. The process wastewater from this operation flows to lagoons. The lagoons are arranged to give maximum use of the land area. The inlet to the first lagoon is arranged so that the heavy solids can be removed readily. The lagoon overflow is discharged to a nearby creek.

Table V-26 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program.

Lead Casting Operations

An estimated 86.3 million liters (22.8 million gallons) of process wastewater are generated in the casting of lead. Three processes have been identified as using or having the potential to use water in the casting of lead.

Continuous Strip Casting Process

An estimated 8.58 million liters (2.27 million gallons) of process wastewater result each year from the continuous strip casting of lead. This represents 9.8 percent of the total process wastewater flow at plants in the lead casting subcategory. Plant survey responses indicated a range of applied flow rates from 96 l/kkg (23 gal/ton) to 207 l/kkg (49.7 gal/ton) with one complete recycle operation and one 85.5 percent recycle operation. All wastewater effluents in this process segment are discharged to POTWs.

Water is applied, as a cooling medium, to the molds and to the product itself. These waters thus become contaminated with pollutants, primarily the toxic metals, which are characteristic of this subcategory and process segment.

Refer to Table III-16 for summaries of the treatment approaches used in this process segment. Plant 10145, Figure V-38, employs a neutralization tank, lagoon and filter to treat wastewaters prior to discharge to a POTW. The continuous strip casting wastewaters are combined with other process wastewaters for treatment and discharge.

Table V-27 summarizes the waste concentration and waste loads observed in the sampling program.

Melting Furnace Scrubber Process

An estimated 77.7 million liters (20.5 million gallons) of process wastewater result each year from lead casting melting furnace scrubber operations. This represents 90% of the total process wastewater flow at plants in the lead casting subcategory. Plant survey respinses, summarized on Table III-16, indicated a range of applied flow rates from 25 l/kkg (6 gal/ton) to 13,344 l/kkg (3,200 gal/ton).

Wastewaters are generated in the process segment as a result of cleaning the gaseous and particulate emissions from the melting furnace. The process wastewaters from these scrubbers may be recirculated either within the scrubber equipment package or discharged to an external treatment system and then recycled. Of the five plants in the industry, four operate at 100% recycle within the scrubber equipment package, while the remaining plant operates with a 99% recycle and a 1% blowdown to a POTW. This last plant recycles its process wastewaters following sedimentation in a central treatment lagoon.

Grid Casting Process

As incomplete casting data were provided by the Battery Manufacturing Industry, the Agency does not have specific process wastewater flow information for this process segment. Wastewaters are generated in this segment by air pollution control devices which are used to scrub the fumes generated in the pouring and casting of lead into battery grids. After evaluating the data and information provided by air pollution control equipment vendors and the industry, the Agency has concluded that the grid casting and lead melting furnace scrubber process segments are similar with respect to the generation of process wastewaters and wastewater characteristics.

Magnesium Foundries

An estimated 4.37 million liters (1.15 million gallons) of process wastewater are generated each year in the casting of magnesium. Two manufacturing processes have been identified as using water in the magnesium casting subcategory.

Grinding Scrubber Process

An estimated 1.89 million liters (0.50 million gallons) of process wastewater result each year from scrubbers collecting dusts from the grinding of magnesium castings. This represents 43.3 percent of the total process wastewater flow at plants in the magnesium casting subcategory. Plant survey responses indicated an applied flow rate of 6,660 l/kkg (1,600 gal/ton) with one 100 percent recycle operation and one 100 percent discharge operation.

Figure III-8 presents a general process and water flow diagram of a representative magnesium foundry grinding scrubber operation.

Scrubbers are provided on grinding systems in order to remove particulate magnesium generated as a result of the grinding operation. The scrubbing process not only serves to remove the particulate magnesium as an airborne contaminant, but also reduces the fire hazards which can result from an accumulation of fine magnesium particles.

Of the two foundries with grinding scrubber systems indicated in the plant data, one plant recycles all of its process wastewater and one plant discharges all of its process wastewater untreated to a receiving stream. The recycle operation employs an "internal" scrubber equipment package to treat the process wastewater. Refer to Table III-17 for descriptions of the treatment approaches used in the magnesium foundry grinding scrubber systems.

Plant 08146, Figure V-39, employs a dust collector scrubber and a magnesium grinding scrubber. The process wastewaters from these scrubbers are discharged untreated to a receiving stream.

Table V-28 summarizes the raw waste and treated effluent concentrations and waste loads observed in the sampling program.

Dust Collection Scrubber Process

An estimated 49962 liters (0.65 million gallons) of process wastewater are generated each year in dust collection operations. This represents 56.7% of the total process wastewater flow in the magnesium casting subcategory. One dust collection system was indicated in the plant survey data. This operation had an applied flow rate of 92 l/kkg (22 gal/ton). Refer to Table III-18 for a summary of the DCP survey data from this plant.

Figure III-8 presents a general process and water flow diagram of a representative magnesium foundry dust collection operation.

As described in the previous dust collection system discussion, this system is used to remove airborne particulates generated as a result of sand handling, mold making, and shakeout operations. The major pollutant load results from the various process chemicals and binders within the casting sand.

The one foundry indicated in the plant data as utilizing a dust collector system discharges all of its process wastewater untreated to a receiving stream.

Plant 08146, Figure V-39, uses scrubbers to clean sand handling dusts and dusts arising from the grinding of magnesium castings. The process wastewater flow is discharged untreated.

This plant was visited during the sampling program, and the raw waste and treated effluent concentrations waste loads observed during this visit are summarized in Table V-29.

Zinc Foundries

An estimated 9.48 billion liters (2.50 billion gallons) of process wastewater are generated each year by the casting of zinc. Ninety-two and a half percent of this flow is recycle, while 1.9 percent is discharged to navigable waters and 5.5 percent is discharged to POTWs. Two manufacturing processes have been identified which use water in the zinc casting subcategory.

Die Casting and Casting Quench Process

An estimated 548 million liters (145 million gallons) of process wastewater are generated each year in die casting and casting quench operations. This represents 5.8 percent of the total process wastewater flow at plants within the zinc casting subcategory. Of this process' wastewater flow 23.8 percent is recirculated, while 30.2 percent is discharged to navigable waters, and 46.0 percent is discharged to POTWs. An estimated 16

percent of the process wastewater is recirculated at 100 percent. Plant survey responses indicated that applied flow rates ranged from 20 l/kkg to 8,960 l/kkg (4.8 to 2,152 gal/ton) while effluent discharge flow rates ranged from 0 and 8,960 l/kkg to (0 to 2,152 gal/ton.)

General process and water flow diagrams of a representative die casting and casting quench operation are presented in Figure III-9. The process wastewater considered in this operation is that which is discharged from the casting quench tanks.

Raw waste loads will vary depending upon the duration of the quenching cycle, the degree of quenching recycle, the nature of the quenching solutions used, the nature (hardness, corrosivity, etc.) of the raw makeup water and the contamination of the quench wastewater with wastes from other sources (example: hydraulic oil leaks from the die casting machines). However, all process wastewaters sampled contained zinc. Test data from casting quench operations indicated the expected higher metal concentrations from the more corrosive streams and also the expected results of contamination from other sources.

A review of the plant data within this subcategory segment indicates that die casting and casting quench process wastewaters are handled in a variety of ways , although they are generated in the same manner. These treatment schemes range from untreated discharges to discharges to publicly owned treatment works (POTWs), and contractor hauling to complete recycle systems. Refer to Table III-19 for descriptions of the treatment systems used in this subcategory segment. Generally, all plants use some form of settling, even if this is only accomplished in the quench tank itself. However, the quantity of castings quenched, the waste flow through the quench tank, and the size of the quench tank are factors which may necessitate the need for a separate settling stage. One plant employing emulsion breaking, pH adjustment, flocculation with a variety of chemicals and clarification installed the treatment equipment in 1956, while two other emulsion breaking systems were installed in 1973 and 1974.

Of the 20 zinc foundries with casting quench operations indicated in the plant data, 4 of these plants indicated that they employed systems involving the complete (100 percent) recycle of their casting quench process wastewaters. Four other plants utilized systems with varying rates of recycle less than 100 percent. Three of these systems had untreated discharges to POTWs, while the other plant provided more extensive treatment including emulsion breaking, chemical precipitation, and clarification prior to discharge to a receiving stream. Five of the 20 plants

discharged all of their casting quench wastewaters untreated to publicly owned treatment works (POTWs), and five plants discharged treated wastewaters to a POTW. Two plants discharged all of their wastewaters to a receiving stream following treatment. The wastes of one plant were removed by a contract hauler.

Of the 10 plants using some type of process wastewater treatment system, the various technologies used are as follows:

a. Settling and skimming: Removal of primary solids and tramp oils is achieved through settling and skimming. In some instances recycle follows.

b. Emulsion breaking: Using alum and sulfuric acid, the emulsified oils are broken out of the emulsion and are then removed as a scum.

c. pH adjustment, flocculation and clarification: Lime, polymer, alum and other chemicals are used to adjust pH and promote floc formation after which the floc is allowed to settle in the clarifier. This step provides for heavy metals removal, some oil removal, and enhanced solids removal compared to settling tanks.

Plant 18139, Figure V-3, has a number of die casting machines and associated quench tanks which are emptied on a scheduled basis. The schedule results in the emptying of one 1135.5 liter (300 gallon) quench tank each operational day. Each quench tank is emptied about once a month. The quench tank discharge mixes with melting furnace scrubber process wastewater, aluminum casting quench tank flows, and other non-foundry flows prior to settling and skimming. The treated process wastewaters are discharged to a POTW. The zinc quench process wastewater makes up 0.2 percent of the total flow.

Plant 04622, Figure V-40, generates casting quench process wastewater which is hauled away on a contract basis by a reprocessor. The oil and grease and phenol concentrations in the process wastewater of this plant are substantially higher than in the wastewaters of the other two plants sampled. The analytical information for this plant is of interest, in that it shows the results of extensive contamination with non-quench wastes (casting machine hydraulic fluids in particular).

Table V-30 summarizes the raw waste and treated effluent concentrations waste loads for those plants visited.

Melting Furnace Scrubber Process

An estimated 8.93 billion liters (2.36 billion gallons) of process wastewater are generated each year by melting furnace scrubber operations. This represents 94 percent of the total process wastewater flow at plants within the zinc casting subcategory. Approximately ninety-seven percent of this process wastewater is recirculated, while 3.0 percent is discharged to POTWs, and 0.2 percent is discharged to navigable waters. An estimated 63.2 percent of the process wastewater is recirculated at complete recycle operations. Plant survey responses indicated a low applied flow rate of 22,770 l/kkg (5,468 gal/ton) and a high applied flow rate of 102,840 l/kkg (24,700 gal/ton). Recycle rates within the manufacturers' scrubber equipment packages ranged between 85 percent and 100 percent.

A general process and water flow diagram of a representative melting furnace scrubber operation is presented in Figure III-9.

The major effluent load is due to the amount and the cleanliness of the scrap used in the furnace charge. The cleanliness of the scrap influences the furnace emissions. Generally, zinc melting furnaces which melt high quality scrap do not require air pollution control devices. However, when dirty, oily scrap is used, furnace emissions are often controlled by the use of scrubbers. The process wastewater from these scrubbers may be either recirculated within the scrubber equipment package (which includes a settling chamber) or may flow to an external treatment system and then recycle back to the scrubber.

Plant 18139, Figure V-3, has melting furnace scrubber systems for both its aluminum and zinc furnaces. The quench tank process wastewater mixes with melting furnace scrubber process wastewater, aluminum casting quench tank flows, and other non-foundry flows prior to settling and skimming. The treated process wastewaters are discharged to a POTW. The scrubber process wastewater comprises 27 percent of the total treatment flow.

Table V-31 summarizes the raw waste and treated effluent concentrations and waste loads observed during the sampling program. Table III-20 describes the treatment approach used for the zinc melting furnace scrubber system.

TABLE V-1

ANNUAL PRODUCTION OF PLANTS WHICH GENERATE PROCESS WASTEWATERS
(THOUSAND TONS OF METAL POURED PER YEAR)

Subcategory	Production of Direct Dischargers	Production of POTW Dischargers	Production of Zero Dischargers	Total
Aluminum	477.2	388.0	48.3	913.5
Copper	39.6	20.0	33.7	93.3
Ferrous	32,166.0	10,119.1	16,705.0	58,990.1
Lead	0	45.7	32.4	78.1
Magnesium	0.5	0	0.07	0.6
Zinc	84.8	447.9	209.1	741.8
Totals	32,768.1	11,020.7	17,028.6	60,817.4

TABLE V-2

METALS CASTING INDUSTRY DISCHARGE SUMMARY
DIRECT DISCHARGERS - BY PROCESS SEGMENT

Subcategory	Process	Emp. Group	Applied Flow (gal/yr x 10^{-3})	Discharge Flow (gal/yr x 10^{-3})	Recycle Flow (gal/yr x 10^{-3})
Aluminum	Casting Quench	<50	236.0	236.0	0.0
		50-249	2,638.4	2,638.4	0.0
			2,874.4	2,874.4	0.0
	Die Casting	50-249	269,654.4	189,084.6	80,569.8
		≥250	295,258.1	60,429.4	234,828.7
			564,912.5	249,514.0	315,398.5
	Die Lube	≥250	559.7	559.7	0.0
	Investment Casting	<50	835.2	835.2	0.0
		50-249	2,675.9	2,675.9	0.0
			3,511.1	3,511.1	0.0
	Melting Furnace Scrubber	50-249	9,773.9	5,053.6	4,720.3
		≥250	321,474.5	128,589.8	192,884.7
			331,248.4	133,643.4	197,605.0
Aluminum Total			903,106.1	390,102.6	513,003.5
Copper	Mold Cooling and Casting Quench	<50	46.4	46.4	0.0
		50-249	19,881.7	19,881.7	0.0
			19,928.1	19,928.1	0.0
	Dust Collection	<50	229.7	229.7	0.0
		50-249	6,108.9	6,108.9	0.0
			6,338.6	6,338.6	0.0
Copper Total			26,266.7	26,266.7	0.0
Ferrous (Ductile Iron)	Mold Cooling and Casting Quench	50-249	30,596.1	11,014.6	19,581.5
		≥250	1,374,676.5	295,949.5	1,078,727.0
			1,405,272.6	306,964.1	1,098,308.5
	Melting Furnace Scrubber	50-249	153,343.7	69,086.6	84,257.1
		≥250	7,331,992.8	3,759,902.8	3,572,090.0
			7,485,336.5	3,828,989.4	3,656,347.1
	Slag Quench	50-249	129,801.1	26,313.6	103,487.5
		≥250	3,639,539.5	3,600,587.2	38,952.3
			3,769,340.6	3,626,900.8	142,439.8
	Dust Collection	≥250	5,094,230.8	2,478,142.2	2,616,088.6
Ferrous (Ductile Iron) Total			17,754,180.5	10,240,996.5	7,513,184.0
Ferrous (Gray Iron)	Mold Cooling and Casting Quench	50-249	31,378.2	31,378.2	0.0
		≥250	92,033.5	92,033.5	0.0
			123,411.7	123,411.7	0.0
	Melting Furnace Scrubber	<50	221,523.5	2,215.2	219,308.3
		50-249	298,949.2	70,202.9	228,746.3
		≥250	7,122,440.1	2,251,091.2	4,871,348.9
			7,642,912.8	2,323,509.3	5,319,403.5
	Slag Quench	50-249	299,508.7	299,508.7	0.0
		≥250	3,710,316.3	2,093,597.6	1,616,718.7
			4,009,825.0	2,393,106.3	1,616,718.7

TABLE V-2
METALS CASTING INDUSTRY DISCHARGE SUMMARY
DIRECT DISCHARGERS - BY PROCESS SEGMENT
PAGE 2

Subcategory	Process	Emp. Group	Applied Flow (gal/yr x 10^{-3})	Discharge Flow (gal/yr x 10^{-3})	Recycle Flow (gal/yr x 10^{-3})
Ferrous (Gray Iron)	Sand Washing	≥250	1,792,610.1	583,592.4	1,209,017.7
	Dust Collection	<50	148,623.0	1,486.2	147,136.8
		50-249	1,137,140.6	76,158.3	1,060,982.3
		≥250	19,689,252.7	8,429,461.0	11,259,791.7
			20,975,016.3	8,507,105.5	12,467,910.8
Ferrous (Gray Iron) Total			34,543,775.9	13,930,725.2	20,613,050.7
Ferrous (Malleable Iron)	Slag Quench	50-249	1,393.0	1,393.0	0.0
		≥250	70,454.0	70,454.0	0.0
			71,847.0	71,847.0	0.0
	Dust Collection	50-249	59,150.3	13,563.1	45,587.2
		≥250	454,162.1	15,295.1	438,867.0
			513,312.4	28,858.2	484,454.2
Ferrous (Malleable Iron) Total			585,159.4	100,705.2	484,454.2
Ferrous (Steel)	Mold Cooling and Casting Quench	50-249	3,931.5	3,931.5	0.0
		≥250	164,003.0	164,003.0	0.0
			167,934.5	167,934.5	0.0
	Sand Washing	≥250	76,929.8	76,929.8	0.0
	Dust Collection	50-249	51,055.2	51,055.2	0.0
		≥250	153,606.3	29,254.9	124,351.4
			204,661.5	80,310.1	124,351.4
Ferrous (Steel) Total			449,525.8	325,174.4	124,351.4
Ferrous Total			53,332,641.6	24,597,601.3	28,735,040.3
Magnesium	Grinding Scrubbers	<50	390.1	390.1	0.0
	Dust Collection	<50	654.2	654.2	0.0
Magnesium Total			1,044.3	1,044.3	0.0
Zinc	Die Casting and Casting Quench	50-249	51,024.9	41,571.2	9,453.7
		≥250	2,100.3	2,100.3	0.0
			53,125.2	43,671.5	9,453.7
	Melting Furnace Scrubber	50-249	297,520.4	5,057.8	292,462.6
Zinc Total			350,645.6	48,729.3	301,916.3
DIRECT DISCHARGERS TOTALS			54,613,704.3	25,063,744.2	29,549,960.1

TABLE V-3

METALS CASTING INDUSTRY DISCHARGE SUMMARY
DIRECT DISCHARGERS - BY SUBCATEGORY

Employee Group	Applied Flow (gal/yr x 10^{-3})			Discharge Flow (gal/yr x 10^{-3})			Recycle Flow (gal/yr x 10^{-3})		
	<50	50-249	>250	<50	50-249	>250	<50	50-249	>250
Subcategory									
Aluminum	1,071.2	284,742.6	617,292.3	1,071.2	199,452.5	189,578.9	0.0	85,290.1	427,713.4
Copper	276.1	25,990.6	0.0	276.1	25,990.6	0.0	0.0	0.0	0.0
Ferrous (Ductile Iron)	0.0	313,740.9	17,440,439.6	0.0	106,414.8	10,134,581.7	0.0	207,326.1	7,305,857.9
Ferrous (Gray Iron)	370,146.5	1,766,976.7	32,406,652.7	3,701.4	477,248.1	13,449,775.7	366,445.1	1,289,728.6	18,956,877.0
Ferrous (Malleable Iron)	0.0	60,543.3	524,616.1	0.0	14,956.1	85,749.1	0.0	45,587.2	438,867.0
Ferrous (Steel)	0.0	54,986.7	394,539.1	0.0	54,986.7	270,187.7	0.0	0.0	124,351.4
Magnesium	1,044.3	0.0	0.0	1,044.3	0.0	0.0	0.0	0.0	0.0
Zinc	0.0	348,545.3	2,100.3	0.0	46,629.0	2,100.3	0.0	301,916.3	0.0
TOTALS	372,538.1	2,855,526.1	51,385,640.1	6,093.0	925,677.8	24,131,973.4	366,445.1	1,929,848.3	27,253,666.7

TABLE V-4

METALS CASTING INDUSTRY DISCHARGE SUMMARY
POTW DISCHARGERS - BY PROCESS SEGMENT

Subcategory	Process	Emp. Group	Applied Flow (gal/yr x 10^{-3})	Discharge Flow (gal/yr x 10^{-3})	Recycle Flow (gal/yr x 10^{-3})
Aluminum	Casting Quench	<50	10,250.7	10,250.7	0.0
		50-249	4,711.5	1,109.9	3,601.6
		≥250	246.0	246.0	0.0
			15,208.8	11,606.6	3,601.6
	Die Casting	50-249	100,580.8	40,554.0	60,026.8
	Die Lube	50-249	534.1	534.1	0.0
		≥250	738.9	738.9	0.0
			1,273.0	1,273.0	0.0
	Investment Casting	<50	8,463.4	8,463.4	0.0
Aluminum Total			125,525.4	61,897.0	63,628.4
Copper	Mold Cooling and Casting Quench	<50	5,776.7	5,776.7	0.0
		50-249	456,511.4	2,282.6	454,228.8
Copper Total			462,288.1	8,059.3	454,228.8
Ferrous (Ductile Iron)	Mold Cooling and Casting Quench	50-249	25,692.6	22,095.6	3,597.0
	Slag Quench	50-249	61,674.3	13,335.6	48,338.7
		≥250	1,695,732.0	10,174.4	1,685,557.6
			1,757,406.3	23,510.0	1,733,896.3
	Dust Collection	<50	41,639.7	4,164.0	37,475.7
		50-249	160,063.8	9,830.9	150,232.9
		≥250	33,881.5	2,066.8	31,814.7
			235,585.0	16,061.7	219,523.3
Ferrous (Ductile Iron) Total			2,018,683.9	61,667.3	1,957,016.6
Ferrous (Gray Iron)	Mold Cooling and Casting Quench	50-249	7,086.8	7,086.8	0.0
		≥250	34,651.6	6,930.3	27,721.3
			41,738.4	14,017.1	27,721.3
	Melting Furnace Scrubber	<50	23,490.0	11,745.0	11,745.0
		50-249	895,661.1	7,559.3	888,101.8
		≥250	1,917,544.2	285,623.1	1,631,921.1
			2,836,695.3	304,927.4	2,531,767.9
	Slag Quench	50-249	22,661.8	11,016.7	11,645.1
		≥250	482,504.4	365,984.3	116,520.1
			505,166.2	377,001.0	128,165.2
	Sand Washing	≥250	249,464.8	47,398.3	202,066.5
	Dust Collection	<50	133,138.3	9,093.5	124,044.8
		50-249	282,053.6	166,466.9	115,586.7
		≥250	2,434,515.5	179,511.6	2,255,003.9
			2,849,707.4	355,072.0	2,494,635.4
Ferrous (Gray Iron) Total			6,482,772.1	1,098,415.8	5,384,356.3

TABLE V-4
METALS CASTING INDUSTRY DISCHARGE SUMMARY
POTW DISCHARGERS - BY PROCESS SEGMENT
PAGE 2

Subcategory	Process	Emp. Group	Applied Flow (gal/yr x 10^{-3})	Discharge Flow (gal/yr x 10^{-3})	Recycle Flow (gal/yr x 10^{-3})
Ferrous (Malleable Iron)	Melting Furnace Scrubber	≥250	295,944.4	887.8	295,056.6
	Slag Quench	50-249	39,726.3	20,368.4	19,357.9
	Dust Collection	50-249	58,813.2	58,535.6	277.6
		≥250	99,701.9	997.0	98,704.9
			158,515.1	59,532.6	98,982.5
Ferrous (Malleable Iron) Total			494,185.8	80,788.8	413,397.0
Ferrous (Steel)	Mold Cooling and Casting Quench	50-249	433,092.2	1,297.2	431,795.0
		≥250	451,656.6	378,051.1	73,605.5
			884,748.8	379,348.3	505,400.5
	Sand Washing	≥250	451,805.3	198,794.3	253,011.0
	Dust Collection	50-249	172,950.1	8,647.5	164,302.6
		≥250	269,136.5	196,429.2	72,707.3
			442,086.6	205,076.7	237,009.9
Ferrous (Steel) Total			1,778,640.7	783,219.3	995,421.4
Ferrous Total			10,774,282.5	2,024,091.2	8,750,191.3
Lead	Continuous Strip Casting	≥250	2,353.0	2,032.8	320.2
	Melting Furnace Scrubber	≥250	123.7	12.4	111.3
Lead Total			2,476.7	2,045.2	431.5
Zinc	Die Casting and Casting Quench	<50	7,858.3	5,884.3	1,974.0
		50-249	60,754.1	60,754.1	0.0
		≥250	14.8	14.8	0.0
			68,627.2	66,653.2	1,974.0
	Melting Furnace Scrubber	50-249	504,588.0	64,705.4	439,882.6
		≥250	67,365.8	6,736.6	60,629.2
			571,953.8	71,442.0	500,511.8
Zinc Total			640,581.0	138,095.2	502,485.8
POTW DISCHARGERS TOTALS			12,005,153.7	2,234,987.9	9,770,965.8

TABLE V-5

METALS CASTING INDUSTRY DISCHARGE SUMMARY
POTW DISCHARGERS - BY SUBCATEGORY

Employee Group	Applied Flow (gal/yr x 10^{-3})			Discharge Flow (gal/yr x 10^{-3})			Recycle Flow (gal/yr x 10^{-3})		
	<50	50-249	>250	<50	50-249	>250	<50	50-249	>250
Subcategory									
Aluminum	18,714.1	105,826.4	984.9	18,714.1	42,198.0	984.9	0.0	63,628.4	0.0
Copper	5,776.7	456,511.4	0.0	5,776.7	2,282.6	0.0	0.0	454,228.8	0.0
Ferrous (Ductile Iron)	41,639.7	247,430.7	1,729,613.5	4,164.0	45,262.1	12,241.2	37,475.7	202,168.6	1,717,372.3
Ferrous (Gray Iron)	156,628.3	1,207,463.3	5,118,680.5	20,838.5	192,129.7	885,447.6	135,789.8	1,015,333.6	4,233,232.9
Ferrous (Malleable Iron)	0.0	98,539.5	395,646.3	0.0	78,904.0	1,884.8	0.0	19,635.5	393,761.5
Ferrous (Steel)	0.0	606,042.3	1,172,598.4	0.0	9,944.7	773,274.6	0.0	596,097.6	399,323.8
Lead	0.0	0.0	2,016.7	0.0	0.0	1,818.1	0.0	0.0	198.6
Zinc	7,858.3	574,531.7	67,380.6	5,884.3	134,649.1	6,751.4	1,974.0	439,882.6	60,629.2
TOTALS	230,617.1	3,296,345.3	8,486,920.9	55,377.6	505,370.2	1,682,402.6	175,239.5	2,790,975.1	6,804,518.3

TABLE V-6

METALS CASTING INDUSTRY DISCHARGE SUMMARY
ZERO DISCHARGERS - BY PROCESS SEGMENT

Subcategory	Process	Emp. Group	Applied Flow (gal/yr x 10^{-3})	Discharge Flow (gal/yr x 10^{-3})	Recycle Flow (gal/yr x 10^{-3})
Aluminum	Casting Quench	<50	9,544.6	0.0	9,544.6
	Die Lube	≥250	2,030.1	0.0	2,030.1
Aluminum Total			11,574.7	0.0	11,574.7
Copper	Dust Collection	<50	164,073.9	0.0	164,073.9
		50-249	44,555.9	0.0	44,555.9
			208,629.8	0.0	208,629.8
	Mold Cooling and Casting Quench	≥250	1,205,663.7	0.0	1,205,663.7
Copper Total			1,414,293.5	0.0	1,414,293.5
Ferrous (Ductile Iron)	Mold Cooling and Casting Quench	50-249	14,288.6	0.0	14,288.6
	Melting Furnace Scrubber	50-249	68,090.4	0.0	68,090.4
		≥250	53,363.2	0.0	53,363.2
			121,453.6	0.0	121,453.6
	Slag Quench	≥250	42,065.7	0.0	42,065.7
	Dust Collection	<50	61,926.6	0.0	61,926.6
		50-249	317,013.9	0.0	317,013.9
		≥250	264,322.2	0.0	264,322.2
			643,262.7	0.0	643,262.7
Ferrous (Ductile Iron) Total			821,070.6	0.0	821,070.6
Ferrous (Gray Iron)	Mold Cooling and Casting Quench	50-249	14,288.6	0.0	14,288.6
		≥250	34,651.6	0.0	34,651.6
			48,940.2	0.0	48,940.2
	Melting Furnace Scrubber	<50	190,733.9	0.0	190,733.9
		50-249	3,382,002.4	0.0	3,382,002.4
		≥250	9,169,190.9	0.0	9,169,190.9
			12,741,927.2	0.0	12,741,927.2
	Slag Quench	50-249	1,088,264.4	0.0	1,088,264.0
		≥250	14,859.9	0.0	14,859.9
			1,103,123.9	0.0	1,103,123.9
	Sand Washing	≥250	41,478.9	0.0	41,478.9
	Dust Collection	<50	49,681.0	0.0	49,681.0
		50-249	5,344,388.0	0.0	5,344,388.0
		≥250	15,261,120.7	0.0	15,261,120.7
			20,655,189.7	0.0	20,655,189.7
Ferrous (Gray Iron) Total			34,590,659.9	0.0	34,590,659.9

TABLE V-6
METALS CASTING INDUSTRY DISCHARGE SUMMARY
ZERO DISCHARGERS - BY PROCESS SEGMENT
PAGE 2

Subcategory	Process	Emp. Group	Applied Flow (gal/yr x 10^{-3})	Discharge Flow (gal/yr x 10^{-3})	Recycle Flow (gal/yr x 10^{-3})
Ferrous (Malleable Iron)	Mold Cooling and Casting Quench	≥250	14,032.8	0.0	14,032.8
	Melting Furnace Scrubber	50-249	184,552.2	0.0	184,552.2
		≥250	48,195.0	0.0	48,195.0
			232,747.2	0.0	232,747.2
	Slag Quench	50-249	66,736.6	0.0	66,736.6
		≥250	48,195.0	0.0	48,195.0
			114,931.6	0.0	114,931.6
	Dust Collection	50-249	266,578.8	0.0	266,578.8
		≥250	2,113,268.2	0.0	2,113,268.2
			2,379,847.0	0.0	2,379,847.0
Ferrous (Malleable Iron) Total			2,741,558.6	0.0	2,741,558.6
Ferrous (Steel)	Mold Cooling and Casting Quench	<50	18,614.0	0.0	18,614.0
		50-249	506,171.1	0.0	506,171.1
		≥250	1,616,996.7	0.0	1,616,996.7
			2,141,781.8	0.0	2,141,781.8
	Dust Collection	50-249	47,081.1	0.0	47,081.1
		≥250	999,925.2	0.0	999,925.2
			1,047,006.3	0.0	1,047,006.3
Ferrous (Steel) Total			3,228,671.8	0.0	3,228,671.8
Ferrous Total			41,342,077.2	0.0	41,342,077.2
Lead	Continuous Strip Casting	≥250	361.4	0.0	361.4
	Melting Furance Scrubber	≥250	20,401.6	0.0	20,401.6
Lead Total			20,763.0	0.0	20,763.0
Magnesium	Grinding Scrubbers	<50	110.5	0.0	110.5
Magnesium Total			110.5	0.0	110.5
Zinc	Die Casting and Casting Quench	<50	13,451.3	0.0	13,451.3
		≥250	9,544.4	0.0	9,544.4
			22,995.7	0.0	22,995.7
	Melting Furnace Scrubber	50-249	1,490,107.0	0.0	1,490,107.0
Zinc Total			1,513,102.7	0.0	1,513,102.7
ZERO DISCHARGER TOTALS			44,301,921.6	0.0	44,301,921.6

TABLE V-7

METALS CASTING INDUSTRY DISCHARGE SUMMARY
ZERO DISCHARGERS - BY SUBCATEGORY

Employee Group	Applied Flow (gal/yr x 10^{-3})			Discharge Flow (gal/yr x 10^{-3})			Recycle Flow (gal/yr x 10^{-3})		
	<50	50-249	>250	<50	50-249	>250	<50	50-249	>250
Subcategory									
Aluminum	9,544.6	0.0	2,030.1	0.0	0.0	0.0	9,544.6	0.0	2,030.1
Copper	164,073.9	44,555.9	1,205,663.7	0.0	0.0	0.0	164,073.9	44,555.9	1,205,663.7
Ferrous (Ductile Iron)	61,926.6	399,392.9	359,751.1	0.0	0.0	0.0	61,926.6	399,392.9	359,751.1
Ferrous (Gray Iron)	240,414.9	9,828,943.0	24,521,302.0	0.0	0.0	0.0	240,414.9	9,828,943.0	24,521,302.0
Ferrous (Malleable Iron)	0.0	517,867.6	2,223,691.0	0.0	0.0	0.0	0.0	517,867.6	2,223,691.0
Ferrous (Steel)	18,614.0	553,252.2	2,616,921.9	0.0	0.0	0.0	18,614.0	553,252.2	2,616,921.9
Lead	0.0	0.0	20,763.0	0.0	0.0	0.0	0.0	0.0	20,763.0
Magnesium	110.5	0.0	0.0	0.0	0.0	0.0	110.5	0.0	0.0
Zinc	13,451.3	1,490,107.0	9,544.4	0.0	0.0	0.0	13,451.3	1,490,107.0	9,544.4
TOTALS	508,135.8	12,834,118.6	30,959,667.2	0.0	0.0	0.0	508,135.8	12,834,118.6	30,959,667.2

TABLE V-8

ACTIVE WET FOUNDRY OPERATIONS[1]
DISCHARGE MODE PROFILE

	Direct Discharge	Discharge to POTWs	Zero Discharge	Total
Aluminum Casting	28	45	33	106
Copper and Copper Alloy Casting	29	21	28	78
Ferrous Casting	212	196	275	683
Lead Casting	0	5	5	10
Magnesium Casting	6	0	1	7
Zinc Casting	12	60	9	81
TOTAL	287	327	351	965

(1) Statistically based projections.

TABLE V-9

LIST OF TOXIC POLLUTANTS

Number	Type of Compound	Parameter
001	Base/Neutral	Acenaphthene
002	Volatile	Acrolein
003	Volatile	Acrylonitrile
004	Volatile	Benzene
005	Base/Neutral	Benzidine
006	Volatile	Carbon tetrachloride
007	Volatile	Chlorobenzene
008	Base/Neutral	1,2,4-trichlorobenzene
009	Base/Neutral	Hexachlorobenzene
010	Volatile	1,2-dichloroethane
011	Volatile	1,1,1-trichloroethane
012	Base/Neutral	Hexachloroethane
013	Volatile	1,1-dichloroethane
014	Volatile	1,1,2-trichloroethane
015	Volatile	1,1,2,2 -tetrachloroethane
016	Volatile	Chloroethane
017	Volatile	bis(chloromethyl)ether
018	Base/Neutral	bis(2-chloroethyl)ether
019	Volatile	2-chloroethyl vinyl ether
020	Base/Neutral	2-chloronaphthalene
021	Acid	2,4,6-trichlorophenol
022	Acid	Parachlorometacresol
023	Volatile	Chloroform
024	Acid	2-chlorophenol
025	Base/Neutral	1,2-dichlorobenzene
026	Base/Neutral	1,3-dichlorobenzene
027	Base/Neutral	1,4-dichlorobenzene
028	Base/Neutral	3,3'-dichlorobenzidine
029	Volatile	1,1-dichloroethylene
030	Volatile	1,2-trans-dichloroethylene
031	Acid	2,4-dichlorophenol
032	Volatile	1,2-dichloropropane
033	Volatile	1,3-dichloropropylene
034	Acid	2,4-dimethylphenol
035	Base/Neutral	2,4-dinitrotoluene
036	Base/Neutral	2,6-dinitrotoluene
037	Base/Nuetral	1,2-diphenylhydrazine
038	Volatile	Ethylbenzene
039	Base/Neutral	Fluoranthene
040	Base/Neutral	4-chlorophenyl phenyl ether

TABLE V-9
LIST OF TOXIC POLLUTANTS
PAGE 2

Number	Type of Compound	Parameter
041	Base/Neutral	4-bromophenyl phenyl ether
042	Base/Neutral	bis (2-chloroisopropyl)ether
043	Base/Neutral	bis (2-chloroethoxy)methane
044	Volatile	Methylene chloride
045	Volatile	Methyl chloride
046	Volatile	Methyl bromide
047	Volatile	Bromoform
048	Volatile	Dichlorobromomethane
049	Volatile	Trichlorofluoromethane
050	Volatile	Dichlorodifluoromethane
051	Volatile	Chlorodibromomethane
052	Base/Neutral	Hexachlorobutadiene
053	Base/Neutral	Hexachlorocyclopentadiene
054	Base/Neutral	Isophorone
055	Base/Neutral	Naphthalene
056	Base/Neutral	Nitrobenzene
057	Acid	2-nitrophenol
058	Acid	4-nitrophenol
059	Acid	2,4-dinitrophenol
060	Acid	4,6-dinitro-o-cresol
061	Base/Neutral	N-nitrosodimethylamine
062	Base/Neutral	N-nitrosodiphenylamine
063	Base/Neutral	N-nitrosodi-n-propylamine
064	Acid	Pentachlorophenol
065	Acid	Phenol
066	Base/Neutral	bis (2-ethylhexyl)phthalate
067	Base/Neutral	Butyl benzyl phthalate
068	Base/Neutral	Di-n-butyl phthalate
069	Base/Neutral	Di-n-octyl phthalate
070	Base/Neutral	Diethyl phthalate
071	Base/Neutral	Dimethyl phthalate
072	Base/Neutral	Benzo(a)anthracene
073	Base/Neutral	Benzo(a)pyrene
074	Base/Neutral	3,4-benzofluoranthene
075	Base/Neutral	Benzo(k)fluoranthene
076	Base/Neutral	Chrysene
077	Base/Neutral	Acenaphthylene
078	Base/Neutral	Anthracene
079	Base/Neutral	Benzo(ghi)perylene
080	Base/Neutral	Fluorene

TABLE V-9
LIST OF TOXIC POLLUTANTS
PAGE 3

Number	Type of Compound	Parameter
081	Base/Neutral	Phenanthrene
082	Base/Neutral	Dibenzo(a,h)anthracene
083	Base/Neutral	Indeno(1,2,3,cd)pyrene
084	Base/Neutral	Pyrene
085	Volatile	Tetrachloroethylene
086	Volatile	Toluene
087	Volatile	Trichloroethylene
088	Volatile	Vinyl chloride
089	Pesticide	Aldrin
090	Pesticide	Dieldrin
091	Pesticide	Chlordane
092	Pesticide	4,4'-DDT
093	Pesticide	4,4'-DDE
094	Pesticide	4,4'-DDD
095	Pesticide	a-endosulfan-Alpha
096	Pesticide	b-endosulfan-Beta
097	Pesticide	Endosulfan sulfate
098	Pesticide	Endrin
099	Pesticide	Endrin aldehyde
100	Pesticide	Heptachlor
101	Pesticide	Heptachlor expoxide
102	Pesticide	a-BHC-Alpha
103	Pesticide	b-BHC-Beta
104	Pesticide	r-BHC-Gamma
105	Pesticide	g-BHC-Delta
106	Pesticide	PCB-1242
107	Pesticide	PCB-1254
108	Pesticide	PCB-1221
109	Pesticide	PCB-1232
110	Pesticide	PCB-1248
111	Pesticide	PCB-1260
112	Pesticide	PCB-1016
113	Pesticide	Toxaphene
114	Inorganic	Antimony
115	Inorganic	Arsenic
116	Inorganic	Asbestos
117	Inorganic	Beryllium
118	Inorganic	Cadmium
119	Inorganic	Chromium
120	Inorganic	Copper
121	Inorganic	Cyanide

TABLE V-9
LIST OF TOXIC POLLUTANTS
PAGE 4

Number	Type of Compound	Parameter
122	Inorganic	Lead
123	Inorganic	Mercury
124	Inorganic	Nickel
125	Inorganic	Selenium
126	Inorganic	Silver
127	Inorganic	Thallium
128	Inorganic	Zinc
129	Base/Neutral	2,3,7,8,-tetrachloro-dibenzo-p-dioxin (TCDD)
130	Volatile	Xylene

TABLE V-10

CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

Acidity, free	Nitrogen
Acidity, total	Phenolic Compounds
Alkalinity (Methyl Orange)	Potassium
Alkalinity (Phenolphthalein)	Silica, Soluble
Aluminum	Sodium
Ammonia-N	Sulfate
Calcium	Sulfide
Carbon, Organic	Temperature
Chloride	Thiocyanate
Cyanate	Tin
Fluoride	Oil and Grease
Hardness	Solids, Dissolved
Iron	Solids, Suspended
Magnesium	Solids, Volatile
Manganese	pH

TABLE V-11

PLANT ASSESSMENT OF THE KNOWN OR BELIEVED PRESENCE OF TOXIC POLLUTANTS IN FOUNDRY RAW PROCESS WASTEWATERS

SUBCATEGORY: Aluminum Casting

All Processes

Pollutant	Known to be Present	Believed to be Present
012 - Hexachloroethane		1
020 - 2-chloronaphthalene		1
031 - 2,4-dichlorophenol		1
065 - Phenol	2	
101 - Heptachlor epoxide		1
105 - g-BHC-Delta		1
110 - PCB-1248	1	
117 - Beryllium		1
118 - Cadmium		1
119 - Chromium	4	2
120 - Copper	5	1
122 - Lead	3	
124 - Nickel	3	1
128 - Zinc	2	

SUBCATEGORY: Copper & Copper Alloy Casting

All Processes

Pollutant	Known to be Present	Believed to be Present
114 - Antimony	2	1
119 - Chromium		1
120 - Copper	2	2
122 - Lead	2	2
124 - Nickel		1

TABLE V-11
PLANT ASSESSMENT OF THE KNOWN OR BELIEVED PRESENCE
OF TOXIC POLLUTANTS IN FOUNDRY RAW PROCESS WASTEWATERS
PAGE 2

SUBCATEGORY: Ferrous Casting

PROCESS: Dust Collection

Pollutant	Known to be Present	Believed to be Present
004 - Benzene	1	1
007 - Chlorobenzene		1
008 - 1,2,4-trichlorobenzene		1
009 - Hexachlorobenzene		1
021 - 2,4,6-trichlorophenol		1
024 - 2-chlorophenol		1
025 - 1,2-dichlorobenzene		1
026 - 1,3-dichlorobenzene		1
027 - 1,4-dichlorobenzene		1
031 - 2,4-dichlorophenol		1
034 - 2,4-dimethyl phenol		1
035 - 2,4-dinitrotoluene		1
036 - 2,6-dinitrotoluene		1
038 - Ethylbenzene		1
052 - Hexachlorobutadiene		1
055 - Naphthalene		1
064 - Pentachlorophenol		1
065 - Phenol	30	15
086 - Toluene		2
114 - Antimony	1	1
118 - Cadmium	2	
119 - Chromium	11	
120 - Copper	12	
121 - Cyanide		3
122 - Lead	10	
124 - Nickel	9	1
125 - Selenium		1
126 - Silver	2	
127 - Thallium	1	
128 - Zinc	10	

TABLE V-11
PLANT ASSESSMENT OF THE KNOWN OR BELIEVED PRESENCE
OF TOXIC POLLUTANTS IN FOUNDRY RAW PROCESS WASTEWATERS
PAGE 3

SUBCATEGORY: Ferrous Casting

PROCESS: Melting Furnace Scrubber

Pollutant	Known to be Present	Believed to be Present
065 - Phenol	2	2
105 - g-BHC-Delta	1	
114 - Antimony	2	
115 - Arsenic	2	
118 - Cadmium	4	3
119 - Chromium	9	5
120 - Copper	9	7
121 - Cyanide	2	2
122 - Lead	10	3
123 - Mercury	3	
124 - Nickel	10	4
125 - Selenium	4	
126 - Silver	4	
127 - Thallium	1	
128 - Zinc	14	

SUBCATEGORY: Ferrous Casting

PROCESS: Slag Quenching

Pollutant	Known to be Present	Believed to be Present
114 - Antimony	1	
118 - Cadmium	4	
119 - Chromium	6	1
120 - Copper	6	1
122 - Lead	6	
123 - Mercury	2	
124 - Nickel	4	
125 - Selenium	1	
126 - Silver	3	
127 - Thallium	1	
128 - Zinc	7	

TABLE V-11
PLANT ASSESSMENT OF THE KNOWN OR BELIEVED PRESENCE
OF TOXIC POLLUTANTS IN FOUNDRY RAW PROCESS WASTEWATERS
PAGE 4

SUBCATEGORY: Ferrous Casting

PROCESS: Sand Washing

Pollutant	Known to be Present	Believed to be Present
065 - Phenol	1	
122 - Lead	1	
124 - Nickel	1	
128 - Zinc	1	

SUBCATEGORY: Lead Casting

All Processes

Pollutant	Known to be Present	Believed to be Present
010 - 1,2-dichloroethane		1
011 - 1,1,1-trichloroethane		5
044 - Methylene Chloride	6	
050 - Dichlordifluoromethane		4
055 - Naphthalene		6
086 - Toluene		1
106 - PCB-1242		1
107 - PCB-1254		1
111 - PCB-1260		1
114 - Antimony	38	8
115 - Arsenic	30	7
118 - Cadmium	24	2
119 - Chromium	15	2
120 - Copper	14	32
122 - Lead	65	9
123 - Mercury		6
124 - Nickel	20	8
125 - Selenium	6	
126 - Silver	6	5
128 - Zinc	21	7
130 - Xylene		3

TABLE V-11
PLANT ASSESSMENT OF THE KNOWN OR BELIEVED PRESENCE
OF TOXIC POLLUTANTS IN FOUNDRY RAW PROCESS WASTEWATERS
PAGE 5

SUBCATEGORY: Magnesium Casting

All Processes

Pollutant	Known to be Present	Believed to be Present
117 - Beryllium	1	
120 - Copper	1	
124 - Nickel	1	
128 - Zinc	1	

SUBCATEGORY: Zinc Casting

All Processes

Pollutant	Known to be Present	Believed to be Present
055 - Naphthalene		1
065 - Phenol		1
073 - Benzo(a)pyrene	1	
114 - Antimony	3	
115 - Arsenic	1	
117 - Beryllium		1
118 - Cadmium	3	1
120 - Copper	1	
121 - Cyanide	1	1
124 - Nickel	1	
128 - Zinc	9	1

TABLE V-12

TOXIC POLLUTANTS CONSIDERED TO BE
PRESENT IN FOUNDRY PROCESS WASTEWATERS

SUBCATEGORY: Aluminum Casting
ALL PROCESSES

004 - Benzene
006 - Carbon tetrachloride
044 - Methylene chloride
061 - N-nitrosodimethylamine
062 - N-nitrosodiphenylamine
063 - N-nitrosodi-n-propylamine
065 - Phenol
086 - Toluene
124 - Nickel
125 - Selenium
128 - Zinc

SUBCATEGORY: Copper Casting
ALL PROCESSES

114 - Antimony
117 - Beryllium
119 - Chromium
120 - Copper
122 - Lead
124 - Nickel
128 - Zinc

SUBCATEGORY: Ferrous Casting
PROCESS: Dust Collection

003 - Acrylonitrile
004 - Benzene
055 - Naphthalene
061 - N-nitrosodimethylamine
062 - N-nitrosodiphenylamine
063 - N-nitrosodi-n-propylamine
065 - Phenol
086 - Toluene
119 - Chromium
120 - Copper
121 - Cyanide
122 - Lead
124 - Nickel
125 - Selenium
128 - Zinc

SUBCATEGORY: Ferrous Casting
PROCESS: Melting Furnace Scrubber

004 - Benzene
055 - Naphthalene
061 - N-nitrosodimethylamine
062 - N-nitrosodiphenylamine
063 - N-nitrosodi-n-propylamine
065 - Phenol
086 - Toluene
118 - Cadmium
119 - Chromium
120 - Copper
122 - Lead
124 - Nickel
125 - Selenium
128 - Zinc

TABLE V-12
TOXIC POLLUTANTS CONSIDERED TO BE
PRESENT IN FOUNDRY PROCESS WASTEWATERS
PAGE 2

SUBCATEGORY: Ferrous Casting
PROCESS: Slag Quenching

055 - Naphthalene
061 - N-nitrosodimethylamine
062 - N-nitrosodiphenylamine
063 - N-nitrosodi-n-propylamine
065 - Phenol
086 - Toluene
118 - Cadmium
119 - Chromium
120 - Copper
122 - Lead
124 - Nickel
125 - Selenium
128 - Zinc

SUBCATEGORY: Ferrous Casting
PROCESS: Sand Washing

003 - Acrylonitrile
004 - Benzene
055 - Naphthalene
061 - N-nitrosodimethylamine
062 - N-nitrosodiphenylamine
063 - N-nitrosodi-n-propylamine
065 - Phenol
086 - Toluene
119 - Chromium
120 - Copper
121 - Cyanide
122 - Lead
124 - Nickel
125 - Selenium
128 - Zinc

SUBCATEGORY: Lead Casting
ALL PROCESSES

011 - 1,1,1-trichloroethane
023 - Chloroform
044 - Methylene chloride
055 - Naphthalene
065 - Phenol
078 - Anthracene
081 - Phenanthrene
084 - Pyrene
114 - Antimony
115 - Arsenic
118 - Cadmium
119 - Chromium
120 - Copper
122 - Lead
123 - Mercury
124 - Nickel
126 - Silver
128 - Zinc

SUBCATEGORY: Magnesium Casting
ALL PROCESSES

065 - Phenol

TABLE V-12
TOXIC POLLUTANTS CONSIDERED TO BE
PRESENT IN FOUNDRY PROCESS WASTEWATERS
PAGE 3

SUBCATEGORY: Zinc Casting
ALL PROCESSES

004 - Benzene
006 - Carbon tetrachloride
044 - Methylene chloride
061 - N-nitrosodimethylamine
062 - N-nitrosodiphenylamine
063 - N-nitrosodi-n-propylamine
065 - Phenol
086 - Toluene
124 - Nickel
128 - Zinc

TABLE V-13

INORGANIC TOXIC POLLUTANTS SELECTED FOR SAMPLING AND ANALYSIS DURING VERIFICATION PLANT VISITS

	Sb	As	Be	Cd	Cr	Cu	CN^- (Total)	Pb	Hg	Ni	Se	Ag	Tl	Zn
Aluminum Subcategory														
Investment Casting					X	X	X	X	X	X	X			X
Melting Furnace Scrubbers							X	X	X	X	X			X
Casting Quench					X		X	X	X	X	X			X
Die Casting					X		X	X	X	X	X			X
Die Lube					X		X	X	X	X	X			X
Copper and Copper Alloy Subcategory														
Dust Collection Systems				X	X	X	X	X	X	X	X			X
Mold Cooling and Casting Quench				X		X	X	X	X	X	X			X
Ferrous Subcategory														
Dust Collection Systems	X	X	X	X	X	X	X	X	X	X	X			X
Melting Furnace Scrubbers	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Slag Quenching				X	X	X	X	X	X	X	X			X
Casting Quench and Mold Cooling	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sand Washing	X	X	X	X	X	X	X	X	X	X	X			X
Lead Subcategory														
Continuous Strip Casting	X	X		X	X	X		X	X	X		X		X
Melting Furnace Scrubber	X	X		X	X	X		X	X	X		X		X
Magnesium Subcategory														
Grinding Scrubber Systems						X	X	X	X		X			X
Dust Collection Systems						X	X	X	X		X			X
Zinc Subcategory														
Casting Quench					X	X	X	X	X	X	X			X
Melting Furnace Scrubbers					X	X	X	X	X	X	X			X

TABLE V-14

TYPES AND AMOUNTS OF BINDERS USED IN FOUNDRIES

Binder	Pounds per Year							
	Aluminum	Copper	Iron	Steel	Magnesium	Zinc	Total	%
Linseed Oil	-	40,447	10,504,383	872,015	-	-	11,416,845	6.5
Alkyd Oil	28,800	7,160	3,942,725	676,145	-	-	4,654,830	2.6
Urea Formaldehyde	555,000	164,236	22,183,186	426,406	-	-	23,328,828	13.2
Furan: No Bake	-	48,285	3,614,239	1,277,424	-	-	4,939,948	2.8
Furan: Hot Bake	-	7,631	1,907,936	4,262,400	-	-	6,177,967	3.5
Oil Urethane	-	-	580,308	-	-	-	580,308	0.3
Furnace Bake	-	-	-	-	-	-	-	-
Sulfonic Acids	-	-	737,617	72,150	-	-	809,767	0.5
Phenolic Urethane	2,132	162,415	18,209,723	5,350,200	-	-	23,724,470	13.5
Cold Box	-	-	-	-	-	-	-	-
Cold Box Isocyanates	1,243	-	4,752,151	-	-	-	4,753,394	2.7
Silicate	493,284	4,662	575,749	921,780	-	-	1,995,475	1.1
Colloided Silica	521,700	-	21,700	75,036	-	-	618,436	0.4
Hot Box	75,480	173,915	79,006,515	567,594	-	-	79,823,504	45.3
No Bake	-	15,318	5,238,642	3,120,183	17,100	3,330	8,394,573	4.8
CO_2 Process	668,775	44,400	1,471,304	2,649,667	16,000	-	4,850,146	2.8
Air Setting Process	-	-	-	-	-	-	-	-
Total							176,068,491	100

TABLE V-15

CHARACTERISTICS OF ALUMINUM
INVESTMENT CASTING PROCESS WASTEWATERS

Raw Wastewater

Plant:	4704
Production (kkg/day):	4.54 (5 TPD)
Flow (l/kkg):	20296 (4867 GPT)
Sample Points:	B+D+E

Pollutants	mg/l	kg/kkg (lbs/1000 lbs)
085 Tetrachloroethylene	0.105	0.00213
087 Trichloroethylene	0.067	0.00136
120 Copper	0.48	0.0097
128 Zinc	0.53	0.0107
Oil and Grease	27	0.54
TSS	951	19.29
pH (Units)	6.6-8.6	

Treated Effluent

Plant:	4704
Flow (l/kkg):	20296 (4867 GPT)
Sample Points:	((B+D+E)/(B+D+E+F))H
C&TT:	FLP,TP,FFOG

Pollutants	mg/l	kg/kkg (lbs/1000 lbs)
085 Tetrachloroethylene	0.098	0.00199
087 Trichloroethylene	0.074	0.0015
120 Copper	0.06	0.00123
128 Zinc	0.10	0.00203
Oil and Grease	11	0.22
TSS	81	1.65
pH (Units)	6.6-9.8	

Note: For definitions of C&TT codes refer to Table III-21.

TABLE V-16

CHARACTERISTICS OF ALUMINUM
MELTING FURNACE SCRUBBER PROCESS WASTEWATERS

Raw Wastewater

Plant:	17089		18139		
Production (kkg/day):	207.9 (229 TPD)		42.4 (46.7 TPD)		
Flow (l/kkg):	11854 (2842 GPT)		4116 (987 GPT)		
Sample Points:	E		C		
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	Average kg/kkg (lbs/1000 lbs)
021 2,4,6-trichlorophenol	0.139	0.00165	0.014	0.000056	0.000853
039 Fluoranthene	0.012	0.000146	0.010	0.000041	0.000094
073 Benzo(a)pyrene	ND	0.000	0.036	0.000148	0.000075
128 Zinc	0.26	0.00313	18.54	0.0542	0.0287
Ammonia (N)	0.10	0.00119	0.30	0.00124	0.00122
Phenols (4AAP)	0.841	0.00996	0.032	0.000132	0.00505
Sulfide	1.40	0.0166	0.33	0.00137	0.0180
Oil and Grease	13	0.154	3	0.0110	0.0825
TSS	48	0.569	9	0.0384	0.304
pH (Units)	7.3-7.4		8.1-8.2		

Treated Effluent

Plant:	17089		18139	
Flow (l/kkg):	4143 (994 GPT)		4116 (987 GPT)	
Sample Points:	((E/(D+E+A))G		(C/(B+C+D+E+H))G	
C&TT:	OS,FLA,FLP,CL,T,FDSP,CY,RTP-65		OS,SB	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
021 2,4,6-trichlorophenol	0.051	0.000211	0.006	0.000025
039 Fluoranthene	0.009	0.000037	0.017	0.000072
073 Benzo(a)pyrene	0.0	0.000	ND	0.000
128 Zinc	0.05	0.000227	13.24	0.0387
Ammonia (N)	0.1	0.000415	0.30	0.00136
Phenols (4AAP)	0.151	0.000626	0.005	0.000020
Sulfide	0.5	0.00217	0.40	0.00165
Oil and Grease	2	0.0081	3	0.012
TSS	9	0.0378	7	0.0291
pH (Units)	7.0-8.0		7.1-8.4	

ND: Not Detected

Note: For definitions of C&TT codes, refer to Table III-21.

TABLE V-17

CHARACTERISTICS OF ALUMINUM
CASTING QUENCH PROCESS WASTEWATERS

Raw Wastewater

Plant:	10308		17089		18139		
Production (kkg/day):	25.3 (27.9 TPD)		234.3 (258 TPD)		1.9 (2.1 TPD)		
Flow (l/kkg):	116 (27.9 GPT)		5069 (1216 GPT)		600 (144 GPT)		
Sample Points:	C		C		E		
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	Average kg/kkg (lbs/1000 lbs)
021 2,4,6-trichlorophenol	0.325	0.000035	0.702	0.0036	0.203	0.00012	0.00125
031 2,4-dichlorophenol	ND	0.000	0.073	0.000371	ND	0.000	0.000124
039 Fluoranthene	0.011	0.000001	0.003	0.000017	0.226	0.00013	0.0000493
067 Butyl benzyl phthalate	0.043	0.000005	ND	0.000	0.053	0.0030	0.0010
084 Pyrene	0.011	0.000001	0.010	0.000052	0.279	0.000159	0.0000071
085 Tetrachloroethylene	0.107	0.000012	0.007	0.0034	0.135	0.000077	0.00116
120 Copper	0.08	0.000008	0.07	0.00036	0.26	0.00015	0.000173
128 Zinc	9.85	0.00106	0.84	0.0043	0.31	0.000174	0.00553
130 Xylene	ND	0.000	ND	0.000	0.022	0.000012	0.000004
Sulfide	40.0	0.0043	0.40	0.0019	1.05	0.00060	0.00227
Oil and Grease	150	0.0162	505	2.56	163	0.093	0.890
TSS	63	0.0067	111	0.56	990	0.56	0.376
pH (Units)	8.6		7.2-7.7		5.4-6.1		

Treated Effluent

Plant:	10308		17089		18139	
Flow (l/kkg):	116 (27.9 GPT)		1769 (424 GPT)		600 (144 GPT)	
Sample Points:	(C/(B+C+D+E))I		(D/(D+E+A))G		(E/(B+C+D+E+H))G	
C&TT:	NA,NC,GF,EB,FLA, FLC,FLP,SB,SS		OS,FLA,FLP,CL, T,FDSP,CY,RTP-65		OS,SB	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
021 2,4,6-trichlorophenol	ND	0.000	0.285	0.000503	0.091	0.000052
031 2,4-dichlorophenol	0.00	0.000	0.017	0.000031	0.00	0.00
039 Fluoranthene	ND	0.000	0.002	0.000004	0.395	0.000226
067 Butyl benzyl phthalate	ND	0.000	0.00	0.000	0.032	0.000018
084 Pyrene	ND	0.000	0.003	0.000005	0.328	0.000187
085 Tetrachloroethylene	0.064	0.000007	0.069	0.000121	0.169	0.000097
120 Copper	0.02	0.000002	0.01	0.000034	0.30	0.000174
128 Zinc	1.01	0.000109	0.63	0.0032	0.22	0.000124
130 Xylene	ND	0.000	ND	0.000	ND	0.000
Sulfide	7.8	0.00084	0.5	0.0023	1.26	0.00072
Oil and Grease	8	0.00085	12	0.058	181	0.103
TSS	5	0.00059	8	0.041	749	0.428
pH (Units)	7.9-9.1		7.0-8.0		5.4-8.4	

ND: Not Detected

Note: For definitions of C&TT codes, refer to Table III-21.

TABLE V-18

CHARACTERISTICS OF ALUMINUM
DIE CASTING PROCESS WASTEWATERS

Raw Wastewater

Plant:	17089		12040			
Production (kkg/day):	234.3 (258 TPD)		46.1 (50.8 TPD)			
Flow (l/kkg):	5074 (1217 GPT)		5556 (1333 GPT)			
Sample Points:	C		B			
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	Average kg/kkg (lbs/1000 lbs)	
001 Acenaphthene	ND	0.000	0.204	0.0011	0.00055	
021 2,4,6-trichlorophenol	0.702	0.00356	ND	0.000	0.00178	
022 Parachlorometacresol	0.032	0.000161	0.108	0.000599	0.00038	
023 Chloroform	0.275	0.0014	0.018	0.00010	0.00075	
039 Fluoranthene	0.003	0.000017	0.437	0.0024	0.00121	
063 N-nitrosodi-n-propylamine	ND	0.000	0.05	0.000275	0.00014	
065 Phenol	1.673	0.0085	0.026	0.000143	0.0043	
067 Butyl benzyl phthalate	ND	0.000	0.685	0.0038	0.0019	
072 Benzo(a)anthracene	6.2*	0.032	ND	0.000	0.016	
076 Chrysene	6.2*	0.032	0.806	0.00447	0.0182	
084 Pyrene	0.010	0.000052	0.082	0.00046	0.000256	
085 Tetrachloroethylene	0.007	0.000034	0.082	0.00046	0.000247	
122 Lead	0.05	0.0013	0.25	0.0014	0.00135	
128 Zinc	0.84	0.0043	3.67	0.0204	0.0124	
130 Xylene	ND	0.000	0.045	0.00025	0.000125	
Phenols (4AAP)	3.26	0.0165	0.087	0.00048	0.00849	
Oil and Grease	505	2.56	708	3.93	3.245	
TSS	111	0.56	536	2.98	2.05	
pH (Units)	7.2-7.7		7.1-7.2			

Treated Effluent

Plant:	17089	12040
Flow (l/kkg):	1768 (424 GPT)	5556 (1333)
Sample Points:	(D/(D+E+A))G	(B/D)E
C&TT:	OS,FLA,FLP,CL,T, FDSP,CY,RTP-65	EB,FLP,GF,NC,SB, VF,NA,FLA,SS

Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
001 Acenaphthene	0.00	0.000	#	#
021 2,4,6-trichlorophenol	0.285	0.000503	#	#
022 Parachlorometacresol	ND	0.000	0.061	0.00034
023 Chloroform	0.419	0.000741	#	#
039 Fluoranthene	0.002	0.000004	#	#
063 N-nitrosodi-n-propylamine	ND	0.000	ND	0.000
065 Phenol	0.053	0.000093	#	#
067 Butyl benzyl phthalate	0.00	0.000	0.017	0.000098
072 Benzo(a)anthracene	#	#	#	#
076 Chrysene	#	#	0.258	0.00143
084 Pyrene	0.003	0.000005	#	#
085 Tetrachloroethylene	0.069	0.000121	0.032	0.000178
122 Lead	0.05	0.000089	0.103	0.00057
128 Zinc	0.64	0.0011	4.29	0.0238
130 Xylene	ND	0.000	0.0158	0.000088
Phenols (4AAP)	0.689	0.0012	0.064	0.000357
Oil and Grease	12	0.0204	3.57	0.0198
TSS	8	0.0143	2.4	0.0135
pH (Units)	7.0-8.0		7.1-9.1	

ND: Not Detected
: Calculation could not be completed.
* : Could not be separated.

Note: For definitions of C&TT codes, refer to Table III-21.

TABLE V-19

CHARACTERISTICS OF ALUMINUM
DIE LUBE PROCESS WASTEWATERS

Raw Wastewaters

Plant:	20147
Production (kkg/day):	156.2 (172 TPD)
Flow (l/kkg):	153.5 (36.8 GPT)
Sample Points:	C+G

Pollutants		mg/l	kg/kkg (lbs/1000 lbs)
005	Benzidine	1.385	0.000213
006	Carbon tetrachloride	0.305	0.000047
007	Chlorobenzene	0.295	0.000045
010	1,2-dichloroethane	0.160	0.000024
011	1,1,1-trichloroethane	17.466	0.268
013	1,1-dichloroethane	0.053	0.0000081
021	2,4,6-trichlorophenol	0.225	0.000035
023	Chloroform	0.527	0.0081
039	Fluoranthene	2.915	0.000447
044	Methylene chloride	3.085	0.000474
055	Naphthalene	1.439	0.000221
058	4-nitrophenol	0.082	0.000013
064	Pentachlorophenol	1.020	0.000157
065	Phenol	21.863	0.00336
066	bis(2-ethylhexyl)phthalate	382.335	0.0587
067	Butyl benzyl phthalate	0.029	0.0000045
072	Benzo(a)anthracene	11.295	0.00173
077	Acenaphthylene	0.82	0.000126
078	Anthracene	0.66*	0.000098
080	Fluorene	3.664	0.000562
081	Phenanthrene	0.66*	0.000098
084	Pyrene	0.346	0.000053
085	Tetrachlorethylene	0.132	0.000020
087	Trichloroethylene	0.281	0.000043
091	Chlordane	0.068	0.000010
120	Copper	0.65	0.000099
122	Lead	2.55	0.000391
128	Zinc	2.15	0.000330
130	Xylene	33.119	0.00508
	Ammonia (N)	22.95	0.0035
	Phenols (4AAP)	81.02	0.0124
	Sulfide	1.6	0.000239
	Oil and Grease	21193	3.25
	TSS	2092	0.32
	pH (Units)	6.9-7.7	

TABLE V-19
CHARACTERISTICS OF ALUMINUM
DIE LUBE PROCESS WASTEWATERS
PAGE 2

Treated Effluent

Plant:	20147
Flow (l/kkg):	0 (0 GPT)
Sample Points:	E
C&TT:	CY,FFOG,RTP-100

Pollutants		mg/l	kg/kkg (lbs/1000 lbs)
005	Benzidine	ND	-
006	Carbon tetrachloride	0.605	-
007	Chlorobenzene	1.00	-
010	1,2-dichloroethane	ND	-
011	1,1,1-trichloroethane	1.262	-
013	1,1-dichloroethane	ND	-
021	2,4,6-trichlorophenol	1.877	-
023	Chloroform	0.286	-
039	Fluoranthene	ND	-
044	Methylene chloride	2.204	-
055	Naphthalene	0.090	-
058	4-nitrophenol	ND	-
064	Pentachlorophenol	ND	-
065	Phenol	40.75	-
066	Bis(2-ethylhexyl)phthalate	404.12	-
067	Butyl benzyl phthalate	ND	-
072	Benzo(a)anthracene	ND	-
077	Acenaphthylene	ND	-
078	Anthracene	ND	-
080	Fluorene	5.70	-
081	Phenanthrene	ND	-
084	Pyrene	0.18	-
085	Tetrachloroethylene	0.965	-
087	Trichloroethylene	0.125	-
091	Chlordane	0.037	-
120	Copper	0.61	-
122	Lead	2.95	-
128	Zinc	2.14	-
130	Xylene	36.271	-
	Ammonia (N)	16.8	-
	Phenols (4AAP)	82.29	-
	Sulfide	0.2	-
	Oil and Grease	26809	-
	TSS	3078	-
	pH (Units)	6.7-7.1	

ND: Not Detected
* : Could not be separated.
- : Zero discharge, therefore, no effluent loads.

Note: For definitions of C&TT codes, refer to Table III-21.

TABLE V-20

CHARACTERISTICS OF COPPER
DUST COLLECTION PROCESS WASTEWATERS

Raw Wastewater

Plant:		9094	
Sand Handled (kkg/day):		386.8 (426 TPD)	
Flow (l/kkg):		549 (132 GPT)	
Sample Point:		D+E	
Pollutants		mg/l	kg/kkg (lbs/1000 lbs)
067	Butyl benzyl phthalate	0.191	0.00105
074	3,4-benzofluoranthene	0.010*	0.000006
075	Benzo(k)fluoranthene	0.010*	0.000006
084	Pyrene	0.022	0.000012
120	Copper	107.27	0.0589
122	Lead	26.97	0.0148
124	Nickel	0.76	0.00415
128	Zinc	129.62	0.0712
	Manganese	0.93	0.000509
	Phenols (4AAP)	2.093	0.00115
	Oil and Grease	11.0	0.00603
	TSS	613	0.00337
	pH (Units)	7.0-7.3	

Treated Effluent

Plant:		9094	
Flow (l/kkg):		0(0 GPT)	
Sample Points:		[(D+E)/(B+E)]C	
C&TT:		IR,SL,RTP-100	
Pollutants		mg/l	kg/kkg (lbs/1000 lbs)
067	Butyl benzyl phthalate	0.005	-
074	3,4-benzofluoranthene	ND	-
075	Benzo(k)fluoranthene	ND	-
084	Pyrene	0.016	-
120	Copper	0.16	-
122	Lead	0.08	-
124	Nickel	0.01	-
128	Zinc	0.43	-
	Manganese	0.03	-
	Phenols (4AAP)	0.018	-
	Oil and Grease	0.58	-
	TSS	2.0	-
	pH (Units)	7.0-8.3	

-: Zero discharge, therefore, no effluent loads.
*: Could not be separated

Note: For definitions of C&TT codes, refer to Table III-21.

TABLE V-21

CHARACTERISTICS OF COPPER
MOLD COOLING AND CASTING QUENCH PROCESS WASTEWATERS

Raw Wastewater

Plant:	6809		4736	
Production (kkg/day):	648.3 (714 TPD)		102 (112 TPD)	
Flow (l/kkg):	757 (181.5 GPT)		(1)	
Sample Points:	C		D	
Pollutants	**mg/l**	**kg/kkg (lbs/1000 lbs)**	**mg/l**	**kg/kkg (lbs/1000 lbs)**
120 Copper	0.36	0.000273	1.1	
128 Zinc	2.10	0.00159	3.5	
Oil and Grease	45	0.0338	<1	
TSS	56	0.0424	16	(1)
pH (Units)	8.2-8.4		8.1	

Treated Effluent

Plant:	6809		NA
Flow (l/kkg):	757 (181.5 GPT)		
Sample Points:	(C/D)(E)		
C&TT:	CT,RTP-(Unk)		
Pollutants	**mg/l**	**kg/kkg (lbs/1000 lbs)**	
120 Copper	0.109	0.000165	
128 Zinc	1.405	0.00213	
Oil and Grease	5.6	0.00845	
TSS	13.1	0.0199	
pH (Units)	7.6-8.4		

(1) Flow data were not available.
NA: Not Applicable

Note: For definitions of C&TT codes, refer to Table III-21.

TABLE V-22

CHARACTERISTICS OF FERROUS DUST
COLLECTION PROCESS WASTEWATERS

Raw Wastewaters

Plant:	15520	06956	07929	57100	59101	55122
Sand Handled (kkg/day):	3341.4 (3680 TPD)	208.8 (230 TPD)	559.3 (616 TPD)	454.0 (500 TPD)	1089.6 (1200 TPD)	7760.7 (8547 TPD)
Flow (l/kkg):	380 (91.2 GPT)	7127 (1710 GPT)	2408 (577 GPT)	1001 (240 GPT)	6005 (1440 GPT)	1218 (292 GPT)
Sample Points:	E+G	J	C+D+F+G+H+J	1	6	5

	Pollutants	15520 mg/l	15520 kg/kkg (lbs/1000 lbs)	06956 mg/l	06956 kg/kkg (lbs/1000 lbs)	07929 mg/l	07929 kg/kkg (lbs/1000 lbs)	57100 mg/l	57100 kg/kkg (lbs/1000 lbs)	59101 mg/l	59101 kg/kkg (lbs/1000 lbs)	55122 mg/l	55122 kg/kkg (lbs/1000 lbs)
001	Acenaphthene	0.008	0.000003	0.028	0.00020	0.008	0.000019	NA	NA	NA	NA	NA	NA
031	2,4-dichlorophenol	0.004	0.000001	ND	0.000	0.297	0.000714	NA	NA	NA	NA	NA	NA
034	2,4-dimethylphenol	0.005	0.000002	1.136	0.00809	0.061	0.000147	NA	NA	NA	NA	NA	NA
039	Fluoranthene	0.004	0.000001	0.013	0.000095	0.035	0.000085	NA	NA	NA	NA	NA	NA
062	N-nitrosodiphenyl-amine	ND	0.000	0.016	0.000114	0.003	0.000008	NA	NA	NA	NA	NA	NA
064	Pentachlorophenol	0.009	0.000003	ND	0.000	0.030	0.000072	NA	NA	NA	NA	NA	NA
065	Phenol	0.004	0.000001	4.776	0.034	2.28	0.00549	NA	NA	NA	NA	NA	NA
067	Butyl benzyl phthalate	0.002	0.000001	0.027	0.000193	0.020	0.000049	NA	NA	NA	NA	NA	NA
072	Benzo(a) anthracene	ND	0.000	ND	0.000	0.005	0.000013	NA	NA	NA	NA	NA	NA
076	Chrysene	0.003	0.000001	0.013	0.000093	0.009	0.000022	NA	NA	NA	NA	NA	NA
077	Acenaphthylene	0.007	0.000003	0.010	0.000071	0.007	0.000018	NA	NA	NA	NA	NA	NA
080	Fluorene	0.004	0.000001	0.039	0.000281	0.014	0.000034	NA	NA	NA	NA	NA	NA
081	Phenanthrene	0.002	0.000001	0.137	0.00098	0.016	0.000038	NA	NA	NA	NA	NA	NA
084	Pyrene	0.011	0.000004	0.014	0.000098	0.033	0.000079	NA	NA	NA	NA	NA	NA
085	Tetrachloroethylene	0.005	0.000002	0.058	0.000416	0.006	0.000015	NA	NA	NA	NA	NA	NA
120	Copper	0.12	0.000046	0.10	0.00131	0.17	0.000413	NA	NA	NA	NA	2.87	0.0035
122	Lead	0.06	0.000023	0.58	0.00414	0.24	0.000572	NA	NA	NA	NA	<0.25	0.00030
124	Nickel	0.02	0.000629	0.02	0.000167	0.05	0.00011	NA	NA	NA	NA	0.58	0.00071
128	Zinc	1.11	0.000422	1.37	0.00975	0.35	0.000834	NA	NA	NA	NA	0.70	0.00085
	Ammonia (N)	15.4	0.00585	24.7	0.176	50.0	0.120	6.8	0.00681	1.89	0.0113	NA	NA
	Iron	0.026	0.00001	NA	NA	0.20	0.00049	93.5	0.0935	77.0	0.462	1080	1.315
	Manganese	3.29	0.00125	1.70	0.012	0.51	0.00124	<0.8	0.000801	32.0	0.192	11.5	0.014
	Phenols (4AAP)	0.291	0.00011	12.895	0.0918	9.767	0.0235	4.08	0.00408	1.14	0.0068	NA	NA
	Sulfide	0.8	0.0312	0.8	0.00547	3.5	0.0084	<0.02	0.000020	1.1	0.0066	1.0	0.0012
	Oil & Grease	11.0	0.00425	7.0	0.0476	20.0	0.0483	150	0.150	21	0.126	20.4	0.025
	TSS	440	0.167	4555	32.43	1500	3.61	5380	5.38	4170	25.0	4760	5.79
	pH (Units)	7.0-7.4		7.0-7.5		7.3-7.6		7.5		7.6		7.6-7.7	

TABLE V-22
CHARACTERISTICS OF FERROUS DUST
COLLECTION PROCESS WASTEWATERS
PAGE 2

Treated Effluent

Plant:	15520	06956	07929	57100	59101	55122
Flow (l/kkg):	97.9 (23.5 GPT)	339.4 (81.4 GPT)	0	200 (48 GPT)	400 (96 GPT)	117 (28 GPT)
Sample Points:	(E+C)/(F+A) H	(J/(B+G))E	B	2	(3/(2+3)) 4	(5/(4+5)) 7
C&TT:	SB,RTP-74	CL,NL,FLP,SL, RTP-95	SB,CY,RTP-100	SB,RTP-80	SL,RTP-93	CY,FLP,R,VF,RTP-99

	Pollutants	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)
001	Acenaphthene	0.025	0.000002	0.013	0.000005	0.003	-	NA	NA	NA	NA	NA	NA
031	2,4-dichlorophenol	0.004	*	0.00	0.000	0.048	-	NA	NA	NA	NA	NA	NA
034	2,4-dimethylphenol	0.004	*	0.250	0.000085	0.007	-	NA	NA	NA	NA	NA	NA
039	Fluoranthene	0.014	0.000001	0.009	0.000003	0.033	-	NA	NA	NA	NA	NA	NA
062	N-nitrosodiphenyl-amine	0.00	0.000	0.018	0.000006	ND	-	NA	NA	NA	NA	NA	NA
064	Pentachlorophenol	0.014	0.000001	0.00	0.000	0.024	-	NA	NA	NA	NA	NA	NA
065	Phenol	0.003	*	0.076	0.000026	0.033	-	NA	NA	NA	NA	NA	NA
067	Butyl benzyl phthalate	#	#	0.022	0.000008	0.004	-	NA	NA	NA	NA	NA	NA
072	Benzo(a) anthracene	0.00	0.00	ND	0.000	0.007	-	NA	NA	NA	NA	NA	NA
076	Chrysene	0.008	0.000001	0.003	0.000001	0.015	-	NA	NA	NA	NA	NA	NA
077	Acenaphthylene	0.025	0.000002	0.010	0.000003	ND	-	NA	NA	NA	NA	NA	NA
080	Fluorene	0.014	0.000001	0.039	0.000013	0.000	-	NA	NA	NA	NA	NA	NA
081	Phenanthrene	#	#	0.00	0.000	ND	-	NA	NA	NA	NA	NA	NA
084	Pyrene	0.045	0.000004	0.008	0.000003	0.02	-	NA	NA	NA	NA	NA	NA
085	Tetrachloroethylene	0.005	0.000001	0.046	0.000016	0.007	-	NA	NA	NA	NA	NA	NA
120	Copper	0.02	0.000002	0.02	0.000007	0.15	-	NA	NA	NA	NA	0.02	0.000002
122	Lead	0.00	0.00	0.01	0.000002	0.20	-	NA	NA	NA	NA	0.06	0.000007
124	Nickel	0.01	0.000001	0.02	0.000007	0.04	-	NA	NA	NA	NA	0.04	0.000005
128	Zinc	0.36	0.000035	0.03	0.000009	0.36	-	NA	NA	NA	NA	0.21	0.000025
	Ammonia (N)	27.1	0.00265	22.1	0.0075	53.1	-	6.2	0.00124	0.49	0.000196	NA	NA
	Iron	0.026	0.000002	NA	NA	0.14	-	78.0	0.0156	0.29	0.000116	4.0	0.00047
	Manganese	1.54	0.000151	0.11	0.000037	0.35	-	<0.8	0.00016	0.34	0.000136	0.13	0.000015
	Phenols (4AAP)	0.255	0.000025	4.8	0.0016	0.765	-	4.12	0.00082	0.038	0.000015	NA	NA
	Sulfide	0.2	0.000016	0.5	0.000159	506	-	<0.02	0.000004	0.76	0.00030	0.02	0.000002
	Oil & Grease	3.0	0.00026	4.0	0.0012	15.0	-	138	0.0276	11.3	0.0045	2.0	0.00023
	TSS	71	0.00696	235	0.0797	600	-	12880	2.58	5	0.0020	3	0.00035
	pH (Units)	6.7-7.8		6.5-8.9		7.5-7.8		7.6		8.1		7.4-7.5	

TABLE V-22
CHARACTERISTICS OF FERROUS DUST
COLLECTION PROCESS WASTEWATERS
PAGE 3

Raw Wastewaters

Plant:		57775		53642		50315		59212		55217
Sand Handled (kkg/day):		(1)		1089.6 (1200 TPD)		1095.9 (1207 TPD)		2615.0 (2880 TPD)		1898.6 (2091 TPD)
Flow (l/kkg):				6005 (1440 GPT)		2281 (547 GPT)		459 (110 GPT)		1318 (316 GPT)
Sample Points:				6		4		2		4
Pollutants			mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)
001	Acenaphthene		NA	NA	NA	NA	NA	NA	NA	NA
031	2,4-dichlorophenol		NA	NA	NA	NA	NA	NA	NA	NA
034	2,4-dimethyl phenol		NA	NA	NA	NA	NA	NA	NA	NA
039	Fluoranthene		NA	NA	NA	NA	NA	NA	NA	NA
062	N-nitrosodiphenyl-amine		NA	NA	NA	NA	NA	NA	NA	NA
064	Pentachlorophenol		NA	NA	NA	NA	NA	NA	NA	NA
065	Phenol		NA	NA	NA	NA	NA	NA	NA	NA
067	Butyl benzyl phthalate		NA	NA	NA	NA	NA	NA	NA	NA
072	Benzo(a) anthracene		NA	NA	NA	NA	NA	NA	NA	NA
076	Chrysene		NA	NA	NA	NA	NA	NA	NA	NA
077	Acenaphthylene		NA	NA	NA	NA	NA	NA	NA	NA
080	Fluorene		NA	NA	NA	NA	NA	NA	NA	NA
081	Phenanthrene		NA	NA	NA	NA	NA	NA	NA	NA
084	Pyrene		NA	NA	NA	NA	NA	NA	NA	NA
085	Tetrachloro-ethylene		NA	NA	NA	NA	NA	NA	NA	NA
120	Copper		0.94	0.0056	0.25	0.00057	NA	NA	0.69	0.00091
122	Lead		0.71	0.0043	2.38	0.0054	NA	NA	0.41	0.00054
124	Nickel		0.72	0.0043	0.10	0.00023	NA	NA	0.43	0.00057
128	Zinc		1.3	0.0078	9.5	0.0217	NA	NA	2.3	0.0030
	Ammonia (N)		NA	NA	2.5	0.0057	51.3	0.0235	3.8	0.0050
	Iron		790	4.74	116	0.265	710	0.326	398	0.524
	Manganese		420	0.252	7.65	0.0174	8.0	0.0037	5.7	0.0075
	Phenols (4AAP)		1.98	0.0119	0.154	0.00035	2.17	0.00099	0.314	0.00041
	Sulfide		9.6	0.0576	1.5	0.0034	3.2	0.0015	<0.5	0.00066
	Oil & Grease		55	0.33	17.0	0.039	20.8	0.0095	37.5	0.049
	TSS		20030	120.3	1650	3.76	20800	9.54	6600	8.70
	pH (Units)		7.8		8.5-8.7		7.3		7.6-7.7	

TABLE V-22
CHARACTERISTICS OF FERROUS DUST
COLLECTION PROCESS WASTEWATERS
PAGE 4

Treated Effluent

Plant:	57775	53642	50315	59212	55217
Flow (l/kkg):	456 (109 GPT)	667 (160 GPT)	0 (0 GPT)	20.9 (5 GPT)	0 (0 GPT)
Sample Points:	2	8	(4/(4+5))6	-	5
C&TT:	DT,FLP,NC, RTP-93	NL,FLP,FLA, CY,T,VF,RTP-89	SL,RTP-100	DT,NA,FLP, SB,RTP-95	SL,RTP-100

	Pollutants	57775 mg/l	57775 kg/kkg (lbs/ 1000 lbs)	53642 mg/l	53642 kg/kkg (lbs/ 1000 lbs)	50315 mg/l	50315 kg/kkg (lbs/ 1000 lbs)	59212 mg/l	59212 kg/kkg (lbs/ 1000 lbs)	55217 mg/l	55217 kg/kkg (lbs/ 1000 lbs)
001	Acenaphthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
031	2,4-dichlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
034	2,4-dimethyl phenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
039	Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
062	N-nitrosodiphenyl-amine	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
064	Pentachlorophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
065	Phenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
067	Butyl benzyl phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
072	Benzo(a) anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
076	Chrysene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
077	Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
080	Fluorene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
081	Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
084	Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
085	Tetrachloro-ethylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
120	Copper	0.04	0.000018	0.02	0.000013	0.03	-	NA	NA	0.95	-
122	Lead	0.08	0.000036	0.05	0.000033	0.68	-	NA	NA	0.62	-
124	Nickel	0.02	0.000009	0.02	0.000013	0.01	-	NA	NA	0.50	-
128	Zinc	0.14	0.000064	0.09	0.000060	2.8	-	NA	NA	3.2	-
	Ammonia (N)	5.4	0.00245	NA	NA	3.2	-	NA	NA	3.9	-
	Iron	6.4	0.00291	1.70	0.00113	6.9	-	NA	NA	460	-
	Manganese	0.22	0.000100	0.14	0.000093	3.1	-	NA	NA	6.15	-
	Phenols (4AAP)	0.952	0.000433	4.12	0.00275	0.164	-	NA	NA	0.208	-
	Sulfide	1.3	0.000591	0.85	0.00057	0.35	-	NA	NA	<0.5	-
	Oil & Grease	2.5	0.00114	6.0	0.00400	4.1	-	NA	NA	23	-
	TSS	362	0.165	46	0.0307	98	-	NA	NA	6150	-
	pH (Units)	7.4		8.7		8.8-9.1				7.8-7.9	

TABLE V-22
CHARACTERISTICS OF FERROUS DUST
COLLECTION PROCESS WASTEWATERS
PAGE 5

Raw Wastewaters

Plant:	51115	53219	56771	20009
Sand Handled (kkg/day):	617.4 (680 TPD)	(1)	(1)	(2)
Flow (l/kkg):	265 (63.5 GPT)			
Sample Points:	3			

Pollutants		mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	Average kg/kkg (lbs/ 1000 lbs)
001	Acenaphthene	NA	NA	0.041	(2)	0.000074
031	2,4-dichlorophenol	NA	NA	ND		0.000238
034	2,4-dimethyl phenol	NA	NA	0.084		0.00275
039	Fluoranthene	NA	NA	0.012		0.000060
062	N-nitrosodiphenyl-amine	NA	NA	ND		0.000041
064	Pentachlorophenol	NA	NA	0.009		0.000025
065	Phenol	NA	NA	0.321		0.013
067	Butyl benzyl phthalate	NA	NA	0.011		0.000081
072	Benzo(a) anthracene	NA	NA	0.017		0.000004
076	Chrysene	NA	NA	0.007		0.000039
077	Acenaphthylene	NA	NA	0.023		0.000031
080	Fluorene	NA	NA	0.011		0.000094
081	Phenanthrene	NA	NA	0.010		0.000339
084	Pyrene	NA	NA	0.018		0.000060
085	Tetrachloro-ethylene	NA	NA	0.007		0.000144
120	Copper	0.57	0.00015	0.60		0.00156
122	Lead	0.42	0.00011	0.49		0.00192
124	Nickel	0.23	0.000061	0.18		0.00085
128	Zinc	2.67	0.00071	0.32		0.00563
	Ammonia (N)	NA	NA	1.0		0.044
	Iron	217	0.0575	113		0.749
	Manganese	3.4	0.00090	2.0		0.098
	Phenols (4AAP)	NA	NA	4.77		0.0156
	Sulfide	0.02	0.000005	0.9		0.0106
	Oil & Grease	5.4	0.0014	4		0.075
	TSS	4710	1.25	10910		19.63
	pH (Units)	7.8			7.6-7.9	

TABLE V-22
CHARACTERISTICS OF FERROUS DUST
COLLECTION PROCESS WASTEWATERS
PAGE 6

Treated Effluent

Plant:		51115		53219		56771	
Flow (l/kkg):		0 (0 GPT)		92.4(22.2GPT)		83.0(19.9GPT)	
Sample Points:		-		3		6	
C&TT:		FLP,DT,SB, RTP-100		DT,FLP,RTP-98		DT,RTP-Unk	
Pollutants		mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)
001	Acenaphthene	NA	NA	NA	NA	NA	NA
031	2,4-dichlorophenol	NA	NA	NA	NA	NA	NA
034	2,4-dimethyl phenol	NA	NA	NA	NA	NA	NA
039	Fluoranthene	NA	NA	NA	NA	NA	NA
062	N-nitrosodiphenyl-amine	NA	NA	NA	NA	NA	NA
064	Pentachlorophenol	NA	NA	NA	NA	NA	NA
065	Phenol	NA	NA	NA	NA	NA	NA
067	Butyl benzyl phthalate	NA	NA	NA	NA	NA	NA
072	Benzo(a) anthracene	NA	NA	NA	NA	NA	NA
076	Chrysene	NA	NA	NA	NA	NA	NA
077	Acenaphthylene	NA	NA	NA	NA	NA	NA
080	Fluorene	NA	NA	NA	NA	NA	NA
081	Phenanthrene	NA	NA	NA	NA	NA	NA
084	Pyrene	NA	NA	NA	NA	NA	NA
085	Tetrachloro-ethylene	NA	NA	NA	NA	NA	NA
120	Copper	NA	NA	0.06	0.000006	NA	NA
122	Lead	NA	NA	0.10	0.000009	NA	NA
124	Nickel	NA	NA	0.05	0.000005	NA	NA
128	Zinc	NA	NA	0.16	0.000015	NA	NA
	Ammonia (N)	NA	NA	3.25	0.000301	0.28	0.000023
	Iron	NA	NA	3.5	0.000324	93	0.00772
	Manganese	NA	NA	0.17	0.000016	0.70	0.000058
	Phenols (4AAP)	NA	NA	0.64	0.000059	10.4	0.000863
	Sulfide	NA	NA	5.8	0.000537	2.0	0.000166
	Oil & Grease	NA	NA	2	0.000185	27.6	0.00229
	TSS	NA	NA	82	0.00759	3047	0.253
	pH (Units)			7.4-7.5		6.6	

TABLE V-22
CHARACTERISTICS OF FERROUS DUST
COLLECTION PROCESS WASTEWATERS
PAGE 7

Note: For definition of C&TT codes refer to Table III-21.

(1) No raw wastewater data available.
(2) This system operates in such a manner that the quantity of sand passing before the scrubber could not be determined. Therefore, the flow relationship to the quantity of sand handled could not be determined.

ND: Not detected
NA: Not analyzed
: Calculation could not be completed.
* : Value is less than 0.000001.
- : Plant is zero discharge, therefore no effluent load.

TABLE V-23

CHARACTERISTICS OF FERROUS MELTING FURNACE SCRUBBER PROCESS WASTEWATERS

Raw Wastewater

Plant:	15520		06956		58589		53219	
Production (kkg/day):	563.0 (620 TPD)		590.2 (650 TPD)		36.3 (40 TPD)		12.7 (14 TPD)	
Flow (l/kkg):	2063 (495 GPT)		7815 (1874 GPT)		5004 (1200 GPT)		8590 (2060 GPT)	
Sample Points:	B		H		2		2	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
024 2-chlorophenol	0.055	0.000114	0.010	0.000078	NA	NA	NA	NA
031 2,4-dichlorophenol	0.077	0.000158	0.007	0.000057	NA	NA	NA	NA
034 2,4-dimethyl phenol	0.056	0.000115	0.051	0.000402	NA	NA	NA	NA
039 Fluoranthene	0.519	0.00107	0.034	0.000269	NA	NA	NA	NA
059 2,4-dinitrophenol	0.064	0.000132	0.006	0.000050	NA	NA	NA	NA
060 4,6-dinitro-o-cresol	0.061	0.000127	0.015	0.000117	NA	NA	NA	NA
062 N-nitrosodiphenylamine	0.100	0.000202	0.023	0.000183	NA	NA	NA	NA
064 Pentachlorophenol	0.271	0.000558	ND	0.000	NA	NA	NA	NA
065 Phenol	2.705	0.00558	0.685	0.00535	NA	NA	NA	NA
067 Butyl benzyl phthalate	0.116	0.000238	0.021	0.000167	NA	NA	NA	NA
072 Benzo(a)anthracene	0.013	0.000025	0.021	0.000167	NA	NA	NA	NA
076 Chrysene	0.010	0.000021	0.021	0.000167	NA	NA	NA	NA
077 Acenaphthylene	0.155	0.000319	0.024	0.000185	NA	NA	NA	NA
080 Fluorene	0.610	0.00126	0.022	0.000172	NA	NA	NA	NA
081 Phenanthrene	0.110	0.000235	0.075	0.000586	NA	NA	NA	NA
084 Pyrene	1.118	0.00230	0.035	0.000271	NA	NA	NA	NA
085 Tetrachloroethylene	0.028	0.000059	0.047	0.000368	NA	NA	NA	NA
114 Antimony	1.2	0.00238	1.1	0.00835	NA	NA	NA	NA
115 Arsenic	0.19	0.000392	0.11	0.000835	NA	NA	NA	NA
118 Cadmium	1.65	0.00341	0.64	0.00498	NA	NA	NA	NA
119 Chromium	0.46	0.000950	0.23	0.00180	NA	NA	NA	NA
120 Copper	3.66	0.00754	1.84	0.0143	0.46	0.00230	2.5	0.0215
122 Lead	64.23	0.132	136.93	1.069	40	0.200	41.0	0.352
124 Nickel	0.25	0.0506	0.06	0.000443	0.06	0.00030	0.18	0.0015
128 Zinc	335.32	69.122	170.33	1.330	8.8	0.0440	100	0.859
Ammonia (N)	104.5	0.215	11.4	0.0885	2.1	0.011	7.35	0.063
Fluoride	20.0	0.0413	176	1.375	4.8	0.0240	46.5	0.399
Iron	0.377	0.000778	NA	NA	110	0.550	76	0.653
Manganese	91.5	0.189	18.37	0.143	16	0.080	75	0.644
Phenols (4AAP)	15.86	0.0327	2.522	0.0197	0.187	0.00094	0.300	0.00258
Sulfide	18.0	0.0372	0.6	0.00496	1.3	0.0065	5.25	0.045
Oil and Grease	91	0.187	21	0.164	4	0.020	2	0.017
TSS	1164	2.399	574	4.481	458	2.29	1800	15.46
pH (Units)	6.8-6.9		6.0-6.6		3.7		4.3-4.6	

TABLE V-23
CHARACTERISTICS OF FERROUS MELTING FURNACE SCRUBBER PROCESS WASTEWATERS
PAGE 2

Treated Effluent

	15520		06956		58589		53219	
Plant:								
Flow (l/kkg):	12.6 (3.02 GPT)		360 (86.4 GPT)		0 (0 GPT)		8590 (2060 GPT)	
Sample Points:	C		(H/(B+G))E		3		-	
C&TT:	01,CL,VF,RTP-99		CL,FLP,NL,SL,RTP-95		SL,NL,RTP-100		None	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
024 2-chlorophenol	0.085	0.000001	0.010	0.000004	NA	-	NO TREATMENT	
031 2,4-dichlorophenol	0.040	0.000001	0.006	0.000002	NA	-		
034 2,4-dimethylphenol	0.409	0.000005	0.012	0.000004	NA	-		
039 Fluoranthene	0.097	0.000001	0.024	0.000009	NA	-		
059 2,4-dinitrophenol	0.021	*	ND	0.000	NA	-		
060 4,6-dinitro-o-cresol	0.088	0.000001	ND	0.000	NA	-		
062 N-nitrosodiphenylamine	0.137	0.000002	0.028	0.000010	NA	-		
064 Pentachlorophenol	0.137	0.000002	ND	0.000	NA	-		
065 Phenol	2.638	0.000033	0.011	0.000004	NA	-		
067 Butyl benzyl phthalate	0.041	*	0.018	0.000006	NA	-		
072 Benzo(a)anthracene	0.00	*	ND	0.000	NA	-		
076 Chrysene	0.007	*	0.005	0.000002	NA	-		
077 Acenaphthylene	0.016	*	0.024	0.000009	NA	-		
080 Fluorene	0.009	*	0.023	0.000008	NA	-		
081 Phenanthrene	0.021	*	0.00	0.000	NA	-		
084 Pyrene	0.047	0.000001	0.022	0.000008	NA	-		
085 Tetrachloroethylene	0.045	0.000001	0.038	0.000014	NA	-		
114 Antimony	0.4	0.000004	0.3	0.000124	NA	-		
115 Arsenic	0.03	*	0.03	0.000012	NA	-		
118 Cadmium	0.85	0.000011	0.02	0.000009	NA	-		
119 Chromium	0.03	*	0.09	0.000034	NA	-		
120 Copper	0.23	0.000003	0.22	0.000079	0.10	-		
122 Lead	8.48	0.000107	1.53	0.000552	2.2	-		
124 Nickel	0.13	0.000002	0.05	0.000018	0.05	-		
128 Zinc	189.37	0.00238	3.30	0.00119	0.76	-		
Ammonia (N)	92.2	0.00116	10.5	0.00377	2.4	-		
Fluoride	18.4	0.000231	69.4	0.0250	8.6	-		
Iron	0.070	0.000001	NA	NA	7.9	-		
Manganese	45.8	0.000576	1.22	0.000438	1.7	-		
Phenols (4AAP)	12.39	0.000156	0.972	0.000350	0.356	-		
Sulfide	5.8	0.000073	0.4	0.000144	2.5	-		
Oil and Grease	21	0.000265	12	0.00423	3	-		
TSS	71	0.000899	31	0.011	56	-		
pH (Units)	6.7-7.2		6.0-8.9		11.0			

TABLE V-23
CHARACTERISTICS OF FERROUS MELTING FURNACE SCRUBBER PROCESS WASTEWATERS
PAGE 3

Raw Wastewater

Plant:	56123	55217	50315	52491	57775	56789	54321	56771	52881	59212
Production (kkg/day):	178.0 (196 TPD)	197.0 (217 TPD)	123.5 (136 TPD)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Flow (l/kkg):	8373 (2008 GPT)	3007 (721 GPT)	4796 (1150 GPT)							
Sample Points:	3	2	5-(3+2)							

Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	Average kg/kkg (lbs/1000 lbs)
024 2-chlorophenol	NA	NA	NA	NA	NA	NA	0.000096
031 2,4-dichlorophenol	NA	NA	NA	NA	NA	NA	0.000108
034 2,4-dimethylphenol	NA	NA	NA	NA	NA	NA	0.000259
039 Fluoranthene	NA	NA	NA	NA	NA	NA	0.000135
059 2,4-dinitrophenol	NA	NA	NA	NA	NA	NA	0.000091
060 4,6-dinitro-o-cresol	NA	NA	NA	NA	NA	NA	0.000122
062 N-nitrosodiphenylamine	NA	NA	NA	NA	NA	NA	0.000193
064 Pentachlorophenol	NA	NA	NA	NA	NA	NA	0.000558
065 Phenol	NA	NA	NA	NA	NA	NA	0.00547
067 Butyl benzyl phthalate	NA	NA	NA	NA	NA	NA	0.000203
072 Benzo(a)anthracene	NA	NA	NA	NA	NA	NA	0.000096
076 Chrysene	NA	NA	NA	NA	NA	NA	0.000094
077 Acenaphthylene	NA	NA	NA	NA	NA	NA	0.000252
080 Fluorene	NA	NA	NA	NA	NA	NA	0.000716
081 Phenanthrene	NA	NA	NA	NA	NA	NA	0.000411
084 Pyrene	NA	NA	NA	NA	NA	NA	0.00129
085 Tetrachloroethylene	NA	NA	NA	NA	NA	NA	0.000214
114 Antimony	NA	NA	NA	NA	NA	NA	0.00537
115 Arsenic	NA	NA	NA	NA	NA	NA	0.00061
118 Cadmium	NA	NA	NA	NA	NA	NA	0.00420
119 Chromium	NA	NA	NA	NA	NA	NA	0.00138
120 Copper	11.2	0.094	0.50	0.0015	4.4	0.021	0.0232
122 Lead	274	2.29	10.5	0.032	32.0	0.153	0.604
124 Nickel	0.6	0.005	0.06	0.00018	0.94	0.0045	0.00893
128 Zinc	1370	11.47	30	0.090	94.0	0.45	11.91
Ammonia (N)	2.1	0.0178	3.05	0.0092	2.6	0.0125	0.0596
Fluoride	24	0.20	18	0.054	25	0.120	0.32
Iron	428	3.58	35	0.105	522	2.50	1.23
Manganese	356	2.98	23	0.069	40	0.192	0.614
Phenols (4AAP)	0.314	0.0026	0.448	0.0013	NA	NA	0.00997
Sulfide	2.6	0.0218	2.15	0.0065	4.8	0.023	0.021
Oil and Grease	36	0.30	7.5	0.0225	0.8	0.0038	0.102
TSS	8250	69.08	788	2.37	4305	20.64	16.67
pH (Units)	7.6-12.0		7.4-10.8		NA		

TABLE V-23
CHARACTERISTICS OF FERROUS MELTING FURNACE SCRUBBER PROCESS WASTEWATERS
PAGE 4

Treated Effluent

Plant:	56123	55217	50315	52491	57775
Flow (l/kkg):	1001 (240 GPT)	0 (0 GPT)	0 (0 GPT)	518 (122 GPT)	0 (0 GPT)
Sample Points:	5	6	((5-(3+2)/(4+5))6	2	3
C&TT:	DT,NC,FDSP,CY, FLFC,FLP,CL,RTP-88	NC,SL,RTP-100	SL,RTP-100	SB,NC,RTP-97	NC,FLP,DT,RTP-100

Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
024 2-chlorophenol	NA	NA	NA	-	NA	-	NA	NA	NA	-
031 2,4-dichlorophenol	NA	NA	NA	-	NA	-	NA	NA	NA	-
034 2,4-dimethylphenol	NA	NA	NA	-	NA	-	NA	NA	NA	-
039 Fluoranthene	NA	NA	NA	-	NA	-	NA	NA	NA	-
059 2,4-dinitrophenol	NA	NA	NA	-	NA	-	NA	NA	NA	-
060 4,6-dinitro-o-cresol	NA	NA	NA	-	NA	-	NA	NA	NA	-
062 N-nitrosodiphenylamine	NA	NA	NA	-	NA	-	NA	NA	NA	-
064 Pentachlorophenol	NA	NA	NA	-	NA	-	NA	NA	NA	-
065 Phenol	NA	NA	NA	-	NA	-	NA	NA	NA	-
067 Butyl benzyl phthalate	NA	NA	NA	-	NA	-	NA	NA	NA	-
072 Benzo (a) anthracene	NA	NA	NA	-	NA	-	NA	NA	NA	-
076 Chrysene	NA	NA	NA	-	NA	-	NA	NA	NA	-
077 Acenaphthylene	NA	NA	NA	-	NA	-	NA	NA	NA	-
080 Fluorene	NA	NA	NA	-	NA	-	NA	NA	NA	-
081 Phenanthrene	NA	NA	NA	-	NA	-	NA	NA	NA	-
084 Pyrene	NA	NA	NA	-	NA	-	NA	NA	NA	-
085 Tetrachloroethylene	NA	NA	NA	-	NA	-	NA	NA	NA	-
114 Antimony	NA	NA	NA	-	NA	-	NA	NA	NA	-
115 Arsenic	NA	NA	NA	-	NA	-	NA	NA	NA	-
118 Cadmium	NA	NA	NA	-	NA	-	NA	NA	NA	-
119 Chromium	NA	NA	NA	-	NA	-	NA	NA	NA	-
120 Copper	0.03	0.000030	0.06	-	0.6	-	NA	NA	0.46	-
122 Lead	0.92	0.00092	3.0	-	9.2	-	NA	NA	44.5	-
124 Nickel	0.02	0.000020	0.01	-	0.08	-	NA	NA	0.04	-
128 Zinc	3.5	0.0035	8.8	-	28	-	NA	NA	21	-
Ammonia (N)	2.4	0.0024	3.9	-	3.4	-	1.7	0.000865	4.1	-
Fluoride	20.5	0.0205	16.3	-	23	-	37	0.0188	59	-
Iron	1.12	0.00112	2.1	-	31	-	92	0.0468	14	-
Manganese	2.15	0.00215	9.3	-	16	-	120	0.0610	6.0	-
Phenols (4AAP)	0.266	0.000266	0.477	-	NA	-	0.041	0.000021	0.486	-
Sulfide	2.3	0.0023	0.51	-	1.1	-	44	0.0224	21.4	-
Oil and Grease	3.5	0.0035	1.8	-	0.2	-	9	0.00458	7.5	-
TSS	12.5	0.0125	47	-	255	-	5712	2.91	236	-
pH (Units)	7.6-7.7		8.8-9.1		8.8-9.1		8.1		8.9-9.6	

TABLE V-23
CHARACTERISTICS OF FERROUS MELTING FURNACE SCRUBBER PROCESS WASTEWATERS
PAGE 5

Treated Effluent

Plant:	56789		54321		56771		52881		59212	
Flow (l/kkg):	0 (0 GPT)		0 (0 GPT)		0 (0 GPT)		0 (0 GPT)		130 (31.1 GPT)	
Sample Points:	3		5		5		3		3	
C&TT:	NC,FLP,CL,DT,RTP-100		NL,CL,DT,RTP-100		NL,CL,DT,RTP-100		NL,CL,DT,RTP-100		NA,FLP,DT,SB,RTP-99	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
024 2-chlorophenol	NA	-	NA	-	NA	-	NA	-	NA	NA
031 2,4-dichlorophenol	NA	-	NA	-	NA	-	NA	-	NA	NA
034 2,4-dimethylphenol	NA	-	NA	-	NA	-	NA	-	NA	NA
039 Fluoranthene	NA	-	NA	-	NA	-	NA	-	NA	NA
059 2,4-dinitrophenol	NA	-	NA	-	NA	-	NA	-	NA	NA
060 4,6-dinitro-o-cresol	NA	-	NA	-	NA	-	NA	-	NA	NA
062 N-nitrosodiphenylamine	NA	-	NA	-	NA	-	NA	-	NA	NA
064 Pentachlorophenol	NA	-	NA	-	NA	-	NA	-	NA	NA
065 Phenol	NA	-	NA	-	NA	-	NA	-	NA	NA
067 Butyl benzyl phthalate	NA	-	NA	-	NA	-	NA	-	NA	NA
072 Benzo(a)anthracene	NA	-	NA	-	NA	-	NA	-	NA	NA
076 Chrysene	NA	-	NA	-	NA	-	NA	-	NA	NA
077 Acenaphthylene	NA	-	NA	-	NA	-	NA	-	NA	NA
080 Fluorene	NA	-	NA	-	NA	-	NA	-	NA	NA
081 Phenanthrene	NA	-	NA	-	NA	-	NA	-	NA	NA
084 Pyrene	NA	-	NA	-	NA	-	NA	-	NA	NA
085 Tetrachloroethylene	NA	-	NA	-	NA	-	NA	-	NA	NA
114 Antimony	NA	-	NA	-	NA	-	NA	-	NA	NA
115 Arsenic	NA	-	NA	-	NA	-	NA	-	NA	NA
118 Cadmium	NA	-	NA	-	NA	-	NA	-	NA	NA
119 Chromium	NA	-	NA	-	NA	-	NA	-	NA	NA
120 Copper	0.24	-	NA	-	NA	-	NA	-	NA	NA
122 Lead	9.6	-	NA	-	NA	-	NA	-	NA	NA
124 Nickel	0.14	-	NA	-	NA	-	NA	-	NA	NA
128 Zinc	12	-	NA	-	NA	-	NA	-	NA	NA
Ammonia (N)	3.8	-	0.42	-	3.3	-	1.0	-	51	0.00661
Fluoride	433	-	4.4	-	16	-	36	-	0.77	0.000100
Iron	9.2	-	2.1	-	42	-	2.9	-	6.6	0.000856
Manganese	37	-	0.38	-	32	-	0.37	-	31	0.00402
Phenols (4AAP)	0.164	-	0.005	-	0.675	-	0.004	-	0.534	0.000069
Sulfide	1.0	-	0.70	-	3.6	-	2.4	-	4.1	0.000532
Oil and Grease	5	-	3.5	-	26.2	-	3	-	1.7	0.000220
TSS	268	-	34	-	527	-	33	-	41	0.00532
pH (Units)	7.1-7.3		9.1		6.9-7.5		9.2		6.8-7.0	

TABLE V-23
CHARACTERISTICS OF FERROUS MELTING FURNACE SCRUBBER PROCESS WASTEWATERS
PAGE 6

(1) No raw wastewater data available.
* : Value is below 0.000001
- : Zero discharge; therefore, no effluent loads.
NA: Not analyzed
ND: Not detected
01: Ammonia Addition

Note: For definitions of C&TT codes, refer to Table III-21.

TABLE V-24

CHARACTERISTICS OF FERROUS SLAG QUENCHING PROCESS WASTEWATERS

Raw Wastewater

Plant:	15520	06956	51026	55217
Production (kkg/day):	563 (620 TPD)	590.2 (650 TPD)	408.6 (450 TPD)	197 (217 TPD)
Flow (l/kkg):	261 (62.7 GPT)	3640 (873 GPT)	555 (133 GPT)	559 (134 GPT)
Sample Points:	F - (E + G)	K	7	3

Pollutants		mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
034	2,4-dimethyl phenol	0.007	0.000020	0.036	0.00013	NA	NA	NA	NA
062	N-nitrosodiphenylamine	3.0	0.000782	0.011	0.000039	NA	NA	NA	NA
065	Phenol	0.223	0.000058	0.010	0.000036	NA	NA	NA	NA
085	Tetrachloroethylene	0.777	0.000203	0.010	0.000036	NA	NA	NA	NA
118	Cadmium	0.14	0.000038	0.010	0.000036	NA	NA	NA	NA
119	Chromium	0.98	0.000256	0.06	0.000231	NA	NA	NA	NA
120	Copper	0.39	0.000103	0.06	0.000219	NA	NA	0.06	0.0000335
122	Lead	12.60	0.00329	0.74	0.00269	NA	NA	0.26	0.000145
124	Nickel	0.14	0.000038	0.08	0.000304	NA	NA	0.03	0.0000168
128	Zinc	45.90	0.0120	0.67	0.00245	NA	NA	1.2	0.000671
	Ammonia (N)	0.00	0.00	10.4	0.0379	0.192	0.000106	0.73	0.000408
	Fluoride	63.4	0.0166	83.5	0.304	0.13	0.000072	3.6	0.00201
	Iron	0.10	0.000025	6.08	0.0211	1.5	0.000832	14.5	0.00810
	Manganese	45.0	1.17	1.14	0.00413	0.16	0.000089	2.5	0.00140
	Phenols (4AAP)	3.521	0.000920	0.379	0.00138	0.014	0.000008	0.027	0.000015
	Sulfide	14.1	0.00369	7.2	0.0262	0.13	0.000072	1.65	0.000922
	Oil & Grease	28.5	0.0744	4.0	0.0134	2.1	0.00116	2.5	0.00140
	TSS	*	*	89	0.323	48	0.0266	219	0.122
	pH (Units)	7.0 - 7.4		7.2 - 7.3		7.8		8.1 - 8.2	

TABLE V-24
CHARACTERISTICS OF FERROUS
SLAG QUENCHING PROCESS WASTEWATERS
PAGE 2

Raw Wastewater

Plant:	56771		52881		
Production (kkg/day):	125 (193TPD)		78(86TPD)		
Flow (l/kkg):	UNK		UNK		
Sample Points:	2		3		

Pollutants		mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	Average kg/kkg (lbs/1000 lbs)
034	2,4-dimethyl phenol	NA	NA	NA	NA	0.000075
062	N-nitrosodiphenylamine	NA	NA	NA	NA	0.000411
065	Phenol	NA	NA	NA	NA	0.000047
085	Tetrachloroethylene	NA	NA	NA	NA	0.000120
118	Cadmium	NA	NA	NA	NA	0.000037
119	Chromium	NA	NA	NA	NA	0.000244
120	Copper	NA	NA	NA	NA	0.000119
122	Lead	NA	NA	NA	NA	0.00200
124	Nickel	NA	NA	NA	NA	0.000120
128	Zinc	NA	NA	NA	NA	0.00504
	Ammonia (N)	3.82	#	1.02	#	0.00960
	Fluoride	16	#	36	#	0.0807
	Iron	42	#	2.9	#	0.00751
	Manganese	32	#	0.37	#	0.294
	Phenols (4AAP)	0.675	#	0.004	#	0.000581
	Sulfide	3.62	#	2.4	#	0.00772
	Oil & Grease	26.2	#	3	#	0.0226
	TSS	527	#	33	#	0.118
	pH (Units)	6.9 - 7.5		9.2		

TABLE V-24
CHARACTERISTICS OF FERROUS
SLAG QUENCHING PROCESS WASTEWATERS
PAGE 3

Treated Effluent

Plant:		15520		06956		51026		55217		56771	52881
Flow (l/kkg):		66.8 (16.03 GPT)		166.8 (40 GPT)		891 (213 GPT)		0 (0 GPT)		(1)	(1)
Sample Points:		((F-(E + G)/(F + A)) H		(K/(B + G)) (E)		(7/(2+3+6+7))5		(3/(4 + 5) 6			
C&TT:		SB,RTP-74		CL,FLP,NL,SL,RTP-95		SB		SB,RTP-100			
Pollutants		mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)		
034	2,4-dimethyl phenol	#	#	0.008	0.000001	NA	NA	NA	-		
062	N-nitrosodiphenyl-amine	<0.31	0.000021	0.013	0.000002	NA	NA	NA	-		
065	Phenol	<0.213	0.000014	0.00	0.000	NA	NA	NA	-		
085	Tetrachloroethylene	<0.812	0.000054	0.008	0.000001	NA	NA	NA	-		
118	Cadmium	<0.091	0.000006	0.01	0.000002	NA	NA	NA	-		
119	Chromium	<0.298	0.000020	0.03	0.000004	NA	NA	NA	-		
120	Copper	<0.07	0.000005	0.01	0.000001	NA	NA	0.01	-		
122	Lead	<0.766	0.000051	0.01	0.000001	NA	NA	0.07	-		
124	Nickel	<0.071	0.000005	0.07	0.000012	NA	NA	0.00	-		
128	Zinc	14.76	0.00099	0.01	0.000002	NA	NA	0.35	-		
	Ammonia (N)	0.00	0.000	9.7	0.00161	0.12	0.000103	0.94	-		
	Fluoride	29.1	0.00195	33.2	0.00552	0.21	0.000185	3.25	-		
	Iron	<0.102	0.000007	0.03	0.000005	0.18	0.000162	0.86	-		
	Manganese	21.5	0.00144	0.08	0.000013	0.03	0.000030	1.0	-		
	Phenols (4AAP)	3.11	0.000208	0.148	0.000025	0.006	0.000006	0.029	-		
	Sulfide	<0.313	0.000021	4.6	0.000764	0.004	0.000003	0.39	-		
	Oil & Grease	68.6	0.00458	2.0	0.000344	0.4	0.000394	0.6	-		
	TSS	*	*	5.0	0.000794	3.7	0.00332	13	-		
	pH (Units)	7.0 - 8.3		7.2 - 8.9		7.5-7.6		8.8-9.1			

Note: For definitions of C&TT codes refer to Table III-21.

* : Value is not quantifiable.
\# : Calculation could not be completed.
\- : Zero discharge, therefore no effluent load.
NA : Not analyzed
ND : Not detected

(1) No treated effluent data available.

TABLE V-25

CHARACTERISTICS OF FERROUS MOLD COOLING AND CASTING QUENCH PROCESS WASTEWATERS

Raw Wastewaters

Plant:	15654		51026		
Production (kkg/day)	196.1 (216 TPD)		408.6 (450 TPD)		
Flow (l/kkg):	21700 (5200 GPT)		977 (235 GPT)		
Sample Points:	C		3+6		
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)	Average kg/kkg (lbs/1000 lbs)
Iron	NA	NA	7.8	0.00774	0.00774
Oil and Grease	9.0	0.188	22.4	0.022	0.105
TSS	147	3.191	170	0.1687	1.680
pH (Units)	8.5-8.7		7.2-11.1		

Treated Effluent

Plant:	15654		51026	
Flow (l/kkg):	0 (0 GPT)		NA	
Sample Points:	B		NA	
C&TT:	CT,SB,RTP-100		SL	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)	mg/l	kg/kkg (lbs/1000 lbs)
Iron	NA	-	NA	NA
Oil and Grease	9.0	-	NA	NA
TSS	216	-	NA	NA
pH (Units)	8.5-8.6		NA	NA

Note: For definitions of C&TT codes refer to Table III-21.

-: Zero discharge; therefore, no effluent loads.
NA: Not available

TABLE V-26

CHARACTERISTICS OF FERROUS SAND WASHING PROCESS WASTEWATERS

Raw Wastewaters

Plant:	15520	20009	59101	51473	51026	51115	
Sand Washed (kkg/day):	3305 (3640 TPD)	209 (230 TPD)	160 (176 TPD)	29 (32 TPD)	45 (50 TPD)	98 (108 TPD)	
Flow (l/kkg):	693 (166 GPT)	6580 (1578 GPT)	26605 (6380 GPT)	5004 (1200 GPT)	12010 (2880 GPT)	888 (213 GPT)	
Sample Points:	J+K	B+C	2	2	2	2	

	Pollutants	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	Average kg/kkg (lbs/ 1000 lbs)
001	Acenaphthene	0.001	0.000001	0.069	0.000455	NA	NA	NA	NA	NA	NA	NA	NA	0.000228
065	Phenol	0.008	0.000006	0.937	0.00616	NA	NA	NA	NA	NA	NA	NA	NA	0.00308
077	Acenaphthylene	0.001	0.000001	0.018	0.000118	NA	NA	NA	NA	NA	NA	NA	NA	0.0000595
084	Pyrene	0.004	0.000003	0.020	0.000128	NA	NA	NA	NA	NA	NA	NA	NA	0.0000655
119	Chromium	0.03	0.000021	0.23	0.00151	NA	NA	NA	NA	NA	NA	NA	NA	0.000766
120	Copper	0.05	0.000034	0.47	0.00310	NA	NA	0.5	0.00250	NA	NA	1.87	0.00166	0.00182
122	Lead	0.22	0.000153	0.37	0.00245	NA	NA	2.0	0.0100	NA	NA	2.1	0.00187	0.00362
124	Nickel	0.02	0.00109	0.12	0.000786	NA	NA	0.2	0.00100	NA	NA	0.80	0.000710	0.000897
128	Zinc	0.55	0.000384	0.66	0.00432	NA	NA	4.4	0.0220	NA	NA	12.7	0.0113	0.00950
	Ammonia (N)	8.7	0.0060	0.4	0.00282	3.26	0.0867	0.21	0.00105	0.246	0.00295	ND	ND	0.0199
	Iron	0.045	0.000031	0.05	0.000347	61.3	1.63	380	1.90	22.5	0.270	617.0	0.548	0.725
	Manganese	0.97	0.000674	1.56	0.0102	1.8	0.0479	3.6	0.018	0.44	0.00528	10.0	0.00888	0.0152
	Phenols (4AAP)	0.036	0.000025	7.084	0.0466	0.591	0.0157	0.081	0.000405	0.008	0.000096	ND	ND	0.0126
	Sulfide	1.0	0.00068	0.3	0.00210	<0.5	0.0133	0.00	0.00	0.25	0.00300	0.04	0.000036	0.00319
	Oil & Grease	2.0	0.00139	4.0	0.0289	14.0	0.372	NA	NA	3.55	0.0426	27.7	0.0246	0.0939
	TSS	815	0.565	3473	22.83	5933	157.8	8200	41.03	226	2.71	20910	18.57	40.58
	pH (Units)	6.4-7.3		7.0-7.6		7.5		6.3		7.7-7.9		8.2		

TABLE V-26
CHARACTERISTICS OF FERROUS SAND
WASHING PROCESS WASTEWATERS
PAGE 2

Treated Effluent

Plant:	15520	20009	59101	51473	51026	51115
Flow (l/kkg):	109 (26 GPT)	2900 (695 GPT)	26605 (6380 GPT)	5004 (1200 GPT)	12010 (2880 GPT)	0 (0 GPT)
Sample Points:	((J+K)/(J+K+H)) L	((B+C)/(B+C+D))F	(2/(2+3))4	3	-	-
C&TT:	SB,CY,RTP-84	SL,RTP-56	SL	SB	SL	DT,SL,RTP-100

Pollutants	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)	mg/l	kg/kkg (lbs/ 1000 lbs)
001 Acenaphthene	0.001	*	0.030	0.000088	NA	NA	NA	NA	NA	NA	NA	-
065 Phenol	0.009	0.000001	0.724	0.00210	NA	NA	NA	NA	NA	NA	NA	-
077 Acenaphthylene	0.001	*	0.016	0.000047	NA	NA	NA	NA	NA	NA	NA	-
084 Pyrene	0.005	0.000001	0.013	0.000039	NA	NA	NA	NA	NA	NA	NA	-
119 Chromium	0.03	0.000003	0.09	0.000248	NA	NA	NA	NA	NA	NA	NA	-
120 Copper	0.08	0.000008	0.31	0.00090	NA	NA	0.5	0.00250	NA	NA	NA	-
122 Lead	0.07	0.000007	0.19	0.000541	NA	NA	1.6	0.00801	NA	NA	NA	-
124 Nickel	0.02	0.000002	0.05	0.000132	NA	NA	0.18	0.000901	NA	NA	NA	-
128 Zinc	9.12	0.000992	0.32	0.000915	NA	NA	3.3	0.0165	NA	NA	NA	-
Ammonia (N)	7.6	0.000827	0.2	0.000556	0.84	0.0223	0.25	0.00125	NA	NA	NA	-
Iron	0.056	0.000006	0.04	0.000112	0.23	0.00612	260.0	1.30	NA	NA	NA	-
Manganese	0.63	0.000069	0.74	0.00214	0.02	0.000532	2.8	0.0140	NA	NA	NA	-
Phenols (4AAP)	0.008	0.000001	6.96	0.0201	0.020	0.000532	0.068	0.000340	NA	NA	NA	-
Sulfide	0.7	0.000074	0.3	0.000919	0.34	0.00905	0.8	0.00400	NA	NA	NA	-
Oil & Grease	3	0.000323	7.0	0.019	7.6	0.202	NA	NA	NA	NA	NA	-
TSS	207	0.0225	594.0	1.72	7.1	0.189	1100	5.50	NA	NA	NA	-
pH (Units)	5.0-7.8		6.9-7.6		8.1		6.3					

Note: For definitions of C&TT codes refer to Table III-21.

ND : Not detected
NA : Not analyzed
* : Value is below 0.000001
- : Zero discharge, therefore no effluent loads.

TABLE V-27

CHARACTERISTICS OF LEAD
CONTINUOUS STRIP CASTING PROCESS WASTEWATERS

Raw Wastewater

Plant:		10145	
Flow (l/kkg):		25.3	
Sample Point:		S03	
Pollutants	mg/l		kg/kkg (lbs/1000 lbs)
120 Copper	0.046		0.000001
122 Lead	0.848		0.000021
128 Zinc	0.014		0.0000004
Oil and Grease	<5		<0.000126
TSS	5		0.000126
pH (units)		7.7	

Note: A representative discrete continuous strip casting treated effluent sample could not be obtained.

TABLE V-28

CHARACTERISTICS OF MAGNESIUM
GRINDING SCRUBBER PROCESS WASTEWATERS

Raw Wastewater

Plant:		08146	
Production (kkg/day):		0.726 (0.80 TPD)	
Flow (l/kkg):		6737 (1616 GPT)	
Sample Points:		B	
Pollutants	mg/l		kg/kkg (lbs/1000 lbs)
128 Zinc	1.19		0.00802
Manganese	0.29		0.00196
Oil and Grease	4.0		0.030
TSS	37.0		0.251
pH (Units)		9.4-10.0	

Treated Effluent

Plant:		08146	
Flow:		--	
Sample Points:		--	
C&TT:		None	
Pollutants	mg/l		kg/kkg (lbs/1000 lbs)
128 Zinc		NO TREATMENT	
Manganese			
Oil and Grease			
TSS			
pH (Units)			

TABLE V-29

CHARACTERISTICS OF MAGNESIUM
DUST COLLECTION PROCESS WASTEWATERS

Raw Wastewater

Plant:	08146	
Sand Handled (kkg/day):	90.8 (100 TPD)	
Flow (l/kkg):	90 (21.6 GPT)	
Sample Points:	C	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)
128 Zinc	0.36	0.000033
Phenols (4AAP)	1.141	0.000103
Sulfide	12.6	0.00113
Oil and Grease	11.0	0.000992
TSS	26.0	0.00232
pH (Units)	7.4-7.8	

Treated Effluent

Plant:	08146	
Flow:	--	
Sample Points:	--	
C&TT:	None	
Pollutants	mg/l	kg/kkg (lbs/1000 lbs)
128 Zinc	NO TREATMENT	
Phenols (4AAP)		
Sulfide		
Oil and Grease		
TSS		
pH (Units)		

TABLE V-30

CHARACTERISTICS OF ZINC CASTING
QUENCH PROCESS WASTEWATERS

Raw Wastewater

Plant:	10308	18139	12040	04622	
Production (kkg/day):	25.6 (28.2 TPD)	3.9 (4.3 TPD)	10.4 (11.5 TPD)	15.3 (16.8 TPD)	
Flow (l/kkg):	117.1 (28.1 GPT)	293.2 (70.3 GPT)	7339 (1760 GPT)	393.2 (94.3 GPT)	
Sample Points:	B	D	C	B	
Pollutants	mg/l / kg/kkg (lbs/1000 lbs)	mg/l / kg/kkg (lbs/1000 lbs)	mg/l / kg/kkg (lbs/1000 lbs)	mg/l / kg/kkg (lbs/1000 lbs)	Average kg/kkg (lbs/1000 lbs)
021 2,4,6-trichlorophenol	0.047 / 0.000006	0.071 / 0.000020	0.031 / 0.000224	ND / 0.000	0.0000625
022 Parachlorometacresol	ND / 0.000	0.017 / 0.000005	0.169 / 0.00124	0.030 / 0.000012	0.000313
084 Pyrene	0.009 / 0.000001	0.013 / 0.000004	0.005 / 0.000039	ND / 0.000	0.000011
085 Tetrachloroethylene	ND / 0.000	0.011 / 0.000003	0.063 / 0.00046	0.142 / 0.000056	0.000130
122 Lead	0.05 / 0.000006	0.05 / 0.000015	0.35 / 0.00256	0.09 / 0.000035	0.000654
128 Zinc	321.46 / 0.041	3.89 / 0.00109	2.94 / 0.0215	62.12 / 0.0244	0.0220
Manganese	0.27 / 0.000034	0.07 / 0.000020	0.15 / 0.0011	0.17 / 0.000067	0.000305
Phenols (4AAP)	0.102 / 0.000013	0.064 / 0.000018	0.115 / 0.00084	1.423 / 0.000559	0.000358
Sulfide	0.9 / 0.000117	0.32 / 0.000088	0.4 / 0.00317	0.2 / 0.000079	0.000864
Oil and Grease	74.0 / 0.0095	25 / 0.00705	1,289 / 9.41	17,133 / 6.73	4.039
TSS	86.0 / 0.011	45 / 0.0125	686 / 5.01	3.807 / 1.49	1.631
pH (Units)	5.7	7.3-7.5	7.2-7.4	7.4	

Treated Effluent

Plant:	10308	18139	12040	04622
Flow (k/kkg):	117.1 (28.1 GPT)	293.2 (70.3 GPT)	7339 (1760 GPT)	--
Sample Points:	(B/(B+C+D+E))I	D/(B+C+D+E+H) G	(C/D)E	--
C&TT:	NA,NC,GF,EB,FLA,FLC, FLP,SB,SS	OS,SB	EB,FLP,GF,NC,SB,VF, FLA,SS	
Pollutants	mg/l / kg/kkg (lbs/1000 lbs)	mg/l / kg/kkg (lbs/1000 lbs)	mg/l / kg/kkg (lbs/1000 lbs)	mg/l / kg/kkg (lbs/1000 lbs)
021 2,4,6-trichlorophenol	ND / 0.000	0.032 / 0.000009	0.025 / 0.000183	NO TREATMENT
022 Parachlorometacresol	0.00 / 0.000	ND / 0.000	0.0953 / 0.00070	
084 Pyrene	ND / 0.000	0.016 / 0.000004	0.00 / 0.000	
085 Tetrachloroethylene	0.00 / 0.000	0.013 / 0.000004	0.025 / 0.000183	
122 Lead	0.01 / 0.000001	0.03 / 0.000009	0.145 / 0.00106	
128 Zinc	32.99 / 0.00431	2.78 / 0.000776	2.50 / 0.0183	
Manganese	0.10 / 0.000012	0.10 / 0.000027	<0.006 / <0.000044	
Phenols (4AAP)	0.345 / 0.000044	0.01 / 0.000003	0.087 / 0.000639	
Sulfide	0.20 / 0.000023	0.38 / 0.000106	<0.218 / <0.00160	
Oil and Grease	4.0 / 0.00499	28 / 0.00784	6.59 / 0.0484	
TSS	8.0 / 0.000964	34 / 0.00948	0.165 / 0.0012	
pH (Units)	7.9-9.1	4.6-8.2	7.2-9.1	

Note: For definitions of C&TT codes refer to Table III-21.

ND: Not Detected

TABLE V-31

CHARACTERISTICS OF ZINC
MELTING FURNACE SCRUBBER
PROCESS WASTEWATERS

Raw Wastewater

Plant:		18139	
Production (kkg/day):		59.7 (65.7 TPD)	
Flow (l/kkg):		2925 (701 GPT)	
Sample Points:		B	
Pollutants		mg/l	kg/kkg (lbs/1000 lbs)
021	2,4,6-trichlorophenol	1.374	0.00402
022	Parachlorometacresol	0.081	0.000273
031	2,4-dichlorophenol	1.268	0.00376
034	2,4-dimethylphenol	4.342	1.269
055	Naphthalene	1.623	0.00474
065	Phenol	15.697	0.0459
067	Butyl benzyl phthalate	0.080	0.000234
128	Zinc	18.54	0.0542
	Phenols (4AAP)	90.744	0.265
	Oil and Grease	760	2.221
	TSS	429	1.254
	pH (Units)	4.6-4.7	

Treated Effluent

Plant:		18139	
Flow (l/kkg):		2925 (701 GPT)	
Sample Points:		(B/(B+C+D+E+H))G	
C&TT:		OS,SB	
Pollutants		mg/l	kg/kkg (lbs/1000 lbs)
021	2,4,6-trichlorophenol	0.617	0.00180
022	Parachlorometacresol	ND	0.000
031	2,4-dichlorophenol	0.220	0.000643
034	2,4-dimethylphenol	0.096	0.000281
055	Naphthalene	0.049	0.000144
065	Phenol	1.65	0.00484
067	Butyl benzyl phthalate	0.049	0.000144
128	Zinc	13.24	0.0387
	Phenols	14.194	0.0415
	Oil and Grease	845	2.470
	TSS	325	0.949
	pH (Units)	4.6-8.2	

Note: For definitions of C&TT codes refer to Table III-21.

ND: Not Detected

TABLE V-32

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: ALUMINUM
PROCESS : INVESTMENT CASTING

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
085	TETRACHLOROETHYLENE	9	0.000	0.170	0.076	0.069
087	TRICHLOROETHYLENE	9	0.000	0.150	0.055	0.050
120	COPPER	9	0.020	1.300	0.251	0.080
128	ZINC	9	0.000	1.400	0.278	0.110
131	SUSPENDED SOLIDS, TOTAL (TSS)	9	2.000	4674.000	1035.444	654.000
132	OIL AND GREASE (O&G)	9	9.000	41.000	22.444	24.000
136	PH (STANDARD UNITS)	9	6.600	8.600	6.956	6.900

TABLE V-32

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: ALUMINUM
PROCESS : MELTING FURNACE SCRUBBER

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
021	2,4,6-TRICHLOROPHENOL	6	0.000	0.235	0.073	0.041
039	FLUORANTHENE	6	0.000	0.023	0.006	0.000
073	BENZO (A) PYRENE	6	0.000	0.084	0.018	0.000
128	ZINC	6	0.040	0.300	0.185	0.210
131	SUSPENDED SOLIDS, TOTAL (TSS)	6	2.000	53.000	28.667	27.000
132	OIL AND GREASE (O&G)	6	2.000	16.000	7.833	6.500
133	AMMONIA, AS N	6	0.000	0.600	0.133	0.000
135	SULFIDE	6	0.000	2.900	0.733	0.200
136	PH (STANDARD UNITS)	6	7.300	8.200	7.750	7.750
191	PHENOLIC COMPOUNDS (PHENOL)	6	0.002	1.280	0.436	0.111

TABLE V-32

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: ALUMINUM
PROCESS : CASTING QUENCH

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
021	2,4,6-TRICHLOROPHENOL	7	0.000	2.000	0.426	0.101
031	2,4-DICHLOROPHENOL	7	0.000	0.150	0.031	0.000
039	FLUORANTHENE	7	0.000	0.430	0.092	0.000
067	BUTYL BENZYL PHTHALATE	7	0.000	0.082	0.027	0.000
084	PYRENE	7	0.000	0.500	0.117	0.021
085	TETRACHLOROETHYLENE	7	0.000	0.255	0.069	0.000
106	PCB-1242	5	0.000	0.000	0.000	0.000
107	PCB-1254	5	0.000	0.000	0.000	0.000
108	PCB-1221	5	0.000	0.000	0.000	0.000
109	PCB-1232	5	0.000	0.000	0.000	0.000
110	PCB-1248	5	0.000	0.000	0.000	0.000
111	PCB-1260	5	0.000	0.000	0.000	0.000
112	PCB-1016	5	0.000	0.000	0.000	0.000
120	COPPER	4	0.070	0.300	0.157	0.130
128	ZINC	7	0.130	9.100	1.786	0.570
130	XYLENE	7	0.000	0.000	0.000	0.000
131	SUSPENDED SOLIDS, TOTAL (TSS)	7	58.000	1307.000	458.857	160.000
132	OIL AND GREASE (O&G)	7	103.000	798.000	302.143	182.000
135	SULFIDE	7	0.000	37.000	5.761	0.200
136	PH (STANDARD UNITS)	7	5.400	8.600	6.886	7.200

TABLE V-32

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: ALUMINUM
PROCESS : DIE CASTING

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
001	ACENAPHTHENE	6	0.000	0.380	0.102	0.000
021	2,4,6-TRICHLOROPHENOL	6	0.000	2.000	0.350	0.000
022	P-CHLORO-M-CRESOL	6	0.000	0.150	0.070	0.081
023	CHLOROFORM	6	0.000	0.460	0.145	0.025
039	FLUORANTHENE	6	0.000	0.820	0.216	0.000
063	N-NITROSODI-N-PROPYLAMINE	6	0.000	0.078	0.017	0.000
065	PHENOL	6	0.000	5.000	0.843	0.000
067	BUTYL BENZYL PHTHALATE	6	0.000	2.000	0.342	0.000
072	BENZO (A) ANTHRACENE	6	0.000	0.000	0.000	0.000
076	CHRYSENE	6	0.000	1.200	0.402	0.006
084	PYRENE	6	0.000	0.224	0.043	0.006
085	TETRACHLOROETHYLENE	6	0.000	0.110	0.041	0.023
106	PCB-1242	4	0.000	0.000	0.000	0.000
107	PCB-1254	4	0.000	0.000	0.000	0.000
108	PCB-1221	4	0.000	0.000	0.000	0.000
109	PCB-1232	4	0.000	0.000	0.000	0.000
110	PCB-1248	4	0.000	0.000	0.000	0.000
111	PCB-1260	4	0.000	0.000	0.000	0.000
112	PCB-1016	4	0.000	0.000	0.000	0.000
122	LEAD	6	0.000	0.260	0.138	0.160
128	ZINC	6	0.130	7.100	2.255	1.550
130	XYLENE	6	0.000	0.097	0.022	0.000
131	SUSPENDED SOLIDS, TOTAL (TSS)	6	74.000	554.000	322.833	338.000
132	OIL AND GREASE (O&G)	6	356.000	1041.000	605.167	539.500
136	PH (STANDARD UNITS)	6	7.100	7.700	7.267	7.200
191	PHENOLIC COMPOUNDS (PHENOL)	6	0.054	5.430	1.668	0.193

TABLE V-32

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: ALUMINUM
PROCESS : DIE LUBE

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
005	BENZIDINE	5	0.000	7.600	1.520	0.000
006	CARBON TETRACHLORIDE	5	0.000	1.400	0.287	0.000
007	CHLOROBENZENE	5	0.000	1.600	0.469	0.017
010	1,2-DICHLOROETHANE	5	0.000	0.520	0.104	0.000
011	1,1,1-TRICHLOROETHANE	5	2.750	37.000	17.610	7.200
013	1,1-DICHLOROETHANE	5	0.000	0.165	0.033	0.000
021	2,4,6-TRICHLOROPHENOL	5	0.000	0.970	0.212	0.015
023	CHLOROFORM	5	0.000	1.300	0.533	0.290
039	FLUORANTHENE	5	0.000	16.000	3.200	0.000
044	METHYLENE CHLORIDE	5	0.330	6.200	3.146	2.300
055	NAPHTHALENE	5	0.000	7.900	1.580	0.000
058	4-NITROPHENOL	5	0.000	0.450	0.090	0.000
064	PENTACHLOROPHENOL	5	0.000	4.800	0.960	0.000
065	PHENOL	5	0.000	40.000	21.400	29.000
066	BIS-(2-ETHYLHEXYL)PHTHALATE	5	0.059	1000.000	361.412	43.000
067	BUTYL BENZYL PHTHALATE	5	0.000	1.600	0.320	0.000
072	BENZO (A) ANTHRACENE	5	0.000	62.000	12.400	0.000
077	ACENAPHTHYLENE	5	0.000	4.500	0.900	0.000
078	ANTHRACENE	5	0.000	0.000	0.000	0.000
080	FLUORENE	5	0.000	20.000	4.019	0.000
081	PHENANTHRENE	5	0.000	0.000	0.000	0.000
084	PYRENE	5	0.000	1.900	0.380	0.000
085	TETRACHLOROETHYLENE	5	0.000	0.250	0.129	0.090
087	TRICHLOROETHYLENE	5	0.180	0.410	0.281	0.240
091	CHLORDANE	5	0.000	0.240	0.070	0.000
120	COPPER	5	0.200	1.300	0.660	0.630
122	LEAD	5	0.730	6.000	2.596	2.600
128	ZINC	5	1.300	3.600	2.200	1.800
130	XYLENE	5	1.200	97.000	32.020	23.000
131	SUSPENDED SOLIDS, TOTAL (TSS)	5	640.000	3576.000	2123.200	2660.000
132	OIL AND GREASE (O&G)	5	306.000	49900.000	22417.200	15600.000
133	AMMONIA, AS N	5	19.000	29.000	23.000	23.000
135	SULFIDE	5	0.000	6.300	1.320	0.000
136	PH (STANDARD UNITS)	5	6.900	7.100	6.980	7.000
191	PHENOLIC COMPOUNDS (PHENOL)	5	55.400	125.000	82.320	76.000

TABLE V-33

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: COPPER
PROCESS : DUST COLLECTION

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
067	BUTYL BENZYL PHTHALATE	6	0.000	0.710	0.180	0.030
074	3,4-BENZOFLUORANTHENE	6	0.000	0.000	0.000	0.000
075	BENZO (K) FLUORANTHENE	6	0.000	0.000	0.000	0.000
084	PYRENE	6	0.000	0.044	0.021	0.022
120	COPPER	4	1.100	250.000	91.100	56.650
122	LEAD	6	2.100	53.000	23.550	21.700
124	NICKEL	4	0.040	1.700	0.652	0.435
128	ZINC	6	7.500	240.000	113.917	109.000
131	SUSPENDED SOLIDS, TOTAL (TSS)	6	316.000	1002.000	611.000	487.000
132	OIL AND GREASE (O&G)	6	2.000	32.000	10.500	3.500
136	PH (STANDARD UNITS)	6	7.000	7.300	7.150	7.150
138	MANGANESE	6	0.160	1.400	0.828	0.830
191	PHENOLIC COMPOUNDS (PHENOL)	6	0.165	3.270	2.046	2.190

TABLE V-33

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: COPPER
PROCESS : MOLD COOLING & CASTING QUENCH

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
120	COPPER	2	0.270	0.450	0.360	0.360
128	ZINC	3	1.900	2.300	2.100	2.100
131	SUSPENDED SOLIDS, TOTAL (TSS)	3	26.000	82.000	56.000	60.000
132	OIL AND GREASE (O&G)	3	9.000	110.000	44.667	15.000
136	PH (STANDARD UNITS)	3	8.200	8.400	8.300	8.300

TABLE V-34
FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: FERROUS
PROCESS : SAND WASHING

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
001	ACENAPHTHENE	10	0.000	0.110	0.019	0.000
065	PHENOL	10	0.000	1.600	0.215	0.005
077	ACENAPHTHYLENE	10	0.000	0.028	0.004	0.000
084	PYRENE	10	0.000	0.027	0.004	0.000
119	CHROMIUM	8	0.000	0.320	0.091	0.055
120	COPPER	12	0.030	2.100	0.635	0.275
122	LEAD	14	0.028	2.200	0.774	0.295
124	NICKEL	12	0.000	0.950	0.251	0.085
128	ZINC	14	0.170	14.000	3.389	0.660
131	SUSPENDED SOLIDS, TOTAL (TSS)	23	202.000	28010.000	4574.261	1350.000
132	OIL AND GREASE (O&G)	13	1.000	27.700	6.369	3.000
133	AMMONIA, AS N	20	0.086	11.000	3.194	0.830
135	SULFIDE	15	0.000	2.200	0.456	0.250
136	PH (STANDARD UNITS)	15	6.300	8.200	7.280	7.300
138	MANGANESE	15	0.410	10.000	1.799	1.000
163	IRON	23	7.200	750.000	126.791	30.000
191	PHENOLIC COMPOUNDS (PHENOL)	20	0.007	9.620	1.028	0.046

TABLE V-34

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: FERROUS
PROCESS : MOLD COOLING & CASTING QUENCH

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
131	SUSPENDED SOLIDS, TOTAL (TSS)	9	6.000	564.000	239.889	141.000
132	OIL AND GREASE (O&G)	5	1.700	22.700	10.080	9.000
136	PH (STANDARD UNITS)	5	7.200	11.100	8.820	8.600
163	IRON	9	5.600	9.800	7.556	7.400

TABLE V-34

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: FERROUS
PROCESS : SLAG QUENCH

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
034	2,4-DIMETHYLPHENOL	3	0.024	0.052	0.036	0.031
062	N-NITROSODIPHENYLAMINE	3	0.000	0.012	0.004	0.000
065	PHENOL	3	0.000	0.000	0.000	0.000
085	TETRACHLOROETHYLENE	3	0.000	0.000	0.000	0.000
118	CADMIUM	3	0.000	0.010	0.003	0.000
119	CHROMIUM	3	0.050	0.080	0.063	0.060
120	COPPER	5	0.030	0.090	0.058	0.050
122	LEAD	5	0.270	1.100	0.696	0.620
124	NICKEL	5	0.000	0.100	0.054	0.060
128	ZINC	5	0.510	4.000	1.464	0.910
131	SUSPENDED SOLIDS, TOTAL (TSS)	8	45.000	114.000	73.625	76.000
132	OIL AND GREASE (O&G)	6	0.000	7.000	3.183	2.550
133	AMMONIA, AS N	8	0.000	11.000	3.986	0.220
135	SULFIDE	6	0.000	17.000	3.622	0.565
136	PH (STANDARD UNITS)	6	7.200	8.000	7.533	7.500
137	FLUORIDE	6	0.070	99.000	41.712	36.565
138	MANGANESE	6	0.160	1.800	0.980	1.050
163	IRON	8	1.300	7.200	3.987	4.000
191	PHENOLIC COMPOUNDS (PHENOL)	8	0.006	0.521	0.150	0.018

TABLE V-34

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: FERROUS
PROCESS : MELTING FURNACE SCRUBBER

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
024	2-CHLOROPHENOL	6	0.000	0.082	0.027	0.013
031	2,4-DICHLOROPHENOL	6	0.000	0.185	0.040	0.006
034	2,4-DIMETHYLPHENOL	6	0.000	0.100	0.053	0.056
039	FLUORANTHENE	6	0.000	1.500	0.274	0.034
059	2,4-DINITROPHENOL	6	0.000	0.130	0.035	0.009
060	4,6-DINITRO-O-CRESOL	6	0.000	0.110	0.038	0.022
062	N-NITROSODIPHENYLAMINE	6	0.000	0.180	0.062	0.035
064	PENTACHLOROPHENOL	6	0.000	0.470	0.135	0.000
065	PHENOL	6	0.580	3.600	1.692	1.090
067	BUTYL BENZYL PHTHALATE	6	0.000	0.320	0.063	0.008
072	BENZO (A) ANTHRACENE	6	0.000	0.047	0.015	0.008
076	CHRYSENE	6	0.000	0.029	0.012	0.010
077	ACENAPHTHYLENE	6	0.000	0.430	0.087	0.021
080	FLUORENE	6	0.000	1.800	0.314	0.020
081	PHENANTHRENE	6	0.000	0.000	0.000	0.000
084	PYRENE	6	0.000	3.300	0.573	0.032
085	TETRACHLOROETHYLENE	6	0.000	0.077	0.036	0.042
114	ANTIMONY	5	0.700	1.400	1.100	1.100
115	ARSENIC	6	0.080	0.270	0.148	0.140
118	CADMIUM	5	0.530	1.800	1.042	0.820
119	CHROMIUM	5	0.170	0.490	0.322	0.280
120	COPPER	12	0.360	14.000	3.472	2.100
122	LEAD	13	1.300	328.000	99.485	91.000
124	NICKEL	12	0.000	0.600	0.197	0.125
128	ZINC	13	8.800	1724.000	348.523	160.000
131	SUSPENDED SOLIDS, TOTAL (TSS)	13	295.000	9600.000	1925.538	582.000
132	OIL AND GREASE (O&G)	13	1.000	112.000	33.000	15.000
133	AMMONIA, AS N	13	1.400	120.000	28.777	7.900
135	SULFIDE	13	0.000	26.100	5.923	2.000
136	PH (STANDARD UNITS)	13	3.700	12.000	6.908	6.800
137	FLUORIDE	13	4.800	242.000	59.138	22.000
138	MANGANESE	13	9.900	392.000	96.377	68.000
163	IRON	13	14.000	528.000	142.923	96.000
191	PHENOLIC COMPOUNDS (PHENOL)	13	0.118	16.900	4.413	0.779

TABLE V-34

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: FERROUS
PROCESS : DUST COLLECTION

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
001	ACENAPHTHENE	25	0.000	0.060	0.007	0.000
031	2,4-DICHLOROPHENOL	25	0.000	1.400	0.203	0.060
034	2,4-DIMETHYLPHENOL	25	0.000	1.200	0.175	0.014
039	FLUORANTHENE	25	0.000	0.073	0.026	0.029
062	N-NITROSODIPHENYLAMINE	25	0.000	0.046	0.004	0.000
064	PENTACHLOROPHENOL	25	0.000	0.100	0.023	0.020
065	PHENOL	25	0.000	17.000	2.330	0.018
067	BUTYL BENZYL PHTHALATE	25	0.000	0.130	0.015	0.000
072	BENZO (A) ANTHRACENE	25	0.000	0.018	0.001	0.000
076	CHRYSENE	25	0.000	0.026	0.008	0.010
077	ACENAPHTHYLENE	25	0.000	0.074	0.006	0.000
080	FLUORENE	25	0.000	0.077	0.014	0.000
081	PHENANTHRENE	25	0.000	0.000	0.000	0.000
084	PYRENE	25	0.000	0.065	0.025	0.027
085	TETRACHLOROETHYLENE	25	0.000	0.110	0.007	0.000
120	COPPER	34	0.030	11.200	1.283	0.240
122	LEAD	41	0.000	300.000	11.278	0.270
124	NICKEL	34	0.000	1.100	0.276	0.060
128	ZINC	41	0.250	1624.000	61.538	0.550
131	SUSPENDED SOLIDS, TOTAL (TSS)	51	47.000	39000.000	6169.039	3550.000
132	OIL AND GREASE (O&G)	36	4.000	150.000	24.528	18.650
133	AMMONIA, AS N	40	1.200	70.000	34.150	39.550
135	SULFIDE	37	0.000	9.800	2.538	1.250
136	PH (STANDARD UNITS)	37	7.000	9.400	7.503	7.500
138	MANGANESE	37	0.000	198.000	9.997	0.940
163	IRON	52	5.300	1350.000	311.852	74.000
191	PHENOLIC COMPOUNDS (PHENOL)	42	0.107	59.500	6.103	1.390

TABLE V-35

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: LEAD
PROCESS : CONTINUOUS STRIP CASTING

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
120	COPPER	1	0.046	0.046	0.046	0.046
122	LEAD	1	0.848	0.848	0.848	0.848
128	ZINC	1	0.014	0.014	0.014	0.014
131	SUSPENDED SOLIDS, TOTAL (TSS)	1	5.000	5.000	5.000	5.000
132	OIL AND GREASE (O&G)	1	5.000	5.000	5.000	5.000
136	PH (STANDARD UNITS)	1	7.700	7.700	7.700	7.700

TABLE V-36

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: MAGNESIUM
PROCESS : GRINDING SCRUBBERS

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
128	ZINC	3	0.380	1.700	1.160	1.400
131	SUSPENDED SOLIDS, TOTAL (TSS)	3	10.000	63.000	36.333	36.000
132	OIL AND GREASE (O&G)	3	1.000	11.000	4.333	1.000
136	PH (STANDARD UNITS)	3	9.400	10.000	9.767	9.900
138	MANGANESE	3	0.080	0.420	0.283	0.350

TABLE V-36

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: MAGNESIUM
PROCESS : DUST COLLECTION

POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
001	ACENAPHTHENE	3	0.000	0.064	0.021	0.000
128	ZINC	3	0.290	0.400	0.363	0.400
131	SUSPENDED SOLIDS, TOTAL (TSS)	3	7.000	40.000	25.667	30.000
132	OIL AND GREASE (O&G)	3	4.000	17.000	11.000	12.000
135	SULFIDE	3	5.600	21.000	12.533	11.000
136	PH (STANDARD UNITS)	3	7.400	7.800	7.567	7.500

TABLE V-37

FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

SUBCATEGORY: ZINC
PROCESS : CASTING QUENCH

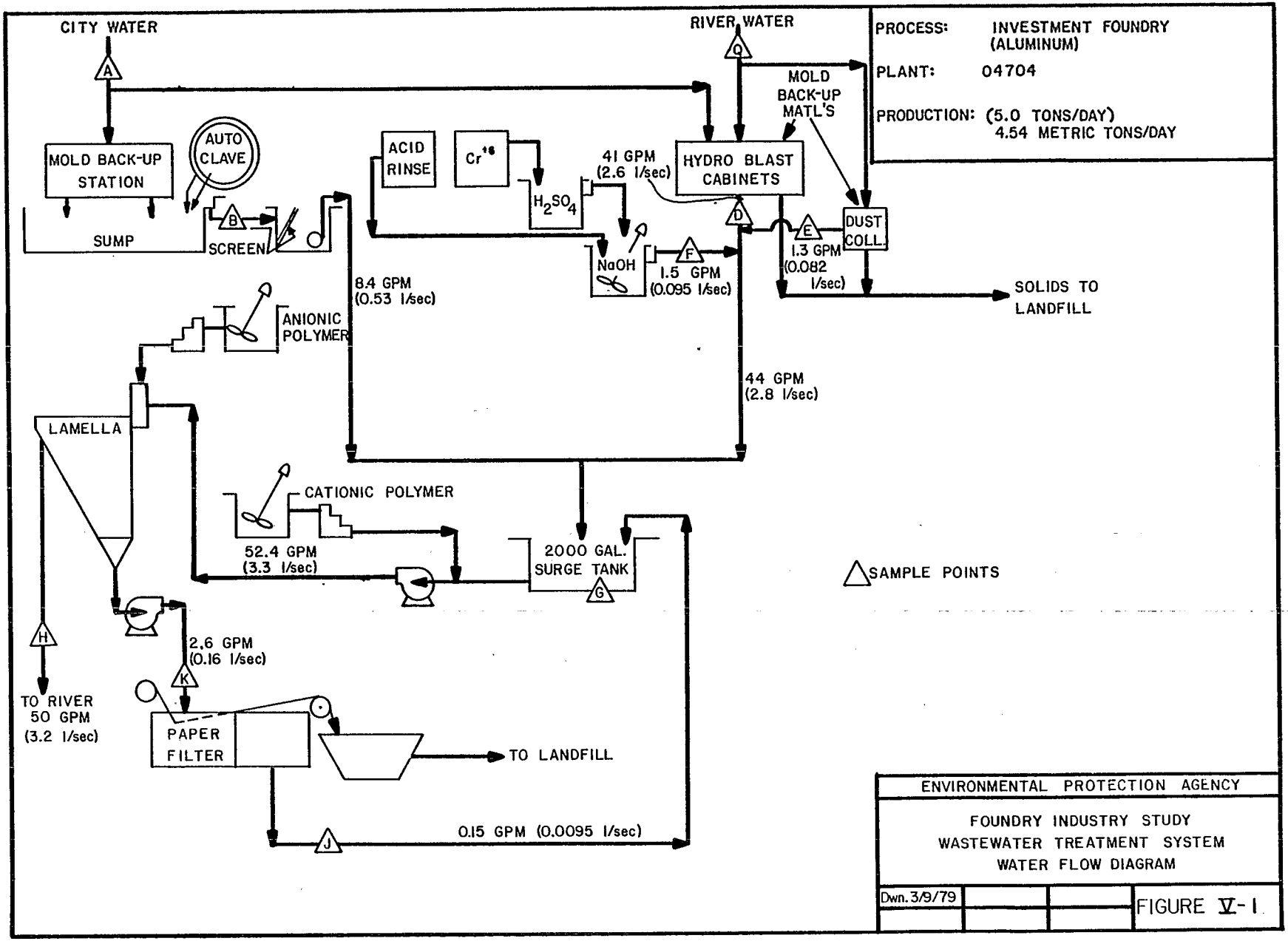
POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
021	2,4,6-TRICHLOROPHENOL	8	0.000	0.130	0.043	0.025
022	P-CHLORO-M-CRESOL	8	0.000	0.400	0.072	0.015
084	PYRENE	8	0.000	0.018	0.004	0.000
085	TETRACHLOROETHYLENE	8	0.000	0.142	0.044	0.020
122	LEAD	8	0.000	0.420	0.142	0.045
128	ZINC	8	2.300	350.000	53.987	3.550
131	SUSPENDED SOLIDS, TOTAL (TSS)	8	8.000	3800.000	759.500	349.000
132	OIL AND GREASE (O&G)	8	19.000	17100.000	2639.125	420.000
135	SULFIDE	8	0.000	1.000	0.212	0.000
136	PH (STANDARD UNITS)	8	5.700	7.500	7.162	7.350
138	MANGANESE	8	0.000	0.290	0.114	0.070
191	PHENOLIC COMPOUNDS (PHENOL)	8	0.020	1.420	0.257	0.090

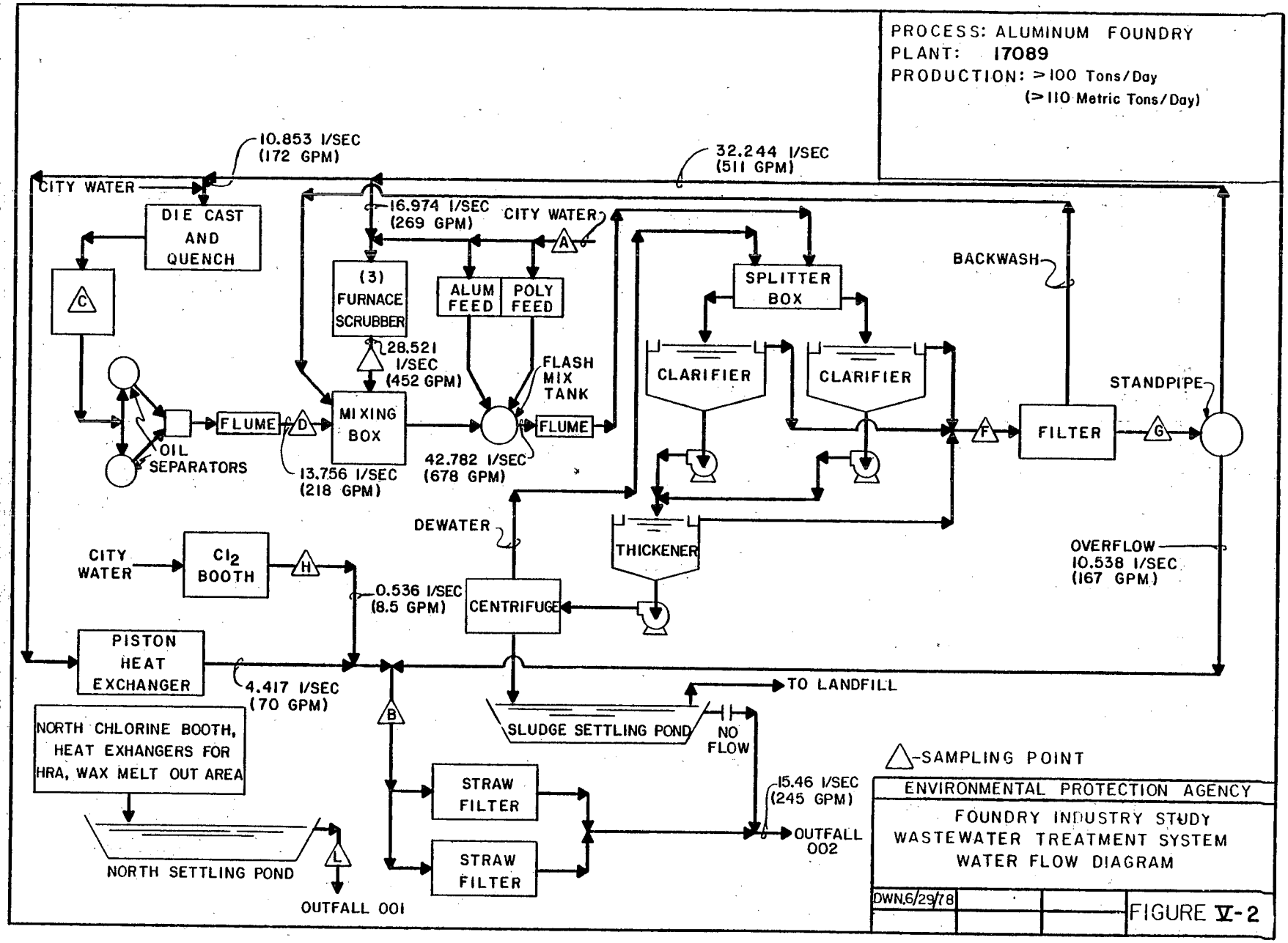
TABLE V-37

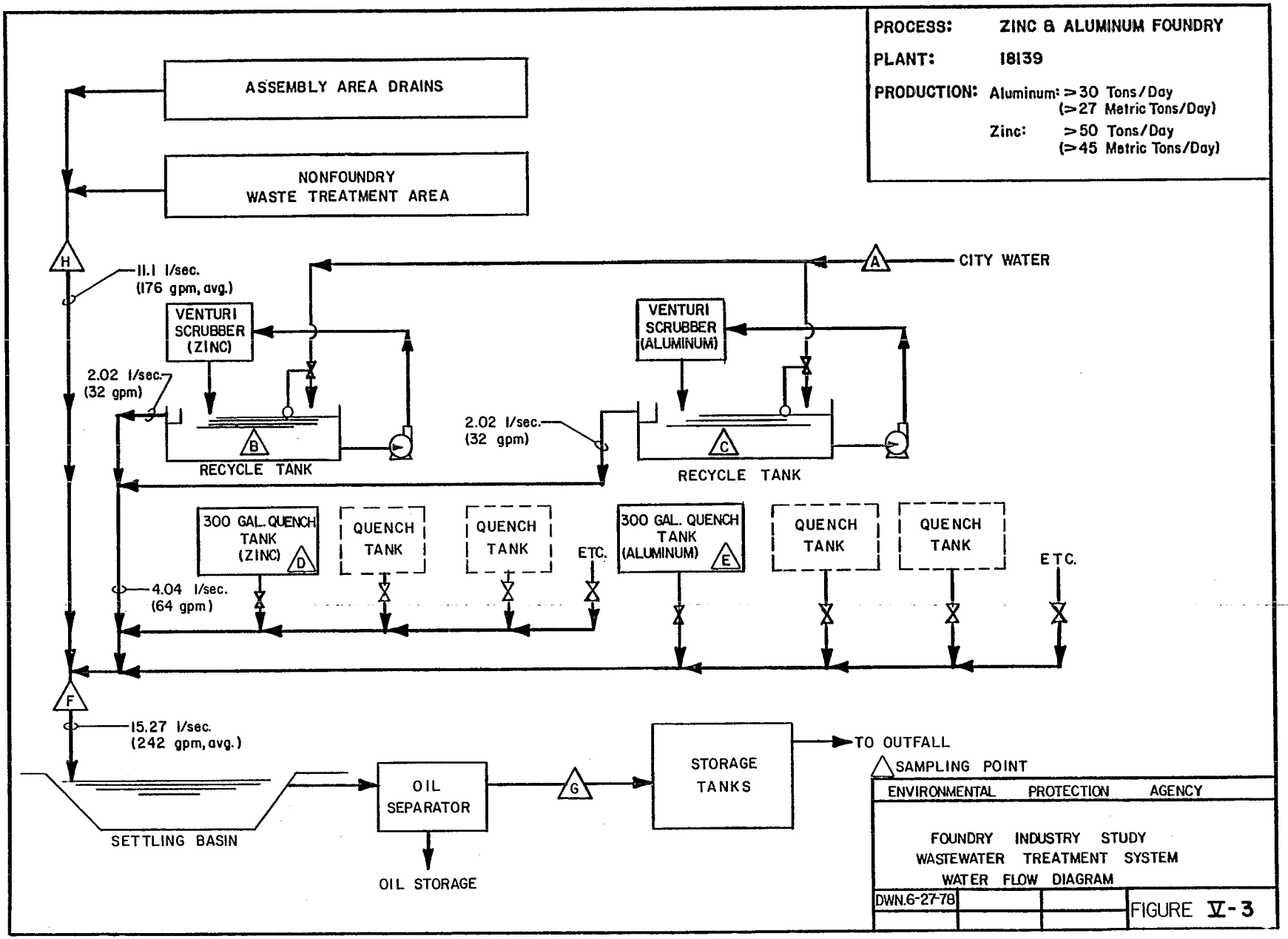
FOUNDRY GUIDELINES STUDY
RAW WASTEWATER
ANALYZED DATA PROFILE

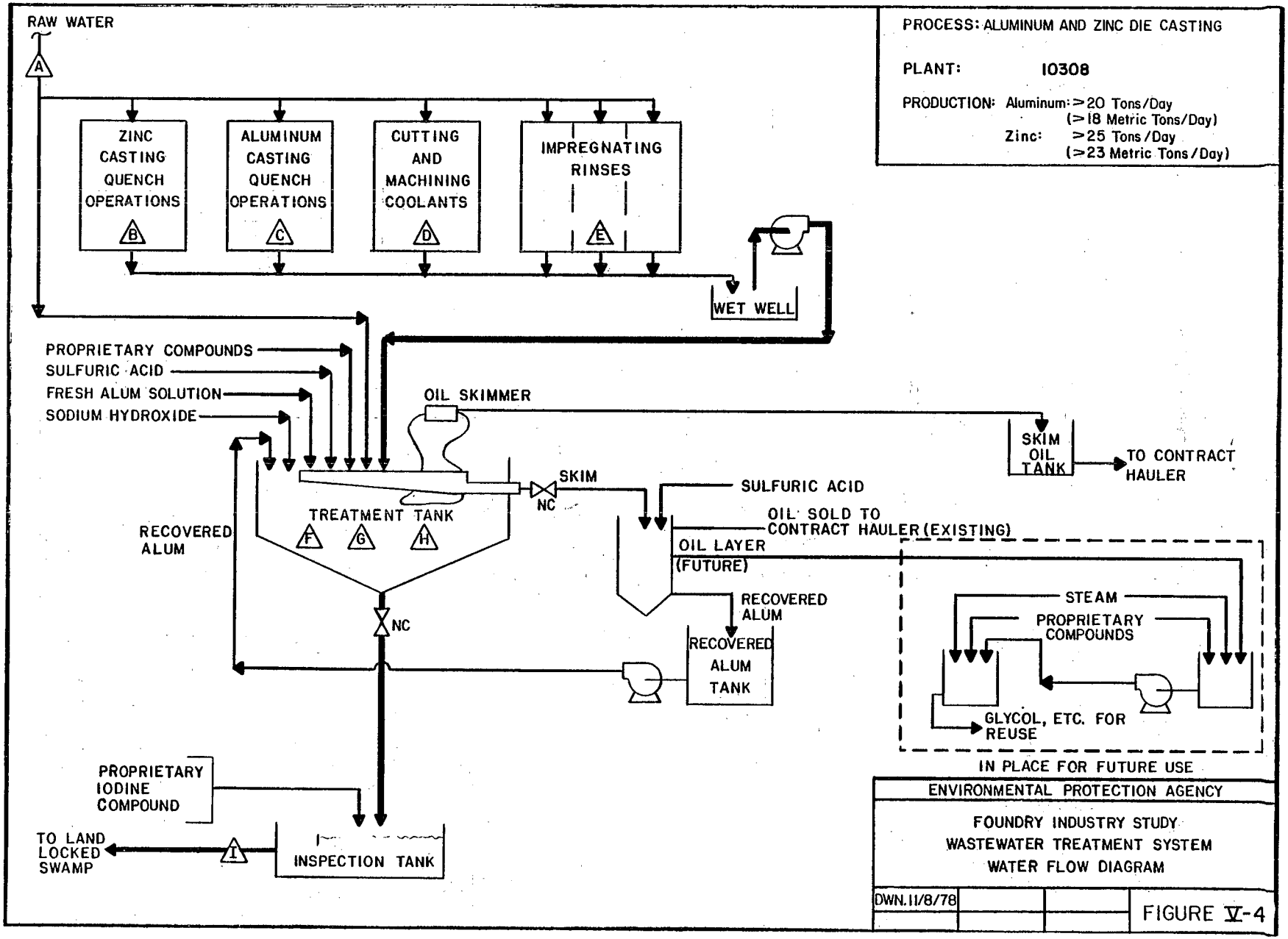
SUBCATEGORY: ZINC
PROCESS : MELTING FURNACE SCRUBBER

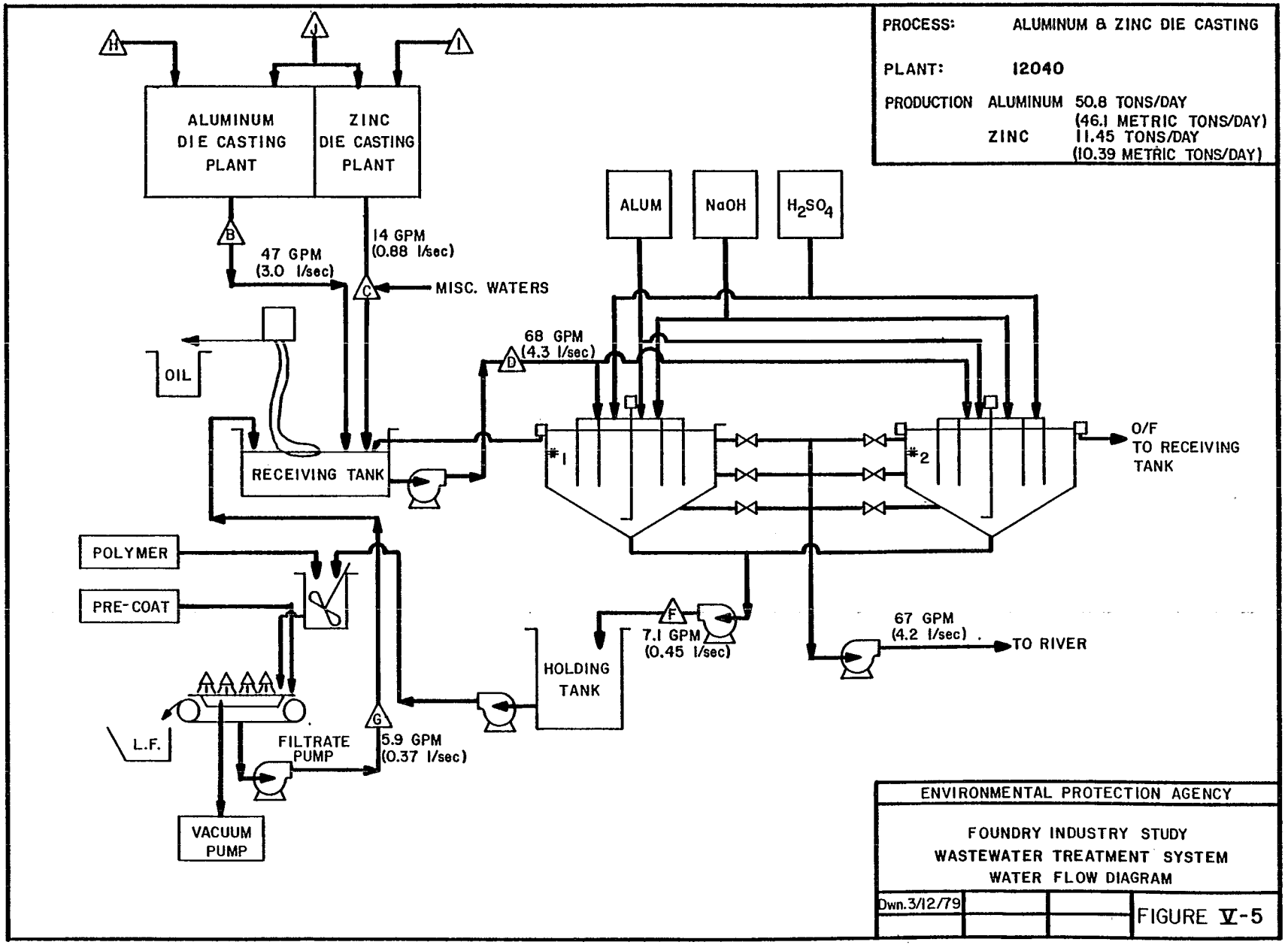
POLLUTANT NUMBER	POLLUTANT NAME	COUNT CONC	MINIMUM CONC	MAXIMUM CONC	AVG CONC	MEDIAN CONC
021	2,4,6-TRICHLOROPHENOL	3	0.495	2.650	1.372	0.970
022	P-CHLORO-M-CRESOL	3	0.000	0.280	0.093	0.000
031	2,4-DICHLOROPHENOL	3	0.805	1.950	1.285	1.100
034	2,4-DIMETHYLPHENOL	3	1.200	9.300	4.333	2.500
055	NAPHTHALENE	3	0.000	4.000	1.617	0.850
065	PHENOL	3	10.000	19.000	15.667	18.000
067	BUTYL BENZYL PHTHALATE	3	0.000	0.120	0.080	0.120
128	ZINC	3	7.500	25.000	18.500	23.000
131	SUSPENDED SOLIDS, TOTAL (TSS)	3	316.000	606.000	428.333	363.000
132	OIL AND GREASE (O&G)	3	646.000	885.000	758.333	744.000
136	PH (STANDARD UNITS)	3	4.600	4.700	4.667	4.700
191	PHENOLIC COMPOUNDS (PHENOL)	3	49.300	123.000	90.567	99.400

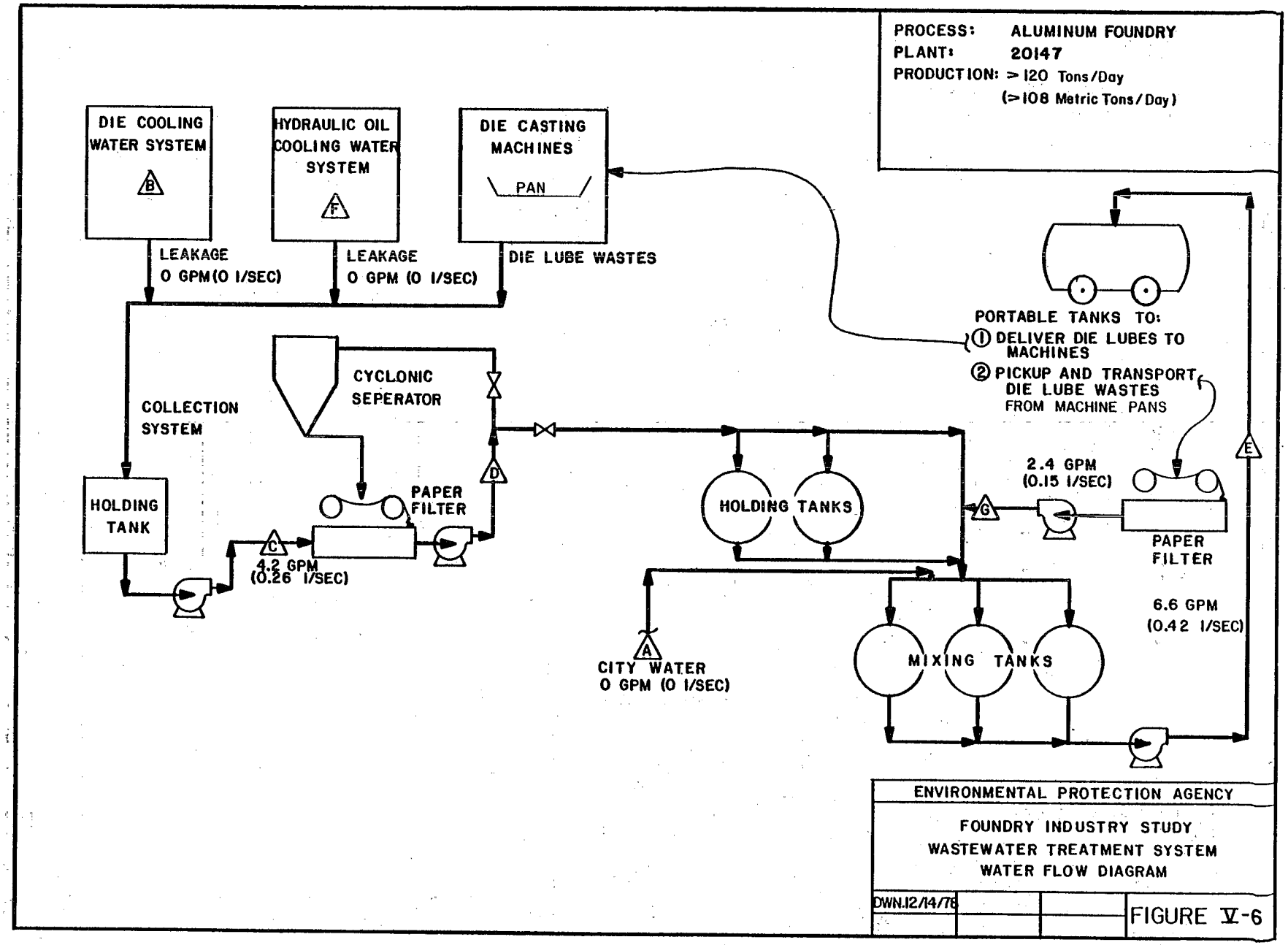

CITY WATER
A
MOLD BACK-UP STATION
AUTO CLAVE
SUMP
B
SCREEN
ACID RINSE
Cr+6
H2SO4
41 GPM (2.6 l/sec)
RIVER WATER
Q
MOLD BACK-UP MATL'S
HYDRO BLAST CABINETS
D
E
DUST COLL.
1.3 GPM (0.082 l/sec)
NaOH
F
1.5 GPM (0.095 l/sec)
SOLIDS TO LANDFILL
8.4 GPM (0.53 l/sec)
ANIONIC POLYMER
44 GPM (2.8 l/sec)
LAMELLA
CATIONIC POLYMER
52.4 GPM (3.3 l/sec)
2000 GAL. SURGE TANK
G
SAMPLE POINTS
H
2.6 GPM (0.16 l/sec)
K
TO RIVER 50 GPM (3.2 l/sec)
PAPER FILTER
TO LANDFILL
J
0.15 GPM (0.0095 l/sec)
PROCESS: INVESTMENT FOUNDRY (ALUMINUM)
PLANT: 04704
PRODUCTION: (5.0 TONS/DAY) 4.54 METRIC TONS/DAY
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 3/9/79
FIGURE V-1


PROCESS: ALUMINUM FOUNDRY
PLANT: 17089
PRODUCTION: >100 Tons/Day
(>110 Metric Tons/Day)
10.853 l/SEC
(172 GPM)
CITY WATER
32.244 l/SEC
(511 GPM)
DIE CAST AND QUENCH
16.974 l/SEC
(269 GPM)
CITY WATER
A
(3) FURNACE SCRUBBER
ALUM FEED
POLY FEED
BACKWASH
SPLITTER BOX
C
28.521 l/SEC
(452 GPM)
FLASH MIX TANK
CLARIFIER
CLARIFIER
STANDPIPE
FLUME
D
MIXING BOX
FLUME
OIL SEPARATORS
13.756 l/SEC
(218 GPM)
42.782 l/SEC
(678 GPM)
F
FILTER
G
DEWATER
THICKENER
CITY WATER
Cl2 BOOTH
H
OVERFLOW
10.538 l/SEC
(167 GPM)
0.536 l/SEC
(8.5 GPM)
CENTRIFUGE
PISTON HEAT EXCHANGER
4.417 l/SEC
(70 GPM)
TO LANDFILL
B
SLUDGE SETTLING POND
NO FLOW
NORTH CHLORINE BOOTH, HEAT EXHANGERS FOR HRA, WAX MELT OUT AREA
STRAW FILTER
STRAW FILTER
15.46 l/SEC
(245 GPM)
OUTFALL 002
NORTH SETTLING POND
L
OUTFALL 001
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.6/29/78
FIGURE V-2

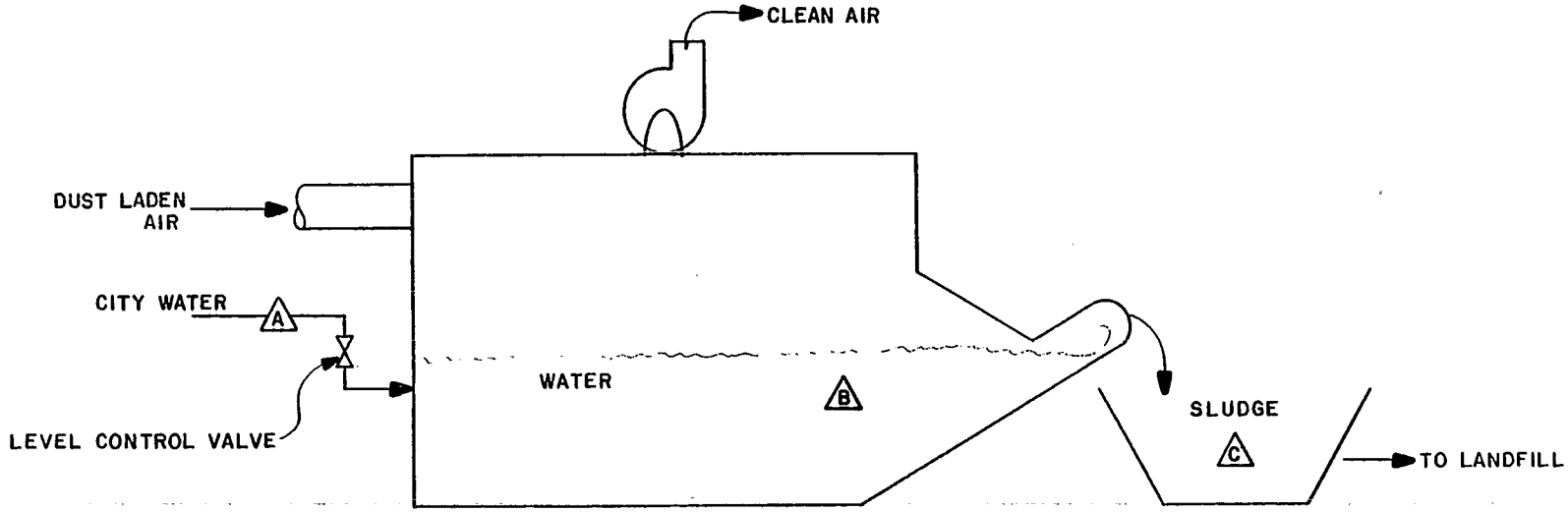

PROCESS: ZINC & ALUMINUM FOUNDRY
PLANT: 18139
PRODUCTION: Aluminum: >30 Tons/Day (>27 Metric Tons/Day)
Zinc: >50 Tons/Day (>45 Metric Tons/Day)
ASSEMBLY AREA DRAINS
NONFOUNDRY WASTE TREATMENT AREA
H
11.1 l/sec. (176 gpm, avg.)
A
CITY WATER
VENTURI SCRUBBER (ZINC)
VENTURI SCRUBBER (ALUMINUM)
2.02 l/sec. (32 gpm)
2.02 l/sec. (32 gpm)
B
RECYCLE TANK
C
RECYCLE TANK
300 GAL. QUENCH TANK (ZINC)
D
QUENCH TANK
QUENCH TANK
ETC.
300 GAL. QUENCH TANK (ALUMINUM)
E
QUENCH TANK
QUENCH TANK
ETC.
4.04 l/sec. (64 gpm)
F
15.27 l/sec. (242 gpm, avg.)
SETTLING BASIN
OIL SEPARATOR
G
STORAGE TANKS
TO OUTFALL
SAMPLING POINT
OIL STORAGE
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.6-27-78
FIGURE V-3


PROCESS: ALUMINUM AND ZINC DIE CASTING
PLANT: 10308
PRODUCTION: Aluminum: >20 Tons/Day (>18 Metric Tons/Day)
Zinc: >25 Tons/Day (>23 Metric Tons/Day)
RAW WATER
A
ZINC CASTING QUENCH OPERATIONS
B
ALUMINUM CASTING QUENCH OPERATIONS
C
CUTTING AND MACHINING COOLANTS
D
IMPREGNATING RINSES
E
WET WELL
PROPRIETARY COMPOUNDS
SULFURIC ACID
FRESH ALUM SOLUTION
SODIUM HYDROXIDE
OIL SKIMMER
SKIM OIL TANK
TO CONTRACT HAULER
SKIM
NC
SULFURIC ACID
TREATMENT TANK
F
G
H
RECOVERED ALUM
OIL SOLD TO CONTRACT HAULER (EXISTING)
OIL LAYER (FUTURE)
RECOVERED ALUM
NC
RECOVERED ALUM TANK
STEAM
PROPRIETARY COMPOUNDS
GLYCOL, ETC. FOR REUSE
IN PLACE FOR FUTURE USE
PROPRIETARY IODINE COMPOUND
TO LAND LOCKED SWAMP
I
INSPECTION TANK
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN. 11/8/78
FIGURE V-4


PROCESS: ALUMINUM & ZINC DIE CASTING
PLANT: 12040
PRODUCTION ALUMINUM 50.8 TONS/DAY (46.1 METRIC TONS/DAY)
ZINC 11.45 TONS/DAY (10.39 METRIC TONS/DAY)
ALUMINUM DIE CASTING PLANT
ZINC DIE CASTING PLANT
H
J
I
B
47 GPM (3.0 l/sec)
14 GPM (0.88 l/sec)
C
MISC. WATERS
ALUM
NaOH
H_2SO_4
OIL
68 GPM (4.3 l/sec)
D
RECEIVING TANK
#1
#2
O/F TO RECEIVING TANK
POLYMER
PRE-COAT
HOLDING TANK
F
7.1 GPM (0.45 l/sec)
67 GPM (4.2 l/sec)
TO RIVER
L.F.
FILTRATE PUMP
G
5.9 GPM (0.37 l/sec)
VACUUM PUMP
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 3/12/79
FIGURE V-5


PROCESS: ALUMINUM FOUNDRY
PLANT: 20147
PRODUCTION: > 120 Tons/Day
(>108 Metric Tons/Day)
DIE COOLING WATER SYSTEM
B
HYDRAULIC OIL COOLING WATER SYSTEM
F
DIE CASTING MACHINES
PAN
LEAKAGE
0 GPM (0 l/SEC)
LEAKAGE
0 GPM (0 l/SEC)
DIE LUBE WASTES
PORTABLE TANKS TO:
① DELIVER DIE LUBES TO MACHINES
② PICKUP AND TRANSPORT DIE LUBE WASTES FROM MACHINE PANS
COLLECTION SYSTEM
CYCLONIC SEPERATOR
HOLDING TANK
PAPER FILTER
C
4.2 GPM
(0.26 l/SEC)
D
HOLDING TANKS
2.4 GPM
(0.15 l/SEC)
G
PAPER FILTER
E
6.6 GPM
(0.42 l/SEC)
A
CITY WATER
0 GPM (0 l/SEC)
MIXING TANKS
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.12/14/78
FIGURE V-6

PROCESS:	BRONZE FOUNDRY DUST COLLECTION
PLANT:	19872
PRODUCTION:	45 TONS OF SAND/DAY (40.8 METRIC TONS OF SAND/DAY) 24 TONS OF METAL/DAY (21.8 METRIC TONS OF METAL/DAY)

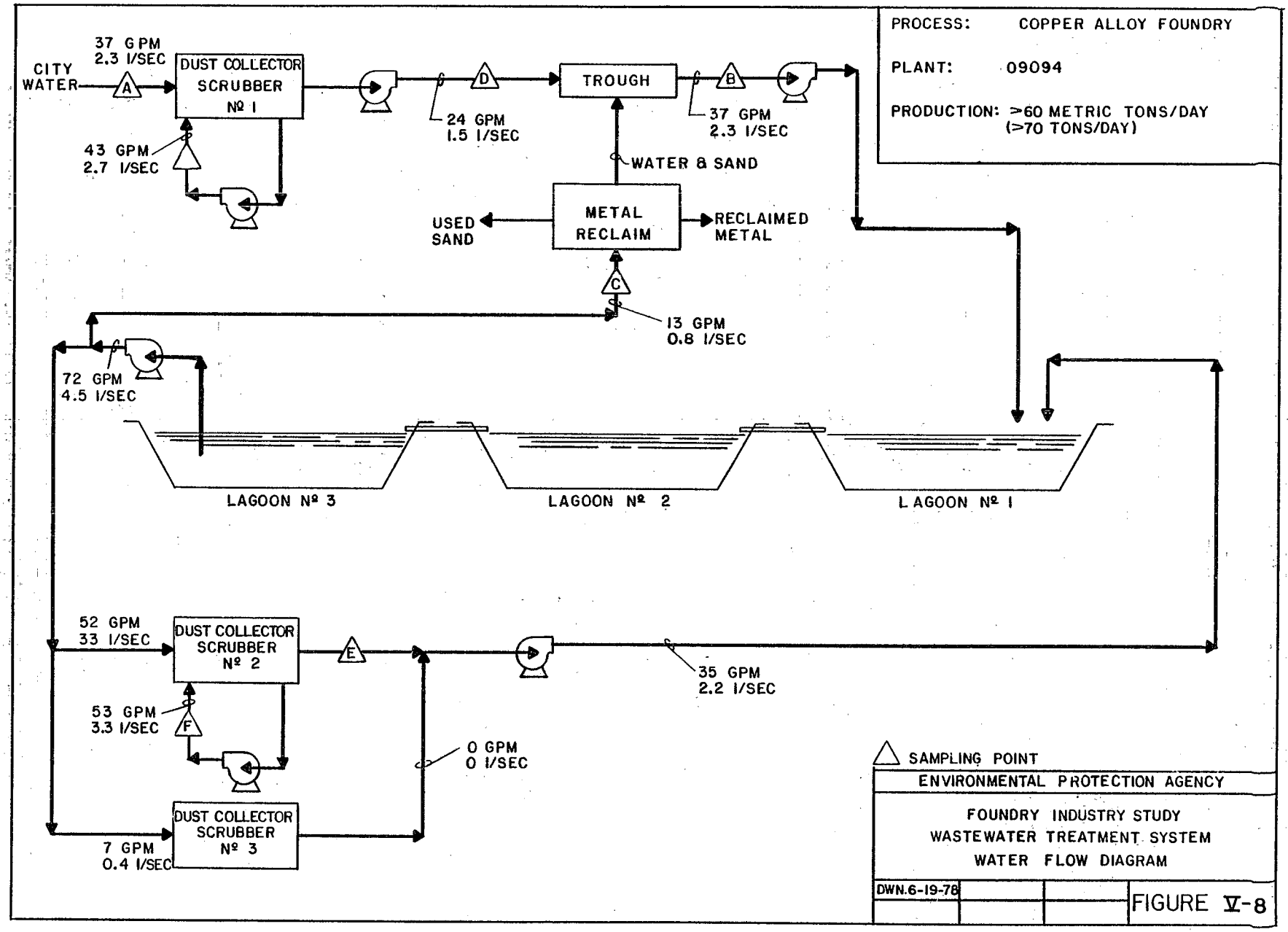


ENVIRONMENTAL PROTECTION AGENCY

FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

DWN.2/21/79

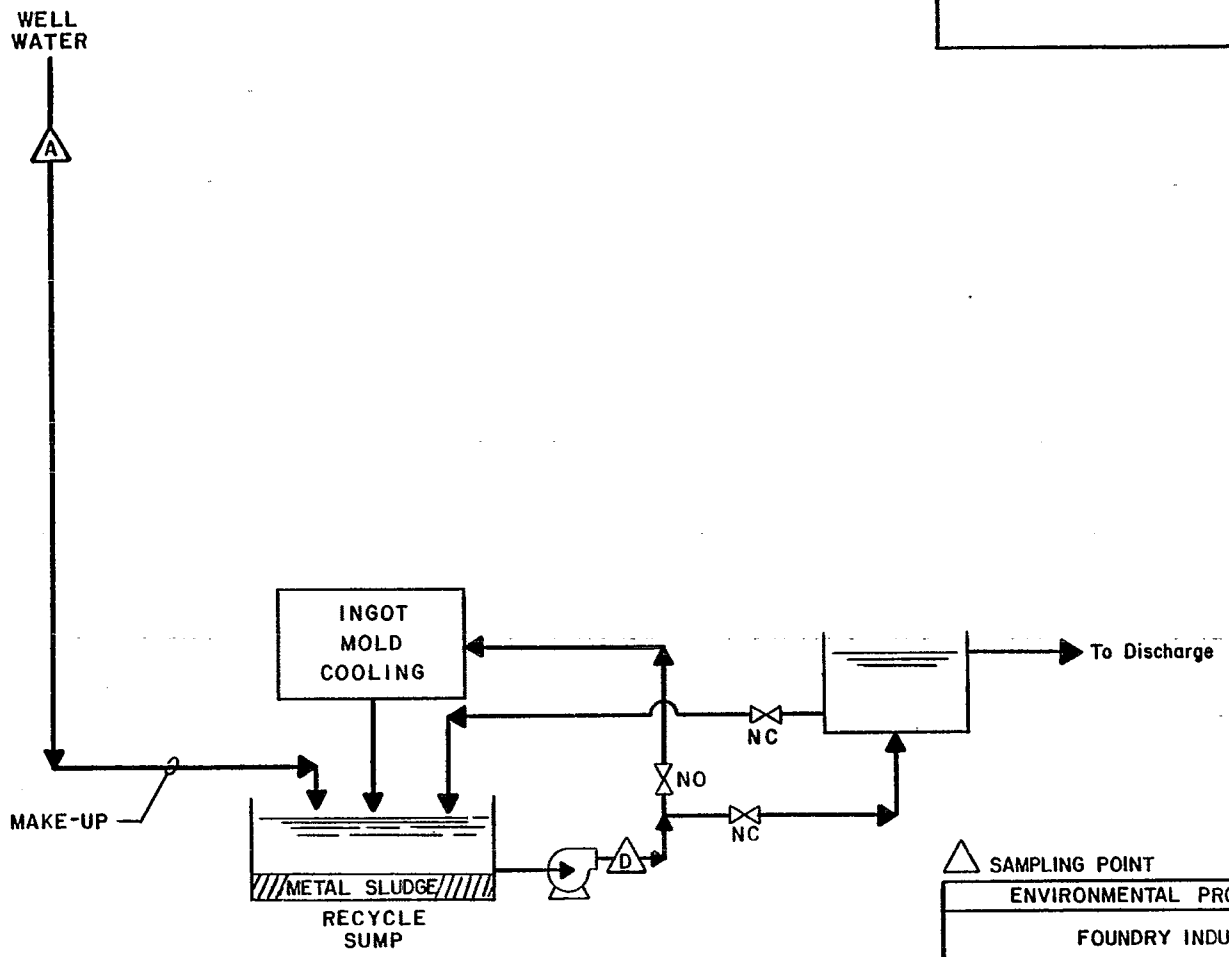
FIGURE V-7


PROCESS: COPPER ALLOY FOUNDRY
PLANT: 09094
PRODUCTION: >60 METRIC TONS/DAY (>70 TONS/DAY)
CITY WATER
37 GPM 2.3 l/SEC
A
DUST COLLECTOR SCRUBBER Nº 1
43 GPM 2.7 l/SEC
24 GPM 1.5 l/SEC
D
TROUGH
37 GPM 2.3 l/SEC
B
WATER & SAND
METAL RECLAIM
USED SAND
RECLAIMED METAL
C
13 GPM 0.8 l/SEC
72 GPM 4.5 l/SEC
LAGOON Nº 3
LAGOON Nº 2
LAGOON Nº 1
52 GPM 33 l/SEC
DUST COLLECTOR SCRUBBER Nº 2
E
35 GPM 2.2 l/SEC
53 GPM 3.3 l/SEC
F
0 GPM 0 l/SEC
DUST COLLECTOR SCRUBBER Nº 3
7 GPM 0.4 l/SEC
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.6-19-78
FIGURE V-8

PROCESS: BRASS & COPPER FOUNDRY

PLANT: 04736

PRODUCTION: 102 METRIC TONS/DAY (112 TONS/DAY)



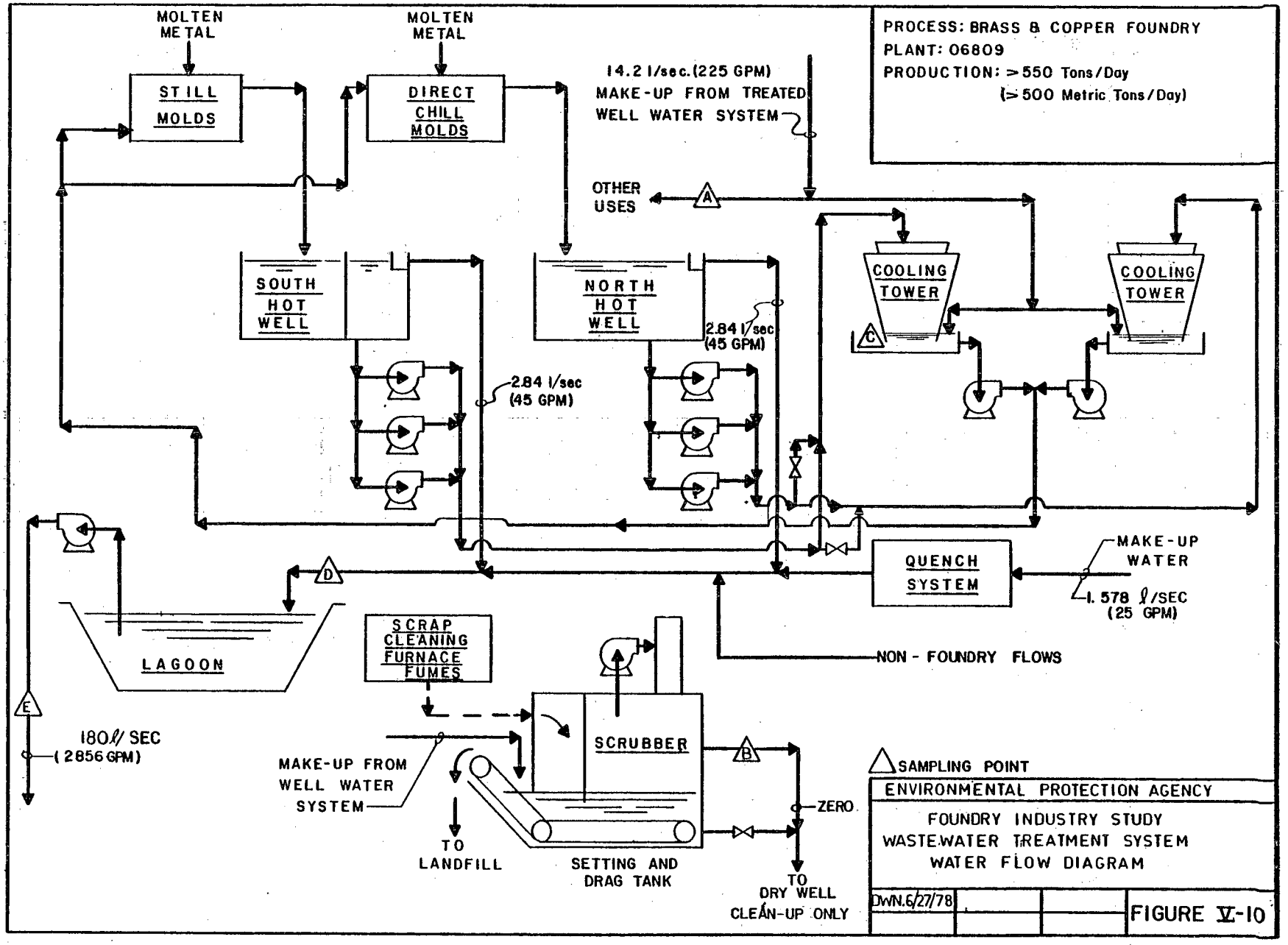
△ SAMPLING POINT

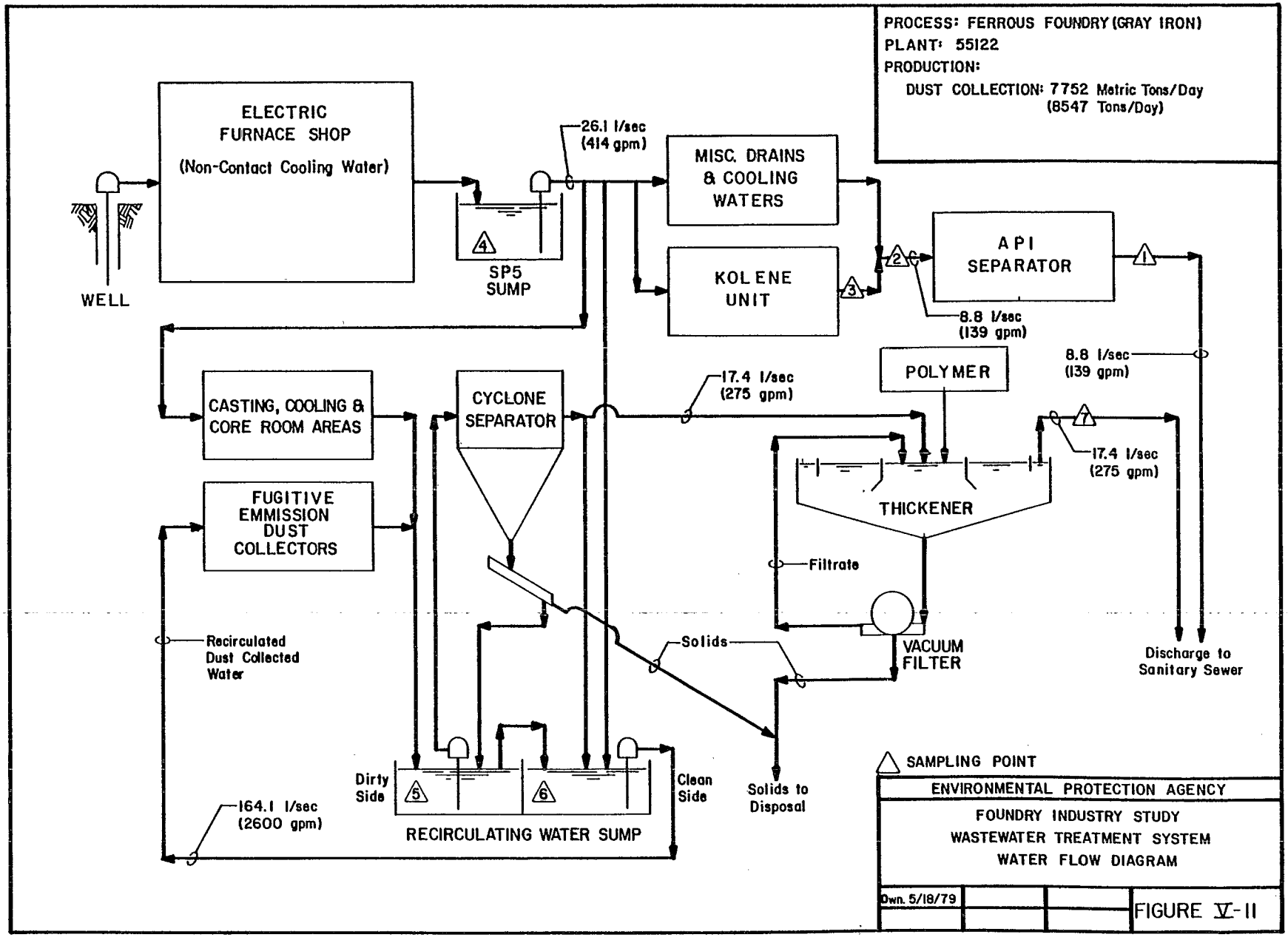
ENVIRONMENTAL PROTECTION AGENCY

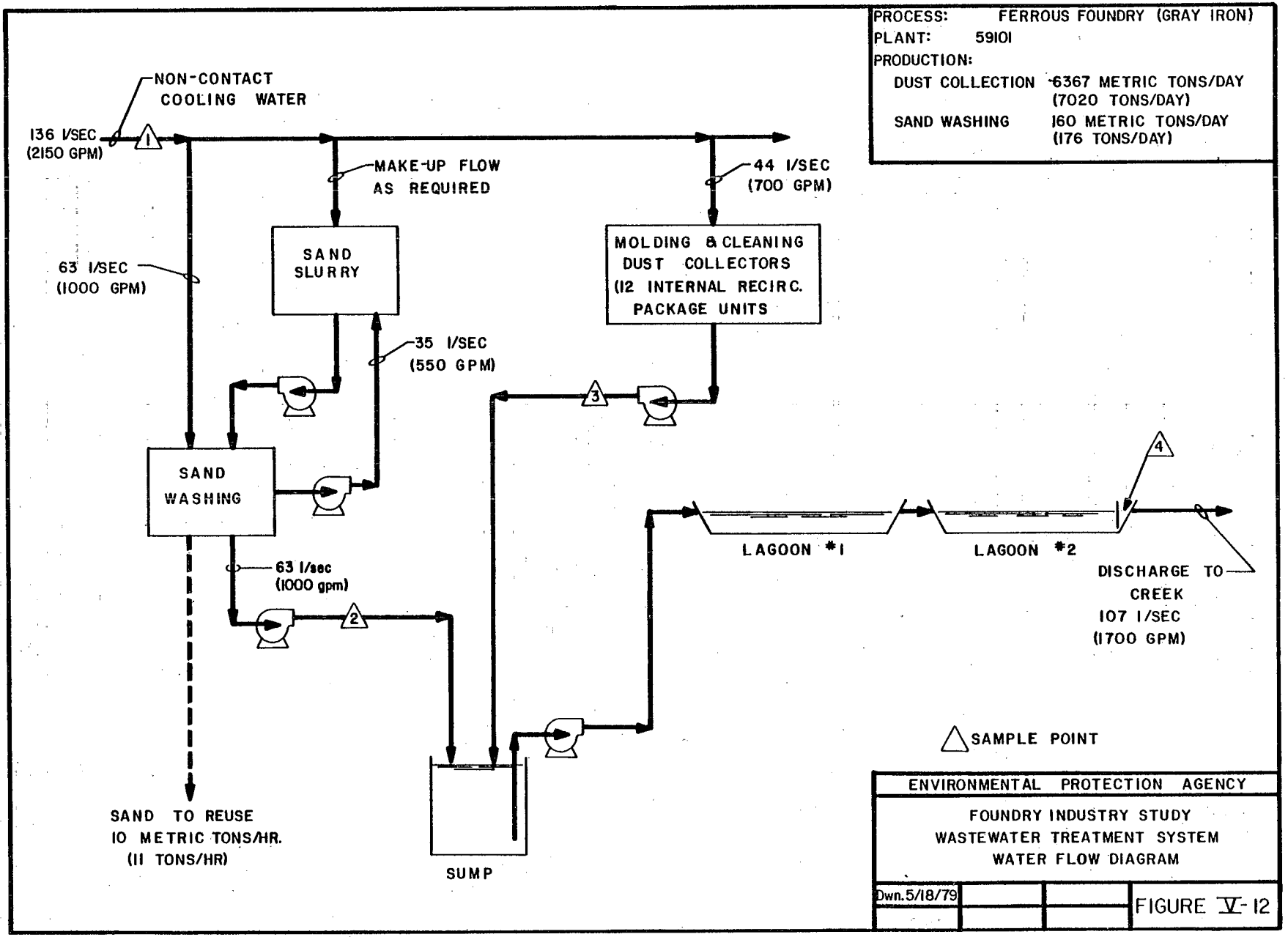
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

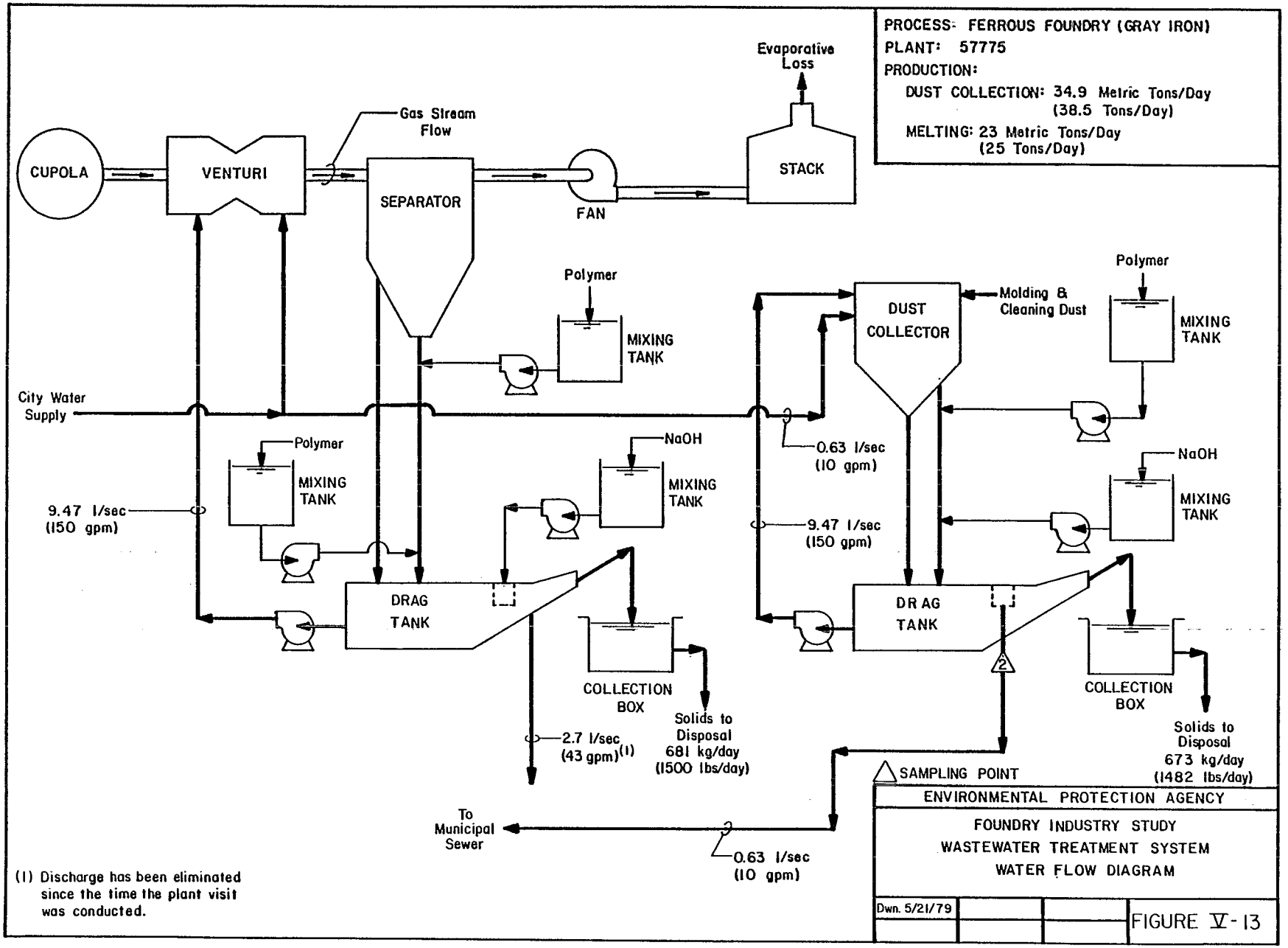
DWN.6-20-78

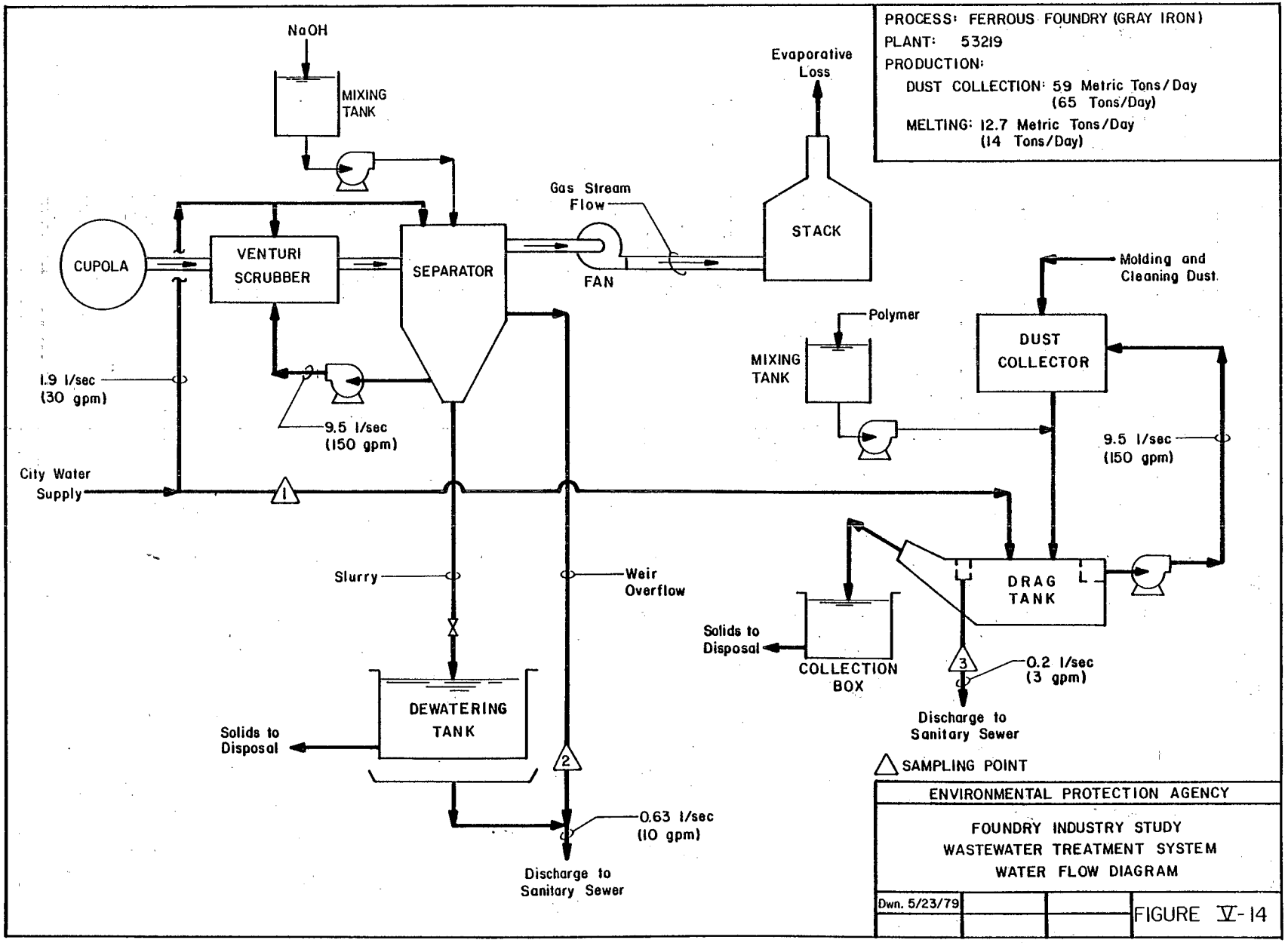
FIGURE V-9

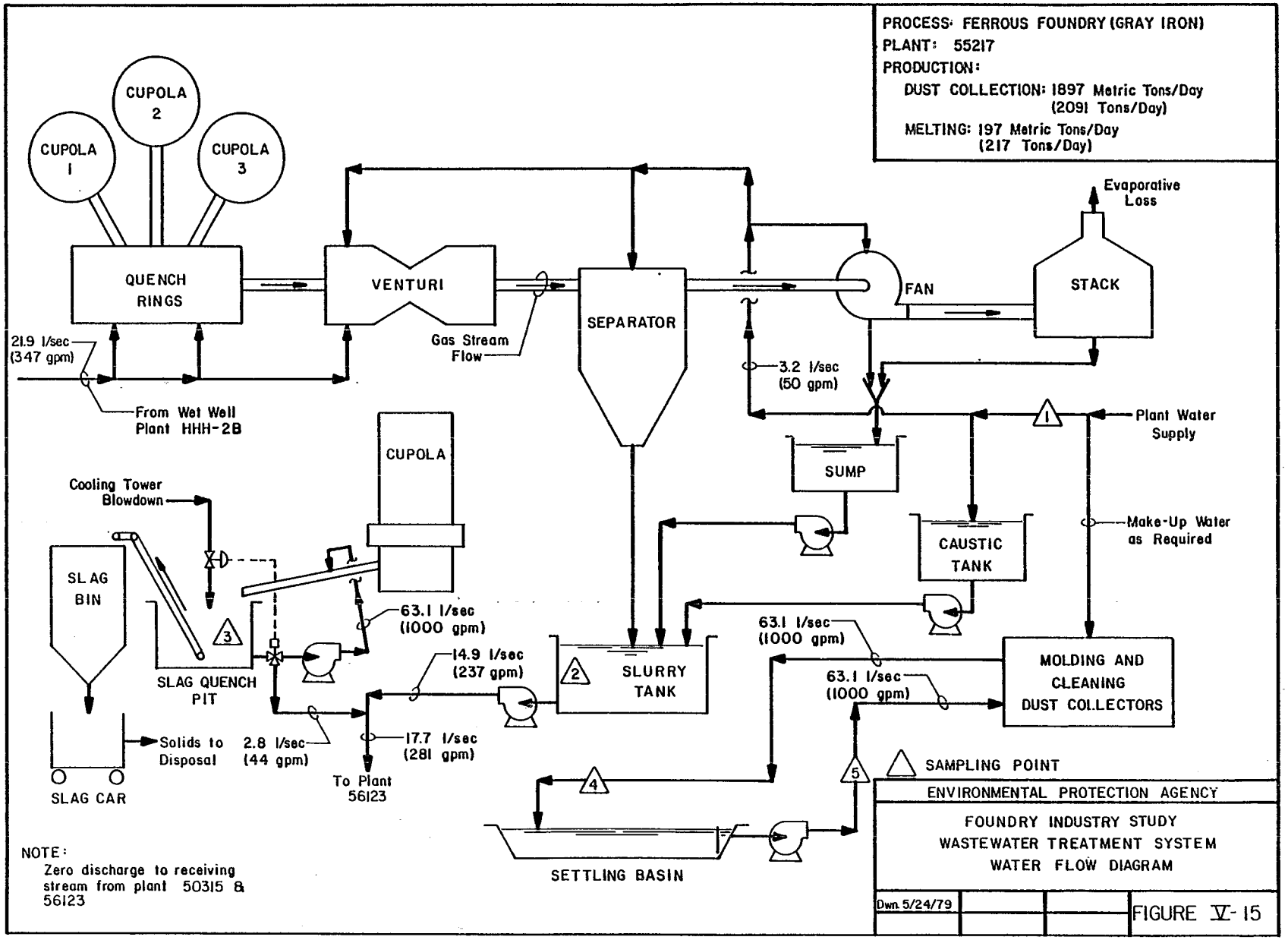

MOLTEN METAL
MOLTEN METAL
STILL MOLDS
DIRECT CHILL MOLDS
14.2 l/sec.(225 GPM) MAKE-UP FROM TREATED WELL WATER SYSTEM
OTHER USES
A
SOUTH HOT WELL
NORTH HOT WELL
2.84 l/sec (45 GPM)
2.84 l/sec (45 GPM)
COOLING TOWER
COOLING TOWER
C
QUENCH SYSTEM
MAKE-UP WATER
1.578 l/SEC (25 GPM)
NON - FOUNDRY FLOWS
D
LAGOON
SCRAP CLEANING FURNACE FUMES
SCRUBBER
B
E
180 l/ SEC (2856 GPM)
MAKE-UP FROM WELL WATER SYSTEM
TO LANDFILL
SETTING AND DRAG TANK
ZERO
TO DRY WELL CLEAN-UP ONLY
PROCESS: BRASS & COPPER FOUNDRY
PLANT: 06809
PRODUCTION: > 550 Tons/Day
(> 500 Metric Tons/Day)
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.6/27/78
FIGURE V-10

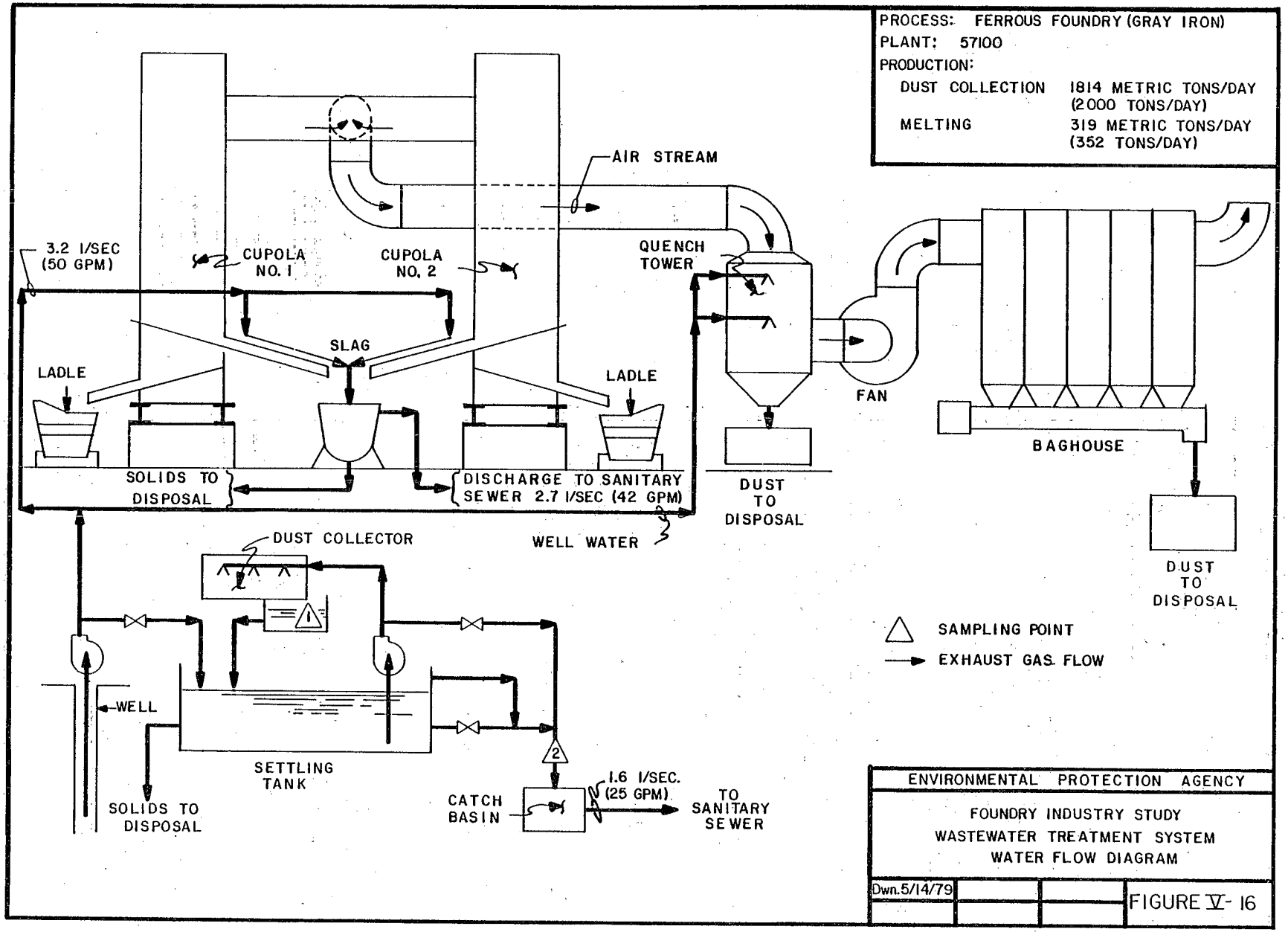

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 55122
PRODUCTION:
DUST COLLECTION: 7752 Metric Tons/Day
(8547 Tons/Day)
ELECTRIC FURNACE SHOP
(Non-Contact Cooling Water)
WELL
SP5 SUMP
26.1 l/sec (414 gpm)
MISC. DRAINS & COOLING WATERS
KOLENE UNIT
API SEPARATOR
8.8 l/sec (139 gpm)
POLYMER
8.8 l/sec (139 gpm)
CASTING, COOLING & CORE ROOM AREAS
CYCLONE SEPARATOR
17.4 l/sec (275 gpm)
FUGITIVE EMMISSION DUST COLLECTORS
THICKENER
17.4 l/sec (275 gpm)
Filtrate
Recirculated Dust Collected Water
Solids
VACUUM FILTER
Discharge to Sanitary Sewer
Dirty Side
Clean Side
164.1 l/sec (2600 gpm)
RECIRCULATING WATER SUMP
Solids to Disposal
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/18/79
FIGURE V-11

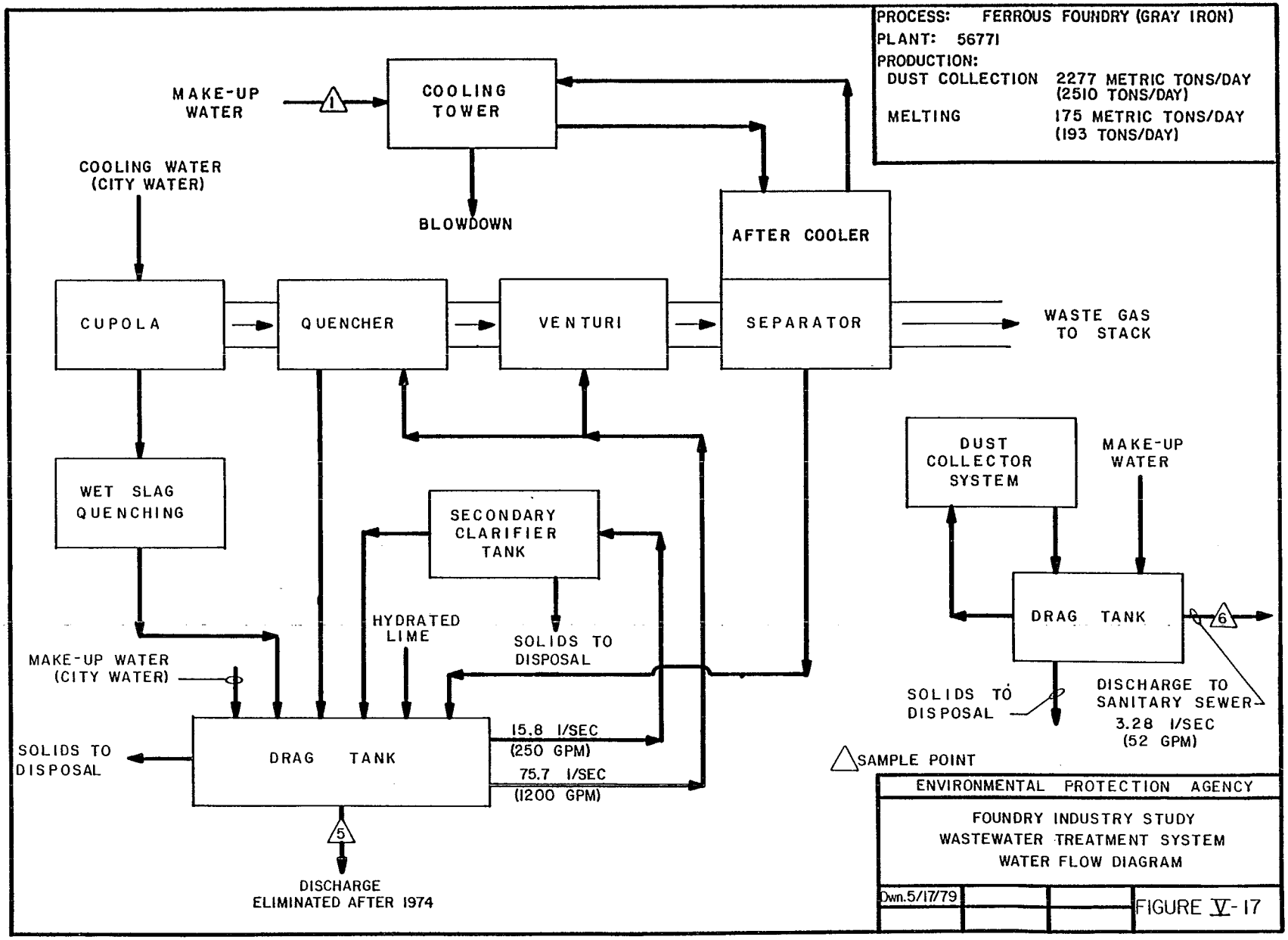

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 59101
PRODUCTION:
DUST COLLECTION 6367 METRIC TONS/DAY (7020 TONS/DAY)
SAND WASHING 160 METRIC TONS/DAY (176 TONS/DAY)
NON-CONTACT COOLING WATER
136 l/SEC (2150 GPM)
1
MAKE-UP FLOW AS REQUIRED
44 l/SEC (700 GPM)
SAND SLURRY
MOLDING & CLEANING DUST COLLECTORS (12 INTERNAL RECIRC. PACKAGE UNITS
63 l/SEC (1000 GPM)
35 l/SEC (550 GPM)
3
SAND WASHING
4
LAGOON #1
LAGOON #2
DISCHARGE TO CREEK 107 l/SEC (1700 GPM)
63 l/sec (1000 gpm)
2
SAND TO REUSE 10 METRIC TONS/HR. (11 TONS/HR)
SUMP
SAMPLE POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/18/79
FIGURE V-12

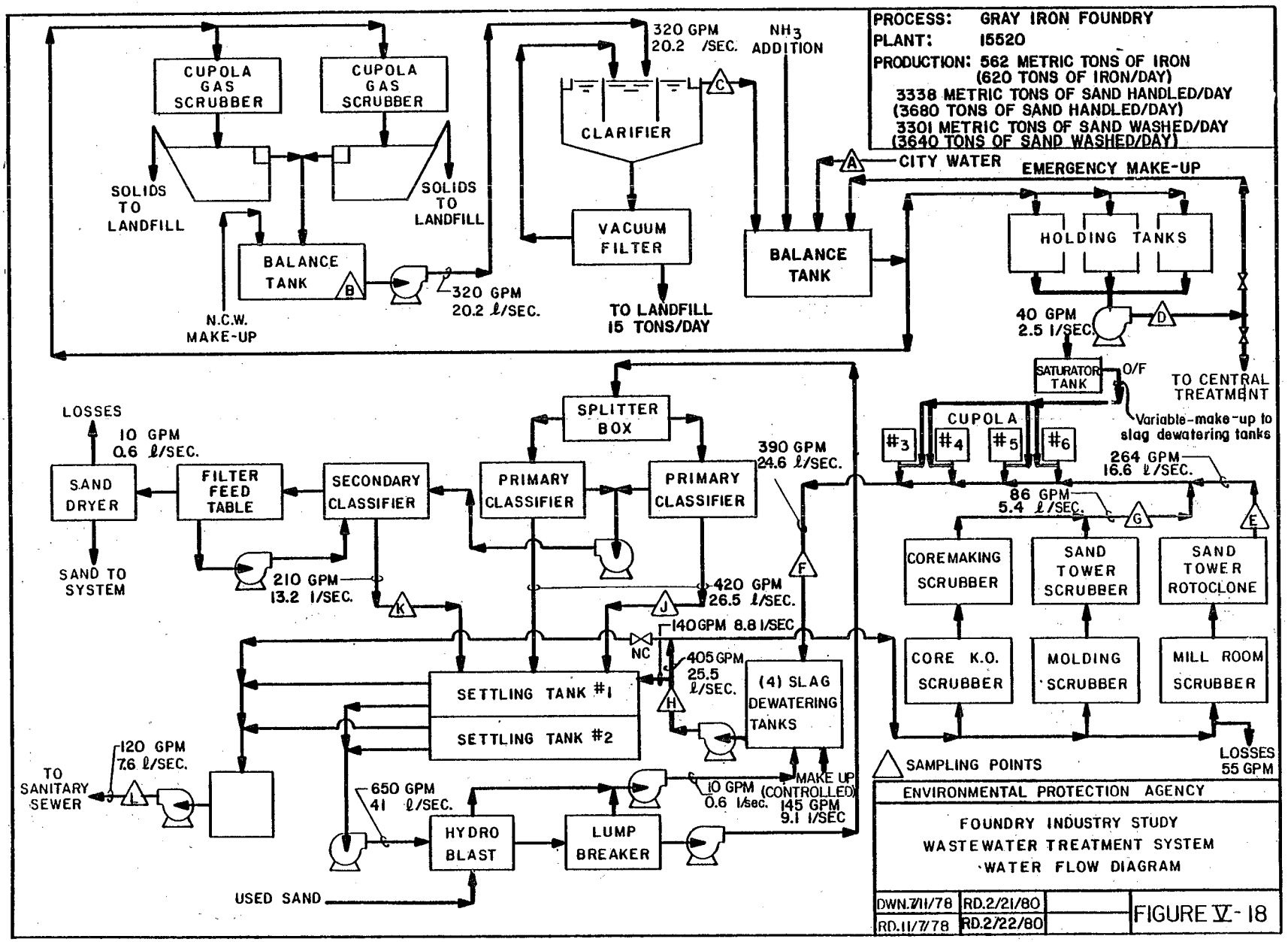

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 57775
PRODUCTION:
DUST COLLECTION: 34.9 Metric Tons/Day (38.5 Tons/Day)
MELTING: 23 Metric Tons/Day (25 Tons/Day)
Evaporative Loss
Gas Stream Flow
CUPOLA
VENTURI
SEPARATOR
FAN
STACK
Polymer
MIXING TANK
DUST COLLECTOR
Molding & Cleaning Dust
City Water Supply
0.63 l/sec (10 gpm)
9.47 l/sec (150 gpm)
NaOH
DRAG TANK
COLLECTION BOX
Solids to Disposal 681 kg/day (1500 lbs/day)
2.7 l/sec (43 gpm)(1)
Solids to Disposal 673 kg/day (1482 lbs/day)
SAMPLING POINT
To Municipal Sewer
(1) Discharge has been eliminated since the time the plant visit was conducted.
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/21/79
FIGURE V-13

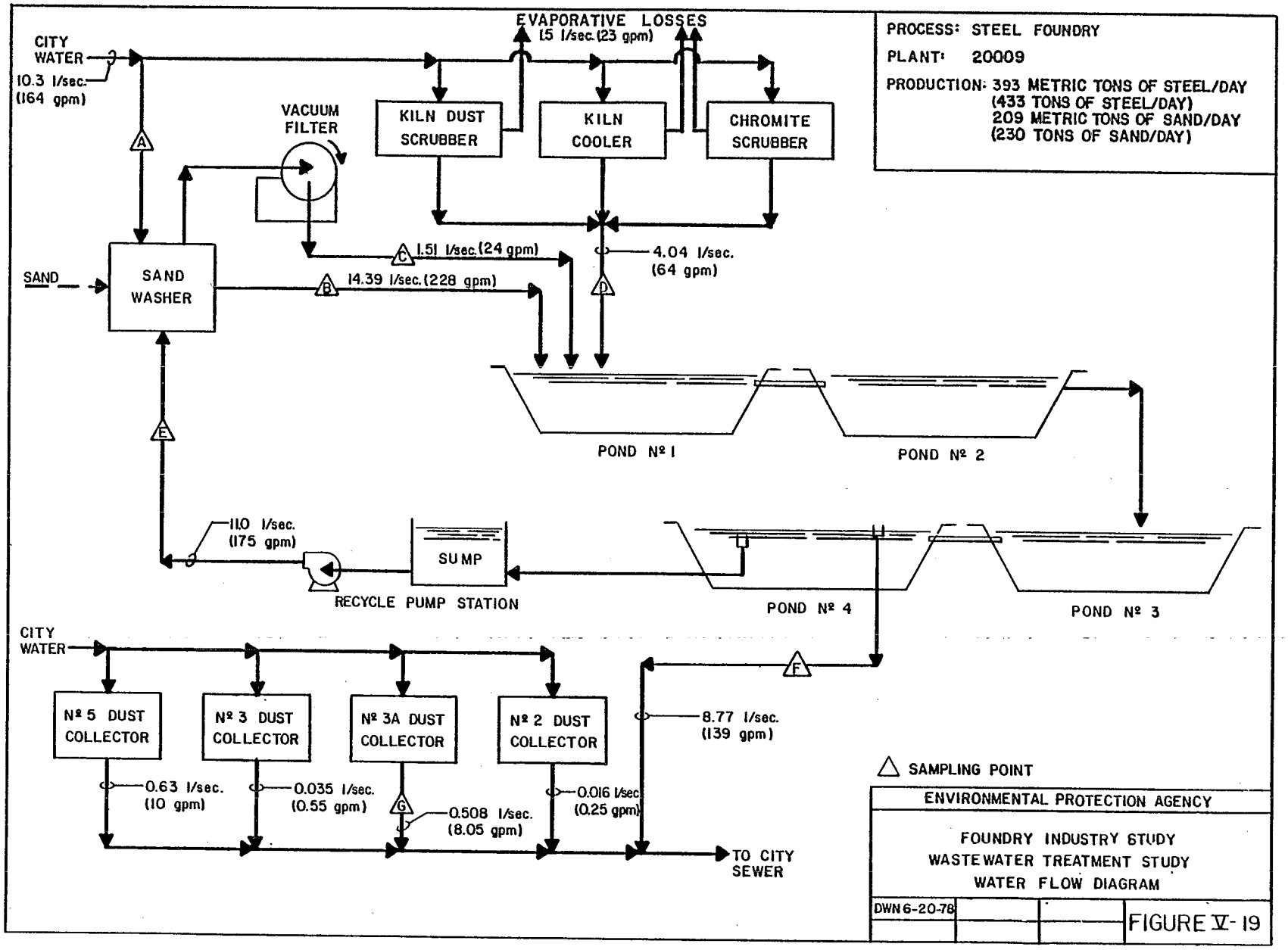

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 53219
PRODUCTION:
DUST COLLECTION: 59 Metric Tons/Day (65 Tons/Day)
MELTING: 12.7 Metric Tons/Day (14 Tons/Day)
NaOH
MIXING TANK
Evaporative Loss
Gas Stream Flow
STACK
CUPOLA
VENTURI SCRUBBER
SEPARATOR
FAN
Molding and Cleaning Dust
Polymer
MIXING TANK
DUST COLLECTOR
1.9 l/sec (30 gpm)
9.5 l/sec (150 gpm)
9.5 l/sec (150 gpm)
City Water Supply
1
Slurry
Weir Overflow
DRAG TANK
Solids to Disposal
COLLECTION BOX
3
0.2 l/sec (3 gpm)
Discharge to Sanitary Sewer
DEWATERING TANK
Solids to Disposal
2
0.63 l/sec (10 gpm)
Discharge to Sanitary Sewer
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/23/79
FIGURE V-14

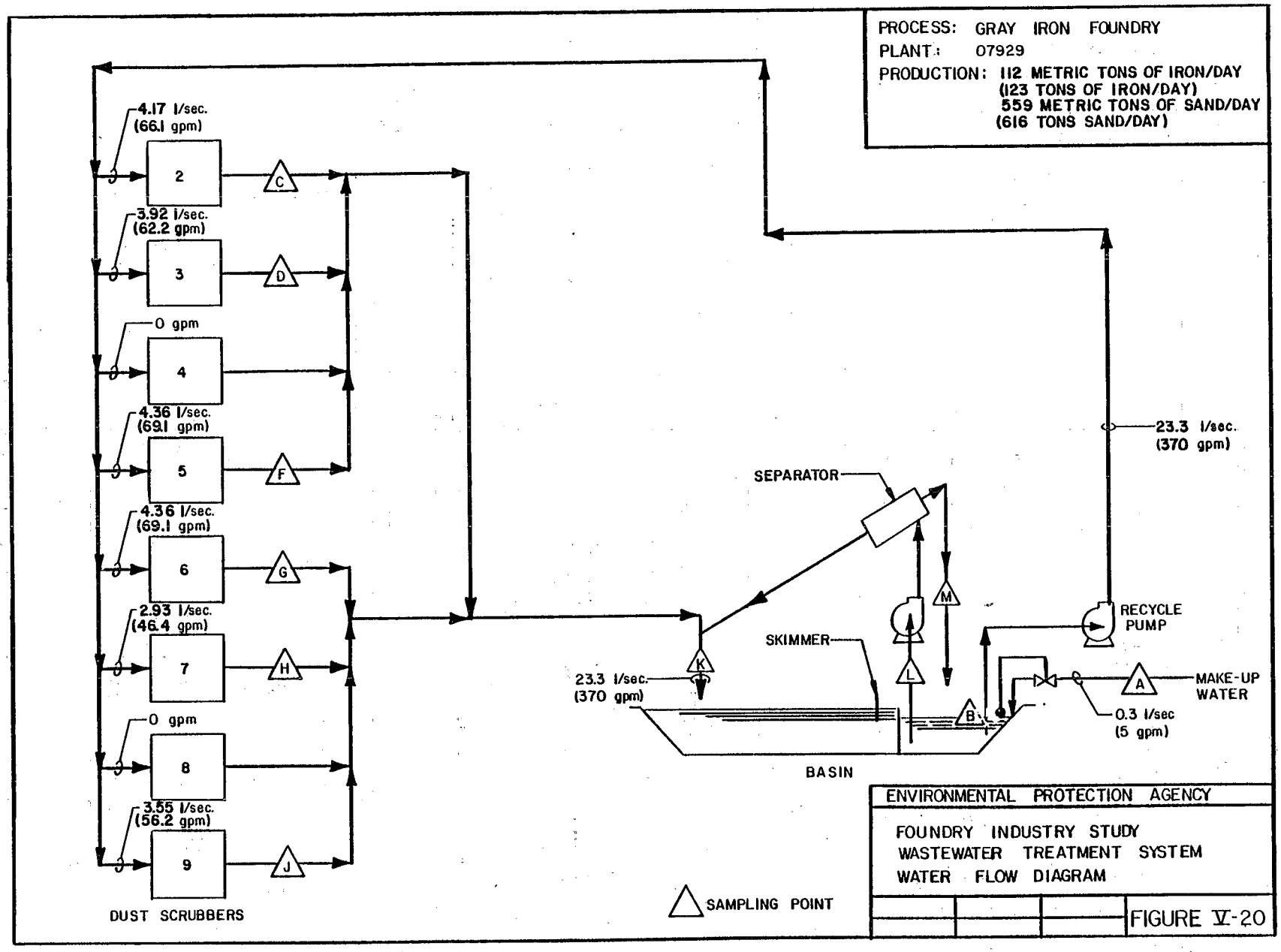

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 55217
PRODUCTION:
DUST COLLECTION: 1897 Metric Tons/Day (2091 Tons/Day)
MELTING: 197 Metric Tons/Day (217 Tons/Day)
CUPOLA 1
CUPOLA 2
CUPOLA 3
QUENCH RINGS
VENTURI
SEPARATOR
FAN
STACK
Evaporative Loss
21.9 l/sec (347 gpm)
From Wet Well Plant HHH-28
Gas Stream Flow
3.2 l/sec (50 gpm)
Plant Water Supply
SUMP
CUPOLA
Cooling Tower Blowdown
SLAG BIN
CAUSTIC TANK
Make-Up Water as Required
63.1 l/sec (1000 gpm)
14.9 l/sec (237 gpm)
SLAG QUENCH PIT
SLURRY TANK
63.1 l/sec (1000 gpm)
MOLDING AND CLEANING DUST COLLECTORS
63.1 l/sec (1000 gpm)
Solids to Disposal
2.8 l/sec (44 gpm)
17.7 l/sec (281 gpm)
To Plant 56123
SLAG CAR
SAMPLING POINT
SETTLING BASIN
NOTE:
Zero discharge to receiving stream from plant 50315 & 56123
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/24/79
FIGURE V-15

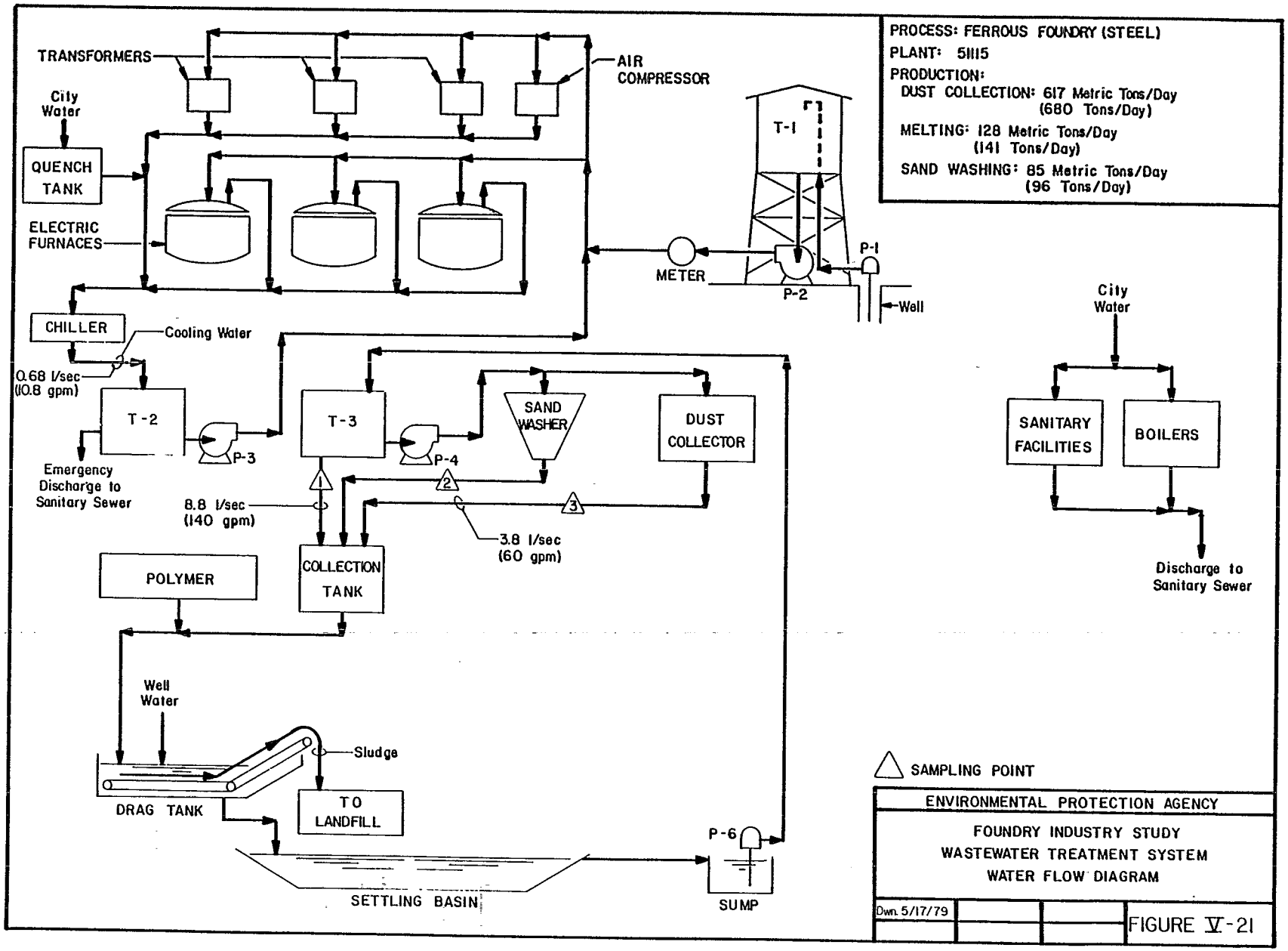

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 57100
PRODUCTION:
DUST COLLECTION 1814 METRIC TONS/DAY (2000 TONS/DAY)
MELTING 319 METRIC TONS/DAY (352 TONS/DAY)
AIR STREAM
3.2 I/SEC (50 GPM)
CUPOLA NO. 1
CUPOLA NO. 2
QUENCH TOWER
SLAG
LADLE
LADLE
FAN
BAGHOUSE
SOLIDS TO DISPOSAL
DISCHARGE TO SANITARY SEWER 2.7 I/SEC (42 GPM)
DUST TO DISPOSAL
WELL WATER
DUST TO DISPOSAL
DUST COLLECTOR
SAMPLING POINT
EXHAUST GAS FLOW
WELL
SETTLING TANK
SOLIDS TO DISPOSAL
CATCH BASIN
1.6 I/SEC. (25 GPM)
TO SANITARY SEWER
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn.5/14/79
FIGURE V- 16

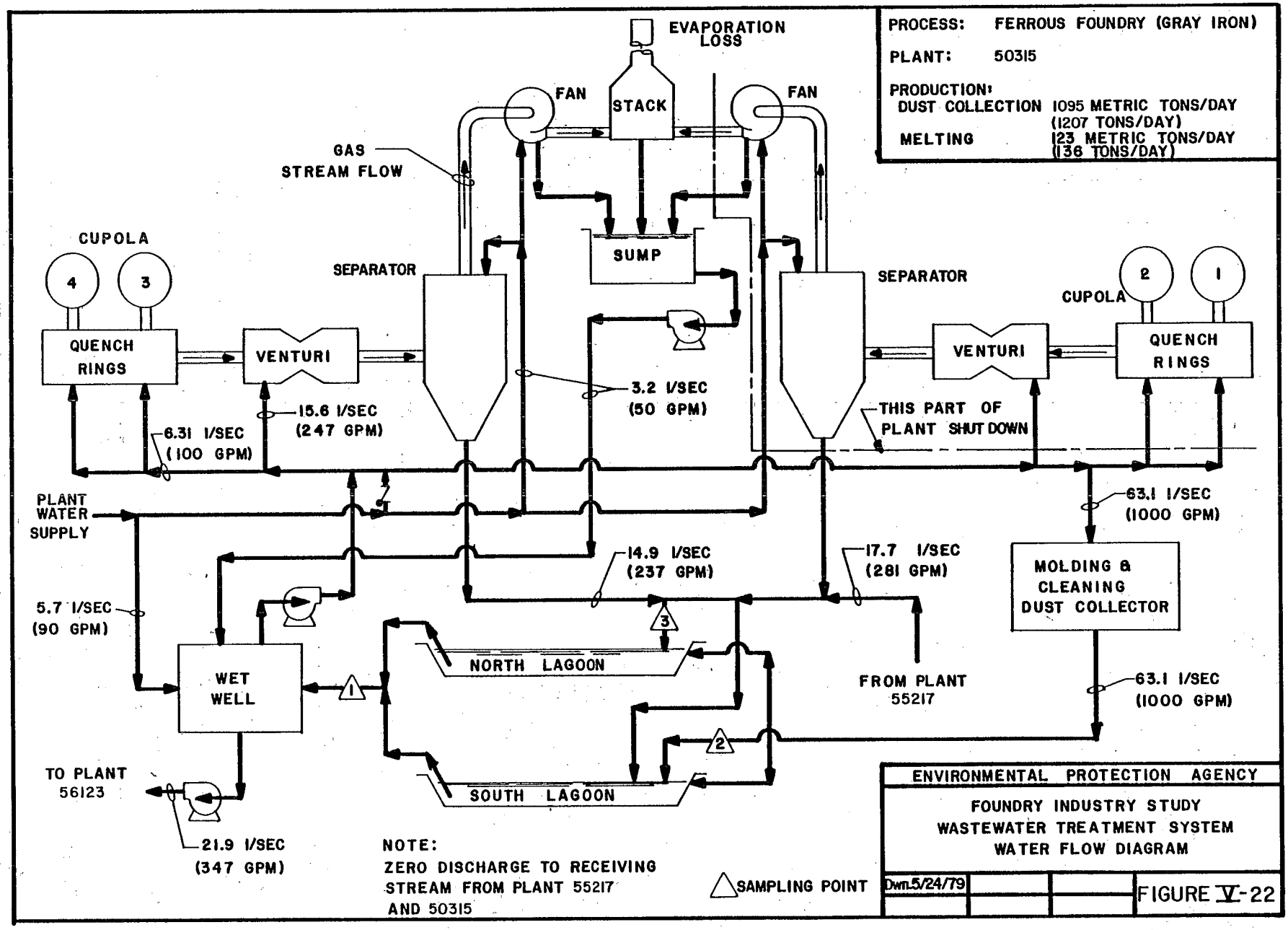

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 56771
PRODUCTION:
DUST COLLECTION 2277 METRIC TONS/DAY (2510 TONS/DAY)
MELTING 175 METRIC TONS/DAY (193 TONS/DAY)
MAKE-UP WATER
1
COOLING TOWER
BLOWDOWN
COOLING WATER (CITY WATER)
AFTER COOLER
CUPOLA
QUENCHER
VENTURI
SEPARATOR
WASTE GAS TO STACK
WET SLAG QUENCHING
SECONDARY CLARIFIER TANK
DUST COLLECTOR SYSTEM
MAKE-UP WATER
HYDRATED LIME
SOLIDS TO DISPOSAL
DRAG TANK
6
MAKE-UP WATER (CITY WATER)
SOLIDS TO DISPOSAL
DISCHARGE TO SANITARY SEWER
3.28 l/SEC (52 GPM)
15.8 l/SEC (250 GPM)
75.7 l/SEC (1200 GPM)
SOLIDS TO DISPOSAL
DRAG TANK
SAMPLE POINT
5
DISCHARGE ELIMINATED AFTER 1974
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn.5/17/79
FIGURE V-17

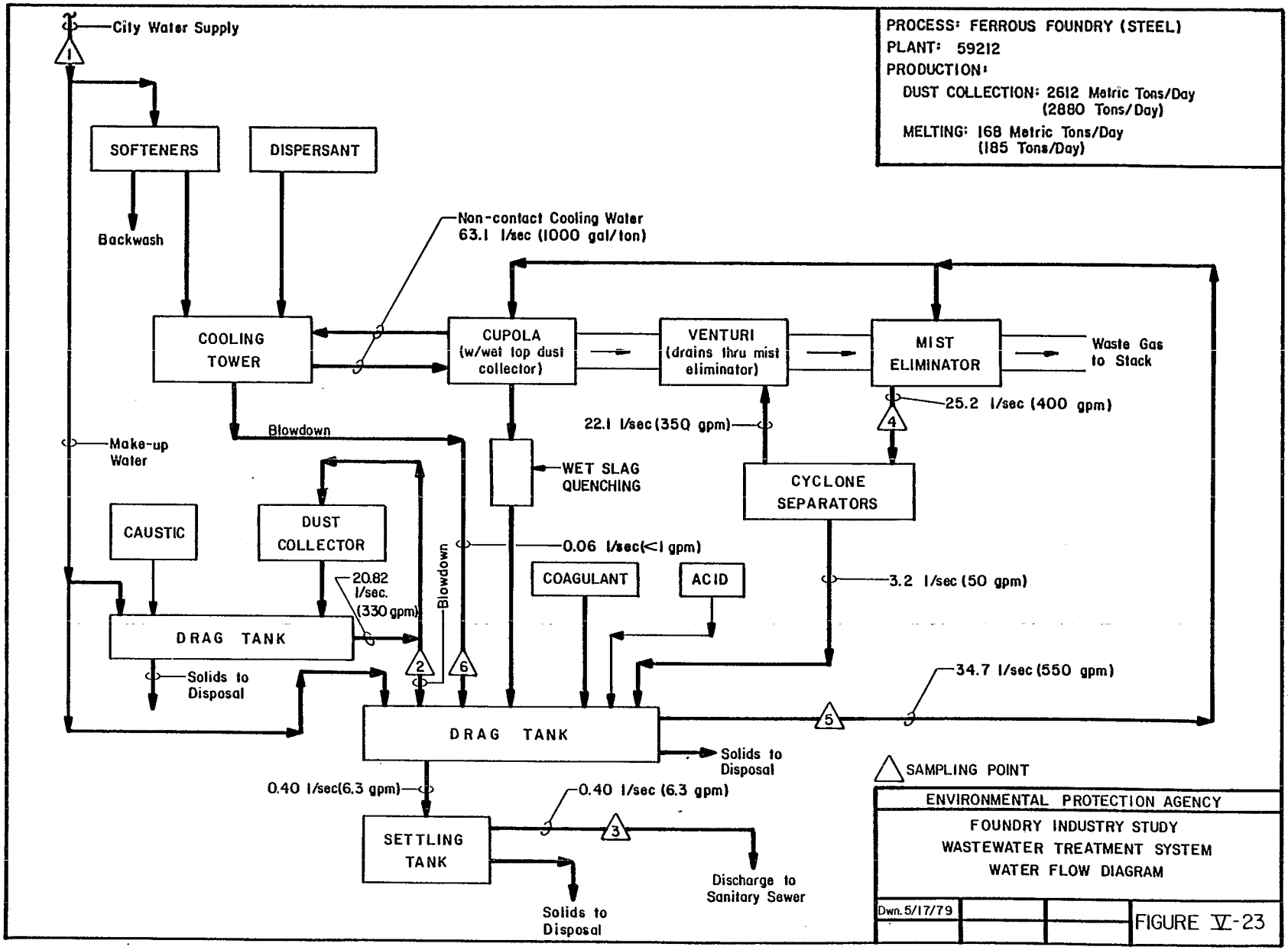

PROCESS: GRAY IRON FOUNDRY
PLANT: 15520
PRODUCTION: 562 METRIC TONS OF IRON (620 TONS OF IRON/DAY)
3338 METRIC TONS OF SAND HANDLED/DAY (3680 TONS OF SAND HANDLED/DAY)
3301 METRIC TONS OF SAND WASHED/DAY (3640 TONS OF SAND WASHED/DAY)
CUPOLA GAS SCRUBBER
CUPOLA GAS SCRUBBER
SOLIDS TO LANDFILL
SOLIDS TO LANDFILL
BALANCE TANK
N.C.W. MAKE-UP
320 GPM 20.2 ℓ/SEC.
320 GPM 20.2 /SEC.
NH3 ADDITION
CLARIFIER
VACUUM FILTER
TO LANDFILL 15 TONS/DAY
CITY WATER
EMERGENCY MAKE-UP
BALANCE TANK
HOLDING TANKS
40 GPM 2.5 l/SEC.
SATURATOR TANK
O/F
TO CENTRAL TREATMENT
Variable-make-up to slag dewatering tanks
CUPOLA
#3
#4
#5
#6
264 GPM 16.6 ℓ/SEC.
86 GPM 5.4 ℓ/SEC.
LOSSES
10 GPM 0.6 ℓ/SEC.
SAND DRYER
SAND TO SYSTEM
FILTER FEED TABLE
SECONDARY CLASSIFIER
PRIMARY CLASSIFIER
PRIMARY CLASSIFIER
SPLITTER BOX
390 GPM 24.6 ℓ/SEC.
210 GPM 13.2 l/SEC.
420 GPM 26.5 ℓ/SEC.
140GPM 8.8 l/SEC
NC
405GPM 25.5 ℓ/SEC.
SETTLING TANK #1
SETTLING TANK #2
(4) SLAG DEWATERING TANKS
CORE MAKING SCRUBBER
SAND TOWER SCRUBBER
SAND TOWER ROTOCLONE
CORE K.O. SCRUBBER
MOLDING SCRUBBER
MILL ROOM SCRUBBER
LOSSES 55 GPM
120 GPM 7.6 ℓ/SEC.
TO SANITARY SEWER
650 GPM 41 ℓ/SEC.
HYDRO BLAST
LUMP BREAKER
10 GPM (CONTROLLED) 0.6 l/sec.
MAKE UP 145 GPM 9.1 l/SEC
USED SAND
SAMPLING POINTS
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.7/11/78
RD.2/21/80
RD.11/7/78
RD.2/22/80
FIGURE V-18

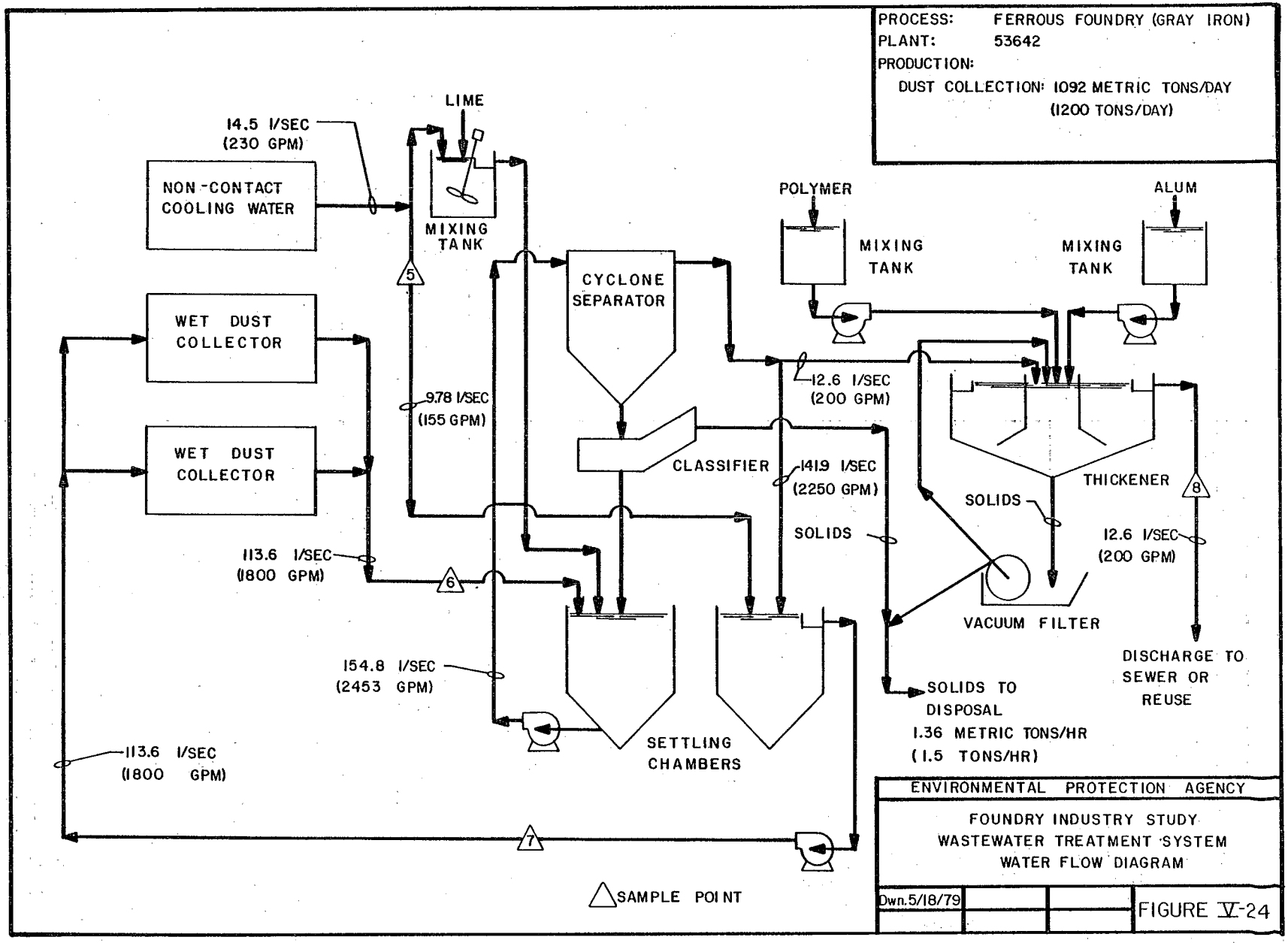

EVAPORATIVE LOSSES
1.5 l/sec.(23 gpm)
CITY WATER
10.3 l/sec. (164 gpm)
VACUUM FILTER
KILN DUST SCRUBBER
KILN COOLER
CHROMITE SCRUBBER
A
SAND
SAND WASHER
B
14.39 l/sec.(228 gpm)
C
1.51 l/sec.(24 gpm)
D
4.04 l/sec. (64 gpm)
POND Nº 1
POND Nº 2
E
11.0 l/sec. (175 gpm)
SUMP
RECYCLE PUMP STATION
POND Nº 4
POND Nº 3
F
CITY WATER
Nº 5 DUST COLLECTOR
Nº 3 DUST COLLECTOR
Nº 3A DUST COLLECTOR
Nº 2 DUST COLLECTOR
8.77 l/sec. (139 gpm)
0.63 l/sec. (10 gpm)
0.035 l/sec. (0.55 gpm)
G
0.508 l/sec. (8.05 gpm)
0.016 l/sec (0.25 gpm)
TO CITY SEWER
PROCESS: STEEL FOUNDRY
PLANT: 20009
PRODUCTION: 393 METRIC TONS OF STEEL/DAY
(433 TONS OF STEEL/DAY)
209 METRIC TONS OF SAND/DAY
(230 TONS OF SAND/DAY)
△ SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT STUDY
WATER FLOW DIAGRAM
DWN 6-20-78
FIGURE V-19

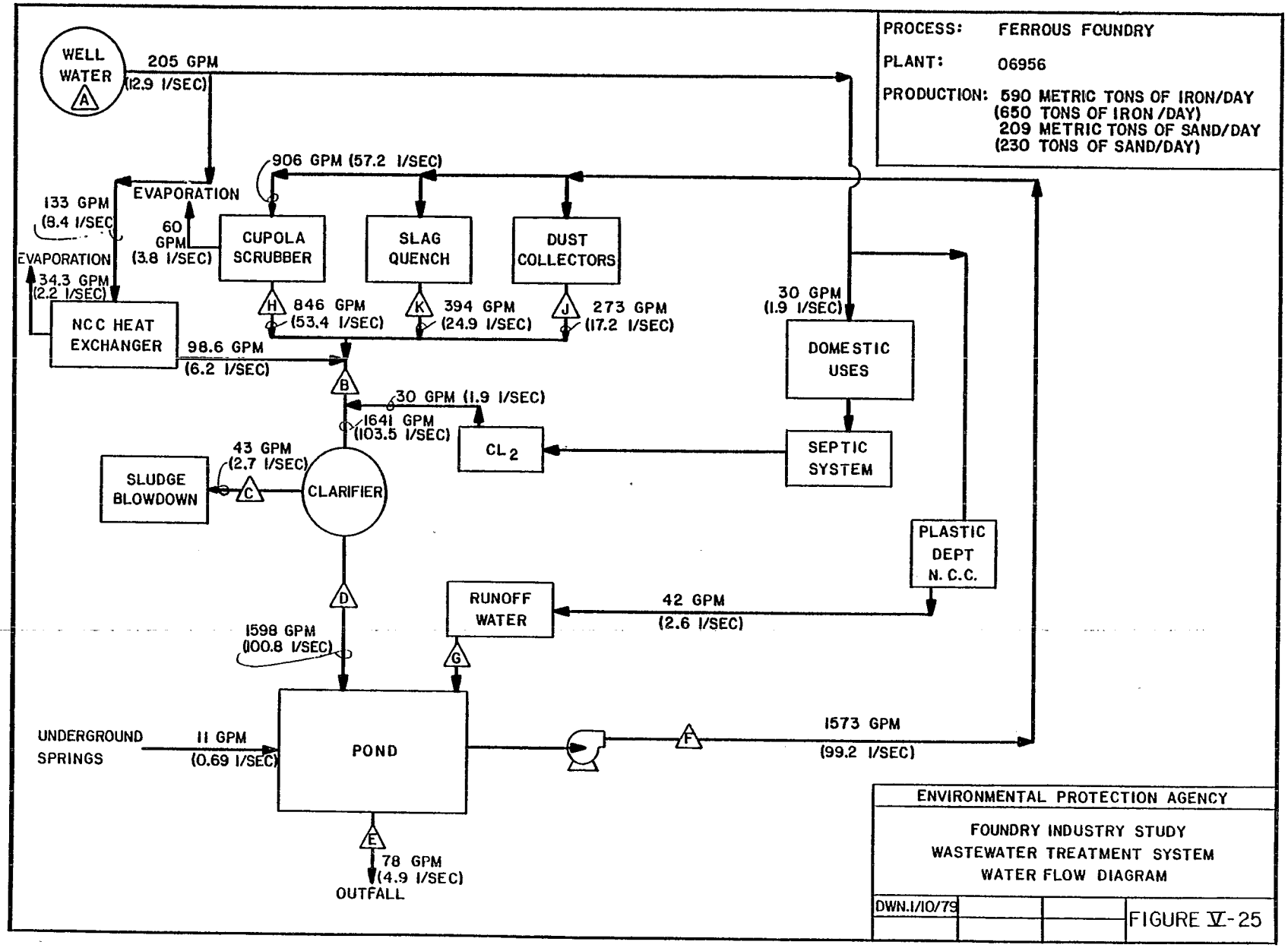

PROCESS: GRAY IRON FOUNDRY
PLANT: 07929
PRODUCTION: 112 METRIC TONS OF IRON/DAY
(123 TONS OF IRON/DAY)
559 METRIC TONS OF SAND/DAY
(616 TONS SAND/DAY)
4.17 l/sec.
(66.1 gpm)
2
C
3.92 l/sec.
(62.2 gpm)
3
D
0 gpm
4
4.36 l/sec.
(69.1 gpm)
5
F
4.36 l/sec.
(69.1 gpm)
6
G
2.93 l/sec.
(46.4 gpm)
7
H
0 gpm
8
3.55 l/sec.
(56.2 gpm)
9
J
DUST SCRUBBERS
23.3 l/sec.
(370 gpm)
SEPARATOR
SKIMMER
K
L
M
B
BASIN
RECYCLE
PUMP
A
MAKE-UP
WATER
0.3 l/sec
(5 gpm)
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
FIGURE V-20

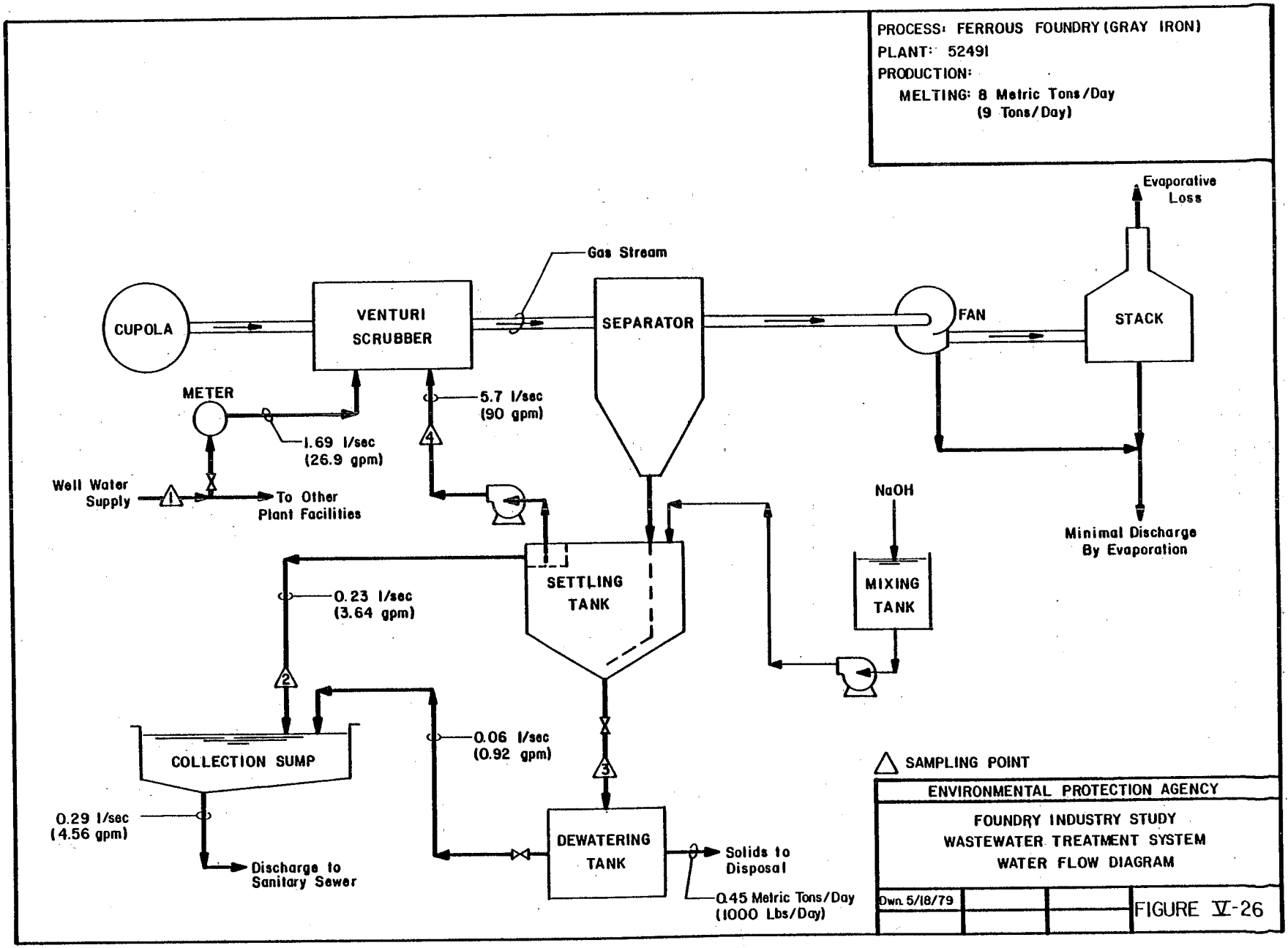

PROCESS: FERROUS FOUNDRY (STEEL)
PLANT: 5115
PRODUCTION:
DUST COLLECTION: 617 Metric Tons/Day (680 Tons/Day)
MELTING: 128 Metric Tons/Day (141 Tons/Day)
SAND WASHING: 85 Metric Tons/Day (96 Tons/Day)
TRANSFORMERS
AIR COMPRESSOR
City Water
QUENCH TANK
ELECTRIC FURNACES
T-1
METER
P-1
P-2
Well
CHILLER
Cooling Water
0.68 l/sec (10.8 gpm)
T-2
P-3
T-3
P-4
SAND WASHER
DUST COLLECTOR
Emergency Discharge to Sanitary Sewer
8.8 l/sec (140 gpm)
3.8 l/sec (60 gpm)
POLYMER
COLLECTION TANK
Well Water
Sludge
DRAG TANK
TO LANDFILL
SETTLING BASIN
P-6
SUMP
City Water
SANITARY FACILITIES
BOILERS
Discharge to Sanitary Sewer
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/17/79
FIGURE V-21

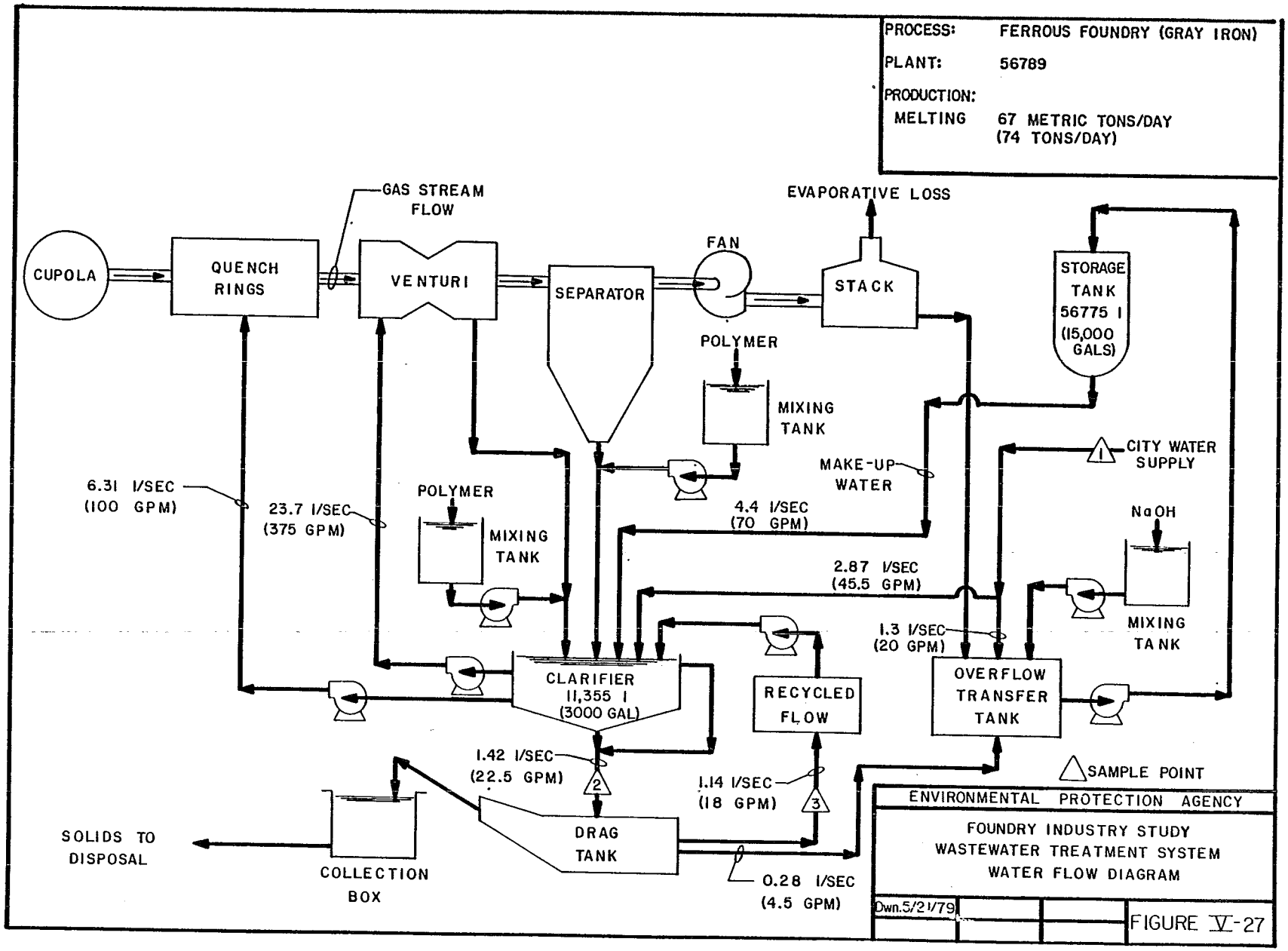

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 50315
PRODUCTION:
DUST COLLECTION 1095 METRIC TONS/DAY (1207 TONS/DAY)
MELTING 123 METRIC TONS/DAY (136 TONS/DAY)
EVAPORATION LOSS
FAN
STACK
FAN
GAS STREAM FLOW
CUPOLA
4
3
SEPARATOR
SUMP
SEPARATOR
CUPOLA
2
1
QUENCH RINGS
VENTURI
VENTURI
QUENCH RINGS
3.2 l/SEC (50 GPM)
THIS PART OF PLANT SHUT DOWN
6.31 l/SEC (100 GPM)
15.6 l/SEC (247 GPM)
PLANT WATER SUPPLY
63.1 l/SEC (1000 GPM)
14.9 l/SEC (237 GPM)
17.7 l/SEC (281 GPM)
MOLDING & CLEANING DUST COLLECTOR
5.7 l/SEC (90 GPM)
WET WELL
NORTH LAGOON
FROM PLANT 55217
63.1 l/SEC (1000 GPM)
TO PLANT 56123
SOUTH LAGOON
21.9 l/SEC (347 GPM)
NOTE:
ZERO DISCHARGE TO RECEIVING STREAM FROM PLANT 55217 AND 50315
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn 5/24/79
FIGURE V-22

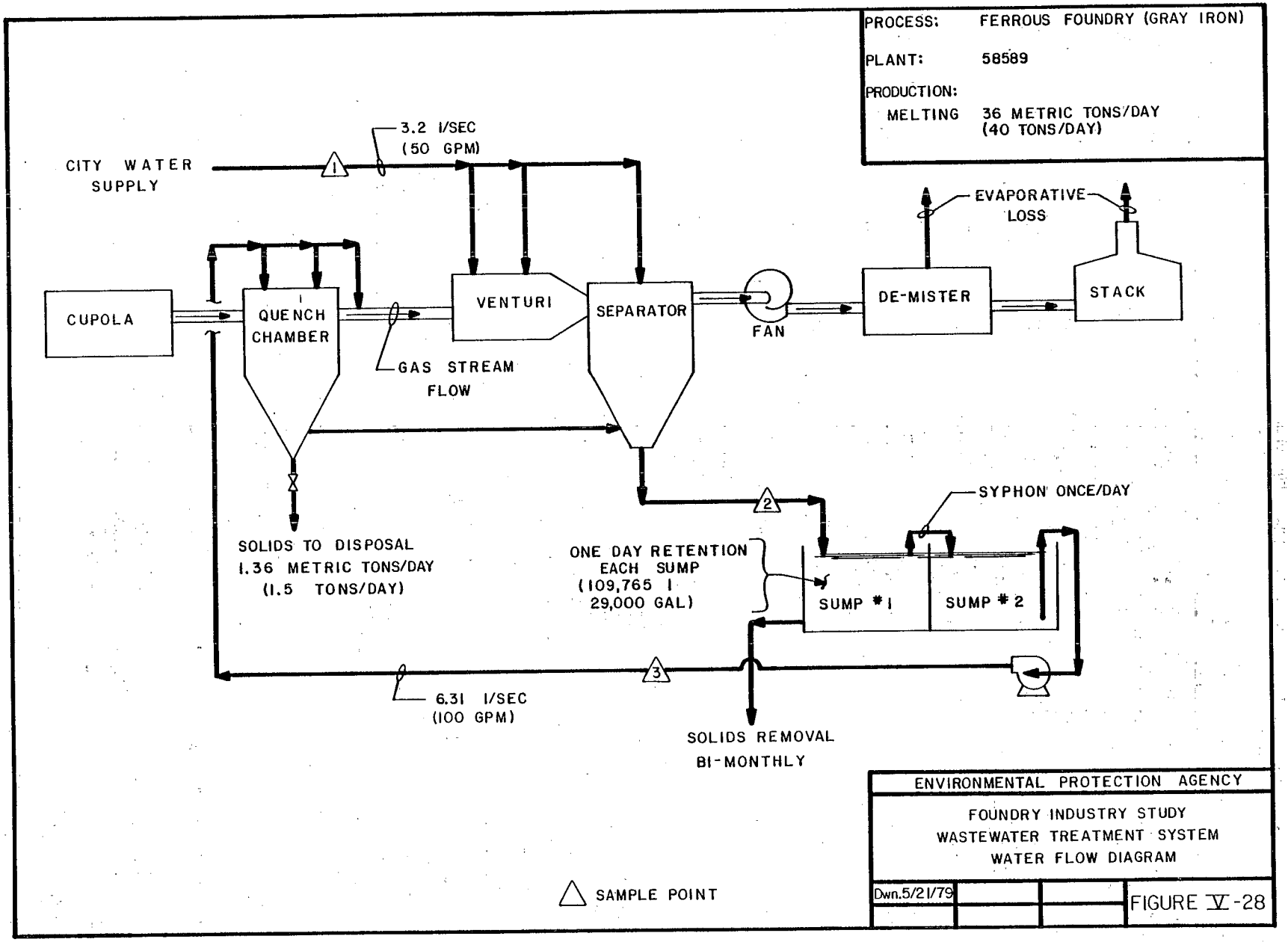

City Water Supply
1
SOFTENERS
DISPERSANT
Backwash
Non-contact Cooling Water
63.1 l/sec (1000 gal/ton)
COOLING TOWER
CUPOLA (w/wet top dust collector)
VENTURI (drains thru mist eliminator)
MIST ELIMINATOR
Waste Gas to Stack
25.2 l/sec (400 gpm)
4
22.1 l/sec (350 gpm)
Blowdown
Make-up Water
WET SLAG QUENCHING
CYCLONE SEPARATORS
CAUSTIC
DUST COLLECTOR
0.06 l/sec(<1 gpm)
20.82 l/sec. (330 gpm)
Blowdown
COAGULANT
ACID
3.2 l/sec (50 gpm)
DRAG TANK
2
6
Solids to Disposal
34.7 l/sec (550 gpm)
5
DRAG TANK
Solids to Disposal
SAMPLING POINT
0.40 l/sec(6.3 gpm)
0.40 l/sec (6.3 gpm)
SETTLING TANK
3
Discharge to Sanitary Sewer
Solids to Disposal
PROCESS: FERROUS FOUNDRY (STEEL)
PLANT: 59212
PRODUCTION:
DUST COLLECTION: 2612 Metric Tons/Day (2880 Tons/Day)
MELTING: 168 Metric Tons/Day (185 Tons/Day)
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/17/79
FIGURE V-23

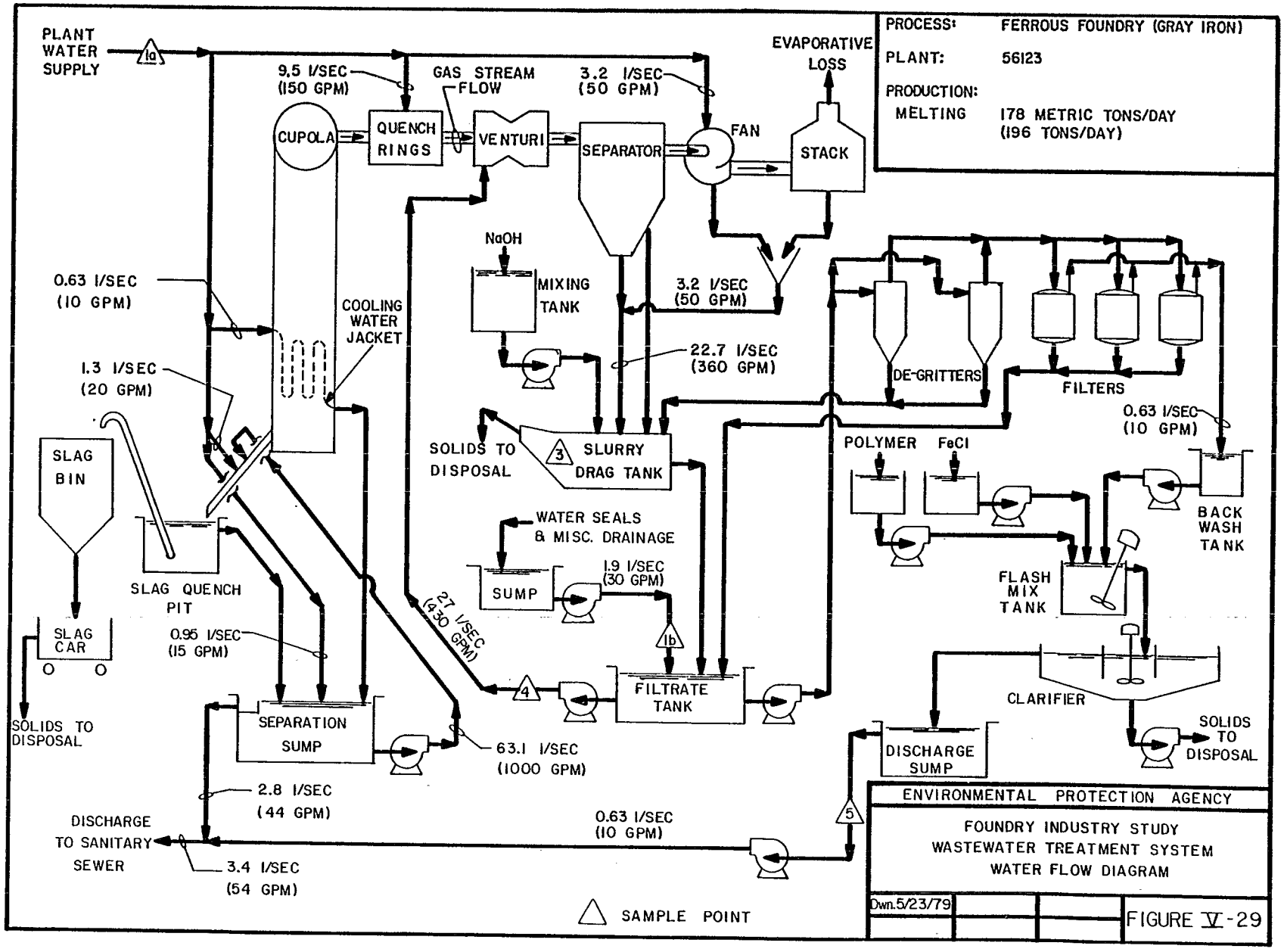

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 53642
PRODUCTION:
DUST COLLECTION: 1092 METRIC TONS/DAY
(1200 TONS/DAY)
LIME
14.5 l/SEC
(230 GPM)
NON-CONTACT
COOLING WATER
MIXING
TANK
5
CYCLONE
SEPARATOR
POLYMER
MIXING
TANK
ALUM
MIXING
TANK
WET DUST
COLLECTOR
WET DUST
COLLECTOR
9.78 l/SEC
(155 GPM)
12.6 l/SEC
(200 GPM)
CLASSIFIER
1419 l/SEC
(2250 GPM)
THICKENER
8
SOLIDS
SOLIDS
12.6 l/SEC
(200 GPM)
113.6 l/SEC
(1800 GPM)
6
VACUUM FILTER
DISCHARGE TO
SEWER OR
REUSE
154.8 l/SEC
(2453 GPM)
SOLIDS TO
DISPOSAL
1.36 METRIC TONS/HR
(1.5 TONS/HR)
SETTLING
CHAMBERS
113.6 l/SEC
(1800 GPM)
7
SAMPLE POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn.5/18/79
FIGURE V-24

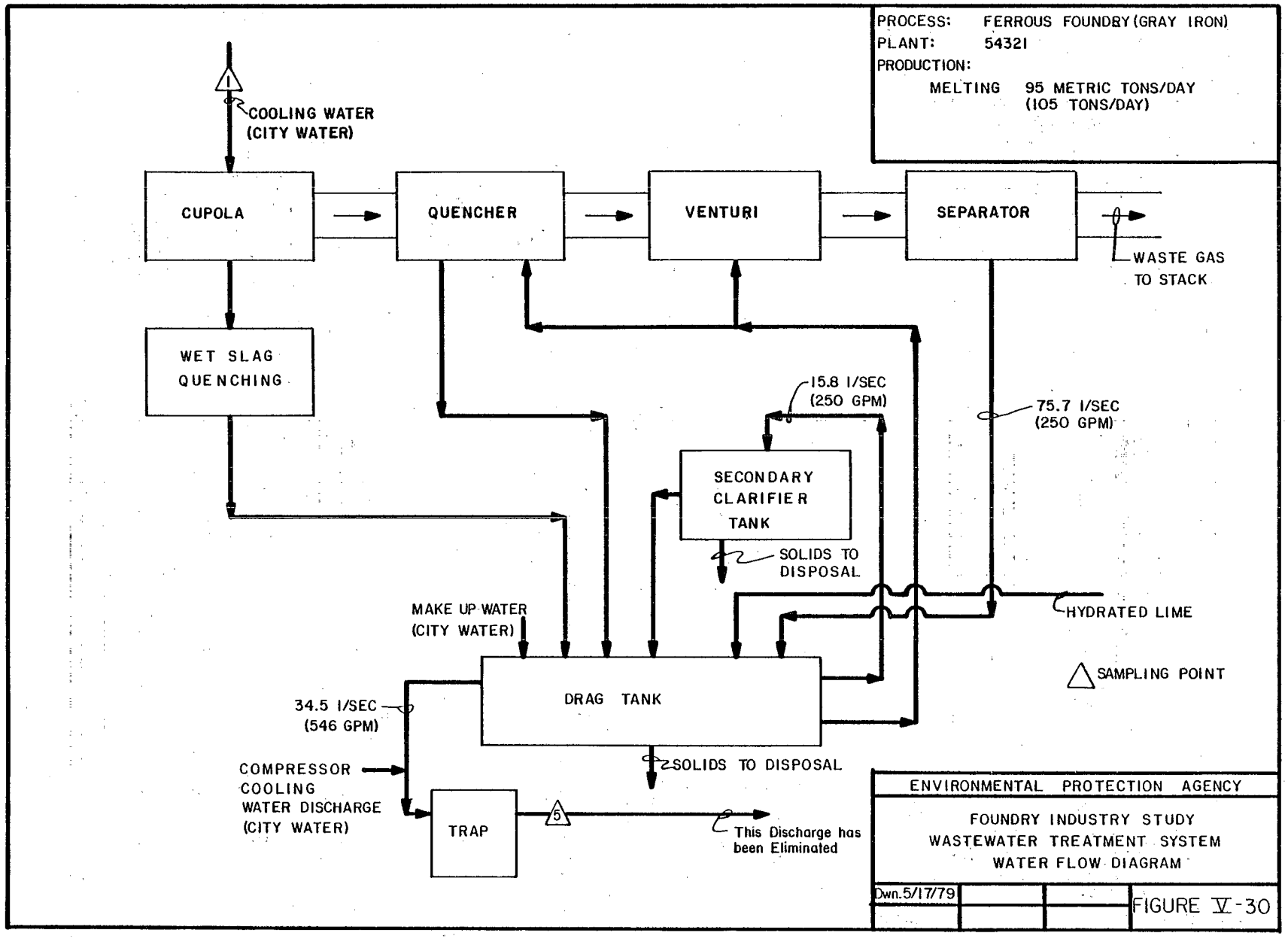

PROCESS: FERROUS FOUNDRY
PLANT: 06956
PRODUCTION: 590 METRIC TONS OF IRON/DAY (650 TONS OF IRON /DAY)
209 METRIC TONS OF SAND/DAY (230 TONS OF SAND/DAY)
WELL WATER
A
205 GPM (12.9 I/SEC)
906 GPM (57.2 I/SEC)
EVAPORATION
133 GPM (8.4 I/SEC)
60 GPM (3.8 I/SEC)
CUPOLA SCRUBBER
SLAG QUENCH
DUST COLLECTORS
EVAPORATION
34.3 GPM (2.2 I/SEC)
NCC HEAT EXCHANGER
H
846 GPM (53.4 I/SEC)
K
394 GPM (24.9 I/SEC)
J
273 GPM (17.2 I/SEC)
98.6 GPM (6.2 I/SEC)
B
30 GPM (1.9 I/SEC)
1641 GPM (103.5 I/SEC)
30 GPM (1.9 I/SEC)
DOMESTIC USES
CL2
SEPTIC SYSTEM
43 GPM (2.7 I/SEC)
SLUDGE BLOWDOWN
C
CLARIFIER
PLASTIC DEPT N. C. C.
D
RUNOFF WATER
42 GPM (2.6 I/SEC)
1598 GPM (100.8 I/SEC)
G
UNDERGROUND SPRINGS
11 GPM (0.69 I/SEC)
POND
F
1573 GPM (99.2 I/SEC)
E
78 GPM (4.9 I/SEC)
OUTFALL
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.1/10/79
FIGURE V-25


PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 52491
PRODUCTION:
MELTING: 8 Metric Tons/Day
(9 Tons/Day)
Evaporative Loss
Gas Stream
CUPOLA
VENTURI SCRUBBER
SEPARATOR
FAN
STACK
METER
1.69 l/sec
(26.9 gpm)
5.7 l/sec
(90 gpm)
Well Water Supply
1
To Other Plant Facilities
4
NaOH
Minimal Discharge By Evaporation
SETTLING TANK
MIXING TANK
0.23 l/sec
(3.64 gpm)
2
COLLECTION SUMP
0.06 l/sec
(0.92 gpm)
3
0.29 l/sec
(4.56 gpm)
Discharge to Sanitary Sewer
DEWATERING TANK
Solids to Disposal
0.45 Metric Tons/Day
(1000 Lbs/Day)
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/18/79
FIGURE V-26

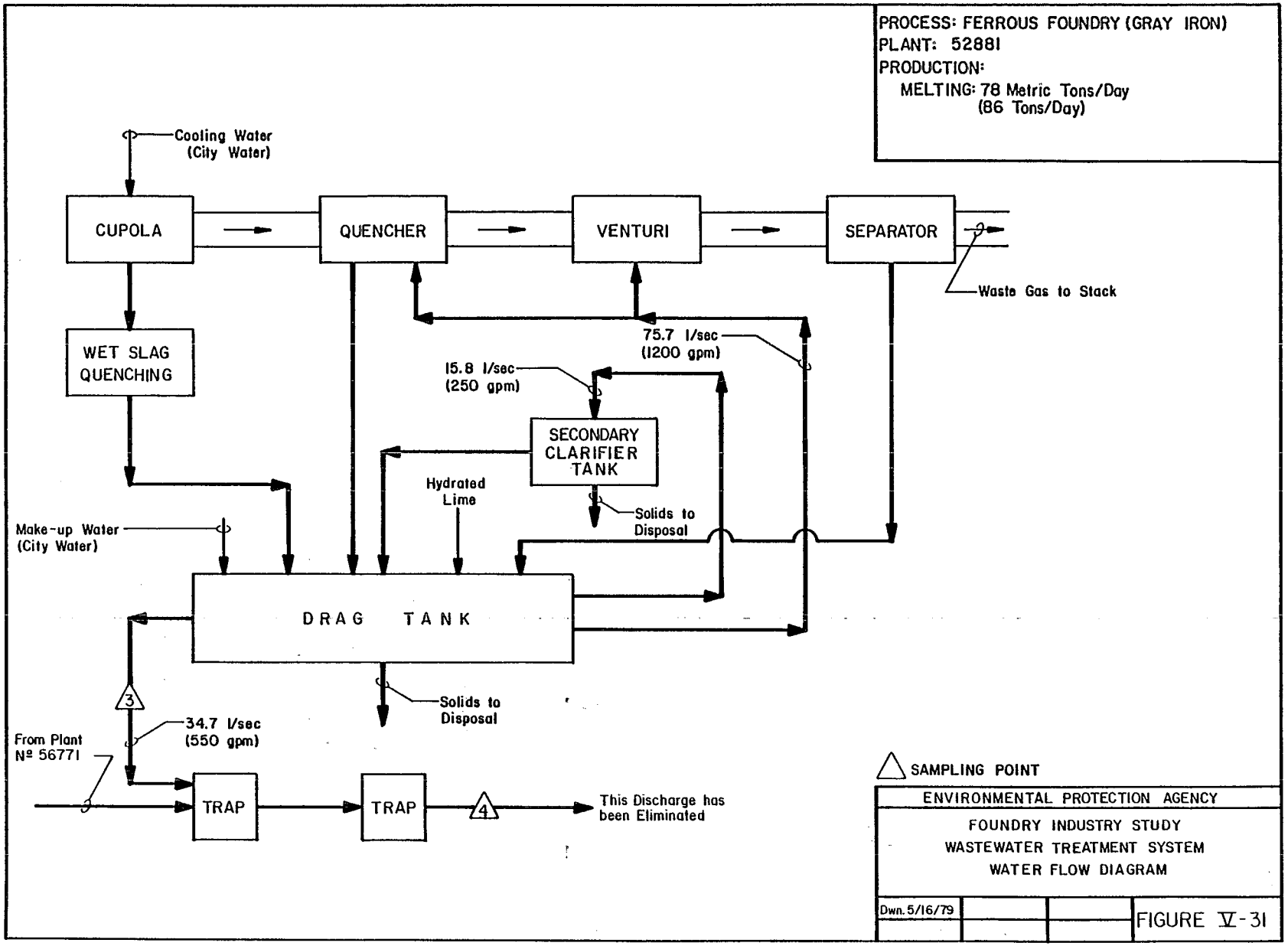

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 56789
PRODUCTION:
MELTING 67 METRIC TONS/DAY (74 TONS/DAY)
CUPOLA
QUENCH RINGS
GAS STREAM FLOW
VENTURI
SEPARATOR
FAN
EVAPORATIVE LOSS
STACK
STORAGE TANK 56775 l (15,000 GALS)
POLYMER
MIXING TANK
MAKE-UP WATER
CITY WATER SUPPLY
6.31 l/SEC (100 GPM)
23.7 l/SEC (375 GPM)
POLYMER
MIXING TANK
4.4 l/SEC (70 GPM)
NaOH
2.87 l/SEC (45.5 GPM)
MIXING TANK
1.3 l/SEC (20 GPM)
CLARIFIER 11,355 l (3000 GAL)
RECYCLED FLOW
OVERFLOW TRANSFER TANK
1.42 l/SEC (22.5 GPM)
1.14 l/SEC (18 GPM)
SAMPLE POINT
SOLIDS TO DISPOSAL
COLLECTION BOX
DRAG TANK
0.28 l/SEC (4.5 GPM)
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn.5/21/79
FIGURE V-27


PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 58589
PRODUCTION:
MELTING 36 METRIC TONS/DAY (40 TONS/DAY)
CITY WATER SUPPLY
3.2 l/SEC (50 GPM)
1
EVAPORATIVE LOSS
CUPOLA
QUENCH CHAMBER
VENTURI
SEPARATOR
FAN
DE-MISTER
STACK
GAS STREAM FLOW
SOLIDS TO DISPOSAL
1.36 METRIC TONS/DAY
(1.5 TONS/DAY)
2
SYPHON ONCE/DAY
ONE DAY RETENTION EACH SUMP
(109,765 l 29,000 GAL)
SUMP #1
SUMP #2
3
6.31 l/SEC (100 GPM)
SOLIDS REMOVAL BI-MONTHLY
SAMPLE POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn.5/21/79
FIGURE V-28


PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 56123
PRODUCTION:
MELTING 178 METRIC TONS/DAY (196 TONS/DAY)
PLANT WATER SUPPLY
1a
9.5 l/SEC (150 GPM)
GAS STREAM FLOW
3.2 l/SEC (50 GPM)
EVAPORATIVE LOSS
CUPOLA
QUENCH RINGS
VENTURI
SEPARATOR
FAN
STACK
NaOH
MIXING TANK
0.63 l/SEC (10 GPM)
COOLING WATER JACKET
3.2 l/SEC (50 GPM)
22.7 l/SEC (360 GPM)
1.3 l/SEC (20 GPM)
DE-GRITTERS
FILTERS
0.63 l/SEC (10 GPM)
SOLIDS TO DISPOSAL
3 SLURRY DRAG TANK
POLYMER
FeCl
SLAG BIN
WATER SEALS & MISC. DRAINAGE
BACK WASH TANK
SUMP
1.9 l/SEC (30 GPM)
FLASH MIX TANK
SLAG QUENCH PIT
27 l/SEC (430 GPM)
1b
SLAG CAR
0.95 l/SEC (15 GPM)
4
FILTRATE TANK
CLARIFIER
SOLIDS TO DISPOSAL
SEPARATION SUMP
63.1 l/SEC (1000 GPM)
DISCHARGE SUMP
2.8 l/SEC (44 GPM)
5
DISCHARGE TO SANITARY SEWER
0.63 l/SEC (10 GPM)
3.4 l/SEC (54 GPM)
SAMPLE POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn.5/23/79
FIGURE V-29


PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 54321
PRODUCTION:
MELTING 95 METRIC TONS/DAY
(105 TONS/DAY)
1
COOLING WATER
(CITY WATER)
CUPOLA
QUENCHER
VENTURI
SEPARATOR
WASTE GAS
TO STACK
WET SLAG
QUENCHING
15.8 l/SEC
(250 GPM)
75.7 l/SEC
(250 GPM)
SECONDARY
CLARIFIER
TANK
SOLIDS TO
DISPOSAL
MAKE UP WATER
(CITY WATER)
HYDRATED LIME
SAMPLING POINT
DRAG TANK
34.5 l/SEC
(546 GPM)
SOLIDS TO DISPOSAL
COMPRESSOR
COOLING
WATER DISCHARGE
(CITY WATER)
TRAP
5
This Discharge has
been Eliminated
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn.5/17/79
FIGURE V-30

PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 52881
PRODUCTION:
MELTING: 78 Metric Tons/Day
(86 Tons/Day)



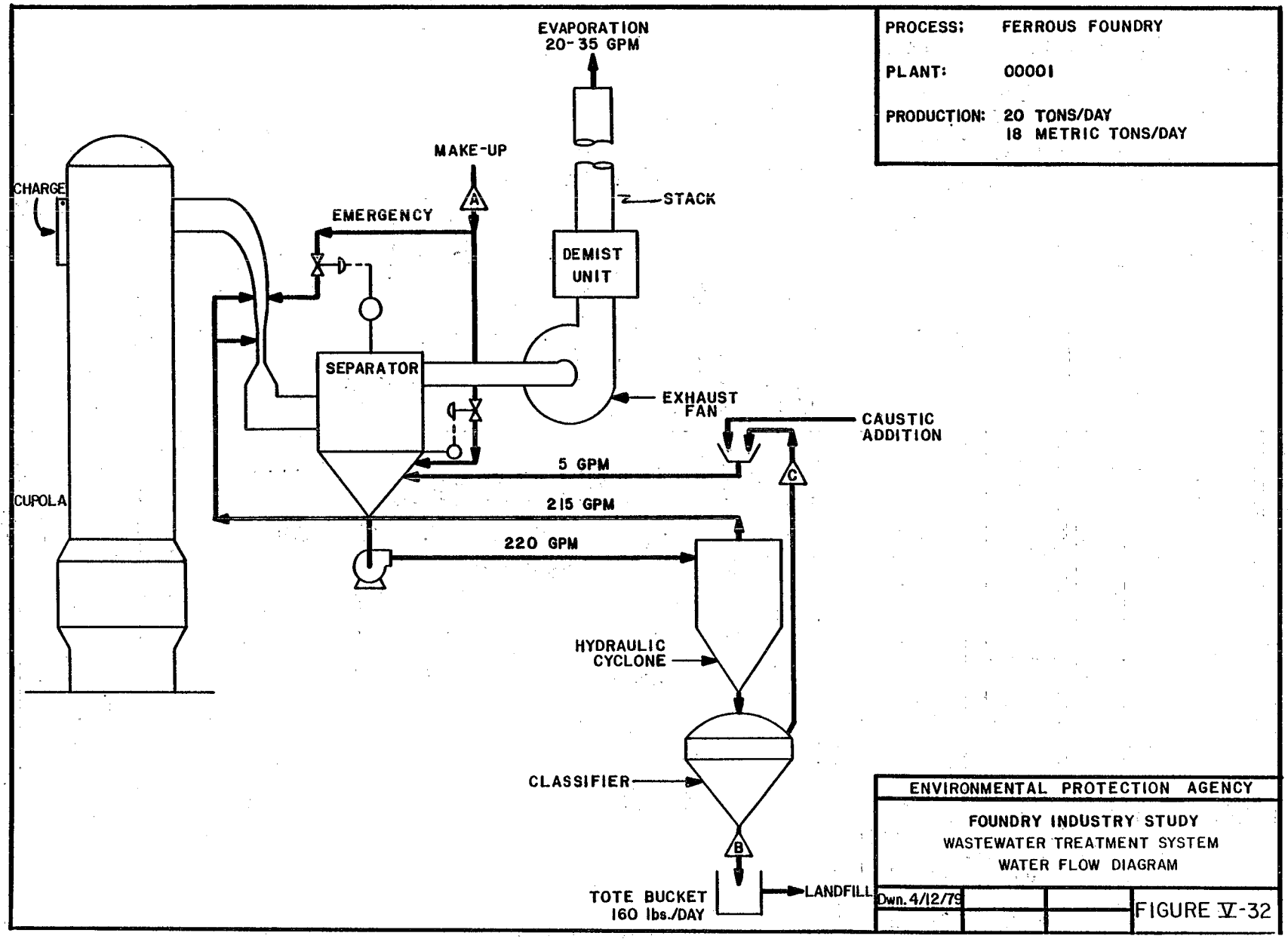
△ SAMPLING POINT

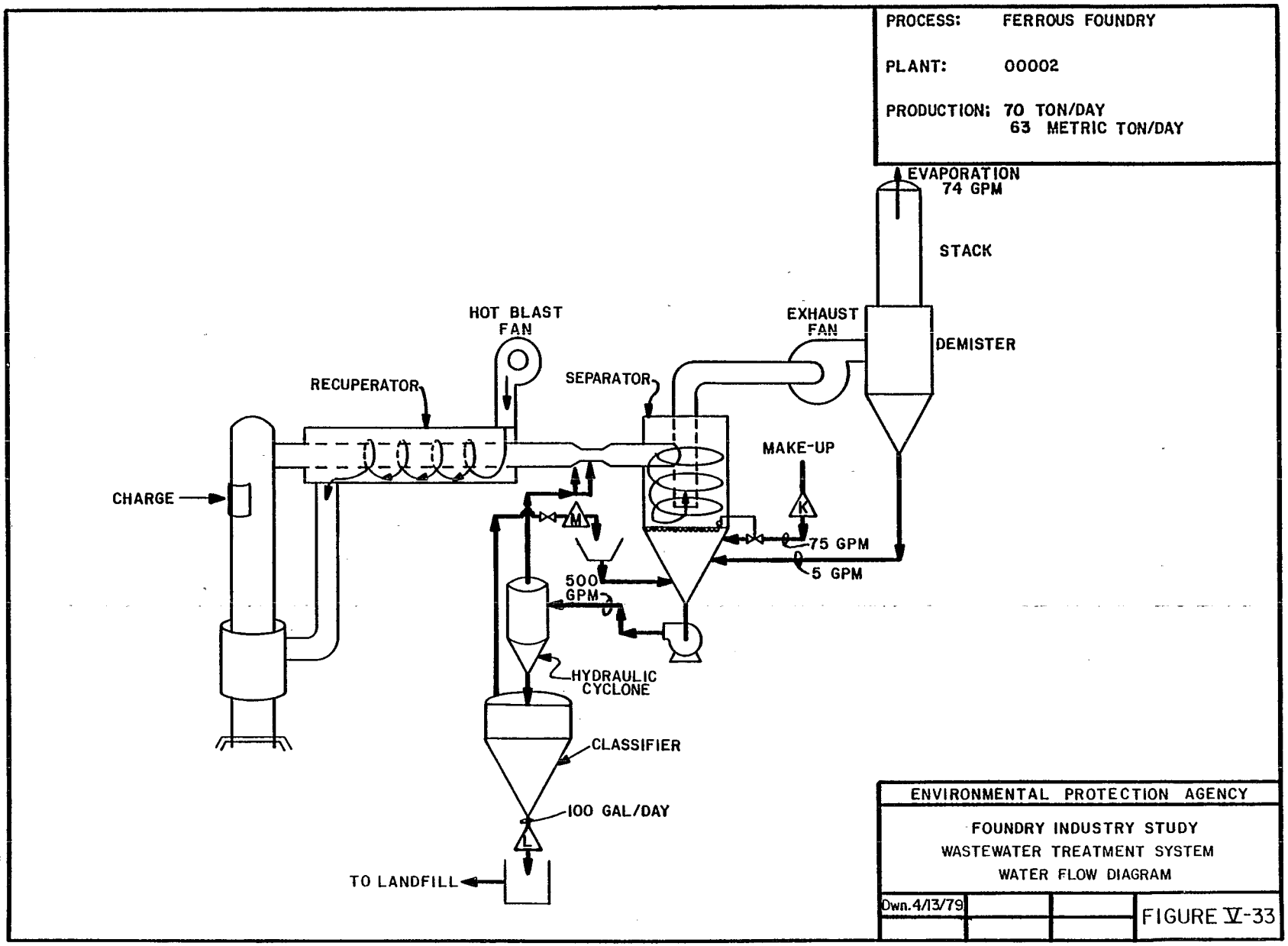
ENVIRONMENTAL PROTECTION AGENCY

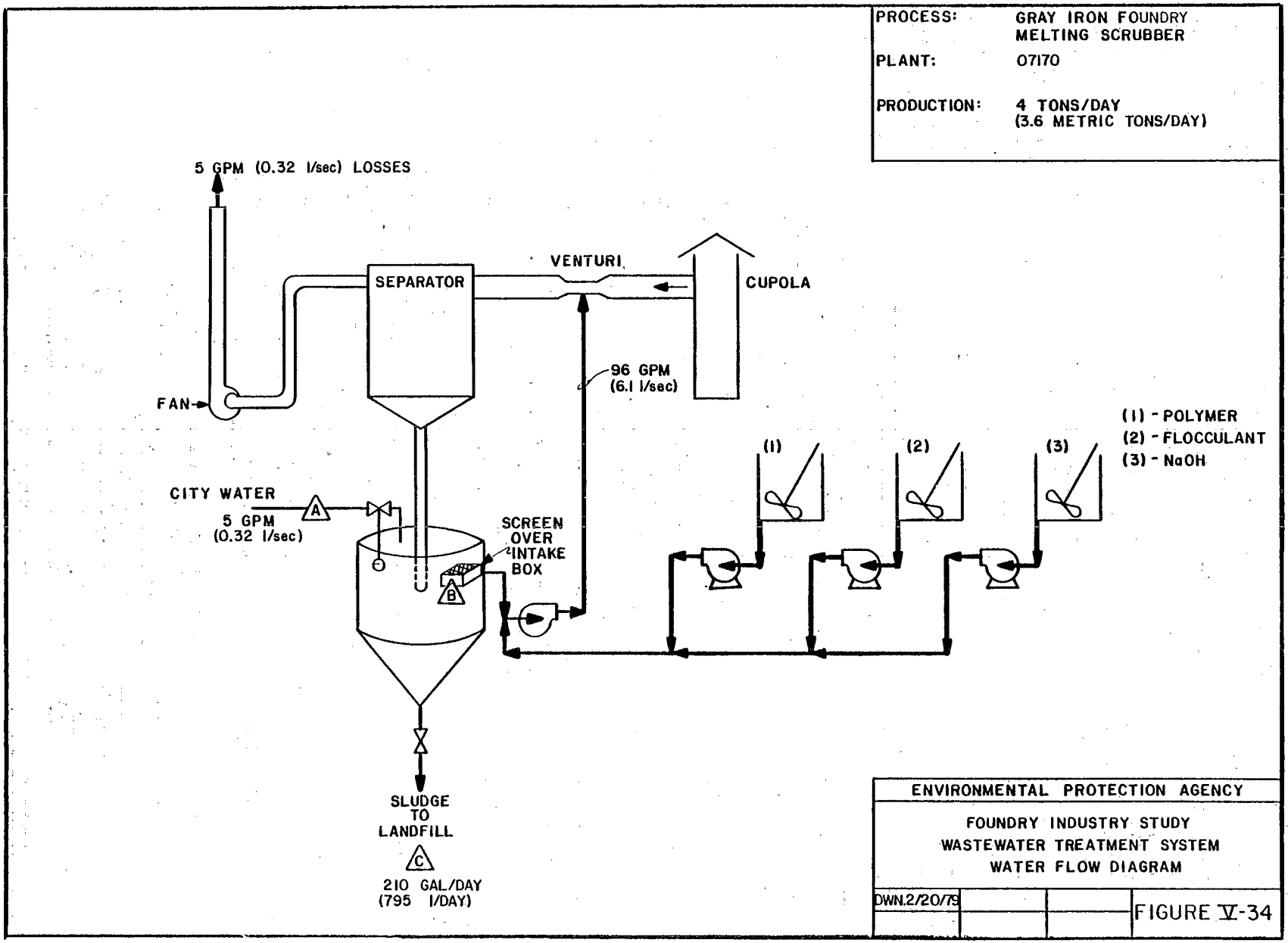
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

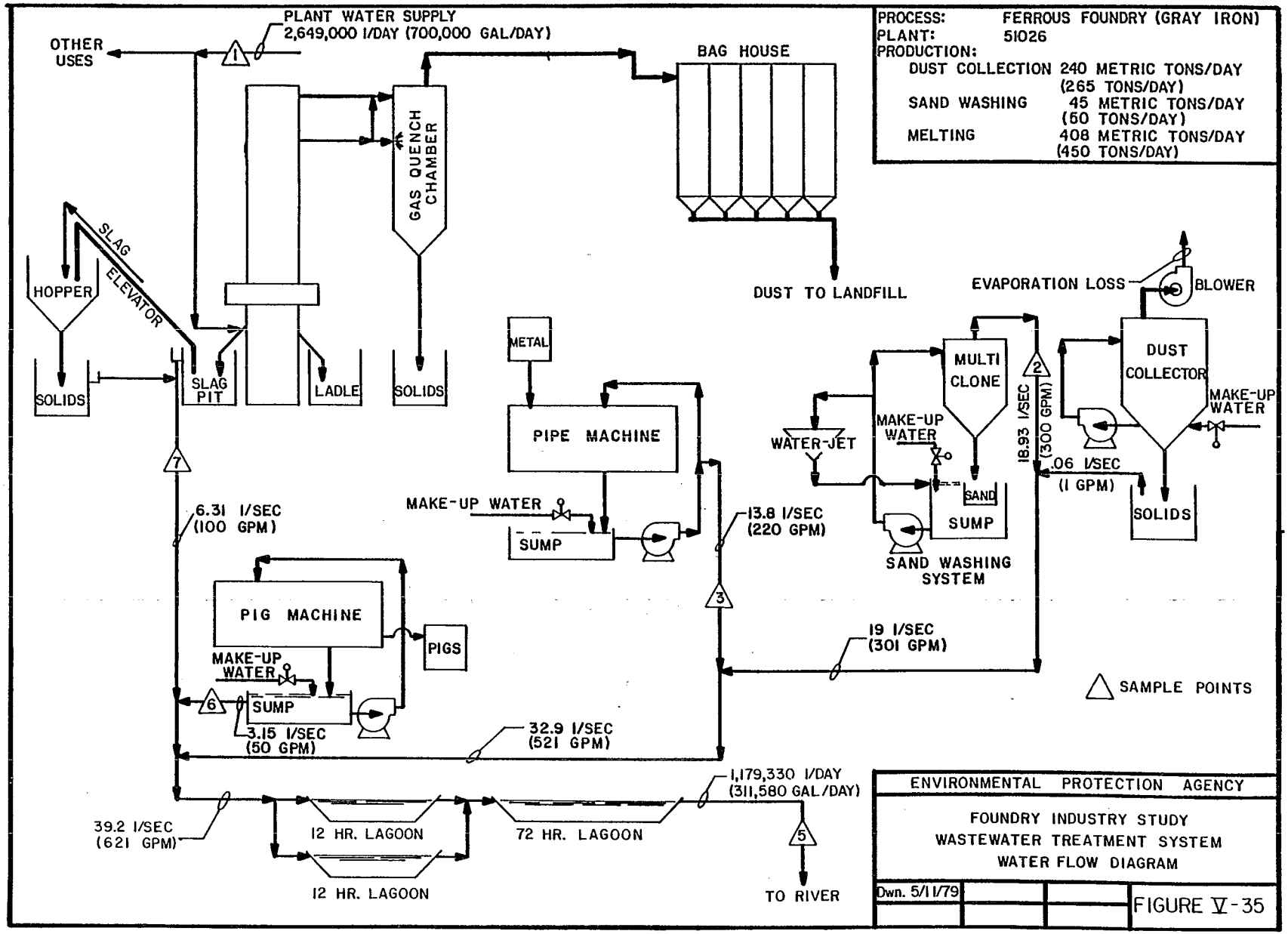
Dwn. 5/16/79

FIGURE V-31

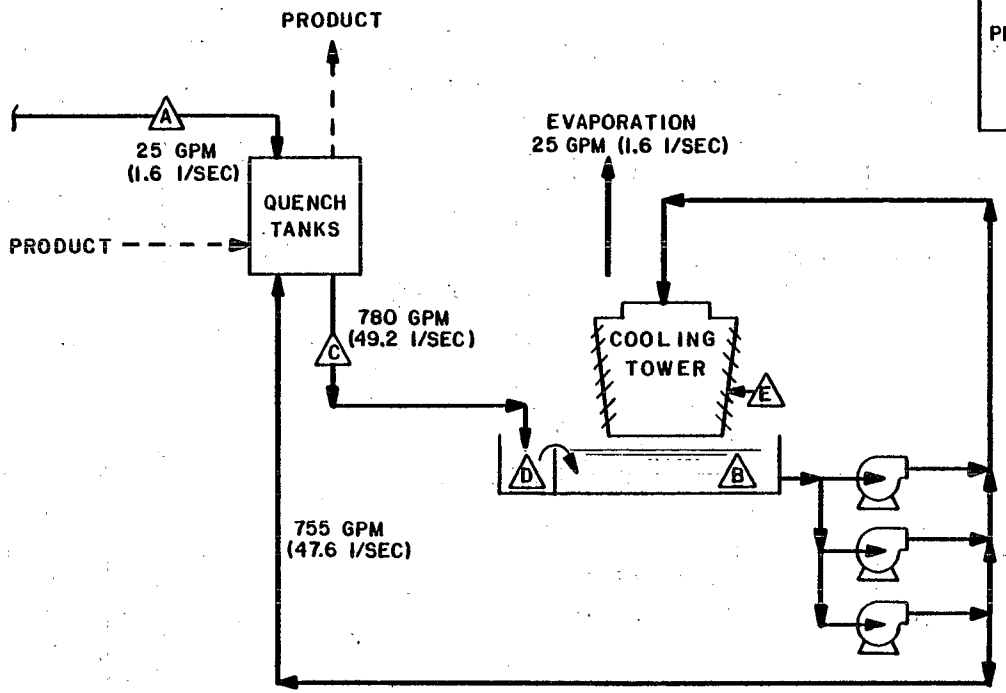

EVAPORATION
20-35 GPM
MAKE-UP
A
CHARGE
EMERGENCY
STACK
DEMIST
UNIT
SEPARATOR
EXHAUST
FAN
CAUSTIC
ADDITION
5 GPM
C
CUPOLA
215 GPM
220 GPM
HYDRAULIC
CYCLONE
CLASSIFIER
B
TOTE BUCKET
160 lbs./DAY
LANDFILL
PROCESS: FERROUS FOUNDRY
PLANT: 00001
PRODUCTION: 20 TONS/DAY
18 METRIC TONS/DAY
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 4/12/79
FIGURE V-32

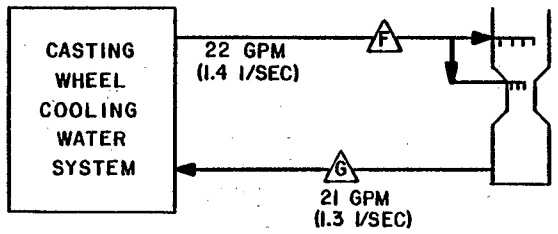

PROCESS: FERROUS FOUNDRY
PLANT: 00002
PRODUCTION: 70 TON/DAY
63 METRIC TON/DAY
EVAPORATION
74 GPM
STACK
DEMISTER
EXHAUST
FAN
HOT BLAST
FAN
RECUPERATOR
SEPARATOR
MAKE-UP
CHARGE
M
K
75 GPM
5 GPM
500
GPM
HYDRAULIC
CYCLONE
CLASSIFIER
100 GAL/DAY
L
TO LANDFILL
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 4/13/79
FIGURE V-33


PROCESS: GRAY IRON FOUNDRY MELTING SCRUBBER
PLANT: 07170
PRODUCTION: 4 TONS/DAY (3.6 METRIC TONS/DAY)
5 GPM (0.32 l/sec) LOSSES
SEPARATOR
VENTURI
CUPOLA
96 GPM (6.1 l/sec)
FAN
(1) - POLYMER
(2) - FLOCCULANT
(3) - NaOH
(1)
(2)
(3)
CITY WATER
5 GPM (0.32 l/sec)
A
SCREEN OVER INTAKE BOX
B
SLUDGE TO LANDFILL
C
210 GAL/DAY (795 l/DAY)
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN.2/20/79
FIGURE V-34


PROCESS: FERROUS FOUNDRY (GRAY IRON)
PLANT: 51026
PRODUCTION:
DUST COLLECTION 240 METRIC TONS/DAY (265 TONS/DAY)
SAND WASHING 45 METRIC TONS/DAY (50 TONS/DAY)
MELTING 408 METRIC TONS/DAY (450 TONS/DAY)
PLANT WATER SUPPLY
2,649,000 I/DAY (700,000 GAL/DAY)
OTHER USES
BAG HOUSE
GAS QUENCH CHAMBER
DUST TO LANDFILL
EVAPORATION LOSS
BLOWER
HOPPER
SLAG ELEVATOR
SOLIDS
SLAG PIT
LADLE
SOLIDS
METAL
PIPE MACHINE
MAKE-UP WATER
SUMP
MULTI CLONE
WATER-JET
MAKE-UP WATER
SAND
SUMP
SAND WASHING SYSTEM
18.93 I/SEC (300 GPM)
.06 I/SEC (1 GPM)
DUST COLLECTOR
MAKE-UP WATER
SOLIDS
6.31 I/SEC (100 GPM)
13.8 I/SEC (220 GPM)
PIG MACHINE
PIGS
MAKE-UP WATER
SUMP
3.15 I/SEC (50 GPM)
19 I/SEC (301 GPM)
32.9 I/SEC (521 GPM)
SAMPLE POINTS
1,179,330 I/DAY (311,580 GAL/DAY)
39.2 I/SEC (621 GPM)
12 HR. LAGOON
72 HR. LAGOON
12 HR. LAGOON
TO RIVER
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/11/79
FIGURE V-35

PROCESS:	STEEL FOUNDRY
PLANT:	15654
PRODUCTION:	216 TONS/DAY (196 KKG/DAY)





EVAPORATIVE LOSSES 1 GPM (0.1 l/SEC)

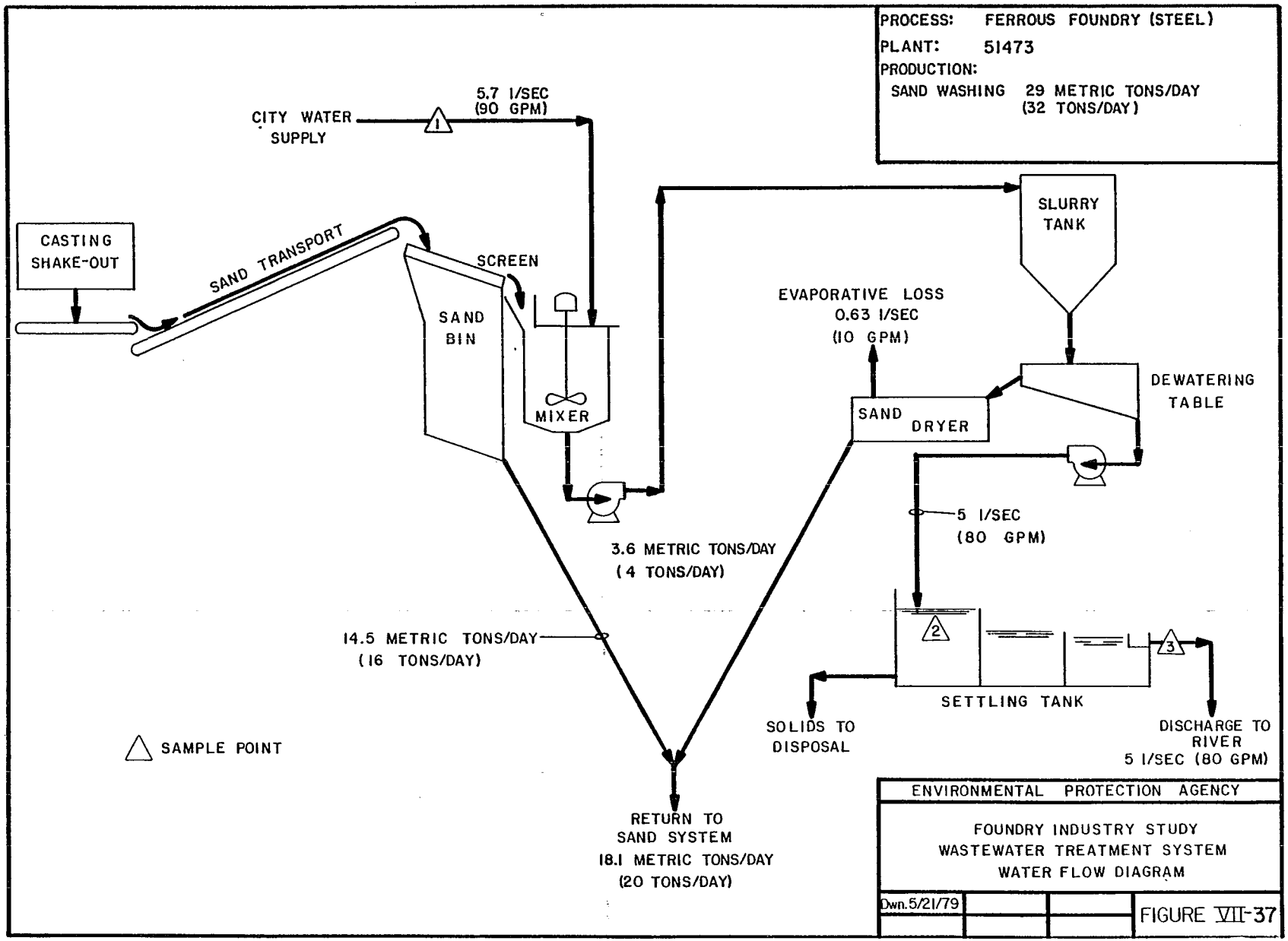
SAND DRYER SCRUBBER

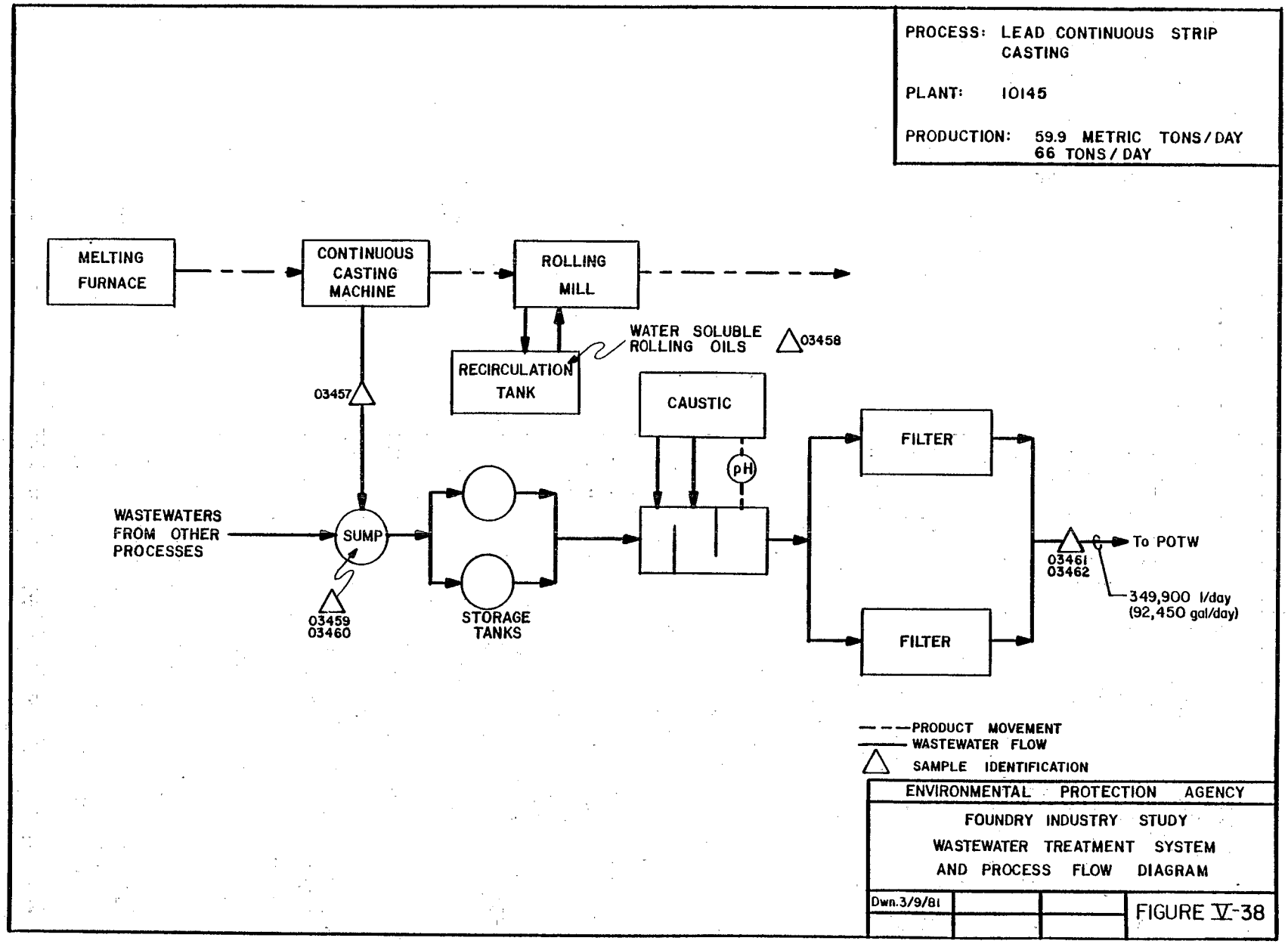
ENVIRONMENTAL PROTECTION AGENCY

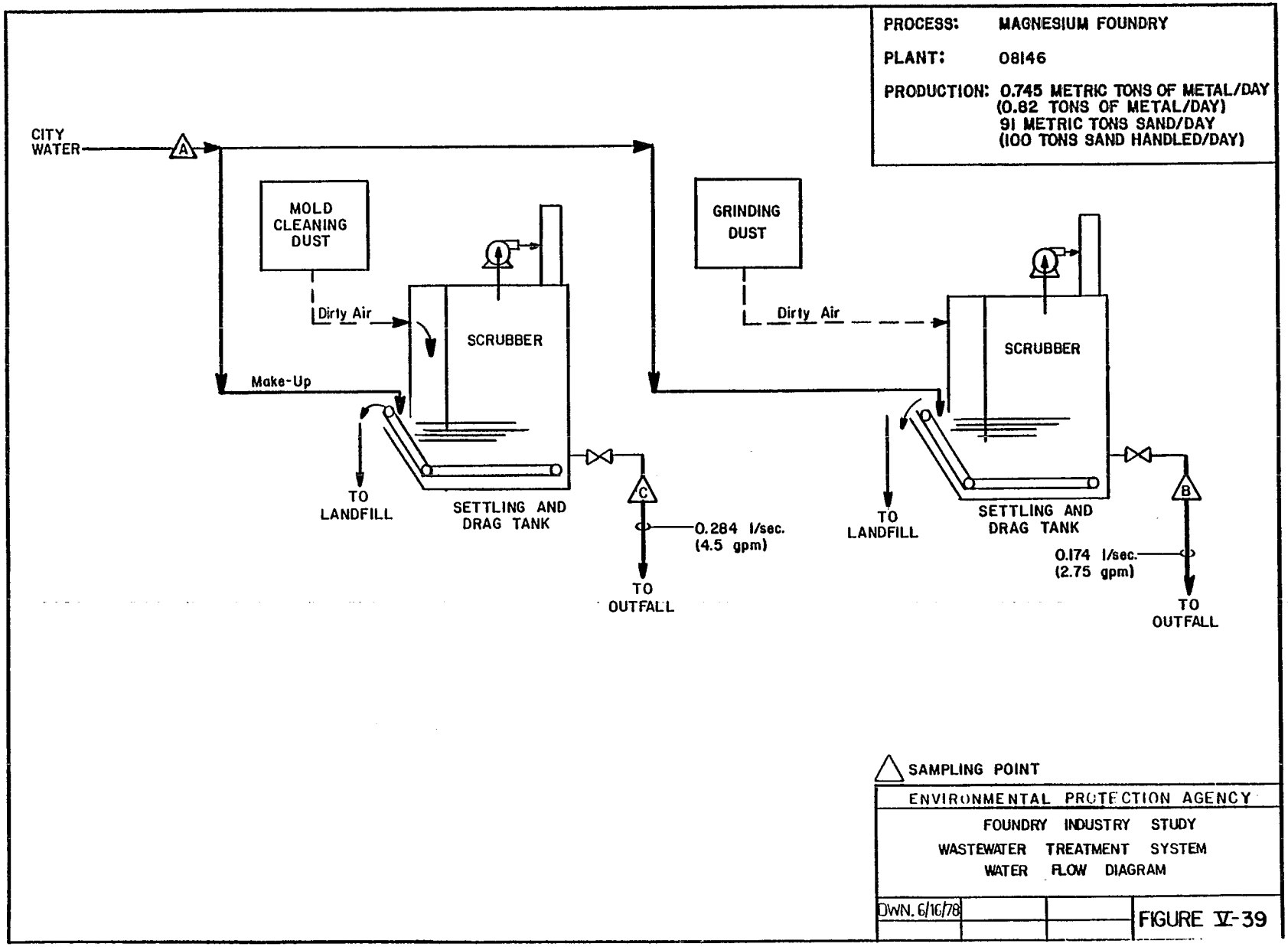
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

DWN.12/15/78

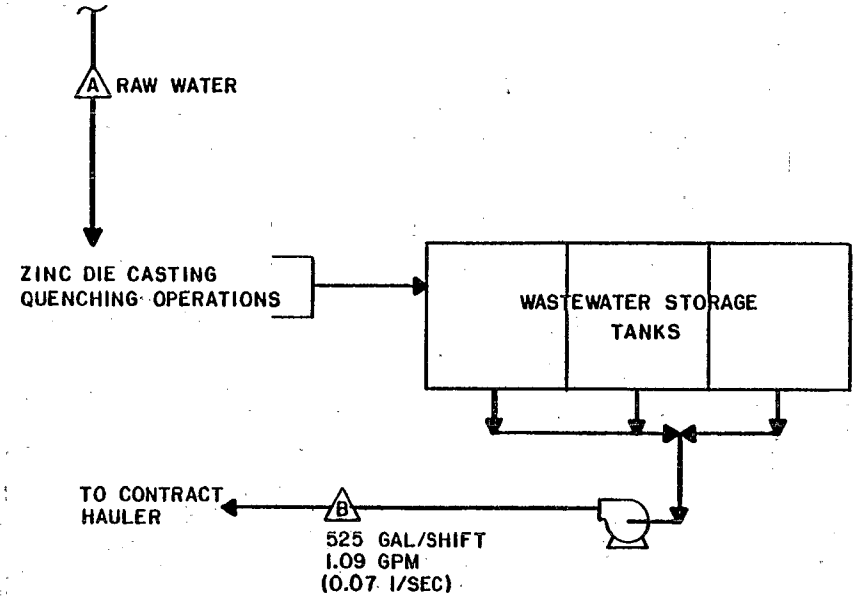
FIGURE V-36


PROCESS: FERROUS FOUNDRY (STEEL)
PLANT: 51473
PRODUCTION:
SAND WASHING 29 METRIC TONS/DAY
(32 TONS/DAY)
CITY WATER SUPPLY
5.7 I/SEC
(90 GPM)
1
CASTING SHAKE-OUT
SAND TRANSPORT
SCREEN
SAND BIN
MIXER
SLURRY TANK
EVAPORATIVE LOSS
0.63 I/SEC
(10 GPM)
DEWATERING TABLE
SAND DRYER
5 I/SEC
(80 GPM)
3.6 METRIC TONS/DAY
(4 TONS/DAY)
14.5 METRIC TONS/DAY
(16 TONS/DAY)
2
3
SETTLING TANK
SOLIDS TO DISPOSAL
DISCHARGE TO RIVER
5 I/SEC (80 GPM)
SAMPLE POINT
RETURN TO SAND SYSTEM
18.1 METRIC TONS/DAY
(20 TONS/DAY)
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
Dwn. 5/21/79
FIGURE VII-37


PROCESS: LEAD CONTINUOUS STRIP CASTING
PLANT: 10145
PRODUCTION: 59.9 METRIC TONS/DAY
66 TONS/DAY
MELTING FURNACE
CONTINUOUS CASTING MACHINE
ROLLING MILL
WATER SOLUBLE ROLLING OILS
03458
RECIRCULATION TANK
03457
CAUSTIC
pH
FILTER
FILTER
WASTEWATERS FROM OTHER PROCESSES
SUMP
03459
03460
STORAGE TANKS
03461
03462
To POTW
349,900 l/day
(92,450 gal/day)
PRODUCT MOVEMENT
WASTEWATER FLOW
SAMPLE IDENTIFICATION
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
AND PROCESS FLOW DIAGRAM
Dwn. 3/9/81
FIGURE V-38


PROCESS: MAGNESIUM FOUNDRY
PLANT: 08146
PRODUCTION: 0.745 METRIC TONS OF METAL/DAY
(0.82 TONS OF METAL/DAY)
91 METRIC TONS SAND/DAY
(100 TONS SAND HANDLED/DAY)
CITY WATER
A
MOLD CLEANING DUST
Dirty Air
SCRUBBER
Make-Up
TO LANDFILL
SETTLING AND DRAG TANK
C
0.284 l/sec.
(4.5 gpm)
TO OUTFALL
GRINDING DUST
Dirty Air
SCRUBBER
TO LANDFILL
SETTLING AND DRAG TANK
B
0.174 l/sec.
(2.75 gpm)
TO OUTFALL
SAMPLING POINT
ENVIRONMENTAL PROTECTION AGENCY
FOUNDRY INDUSTRY STUDY
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
DWN. 6/16/78
FIGURE V-39

PROCESS:	ZINC DIE CASTING
PLANT:	04622
PRODUCTION:	METAL USED 16.8 TONS/DAY (15.2 METRIC TONS/DAY)



ENVIRONMENTAL PROTECTION AGENCY			
FOUNDRY INDUSTRY STUDY WASTEWATER TREATMENT SYSTEM WATER FLOW DIAGRAM			
DWN. 11/9/78			FIGURE V-40

SECTION VI

SELECTION OF POLLUTANTS

Section V presented the pollutants to be examined for possible regulation along with data from plant sampling visits and chemical analyses.

This section discusses those pollutants which were not found in the raw process wastewaters or were detected at such small levels that their presence could not be quantified. Additionally, pollutants known to be present in raw process wastewaters are discussed. Toxic pollutants known to be present are discussed in numerical order, followed by nonconventional pollutants and then conventional pollutant parameters, each in alphabetical order.

Finally, the pollutant parameters selected for consideration for specific regulation for the discharge alternatives discussed in Sections IX through XIII of this document, and those eliminated from further consideration in each subcategory are discussed. The rationale for those selections is also presented.

POLLUTANTS NOT DETECTED IN RAW PROCESS WASTEWATERS

Table VI-1 lists the 21 pollutants that were not detected in any raw process wastewater samples in this category. These pollutants have been eliminated from further consideration for regulation.

POLLUTANTS DETECTED IN RAW PROCESS WASTEWATERS BELOW QUANTIFIABLE LIMITS

Table VI-2 lists the 14 pollutants that were found in raw process wastewaters at nonquantifiable levels in all raw process wastewaters samples analyzed in this category. These pollutants have also been eliminated from further consideration for regulation.

POLLUTANTS PRESENT IN RAW PROCESS WASTEWATERS

Table VI-3 lists those pollutants present in quantifiable in raw process wastewaters. A pollutant is considered to be present if any of the following three conditions are satisfied: 1) the average raw wastewater concentration of a pollutant for all plants sampled within the subcategory is 0.010 mg/l or greater, 2) the pollutant is identified as "known to be present" in the plant DCP response, or 3) examination of the metal molding and

casting manufacturing processes indicates that a pollutant is associated with a specific manufacturing process due to the nature of the manufacturing process, raw materials used, air pollution control devices, or other production related parameters.

Ninty-two toxic pollutants were found in quantifiable amounts in wastewaters of the metal molding and casting category. These pollutants are listed in Table VI-3 and are discussed briefly below. These discussions: provide details regarding the process origin of the pollutant; discuss whether the pollutant is a naturally occurring element, processed metal, or process chemical; describe the general physical properties and the form of each pollutant; describe the toxic effects of the pollutant in humans and other animals; and discuss the behavior of each pollutant in POTWs at the concentrations that might be expected from industrial dischargers. The literature relied upon for these discussions is listed in Section XV. Particular attention has been given to documents generated by the EPA Criteria and Standards Division, and the Monitoring and Data Support Division.

Acenaphthene(1). Acenaphthene (1,2-dihydroacenaphthylene, or 1,8-ethylene-naphthalene) is a polynuclear aromatic hydrocarbon (PAH) with molecular weight of 154 and a formula of $C_{12}H_{10}$. The structure is:

Acenaphthene occurs in coal tar produced during high temperature coking of coal. It has been detected in cigarette smoke and gasoline exhaust condensates.

The pure compound is a white crystalline solid at room temperature, with a melting range of 95 to 97°C (203 to 207°F) and a boiling range of 278 to 280°C (532 to 536°F). Its vapor pressure at room temperature is less than 0.02 mm Hg. Acenaphthene is slightly soluble in water (100 mg/l), but even more soluble in organic solvents such as ethanol, toluene, and chloroform. Acenaphthene can be oxidized by oxygen or ozone in the presence of certain catalysts. It is stable under laboratory conditions.

Acenaphthene is used as a dye intermediate, in the manufacture of some plastics, and as an insecticide and fungicide.

So little research has been performed on acenaphthene that its mammalian and human health effects are virtually unknown. The water quality criterion of 0.02 mg/l is recommended to prevent the adverse effects on humans due to the organoleptic properties of acenaphthene in water. Limited acute and chronic toxicity

data for freshwater aquatic life show that adverse effects occur at higher concentrations than those cited for human health risks.

No detailed study of acenaphthene behavior in POTWs is available. However, it has been demonstrated that none of the organic priority pollutants studied so far can be broken down by biological treatment processes as readily as fatty acids, carbohydrates, or proteins. Many of the priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained by most municipal wastewaters. General observations relating molecular structure to ease of degradation have been developed for all of the organic priority pollutants.

The conclusion reached by study of the limited data is that biological treatment produces little or no degradation of acenaphthene. No evidence is available to draw conclusions about its possible toxic or inhibitory effect on POTW operations.

Its water solubility would allow acenaphthene present in the influent to pass through a POTW into the effluent. The hydrocarbon character of this compound makes it sufficiently hydrophobic that adsorption onto suspended solids and retention in the sludge may also be a significant route for removal of acenaphthene from the POTW.

Acenaphthene has been demonstrated to affect the growth of plants through improper nuclear division and polypoidal chromosome number. However, it is not expected that land application of sewage sludge containing acenaphthene, at the low concentrations which are to be expected in a POTW sludge, would result in any adverse effects on animals ingesting plants grown in such soil.

Benzene (4). Benzene (C_6H_6) is a clear, colorless, liquid obtained mainly from petroleum feedstocks by several different processes. Some is recovered from light oil obtained from coal carbonization gases. It boils at 80°C and has a vapor pressure of 100 mm Hg at 26°C. It is slightly soluble in water (1.8 g/l at 25°C) and it dissolves in hydrocarbon solvents. Annual U.S. production is three to four million tons.

Most of the benzene used in the U.S. goes into chemical manufacture. About half of that is converted to ethylbenzene which is used to make styrene. Some benzene is used in motor fuels.

Benzene is harmful to human health according to numerous published studies. Most studies relate effects of inhaled benzene vapors. These effects include nausea, loss of muscle

coordination, and excitement, followed by depression and coma. Death is usually the result of respiratory or cardiac failure. Two specific blood disorders are related to benzene exposure. One of these, acute myelogenous leukemia, represents a carcinogenic effect of benzene. However, most human exposure data is based on exposure in occupational settings, and benzene carcinogenesis is not considered to be firmly established.

Oral administration of benzene to laboratory animals produced leukopenia, a reduction in the number of leukocytes in the blood. Subcutaneous injection of benzene-oil solutions has produced suggestive, but not conclusive, evidence of benzene carcinogenesis.

Benzene demonstrated teratogenic effects in laboratory animals, and mutagenic effects in humans and other animals.

For maximum protection of human health from the potential carcinogenic effects of exposure to benzene, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of benzene estimated to result in additional lifetime cancer risk at levels of 10^{-7}, 10^{-6}, and 10^{-5} are 0.00015 mg/l, 0.0015 mg/l, and 0.015 mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.478 mg/l to keep the lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human risks.

Some studies have been reported regarding the behavior of benzene in POTWs. Biochemical oxidation of benzene under laboratory conditions, at concentrations of 3 to 10 mg/l, produced 24, 27, 24, and 29 percent degradation in 5, 10, 15, and 20 days, respectively, using unacclimated seed cultures in fresh water. Degradation of 58, 67, 76, and 80 percent was produced in the same time periods using acclimated seed cultures. Other studies produced similar results. Based on these data and general conclusions relating molecular structure to biochemical oxidation, it is expected that biological treatment in POTWs will remove benzene readily from the water. Other reports indicate that most of the benzene entering a POTW is removed to the sludge, and that influent concentrations of 1 g/l inhibit sludge digestion. An EPA study of the fate of priority pollutants in POTWs reveals removal efficiencies of 70 to 98 percent for three POTWs where influent benzene levels were 5×10^{-3} to 143×10^{-3} mg/l. Four other POTW samples had influent benzene concentrations of 1 or 2 $\times 10^{-3}$ mg/l, and removals appeared indeterminate because of the limits of quantification for

analyses. There is no information about possible effects of benzene on crops grown in soils amended with sludge containing benzene.

Benzidine (5). Benzidine ($NH_2(C_6H_4)_2NH_2$) is a grayish-yellow, white or reddish-gray crystalline powder. It melts at 127°C (260°F), and boils at 400°C (752°F). This chemical is soluble in hot water, alcohol, and ether, but only slightly soluble in water. It is derived by: (a) reducing nitrobenzene with zinc dust in an alkaline solution followed by distillation; (b) the electrolysis of nitrobenzene, followed by distillation; or, (c) the nitration of diphenyl followed by reduction of the product with zinc dust in an alkaline solution, with subsequent distillation. It is used in the synthesis of a variety of organic chemicals, such as stiffening agents in rubber compounding.

Available data indicate that benzidine is acutely toxic to freshwater aquatic life at concentrations as low as 2.50 mg/l and would occur at lower concentrations among species that are more sensitive than those tested. However, no data are available concerning the chronic toxicity to sensitive freshwater and saltwater aquatic life.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to benzidine, through the ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risk at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0000012 mg/l, 0.00000012 mg/l, and 0.000000012 mg/l respectively.

With respect to treatment in POTWs, laboratory studies have shown that benzidine is amenable to treatment via biochemical oxidation. The expected 30-day average treated effluent concentration is 0.025 mg/l.

Carbon tetrachloride (6). Carbon tetrachloride (CCl_4), also called tetrachloromethane, is a colorless liquid produced primarily by the chlorination of hydrocarbons - particularly methane. Carbon tetrachloride boils at 77°C and has a vapor pressure of 90 mm Hg at 20°C. It is slightly soluble in water (0.8 mg/l at 25°C) and soluble in many organic solvents. Approximately one-third of a million tons is produced annually in the U.S.

Carbon tetrachloride, which was displaced by perchloroethylene as a dry cleaning agent in the 1930's, is used principally as an

intermediate for production of chlorofluoromethanes for refrigerants, aerosols, and blowing agents. It is also used as a grain fumigant.

Carbon tetrachloride produces a variety of toxic effects in humans. Ingestion of relatively large quantities - greater than five grams - has frequently proven fatal. Symptoms are burning sensation in the mouth, esophagus, and stomach, followed by abdominal pains, nausea, diarrhea, dizziness, abnormal pulse, and coma. When death does not occur immediately, liver and kidney damage are usually found. Symptoms of chronic poisoning are not as well defined. General fatigue, headache, and anxiety have been observed, accompanied by digestive tract and kidney discomfort or pain.

Data concerning teratogenicity and mutagenicity of carbon tetrachloride are scarce and inconclusive. However, carbon tetrachloride has been demonstrated to be carcinogenic in laboratory animals. The liver was the target organ.

For the maximum protection of human health from the potential carcinogenic effects of exposure to carbon tetrachloride, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of carbon tetrachloride estimated to result in additional lifetime cancer risk at risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 0.000026 mg/l, 0.00026 mg/l, and 0.0026 mg/l, respectively.

Data on the behavior of carbon tetrachloride in POTWs are not available. Many of the organic priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be found in most municipal wastewaters. General observations have been developed relating molecular structure to ease of degradation for all of the organic priority pollutants. The conclusion reached by study of the limited data is that biological treatment produces a moderate degree of removal of carbon tetrachloride in POTWs. No information was found regarding the possible interference of carbon tetrachloride with treatment processes. Based on the water solubility of carbon tetrachloride, and the vapor pressure of this compound, it is expected that some of the undegraded carbon tetrachloride will pass through to the POTW effluent, and some will be volatilized in aerobic processes.

Chlorobenzene (7). Chlorobenzene (C_6H_5Cl), also called monochlorobenzene is a clear, colorless, liquid manufactured by the liquid phase chlorination of benzene over a catalyst. It boils at 132°C (270°F) and has a vapor pressure of 12.5 mm Hg at

25°C. It is almost insoluble in water (0.5 g/l at 30°C), but dissolves in hydrocarbon solvents. U.S. annual production is near 150,000 tons.

Principal uses of chlorobenzene are as a solvent and as an intermediate for dyes and pesticides. Formerly it was used as an intermediate for DDT production, but elimination of production of that compound reduced annual U.S. production requirements for chlorobenzene by half.

Data on the threat to human health posed by chlorobenzene are limited in number. Laboratory animals administered large doses of chlorobenzene subcutaneously, died as a result of central nervous system depression. At slightly lower dose rates, animals died of liver or kidney damage. Metabolic disturbances occurred also. At even lower dose rates of orally administered chlorobenzene, similar effects were observed, but some animals survived longer than at higher dose rates. No studies have been reported regarding evaluation of the teratogenic, mutagenic, or carcinogenic potential of chlorobenzene.

For the prevention of adverse effects due to the organoleptic properties of chlorobenzene in water, the recommended criterion is 0.020 mg/l.

Limited data are available on which to base conclusions about the behavior of chlorobenzene in POTWs. Laboratory studies of the biochemical oxidation of chlorobenzene have been carried out at concentrations greater than those expected to normally be present in POTW influents. Results showed the extent of degradation to be 25, 28, and 44 percent after 5, 10, and 20 days, respectively. In another, similar study using a phenol-adapted culture, 4 percent degradation was observed after 3 hours with a solution containing 80 mg/l. On the basis of these results and general conclusions about the relationship of molecular structure to biochemical oxidation, it is concluded that chlorobenzene will be removed to a moderate degree by biological treatment in POTWs. A substantial percentage of the chlorobenzene remains intact and is expected to volatilize from the POTW in aeration processes. The estimated half-life of chlorobenzene in water, based on water solubility, vapor pressure and molecular weight, is 5.8 hours.

1,2,4-trichlorobenzene (8). 1,2,4-trichlorobenzene ($C_6H_3Cl_3$, 1,2,4-TCB) is a liquid at room temperature, solidifying to a crystalline solid at 17°C (3°F) and boiling at 214°C (417°F). It is produced by liquid phase chlorination of benzene in the presence of a catalyst. Its vapor pressure is 4 mm Hg at 25°C. 1,2,4-TCB is insoluble in water and soluble in organic solvents. Annual U.S. production is in the range of 15,000 tons. 1,2,4-TCB

is used in limited quantities as a solvent and as a dye carrier in the textile industry. It is also used as a heat transfer medium and as a transformer fluid. The compound can be selectively chlorinated to 1,2,4,5-tetrachlorobenzene using iodine plus antimony trichloride as catalysts.

No reports were available regarding the toxic effects of 1,2,4-TCB on humans. Limited data, from studies of effects in laboratory animals fed 1,2,4-TCB, indicate depression of activity at low doses and predeath extension convulsions at lethal doses. Metabolic disturbances and liver changes were also observed. Studies for the purpose of determining teratogenic or mutagenic properties of 1,2,4-TCB have not been conducted. No studies have been made of carcinogenic behavior of 1,2,4-TCB administered orally.

For the prevention of adverse effects due to the organoleptic properties of 1,2,4-trichlorobenzene in water, the water quality criterion is 0.013 mg/l.

Data on the behavior of 1,2,4-TCB in POTWs are not available. However, this compound has been investigated in a laboratory scale study of biochemical oxidation at concentrations higher than those expected to be contained by most municipal wastewaters. Degradations of 0, 87, and 100 percent were observed after 5, 10, and 20 days, respectively. Using this observation and general observations relating molecular structure to ease of degradation for all of the organic priority pollutants, the conclusion was reached that biological treatment produces a high degree of removal in POTWs.

1,2-dichloroethane (10). 1,2-dichloroethane ($ClCH_2CH_2Cl$) is a colorless, oily liquid with a chloroform-like odor and a sweet taste. Stable in the presence of water, alkalies, acids, or actively reacting chemicals, it is resistant to oxidation. Miscible with most common solvents, it is only slightly soluble in water. It boils at 83.5°C (182°F), flashes at 21°C (70°F) and has a vapor pressure of 100 mm Hg at 29.4°C. This chemical is derived by the action of chlorine on ethylene with subsequent distillation, with ethylene dibromide as a catalyst. It is used as a solvent for oils, resins, gums, and other products and for metal degreasing.

Available data indicate that acute toxicity to freshwater aquatic life occurs at 118 mg/l, and that chronic toxicity occurs at a concentration of 29 mg/l. Available data for saltwater fish and invertebrate species indicate that acute toxicity occurs at 113 mg/l.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to 1,2-dichloroethane, through the ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risk at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0094 mg/l, 0.00094 mg/l, and 0.000094 mg/l respectively.

With respect to treatment in POTWs, laboratory studies have shown that 1,2-dichloroethane is only moderately amenable to treatment via biochemical oxidation. This is corroborated by the physical property data presented above. It should be noted that the optimum estimated 30-day average treated effluent concentration of 0.10 mg/l is greater than the level at which this pollutant was found in any foundry process wastewater.

1,1,1-trichloroethane(11). 1,1,1-trichloroethane is one of the two possible trichloroethanes. It is manufactured by hydrochlorinating vinyl chloride to 1,1-dichloroethane, which is then chlorinated to the desired product. 1,1,1-trichloroethane is a liquid at room temperature with a vapor pressure of 96 mm Hg at 20°C and a boiling point of 74°C. Its formula is CCl_3CH_3. It is slightly soluble in water (0.48 g/l) and is very soluble in organic solvents. U.S. annual production is greater than one-third of a million tons.

1,1,1-trichloroethane is used as an industrial solvent and degreasing agent.

Most human toxicity data for 1,1,1-trichloroethane relates to inhalation and dermal exposure routes. Limited data are available for determining toxicity of ingested 1,1,1-trichloroethane, and those data are all for the compound itself, not for solutions in water. No data are available regarding its toxicity to fish and aquatic organisms. For the protection of human health from the toxic properties of 1,1,1-trichloroethane, ingested through the consumption of water and fish, the ambient water criterion is 15.7 mg/l. The criterion is based on bioassay for possible carcinogenicity.

No detailed study of 1,1,1-trichloroethane behavior in POTWs is available. However, it has been demonstrated that none of the organic priority pollutants of this type can be broken down by biological treatment processes as readily as fatty acids, carbohydrates, or proteins.

Biochemical oxidation of many of the organic priority pollutants has been investigated, at least in laboratory scale studies, at

concentrations higher than commonly expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment produces a moderate degree of degradation of 1,1,1-trichloroethane. No evidence is available for drawing conclusions about its possible toxic or inhibitory effect on POTW operations. However, for degradation to occur, a fairly constant input of the compound would be necessary.

Its water solubility would allow 1,1,1-trichloroethane, present in the influent and not biodegradable, to pass through a POTW into the effluent. One factor which has received some attention, but no detailed study, is the volatilization of the lower molecular weight organics from POTWs. If 1,1,1-trichloroethane is not biodegraded, it will volatilize during aeration processes in the POTW.

1,1-dichloroethane(13). 1,1-dichloroethane, also called ethylidene dichloride and ethylidene chloride, is a colorless liquid manufactured by reacting hydrogen chloride with vinyl chloride in 1,1-dichloroethane solution in the presence of a catalyst. However, it is reportedly not manufactured commercially in the U.S. 1,1-dichloroethane boils at 57°C and has a vapor pressure of 182 mm Hg at 20°C. It is slightly soluble in water (5.5 g/l at 20°C) and very soluble in organic solvents.

1,1-dichloroethane is used as an extractant for heat-sensitive substances and as a solvent for rubber and silicone grease.

1,1-dichloroethane is less toxic than its isomer (1,2-dichloroethane), but its use as an anesthetic has been discontinued because of marked excitation of the heart. It causes central nervous system depression in humans. There are insufficient data to derive water quality criteria for 1,1-dichloroethane.

Data on the behavior of 1,1-dichloroethane in POTWs are not available. Many of the organic priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained by most municipal wastewaters. General observations have been developed, relating molecular structure to ease of degradation, for all of the organic priority pollutants. The conclusion reached by study of the limited data is that biological treatment produces only a moderate removal of 1,1-dichloroethane in POTWs by degradation.

The high vapor pressure of 1,1-dichloroethane is expected to result in volatilization of some of the compound from aerobic processes in POTWs. Its water solubility will result in some of the 1,1-dichloroethane which enters the POTW leaving in the effluent from the POTW.

1,1,2-trichloroethane(14). 1,1,2-trichloroethane is one of the two possible trichloroethanes and is sometimes called ethane trichloride or vinyl trichloride. It is used as a solvent for fats, oils, waxes, and resins, in the manufacture of 1,1-dichloroethylene, and as an intermediate in organic synthesis.

1,1,2-trichloroethane is a clear, colorless liquid at room temperature with a vapor pressure of 16.7 mm Hg at 20°C, and a boiling point of 113°C. It is insoluble in water and very soluble in organic solvents. The formula is $CHCl_2CH_2Cl$.

Human toxicity data for 1,1,2-trichloroethane does not appear in the literature. The compound does produce liver and kidney damage in laboratory animals after intraperitoneal administration. No literature data were found concerning teratogenicity or mutagenicity of 1,1,2-trichloroethane. However, mice treated with 1,1,2-trichloroethane showed increased incidence of hepatocellular carcinoma. Although bioconcentration factors are not available for 1,1,2-trichloroethane in fish and other freshwater aquatic organisms, it is concluded on the basis of octanol-water partition coefficients that bioconcentration does occur.

For the maximum protection of human health from the potential carcinogenic effects of exposure to 1,1,2-trichloroethane, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of this compound estimated to result in additional lifetime cancer risks at risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 0.000027 mg/l, 0.00027 mg/l, and 0.0027 mg/l, respectively.

No detailed study of 1,1,2-trichloroethane behavior in POTWs is available. However, it is reported that small amounts are formed by chlorination processes, and that this compound persists in the environment (greater than two years) and it is not biologically degraded. This information is not completely consistent with the conclusions based on laboratory scale biochemical oxidation studies and relating molecular structure to ease of degradation. That study concluded that biological treatment in POTWs will produce moderate removal of 1,1,2-trichloroethane.

The lack of water solubility and the relatively high vapor pressure may lead to removal of this compound from POTWs by volatilization.

1,1,2,2-tetrachloroethane (15). 1,1,2,2-tetrachloroethane ($CHCl_2CHCl_2$) is a heavy, colorless, mobile, nonflammable, corrosive, toxic liquid. While it has a chloroform-like odor, it is more toxic than chloroform. It is soluble in alcohol or ether, but insoluble in water. It has no flash point, boils at 146.5°C (296°F) and has a vapor pressure of 5 mm Hg at 20.7°C. It results from the interaction of acetylene and chlorine, with subsequent distillation. This chemical is used in organic synthesis, as a solvent, and for metal cleaning and degreasing.

Available freshwater data indicate that acute toxicity occurs at concentrations of 9.32 mg/l, and that chronic toxicity occurs at 4.000 mg/l. Available saltwater data indicate that acute toxicity occurs at 9.020 mg/l.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to 1,1,2,2-tetrachloroethane, through contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risk at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0017 mg/l, 0.00017 mg/l, and 0.000017 mg/l

With respect to treatment in POTWs, laboratory studies have shown that 1,1,2,2-tetrachloroethane is not amenable to treatment via biochemical oxidation. As this pollutant is insoluble in water, any removal of this pollutant which would occur in a POTW, would be related to physical treatment processes.

Bis(2-chloroethyl) ether (18). Bis(2-chloroethyl) ether ($ClCH_2CH_2OCH_2CH_2CL$) is a colorless, stable, non-corrosive liquid with an odor similar to that of ethylene dichloride. Its boils at 178.5°C (353°F), flashes at 55°C (131°F) and has a vapor pressure of 1 mm Hg at 23.5°C. It is miscible with most organic solvents, immiscible with the paraffin hydrocarbons, and insoluble with water. It is used as a solvent for oils, waxes, and resins, as a wetting and penetrating compound, as a solvent in the production of lubricating oils, and in the synthesis of various organics.

The available data for this pollutant indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 238 mg/l. No data are available concerning this pollutant's chronic toxicity to freshwater aquatic life and acute and chronic toxicity to saltwater aquatic life.

For the maximum protection of human health from the potential carcinogenic effects of exposure to this pollutant, through ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0003 mg/l, 0.00003 mg/l, 0.000003 mg/l respectively.

With respect to treatment in POTWs, laboratory studies have shown that bis(2-chloroethyl) ether is not amenable to treatment via biochemical oxidation. As this pollutant is insoluble in water, any removal of this pollutant, which would occur in a POTW, would be related to physical treatment processes.

2,4,6-trichlorophenol (21). 2,4,6-trichlorophenol ($Cl_3C_6H_2OH$, abbreviated here to 2,4,6 TCP) is a colorless crystalline solid at room temperature. It is prepared by the direct chlorination of phenol. 2,4,6-TCP melts at 68°C (154°F) and is slightly soluble in water (0.8 gm/l at 25°C). This phenol does not produce a color with 4-aminoantipyrene, therefore it does not contribute to the non-conventional pollutant parameter "Total Phenols." No data were found on production volumes.

2,4,6-TCP is used as a fungicide, bactericide, glue and wood preservative, and for antimildew treatment. It is also used for the manufacture of 2,3,4,6,-tetrachlorophenol and pentachlorophenol.

No data were found on human toxicity effects of 2,4,6-TCP. Reports of studies with laboratory animals indicate that 2,4,6-TCP produced convulsions when injected interperitoneally. Body temperature was elevated also. The compound also produced inhibition of ATP production in isolated rat liver mitochondria, increased mutation rates in one strain of bacteria, and produced a genetic change in rats. No studies on teratogenicity were found.

For the maximum protection of human health from the potential carcinogenic effects of exposure to 2,4,6-trichlorophenol, through ingestion of water and contaminated aquatic organisms, the ambient water concentration should be zero. The estimated levels which would result in increased lifetime cancer risks of 10^{-7}, 10^{-6}, and 10^{-5} are 1.18×10^{-5} mg/l, 1.18×10^{-4} mg/l, and 1.18×10^{-3} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 3.6×10^{-3} mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects in aquatic species can occur at 9.7×10^{-4} mg/l.

Although no data were found regarding the behavior of 2,4,6-TCP in POTWs, studies of the biochemical oxidation of the compound have been made on a laboratory scale at concentrations higher than those normally expected in municipal wastewaters. Biochemical oxidation of 2,4,6-TCP at 100 mg/l produced 23 percent degradation using a phenol-adapted acclimated seed culture. Based on these results, biological treatment in a POTW is expected to produce a moderate degree of degradation. Another study indicates that 2,4,6-TCP may be produced in POTWs by chlorination of phenol during normal chlorination treatment.

Parachlorometacresol (22). Parachlorometacresol (ClC_7H_6OH) is thought to be 4-chloro-3-methylphenol (4-chlorometacresol, or 2-chloro-5- hydroxytoluene, but is also used by some authorities to refer to 6-chloro-3-methylphenol (6-chlorometacresol, or 4-chloro-3-hydroxytoluene), depending on whether the chlorine is considered to be para to the methyl or to the hydroxy group. It is assumed for the purposes of this document that the subject compound is 2-chloro-5-hydroxytoluene. This compound is a colorless crystalline solid melting at 66-68°C (151-154°F). It is slightly soluble in water (3.8 gm/l) and soluble in organic solvents. This phenol reacts with 4-aminoantipyrene to give a colored product and therefore contributes to the non-conventional pollutant parameter designated "Total Phenols." No information on manufacturing methods or volumes produced was found.

Parachlorometacresol (abbreviated here as PCMC) is marketed as a microbicide, and was proposed as an antiseptic and disinfectant, more than forty years ago. It is used in glues, gums, paints, inks, textiles, and leather goods. PCMC was found in raw wastewaters from the die casting quench operation from one subcategory of foundry operations.

Although no human toxicity data are available for PCMC, studies on laboratory animals have demonstrated that this compound is toxic when administered subcutaneously and intravenously. Death was preceeded by severe muscle tremors. At high dosages, kidney damage occurred. On the other hand, an unspecified isomer of chlorocresol, presumed to be PCMC, is used at a concentration of 0.15 percent to preserve mucous heparin, a natural product administrated intravenously as an anticoagulant. The report does not indicate the total amount of PCMC typically received. No information was found regarding possible teratogenicity, or carcinogenicity of PCMC.

Two reports indicate that PCMC undergoes degradation in biochemical oxidation treatments carried out at concentrations higher than are expected to be encountered in POTW influents. One study showed 59 percent degradation in 3.5 hours, when a

phenol-adapted acclimated seed culture was used with a solution of 60 mg/l PCMC. The other study showed 100 percent degradation of a 20 mg/l solution of PCMC in two weeks in an aerobic activated sludge test system. No degradation of PCMC occurred under anaerobic conditions. From a review of limited data, it is expected that PCMC will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

Chloroform(23). Chloroform is a colorless liquid manufactured commercially by chlorination of methane. Careful control of conditions maximizes chloroform production, but other products must be separated. Chloroform boils at 61°C (142°F) and has a vapor pressure of 200 mm Hg at 25°C. It is slightly soluble in water (8.22 g/l at 20°C) and readily soluble in organic solvents.

Chloroform is used as a solvent and to manufacture refrigerants, pharmaceuticals, plastics, and anesthetics. It is seldom used as an anesthetic.

Toxic effects of chloroform on humans include central nervous system depression, gastrointestinal irritation, liver and kidney damage and possible cardiac sensitization to adrenalin. Carcinogenicity has been demonstrated for chloroform on laboratory animals.

For the maximum protection of human health from the potential carcinogenic effects of exposure to chloroform, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of chloroform estimated to result in additional lifetime cancer risks at the levels of 10^{-7}, 10^{-6}, and 10^{-5} were 0.000021 mg/l, 0.00021 mg/l, and 0.0021 mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.157 mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

No data are available regarding the behavior of chloroform in a POTW. However, the biochemical oxidation of this compound was studied in one laboratory scale study at concentrations higher than those expected to be contained by most municipal wastewaters. After 5, 10, and 20 days no degradation of chloroform was observed. The conclusion reached is that biological treatment produces little or no removal by degradation of chloroform in POTWs. An EPA study of the fate of priority pollutants in POTWs reveals removal efficiencies of 0 to 80 percent for influent concentrations ranging from 5 to 46 x 10^{-3} mg/l at seven POTWs.

The high vapor pressure of chloroform is expected to result in volatilization of the compound from aerobic treatment steps in POTWs. Remaining chloroform is expected to pass through into the POTW effluent.

2-chlorophenol (24). 2-chlorophenol (ClC_6H_4OH), also called ortho-chlorophenol, is a colorless liquid at room temperature, manufactured by direct chlorination of phenol followed by distillation to separate it from the other principal product, 4-chlorophenol. 2-chlorophenol solidifies below 7°C (45°F) and boils at 176°C (349°F). It is soluble in water (28.5 gm/l at 20°C) and soluble in several types of organic solvents. This phenol gives a strong color with 4-aminoantipyrene and therefore contributes to the non-conventional pollutant parameter "Total Phenols." Production statistics could not be found. 2-chlorophenol is used almost exclusively as a chemical intermediate in the production of pesticides and dyes. Production of some phenolic resins uses 2-chlorophenol.

Very few data are available concerning the toxic effects of 2-chlorophenol on humans. The compound is more toxic to laboratory mammals when administered orally, than when administered subcutaneously or intravenously. This effect is attributed to the fact that the compound is almost completely in the un-ionized state at the low pH of the stomach, and hence, is more readily absorbed into the body. Initial symptoms are restlessness, increased respiration rate, followed by motor weakness and convulsions induced by noise or touch, and coma. Following lethal doses, kidney, liver, and intestinal damage were observed. No studies were found which addressed the teratogenicity or mutagenicity of 2-chlorophenol. Studies of 2-chlorophenol as a promoter of carcinogenic activity of other carcinogens were conducted by dermal application. Results do not bear a determinable relationship to results of oral administration studies.

For controlling undesirable taste and odor quality of ambient water due to the organoleptic properties of 2-chlorophenol in water, the estimated level is 1×10^{-4} mg/l. Data show that adverse effects on aquatic life occur at concentrations higher than that cited for organoleptic effects.

Data on the behavior of 2-chlorophenol in POTWs are not available. However, laboratory scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewaters. At 1 mg/l of 2-chlorophenol, an acclimated culture produced 100 percent degradation by biochemical oxidation after 15 days. Another study showed 45, 70, and 79 percent degradation by biochemical oxidation after 5,

10, and 20 days, respectively. The conclusion, reached by the study of these limited data, and general observations, on all organic priority pollutants relating molecular structure to ease of biochemical oxidation, is that 2-chlorophenol is removed to a high degree or completely by biological treatment in POTWs. Undegraded 2-chlorophenol is expected to pass through POTWs into the effluent because of the water solubility. Some 2-chlorophenol is also expected to be generated by chlorination treatments of POTW effluents containing phenol.

1,2-trans-dichloroethylene(30). 1,2-trans-dichloroethylene (trans-1,2-DCE) is a clear, colorless liquid with the formula CHClCHCl. Trans-1,2-DCE is produced in a mixture with the cis-isomer by chlorination of acetylene. The cis-isomer has distinctly different physical properties. Industrially, the mixture is used rather than the separate isomers. Trans-1,2-DCE has a boiling point of 48°C, and a vapor pressure of 324 mm Hg at 25°C.

The principal use of 1,2-dichloroethylene (mixed isomers) is to produce vinyl chloride. It is used as a lead scavenger in gasoline, as a general solvent, and for the synthesis of various other organic chemicals. When it is used as a solvent, trans-1,2-DCE can enter wastewater streams.

For the maximum protection of human health from the potential effects of exposure to 1,2-trans-dichloroethylene, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of 1,2-trans-dichloroethylene estimated to result in additional lifetime cancer risk at risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 3.3×10^{-6} mg/l, $3.3\ 10^{-5}$ mg/l, and 3.3×10^{-4} mg/l, respectively. If contaminated aquatic organisms alone are consumed excluding the consumption of water, the water concentration should be less than 0.018 mg/l to keep the lifetime cancer risk below 10^{-5}. Limited acute and chronic toxicity data for freshwater aquatic life show that adverse effects occur at concentrations higher than those cited for human health risks.

The behavior of trans-1,2-DCE in POTWs has not been studied. However, its high vapor pressure is expected to result in the release of a significant percentage of this compound to the atmosphere in any treatment involving aeration. Degradation of the dichloroethylenes in air is reported to occur, with a half-life of 8 weeks.

Biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory scale studies at concentrations higher than would normally be expected in

municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by the study of the limited data, is that biochemical oxidation produces little or no degradation of 1,2-trans-dichloroethylene. No evidence is available for drawing conclusions about the possible toxic or inhibitory effects of 1,2-trans-dichloroethylene on POTW operations. It is expected that its low molecular weight and degree of water solubility will result in trans-1,2-DCE passing through a POTW to the effluent, if it is not degraded or volatilized. Very little trans-1,2-DCE is expected to be found in sludge from POTWs.

2,4-dichlorophenol (31). 2,4-dichlorophenol ($Cl_2C_6H_3OH$) is a colorless, crystalline solid manufactured by chlorination of phenol dissolved in liquid sulfur dioxide or by chlorination of molten phenol (a lower yield method). 2,4-dichlorophenol (2,4-DCP) melts at 45°C (113°F) and has a vapor pressure of less than 1 mm Hg at 25°C (vapor pressure equals 1 mm Hg at 53°C). 2,4-DCP is slightly soluble in water (4.6 g/l at 20°C) and soluble in many organic solvents. 2,4-DCP reacts to give a strong color development with 4-aminoantipyrene, and therefore contributes to the non-conventional pollutant designated "Total Phenols." Annual U.S. production of 2,4-DCP is about 25,000 tons.

The principal use of 2,4-DCP is for the manufacture of the herbicide 2,4-dichloro-phenoxyacetic acid (2,4-D) and other pesticides.

Few data exist concerning the toxic effects of 2,4-DCP on humans. Symptoms exhibited by laboratory animals injected with fatal doses of 2,4-DCP included loss of muscle tone, followed by rapid, then slow breathing. In vitro experiments revealed inhibition of oxidative phosphorylation (a primary metabolic function) by 2,4-DCP in rat liver mitochondria and rat brain homogenates. No studies were found which addressed the teratogenicity, or the mutagenicity in mammals, of 2,4-DCP. The only studies of carcinogenic properties of 2,4-DCP used dermal application, which has no established relationship to oral administration results.

For the prevention of adverse effects due to the organoleptic properties of 2,4-dichlorophenol in water, the criterion is 0.0005 mg/l.

Data on the behavior of 2,4-dichlorophenol in POTWs are not available. However, laboratory scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewaters. Biochemical oxidation produced degradation of 70,72, and 72 percent after 5,10 and 20 days,

respectively, in one study. In another study, using an acclimated phenol-adapted culture, 30 percent degradation was measured after 3.5 hours. Based on these limited data, and on general observations relating molecular structure to ease of biological oxidation, it is concluded that 2,4-DCP is removed to a high degree or completely by biological treatment in POTWs. Undegraded 2,4-DCP is expected to pass through POTWs to the effluent. Some 2,4-DCP may be formed in POTWs by chlorination of effluents containing phenol.

1,3-dichloropropylene (33). 1,3-dichloropropylene ($CHCl:CHCH_2Cl$) is a colorless liquid. The boiling point of its cis-isomer is 104°C (219°F), while the boiling point of its trans-isomer is 112°C (234°F). It is derived from the chlorination of propylene. While it is soluble in acetone, toluene, and octane, it is insoluble in water. This chemical is used in various organic synthesis procedures.

The available data indicate that acute and chronic toxicity to freshwater aquatic life occur at concentrations as low as 6.06 mg/l and 0.244 mg/l respectively. The available data for this pollutant indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 0.79 mg/l. No data are available concerning the chronic toxicity of this pollutant to saltwater aquatic life.

For the protection of human health from the toxic properties of this pollutant, ingested through aquatic organisms alone, the ambient water criterion is determined to be 14.1 mg/l.

With respect to treatment in POTWs, laboratory studies have shown that 1,3-dichloropropylene is only moderately amenable to treatment via biochemical oxidation. The optimum expected 30-day average treated effluent concentration for this pollutant is 0.100 mg/l.

2,4-dimethylphenol(34). 2,4-dimethylphenol (2,4-DMP), also called 2,4-xylenol, is a colorless, crystalline solid at room temperature (25°C), but melts at 27 to 28°C (81 to 82°F). 2,4-DMP is slightly soluble in water and, as a weak acid, is soluble in alkaline solutions. Its vapor pressure is less than 1 mm Hg at room temperature.

2,4-DMP is a natural product, occurring in coal and petroleum sources. It is used commercially as an intermediate for the manufacture of pesticides, dyestuffs, plastics, resins, and surfactants. It is found in the water runoff from asphalt surfaces. It can find its way into the wastewater of a manufacturing plant from any of several sources.

Analytical procedures specific to this compound are used for its identification and quantification in wastewaters. This compound does not contribute to "Total Phenols" determined by the 4-aminoantipyrene method.

Three methylphenol isomers (cresols) and six dimethylphenol isomers (xylenols) generally occur together in natural products, industrial processes, commercial products, and phenolic wastes. Therefore, data are not available for human exposure to 2,4-DMP alone. In addition to this, most mammalian tests for toxicity of individual dimethylphenol isomers have been conducted with isomers other than 2,4-DMP.

In general, the mixtures of phenol, methylphenols, and dimethylphenols contain compounds which produced acute poisoning in laboratory animals. Symptoms were difficult breathing, rapid muscular spasms, disturbance of motor coordination, and assymetrical body position. In a 1977 National Academy of Science publication, the conclusion was reached that, "In view of the relative paucity of data on the mutagenicity, carcinogenicity, teratogenicity, and long term oral toxicity of 2,4 dimethylphenol, estimates of the effects of chronic oral exposure at low levels cannot be made with any confidence." No ambient water quality criterion can be set at this time. In order to protect public health, exposure to this compound should be minimized as soon as possible.

Toxicity data for fish and freshwater aquatic life are limited. Acute toxicity to freshwater aquatic life occurs at 2,4-dimethylphenol concentrations of 2.12 mg/l. For controlling undesirable taste and odor quality of ambient water, due to the organoleptic effects of 2,4-dimethylphenol in water, the estimated level is 0.4 mg/l.

The behavior of 2,4-DMP in POTWs has not been studied. As a weak acid its behavior may be somewhat dependent on the pH of the influent to the POTW. However, over the normal limited range of POTW pH, little effect of pH would be expected.

Biological degradability of 2,4-DMP, as determined in one study, showed 94.5 percent removal, based on chemical oxygen demand (COD). Thus, substantial removal is expected for this compound. Another study determined that persistence of 2,4-DMP in the environment is low, thus any of the compound which remained in the sludge or passed through the POTW into the effluent would be degraded within a moderate length of time (estimated as 2 months in the report).

2,4-dinitrotoluene (35). 2,4-dinitrotoluene [$(NO_2)_2C_6H_3CH_3$], a yellow crystalline compound, is manufactured as a co-product with the 2,6-isomer by nitration of nitrotoluene. It melts at 71°C. 2,4-dinitrotoluene is insoluble in water (0.27 g/l at 22°C) and soluble in a number of organic solvents. Production data for the 2,4-isomer alone are not available. The 2,4-and 2,6-isomers are manufactured in an 80:20 or 65:35 ratio, depending on the process used. Annual U.S. commercial production is about 150,000 tons of the two isomers. Unspecified amounts are produced by the U.S. government and further nitrated to trinitrotoluene (TNT) for military use.

The major use of the dinitrotoluene mixture is for production of toluene diisocyanate used to make polyurethanes. Another use is in production of dyestuffs.

The toxic effect of 2,4-dinitrotoluene in humans is primarily methemoglobinemia (a blood condition hindering oxygen transport by the blood). Symptoms depend on severity of the disease, but include cyanosis, dizziness, pain in joints, headache, and loss of appetite in workers inhaling the compound. Laboratory animals, fed oral doses of 2,4-dinitrotoluene, exhibited many of the same symptoms. Aside from the effects in red blood cells, effects are observed in the nervous system and testes.

Chronic exposure to 2,4-dinitrotoluene may produce liver damage and reversible anemia. No data were found on teratogenicity of this compound. Mutagenic data are limited and are regarded as confusing. Data resulting from studies of carcinogenicity of 2,4-dinitrotoluene point to a need for further testing for this property.

For the maximum protection of human health from the potential carcinogenic effects of exposure to 2,4-dinitrotoluene, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of 2,4-dinitrotoluene estimated to result in additional lifetime cancer risk at risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 0.0074 mg/l, 0.074 mg/l, and 0.740 mg/l, respectively.

Data on the behavior of 2,4-dinitrotoluene in POTWs are not available. However, biochemical oxidation of 2,4-dinitrophenol was investigated on a laboratory scale. At 100 mg/l of 2,4-dinitrophenol, a concentration considerably higher than that expected in municipal wastewaters, biochemical oxidation by an acclimated, phenol-adapted seed culture produced 52 percent degradation in three hours. Based on this limited information and general observations relating molecular structure to ease of degradation for all the organic priority pollutants, it was

concluded that biological treatment in POTWs removes 2,4-dinitrotoluene to a high degree or completely. No information is available regarding possible interference by 2,4-dinitrotoluene in POTW treatment processes, or on the possible detrimental effect on sludge used to amend soils in which food crops are grown.

2,6-dinitrotoluene (36). 2,6-dinitrotoluene [$(NO_2)_2C_6H_3CH_3$] is a crystalline solid produced as a co-product with 2,4-dinitrotoluene by nitration of nitrotoluene. It melts at 66°C. No solubility or vapor pressure data are given in the literature, but this compound is expected to be insoluble, just as the 2,4-dinitrotoluene isomer is (0.27 g/l at 22°C). Production data for the 2,6-isomer are not available. The 2,4- and 2,6- isomers are manufactured in an 80:20 or 65:35 ratio depending on the process used. Annual U.S. commercial production is about 150,000 tons of the two isomers. Unspecified amounts are produced by the U.S. government and further nitrated to trinitrotoluene (TNT) for military use.

The major use of the dinitrotoluene mixture is for production of toluene diisocyanate used to make polyurethanes. Another use is in production of dyestuffs.

No toxicity data are available in the literature for 2,6-dinitrotoluene. The 2,4-isomer is toxic and is classed as a potential carcinogen on the basis of tumerogenic effects and other considerations. No water quality criterion has been established for 2,6-dinitrotoluene.

Data on the behavior of 2,6-dinitrotoluene in POTWs are not available. Biochemical oxidation of many of the organic priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained by most municipal wastewaters. General observations have been developed relating molecular structure to ease of degradataion for all the organic priority pollutants. Based on a study of the limited data, it is expected that 2,6-dinitrotoluene will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in a POTW. No information is available regarding possible interference by 2,6-dinitrotoluene in POTW processes, or the possible detrimental effects on sludge used to amend soils in which crops are grown.

Ethylbenzene(38). Ethylbenzene is a colorless, flammable liquid manufactured commercially from benzene and ethylene. Approximately half of the benzene used in the U.S. goes into the manufacture of more than three million tons of ethylbenzene annually. Ethylbenzene boils at 136°C (277°F) and has a vapor

pressure of 7 mm Hg at 20°C. It is slightly soluble in water (0.14 g/l at 15°C) and is very soluble in organic solvents.

About 98 percent of the ethylbenzene produced in the U.S. goes into the production of styrene, much of which is used in the plastics and synthetic rubber industries. Ethylbenzene is a constituent of xylene mixtures used as dilutents in the paint industry, agricultural insecticide sprays, and gasoline blends.

Although humans are exposed to ethylbenzene from a variety of sources in the environment, little information on effects of ethylbenzene in man or animals is available. Inhalation can irritate eyes, affect the respiratory tract, or cause vertigo. In laboratory animals, ethylbenzene exhibited low toxicity. There are no data available on teratogenicity, mutagenicity, or carcinogenicity of ethylbenzene.

Criteria are based on data derived from inhalation exposure limits. For the protection of human health from the toxic properties of ethylbenzene, ingested through water and contaminated aquatic organisms, the ambient water quality criterion is 1.4 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 3.28 mg/l. Available data show that at concentrations of 0.43 mg/l, adverse effects on aquatic life occur.

The behavior of ethylbenzene in POTWs has not been studied in detail. Laboratory scale studies of the biochemical oxidation of ethylbenzene at concentrations greater than would normally be found in municipal wastewaters have demonstrated varying degrees of degradation. In one study with phenol-acclimated seed cultures, 27 percent degradation was observed in a half day at 250 mg/l ethylbenzene. Another study, at unspecified conditions, showed 32, 38, and 45 percent degradation after 5, 10, and 20 days, respectively. Based on these results and general observations relating molecular structure to ease of degradation, it is expected that ethylbenzene will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

An EPA study of seven POTWs showed removals of 77 to 100 percent in five POTWs having influent ethyl benzene concentrations of 10 to 44 x 10^{-3} mg/l. The other two POTWs had influent concentrations of 2 x 10^{-3} mg/l or less. Other studies suggest that most of the ethylbenzene entering a POTW is removed from the aqueous stream to the sludge. The ethylbenzene contained in the sludge removed from the POTW may volatilize.

Fluoranthene(39). Fluoranthene (1,2-benzacenaphthene) is one of the compounds called polynuclear aromatic hydrocarbons (PAH). A pale yellow solid at room temperature, it melts at 111°C (232°F) and has a negligible vapor pressure at 25°C. Water solubility is low (0.2 mg/l). Its molecular formula is $C_{16}H_{10}$.

Fluoranthene, along with many other PAHs, is found throughout the environment. It is produced by pyrolytic processing of organic raw materials, such as coal and petroleum, at high temperature (coking processes). It occurs naturally as a product of plant biosynthesis. Cigarette smoke contains fluoranthene. Although it is not used as the pure compound in industry, it has been found at relatively higher concentrations (0.002 mg/l) than most other PAHs in at least one industrial effluent. Furthermore, in a 1977 EPA survey to determine levels of PAH in U.S. drinking water supplies, none of the 110 samples analyzed showed any PAH other than fluoranthene.

Experiments with laboratory animals indicate that fluoranthene presents a relatively low degree of toxic potential from acute exposure, including oral administration. Where death occured, no information was reported concerning target organs or the specific cause of death.

There is no epidemiological evidence to prove that PAHs in general, and fluoranthene, in particular, present in drinking water are related to the development of cancer. The only studies directed toward determining carcinogenicity of fluoranthene have been skin tests on laboratory animals. Results of these tests show that fluoranthene has no activity as a complete carcinogen (i.e., an agent which produces cancer when applied by itself), but exhibits significant cocarcinogenicity (i.e., in combination with a carcinogen, it increases the carcinogenic activity).

Based on the limited animal study data, and following an established procedure, the ambient water criterion for fluoranthene, through water and contaminated aquatic organisms, is determined to be 0.042 mg/l for the protection of human health from its toxic properties. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 0.054 mg/l. Available data show that adverse effects on aquatic life occur at concentrations of 0.016 mg/l.

Results of studies of the behavior of fluoranthene, in conventional sewage treatment processes found in POTWs, have been published. Removal of fluoranthene during primary sedimentation was found to be 62 to 66 percent (from an initial value of 0.00323 to 0.0435 mg/l to a final value of 0.00122 to 0.0146

mg/l), and the removal was 91 to 99 percent (final values of 0.00028 to 0.00026 mg/l) after biological purification with activated sludge processes.

A review was made of data on biochemical oxidation of many of the organic priority pollutants investigated in laboratory scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment produces little or no degradation of fluoranthene. The same study however concludes that fluoranthene would be readily removed by filtration and oil water separation and other methods which rely on water insolubility, or adsorption on other particulate surfaces. This latter conclusion is supported by the previously cited study showing significant removal by primary sedimentation.

No studies were found to give data on either the possible interference of fluoranthene with POTW operations, or the persistence of fluoranthene in sludges on POTW effluent waters. Several studies have documented the ubiquity of fluoranthene in the environment, and it cannot be readily determined if this results from persistence of anthropogenic fluoranthene or the replacement of degraded fluoranthene by natural processes such as biosynthesis in plants.

Bis(2-chloroethyoxy)methane (43). Bis(2-chloroethoxy) methane [$CH_2(OCH_2CH_2Cl)_2$] is a colorless liquid. It boils at 218.1°C (424°F), flashes at 110°C (230°F), and has a vapor pressure of 1 mm Hg at 53°C. Slightly soluble in water, this chemical is decomposed by mineral acids. This chemical is used as a solvent and as an intermediate for polysulfide rubber.

The available data indicate that this pollutant is acutely toxic to freshwater aquatic life at concentrations as low as 0.36 mg/l, and that chronic toxicity occurs at concentrations as low as 0.122 mg/l. No data are available to determine acute or chronic toxicity levels for saltwater aquatic life.

With respect to human health effects, a satisfactory criterion cannot be derived at this time, due to the insufficiency in the available data.

Concerning treatment in POTWs, laboratory studies have shown that this pollutant is only moderately amenable to treatment via biochemical oxidation. It should be noted, however, that the optimum estimated 30-day average treated effluent concentration

of 0.10 mg/l is greater than the level at which this contaminant was found in any foundry process wastewater.

Methylene chloride(44). Methylene chloride, also called dichloromethane (CH_2Cl_2), is a colorless liquid manufactured by chlorination of methane or methyl chloride followed by separation from the higher chlorinated methanes formed as co-products. Methylene chloride boils at 40°C, and has a vapor pressure of 362 mm Hg at 20°C. It is slightly soluble in water (20 g/l at 20PC), and very soluble in organic solvents. U.S. annual production is about 250,000 tons.

Methylene chloride is a common industrial solvent found in insecticides, metal cleaners, paint, and paint and varnish removers.

Methylene chloride is not generally regarded as being highly toxic to humans. Most human toxicity data are for exposure by inhalation. Inhaled methylene chloride acts as a central nervous system depressant. There is also evidence that the compound causes heart failure when large amounts are inhaled.

Methylene chloride does produce mutation in tests for this effect. In addition, a bioassay recognized for its extremely high sensitivity to strong and weak carcinogens, produced results which were marginally significant. Thus, potential carcinogenic effects of methylene chloride are not confirmed or denied, but are under continuous study. Difficulty in conducting tests and interpreting data results from the low boiling point (40°C) of methylene chloride. This increases the difficulty of maintaining the compound in growth media during incubation at 37°C. In addition, it is difficult to remove all impurities, some of which might themselves be carcinogenic.

For the protection of human health from the toxic properties of methylene chloride, ingested through water and contaminated aquatic organisms, the ambient water criterion is 0.002 mg/l.

The behavior of methylene chloride in POTWs has not been studied in any detail. However, the biochemical oxidation of this compound was studied in one laboratory scale study at concentrations higher than those expected to be contained by most municipal wastewaters. After five days, no degradation of methylene chloride was observed. The conclusion reached is that biological treatment produces litte or no removal by degradation of methylene chloride in POTWs.

The high vapor pressure of methylene chloride is expected to result in volatilization of the compound from aerobic treatment

steps in POTWs. It has been reported that methylene chloride inhibits anaerobic processes in POTWs. Any methylene chloride that is not volatilized in the POTW is expected to pass through into the effluent.

Methyl chloride (45). Methyl chloride (CH_3Cl) is a colorless, noncorrosive liquifiable gas which is transparent in both the gaseous and liquid states. It has a faintly sweet, ethereal odor. It boils at -23.7°C (-11°F). It is slightly soluble in water (by which it is decomposed) and soluble in alcohol, chloroform, benzene, carbon tetrachloride, and glacial acetic acid. It is derived by: (a) the chlorination of methane; and, (b) the action of hydrochloric acid on methanol, either in vapor or liquid phase. It is used as an extractant and solvent, as a pesticide, in the synthesis of organic chemicals, and in silicones.

The available data for this pollutant indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 11.0 mg/l. No data are available concerning this pollutant's chronic toxicity to sensitive freshwater aquatic life. The available data for this pollutant indicate that acute and chronic toxicities to saltwater aquatic life occur at concentrations as low as 12.0 mg/l and 6.40 mg/l respectively. With respect to saltwater aquatic life, a decrease in algal cell numbers was found to occur at concentrations as low as 11.5 mg/l.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0019 mg/l, 0.00019 mg/l, and 0.000019 mg/l respectively.

Concerning treatment in POTWs, laboratory studies have shown that methyl chloride is not amenable to treatment via biochemical oxidation. It should be noted that the optimum treated effluent level of 0.100 mg/l is greater than the levels at which this pollutant was found in any foundry sampled.

Bromoform (47). Bromoform ($CHBr_3$) is a colorless, heavy liquid whose odor and taste are similar to those of chloroform. It is soluble in alcohol, ether, chloroform, benzene, solvent naphtha, and fixed and volatile oils, while being only slightly soluble in water. It melts at 9°C (48°F), boils at 151°C (304°F) and has a vapor pressure of 5 mm Hg of 22°C. This chemical is derived from the heating of acetone or ethyl alcohol with bromine and alkali hydroxide, with recovery by distillation. This product is used

as an intermediate in organic synthesis and as a solvent for waxes, greases and oils.

Available freshwater data indicate that acute toxicity occurs at concentrations as low as 11 mg/l. No data are available concerning chronic toxicity to sensitive freshwater aquatic life. The available data indicate that acute and chronic toxicity to saltwater aquatic life occur at concentrations as low as 12.0 mg/l and 6.4 mg/l respectively.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to bromoform, through contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risk at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0019 mg/l, 0.00019 mg/l, and 0.000019 mg/l respectively.

With respect to treatment in POTWs, laboratory studies have shown that bromoform is not amenable to treatment incorporating biochemical oxidation.

Dichlorobromomethane (48). Dichlorobromomethane ($CHCl_2Br$) is a colorless liquid which boils at 90.1°C (194°F). No solubility data was available for this chemical. This chemical is used as an additive in certain organic synthesis processes.

Available freshwater data indicate that acute toxicity occurs at concentrations as low as 11 mg/l. No data are available concerning chronic toxicity to sensitive freshwater aquatic life. The available data indicate that acute and chronic toxicities to saltwater aquatic life occur at concentrations as low as 12.0 mg/l and 6.4 mg/l respectively.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to dichlorobromomethane, through contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risk at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0019 mg/l, 0.00019 mg/l, and 0.000019 mg/l respectively.

With respect to treatment in POTWs, laboratory studies indicate that this pollutant is not amenable to treatment via biochemical oxidation.

Trichlorofluoromethane (49). Trichlorofluoromethane (CCl_3F) is a colorless, nearly odorless, volatile liquid. It boils at 23.7°C (75°F) and has a vapor pressure of 760 mm Hg at 23.7°C. It is

derived from the reaction of carbon tetrachloride and hydrogen fluoride in the presence of fluorinating agents such as antimony tri- and penta-fluoride. It is used as a solvent and chemical intermediate.

The available data for this pollutant indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 11.0 mg/l. No data are available concerning this pollutant's chronic toxicity to sensitive freshwater aquatic life. The available data for this pollutant indicate that acute and chronic toxicities to saltwater aquatic life occur at concentrations as low as 12.0 mg/l and 6.40 mg/l respectively. With respect to saltwater aquatic life, a decrease in algal cell numbers was found to occur at concentrations as low as 11.5 mg/l.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0019 mg/l, 0.00019 mg/l, and 0.000019 mg/l respectively.

With respect to treatment in POTWs, laboratory studies have indicated that this pollutant is not amenable to treatment via biochemical oxidation.

Chlorodibromomethane (51). Chlorodibromomethane ($CHBr_2Cl$) is a clear, colorless, heavy liquid. It boils at 116°C (241°F). This pollutant is used in the synthesis of various organic compounds.

The available data for this pollutant indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 11.0 mg/l. No data are available concerning this pollutant's chronic toxicity to sensitive freshwater aquatic life. The available data for this pollutant indicate that acute and chronic toxicities to saltwater aquatic life occur at concentrations as low as 12.0 mg/l and 6.40 mg/l respectively. With respect to saltwater aquatic life, a decrease in algal cell numbers was found to occur at concentrations as low as 11.5 mg/l.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, 10^{-7} are 0.0019 mg/l, 0.00019 mg/l, and 0.000019 mg/l respectively.

With respect to treatment in POTWs, laboratory studies indicate that this pollutant is not amenable to treatment via biochemical oxidation. It should be noted that the optimum expected treated effluent level of 0.100 mg/l for this pollutant is greater than the level at which this pollutant was found in any foundry sampled.

Isophorone(54). Isophorone is an industrial chemical produced at a level of tens of millions of pounds annually in the U.S. The chemical name for isophorone is 3,5,5-trimethy2-cyclo-hexene-1-one and it is also known as trimethyl cyclohexanone and isoacetophorone. The formula is $C_6H_5(CH_3)_3O$. Normally, it is produced as the gamma-isomer; technical grades contain about 3 percent of the beta-isomer (3,5-5-trimethyl-3-cyclohexen-1-one). The pure gamma-isomer is a water-white liquid, with vapor pressure less than 1 mm Hg at room temperature, and a boiling point of 215.2°C. It has a camphor- or peppermint-like odor and yellows upon standing. It is slightly soluble (12 mg/l) in water and dissolves in fats and oils.

Isophorone is synthesized from acetone and is used commercially as a solvent or co-solvent for finishes, lacquers, polyvinyl and nitrocellulose resins, pesticides, herbicides, fats, oils, and gums. It is also used as a chemical feedstock.

Because isophorone is an industrially used solvent, most toxicity data are for inhalation exposure. Oral administration to laboratory animals in two different studies revealed no acute or chronic effects during 90 days, and no hematological or pathological abnormalities were reported. Apparently, no studies have been completed on the carcinogenicity of isophorone.

Isophorone does undergo bioconcentration in the lipids of aquatic organisms and fish.

Based on subacute data, the ambient water quality criterion for isophorone, ingested through consumption of water and fish, is set at 460 mg/l for the protection of human health from its toxic properties.

Studies of the effects of isophorone on fish and aquatic organisms reveal relatively low toxicity, compared to some other priority pollutants.

The behavior of isophorone in POTWs has not been studied. However, the biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular

structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by the study of the limited data is that biochemical treatment in POTWs produces moderate removal of isophorone. This conclusion is consistent with the findings of an experimental study of microbiological degradation of isophorone which showed about 45 percent bio-oxidation in 15 to 20 days in domestic wastewater, but only 9 percent in salt water. No data were found on the persistence of isophorone in sewage sludge.

Naphthalene(55). Naphthalene is an aromatic hydrocarbon with two orthocondensed benzene rings and a molecular formula of $C_{10}H_8$. As such, it is properly classed as a polynuclear aromatic hydrocarbon (PAH). Pure naphthalene is a white crystalline solid melting at 80°C (176°F). For a solid, it has a relatively high vapor pressure (0.05 mm Hg at 20°C), and moderate water solubility (19 mg/l at 20°C). Naphthalene is the most abundant single component of coal tar. Production is more than a third of a million tons annually in the U.S. About three fourths of the production is used as feedstock for phthalic anhydride manufacture. Most of the remaining production goes into the manufacture of insecticides, dyestuffs, pigments, and pharmaceuticals. Chlorinated and partially hydrogenated naphthalenes are used in some solvent mixtures. Naphthalene is also used as a moth repellent.

Naphthalene, ingested by humans, has reportedly caused vision loss (cataracts), hemolytic anemia, and occasionally, renal disease. These effects of naphthalene ingestion are confirmed by studies on laboratory animals. No carcinogenicity studies are available which can be used to demonstrate carcinogenic activity for naphthalene. Naphthalene does bioconcentrate in aquatic organisms.

The available data base is insufficient to establish an ambient water criterion for the protection of human health from the toxic properties of naphthalene. Available data show that adverse effects in aquatic life occur at concentrations as low as 0.62 mg/l.

Only a limited number of studies have been conducted to determine the effects of naphthalene on aquatic organisms. The data from those studies show only moderate toxicity.

Naphthalene has been detected in sewage plant effluents at concentrations up to 22 µg/l in studies carried out by the U.S. EPA. Influent levels were not reported. The behavior of naphthalene in POTWs has not been studied. However, recent studies have determined that naphthalene will accumulate in

sediments at 100 times the concentration in overlying water. These results suggest that naphthalene will be readily removed by primary and secondary settling in POTWs, if it is not biologically degraded.

Biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory scale studies at concentrations higher than would normally be expected in municipal wastewater. General observations relating molecular structure to ease of degradation have been developed for all of these pollutants. The conclusion reached by study of the limited data is that biological treatment produces a high removal by degradation of naphthalene. One recent study has shown that microorganisms can degrade naphthalene, first to a dihydro compound, and ultimately to carbon dioxide and water.

Nitrobenzene (56). Nitrobenzene ($C_6H_5NO_2$), also called nitrobenzol and oil of mirbane, is a pale yellow, oily liquid, manufactured by reacting benzene with nitric acid and sulfuric acid. Nitrobenzene boils at 210°C (410°F) and has a vapor pressure of 0.34 mm Hg at 25°C. It is slightly soluble in water (1.9 g/l at 20°C), and is miscible with most organic solvents. Estimates of annual U.S. production vary widely, ranging from 100 to 350 thousand tons.

Almost the entire volume of nitrobenzene produced (97 percent) is converted to aniline, which is used in dyes, rubber, and medicinals. Other uses for nitrobenzene include: solvent for organic synthesis, metal polish, shoe polish, and perfume.

The toxic effects of ingested or inhaled nitrobenzene in humans are related to its action in blood: methemoglobinemia and cyanosis. Nitrobenzene administered orally to laboratory animals caused degeneration of heart, kidney, and liver tissue; paralysis; and death. Nitrobenzene has also exhibited teratogenicity in laboratory animals, but studies conducted to determine mutagenicity or carcinogenicity did not reveal either of these properties.

For the prevention of adverse effects due to the organoleptic properties of nitrobenzene in water, the criterion is 0.030 mg/l.

Data on the behavior of nitrobenzene in POTWs are not available. However, laboratory scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewaters. Biochemical oxidation produced no degradation after 5, 10, and 20 days. A second study also reported no degradation after 28 hours, using an acclimated, phenol-adapted seed culture with nitrobenzene at 100 mg/l. Based

on these limited data, and on general observations relating molecular structure to ease of biological oxidation, it is concluded that little or no removal of nitrobenzene occurs during biological treatment in POTWs. The low water solubility and low vapor pressure of nitrobenzene lead to the expectation that nitrobenzene will be removed from POTWs in the effluent and by volatilization during aerobic treatment.

2-nitrophenol (57). 2-nitrophenol ($NO_2C_6H_4OH$), also called ortho-nitrophenol, is a light yellow crystalline solid, manufactured commercially by hydrolysis of 2-chloro-nitrobenzene with aqueous sodium hydroxide. 2-nitrophenol melts at 45°C (113°F) and has a vapor pressure of 1 mm Hg at 49°C. 2-nitrophenol is slightly soluble in water (2.1 g/l at 20°C) and soluble in organic solvents. This phenol does not react to give a color with 4-aminoantipyrene, and therefore does not contribute to the non-conventional pollutant parameter "Total Phenols." U.S. annual production is five thousand to eight thousand tons.

The principle use of ortho-nitrophenol is to synthesize ortho-aminophenol, ortho-nitroanisole, and other dyestuff intermediates.

The toxic effects of 2-nitrophenol on humans have not been extensively studied. Data from experiments with laboratory animals indicate that exposure to this compound causes kidney and liver damage. Other studies indicate that the compound acts directly on cell membranes, and inhibits certain enzyme systems in vitro. No information regarding potential teratogenicity was found. Available data indicate that this compound does not pose a mutagenic hazard to humans. Very limited data for 2-nitrophenol do not reveal potential carcinogenic effects.

The available data base is insufficient to establish an ambient water criterion for the protection of human health from exposure to 2-nitrophenol. No data are available on which to evaluate the adverse effects of 2-nitrophenol on aquatic life.

Data on the behavior of 2-nitrophenol in POTWs were not available. However, laboratory scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewater. Biochemical oxidation using adapted cultures from various sources produced 95 percent degradation in three to six days in one study. Similar results were reported for other studies. Based on these data, and on general observations relating molecular structure to ease of biological oxidation, it is expected that 2-nitrophenol will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

4-nitrophenol (58). 4-nitrophenol ($NO_2C_6H_4OH$), also called para-nitrophenol, is a colorless to yellowish crystalline solid manufactured commercially by hydrolysis of 4-chloro-nitrobenzene with aqueous sodium hydroxide. 4-nitrophenol melts at 114°C (237°F). Vapor pressure is not cited in the usual sources. 4-nitrophenol is slightly soluble in water (15 g/l at 25°C) and soluble in organic solvents. This phenol does not react to give a color with 4-aminoantipyrene, and therefore does not contribute to the non-conventional pollutant parameter "Total Phenols." U.S. annual production is about 20,000 tons.

Para-nitrophenol is used to prepare phenetidine, aceta-phene-ti-dine, azo and sulfur dyes, photochemicals, and pesticides.

The toxic effects of 4-nitrophenol on humans have not been extensively studied. Data from experiments with laboratory animals indicate that exposure to this compound results in methemoglobinemia (a metabolic disorder of blood), shortness of breath, and stimulation followed by depression. Other studies indicate that the compound acts directly on cell membranes, and inhibits certain enzyme systems in vitro. No information regarding potential teratogenicity was found. Available data indicate that this compound does not pose a mutagenic hazard to humans. Very limited data for 4-nitrophenol do not reveal potential carcinogenic effects, although the compound has been selected by the national cancer institute for testing under the Carcinogenic Bioassay Program.

No U.S. standards for exposure to 4-nitrophenol in ambient water have been established.

Data on the behavior of 4 nitrophenol in POTWs are not available. However, laboratory scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewater. Biochemical oxidation using adapated cultures from various sources produced 95 percent degradation in three to six days in one study. Similar results were reported for other studies. Based on these data, and on general observations relating molecular structure to ease of biological oxidation, it is expected that complete or nearly complete removal of 4-nitrophenol occurs during biological treatment in POTWs.

2,4-dinitrophenol (59). 2,4-dinitrophenol [$(NO_2)_2C_6H_3OH$], a yellow crystalline solid, is manufactured commercially by hydrolysis of 2,4-dinitro-1-chlorobenzene with sodium hydroxide. 2,4-dinitrophenol sublimes at 114°C (237°F). Vapor pressure is not cited in usual sources. It is slightly soluble in water (7.9 g/l at 25°C) and soluble in organic solvents. This phenol does

not react with 4-aminoantipyrene and therefore does not contribute to the non-conventional pollutant parameter "Total Phenols." U.S. annual production is about 500 tons.

2,4-dinitrophenol is used to manufacture sulfur and azo dyes, photochemicals, explosives, and pesticides.

The toxic effects of 2,4-dinitrophenol in humans are generally attributed to this pollutant's ability to uncouple oxidative phosphorylation. In brief, this means that sufficient 2,4-dinitrophenol short-circuits cell metabolism by preventing utilization of energy provided by respiration and glycolosis. Specific symptoms are gastrointestinal disturbances, weakness, dizziness, headache, and loss of weight. More acute poisoning includes symptoms such as: burning thirst, agitation, irregular breathing, and abnormally high fever. This compound also inhibits other enzyme systems; and acts directly on the cell membrane, inhibiting chloride permeability. Ingestion of 2,4-dinitrophenol also causes cataracts in humans.

Based on available data, it appears unlikely that 2,4-dinitrophenol poses a teratogenic hazard to humans. Results of studies of mutagenic activity of this compound are inconclusive as far as humans are concerned. Available data suggest that 2,4-dinitrophenol does not possess carcinogenic properties.

To protect human health from the adverse effects of 2,4-dinitrophenol, ingested in contaminated water and fish, the suggested water quality criterion is 0.0686 mg/l.

Data on the behavior of 2,4-dinitrophenol in POTWs are not available. However, laboratory scale studies have been conducted at concentrations higher than those expected to be found in municipal wastewaters. Biochemical oxidation using a phenol-adapted seed culture produced 92 percent degradation in 3.5 hours. Similar results were reported for other studies. Based on these data, and on general observations relating molecular structure to ease of biological oxidation, it is expected that complete or nearly complete removal of 2,4-dinitrophenol occurs during biological treatment in POTWs.

4,6-dinitro-o-cresol (60). 4,6-dinitro-o-cresol (DNOC) is a yellow crystalline solid derived from o-cresol. DNOC melts at 85.8°C and has a vapor pressure of 0.000052 mm Hg at 20°C. DNOC is sparingly soluble in water (100 mg/l at 20°C), while it is readily soluble in alkaline aqueous solutions, ether, acetone, and alcohol. DNOC is produced by sulfonation of o-cresol followed by treatment with nitric acid.

DNOC is used primarily as a blossom thinning agent on fruit trees and as a fungicide, insecticide and miticide on fruit trees during the dormant season. It is highly toxic to plants in the growing stage. DNOC is not manufactured in the U.S. as an agricultural chemical. Imports of DNOC have been decreasing recently with only 30,000 lbs being imported in 1976.

While DNOC is highly toxic to plants, it is also very toxic to humans and is considered to be one of the more dangerous agricultural pesticides. The available literature concerning humans indicates that DNOC may be absorbed in acutely toxic amounts through the respiratory and gastrointestinal tracts and through the skin, and that it accumulates in the blood. Symptoms of poisoning include profuse sweating, thirst, loss of weight, headache, malaise, and yellow staining to the skin, hair, sclera, and conjunctiva.

There is no evidence to suggest that DNOC is teratogenic, mutagenic, or carcinogenic. The effects of DNOC in the human due to chronic exposure are basically the same as those effects resulting from acute exposure. Although DNOC is considered a cumulative poison in humans, cataract formation is the only chronic effect noted in any human or experimental animal study. It is believed that DNOC accumulates in the human body, and that toxic symptoms may develop when blood levels exceed 20 mg/kg.

For the protection of human health from the toxic properties of dinitro-o-cresol, ingested through water and contaminated aquatic organisms, the ambient water criterion is determined to be 0.0134 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is determined to be 0.765 mg/l. No data are available concerning the adverse effects of 4,6-dinitro-o-cresol on aquatic life.

Some studies have been reported regarding the behavior of DNOC in POTWs. Biochemical oxidation of DNOC under laboratory conditions at a concentration of 100 mg/l produced 22 percent degradation in 3.5 hours, using acclimated phenol adapted seed cultures. In addition, the nitro group in the number 4 (para) position seems to impart a destabilizing effect on the molecule. Based on these data and general conclusions relating molecular structure to biochemical oxidation, it is expected that 4,6-dinitro-o-cresol will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

N-nitrosodiphenylamine (62). N-nitrosodiphenylamine [$(C_6H_5)_2NNO$], also called nitrous diphenylamide, is a yellow crystalline solid manufactured by nitrosation of diphenylamine. It melts at 66°C (151°F) and is insoluble in water, but soluble in several organic

solvents other than hydrocarbons. Production in the U.S. has approached 1500 tons per year. The compound is used as a retarder for rubber vulcanization and as a pesticide for control of scorch (a fungus disease of plants).

N-nitroso compounds are acutely toxic to every animal species tested and are also poisonous to humans. N-nitrosodiphenylamine toxicity in adult rats lies in the midrange of the values for 60 N-nitroso compounds tested. Liver damage is the principal toxic effect. N-nitrosodiphenylamine, unlike many other N-nitrosoamines, does not show mutagenic activity. N-nitrosodiphenylamine has been reported by several investigations to be non-carcinogenic. However, the compound is capable of trans-nitrosation and could thereby convert other amines to carcinogenic N-nitrosoamines. Sixty-seven of 87 N-nitrosoamines studied were reported to have carcinogenic activity. No water quality criterion has been proposed for N-nitrosodiphenylamine.

No data are available on the behavior of N-nitrosodiphenylamine in POTWs. Biochemical oxidation of many of the organic priority pollutants has been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained in most municipal wastewaters. General observations have been developed relating molecular structure to ease of degradation for all the organic priority pollutants. The conclusion reached by study of the limited data is that biological treatment produces little or no removal of N-nitrosodiphenylamine in POTWs. No information is available regarding possible interference by N-nitrosodiphenylamine in POTW processes, or on the possible detrimental effects on sludge used to amend soils in which crops are grown. However, no interference or detrimental effects are expected, because N-nitroso compounds are widely distributed in the soil and water environment, at low concentrations, as a result of microbial action on nitrates and nitrosatable compounds.

N-nitrosodi-n-propylamine (63). No physical properties or usage data could be found for this pollutant. It can be formed from the interaction of nitrite with secondary and tertiary amines.

The available data for this pollutant indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 5.85 mg/l. No data are available concerning this pollutant's chronic toxicity to freshwater and saltwater aquatic life. The available data indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 3,300 mg/l.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.00016 mg/l, 0.000016 mg/l, and 0.0000016 mg/l respectively.

With respect to treatment in POTWs, laboratory studies indicate that this pollutant is not amenable to treatment via biochemical oxidation.

Pentachlorophenol(64). Pentachlorophenol (C_6Cl_5OH) is a white crystalline solid produced commercially by chlorination of phenol or polychlorophenols. U.S. annual production is in excess of 20,000 tons. Pentachlorophenol melts at 190°C (374°F) and is slightly soluble in water (14 mg/l). Pentachlorophenol is not detected by the 4-aminoantipyrene method.

Pentachlorophenol is a bactericide and fungicide and is used for the preservation of wood and wood products. It is competitive with creosote in that application. It is also used as a preservative in glues, starches, and photographic papers. It is an effective algicide and herbicide.

Although data are available on the human toxicity effects of pentachlorophenol, interpretation of data is frequently uncertain. Occupational exposure observations must be examined carefully, because exposure to pentachlorophenol is frequently accompanied by exposure to other wood preservatives. Additionally, experimental results and occupational exposure observations must be examined carefully, to make sure that observed effects are produced by the pentachlorophenol itself and not by the by-products which usually contaminate pentachlorophenol.

Acute and chronic toxic effects of pentachlorophenol in humans are similar; muscle weakness, headache, loss of appetite, abdominal pain, weight loss, and irritation of skin, eyes, and respiratory tract. Available literature indicates that pentachlorophenol does not accumulate in body tissues to any significant extent. Studies on laboratory animals of distribution of the compound in body tissues showed the highest levels of pentachlorophenol in liver, kidney, and intestine, while the lowest levels were in brain, fat, muscle, and bone.

Toxic effects of pentachlorophenol in aquatic organisms are much greater at a pH of 6, where this weak acid is predominately in the undissociated form than at a pH of 9, where the ionic form

predominates. Similar results were observed in mammals, where oral lethal doses of pentachlorophenol were lower when the compound was administered in hydrocarbon solvents (un-ionized form) than when it was administered as the sodium salt (ionized form) in water.

There appear to be no significant teratogenic, mutagenic, or carcinogenic effects of pentachlorophenol.

For the protection of human health from the toxic properties of pentachlorophenol, ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 1.01 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is determined to be 29.4 mg/l. Available data show that adverse effects on aquatic life occur at concentrations as low as 0.0032 mg/l.

Only limited data are available for reaching conclusions about the behavior of pentachlorophenol in POTWs. Pentachlorophenol has been found in the influent to POTWs. In a study of one POTW, the mean removal was 59 percent over a 7 day period. Trickling filters removed 44 percent of the influent pentachlorophenol, suggesting that biological degradation occurs. The same report compared removal of pentachlorophenol at the same plant and two additional POTWs on a later date, and obtained values of 4.4, 19.5 and 28.6 percent removal, the last value being for the plant which achieved 59 percent removal in the original study. Influent concentrations of pentachlorophenol ranged from 0.0014 to 0.0046 mg/l. Other studies, including the general review of data relating molecular structure to biological oxidation, indicate that pentachlorophenol is not removed by biological treatment processes in POTWs. Anaerobic digestion processes are inhibited by 0.4 mg/l of pentachlorophenol.

The low water solubility and low volatility of pentachlorophenol lead to the expectation that most of the compund will remain in the sludge in a POTW. The effect on plants grown on land treated with sludge containing pentachlorophenol is unpredictable. Laboratory studies show that this compound affects crop germination at 5.4 mg/l. However, photodecomposition of pentachlorophenol occurs in sunlight. The effects of the various breakdown products which may remain in the soil were not found in the literature.

Phenol(65). Phenol, also called hydroxybenzene and carbolic acid, is a clear, colorless, hygroscopic, deliquescent, crystalline solid at room temperature. Its melting point is 43°C (109°F) and its vapor pressure at room temperature is 0.35 mm Hg.

It is very soluble in water (67 gm/l at 16°C) and can be dissolved in benzene, oils, and petroleum solids. Its formula is C_6H_5OH.

Although a small percent of the annual production of phenol is derived from coal tar as a naturally occuring product, most of the phenol is synthesized. Two of the methods are fusion of benzene sulfonate with sodium hydroxide, and oxidation of cumene followed by cleavage with a catalyst. Annual production in the U.S. is in excess of one million tons. Phenol is generated during the distillation of wood and the microbiological decomposition of organic matter in the mammalian intestinal tract.

Phenol is used as a disinfectant, in the manufacture of resins, dyestuffs, and pharmaceuticals, and in the photo processing industry. In this discussion, phenol is the specific compound which is separated by methylene chloride extraction of an acidified sample and identified and quantified by GC/MS. Phenol also contributes to the pollutant "Total Phenols", discussed elsewhere, which are determined by the 4-AAP colorimetric method.

Phenol exhibits acute and sub-acute toxicity in humans and laboratory animals. Acute oral doses of phenol in humans cause sudden collapse and unconsciousness due to the action of phenol on the central nervous system. Death occurs by respiratory arrest. Sub-acute oral doses in mammals are rapidly absorbed, then quickly distributed to various organs, then cleared from the body by urinary excretion and metabolism. Long term exposure, by drinking phenol contaminated water, has resulted in statistically significant increases in reported cases of diarrhea, mouth sores, and burning of the mouth. In laboratory animals, long term oral administration at low levels produced slight liver and kidney damage. No reports were found regarding carcinogenicity of phenol administered orally - all carcinogenicity studies involved skin tests.

For the protection of human health from phenol ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 3.5 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 769 mg/l. Available data show that adverse effects in aquatic life occur at concentrations as low as 2.56 mg/l.

Data have been developed on the behavior of phenol in POTWs. Phenol is biodegradable by biota present in POTWs. The ability of a POTW to treat phenol-bearing influents depends upon acclimation of the biota and the constancy of the phenol

concentration. It appears that an induction period is required to build up the population of organisms which can degrade phenol. Too large a concentration will result in upset or pass through in the POTW, but the specific level causing upset depends on the immediate past history of phenol concentrations in the influent. Phenol levels as high as 200 mg/l have been treated with 95 percent removal in POTWs, but more or less continuous presence of phenol is necessary to maintain the population of microorganisms that degrade phenol.

Phenol which is not degraded is expected to pass thorugh the POTW because of its very high water solubility. However, in POTWs where chlorination is practiced for disinfection of the POTW effluent, chlorination of phenol may occur. The products of that reaction may be priority pollutants.

The EPA has developed data on influent and effluent concentrations of total phenols in a study of 103 POTWs. However, the analytical procedure was the 4-AAP method mentioned earlier, and not the GC/MS method specifically for phenol. Discussion of the study, which of course includes phenol, is presented under the pollutant heading "Total Phenols."

Phthalate Esters (66-71). Phthalic acid, or 1,2-benzenedicarboxylic acid, is one of three isomeric benzenedicarboxylic acids produced by the chemical industry. The other two isomeric forms are called isophthalic and terephathalic acids. The formula for all three acids is $C_6H_4(COOH)_2$. Some esters of phthalic acid are designated as priority pollutants. They will be discussed as a group here, and specific properties of individual phthalate esters will be discussed afterwards.

Phthalic acid esters are manufactured in the U.S. at an annual rate in excess of 1 billion pounds. They are used as plasticizers - primarily in the production of polyvinyl chloride (PVC) resins. The most widely used phthalate plasticizer is bis (2-ethylhexyl) phthalate (66) which accounts for nearly one third of the phthalate esters produced. This particular ester is commonly referred to as dioctyl phthalate (DOP) and should not be confused with one of the less used esters, di-n-octyl phthalate (69), which is also used as a plastcizer. In addition to these two isomeric dioctyl phthalates, four other esters, also used primarily as plasticizers, are designated as priority pollutants. They are: butyl benzyl phthalate (67), di-n-butyl phthalate (68), diethyl phthalate (70), and dimethyl phthalate (71).

Industrially, phthalate esters are prepared from phthalic anhydride and the specific alcohol to form the ester. Some evidence is available suggesting that phthalic acid esters also

may be synthesized by certain plant and animal tissues. The extent to which this occurs in nature is not known.

Phthalate esters used as plasticizers can be present in concentrations up to 60 percent of the total weight of the PVC plastic. The plasticizer is not linked by primary chemical bonds to the PVC resin. Rather, it is locked into the structure of intermeshing polymer molecules and held by van der Waals forces. The result is that the plasticizer is easily extracted. Plasticizers are responsible for the odor associated with new plastic toys or flexible sheet that has been contained in a sealed package.

Although the phthalate esters are not soluble, or are only very slightly soluble in water, they do migrate into aqueous solutions placed in contact with the plastic. Thus industrial facilities with tank linings, wire and cable coverings, tubing, and sheet flooring of PVC are expected to discharge some phthalate esters in their raw waste. In addition to their use as plasticizers, phthalate esters are used in lubricating oils and pesticide carriers. These also can contribute to industrial discharge of phthalate esters.

From the accumulated data on acute toxicity in animals, phthalate esters may be considered as having a rather low order of toxicity. Human toxicity data are limited. It is thought that the toxic effects of the esters are most likely due to one of the metabolic products, in particular the monoester. Oral acute toxicity in animals is greater for the lower molecular weight esters than for the higher molecular weight esters.

Orally administered phthalate esters generally produced enlarging of liver and kidney, and atrophy of testes in laboratory animals. Specific esters produced enlargement of heart and brain, spleenitis, and degeneration of central nervous system tissue.

Subacute doses administered orally to laboratory animals produced some decrease in growth and degeneration of the testes. Chronic studies in animals showed similar effects to those found in acute and subacute studies, but to a much lower degree. The same organs were enlarged, but pathological changes were not usually detected.

A recent study of several phthalic esters produced suggestive but not conclusive evidence that dimethyl and diethyl phthalates have a cancer liability. Only four of the six priority pollutant esters were included in the study. Phthalate esters do bioconcentrate in fish. The factors, weighted for relative consumption of various aquatic and marine food groups, are used

to calculate ambient water quality criteria for four phthalate esters. The values are included in the discussion of the specific esters.

Studies of toxicity of phthalate esters in freshwater and salt water organisms are scarce. A chronic toxicity test with bis(2-ethylhexyl) phthalate showed that significant reproductive impairment occurred at 3 mg/l in the freshwater crustacean, Daphnia magna. In acute toxicity studies, saltwater fish and organisms showed sensitivity differences of up to eight-fold to butyl benzyl, diethyl, and dimethyl phthalates. This suggests that each ester must be evaluated individually for toxic effects.

The behavior of phthalate esters in POTWs has not been studied. However, the biochemical oxidation of many of the organic priority pollutants has been investigated in laboratory scale studies at concentrations higher than would normally be expected in municipal wastewater. Three of the phthalate esters were studied. Bis(2-ethylhexyl) phthalate was found to be degraded slightly or not at all, and its removal by biological treatment in a POTW is expected to be slight or zero. Di-n-butyl phthalate and diethyl phthalate were degraded to a moderate degree, and their removal by biological treatment in a POTW is expected to occur to a moderate degree. Based on these data and other observations relating molecular structure to ease of biochemical degradation of other organic pollutants, it is expected that butyl benzyl and dimethyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in a POTW. An EPA study of seven POTWs revealed that for all but di-n-octyl phthalate, which was not studied, removals ranged from 62 to 87 percent.

No informations was found on possible interference with POTW operation or the possible effects on sludge by the phthalate esters. The water insoluble phthalate esters - butyl benzyl and di-n-octyl phthalate - would tend to remain in sludge, whereas the other four priority pollutant phthalate esters with water solubilities ranging from 50 mg/l to 4.5 mg/l would probably pass through into the POTW effluent.

Bis (2-ethylhexyl) phthalate(66). In addition to the general remarks and discussion on phthalate esters, specific information on bis(2-ethylhexyl) phthalate is provided. Little information is available about the physical properties of bis(2-ethylhexyl) phthalate. It is a liquid boiling at 387°C at 5mm Hg and is insoluble in water. Its formula is $C_6H_4(COOC_8H_{17})_2$. This priority pollutant constitutes about one third of the phthalate ester production in the U.S. It is commonly referred to as dioctyl phthalate, or DOP, in the plastics industry, where it is

the most extensively used compound for the plasticization of polyvinyl chloride (PVC). Bis(2-ethylhexyl) phthalate has been approved by the FDA for use in plastics in contact with food. Therefore, it may be found in wastewaters coming in contact with discarded plastic food wrappers as well as the PVC films and shapes normally found in industrial plants. This priority pollutant is also a commonly used organic diffusion pump oil, where its low vapor pressure is an advantage.

For the protection of human health from the toxic properties of bis(2-ethylhexyl) phthalate, ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 15 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is determined to be 50 mg/l.

Although the behavior of bis(2-ethylhexyl) phthalate in POTWs has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewater. In fresh water with a non-acclimated seed culture, no biochemical oxidation was observed after 5, 10, and 20 days. However, with an acclimated seed culture, biological oxidation occurred to the extents of 13, 0, 6, and 23 percent of theoretical oxidation after 5, 10, 15 and 20 days, respectively. Bis(2-ethylhexyl) phthalate concentrations were 3 to 10 mg/l. Little or no removal of bis(2-ethylhexyl) phthalate by biological treatment in POTWs is expected.

Butyl benzyl phthalate(67). In addition to the general remarks and discussion on phthalate esters, specific information on butyl benzyl phthalate is provided. No information was found on the physical properties of this compound.

Butyl benzyl phthalate is used as a plasticizer for PVC. Two special applications differentiate it from other phthalate esters. It is approved by the U.S. FDA for food contact in wrappers and containers; and it is the industry standard for plasticization of vinyl flooring, because it provides stain resistance.

No ambient water quality criterion is proposed for butyl benzyl phthalate.

Butyl benzyl phthalate removal, by biological treatment in a POTW, is expected to occur to a moderate degree.

Di-n-butyl phthalate (68). In addition to the general remarks and discussion on phthalate esters, specific information on

di-n-butyl phthalate (DBP) is provided. DBP is a colorless, oily liquid, boiling at 340°C. Its water solubility at room temperature is reported to be 0.4 g/l and 4.5 g/l in two different chemistry handbooks. The formula for DBP, $C_6H_4(COOC_4H_9)_2$ is the same as for its isomer, di-isobutyl phthalate. DCP production is one to two percent of total U.S. phthalate ester production.

Dibutyl phthalate is used to a limited extent as a plasticizer for polyvinyl chloride (PVC). It is not approved for contact with food. It is used in liquid lipsticks and as a dilutent for polysulfide dental impression materials. DBP is used as a plasticizer for nitrocellulose in making gun powder, and as a fuel in solid propellants for rockets. Further uses are insecticides, safety glass manufacture, textile lubricating agents, printing inks, adhesives, paper coatings and resin solvents.

For protection of human health from the toxic properties of dibutyl phthalate, ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 34 mg/l. If contaminated aquatic organisms are consumed, excluding the consumption of water, the ambient water criterion is 154 mg/l.

Although the behavior of di-n-butyl phthalate in POTWs has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewaters. Biochemical oxidation of 35, 43, and 45 percent of theoretical oxidation were obtained after 5, 10, and 20 days, respectively, using sewage microorganisms as an unacclimated seed culture. Based on these data, it is expected that di-n-butyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs. Biological treatment in POTWs is expected to remove di-n-butyl phthalate to a moderate degree.

Di-n-octyl phthalate(69). In addition to the general remarks and discussion on phthalate esters, specific information on di-n-octyl phthalate is provided. Di-n-octyl phthalate is not to be confused with the isomeric bis(2-ethylhexyl) phthalate which is commonly referred to in the plastics industry as DOP. Di-n-octyl phthalate is a liquid which boils at 220°C at 5 mm Hg. It is insoluble in water. Its molecular formula is $C_6H_4(COOC_8H_{17})_2$. Its production constitutes about one percent of all phthalate ester production in the U.S.

Industrially, di-n-octyl phthalate is used to plasticize polyvinyl chloride (PVC) resins.

No ambient water quality criterion is proposed for di-n-octyl phthalate. Biological treatment in POTW is expected to lead to little or no removal of di-n-octyl phthalate.

Diethyl phthalate (70). In addition to the general remarks and discussion on phthalate esters, specific information on diethyl phthalate is provided. Diethyl phthalate, or DEP, is a colorless liquid boiling at 296°C, and is insoluble in water. Its molecular formula is $C_6H_4(COOC_2H_5)_2$. Production of diethyl phthalate constitutes about 1.5 percent of phthalate ester production in the U.S.

Diethyl phthalate is approved for use in plastic food containers by the U.S. FDA. In addition to its use as a polyvinyl chloride (PVC) plasticizer, DEP is used to plasticize cellulose nitrate for gun powder, to dilute polysulfide dental impression materials, and as an accelerator for dyeing triacetate fibers. An additional use, which would contribute to its wide distribution in the environment, is as an approved special denaturant for ethyl alcohol. The alcohol-containing products, for which DEP is an approved denaturant, include a wide range of personal care items such as bath preparations, bay rum, colognes, hair preparations, face and hand creams, perfumes and toilet soaps. Additionally, this denaturant is approved for use in biocides, cleaning solutions, disinfectants, insecticides, fungicides, and room deodorants which have ethyl alcohol as part of the formulation. It is expected, therefore, that people and buildings would have some surface loading of this priority pollutant which would find its way into raw wastewaters.

For the protection of human health from the toxic properties of diethyl phthalate, ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 350 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 1800 mg/l.

Although the behavior of diethyl phthalate in POTWs has not been studied, biochemical oxidation of this priority pollutant has been studied on a laboratory scale at concentrations higher than would normally be expected in municipal wastewaters. Biochemical oxidation of 79, 84, and 89 percent of theoretical was observed after 5, 5, and 20 days, respectively. Based on these results, it is expected that diethyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

Dimethyl phthalate (71). In addition to the general remarks and discussion on phthalate esters, specific information on dimethyl phthalate (DMP) is provided. DMP has the lowest molecular weight of the phthalate esters - M.W. of 194 compared to M.W. of 391 for bis(2-ethylhexyl)phthalate. DMP has a boiling point of 282°C. It is a colorless liquid, soluble in water to the extent of 5 mg/l. Its molecular formula is $C_6H_4(COOCH_3)_2$.

Dimethyl phthalate production in the U.S. is just under one percent of total phthalate ester production. DMP is used to some extent as a plasticizer in cellulosics. However, its principle specific use is for dispersion of polyvinylidene fluoride (PVDF). PVDF is resistant to most chemicals and finds use as electrical insulation, chemical process equipment (particularly pipe), and as a base for long-life finishes for exterior metal siding. Coil coating techniques are used to apply PVDF dispersions to aluminum or galvanized steel siding.

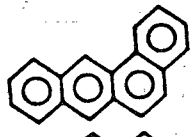
For the protection of human health from the toxic properties of dimethyl phthalate, ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 313 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is 2800 mg/l.

Based on limited data and observations relating molecular structure to ease of biochemical degradation of other organic pollutants, it is expected that dimethyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs.

Polynuclear Aromatic Hydrocarbons(72-84). The polynuclear aromatic hydrocarbons (PAH) selected as priority pollutants are a group of 13 compounds consisting of substituted and unsubstituted polycyclic aromatic rings. The general class of PAHs includes heterocyclics, but none of those were selected as priority pollutants. PAHs are formed as the result of incomplete combustion when organic compounds are burned with insufficient oxygen. PAHs are found in coke oven emissions, vehicular emissions, and volatile products of oil and gas burning. The compounds chosen as priority pollutants are listed with their structural formulas and melting points (m.p.). All are insoluble in water.

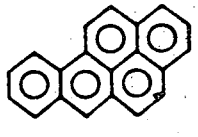
72 Benzo(a)anthracene (1,2-benzanthracene)*

m.p. 162°C (324°F)

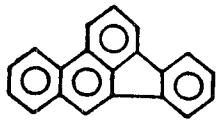


73 Benzo(a)pyrene (3,4-benzopyrene)*

m.p. 176°C (349°F)

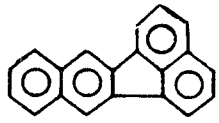


74 3,4-benzofluoranthene*



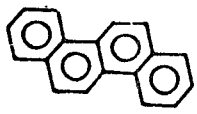
m.p. 168°C (334°F)

75 Benzo(k)fluoranthene (11,12-benzofluoranthene)*



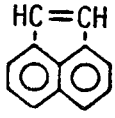
m.p. 217°C (391°F)

76 Chrysene (1,2-benzophenanthrene)*



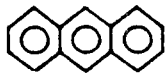
m.p. 255°C (491°F)

77 Acenaphthylene*



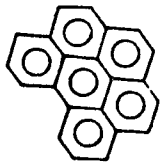
m.p. 92°C (198°F)

78 Anthracene*



m.p. 216°C (421°F)

79 Benzo(ghi)perylene (1,12-benzoperylene)

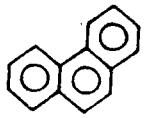


m.p. not reported

80 Fluorene (alpha-diphenylenemethane)*

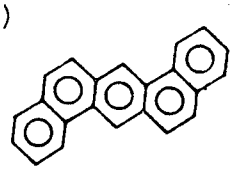
m.p. 116°C (241°F)

81 Phenanthrene*



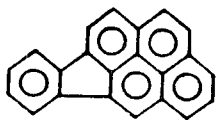
m.p. 101°C (214°F)

82 Dibenzo(a,h)anthracene (1,2,5,6-dibenzoanthracene)



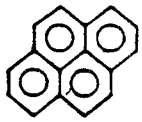
m.p. 269°C (516°F)

83 Indeno(1,2,3-cd)pyrene (2,3-o-phenylenepyrene)



m.p. not available

84 Pyrene*



m.p. 156°C (313°F)

Note: An asterisk indicates that the pollutant is known to be present in metal molding and casting process wastewaters.

Some of these priority pollutants have commercial or industrial uses. Benzo(a)anthracene, benzo(a)pyrene, chrysene, anthracene, dibenzo(a,h)anthracene, and pyrene are all used as antioxidants. Chrysene, acenaphthylene, anthracene, fluorene, phenanthrene, and pyrene are all used for synthesis of dyestuffs or other organic chemicals. 3,4-benzofluoranthrene, benzo(k)fluoranthene, benzo (ghi) perylene, and indeno (1,2,3-cd)pyrene have no known industrial uses, according to the results of a recent literature search.

Several of the PAH priority pollutants are found in smoked meats, in smoke flavoring mixtures, in vegetable oils, and in coffee. They are found in soils and sediments in river beds. Consequently, they are also found in many drinking water supplies. The wide distribution of these pollutants in complex mixtures, with the many other PAHs which have not been designated as priority pollutants, results in exposures by humans that cannot be associated with specific individual compounds.

The screening and verification analysis procedures used for the organic priority pollutants are based on gas chromatography (GC). Three pairs of the PAHs have identical elution times on the column specified in the protocol, which means that the parameters of the pair are not differentiated. For these three pairs [anthracene (78) - phenanthrene (81); 3,4-benzofluoranthene (74) - benzo(k)fluoranthene (75); and benzo(a)anthracene (72) - chrysene (76)] results are obtained and reported as "either-or." Either both are present in the combined concentration reported, or one is present in the concentration reported. When detections below reportable limits are recorded, no further analysis is required. For samples where the concentrations of coeluting pairs have a significant value, additional analyses are conducted, using different procedures that resolve the particular pair.

There are no studies to document the possible carcinogenic risks to humans by direct ingestion. Air pollution studies indicate an excess of lung cancer mortality among workers exposed to large amounts of PAH containing materials such as coal gas, tars, and coke-oven emissions. However, no definite proof exists that the PAH present in these materials are responsible for the cancers observed.

Animal studies have demonstrated the toxicity of PAH by oral and dermal administration. The carcinogenicity of PAH has been

traced to formation of PAH metabolites which, in turn, lead to tumor formation. Because the levels of PAH which induce cancer are very low, little work has been done on other health hazards resulting from exposure. It has been established in animal studies that tissue damage and systemic toxicity can result from exposure to non-carcinogenic PAH compounds.

Because there were no studies available regarding chronic oral exposures to PAH mixtures, proposed water quality criteria were derived using data on exposure to a single compound. Two studies were selected, one involving benzo(a)pyrene ingestion and one involving dibenzo(a,h)anthracene ingestion. Both are known animal carcinogens.

For the maximum protection of human health from the potential carcinogenic effects of exposure to polynuclear aromatic hydrocarbons (PAH), through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of PAH estimated to result in additional lifetime cancer risk of 10^{-7}, 10^{-6}2. and 10^{-5} are 2.8 x 10^{-7} mg/1, 2,8 x 10^{-6} mg/1 and 2.8 x 10^{-5} mg/1 respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 3.11 x 10^{-4} mg/1 to keep the increased lifetime cancer risk below 10^{-5}. Available data show the adverse effects on aquatic life occur at concentrations higher than those cited for human health risk.

The behavior of PAHs in POTWs has received only a limited amount of study. It is reported that up to 90 percent of the PAHs entering a POTW will be retained in the sludge generated by conventional sewage treatment processes. Some of the PAHs can inhibit bacterial growth when they are present at concentrations as low as 0.018 mg/1. Biological treatment in activated sludge units has been shown to reduce the concentration of phenanthrene and anthracene to some extent. However, a study of biochemical oxidation of fluorene on a laboratory scale showed no degradation after 5, 10, and 20 days. On the basis of that study and studies of other organic priority pollutants, some general observations were made relating molecular structure to ease of degradation. Those observations lead to the conclusion that the 13 PAHs selected to represent that group as priority pollutants, will be removed only slightly or not at all by biological treatment methods in POTWs. Based on their water insolubility and tendency to attach to sediment particles, very little pass through of PAHs to POTWs effluents is expected.

For a recent Agency study, Fate of Priority Pollutants in Publicly Owned Treatment Works, the pollutant concentrations in the influent, effluent and sludge of 20 POTWs were measured. The

results show that indeed the PAHs are concentrated in the sludges, and that little or no PAHs are discharged in the effluent of POTWs. The differences in average concentrations from influent to effluent range from 50 to 100 percent removal with all but one PAH above 80 percent removal. The data indicate that all or nearly all of the PAHs are concentrated in the sludge.

No data are available at this time to support any conclusions about PAH contamination of land on which sewage sludge containing PAH is spread.

Tetrachloroethylene(85). Tetrachloroethylene (CCl_2CCl_2), also called perchloroethylene and PCE, is a colorless nonflammable liquid produced mainly by two methods - chlorination and pyrolysis of ethane and propane, and oxychlorination of dichloroethane. U.S. annual production exceeds 300,000 tons. PCE boils at 121°C (250°F) and has a vapor pressure of 19 mm Hg at 20°C. It is insoluble in water but soluble in organic solvents.

Approximately two-thirds of the U.S. production of PCE is used for dry cleaning. Textile processing and metal degreasing, in equal amounts consume about one-quarter of the U.S. production.

The principal toxic effect of PCE on humans is central nervous system depression, when the compound is inhaled. Headache, fatigue, sleepiness, dizziness and sensations of intoxication are reported. Severity of effects increases with vapor concentration. High integrated exposure (concentration times duration) produces kidney and liver damage. Very limited data on PCE ingested by laboratory animals indicate that liver damage occurs when PCE is administered by that route. PCE tends to distribute to fat in mammalian bodies.

One report found in the literature suggests, but does not conclude, that PCE is teratogenic. PCE has been demonstrated to be a liver carcinogen in B6C3F1 mice.

For the maximum protection of human health from the potential carcinogenic effects of exposure to tetrachloroethylene, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of tetrachloroethylene estimated to result in additional lifetime cancer risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 8 x 10^{-5} mg/l, 8 x 10^{-4} mg/l, 8 x 10^{-3}mg/l respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.088 mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data

show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

No data were found regarding the behavior of PCE in POTWs. Many of the organic priority pollutants have been investigated, at least in laboratory scale studies, at concentrations higher than those expected to be contained by most municipal wastewaters. General observations have been developed relating molecular structure to ease of degradation for all of the organic priority pollutants. Based on study of the limited data, it is expected that PCE will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTWs. An EPA study of seven POTWs revealed removals of 40 to 100 percent. Sludge concentrations of tetrachloroethylene ranged from 1×10^{-3} to 1.6 mg/l. Some PCE is expected to be volatilized in aerobic treatment processes and little, if any, is expected to pass through into the effluent from the POTW.

Toluene(86). Toluene is a clear, colorless liquid with a benzene-like odor. It is a naturally occuring compound derived primarily from petroleum or petrochemical processes. Some toluene is obtained from the manufacture of metallurgical coke. Toluene is also referred to as totuol, methylbenzene, methacide, and phenymethane. It is an aromatic hydrocarbon with the formula $C_6H_5CH_3$. It boils at 111°C and has a vapor pressure of 30 mm Hg at room temperature. The water solubility of toluene is 535 mg/l, and it is miscible with a variety of organic solvents. Annual production of toluene in the U.S. is greater than 2 million metric tons. Approximately two-thirds of the toluene is converted to benzene and the remaining 30 percent is divided approximately equally into chemical manufacture, and use as a paint solvent and aviation gasoline additive. An estimated 5,000 metric tons is discharged to the environment annually as a constituent in wastewater.

Most data on the effects of toluene in humans and other mammals have been based on inhalation exposure or dermal contact studies. There appear to be no reports of oral administration of toluene to human subjects. A long term toxicity study on female rats revealed no adverse effects on growth, mortality, appearance and behavior, organ to body weight ratios, blood-urea nitrogen levels, bone marrow counts, peripheral blood counts, or morphology of major organs. The effects of inhaled toluene on the central nervous system, both at high and low concentrations, have been studied in humans and animals. However, ingested toluene is expected to be handled differently by the body, because it is absorbed more slowly and must first pass through the liver before reaching the nervous system. Toluene is extensively and rapidly metabolized in the liver. One of the

principal metabolic products of toluene is benzoic acid, which itself seems to have little potential to produce tissue injury.

Toluene does not appear to be teratogenic in laboratory animals or man. Nor is there any conclusive evidence that toluene is mutagenic. Toluene has not been demonstrated to be positive in any in vitro mutagenicity or carcinogenicity bioassay system, nor to be carcinogenic in animals or man.

Toluene has been found in fish caught in harbor waters in the vicinity of petroleum and petrochemical plants. Bioconcentration studies have not been conducted, but bioconcentration factors have been calculated on the basis of the octanol-water partition coefficient.

For the protection of human health from the toxic properties of toluene, ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 14.3 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water quality criterion is 424 mg/l. Available data show that adverse affects on aquatic life occur at concentrations as low as 5 mg/l.

Acute toxicity tests have been conducted with toluene and a variety of freshwater fish and Daphnia magna. The latter appears to be significantly more resistant than fish. No test results have been reported for the chronic effects of toluene on freshwater fish or invertebrate species.

Only one study of toluene behavior in POTWs is available. However, the biochemical oxidation of many of the priority pollutants has been investigated in laboratory scale studies at concentrations centrations greater than those expected to be contained by most municipal wastewaters. At toluene concentrations ranging from 3 to 250 mg/l, biochemical oxidation proceeded to fifty percent of theoretical or greater. The time period varied from a few hours to 20 days, depending on whether or not the seed culture was acclimated. Phenol adapted acclimated seed cultures gave the most rapid and extensive biochemical oxidation. Based on study of the limited data, it is expected that toluene will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in a POTW. The volatility and relatively low water solubility of toluene lead to the expectation that aeration processes will remove significant quantities of toluene from the POTW. The EPA studied toluene removal in seven POTWs. The removals ranged from 40 to 100 percent. Sludge concentrations of toluene ranged from 54 x 10^{-3} to 1.85 mg/l.

Trichloroethylene(87). Trichloroethylene (1,1,2-trichlorethylene or TCE) is a clear colorless boiling at 87°C (189°F). It has a vapor pressure of 77 mm Hg at room temperature and is slightly soluble in water (1 gm/l). U.S. production is greater than 0.25 million metric tons annually. It is produced from tetrachloroethane by treatment with lime in the presence of water.

TCE is used for vapor phase degreasing of metal parts, cleaning and drying electronic components, as a solvent for paints, as a refrigerant, for extraction of oils, fats, and waxes, and for dry cleaning. Its widespread use and relatively high volatility result in detectable levels in many parts of the environment.

Data on the effects produced by ingested TCE are limited. Most studies have been directed at inhalation exposure. Nervous system disorders and liver damage are frequent results of inhalation exposure. In the short term exposures, TCE acts as a central nervous system depressant - it was used as an anesthetic before its other long term effects were defined.

TCE has been shown to induce transformation in a highly sensitive in vitro Fischer rat embryo cell system (F1706) that is used for identifying carcinogens. Severe and persistent toxicity to the liver was recently demonstrated when TCE was shown to produce carcinoma of the liver in mouse strain B6C3F1. One systematic study of TCE exposure and the incidence of human cancer was based on 518 men exposed to TCE. The authors of that study concluded that, although the cancer risk to man cannot be ruled out, exposure to low levels of TCE probably does not present a very serious and general cancer hazard.

TCE is bioconcentrated in aquatic species, making the consumption of such species by humans a significant source of TCE. For the protection of human health from the potential carcinogenic effects of exposure to trichloroethylene, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of trichloroethylene estimated to result in additional lifetime cancer risk of 1 in 100,000 corresponds to an ambient water concentration of 0.00021 mg/l.

Only a very limited amount of data on the effects of TCE on freshwater aquatic life are available. One species of fish (fathead minnows) showed a loss of equilibrium at concentrations below those resulting in lethal effects. The limited data for aquatic life show that adverse effects occur at concentrations higher than those cited for human health risks.

For a recent Agency study, Fate of Priority Pollutants in Publicly Owned Treatment Works, the pollutant concentrations in the influent, effluent, and sludge of 20 POTWs were measured. No conclusions were made; however, trichloroethylene appeared in 95 percent of the influent stream samples but only in 54 percent of the effluent stream samples. This indicates that trichloroethylene either is concentrated in the sludge or escapes to the atmosphere. Concentrations in 50 percent of the sludge samples indicate that much of the trichloroethylene is concentrated there.

Aldrin (89). Aldrin ($C_{12}H_8Cl_6$) is a brown to white crystalline solid which is used as an insecticide. It melts at 104-105.5°C (219-222°F). While soluble in most organic solvents, aldrin is insoluble in water. It is not affected by alkalies or dilute acids, and is compatible with most herbicides, fertilizers, fungicides, and insecticides.

For freshwater aquatic life, the concentration of aldrin should not exceed 0.003 mg/l. For saltwater aquatic life, the concentration of this pollutant should not exceed 0.0013 mg/l at any time. No data are available concerning this pollutant's chronic toxicity.

For the maximum protection of human health from the potential carcinogenic effects of exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.00000074 mg/l, 0.000000074 mg/l, and 0.0000000074 mg/l respectively.

With respect to discharges to a POTW, it must be noted that this pollutant is toxic to biological organisms. As this pollutant can interfere with the biological treatment processes in a POTW, its discharge to a POTW must be carefully controlled.

Chlordane (91). Chlordane ($C_{10}H_6Cl_8$) is a colorless, odorless, viscous liquid. It boils at 175°C (347°F) and decomposes in weak alkalies. This chemical is soluble in many organic solvents, insoluble in water, and miscible in deodorized kerosene. In addition to its use as an insecticide, this chemical is also used in oil emulsions and dispersible liquids.

The criterion to protect freshwater aquatic life is 0.0000043 mg/l as a 24 hour average and the concentration should not exceed 0.0024 mg/l at any time. The criterion to protect saltwater aquatic life is 0.000004 mg/l as a 24 hour average and the concentration should not exceed 0.00009 mg/l at any time.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to chlordane, through the ingestion of contaminated water and contaminated aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risk at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.0000046 mg/l, 0.00000046 mg/l, and 0.000000046 mg/l respectively.

With respect to treatment in POTWs, this substance is biodegradable, but can also accumulate in biological organisms and exert a toxic effect. Therefore, the discharge of this pollutant to a POTW must be carefully controlled to avoid inhibitory effects on the POTW treatment process.

4,4'-DDT(92). 4,4'-DDT $(ClC_6H_4)_2CHCCl_3$ is a colorless crystal or a slightly off-white powder which is odorless or slightly aromatic. It is soluble in acetone, ether, benzene, carbon tetrachloride, kerosene, dioxane, and pyridine, but insoluble in water. It is not compatible with alkaline materials. This compound is derived by condensing chloral or chloral hydrate with chlorobenzene in the presence of fuming sulfuric acid. It is used as an insecticide.

For this pollutant, the criterion to protect freshwater and saltwater aquatic life is 0.0000010 mg/l as a 24 hour average. The concentrations which should not be exceeded at any time are 0.0011 mg/l for fresh waters and 0.00013 mg/l for saltwaters.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentrations should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.00000024 mg/l, 0.000000024 mg/l, and 0.0000000024 mg/l respectively.

With respect to discharge to a POTW, it must be noted that this pollutant is toxic to biological organisms. As this pollutant can interfere with the biological treatment process in a POTW, its discharge to a POTW must be carefully controlled.

4,4'-DDE (93). 4,4'-DDE $(ClC_6H_4)_2$ $CHCCl_3$ is a colorless crystal or slightly off-white powder which is odorless or exhibits a slight aromatic odor. It is soluble in acetone, ether, benzene, carbon tetrachloride, kerosene, dioxane, and pyridine but is insoluble in water. It is not compatible with alkaline materials. This pollutant is derived by condensing chloral or

chloral hydrate with chlorobenzene in the presence of fuming sulfuric acid. It is used as a pesticide.

For this pollutant, the criterion to protect freshwater and saltwater aquatic life is 0.0000010 mg/l as a 24-hour average. The concentrations which should not be exceeded at any time are 0.0011 mg/l for freshwaters and 0.00013 mg/l for saltwaters.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.00000024 mg/l, 0.000000024 mg/l, and 0.0000000027 mg/l respectively.

With respect to discharges to a POTW, it must be noted that this pollutant is toxic to biological organisms. As this pollutant can interfere with the biological treatment processes in a POTW, its discharge to a POTW must be carefully controlled.

Endrin Aldehyde (99). Endrin aldehyde is a biodegradation product of endrin. While known to be toxic no additional data pertaining to aquatic toxicity, ambient water quality criteria, and cancer risk levels are available.

Heptachlor epoxide (101). Heptachlor epoxide ($C_{10}H_9Cl_7O$) is a degradation product of heptachlor and subsequently also acts as an insecticide.

The criteria to protect fresh water and saltwater aquatic life are 0.0000053 mg/l and 0.0000050 mg/l respectively. The concentrations which should not be exceeded at any time are 0.00052 mg/l for freshwaters and 0.0000053 mg/l for saltwaters.

For the maximum protection of human health from the potential carcinogenic effects due to exposure to this pollutant, through the ingestion of contaminated water and aquatic organisms, the ambient water concentration should be zero. Concentrations of this pollutant estimated to result in additional lifetime cancer risks at risk levels of 10^{-5}, 10^{-6}, and 10^{-7} are 0.00000278 mg/l, 0.000000278 mg/l, and 0.0000000278 mg/l respectively.

With respect to discharge to a POTW, it must be noted that this pollutant is toxic to biological organisms. As this pollutant can interfere with the biological treatment processes in a POTW, its discharge to a POTW must be carefully controlled.

Hexachlorocyclohexanes (102, 103, 104 and 105). The alpha, beta, gamma, and delta BHC isomers ($C_6H_6Cl_6$) are white, crystalline powders with slightly musty odors. These isomers melt at about 112°C (234°F) and are: freely soluble in acetone, benzene and chloroform; soluble in alcohol; slightly soluble in ethylene glycol; and practically insoluble in water. These products are derived from the chlorination of benzene in the presence of ultraviolet light. The mixture of stereoisomers is separated by fractional crystallization. These isomers are used as insecticides.

The available data for a mixture of isomers of BHC indicate that acute toxicity to freshwater aquatic life occurs at concentrations as low as 0.1 mg/l and would occur at lower concentrations among species more sensitive than those tested. The available data for a mixture of BHC isomers indicate that acute toxicity to saltwater aquatic life occurs at concentrations as low as 0.00034 mg/l. No data are available concerning chronic toxicity to freshwater or saltwater species.

For maximum protection of human health from the potential carcinogenic effects due to exposure to the BHC isomers, through the ingestion of contaminated waters and contaminated aquatic organisms, the ambient water concentrations for alpha and beta BHC should be zero. Using the present guidelines, a satisfactory criterion for delta BHC cannot be derived at this time, due to an insufficiency of data. Concentrations estimated to result in additional lifetime cancer risk at risk levels of 10^{-5} 10^{-6}, and 10^{-7} are 0.000092 mg/l, 0.0000092 mg/l, and 0.00000092 mg/l for alpha BHC, and 0.000163 mg/l, 0.0000163 mg/l, and 0.00000163 mg/l for beta BHC. For the protection of human health from the ingestion of contaminated water and aquatic organisms, the ambient water criterion for gamma BHC is determined to be 0.000625 mg/l. At this time, a satisfactory criterion for delta BHC cannot be derived.

With respect to the acceptability of these pollutants to POTWs, it must be noted that they are pesticides and therefore toxic to the biological organisms which accomplish treatment in POTWs. Subsequently, the discharge of these substances to POTWs must be controlled.

Polychlorinated biphenyls (106-112). Polychlorinated biphenyls ($C_{12}H_{10}nCln, H_{10}$-nCln where n can range from 1 to 10), designated PCB's, are chlorinated derivatives of biphenyls. The commerical products are complex mixtures of chlorobiphenyls, but are no longer produced in the U.S. The mixtures produced formerly were characterized by the percentage chlorination. Direct chlorination of biphenyl was used to produce mixtures containing

from 21 to 70 percent chlorine. Six of these mixtures have been selected as priority pollutants:

Priority Pollutant Number	Name	Percent Chlorine	Distillation Range(°C)	Pour Point(°C)	25°C Water Solubility µg/l
106	PCB 1242	42	325-366	-19	240
107	PCB 1254	54	365-390	10	12
108	PCB 1221	20.5-21.5	275-320	1	>200
109	PCB 1232	31.4-32.5	290-325	-35.5	-
110	PCB 1248	48	340-375	-7	54
111	PCB 1260	60	385-420	31	2.7
112	PCB 1016	41	323-356	-	225-250

The PCBs 1221, 1232, 1016, 1242, and 1248 are colorless oily liquids; 1254 is a viscous liquid; 1260 is a sticky resin at room temperature. Total annual U.S. production of PCBs averaged about 20,000 tons in 1972-1974.

Prior to 1971, PCBs were used in several applications including plasticizers, heat transfer liquids, hydraulic fluids, lubricants, vacuum pump and compressor fluids; and capacitor and transformer oils. After 1970, when PCB use was restricted to closed systems, the latter two uses were the only commercial applications.

The toxic effects of PCBs ingested by humans have been reported to range from acne-like skin eruptions and pigmentation of the skin to numbness of limbs, hearing and vision problems, and spasms. Interpretation of results is complicated by the fact that the very highly toxic polychlorinated dibenzofurans (PCDFs) are found in many commercial PCB mixtures. Photochemical and thermal decomposition appear to accelerate the transformation of PCBs to PCDFs. Thus the specific effects of PCBs may be masked by the effects of PCDFs. However, if PCDFs are frequently present to some extent in any PCB mixture, then their effects may be properly included in the effects of PCB mixtures.

Studies of effects of PCBs in laboratory animals indicate that liver and kidney damage, large weight losses, eye discharges, and interference with some metabolic processes occur frequently. Teratogenic effects of PCBs in laboratory animals have been observed, but are rare. Growth retardations during gestation, and reproductive failure are more common effects observed in studies of PCB teratogenicity. Carcinogenic effects of PCBs have been studied in laboratory animals with results interpreted as positive. Specific reference has been made to liver cancer in rats in the discussion of water quality criterion formulation.

For the maximum protection of human health from the potential carcinogenic effects of exposure to PCBs, through ingestion of water and contaminated aquatic organisms, the ambient water concentration should be zero. Concentrations of PCBs estimated to result in additional lifetime cancer risk at risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 0.0000000026 mg/l, 0.000000026 mg/l, and 0.00000026 mg/l, respectively.

The behavior of PCBs in POTWs has received limited study. Most PCBs will be removed with sludge. One study showed removals of 82 to 89 percent, depending on suspended solid removal. The PCBs adsorb onto suspended sediments and other particulates. In laboratory scale experiments with PCB 1221, 81 percent was removed by degradation in an activated sludge system in 47 hours. Biodegradation can form polychlorinated dibenzofurans which are more toxic than PCBs (as noted earlier). PCBs at concentrations of 0.1 to 1,000 mg/l inhibit or enhance bacterial growth rates, depending on the bacterial culture and the percentage chlorine in the PCB. Thus, activated sludge may be inhibited by PCBs. Based on studies of bioaccumulation of PCBs in food crops grown on soils amended with PCB-containing sludge, the U.S. FDA has recommended a limit of 10 mg PCB/kg dry weight of sludge used for application to soils bearing food crops.

Antimony(114). Antimony (chemical name - stibium, symbol Sb) classified as a non-metal or metalloid, is a silvery white , brittle, crystalline solid. Antimony is found in small ore bodies throughout the world. Principal ores are oxides of mixed antimony valences, and an oxysulfide ore. Complex ores with metals are important, because the antimony is recovered as a by-product. Antimony melts at 631°C, and is a poor conductor of electricity and heat.

Annual U.S. consumption of primary antimony ranges from 10,000 to 20,000 tons. About half is consumed in metal products - mostly antimonial lead for lead acid storage batteries, and about half in nonmetal products. A principal compound is antimony trioxide which is used as a flame retardant in fabrics, and as an opacifier in glass, ceramics, and enamels. Several antimony compounds are used as catalysts in organic chemicals synthesis, as fluorinating agents (the antimony fluoride), as pigments, and in fireworks. Semiconductor applications are economically significant.

Essentially no information on antimony-induced human health effects, has been derived from community epidemiology studies. The available data are in literature relating effects observed with therapeutic or medicinal uses of antimony compounds and industrial exposure studies. Large therapeutic doses of

antimonial compounds, usually used to treat schistosomiasis, have caused severe nausea, vomiting, convulsions, irregular heart action, liver damage, and skin rashes. Studies of acute industrial antimony poisoning have revealed loss of appetite, diarrhea, headache, and dizziness in addition to the symptoms found in studies of therapeutic doses of antimony.

For the protection of human health from the toxic properties of antimony, ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.146 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion is determined to be 45 mg/l. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

Very little information is available regarding the behavior of antimony in POTWs. The limited solubilities of most antimony compounds expected in POTWs, i.e. the oxides and sulfides, suggest that at least part of the antimony entering a POTW will be precipitated and incorporated into the sludge. However, some antimony is expected to remain dissolved and pass through the POTW into the effluent. Antimony compounds remaining in the sludge under anaerobic conditions may be connected to stibine (SbH_3), a very soluble and very toxic compound. There are no data to show antimony inhibits any POTW processes. Antimony is not known to be essential to the growth of plants, and has been reported to be moderately toxic. Therefore, sludge containing large amounts of antimony could be detrimental to plants, if it is applied in large amounts to croplands.

Arsenic(115). Arsenic (chemical symbol As), is classified as a non-metal or metalloid. Elemental arsenic normally exists in the alpha-crystalline metallic form which is steel gray and brittle, and in the beta form which is dark gray and amorphous. Arsenic sublimes at 615°C (1139°F). Arsenic is widely distributed throughout the world in a large number of minerals. The most important commercial source of arsenic is as a by-product from treatment of copper, lead, cobalt, and gold ores. Arsenic is usually marketed as the trioxide (As_2O_3). Annual U.S. production of the trioxide approaches 40,000 tons.

The principal use of arsenic is in agricultural chemicals (herbicides) for controlling weeds in cotton fields. Arsenicals have various applications in medicinal and veterinary use, as wood preservatives, and in semiconductors.

The effects of arsenic in humans were known by the ancient Greeks and Romans. The principal toxic effects are gastrointestinal

disturbances. Breakdown of red blood cells occurs. Symptoms of acute poisoning include vomiting, diarrhea, abdominal pain, lassitude, dizziness, and headache. Longer exposure produced dry, falling hair, brittle, loose nails, eczema, and exfoliation. Arsenicals also exhibit teratogenic and mutagenic effects in humans. Oral administration of arsenic compounds has been associated clinically with skin cancer for nearly a hundred years. Since 1888, numerous studies have linked occupational exposure to, and therapeutic administration of, arsenic compounds to increased incidence of respiratory and skin cancer.

For the maximum protection of human health from the potential carcinogenic effects of exposure to arsenic, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. Concentrations of arsenic estimated to result in additional lifetime cancer risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 2.2×10^{-10} mg/l, 2.2×10^{-9} mg/l, and 2.2×10^{-8} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 2.7×10^{-4} mg/l to keep the increased lifetime cancer risk below 10^{-5}. Available data show that adverse effects on aquatic life occur at concentrations higher than those cited for human health risks.

A few studies have been made regarding the behavior of arsenic in POTWs. One EPA survey of 9 POTWs reported influent concentrations ranging from 0.0005 to 0.693 mg/l; effluents from 3 POTWs having biological treatment contained 0.0004 - 0.01 mg/l; 2 POTWs showed arsenic removal efficiencies of 50 and 71 percent in biological treatment. Inhibition of treatment processes by sodium arsenate is reported to occur at 0.1 mg/l in activated sludge, and 1.6 mg/l in anaerobic digestion processes. In another study based on data from 60 POTWs, arsenic in sludge ranged from 1.6 to 65.6 mg/kg and the median value was 7.8 mg/kg. Arsenic in sludge spread on cropland may be taken up by plants grown on that land. Edible plants can take up arsenic, but normally their growth is inhibited before the plants are ready for harvest.

Beryllium(117). Beryllium is a dark gray metal of the alkaline earth family. It is relatively rare, but because of its unique properties finds widespread use as an alloying element, especially for hardening copper which is used in springs, electrical contacts, and non-sparking tools. World production is reported to be in the range of 250 tons annually. However, much more reaches the environment as emissions from coal burning operations. Analysis of coal indicates an average beryllium content of 3 ppm and 0.1 to 1.0 percent in coal ash or fly ash.

The principal ores are beryl ($3BeO \cdot Al_2O_3 \cdot 6SiO_2$) and bertrandite [$Be_4Si_2O_7(OH)_2$]. Only two industrial facilities produce beryllium in the U.S. because of limited demand and the highly toxic character. About two-thirds of the annual production goes into alloys, 20 percent into heat sinks, and 10 percent into beryllium oxide (BeO) ceramic products.

Beryllium has a specific gravity of 1.846 making it the lightest metal with a high melting point (1350°C). Beryllium alloys are corrosion resistant, but the metal corrodes in aqueous environments. Most common beryllium compounds are soluble in water, at least to the extent necessary to produce a toxic concentration of beryllium ions.

Most data on toxicity of beryllium is for inhalation of beryllium oxide dust. Some studies on orally administered beryllium in laboratory animals have been reported. Despite the large number of studies implicating beryllium as a carcinogen, there is no recorded instance of cancer being produced by ingestion. However, a recently convened panel of uninvolved experts concluded that epidemiologic evidence is suggestive that beryllium is a carcinogen in man.

In the aquatic environment, beryllium is acutely toxic to fish at concentrations as low as 0.087 mg/l, and chronically toxic to an aquatic organism at 0.003 mg/l. Water softness has a large effect on beryllium toxicity to fish. In soft water, beryllium is reportedly 100 times as toxic as in hard water.

For the maximum protection of human health from the potential carcinogenic effects of exposure to beryllium, through ingestion of water and contaminated aquatic organisms, The ambient water concentration is zero. Concentrations of beryllium estimated to result in additional lifetime cancer risk levels of 10^{-7}, 10^{-6}, and 10^{-5} are 0.00000087 mg/l, 0.0000087 mg/l, and 0.000087 mg/l, respectively.

Information on the behavior of beryllium in POTWs is scarce. Because beryllium hydroxide is insoluble in water, most beryllium entering POTWs will probably be in the form of suspended solids. As a result, most of the beryllium will settle and be removed with sludge. However, beryllium has been shown to inhibit several enzyme systems, to interfere with DNA metabolism in liver, and to induce chromosomal and mitotic abnormalities. This interference in cellular processes may extend to interfere with biological treatment processes. The concentration and effects of beryllium in sludge which could be applied to cropland have not been studied.

Cadmium(118). Cadmium is a relatively rare metallic element that is seldom found in sufficient quantities in a pure state to warrant mining or extraction from the earth's surface. It is found in trace amounts of about 1 ppm throughout the earth's crust. Cadmium is, however, a valuable by-product of zinc production.

Cadmium is used primarily as an electroplated metal, and is found as an impurity in the secondary refining of zinc, lead, and copper. Cadmium appears at a significant level in raw wastewaters from only one of the three subcategories of coil coating - galvanized. The presence of cadmium in the wastewater is attributed to its presence as an impurity in the zinc used to produce galvanized coil stock. Some of the zinc is removed by the cleaning and conversion coating steps.

Cadmium is an extremely dangerous cumulative toxicant, causing progressive chronic poisoning in mammals, fish, and probably other organisms. The metal is not excreted.

Toxic effects of cadmium on man have been reported from throughout the world. Cadmium may be a factor in the development of such human pathological conditions as kidney disease, testicular tumors, hypertension, arteriosclerosis, growth inhibition, chronic disease of old age, and cancer. Cadmium is normally ingested by humans through food and water, as well as by breathing air contaminated by cadmium dust. Cadmium is cumulative in the liver, kidney, pancreas, and thyroid of humans and other animals. A severe bone and kidney syndrome known as itai-itai disease has been documented in Japan as being caused by cadmium ingestion via drinking water and contaminated irrigation water. Ingestion of as little as 0.6 mg/day has produced the disease. Cadmium acts synergistically with other metals. Copper and zinc substantially increase its toxicity.

Cadmium is concentrated by marine organisms, particularly molluscs, which accumulate cadmium in calcareous tissues and in the viscera. A concentration factor of 1000 for cadmium in fish muscle has been reported as having concentration factors of 3000 in marine plants and up to 29,600 in certain marine animals. The eggs and larvae of fish are apparently more sensitive than adult fish to poisoning by cadmium, and crustaceans appear to be more sensitive than fish eggs and larvae.

For the protection of human health from the toxic properties of cadmium, ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.010 mg/l. Available data show that adverse effects on aquatic life

occur at concentrations in the same range as those cited for human health, and they are highly dependent on water hardness.

Cadmium is not destroyed when it is introduced into a POTW, and will either pass through to the POTW effluent or be incorporated in the POTW sludge. In addition, it can interfere with the POTW treatment process.

In a study of 189 POTWs, 75 percent of the primary plants, 57 percent of the trickling filter plants, 66 percent of the activated sludge plants and 62 percent of the biological plants allowed over 90 percent of the influent cadmium to pass through to the POTW effluent. Only 2 of the 189 POTWs allowed less than 20 percent pass through, and none less than 10 percent pass through. POTW effluent concentrations ranged from 0.001 to 1.97 mg/l (mean 0.028 standard deviation 0.167).

Cadmium not passed through the POTW will be retained in the sludge, where it is likely to build up in concentration. Cadmium contamination of sewage sludge limits its use on land, since it increases the level of cadmium in the soil. Data show that cadmium can be incorporated into crops, including vegetables and grains, from contaminated soils. Since the crops themselves show no adverse effects from soils with levels up to 100 mg/kg cadmium, these contaminated crops could have a significant impact on human health. Two Federal agencies have already recognized the potential adverse human health effects posed by the use of sludge on cropland. The FDA recommends that sludge containing over 30 mg/kg of cadmium should not be used on agricultural land. Sewage sludge contains 3 to 300 mg/kg (dry basis) of cadmium (mean = 10 mg/kg; median = 16 mg/kg). The USDA also recommends placing limits on the total cadmium from sludge that may be applied to land.

Chromium(119). Chromium is an elemental metal usually found as a chromite ($FeO \cdot Cr_2O_3$). The metal is normally produced by reducing the oxide with aluminum. A significant proportion of the chromium used is in the form of compounds such as sodium dichromate (Na_2CrO_4), and chromic acid (CrO_3) - both are hexavalent chromium compounds.

Chromium and its compounds are used extensively in the coil coating industry. As the metal, it is found as an alloying component of many steels.

The two chromium forms most frequently found in industry wastewaters are hexavalent and trivalent chromium. Hexavalent chromium is the form used for metal treatments. Some of it is reduced to trivalent chromium as part of the process reaction.

The raw wastewater containing both valence states is usually treated first to reduce remaining hexavalent to trivalent chromium, and second to precipitate the trivalent form as the hydroxide. The hexavalent form is not removed by lime treatment.

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled, and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Hexavalent chromium is a known human carcinogen. Levels of chromate ions that show no effect in man appear to be so low as to prohibit determination, to date.

The toxicity of chromium salts to fish and other aquatic life varies widely with the species, temperature, pH, valence of the chromium, and synergistic or antagonistic effects, especially the effect of water hardness. Studies have shown that trivalent chromium is more toxic to fish of some types than is hexavalent chromium. Hexavalent chromium retards growth of one fish species at 0.0002 mg/l. Fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium. Therefore, both hexavalent and trivalent chromium must be considered harmful to particular fish or organisms.

For the protection of human health from the toxic properties of chromium (except hexavalent chromium), ingested through water and contaminated aquatic organisms, the recommended water quality criterion is 0.050 mg/l.

For the maximum protection of human health from the potential carcinogenic effects of exposure to hexavalent chromium, through ingestion of water and contaminated aquatic organisms, the ambient water concentration is zero. The estimated levels which would result in increased lifetime cancer risks of 10^{-7}, 10^{-6}, and 10^{-5} are 7.4×10^{-8} mg/l, 7.4×10^{-7} mg/l, and 7.4×10^{-6} mg/l respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 1.5×10^{-5} mg/l to keep the increased lifetime cancer risk below 10^{-5}.

Chromium is not destroyed when treated by POTWs (although the oxidation state may change), and will either pass through to the POTW effluent or be incorporated into the POTW sludge. Both oxidation states can cause POTW treatment inhibition and can also limit the usefulness of municipal sludge.

Influent concentrations of chromium to POTW facilities have been observed by EPA to range from 0.005 to 14.0 mg/l, with a median concentration of 0.1 mg/l. The efficiencies for removal of

chromium by the activated sludge process can vary greatly, depending on chromium concentration in the influent, and other operating conditions at the POTW. Chelation of chromium by organic matter and dissolution due to the presence of carbonates can cause deviations from the predicted behavior in treatment systems.

The systematic presence of chromium compounds will halt nitrification in a POTW for short periods, and most of the chromium will be retained in the sludge solids. Hexavalent chromium has been reported to severely affect the nitrification process, but trivalent chromium has little or no toxicity to activated sludge, except at high concentrations. The presence of iron, copper, and low pH will increase the toxicity of chromium in a POTW by releasing the chromium into solution to be ingested by microorganisms in the POTW.

The amount of chromium which passes through to the POTW effluent depends on the type of treatment processes used by the POTW. In a study of 240 POTWs 56 percent of the primary plants allowed more than 80 percent pass through to POTW effluent. More advanced treatment results in less pass through. POTW effluent concentrations ranged from 0.003 to 3.2 mg/l total chromium (mean = 0.197, standard deviation = 0.48), and from 0.002 to 0.1 mg/l hexavalent chromium (mean = 0.017, standard deviation = 0.020).

Chromium not passed through the POTW will be retained in the sludge, where it is likely to build up in concentration. Sludge concentrations of total chromium of over 20,000 mg/kg (dry basis) have been observed. Disposal of sludges, containing very high concentrations of trivalent chromium, can potentially cause problems in uncontrollable landfills. Incineration, or similar destructive oxidation processes can produce hexavalent chromium from lower valance states. Hexavalent chromium is potentially more toxic than trivalent chromium. In cases where high rates of chrome sludge application on land are used, distinct growth inhibition and plant tissue uptake have been noted.

Pretreatment of discharges substantially reduces the concentration of chromium in sludge. In Buffalo, New York, pretreatment of electroplating waste resulted in a decrease in chromium concentrations in POTW sludges from 2,510 to 1,040 mg/kg. A similar reduction occurred in Grand Rapids, Michigan POTWs, where the chromium concentration in sludge decreased from 11,000 to 2,700 mg/kg when pretreatment was made a requirement.

Copper(120). Copper is a metallic element that sometimes is found free, as the native metal, and is also found in minerals

such as cuprite (Cu_2O), malechite [$CuCO_3 \bullet Cu(OH)_2$], azurite [$2CuCO_3 \bullet Cu(OH)_2$], chalcopyrite ($CuFeS_2$), and bornite (Cu_5FeS_4). Copper is obtained from these ores by smelting, leaching, and electrolysis. It is used in the plating, electrical, plumbing, and heating equipment industries, as well as in insecticides and fungicides.

Traces of copper are found in all forms of plant and animal life, and the metal is an essential trace element for nutrition. Copper is not considered to be a cumulative systemic poison for humans, as it is readily excreted by the body, but it can cause symptoms of gastroenteritis, with nausea and intestinal irritations, at relatively low dosages. The limiting factor in domestic water supplies is taste. To prevent this adverse organoleptic effect of copper in water, a criterion of 1 mg/l has been established.

The toxicity of copper to aquatic organisms varies significantly, not only with the species, but also with the physical and chemical characteristics of the water, including temperature, hardness, turbidity, and carbon dioxide content. In hard water, the toxicity of copper salts may be reduced by the precipitation of copper carbonate or other insoluble compounds. The sulfates of copper and zinc, and of copper and calcium are synergistic in their toxic effect on fish.

Relatively high concentrations of copper may be tolerated by adult fish for short periods of time; the critical effect of copper appears to be its higher toxicity to young or juvenile fish. Concentrations of 0.02 to 0.031 mg/l have proved fatal to some common fish species. In general, the salmonoids are very sensitive and the sunfishes are less sensitive to copper.

The recommended criterion to protect saltwater aquatic life is 0.00097 mg/l as a 24-hour average, and 0.018 mg/l maximum concentration.

Copper salts cause undesirable color reactions in the food industry and cause pitting when deposited on some other metals such as aluminum and galvanized steel.

Irrigation water, containing more than minute quantities of copper, can be detrimental to certain crops. Copper appears in all soils, and its concentration ranges from 10 to 80 ppm. In soils, copper occurs in association with hydrous oxides of manganese and iron, and also as soluble and insoluble complexes with organic matter. Copper is essential to the life of plants, and the normal range of concentration in plant tissue is from 5 to 20 ppm. Copper concentrations in plants normally do not build

up to high levels when toxicity occurs. For example, the concentrations of copper in snapbean leaves and pods were less than 50 and 20 mg/kg, respectively, under conditions of severe copper toxicity. Even under conditions of copper toxicity, most of the excess copper accumulates in the roots; very little is moved to the aerial part of the plant.

Copper is not destroyed when treated by a POTW, and will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with the POTW treatment processes and can limit the usefulness of municipal sludge.

The influent concentration of copper to POTW facilities has been observed by the EPA to range from 0.01 to 1.97 mg/l, with a median concentration of 0.12 mg/l. The copper that is removed from the influent stream of a POTW is adsorbed on the sludge or appears in the sludge as the hydroxide of the metal. Bench scale pilot studies have shown that 25 percent to 75 percent of the copper passing through the activated sludge process remains in solution in the final effluent. Four hour slug dosages of copper sulfate, in concentrations exceeding 50 mg/l, were reported to have severe effects on the removal efficiency of an unacclimated system, with the system returning to normal in about 100 hours. Slug dosages of copper in the form of copper cyanide were observed to have much more severe effects on the activated sludge system, but the total system returned to normal in 24 hours.

In a recent study of 268 POTWs, the median pass through was over 80 percent for primary plants, and 40 to 50 percent for trickling filter, activated sludge, and biological treatment plants. POTW effluent concentrations of copper ranged from 0.003 to 1.8 mg/l (mean 0.126, standard deviation 0.242).

Copper which does not pass through the POTW will be retained in the sludge, where it will build up in concentration. The presence of excessive levels of copper in sludge may limit its use on cropland. Sewage sludge contains up to 16,000 mg/kg of copper, with 730 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which usually range from 18 to 80 mg/kg. Experimental data indicate that when dried sludge is spread over tillable land, the copper tends to remain in place down to the depth of tillage, except for copper which is taken up by plants grown in the soil. Recent investigation has shown that the extractable copper content of sludge-treated soil decreased with time, which suggests that a reversion of copper to less soluble forms was occurring.

Cyanide(121). Cyanides are among the most toxic of pollutants commonly observed in industrial wastewaters. Introduction of cyanide into industrial processes is usually by dissolution of potassium cyanide (KCN) or sodium cyanide (NaCN) in process waters. However, hydrogen cyanide (HCN), formed when the above salts are dissolved in water, is probably the most acutely lethal compound.

The relationship of pH to hydrogen cyanide formation is very important. As pH is lowered to below 7, more than 99 percent of the cyanide is present as HCN and less than 1 percent as cyanide ions. Thus, at neutral pH, that of most living organisms, the more toxic form of cyanide prevails.

Cyanide ions combine with numerous heavy metal ions to form complexes. The complexes are in equilibrium with HCN. Thus, the stability of the metal-cyanide complex and the pH determine the concentration of HCN. Stability of the metal-cyanide anion complexes is extremely variable. Those formed with zinc, copper, and cadmium are not stable - they rapidly dissociate, with production of HCN, in near neutral or acid waters. Some of the complexes are extremely stable. Cobaltocyanide is very resistant to acid distillation in the laboratory. Iron cyanide complexes are also stable, but undergo photodecomposition to give HCN upon exposure to sunlight. Synergistic effects have been demonstrated for the metal cyanide complexes, making zinc, copper, and cadmium cyanides more toxic than an equal concentration of sodium cyanide.

The toxic mechanism of cyanide is essentially an inhibition of oxygen metabolism, i.e., rendering the tissues incapable of exchanging oxygen. The cyanogen compounds are true noncumulative protoplasmic poisons. They arrest the activity of all forms of animal life. Cyanide shows a very specific type of toxic action. It inhibits the cytochrome oxidase system. This system is the one which facilitates electron transfer from reduced metabolites to molecular oxygen. The human body can convert cyanide to a non-toxic thiocyanate and eliminate it. However, if the quantity of cyanide ingested is too great at one time, the inhibition of oxygen utilization proves fatal before the detoxifying reaction reduces the cyanide concentration to a safe level.

Cyanides are more toxic to fish than to lower forms of aquatic organisms such as midge larvae, crustaceans, and mussels. Toxicity to fish is a function of chemical form and concentration, and is influenced by the rate of metabolism (temperature), the level of dissolved oxygen, and pH. In laboratory studies free cyanide concentrations ranging from 0.05 to 0.15 mg/l have been proven to be fatal to sensitive fish

species including trout, bluegill, and fathead minnows. Levels above 0.2 mg/l are rapidly fatal to most fish species. Long term sublethal concentrations of cyanide, as low as 0.01 mg/l, have been shown to affect the ability of fish to function normally, e.g., reproduce, grow, and swim.

For the protection of human health from the toxic properties of cyanide, ingested through water and through contaminated aquatic organisms, the ambient water quality criterion is determined to be 0.200 mg/l. Available data show that effects on aquatic life occur at concentrations as low as 3.5×10^{-3} mg/l.

Persistence of cyanide in water is highly variable and depends upon the chemical form of cyanide in the water, the concentration of cyanide, and the nature of other constituents. Cyanide may be destroyed by strong oxidizing agents such as permanganate and chlorine. Chlorine is commonly used to oxidize strong cyanide solutions. Carbon dioxide and nitrogen are the products of complete oxidation. But if the reaction is not complete, the very toxic compound, cyanogen chloride, may remain in the treatment system and subsequently be released to the environment. Partial chlorination may occur as part of a POTW treatment, or during the disinfection treatment of surface water for drinking water preparation.

Cyanides can interfere with treatment processes in POTWs, or pass through to ambient waters. At low concentrations, and with acclimated microflora, cyanide may be decomposed by microorganisms in anaerobic and aerobic environments or waste treatment systems. However, data indicate that much of the cyanide introduced passes through to the POTW effluent. The mean pass through of 14 biological plants was 71 percent. In a recent study of 41 POTWs the effluent concentrations ranged from 0.002 to 100 mg/l (mean = 2.518, standard deviation = 15.6). Cyanide also enhances the toxicity of metals commonly found in POTW effluents, including the priority pollutants cadmium, zinc, and copper.

Data for Grand Rapids, Michigan, showed a significant decline in cyanide concentrations downstream from the POTW after pretreatment regulations were enforced. Concentrations fell from 0.66 mg/l before, to 0.01 mg/l after pretreatment was required.

Lead (122). Lead is a soft, malleable, ductile, blueish-gray, metallic element, usually obtained from the mineral galena (lead sulfide, PbS), anglesite (lead sulfate, $PbSO_4$), or cerussite (lead carbonate, $PbCO_3$). Because it is usually associated with minerals of zinc, silver, copper, gold, cadmium, antimony, and arsenic, special purification methods are frequently used before

and after extraction of the metal from the ore concentrate by smelting.

Lead is widely used for its corrosion resistance, sound and vibration absorption, low melting point (solders), and relatively high imperviousness to various forms of radiation. Small amounts of copper, antimony and other metals can be alloyed with lead to achieve greater hardness, stiffness, or corrosion resistance than is afforded by the pure metal. Lead compounds are used in glazes and paints. About one third of U.S. lead consumption goes into storage batteries. About half of U.S. lead consumption is from secondary lead recovery. U.S. consumption of lead is in the range of one million tons annually.

Lead ingested by humans produces a variety of toxic effects, including impaired reproductive ability, disturbances in blood chemistry, neurological disorders, kidney damage, and adverse cardiovascular effects. Exposure to lead in the diet results in permanent increase in lead levels in the body. Most of the lead entering the body eventually becomes localized in the bones, where it accumulates. Lead is a carcinogen or cocarcinogen in some species of experimental animals. Lead is teratogenic in experimental animals. Mutagenicity data are not available for lead.

For the protection of human health from the toxic properties of lead, ingested through water and contaminated aquatic organisms, the ambient water criterion is 0.050 mg/l. Available data show that adverse effects on aquatic life occur at concentrations as low as 7.5×10^{-4} mg/l.

Lead is not destroyed in POTWs, but is passed through to the effluent or retained in the POTW sludge. It can interfere with POTW treatment processes and can limit the usefulness of POTW sludge for application to agricultural croplands. Threshold concentration for inhibition of the activated sludge process is 0.1 mg/l, and for the nitrification process is 0.5 mg/l. In a study of 214 POTWs, median pass through values were over 80 percent for primary plants and over 60 percent for trickling filter, activated sludge, and biological process plants. Lead concentrations in POTW effluents ranged from 0.003 to 1.8 mg/l (mean = 0.106 standard deviation = 0.222).

Application of lead-containing sludge to cropland should not lead to uptake by crops under most conditions, because normally lead is strongly bound by soil. However, under the unusual conditions of low pH (less than 5.5) and low concentrations of labile phosphorus, lead solubility is increased and plants can accumulate lead.

Mercury (123). Mercury is an elemental metal rarely found in nature as the free metal. Mercury is unique among metals, as it remains a liquid down to about -39°C. It is relatively inert chemically and is insoluble in water. The principal ore is cinnabar (HgS).

Mercury is used industrially as the metal and as mercurous and mercuric salts and compounds. Mercury released to the aqueous environment is subject to biomethylation - conversion to the extremely toxic methyl mercury.

Mercury can be introduced into the body through the skin and the respiratory system as the elemental vapor. Mercuric salts are highly toxic to humans and can be absorbed through the gastrointestinal tract. Fatal doses can vary from 1 to 30 grams. Chronic toxicity of methyl mercury is evidenced primarily by neurological symptoms. Some mercuric salts cause death by kidney failure.

Mercuric salts are extremely toxic to fish and other aquatic life. Mercuric chloride is more lethal than copper, hexavalent chromium, zinc, nickel, and lead towards fish and aquatic life. In the food cycle, algae, containing mercury up to 100 times the concentration in the surrounding sea water, are eaten by fish, which further concentrates the mercury. Predators that eat the fish in turn concentrate the mercury even further.

For the protection of human health from the toxic properties of mercury, ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.0002 mg/l.

Mercury is not destroyed when treated by a POTW, and will either pass through to the POTW effluent or be incorporated into the POTW sludge. At low concentrations, it may reduce POTW removal efficiencies, and at high concentrations, it may upset the POTW operation.

The influent concentrations of mercury to POTWs have been observed by the EPA to range from 0.0002 to 0.24 mg/l, with a median concentration of 0.001 mg/l. Mercury has been reported in the literature to have inhibiting effects upon an activated sludge POTW at levels as low as 0.1 mg/l. At 5 mg/l of mercury, losses of COD removal efficiency of 14 to 40 percent have been reported, while at 10 mg/l, loss of removal of 59 percent has been reported. Upset of an activated sludge POTW is reported in the literature to occur near 200 mg/l. The anaerobic digestion process is much less affected by the presence of mercury, with inhibitory effects being reported at 1365 mg/l.

In a study of 22 POTWs having secondary treatment, the range of removal of mercury from the influent to the POTW ranged from 4 to 99 percent, with median removal of 41 percent. Thus significant pass through of mercury may occur.

In sludges, mercury content may be high, if industrial sources of mercury contamination are present. Little is known about the form in which mercury occurs in sludge. Mercury may undergo biological methylation in sediments, but no methylation has been observed in soils, mud, or sewage sludge.

The mercury content of soils not receiving additions of POTW sewage sludge lies in the range from 0.01 to 0.5 mg/kg. In soils receiving POTW sludges for protracted periods, the concentration of mercury has been observed to approach 1.0 mg/kg. In the soil, mercury enters into reactions with the exchange complex of clay and organic fractions, forming both ionic and covalent bonds. Chemical and microbiological degradation of mercurials can take place side by side in the soil, and the products - ionic or molecular - are retained by organic matter and clay or may be volatilized if gaseous. Because of the high affinity between mercury and the solid soil surfaces, mercury persists in the upper layer of soil.

Mercury can enter plants through the roots, it can readily move to other parts of the plant, and it has been reported to cause injury to plants. In many plants, mercury concentrations range from 0.01 to 0.20 mg/kg, but when plants are supplied with high levels of mercury, these concentrations can exceed 0.5 mg/kg. Bioconcentration occurs in animals ingesting mercury in food.

Nickel(124). Nickel is seldom found in nature as the pure elemental metal. It is a relatively plentiful element and is widely distributed throughout the earth's crust. It occurs in marine organisms and is found in the oceans. The chief commercial ores for nickel are pentlandite [$(Fe,Ni)_9S_8$], and a lateritic ore consisting of hydrated nickel-iron-magnesium silicate.

Nickel has many varied uses. It is used in alloys and as the pure metal. Nickel salts are used for electroplating baths.

The toxicity of nickel to man is thought to be very low, and systemic poisoning of human beings by nickel or nickel salts is almost unknown. In non-human mammals, nickel acts to inhibit insulin release, depress growth, and reduce cholesterol. A high incidence of cancer of the lung and nose has been reported in humans engaged in the refining of nickel.

Nickel salts can kill fish at very low concentrations. However, nickel has been found to be less toxic to some fish than copper, zinc, and iron. Nickel is present in coastal and open ocean water at concentrations in the range of 0.0001 to 0.006 mg/l although the most common values are 0.002 - 0.003 mg/l. Marine animals contain up to 0.4 mg/l and marine plants contain up to 3 mg/l. Higher nickel concentrations have been reported to cause reduction in photosynthetic activity of the giant kelp. A low concentration was found to kill oyster eggs.

For the protection of human health from the toxic properties of nickel, ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.134 mg/l. If contaminated aquatic organisms are consumed, excluding consumption of water, the ambient water criterion is determined to be 1.01 mg/l. Available data show that adverse effects on aquatic life occur for total recoverable nickel concentrations as low as 0.032 mg/l.

Nickel is not destroyed when treated in a POTW, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with POTW treatment processes and can also limit the usefulness of municipal sludge.

Nickel salts have caused inhibition of the biochemical oxidation of sewage in a POTW. In a pilot plant, slug doses of nickel significantly reduced normal treatment efficiencies for a few hours, but the plant acclimated itself somewhat to the slug dosage and appeared to achieve normal treatment efficiencies within 40 hours. It has been reported that the anaerobic digestion process is inhibited only by high concentrations of nickel, while a low concentration of nickel inhibits the nitrification process.

The influent concentration of nickel to POTW facilities has been observed by the EPA to range from 0.01 to 3.19 mg/l, with a median of 0.33 mg/l. In a study of 190 POTWs, nickel pass through was greater than 90 percent for 82 percent of the primary plants. Median pass through for trickling filter, activated sludge, and biological process plants was greater than 80 percent. POTW effluent concentrations ranged from 0.002 to 40 mg/l (mean = 0.410, standard deviation = 3.279).

Nickel not passed through the POTW will be incorporated into the sludge. In a recent two-year study of eight cities, four of the cities had median nickel concentrations of over 350 mg/kg, and two were over 1,000 mg/kg. The maximum nickel concentration observed was 4,010 mg/kg.

Nickel is found in nearly all soils, plants, and waters. Nickel has no known essential function in plants. In soils, nickel typically is found in the range from 10 to 100 mg/kg. Various environmental exposures to nickel appear to correlate with increased incidence of tumors in man. For example, cancer in the maxillary antrum of snuff users may result from using plant material grown on soil high in nickel.

Nickel toxicity may develop in plants from application of sewage sludge on acid soils. Nickel has caused reduction of yields for a variety of crops including oats, mustard, turnips, and cabbage. In one study, nickel decreased the yields of oats significantly at 100 mg/kg.

Whether nickel exerts a toxic effect on plants depends on several soil factors, the amount of nickel applied, and the contents of other metals in the sludge. Unlike copper and zinc, which are more available from inorganic sources than from sludge, nickel uptake by plants seems to be promoted by the presence of the organic matter in sludge. Soil treatments, such as liming, reduce the solubility of nickel. Toxicity of nickel to plants is enhanced in acidic soils.

Selenium(125). Selenium (chemical symbol Se) is a non-metallic element existing in several allotropic forms. Gray selenium, which has a metallic appearance, is the stable form at ordinary temperatures and melts at 220°C. Selenium is a major component of 38 minerals and a minor component of 37 others found in various parts of the world. Most selenium is obtained as a by-product of precious metals recovery from electrolytic copper refinery slimes. U.S. annual production at one time reached one million pounds.

Principal uses of selenium are in semi-conductors, pigments, decoloring of glass, zerography, and metallurgy. It also is used to produce ruby glass used in signal lights. Several selenium compounds are important oxidizing agents in the synthesis of organic chemicals and drug products.

While results of some studies suggest that selenium may be an essential element in human nutrition, the toxic effects of selenium in humans are well established. Lassitude, loss of hair, discoloration and loss of fingernails are symptoms of selenium poisoning. In a fatal case of ingestion of a larger dose of selenium acid, peripheral vascular collapse, pulumonary edema, and coma occurred. Selenium produces mutagenic and teratogenic effects, but it has not been established as exhibiting carcinogenic activity.

For the protection of human health from the toxic properties of selenium, ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.010 mg/l. Available data show that adverse effects on aquatic life occur at concentrations higher than that cited for human toxicity.

Very few data are available regarding the behavior of selenium in POTWs. One EPA survey of 103 POTWs revealed one POTW using biological treatment and having selenium in the influent. The influent concentration was 0.0025 mg/l, while the effluent concentration was 0.0016 mg/l giving a removal of 37 percent. Selenium is not known to be inhibitory to POTW processes. In another study, sludge from POTWs in 16 cities was found to contain from 1.8 to 8.7 mg/kg selenium, compared to 0.01 to 2 mg/kg in untreated soil. These concentrations of selenium in sludge present a potential hazard for humans or other mammuals eating crops grown on soil treated with selenium-containing sludge.

Silver(126). Silver is a soft, lustrous, white metal that is insoluble in water and alkali. In nature, silver is found in the elemental state (native silver) and combined in ores such as argentite (Ag_2S), horn silver (AgCl), proustite (Ag_3AsS_3), and pyrargyrite (Ag_3SbS_3). Silver is used extensively in several industries, among them electroplating.

Metallic silver is not considered to be toxic, but most of its salts are toxic to a large number of organisms. Upon ingestion by humans, many silver salts are absorbed in the circulatory system and deposited in various body tissues, resulting in generalized or sometimes localized gray pigmentation of the skin and mucous membranes know as argyria. There is no known method for removing silver from the tissues once it is deposited, and the effect is cumulative.

Silver is recognized as a bactericide and doses from 1×10^{-6} to 5×10^{-4} mg/l have been reported as sufficient to sterilize water. The criterion for ambient water to protect human health from the toxic properties of silver, ingested through water and through contaminated aquatic organisms, is 0.05 mg/l. Available data show that adverse effects on aquatic life occur at total recoverable silver concentrations as low as 1.2×10^{-3} mg/l.

The chronic toxic effects of silver on the aquatic environment have not been given as much attention as many other heavy metals. Data from existing literature support the fact that silver is very toxic to aquatic organisms. Despite the fact that silver is nearly the most toxic of the heavy metals, there are insufficient

data to adequately evaluate even the effects of hardness on silver toxicity. There are no data available on the toxicity of different forms of silver.

There is no available literature on the incidental removal of silver by POTWs. An incidental removal of about 50 percent is assumed as being representative. This is the highest average incidental removal of any metal for which data are available. (Copper has been indicated to have a median incidental removal rate of 49 percent).

Bioaccumulation and concentration of silver from sewage sludge has not been studied to any great degree. There is some indication that silver could be bioaccumulated in mushrooms, to the extent that there could be adverse physiological effects on humans if they consumed large quantities of mushrooms grown in silver enriched soil. The effect, however, would tend to be unpleasant rather than fatal.

There is little summary data available on the quantity of silver discharged to POTWs. Presumably, there would be a tendency to limit its discharge from a manufacturing facility because of its high intrinsic value.

Thallium (127). Thallium (Tl) is a soft, silver-white, dense, malleable metal. Five major minerals contain 15 to 85 percent thallium, but they are not of commerical importance, because the metal is produced in sufficient quantity as a by-product of lead-zinc smelting of sulfide ores. Thallium melts at 304°C. U.S. annual production of thallium and its compounds is estimated to be 1500 pounds.

Industrial uses of thallium include the manufacture of alloys, electronic devices and special glass. Thallium catalysts are used for industrial organic syntheses.

Acute thallium poisoning in humans has been widely described. Gastrointestinal pains and diarrhea are followed by abnormal sensations in the legs and arms, dizziness, and, later, loss of hair. The central nervous system is also affected. Somnolence, delerium or coma may occur. Studies on the teratogenicity of thallium appear inconclusive; no studies on mutagenicity were found; and no published reports on carcinogenicity of thallium were found.

For the protection of human health from the toxic properties of thallium, ingested through water and contaminated aquatic organisms, the ambient water criterion is 0.004 mg/l.

No reports were found regarding the behavior of thallium in POTWs. It will not be degraded, therefore it must pass through to the effluent or be removed with the sludge. However, since the sulfide (TlS) is very insoluble, if appreciable sulfide is present, dissolved thallium in the influent to POTWs may be precipitated into the sludge. Subsequent use of sludge bearing thallium compounds, as a soil amendment to crop bearing soils, may result in uptake of this element by food plants. Several leafy garden crops (cabbage, lettuce, leek, and endive) exhibit relatively higher concentrations of thallium than other foods such as meat.

Zinc(128). Zinc occurs abundantly in the earth's crust, concentrated in ores. It is readily refined into the pure, stable, silvery-white metal. In addition to its use in alloys, zinc is used as a protective coating on steel. It is applied by hot dipping (i.e. dipping the steel in molten zinc) or by electroplating. The resulting galvanized steel is used as one of the basis materials for coil coating. Zinc salts are also used in conversion coatings in the coil coating industry.

Zinc can have an adverse effect on man and animals at high concentrations. Zinc at concentrations in excess of 5 mg/l causes an undesirable taste, which persists through conventional treatment. For the prevention of adverse effects due to these organoleptic properties of zinc, 5 mg/l was adopted for the ambient water criterion.

Toxic concentrations of zinc compounds cause adverse changes in the morphology and physiology of fish. Lethal concentrations in the range of 0.1 mg/l have been reported. Acutely toxic concentrations induce cellular breakdown of the gills, and possibly the clogging of the gills with mucous. Chronically toxic concentrations of zinc compounds cause general enfeeblement and widespread histological changes to many organs, but not to gills. Abnormal swimming behavior has been reported at 0.04 mg/l. Growth and maturation are retarded by zinc. It has been observed that the effects of zinc poisoning may not become apparent immediately, so that fish removed from zinc-contaminated water may die as long as 48 hours after removal.

In general, salmonoids are most sensitive to elemental zinc in soft water; the rainbow trout is the most sensitive in hard waters. A complex relationship exists between zinc concentration, dissolved zinc concentration, pH, temperature, and calcium and magnesium concentrations. Prediction of harmful effects has been less than reliable and controlled studies have not been extensively documented.

The major concern with zinc compounds in marine waters is not with acute lethal effects, but rather with the long-term sublethal effects of the metallic compounds and complexes. Zinc accumulates in some marine species, and marine animals contain zinc in the range of 6 to 1500 mg/kg. From the point of view of acute lethal effects, invertebrate marine animals seem to be the most sensitive organism tested.

Toxicities of zinc in nutrient solutions have been demonstrated for a number of plants. A variety of fresh water plants tested manifested harmful symptoms at concentrations of 10 mg/l. Zinc sulfate has also been found to be lethal to many plants, and it could impair agricultural uses of the water.

Zinc is not destroyed when treated by POTWs, but will either pass through to the POTW effluent or be retained in the POTW sludge. It can interfere with treatment processes in the POTW and can also limit the usefulness of municipal sludge.

In slug doses, and particularly in the presence of copper, dissolved zinc can interfere with or seriously disrupt the operation of POTW biological processes by reducing overall removal efficiencies, largely as a result of the toxicity of the metal to biological organisms. However, zinc solids in the form of hydroxides or sulfides do not appear to interfere with biological treatment processes, on the basis of available data. Such solids accumulate in the sludge.

The influent concentrations of zinc to POTW facilities have been observed by the EPA to range from 0.017 to 3.91 mg/l, with a median concentration of 0.33 mg/l. Primary treatment is not efficient in removing zinc; however, the microbial floc of secondary treatment readily adsorbs zinc.

In a study of 258 POTWs, the median pass through values were 70 to 88 percent for primary plants, 50 to 60 percent for trickling filter and biological process plants, and 30 to 40 percent for activated process plants. POTW effluent concentrations of zinc ranged from 0.003 to 3.6 mg/l (mean = 0.330, standard deviation = 0.464).

The zinc which does not pass through the POTW is retained in the sludge. The presence of zinc in sludge may limit its use on cropland. Sewage sludge contains 72 to over 30,000 mg/kg of zinc, with 3,366 mg/kg as the mean value. These concentrations are significantly greater than those normally found in soil, which range from 0 to 195 mg/kg, with 94 mg/kg being a common level. Therefore, application of sewage sludge to soil will generally increase the concentration of zinc in the soil. Zinc

can be toxic to plants, depending upon soil pH. Lettuce, tomatoes, turnips, mustard, kale, and beets are especially sensitive to zinc contamination.

Xylene. Xylene (C_6H_4 $(CH_3)_2$) is a colorless flammable liquid with a density of 0.86 g/ml. The boiling point ranges from 137 to 140°C, and the flash point is 29°C. Xylene is practically insoluble in water, but it is miscible with alcohol, ether, and many other organic liquids. Xylene is commonly a mixture of three isomers, ortho, meta, and para-xylene, with m-xylene predominating. Xylene is manufactured from pseudocumene, or by catalytic isomerization of a hydrocarbon fraction.

Xylene is predominately used as a solvent, for the manufacure of dyes and other organics, and as a raw material for production of benzoic acid, phthalic anhydride and other acids and esters used in the manufacture of polyester fibers.

Xylene has been shown to have a narcotic effect on humans exposed to high concentrations. The chronic toxicity of xylene has not been defined, however, it is less toxic than benzene.

Data on the behavior of xylene in POTWs are not available. However, the methyl groups in xylene tend to transfer electrons to the benzene ring and make it more susceptible to biochemical oxidation. This observation, in addition to the low water solubility of xylene, leads to the expectation that aeration processes will remove some xylene from the POTW.

Ammonia. Ammonia (chemical formula NH_3) is a non-conventional pollutant. It is a colorless gas with a very pungent odor, detectable at concentrations of 20 ppm in air by the nose, and is very soluble in water (570 gm/l at 25°C). Ammonia is produced industrially in very large quantities (nearly 20 million tons annually in the U.S.). It is converted to ammonium compounds or shipped in the liquid form (it liquifies at -33°C). Ammonia also results from natural processes. Bacterial action on nitrates or nitrites, as well as dead plant and animal tissue and animal wastes produces ammonia. Typical domestic wastewaters contain 12 to 50 mg/l ammonia.

The principal use of ammonia and its compounds is as a fertilizer. High amounts are introduced into soils and the water runoff from agricultural land by this use. Smaller quantities of ammonia are used as a refrigerant. Aqueous ammonia (2 to 5 percent solution) is widely used as a household cleaner. Ammonium compounds find a variety of uses in various industries.

Ammonia is toxic to humans by inhalation of the gas or ingestion of aqueous solutions. The ionized form (NH_4^+) is less toxic than the unionized form. Ingestion of as little as one ounce of household ammonia has been reported as a fatal dose. Whether inhaled or ingested, ammonia acts destructively on mucous membrane with resulting loss of function. Aside from breaks in liquid ammonia refrigeration equipment, industrial hazard from ammonia exists where solutions of ammonium compounds may be accidently treated with a strong alkali, releasing ammonia gas. As little as 150 ppm ammonia in air is reported to cause laryngeal spasm, and inhalation of 5000 ppm in air is considered sufficient to result in death.

Freshwater ambient water criteria for total ammonia are pH and temperature dependent; un-ionized ammonia criteria is 0.02 mg/l. The reported odor threshold for ammonia in water is 0.037 mg/l. Un-ionized ammonia is acutely or chronically toxic to many important freshwater and marine aquatic organisms at ambient water concentrations below 4.2 mg/l. Salmonoid fishes are especially sensitive to the toxic effects of un-ionized ammonia at concentrations as low as 0.025 mg/l during prolonged exposure. Because the proportion of un-ionized ammonia varies with environmental conditions, and cannot be directly controlled in the ambient water, total ammonia is the pollutant which must be controlled.

The behavior of ammonia in POTWs is well documented, because it is a natural component of domestic wastewaters. Only very high concentrations of ammonia compounds could overload POTWs. One study has shown that concentrations of un-ionized ammonia greater than 90 mg/l reduce gasification in anaerobic digesters, and concentrations of 140 mg/l stop digestion completely. Corrosion of copper piping and excessive consumption of chlorine also result from high ammonia concentrations. Interference with aerobic nitrification processes can occur when large concentrations of ammonia suppress dissolved oxygen. Nitrites are then produced instead of nitrates. Elevated nitrite concentrations in drinking water are known to cause infant methemoglobinemia.

Fluoride. Fluoride ion (F^-) is a non-conventional pollutant. Fluorine is an extremely reactive, pale yellow, gas which is never found free in nature. Compounds of fluorine - fluorides - are found widely distributed in nature. The principal minerals containing fluorine are fluorspar (CaF_2) and cryolite (Na_3AlF_6). Although fluorine is produced commercially in small quantities by electrolysis of potassium bifluoride in anhydrous hydrogen fluoride, the elemental form bears little relation to the combined ion. Total production of fluoride chemicals in the U.S.

is difficult to estimate because of the varied uses. Large volume usage compounds are: calcium fluoride (est. 1,500,000 tons in U.S.) and sodium fluoroaluminate (est. 100,000 tons in U.S.). Some fluoride compounds and their uses are: sodium fluoroaluminate - aluminum production; calcium fluoride - steelmaking, hydrofluoric acid production, enamel, iron foundry; boron trifluoride - organic synthesis; antimony pentafluoride - fluorocarbon production; fluoboric acid and fluoborates - electroplating; perchloryl fluoride (ClO_3F) - rocket fuel oxidizer; hydrogen fluoride - organic fluoride manufacture, pickling acid in stainless steelmaking, manufacture of alumium fluoride; sulfur hexafluoride - insulator in high voltage transformers; polytetrafluoroethylene - inert plastic. Sodium fluoride is used at a concentration of about 1 ppm in many public drinking water supplies to prevent tooth decay in children.

The toxic effects of fluoride on humans include severe gastroenteritis, vomiting, diarrhea, spasms, weakness, thirst, failing pulse and delayed blood coagulation. Most observations of toxic effects are made on individuals who intentionally or accidentally ingest sodium fluoride intended for use as rat poison or insecticide. Lethal doses for adults are estimated to be as low as 2.5 g. At 1.5 ppm in drinking water, motling of tooth enamel is reported, and 14 ppm, consumed over a period of years, may lead to deposition of calcium fluoride in bone and tendons.

Very few data are available on the behavior of fluoride in POTWs. Under usual operating conditions in a POTW, fluorides pass through into the effluent. Very little of the fluoride entering conventional primary and secondary treatment processes is removed. In one study of POTW influents conducted by the U.S. EPA, nine POTWs reported concentrations of fluoride ranging from 0.7 mg/l to 1.2 mg/l, which is the range of concentrations used for fluoridated drinking water.

Iron. Iron is a non-conventional pollutant. It is an abundant metal found at many places in the earth's crust. The most common iron ore is hematite (Fe_2O_3), from which iron is obtained by reduction with carbon. Other forms of commercial ores are magnetite (Fe_3O_4) and taconite (FeSiO). Pure iron is not often found in commercial use, but it is usually alloyed with other metals and minerals. The most common of these is carbon.

Iron is the basic element in the production of steel. Iron with carbon is used for casting of major parts of machines and it can be machined, cast, formed, and welded. Ferrous iron is used in paints, while powdered iron can be sintered and used in powder metallurgy. Iron compounds are also used to precipitate other

metals and undesirable minerals from industrial wastewater streams.

Corrosion products of iron in water cause staining of porcelain fixtures, and ferric iron combines with tannin to produce a dark violet color. The presence of excessive iron in water discourages cows from drinking and thus reduces milk production. High concentrations of ferric and ferrous ions in water kill most fish introduced to the solution within a few hours. The killing action is attributed to coatings of iron hydroxide precipitates on the gills. Iron oxidizing bacteria are dependent on iron in water for growth. These bacteria form slimes that can affect the aesthetic values of bodies of water and cause stoppage of flows in pipes.

Iron is an essential nutrient and micro-nutrient for all forms of growth. Drinking water standards in the U.S. set a limit of 0.3 mg/l of iron in domestic water supplies, based on aesthetic and organoleptic properties of iron in water.

High concentrations of iron do not pass through a POTW into the effluent. In some POTWs iron salts are added to coagulate precipitates and suspended sediments into a sludge. In an EPA study of POTWs the concentration of iron in the effluent of 22 biological POTWs meeting secondary treatment performance levels ranged from 0.048 to 0.569 mg/l with a median value of 0.25 mg/l. This represented removals of 76 to 97 percent with a median of 87 percent removal.

Iron in sewage sludge spread on land used for agricultural purposes is not expected to have a detrimental effect on crops grown on the land.

Manganese. Manganese is a non-conventional pollutant. It is a gray-white metal resembling iron, but more brittle. The pure metal does not occur in nature, but must be produced by reduction of the oxide with sodium, magnesium, or aluminum, or by electrolysis. The principal ores are pyrolusite (MnO_2) and psilomelane (a complex mixture of MnO_2 and oxides of potassium, barium and other alkali and alkaline earth metals). The largest percentage of manganese used in the U.S. is in ferro-manganese alloys. A small amount goes into dry batteries and chemicals.

Manganese is not often present in natural surface waters because its hydroxides and carbonates are only sparingly soluble.

Manganese is undesirable in domestic water supplies because it causes unpleasant tastes, deposits on food during cooking, stains and discolors laundry and plumbing fixtures, and fosters the

growth of some microorganisms in reservoirs, filters, and distribution systems.

Small concentratons of 0.2 to 0.3 mg/l of manganese may cause the formation of heavy encrustations in piping. Excessive manganese is also undesirable in water for use in many industries, including textiles, dyeing, food processing, distilling, brewing, ice, and paper.

The recommended limitation for manganese in drinking water in the U.S. is 0.05 mg/l. The limit appears to be based on aesthetic and economic factors rather than physiological hazards. Most investigators regard manganese to be of no toxicological significance in drinking water at concentrations not causing unpleasant tastes. However, cases of manganese poisoning have been reported in the literature. A small outbreak of encephalitis - like disease, with early symptoms of lethargy and edema, was traced to manganese in the drinking water in a village near Tokyo. Three persons died as a result of poisoning by well water contaminated by manganese derived from dry-cell batteries buried nearby. Excess manganese in the drinking water is also believed to be the cause of a rare disease in Northeastern China.

No data were found regarding the behavior of manganese in POTWs. However, one source reports that typical mineral pickup from domestic water use results in an increase in manganese concentration of 0.2 to 0.4 mg/l in a municipal sewage system. Therefore, it is expected that interference in POTWs, if it occurs, would not be noted until manganese concentrations exceeded 0.4 mg/l.

Phenols(Total). "Total Phenols" is a non-conventional pollutant parameter. Total phenols is the result of analysis using the 4-AAP (4-aminoantipyrene) method. This analytical procedure measures the color development of reaction products between 4-AAP and some phenols. The results are reported as phenol. Thus "total phenol" is not total phenols, because many phenols (notably nitrophenols) do not react. Also, since each reacting phenol contributes to the color development to a different degree, and each phenol has a molecular weight different from others and from phenol itself, analyses of several mixtures containing the same total concentration in mg/l of several phenols will give different numbers, depending on the proportions in the particular mixture.

Despite these limitations of the analytical method, total phenols is a useful parameter when the mix of phenols is relatively constant and an inexpensive monitoring method is desired. In any given plant or even in an industry subcategory, monitoring of

"total phenols" provides an indication of the concentration of this group of priority pollutants, as well as those phenols not selected as priority pollutants. A further advantage is that the method is widely used in water quality determinations.

In an EPA survey of 103 POTWs the concentration of "total phenols" ranged grom 0.0001 mg/l to 0.176 mg/l in the influent, with a median concentration of 0.016 mg/l. Analysis of effluents from 22 of these same POTWs, which had biological treatment meeting secondary treatment performance levels, showed "total phenols" concentrations ranging from 0 mg/l to 0.203 mg/l with a median of 0.007. Removals were 64 to 100 percent with a median of 78 percent.

It must be recognized, however, that six of the eleven priority pollutant phenols could be present in high concentrations and not be detected. Conversely, it is possible, but not probable, to have a high "total phenol" concentration without having any phenol itself or any of the ten other priority pollutant phenols present. A characterization of the phenol mixture to be monitored to establish constancy of composition will allow "total phenols" to be used with confidence.

Sulfides

Sulfides are oxidizable and therefore can exert an oxygen demand on the receiving stream. Their presence, in amounts which consume oxygen at a rate exceeding the oxygen uptake of the stream, can produce a condition of insufficient dissolved oxygen in the receiving water. Sulfides also impart an unpleasant taste and odor to the water and can render the water unfit for other uses.

Sulfides are constituents of many industrial wastes such as those from tanneries, paper mills, chemical plants, and gas works; but they are also generated in sewage and some natural waters by the anaerobic decomposition of organic matter. When added to water, soluble sulfide salts such as Na_2S dissociate into sulfide ions which, in turn, react with the hydrogen ions in the water to form HS^- or H_2S, the proportion of each depending upon the resulting pH value. Thus, when reference is made to sulfides in water, the reader should bear in mind that the sulfide is probably in the form of HS^- or H_2S.

Owing to the unpleasant taste and odor which results when sulfides occur in water, it is unlikely that any person or animal will consume a harmful dose. The thresholds of taste and smell were reported to be 0.2 mg/l of sulfides in pulp mill wastes. For industrial uses, however, even small traces of sulfides are

often detrimental. Sulfides are of little importance in irrigation waters.

The toxicity of solutions of sulfides toward fish increases as the pH value is lowered, i.e., the H_2S or HS- rather than the sulfide ion, appears to be the principle toxic agent. In water containing 3.2 mg/l of sodium sulfide, trout overturned in two hours at pH 9.0, in ten minutes at pH 7.8, and in four minutes at pH 6.0. Inorganic sulfides have proved to be fatal to sensitive fish such as trout at concentrations between 0.5 and 1.0 mg/l as sulfide, even in neutral and somewhat alkaline solutions.

Oil and Grease. Oil and grease are taken together as one pollutant parameter. This is a conventional pollutant and some of its components are:

1. Light Hydrocarbons - These include light fuels such as gasoline, kerosene, and jet fuel, and miscellaneous solvents used for industrial processing, degreasing, or cleaning purposes. The presence of these light hydrocarbons may make the removal of other heavier oil wastes more difficult.

2. Heavy Hydrocarbons, Fuels, and Tars - These include the crude oils, diesel oils, #6 fuel oil, residual oils, slop oils, and in some cases, asphalt and road tar.

3. Lubricants and Cutting Fluids - These generally fall into two classes: non-emulsifiable oils such as lubricating oils and greases and emulsifiable oils such as water soluble oils, rolling oils, cutting oils, and drawing compounds. Emulsifiable oils may contain fat soap or various other additives.

4. Vegetable and Animal Fats and Oils - These originate primarily from processing of foods and natural products.

These compounds can settle or float and may exist as solids or liquids depending upon factors such as method of use, production process, and temperature of wastewater.

Oils and greases, even in small quantities, cause troublesome taste and odor problems. Scum lines from these agents are produced on water treatment basin walls and other containers. Fish and water fowl are adversely affected by oils in their habitat. Oil emulsions may adhere to the gills of fish causing suffocation, and the flesh of fish is tainted when microorganisms that were exposed to waste oil are eaten. Deposition of oil in

the bottom sediments of water can serve to inhibit normal benthic growth. Oil and grease exhibit an oxygen demand.

Many of the organic priority pollutants will be found distributed between the oily phase and the aqueous phase in industrial wastewaters. The presence of phenols, PCBs, PAHs, and almost any other organic pollutant in the oil and grease make characterization of this parameter almost impossible. However, all of these other organics add to the objectionable nature of the oil and grease.

Levels of oil and grease which are toxic to aquatic organisms vary greatly, depending on the type and the species' susceptibility. However, it has been reported that crude oil, in concentrations as low as 0.3 mg/l, is extremely toxic to fresh-water fish. It has been recommended that public water supply sources be essentially free from oil and grease.

Oil and grease in quantities of 100 l/sq km show up as a sheen on the surface of a body of water. The presence of oil slicks decreases the aesthetic value of a waterway.

Oil and grease is compatible with a POTW activated sludge process in limited quantity. However, slug loadings or high concentrations of oil and grease interfere with biological treatment processes. The oils coat surfaces and solid particles, preventing access of oxygen, and sealing in some microorganisms. Land spreading of POTW sludge, containing oil and grease uncontaminated by toxic pollutants, is not expected to affect crops grown on the treated land, or animals eating those crops.

pH. Although not a specific pollutant, pH is related to the acidity or alkalinity of a wastewater stream. It is not, however, a measure of either. The term pH is used to describe the hydrogen ion concentration (or activity) present in a given solution. Values for pH range from 0 to 14, and these numbers are the negative logarithms of the hydrogen ion concentrations. A pH of 7 indicates neutrality. Solutions with a pH above 7 are alkaline, while those solutions with a pH below 7 are acidic. The relationship of pH and acidity and alkalinity is not necessarily linear or direct. Knowledge of the water pH is useful in determining necessary measures for corrosion control, sanitation, and disinfection. Its value is also necessary in the treatment of industrial wastewaters, to determine amounts of chemicals required to remove pollutants, and to measure their effectiveness. Removal of pollutants, especially dissolved solids, is affected by the pH of the wastewater.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add constituents to drinking water such as iron, copper, zinc, cadmium, and lead. The hydrogen ion concentration can affect the taste of the water, and at a low pH, water tastes sour. The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7.0. This is significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Even moderate changes from acceptable criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. For example, metallocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units.

Because of the universal nature of pH and its effect on water quality and treatment, it is selected as a pollutant parameter for all subcategories in the metal molding and casting industry. A neutral pH range (approximately 6-9) is generally desired, because either extreme beyond this range has a deleterious effect on receiving waters or the pollutant nature of other wastewater constituents.

Pretreatment for regulation of pH is covered by the "General Pretreatment Regulations for Existing and New Sources of Pollution," 40 CFR 403.5. This section prohibits the discharge to a POTW of "pollutants which will cause corrosive structural damage to the POTW, but in no case discharges with pH lower than 5.0, unless the works is specially designed to accommodate such discharges."

Total Suspended Solids(TSS). Suspended solids include both organic and inorganic materials. The inorganic compounds include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, and animal and vegetable waste products. These solids may settle out rapidly, and bottom deposits are often a mixture of both organic and inorganic solids. Solids may be suspended in water for a time and then settle to the bed of the stream or lake. These solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, suspended solids increase the turbidity of the water, reduce light penetration, and impair the photosynthetic activity of aquatic plants.

Suspended solids in water interfere with many industrial processes and cause foaming in boilers and encrustations on

equipment exposed to such water, especially as the temperature rises. They are undesirable in process water used in the manufacture of steel, in the textile industry, in laundries, in dyeing, and in cooling systems.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often damaging to the life in the water. Solids, when transformed to sludge deposit, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a food source for sludgeworms and associated organisms.

Disregarding any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries and by clogging the gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids are inimical to aquatic life, because they screen out light, and they promote and maintain the development of noxious conditions through oxygen depletion. This results in the killing of fish and fish food organisms. Suspended solids also reduce the recreational value of the water.

Total suspended solids is a traditional pollutant which is compatible with a well-run POTW. This pollutant with the exception of those components which are described elsewhere in this section, e.g., heavy metal components, does not interfere with the operation of a POTW. However, since a considerable portion of the innocuous TSS may be inseparably bound to the constituents which do interfere with POTW operation, or produce unusable sludge, or subsequently dissolve to produce unacceptable POTW effluent, TSS may be considered a toxic waste hazard.

REGULATION OF SPECIFIC POLLUTANTS

Discussions of individual pollutants selected or not selected for consideration for specific regulation are based on concentrations obtained from sampling and analysis of raw wastewater streams from six subcategories.

Aluminum Casting Subcategory

Pollutants Considered for Specific Regulation in the Aluminum Casting Subcategory

Based on sampling results and examination of the aluminum casting subcategory manufacturing processes and raw materials, forty-one pollutants were selected for consideration for specific regulation through effluent limitations and standards for this subcategory. These pollutants were found in raw wastewaters from processes in this subcategory and are amenable to control by identified wastewater treatment practices (e.g. activated carbon adsorption, chemical precipitation-sedimentation). Discussions of each of these pollutants follow.

Acenaphthene (1) values were detected on 6 of the 21 sampling days in this subcategory. The maximum concentration in this subcategory was 0.38 mg/l. Some of the concentrations are above the treated effluent level achievable with available specific treatment methods. This pollutant may be found in the leakages, which subsequently contaminate process wastewaters, from die casting operations.

Benzidine (5) values were detected on 1 of the 21 sampling days in this subcategory. The concentration found on this day was 2.76 mg/l, a value substantially greater than the treated effluent levels achievable with available treatment methods.

Carbon tetrachloride (6) values were detected on 11 of the 21 sampling days in this subcategory. The maximum concentration found in this subcategory was 0.25 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant is used in metal degreasing and as a general solvent in process solutions.

Chlorobenzene (7) values were detected on 2 of the 21 sampling days in this subcategory. The maximum concentration found was 0.59 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is associated with the process solutions used in this subcategory.

1,2-dichloroethane (10) values were detected on 4 of the 21 sampling days in this subcategory. The maximum concentration found was 0.33 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant is used as a solvent for

various process solutions, as a metal degreasing agent, and as a wetting or penetrating agent.

1,1,1-trichloroethane (11) values were detected on 9 of the 21 sampling days in this subcategory. The maximum concentration found was 16.95 mg/l. This pollutant's presence is associated with the process solutions used in this subcategory.

1,1-dichloroethane (13) values were detected on 1 of the 21 sampling days in this subcategory. The maximum concentration found was 0.105 mg/l. This pollutant is used as a solvent in process solutions.

2,4,6-trichlorophenol (21) values were detected on 13 of the 21 sampling days in this subcategory. The maximum concentration found was 2.0 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant is used as an agent to control biological growth in various process solutions.

Parachlorometacresol (22) values were detected on 7 of the 21 sampling days in this subcategory. The maximum concentration found was 0.925 mg/l. Some of these concentrations are well above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of this pollutant is associated with the contamination of process waters with process equipment lubricants and fluids.

Chloroform (23) values were detected on all 21 sampling days in this subcategory. The maximum concentration found was 0.46 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant is used as a general solvent in this and other subcategories.

2,4-dichlorophenol (31) values were detected on 8 of the 21 sampling days in this subcategory. The maximum concentration found was 0.15 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is related to the solutions used in processes and process equipment in this subcategory.

Fluoranthene (39) values were detected on 15 of the 21 sampling days in this subcategory. The maximum concentration found was 5.8 mg/l. Some of the concentrations are substantially above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is related to the process solutions used in this subcategory.

Methylene chloride (44) values were detected on 16 of the 21 sampling days in this subcategory. The maximum concentration found was 2.46 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels attainable with available specific treatment methods. The presence of this pollutant is related to its use in various process solutions.

Naphthalene (55) values were detected on 8 of the 21 sampling days in this subcategory. The maximum concentration found was 2.87 mg/l. Some of these concentrations are well above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant's presence is related to the process solutions used.

4-nitrophenol (58) values were detected on 1 of the 21 sampling days in this subcategory. The concentration found on this day was 0.45 mg/l, a concentration above the optimum expected 30-day average treated effluent level achievable with available treatment methods. The presence of this pollutant is related to the solutions used in the processes.

N-nitrosodi-n-propylamine (63) values were detected on 2 of the 21 sampling days in this subcategory. The maximum concentration found was 0.078 mg/l. This pollutant's presence is associated with the process solutions used in this subcategory.

Pentachlorophenol (64) values were detected on 2 of the 21 sampling days in this subcategory. The maximum concentration found was 3.05 mg/l. Some of the concentrations are substantially above the treated effluent levels achievable with available specific treatment methods. This pollutant is used as an agent to control biological growth in process solutions. This pollutant's presence may also be related to the contamination of process wastewaters with process equipment fluids and lubricants.

Phenol (65) values were detected on 15 of the 21 sampling days in this subcategory. The maximum concentration found was 36.0 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant is present as a major component of various process solutions and of process equipment fluids.

Bis(2-ethylhexyl)phthalate (66) values were detected on all 21 sampling days in this subcategory. The maximum concentration found was 482.4 mg/l. Some of the concentrations are substantially above the treated effluent levels achievable with

available specific treatment methods. This pollutant's presence can be related to the solutions used in the processes and to the fluids used in process equipment.

Butyl benzyl phthalate (67) values were detected on 12 of the 21 sampling days in this subcategory. The maximum concentration found was 2.0 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels attainable with available specific treatment methods. The presence of this pollutant can also be associated with the solutions used in the processes and with the fluids used in process equipment.

Benzo(a)anthracene (72) values were detected on 6 of the 21 sampling days in this subcategory. The maximum concentration found was 22.54 mg/l. Some of the concentrations are substantially above the treated effluent levels achievable with available specific treatment methods. This pollutant can be found in the solutions used in this subcategory's processes.

Benzo(a)pyrene (73) values were detected on 5 of the 21 sampling days in this subcategory. The maximum concentration found was 0.16 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. As with benzo(a)anthracene, this pollutant can be found in process solutions.

Chrysene (76) values were detected on 9 of the 21 sampling days in this subcategory. The maximum concentration found was 19.0 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is related to the process solutions used in this subcategory.

Acenaphthylene (77) values were detected on 8 of the 21 sampling days in this subcategory. The maximum concentration found was 1.64 mg/l. Some of these concentrations are well above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of this pollutant can be attributed to the process solutions used.

Anthracene (78) values were detected on 9 of the 21 sampling days in this subcategory. The maximum concentration found was 1.35 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available specific treatment methods. This pollutant can be found in process solutions used in this subcategory.

Fluorene (80) values were detected on 10 of the 21 sampling days in this subcategory. The maximum concentration found was 7.27 mg/l. Some of the concentrations are substantially above the treated effluent levels achievable with available specific treatment methods. Fluorene can be found in various process solutions (e.g., die lubes).

Phenanthrene (81) values were detected on 9 of the 21 sampling days in this subcategory. The maximum concentration found was 1.35 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence in process wastewaters is attributable to its presence in process solutions.

Pyrene (84) values were detected on 15 of the 21 sampling days in this subcategory. The maximum concentration found was 0.69 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. Pyrene can be found in many of the process solutions used by plants in this subcategory.

Tetrachloroethylene (85) values were detected on 14 of the 21 sampling days in this subcategory. The maximum concentration found was 0.255 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. The presence of this pollutant in this subcategory's wastewaters is related to its use as a solvent and as a drying agent for metals.

Trichloroethylene (87) values were detected on 14 of the 21 sampling days in this subcategory. The maximum concentration found was 0.328 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence results from its use as a solvent in process solutions and for metal degreasing.

Chlordane (91) values were detected on 6 of the 13 sampling days in this subcategory. The maximum concentration found was 0.24 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. Although most commonly known as a pesticide, chlordane is also used in oil emulsions and dispersible liquids. These latter two uses are related to the process solutions of this subcategory.

Xylene (130) values were detected on 6 of the 21 sampling days in this subcategory. The maximum concentration found was 70.09 mg/l. Some of the concentrations are substantially above the treated effluent levels achievable with available specific

treatment methods. This pollutant is used as both a protective coating and a solvent in process solutions.

Copper (120) values were detected on all 14 sampling days in this subcategory. The maximum concentration found was 1.11 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of copper in process wastewaters is related to its use as an alloying material, as well as to its use in various items of process equipment (dies, etc.).

Lead (122) values were detected on all 20 sampling days in this subcategory. The maximum concentration found was 3.9 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. Lead contamination in process wastewaters results from the presence of lead in process equipment and facilities.

Zinc (128) values were detected on all 20 sampling days in this subcategory. The maximum concentration found was 9.1 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. Zinc's presence as a process wastewater contaminant is related to its use as an alloying material, as well as to its use in process equipment and facilities.

Total suspended solids (TSS) values were found on all 20 sampling days at concentrations as high as 1632.7 mg/l. These TSS concentrations are above the treated effluent levels achievable with available treatment technologies. In addition, the control of TSS in wastewater discharges will also result in the control, to a certain extent, of several toxic pollutants. Consequently, TSS is considered for specific regulation in this subcategory.

Oil and grease values were detected on all 20 sampling days. The maximum concentration found was 23,273 mg/l. Oils and greases, as process wastewater pollutants, originate in the solutions, products, and scrap used in this subcategory's processes. As many of the concentrations are greater than the treated effluent levels typically achievable, oil and grease is considered for specific regulation in this subcategory.

pH can be controlled within the limits of 7.5 to 10.0 with available specific treatment methods and is, therefore, considered for specific regulation in this subcategory.

Ammonia values were detected on all 20 sampling days. The maximum concentration found was 25.2 mg/l. As a number of the concentrations are greater than the treated effluent levels

attainable with available treatment technologies, ammonia is considered for specific regulation in this subcategory. Ammonia can result from the biological degradation of organic constituents in the process solutions.

Sulfide values were detected on all 20 sampling days. The maximum level detected was 37.0 mg/l. As many of these values are greater than the treated effluent levels achievable with specific available treatment methods, sulfide is considered for specific regulation in this subcategory. Sulfide can be generated as a result of the biological degradation of process solution organic compounds.

Phenols values were detected on all 20 of the sampling days in this subcategory. The maximum concentration found was 88.41 mg/l. Some of the concentrations are substantially above the treated effluent levels achievable with available specific treatment methods. This pollutant, detected by wet chemistry techniques (4AAP), encompasses a variety of the individual phenolic compounds. This pollutant's presence in process wastewaters is related to the constituents of process solutions.

Pollutants Not Considered for Specific Regulation in the Aluminum Casting Subcategory

A total of ninety-six pollutants that were evaluated were eliminated from further consideration for specific regulation in the aluminum casting subcategory. Forty pollutants were dropped from further consideration, because their presence in raw process wastewater was not detected in this subcategory. Nineteen pollutants were eliminated from further consideration, because the concentrations of these pollutants were less than the analytically quantifiable limits.

The remaining thirty-seven pollutants were found to be present infrequently or found at levels below those usually achieved by end-of-pipe treatment technologies. Discussions of these pollutants follow.

Benzene (4) concentrations appeared on 16 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.335 mg/l. Eleven concentrations are lower than the analytical quantification limit. Three of the remaining five concentrations are lower than the level considered to be achievable with available specific treatment methods. However, all five concentrations are lower than the level considered likely to cause toxic effects in humans. Therefore, benzene is not considered for specific regulation in this subcategory.

1,1,2,2-tetrachloroethane (15) concentrations appeared on 3 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.013 mg/l. One concentration is below the analytically quantifiable limit. The maximum concentration is less than the concentration achievable by specific treatment methods. Therefore, this pollutant is not considered for specific regulation in this subcategory.

Bis(2-chloroethyl)ether (18) concentrations appeared on 1 of 21 process sampling days in the aluminum subcategory. The concentration was 0.024 mg/l. Because this toxic pollutant was found at only one plant, bis(2-chloroethyl)ether is not considered for specific regulation in this subcategory.

2-chlorophenol (24) concentrations appeared on 4 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.235 mg/l. Two concentrations are below the analytically quantifiable limit. Another concentration is lower than the level considered to be achievable by specific treatment methods. Because this toxic pollutant was found on only one process sampling day at a level considered to be achievable with available specific treatment methods, 2-chlorophenol is not considered for specific regulation in this subcategory.

2,4-dimethylphenol (34) concentrations appeared on 9 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.13 mg/l. Five concentrations are below the analytical quantification limit. Two other concentrations are lower than the level considered to be achievable by specific treatment methods. The two remaining concentrations are lower than the level considered to cause toxic effects in humans. Therefore, 2,4-dimethylphenol is not considered for specific regulation in this subcategory.

Ethylbenzene (38) concentrations appeared on 6 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.033 mg/l. Five concentrations are below the analytically quantifiable limit. The maximum concentration is below the level considered to be achievable by specific treatment methods. Therefore, ethylbenzene is not considered for specific regulation in this subcategory.

Dichlorobromomethane (48) concentrations appeared on 7 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.017 mg/l. Five concentrations are below the analytically quantifiable limit. The remaining two concentrations are lower than the level considered to be achievable by specific treatment methods. Therefore,

dichlorobromomethane is not considered for specific regulation in this subcategory.

2-nitrophenol (57) concentrations appeared on 3 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 1.0 mg/l. One concentration is below the analytically quantifiable limit. Another concentration is below the level considered to be achievable with available specific treatment methods. Because this toxic pollutant was found on only one process sampling day at a level considered to be achievable with available specific treatment methods, 2-nitrophenol is not considered for specific regulation in this subcategory.

2,4-dinitrophenol (59) concentrations appeared on 2 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.41 mg/l. One concentration is below the analytically quantifiable limit. Because this toxic pollutant was found on only one sampling day at a level considered to be achievable with available specific treatment methods, 2,4-dinitrophenol is not considered for specific regulation in this subcategory.

4,6-dinitro-o-cresol (60) concentrations appeared on 3 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.285 mg/l. Two concentrations are below the analytically quantifiable limit. Because this toxic pollutant was found on only one sampling day at a level considered to be achievable with specific treatment methods, 4,6-dinitro-o-cresol is not considered for specific regulation in this subcategory.

Di-n-butyl phthalate (68) concentrations appeared on 18 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 23.6 mg/l. Eight concentrations are below the analytically quantifiable limit. Many other concentrations are lower than the level considered to be achievable with available specific treatment methods. Therefore, di-n-butyl phthalate is not considered for specific regulation in this subcategory.

Diethyl phthalate (70) concentrations appeared on 11 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 9.09 mg/l. Five concentrations are below the analytically quantifiable limit. Many other concentrations are at levels that are considered achievable with available specific treatment methods. However, all of the concentrations were below the human toxicity level for this pollutant. Therefore, diethyl phthalate is not considered for specific regulation in this subcategory.

Dimethyl phthalate (71) concentrations appeared on 5 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 0.035 mg/l. Four concentrations are below the analytically quantifiable limit. The maximum concentration is slightly above the level that is considered achievable with available specific treatment methods. Therefore, dimethyl phthalate is not considered for specific regulation in this subcategory.

Toluene (86) concentrations appeared on 14 of 21 process sampling days in the aluminum subcategory. The maximum concentration was 1.02 mg/l. Eleven concentrations are below the analytically quantifiable limit. One other concentration is lower than the level considered to be achievable with available specific treatment methods. Therefore, toluene is not considered for specific regulation in this subcategory.

Aldrin (89) concentrations appeared on 6 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.018 mg/l. Five concentrations are below that level achievable with end-of-pipe treatment technologies. Because this toxic pollutant appeared on only one process sampling day at an analytically quantifiable limit, aldrin is not considered for specific regulation in this subcategory.

4,4'-DDT (92) concentrations appeared on 9 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.017 mg/l. Eight of the nine concentrations are below the analytically quantifiable level. Because only one quantifiable value was found, 4,4'-DDT is not considered for specific regulation in this subcategory.

4,4'-DDE (93) concentrations appeared on 6 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.013 mg/l. Five concentrations are below the analytically quantifiable limit. Because only one quantifiable value appeared, 4,4'-DDE is not considered for specific regulation in this subcategory.

Heptachlor epoxide (101) concentrations appeared on 4 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.028 mg/l. Three concentrations are below the analytically quantifiable limit. Because this toxic pollutant was found on only one process sampling day at an analytically quantifiable level, heptachlor epoxide is not considered for specific regulation in this subcategory.

a-BHC-Alpha (102) concentrations appeared on 8 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.071 mg/l. Seven concentrations are below the analytically quantifiable limit. Because this toxic pollutant was found on only one process sampling day at an analytically quantifiable level, a-BHC-Alpha is not considered for specific regulation in this subcategory.

b-BHC-Beta (103) concentrations appeared on 6 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.151 mg/l. Four concentrations are below the analytically quantifiable limit. Because this toxic pollutant was found on only two process sampling days at an analytically quantifiable level, b-BHC-Beta is not considered for specific regulation in this subcategory.

r-BHC-Gamma (104) concentrations appeared on 11 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.024 mg/l. Nine concentrations are below the analytically quantifiable limit. Because this toxic pollutant was found on only two process sampling days at an analytically quantifiable level, r-BHC-Gamma is not considered for specific regulation in this subcategory.

g-BHC-Delta (105) concentrations appeared on 7 of 13 process sampling days in the aluminum subcategory. The maximum concentration was 0.039 mg/l. Five concentrations are below the analytically quantifiable limit. Because this toxic pollutant was found on only two process sampling days at an analytically quantifiable level, 6-BHC-Delta is not considered for specific regulation in this subcategory.

Polychlorinated biphenols (PCB-1242, PCB-1254, PCB-1221, PCB-1232, PCB-1248, PCB-1260, PCB-1016) (106-112) concentrations appeared at one plant in the aluminum subcategory. The maximum concentration was 0.013 mg/l. This concentration is above the level considered to be achievable by specific treatment methods. The appearance of these PCBs can be traced to plants which at one time used PCB bearing hydraulic fluids. Hydraulic fluids are a necessity in the operation of die casting machinery. Prior to 1971, PCBs were used extensively in hydraulic fluids. Commercial products containing PCBs are no longer produced in the U.S., and the use of these materials in hydraulic fluids has been eliminated. However, PCB residuals can still be detected after extensive cleaning and flushing of hydraulic oil systems which once contained them. Because PCBs are artifacts of one time use, and because they are no longer used, PCBs are not considered for specific regulation in this subcategory.

Arsenic (115) concentrations appeared on all 4 process sampling days in the aluminum subcategory. The maximum concentration was 0.01 mg/l. Three concentrations are lower than the analytical quantification limit. The maximum concentration is below the level considered to be achievable with available specific treatment methods. Therefore, arsenic is not considered for specific regulation in this subcategory.

Chromium (119) concentrations appeared on all 11 process sampling days in the aluminum subcategory. The maximum concentration was 0.01 mg/l. Ten concentrations are lower than the analytical quantification limit. The maximum concentration is below the level considered to be achievable with available specific treatment methods. Therefore, chromium is not considered for specific regulation in this subcategory.

Cyanide (121) concentrations appeared on all 20 process sampling days in the aluminum subcategory. The maximum concentration was 0.05 mg/l. All concentrations are lower than the level considered to be achievable by specific treatment methods. Therefore, cyanide is not considered for specific regulation in this subcategory.

Mercury (123) concentrations appeared on all 14 process sampling days in the aluminum subcategory. The maximum concentration was 0.0014 mg/l. All concentrations are lower than the level considered to be achievable by specific treatment methods. Therefore, mercury is not considered for specific regulation in this subcategory.

Nickel (124) concentrations appeared on all 14 process sampling days in the aluminum subcategory. The maximum concentration was 0.04 mg/l. This concentration is below the level considered to be achievable by specific treatment methods. Therefore, nickel is not considered for specific regulation in this subcategory.

Fluoride concentrations appeared on all 20 process sampling days in the aluminum subcategory. The maximum concentration was 3.4 mg/l. This concentration is below the level considered to be achievable by specific treatment methods. Therefore, fluoride is not considered for specific regulation in this subcategory.

Manganese concentrations appeared on all 20 process sampling days in the aluminum subcategory. The maximum concentration was 0.56 mg/l. Four concentrations are below the analytical quantification limit. Fourteen concentrations are lower than the level considered to be achievable by specific treatment methods. Because this pollutant was found on only two process sampling days at a concentration above the level considered to be

achievable by specific treatment methods, manganese is not considered for specific regulation in this subcategory.

Iron concentrations appeared on all 12 process sampling days in the aluminum casting subcategory. The maximum concentration was 4.2 mg/l. Three of the concentration values are below the level considered to be analytically quantifiable. Nine of the twelve concentration values are below the level considered to be achievable by specific treatment methods. Therefore, iron is not considered for specific regulation in this subcategory.

Copper Casting Subcategory

Pollutants Considered for Specific Regulation in the Copper Casting Subcategory

Based on sampling results and a careful examination of the copper casting subcategory manufacturing processes and raw materials, thirteen pollutants were selected for consideration for specific regulation through effluent limitations and standards for this subcategory. These pollutants were found in raw wastewaters from processes in this subcategory and are amenable to control by identified wastewater treatment practices (e.g., activated carbon adsorption, oxidation, chemical precipitation-sedimentation). Discussions of these pollutants follow.

Butyl benzyl phthalate (67) values were detected on 4 of the 6 sampling days in this subcategory. The maximum concentration found was 0.55 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. The presence of this pollutant is related to the use of binders and other chemical additives in the casting sands.

3,4-benzofluoranthene (74) values were detected on 2 of the 6 sampling days in this subcategory. The maximum concentration found was 0.013 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant is present as a combustion byproduct of the binders and other sand additives.

Benzo(k)fluoranthene (75) values were detected on 2 of the 6 sampling days in this subcategory. The maximum concentration found was 0.013 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available specific treatment methods. This pollutant is present as a combustion byproduct of the binders and other sand additives.

Pyrene (84) values were detected on 5 of the 6 sampling days in this subcategory. The maximum concentration found was 0.034 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels attainable with available specific treatment methods. This pollutant is a combustion byproduct of the binders and other sand additives.

Copper (120) values were detected on all 4 sampling days in this subcategory. The maximum concentration found was 147.9 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. Copper is considered for specific regulation, as it is the primary metal used in this subcategory.

Lead (122) values were detected on all 6 of sampling days in this subcategory. The maximum concentration found was 32.1 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. Lead's presence as a process wastewater pollutant is related to its use as an alloying material, as well as to its use in process equipment and facilities.

Nickel (124) values were detected on all 4 sampling days in this subcategory. The maximum concentration found was 1.02 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of nickel in process wastewaters is a result of its use as an alloying material for copper, as well as its use in process equipment (molds, etc.) and facilities.

Zinc (128) values were detected on all 6 sampling days in this subcategory. The maximum concentration found was 144.6 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. The presence of this pollutant is attributed to its use as an alloy for copper and to its use in production equipment and facilities.

Total suspended solids were found on all 6 sampling days. The maximum concentration found was 773.9 mg/l. The TSS concentrations are greater than the treated effluent levels achievable with available treatment technologies. In addition, control of TSS in process wastewater discharges will result in the control, to a certain extent, of several toxic pollutants. Therefore, this pollutant is considered for specific regulation.

Oil and grease values were found on all 6 sampling days. The maximum concentration was 110 mg/l. As these concentrations are greater than the treated effluent levels typically achievable

with specific treatment technologies, oil and grease is considered for specific regulation in this subcategory.

pH can be controlled within the limits of 7.5 to 10.0 with available specific treatment methods and is therefore considered for specific regulation in this subcategory.

Manganese values were detected on all 6 sampling days. The maximum concentration found was 0.97 mg/l. As several of these concentrations are greater than the treated effluent levels achievable with specific treatment technologies, manganese is considered for specific regulation in this subcategory.

Phenols values were detected on all 6 sampling days. The maximum concentration found was 2.29 mg/l. As several of these concentrations are greater than the treated effluent levels achievable with specified treatment technologies, phenol is considered for specific regulation in this subcategory.

Pollutants Not Considered for Specific Regulation in the Copper Casting Subcategory

A total of one hundred twenty-four pollutants which were evaluated were eliminated from further consideration for specific regulation in the copper casting subcategory. Fifty-one pollutants were dropped from further consideration because their presence in raw wastewaters was not detected. Forty pollutants were eliminated from further consideration, because the concentrations of these pollutants were less than the analytically quantifiable limits.

The remaining thirty-three pollutants were found to be present infrequently or found at levels below those usually achieved by specific treatment methods. Discussions of these pollutants follow.

Acenaphthene (1) concentrations appeared on 4 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.011 mg/l. Three concentration values appear below the level considered to be analytically quantifiable. The remaining concentration value is only slightly above the level considered to be achievable with available specific treatment methods. Therefore, acenaphthene is not considered for specific regulation in this subcategory.

Carbon tetrachloride (6) concentrations appeared on 1 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.032 mg/l. This concentration is below the

level considered to be achievable by specific treatment methods. Therefore, carbon tetrachloride is not considered for specific regulation in this subcategory.

1,1,1-trichloroethane (11) concentrations appeared on 1 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.14 mg/l. Because this toxic pollutant was found at only one plant, 1,1,1-trichloroethane is not considered for specific regulation in this subcategory.

1,1,2-trichloroethane (14) concentrations appeared on 1 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.013 mg/l. Because this toxic pollutant was found at only one plant, and the maximum concentration is less than the concentration achievable by specific treatment methods, 1,1,2-trichloroethane is not considered for specific regulation in this subcategory.

Chloroform (23) concentrations appeared on all 6 process sampling days in the copper subcategory. The maximum concentration was 0.093 mg/l. Five concentration values are below the level considered to be analytically quantifiable. The remaining concentration is less than the concentration achievable by specific treatment methods. Therefore, chloroform is not considered for specific regulation in this subcategory.

2,4-dimethylphenol (34) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.084 mg/l. This concentration is only slightly above the level considered to be achievable with available specific treatment methods. Therefore, 2,4-dimethylphenol is not considered for specific regulation in this subcategory.

2,6-dinitrotoluene (36) concentrations appeared on 1 of 6 process sampling days in the copper subcategory. The concentration was 0.012 mg/l. The concentration value is below the level considered to be achievable by specific treatment methods. Therefore, 2,6-dinitrotoluene is not considered for specific regulation in this subcategory.

Methylene chloride (44) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.016 mg/l. Two concentration values are below the level considered to be analytically quantifiable. The remaining concentration value is below the level considered to be achievable by specific treatment methods. Therefore, methylene chloride is not considered for specific regulation in this subcategory.

Methyl chloride (45) concentrations appeared on 1 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.028 mg/l. This concentration is below the level considered to be achievable by specific treatment methods. Therefore, methyl chloride is not considered for specific regulation in this subcategory.

Isophorone (54) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.015 mg/l. Two concentration values are below the level considered to be analytically quantifiable. The other concentration value is below the level considered to be achievable by specific treatment methods. Therefore, isophorone is not considered for specific regulation in this subcategory.

4-nitrophenol (58) concentrations appeared on 2 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.019 mg/l. This concentration is below the level considered to be achievable by specific treatment methods. Therefore, 4-nitrophenol not considered for specific regulation in this subcategory.

Pentachlorophenol (64) concentrations appeared on 4 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.051 mg/l. Only one concentration value was detected above the level considered to be achievable with available specific treatment methods. Therefore, pentachlorophenol is not considered for specific regulation in this subcategory.

Phenol (65) concentrations appeared on 5 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.031 mg/l. Two concentration values are below the level considered to be analytically quantifiable. This concentration is below the level considered to be achievable by specific treatment methods. Therefore, phenol is not considered for specific regulation in this subcategory.

Bis(2-ethylhexyl) phthalate (66) concentrations appeared on all 6 process sampling days in the copper subcategory. The maximum concentration was 0.15 mg/l. However, this concentration is much lower than the human toxicity level. Therefore, bis(2-ethylhexyl) phthalate is not considered for specific regulation in this subcategory.

Di-n-butyl phthalate (68) concentrations appeared on 5 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.023 mg/l. Two concentration values are below the level considered to be analytically quantifiable. The

maximum concentration is below the level considered to be achievable by specific treatment methods. Therefore, di-n-butyl phthalate is not considered for specific regulation in this subcategory.

Diethyl phthalate (70) concentrations appeared on 5 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.01 mg/l. Four concentration values are below the level considered to be analytically quantifiable. The remaining concentration is below the level considered to be achievable by specific treatment methods. Therefore, diethyl phthalate is not considered for specific regulation in this subcategory.

Dimethyl phthalate (71) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.151 mg/l. One concentration value is below the level considered to be analytically quantifiable. Only one concentration is above the level considered achievable with available specific treatment methods. Therefore, dimethyl phthalate is not considered for specific regulation in this subcategory.

Benzo(a)anthracene (72) concentrations appeared on 1 of 6 process sampling days in the copper subcategory. This concentration was 0.089 mg/l. Because this toxic pollutant was found on only one sampling day, it is not considered for specific regulation in this subcategory.

Benzo(a)pyrene (73) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.038 mg/l. Two of the concentration values are below the level considered to be analytically quantifiable. Therefore, benzo(a)pyrene is not considered for specific regulation in this subcategory.

Chrysene (76) concentrations appeared on 4 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.108 mg/l. Two of the concentration values are below the level considered to be analytically quantifiable. Therefore, chrysene is not considered for specific regulation in this subcategory.

Acenaphthylene (77) concentrations appeared on 4 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.013 mg/l. Three of the concentration values are below the level considered to be analytically quantifiable. Therefore, acenaphthylene is not considered for specific regulation in this subcategory.

Anthracene (78) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.038 mg/l. These three concentration values are either below the level considered to be analytically quantifiable or inseparable. Therefore, anthracene is not considered for specific regulation in this subcategory.

Phenanthrene (81) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.038 mg/l. These three concentration values are either below the level considered to be analytically quantifiable or inseparable. Therefore, phenanthrene is not considered for specific regulation in this subcategory.

Tetrachloroethylene (85) concentrations appeared on 3 of 6 process sampling days in the copper subcategory. The maximum concentration was 0.28 mg/l. Two of the concentration values are below the level considered to be analytically quantifiable. Therefore, tetrachloroethylene is not considered for specific regulation in this subcategory.

Trichloroethylene (87) concentrations appeared on 1 of 6 process sampling days in the copper subcategory. The concentration was 0.18 mg/l. Because this toxic pollutant was found on only one sampling day, is is not considered for specific regulation in this subcategory.

Arsenic (115) concentrations appeared on both of the process sampling days in the copper subcategory. The maximum concentration was 0.016 mg/l. Arsenic was excluded from verification analysis. This maximum concentration is below the level considered to be achievable by specific treatment methods. Therefore, arsenic is not considered for specific regulation in this subcategory.

Cadmium (118) concentrations appeared on all 4 process sampling days in the copper subcategory. The maximum concentration was 0.13 mg/l. All of the concentrations are below the level considered to be achievable by specific treatment methods. Therefore, cadmium is not considered for specific regulation in this subcategory.

Cyanide (121) concentrations appeared on all 6 process sampling days in the copper subcategory. The maximum concentration was 0.032 mg/l. All of the concentration values are below the level considered to be achievable by specific treatment methods. Therefore, cyanide is not considered for specific regulation in this subcategory.

Mercury (123) concentrations appeared on all 4 process sampling days in the copper subcategory. The maximum concentration was 0.0005 mg/l. One of the concentration values is below the level considered to be analytically quantifiable. All of the values are below the level considered to be achievable by specific treatment methods. Therefore, mercury is not considered for specific regulation in this subcategory.

Ammonia concentrations appeared on all 6 process sampling days in the copper subcategory. The maximum concentration was 2.77 mg/l. All of the concentration values are below the level considered to be toxic in humans. Therefore, ammonia is not considered for specific regulation in this subcategory.

Sulfide concentrations appeared on all 6 process sampling days in the copper subcategory. The maximum conentration was 1.3 mg/l. Four of the concentration values are below the level considered to be analytically quantifiable. The remaining two concentration values are above the levels considered to be achievable by specific treatment methods for their respective operations. However, sulfide is not considered for regulation in this subcategory.

Fluoride concentrations appeared on all 6 process sampling days in the copper subcategory. The maximum concentration was 4.2 mg/l. All of the concentration values are below the level considered to be achievable by specific treatment methods. Therefore, fluoride is not considered for regulation in this subcategory.

Iron concentrations appeared on all 3 process sampling days in the copper casting subcategory. The maximum concentration was 0.07 mg/l. All of the concentration values are below the level considered to be achievable by specific treatment methods. Therefore, iron is not considered for specific regulation in this subcategory.

Ferrous Casting Subcategory

Pollutants Considered for Specific Regulation in the Ferrous Casting Subcategory

Based on sampling results and careful examination of the ferrous casting subcategory manufacturing processes and raw waste materials, thirty-five pollutants were selected for consideration for specific regulation through effluent limitations and standards for this subcategory. These pollutants were found in raw wastewaters from processes in this subcategory and are amenable to control by identified wastewater treatment practices.

(e.g., activated carbon adsorption, chemical precipitation-sedimentation). Disucssions of these pollutants follow.

Acenaphthene (1) values were detected on 27 of the 32 sampling days in this subcategory. The maximum concentration found was 0.081 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. Acenaphthene may be found in dust collection and sand washing wastewaters and in various casting sand additives.

2-chlorophenol (24) values were detected on 17 of the 32 sampling days in this subcategory. The maximum concentration found was 0.082 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant is present as a result of the materials used in Discussions of these pollutants follow. the melting process.

2,4-dichlorophenol (31) values were detected on 14 of the 32 sampling days in this subcategory. The maximum concentration found was 0.372 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant originates in the products used in the casting processes (ie., casting sand additives).

2,4-dimethylphenol (34) values were detected on 22 of the 32 sampling days in this subcategory. The maximum concentration found was 1.2 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant may also originate in the products used in the casting and melting porcesses.

Fluoranthene (39) values were detected on 30 of the 32 sampling days in this subcategory. The maximum concentration found was 1.5 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This contaminant's presence is related to the use of coke in the melting process. As the coke is combusted, this pollutant may be evolved as a by-product.

2,4-dinitrophenol (59) values were detected on 8 of the 32 sampling days in this subcategory. The maximum concentration found was 0.13 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence can also be related to the raw materials (coke and oily scrap) used in the melting processes.

4,6-dinitro-o-cresol (60) values were detected on 12 of the 32 sampling days in this subcategory. The maximum concentration found was 0.137 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant may be found in this subcategory's process wastewaters as a result of the raw materials used in the melting process.

N-nitrosodiphenylamine (62) values were detected on 14 of the 32 sampling days in this subcategory. The maximum concentration found was 5.95 mg/l. Some of the concentrations are well above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is related to the raw materials used in the melting process.

Pentachlorophenol (64) values were detected on 13 of the 32 sampling days in this subcategory. The maximum concentration found was 0.47 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of this pollutant is also associated with the raw materials used in the melting process.

Phenol (65) values were detected on 27 of the 32 sampling days in this subcategory. The maximum concentration found was 7.4 mg/l. Some of the concentrations are well above the treated effluent levels achievable with available specific treatment methods. Phenol's presence is related to the use of coke and oily scrap in the melting process and to the binders and other additives used in casting sand.

Butyl benzyl phthalate (67) values were detected on 23 of the 32 sampling days in this subcategory. The maximum concentration found was 0.32 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is related to the materials used in the casting and melting processes.

Benzo(a)anthracene (72) values were detected on 15 of the 32 sampling days in this subcategory. The maximum concentration found was 0.047 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant may be found as a result of the raw materials used in the melting process.

Chrysene (76) values were detected on 22 of the 32 sampling days in this subcategory. The maximum concentration found was 0.029 mg/l. Some of the concentrations are above the treated

effluent levels achievable with available specific treatment methods. This pollutant's presence is related to the raw materials used in the melting process and to the binders and other additives used in the casting sand. This polluant is also a combustion by-product of coke and the sand additives.

Acenaphthylene (77) values were detected on 25 of the 32 sampling days in this subcategory. The maximum concentration found was 0.43 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant's origin is associated with the raw materials used in the melting process.

Fluorene (80) values were detected on 27 of the 32 sampling days in this subcategory. The maximum concentration found was 1.8 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. As with chrysene, this pollutant is a combustion by-product of coke and the sand additives.

Phenanthrene (81) values were detected on 27 of the 32 sampling days in this subcategory. The maximum concentration found was 0.11 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels attainable with available specific treatment methods.

Pyrene (84) values were detected on 29 of the 32 sampling days in this subcategory. The maximum concentration found was 3.3 mg/l. Some of these concentrations are well above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant may be derived as a combustion by-product of the casting sand binders and other additives.

Tetrachloroethylene (85) values were detected on 27 of the 32 sampling days in this subcategory. The maximum concentration found was 1.56 mg/l. Some of the concentrations are well above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is related to the raw materials used in the melting process.

Antimony (114) values were detected on all 19 sampling days in this subcategory. The maximum concentration found was 1.4 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of this pollutant is related to its use as an alloy.

Arsenic (115) values were detected on 25 of the 27 sampling days in this subcategory. The maximum concentration found was

1.3 mg/l . Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant is present in this subcategory's process wastewaters, as it is a contaminant in the coke used in the melting process.

Cadmium (118) values were detected on 25 of the 26 sampling days in this subcategory. The maximum concentration found was 1.8 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of this pollutant is related to its use as an alloy. It may also be present as a result of the use of plated materials in the scrap charge.

Chromium (119) values were detected on 26 of the 27 sampling days in this subcategory. The maximum concentration found was 3.1 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence is related to its use as an alloying material or as a result of its washing from chromite sands.

Copper (120) values were detected on all 60 sampling days in this subcategory. The maximum concentration found was 14.0 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant originates as a contaminant in the scrap charge.

Lead (122) values were detected on all 63 sampling days in this subcategory. The maximum concentration found was 328.0 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant originates as a contaminant in the scrap charge.

Nickel (124) values were detected on 58 of the 59 sampling days in this subcategory. The maximum concentration found was 0.98 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available specific treatment methods. The presence of this pollutant is related to its use as an alloy in this subcategory.

Zinc (128) values were detected on all 63 sampling days in this subcategory. The maximum concentration found was 1720.0 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant originates as a contaminant in the scrap charge.

Total suspended solids values were found on all 92 sampling days. The maximum concentration found was 39,000 mg/l. The TSS concentrations are greater than the typically achievable effluent levels and are, therefore, considered for specific regulation. In addition, the control of TSS will result in the control, to a certain extent, of several toxic pollutants.

Oil and grease values were detected on all 63 sampling days. The maximum concentration was 150 mg/l. As many of the concentrations are greater than the effluent levels typically achievable, oil and grease is considered for specific regulation in this subcategory.

pH can be controlled within the limits of 7.5 to 10.0 with available specific treatment methods and is therefore considered for specific regulation in this subcategory.

Ammonia values were detected on all 78 sampling days. The maximum value detected was 120 mg/l. As many of these values are well above the treated effluent levels achievable with available treatment methods, ammonia is considered for regulation in this subcategory. Ammonia's presence as a wastewater pollutant results from the various materials used in casting and melting operations.

Sulfide values were detected on all 63 sampling days. The maximum concentration found was 26.1 mg/l. As many of these values are well above the treated effluent levels attainable with available specific treatment methods, sulfide is considered for specific regulation in this subcategory. The presence of this pollutant is related to the various materials used in casting and melting operations.

Fluoride values were detected on all 63 sampling days in this subcategory. The maximum level found was 242 mg/l. As many of these values are well above the attainable treated effluent levels, fluoride is considered for specific regulation in this subcategory. Fluoride's presence as a wastewater pollutant is associated with the fluxes used in melting operations.

Manganese values were detected on all 63 sampling days in this subcategory. The maximum concentration detected was 392 mg/l. As many of these values are greater than the treated effluent levels attainable with available specific treatment methods, manganese is considered for specific regulation in this subcategory. Its presence is related to its use as an alloy.

Iron values were detected on 48 of the 49 sampling days in this subcategory. The maximum dissolved iron concentration detected

was 26 mg/l. Iron is considered for specific regulation in this subcategory, because it is the primary constituent of the products of this subcategory.

Phenols values were detected on all 79 sampling days in this subcategory. The maximum concentration found was 16.5 mg/l. Some of these concentrations are substantially above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant, detected by the 4-AAP wet chemistry technique, encompasses a variety of the individual phenolic compounds. Its presence is related to the raw materials used in the melting process and to the binders and additives used in casting sand.

Pollutants Not Considered for Specific Regulation in the Ferrous Casting Subcategory

A total of one hundred and two pollutants that were evaluated were eliminated from further consideration for specific regulation in the ferrous casting subcategory. Twenty-six pollutants were dropped from further consideration, because their presence in raw process wastewaters was not detected. Thirty-seven pollutants were eliminated from further consideration, because the concentrations of these pollutants were less than the analytically quantifiable limits.

The remaining thirty-nine pollutants were found to be present infrequently, found at levels below those usually achieved by specific treatment methods, or present as a result of site-specific conditions. Discussions of these pollutants follow.

Benzene (4) concentrations appeared on 26 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.361 mg/l. Seventeen concentrations are below the level considered to be analytically quantifiable. Only one of the remaining values is greater than the concentration considered to be achievable with available specific treatment methods. Therefore, benzene is not considered for specific regulation in this subcategory.

Carbon tetrachloride (6) concentrations appeared on 14 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.016 mg/l. Thirteen concentrations are below the level considered to be analytically quantifiable. The remaining value is lower than the concentration considered to be achievable with available specific treatment methods. Therefore, carbon tetrachloride is not considered for specific regulation in this subcategory.

1,2,4-trichlorobenzene (8) concentrations appeared on 6 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.30 mg/l. Five concentrations are below the level considered to be analytically quantifiable. Only one concentration value is greater than the level considered to be achievable with available specific treatment methods. Therefore, 1,2,4-trichlorobenzene is not considered for specific regulation in this subcategory.

1,1,1,-trichloroethane (11) concentrations appeared on 18 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.075 mg/l. Fourteen concentrations are below the level considered to be analytically quantifiable. The remaining values are all lower than the concentration considered to be achievable with available specific treatment methods. Therefore, 1,1,1-trichloroethane is not considered for specific regulation in this subcategory.

Bis(2-chloroethyl) ether (18) concentrations appeared on 4 of 32 process sampling days in the ferrous casting subcategory. The maxium concentration was 0.014 mg/l. Three concentrations are below the level considered to be analytically quantifiable. The remaining value is lower than the concentration considered to be achievable with available specific treatment methods. Therefore, this toxic pollutant is not considered for specific regulation in this subcategory.

2,4,6-trichlorophenol (21) concentrations appeared on 14 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.195 mg/l. All but three of the concentrations are below the level considered to be analytically quantifiable. Therefore, 2,4,6-trichlorophenol is not considered for specific regulation in this subcategory.

Parachlorometacresol (22) concentrations appeared on 8 of 32 process sampling days in the ferrous casting subcategory. The maximum conentration was 0.536 mg/l. Four concentrations are less than the analytically quantifiable limit. Only two concentrations are above the level considered to be achievable with available specific treatment methods. Therefore, parachlorometacresol is not considered for specific regulation in this subcategory.

Chloroform (23) concentrations appeared on all 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.692 mg/l. Sixteen concentrations are less than the analytically quantifiable limit. Fifteen concentrations are lower then that concentration considered to be achievable

with available specific treatment methods. Therefore, chloroform is not considered for specific regulation in this subcategory.

1,2,-trans-dichloroethylene (30) concentrations appeared on 1 of 32 process sampling days in the ferrous casting subcategory. That concentration was 0.033 mg/l. The concentration value is lower than the concentration considered to be achievable with available specific treatment methods, therefore, 1,2-trans-dichloroethylene is not considered for specific regulation in this subcategory.

1,3-dichloropropylene (33) concentrations appeared on 2 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.24 mg/l. Only one concentration value is above that level considered to be achievable with available specific treatment methods. Therefore, 1,3-dichloropropylene is not considered for specific regulation in this subcategory.

Bis(2-chloroethoxy) methane (43) concentrations appeared on 6 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.045 mg/l. Four concentrations are below the level considered to be analytically quantifiable. All conentration values are lower than the concentration considered to be achievable with available specific treatment methods. Therefore, this toxic pollutant is not considered for specific regulation in this subcategory.

Methylene chloride (44) concentrations appeared on 26 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 2.05 mg/l. Twelve concentrations are below the level considered to be analytically quantifiable. Only two of the remaining concentrations are greater than the level considered to be achievable by specific treatment methods. Both of those concentrations are from one plant. Therefore, methylene chloride is not considered for specific regulation in this subcategory.

Methyl chloride (45) concentrations appeared on 1 of 32 process sampling days in the ferrous casting subcategory. The concentration was 0.012 mg/l. Because this toxic pollutant was found at only one plant, at a level lower than the concentration considered to be achievable with available specific treatment methods, methyl chloride is not considered for specific regulation in this subcategory.

Bromoform (47) concentrations appeared on 1 of 32 process sampling days in the ferrous casting subcategory. The concentration was 0.018 mg/l. Because this toxic pollutant was

found at ony one plant, at a level lower than the concentration considered to be achievable with available specific treatment methods, bromoform is not considered for specific regulation in this subcategory.

Trichlorofluoromethane (49) concentrations appeared on 1 of 32 process sampling days in the ferrous casting subcategory. The concentration was 0.12 mg/l. Because this toxic pollutant was found at only one plant, at a level lower than the concentration considered to be achievable with available specific treatment methods, trichlorofluoromethane is not considered for specific regulation in this subcategory.

Chlorodibromomethane (51) concentrations appeared on 1 of 32 process sampling days in the ferrous casting subcategory. The concentration was 0.019 mg/l. Because this toxic pollutant was found at only one plant, at a level lower than the concentration considered to be achievable with available specific treatment methods, chlorodibromomethane is not considered for specific regulation in this subcategory.

Isophorone (54) concentrations appeared on 10 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.074 mg/l. Eight concentration values are below the level considered to be analytically quantifiable. Only one of the remaining concentration values is above the level considered to be achievable by specific treatment methods. Therefore, this toxic pollutant is not considered for regulation in this subcategory.

Naphthalene (55) concentrations appeared on 29 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.13 mg/l. Seventeen concentration values are below the level considered to be analytically quantifiable. Some concentrations are above the level considered to be achievable with available specific treatment methods. However, all of the concentrations are below human toxicity levels. Therefore, naphthalene is not considered for specific regulation in this subcategory.

Nitrobenzene (56) concentrations appeared on 5 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.86 mg/l. Three concentrations are less than the analytically quantifiable limit. Only one of the remaining two concentration values is above the level considered to be achievable with available specific treatment methods. Therefore, nitrobenzene is not considered for specific regulation in this subcategory.

2-nitrophenol (57) concentrations appeared on 15 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.052 mg/l. Eleven concentrations are less than the analytically quantifiable limit. Three of the four remaining concentration values are less than the level considered to be achievable by specific treatment methods. Only the maximum concentration is at the level considered to be achievable with available specific treatment methods. Therefore, 2-nitrophenol is not considered for specific regulation in this subcategory.

4-nitrophenol (58) concentrations appeared on 7 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.16 mg/l. Three concentrations are less than the analytically quantifiable limit. Three of the remaining four concentrations are less than the level considered to be achievable by specific treatment methods. Only the maximum concentration is above the level considered to be achievable with available specific treatment methods. Therefore, 4-nitrophenol is not considered for specific regulation in this subcategory.

Bis(2-ethylhexyl) phthalate (66) concentrations appeared on 31 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.42 mg/l. Ten concentration values are below the level considered to be analytically quantifiable. Many of the concentrations are above the level that is considered achievable with available specific treatment methods. However, all of the concentrations are below human toxicity levels. Therefore, bis(2-ethylhexyl) phthalate is not considered for specific regulation in this subcategory.

Di-n-butyl phthalate (68) concentrations appeared on 30 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.598 mg/l. Seventeen concentrations are less than the analytically quantifiable limit. All of the concentrations are below human toxicity levels. Therefore, di-n-butyl phthalate is not considered for regulation in this subcategory.

Di-n-octyl phthalate (69) concentrations appeared on 5 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.054 mg/l. Three concentrations are less than the analytically quantifiable limit. Only two concentrations are slightly above the level considered to be achievable with specific treatment methods. Therefore, di-n-octyl phthalate is not considered for specific regulation in this subcategory.

Diethyl phthatlate (70) concentrations appeared on 24 of 32 process sampling days in the ferrous casting subcategory. The

maximum concentration was 0.027 mg/l. Fourteen concentrations are less than the analytically quantifiable limit. All other concentrations are below human toxicity levels. Therefore, diethyl phthalate is not considered for specific regulation in this subcategory.

Dimethyl phthalate (71) concentrations appeared on 25 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 2.9 mg/l. Ten concentrations are less than the analytically quantifiable limit. All other concentrations are much lower than human toxicity levels. Therefore, dimethyl phthalate is not considered for specific regulation in this subcategory.

3,4-benzofluoranthene (74) concentrations appeared on 2 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.019 mg/l. One concentration value is below the level considered to be analytically quantifiable. Because this toxic pollutant was found at only one plant, 3,4-benzofluoranthene is not considered for specific regulation in this subcategory.

Benzo(k)fluoranthene (75) concentrations appeared on 2 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.018 mg/l. One concentration value is below the level considered to be analytically quantifiable. Because this toxic pollutant was found at only one plant, benzo(k)fluoranthene is not considered for specific regulation in this subcategory.

Toluene (86) concentrations appeared on 20 of 32 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.015 mg/l. Fifteen concentrations are less than the quantifiable limit. All other concentrations are below the level that is considered to be achievable by specific treatment methods. Therefore, toluene is not considered for specific regulation in this subcategory.

Trichloroethylene (87) concentrations appeared on 18 of 30 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.77 mg/l. Eleven concentrations are less than the analytically quantifiable limit. Six of the remaining concentration values are below the level considered to be achievable with available specific treatment methods. Therefore, trichloroethylene is not considered for specific regulation in this subcategory.

Endrin aldehyde (99) concentrations appeared on 6 of 21 process sampling days in the ferrous casting subcategory. The maximum

concentration was 0.019 mg/l. Four concentrations are below the analytically quantifiable limit. The other two concentrations were found at the same plant. Therefore, endrin aldehyde is not considered for specific regulation in this subcategory.

b-BHC-Beta (103) concentrations appeared on 10 of 21 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.019 mg/l. Eight concentration values are less than the analytically quantifiable limit. Because this pollutant was found on only one process sampling day, b-BHC-Beta is not considered for specific regulation in this subcategory.

Beryllium (117) concentrations appeared on 46 of 48 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.04 mg/l. Forty-two concentrations are less than the analytically quantifiable limit. All other concentrations are below the level considered to be achievable with available specific treatment methods. Therefore, beryllium is not considered for specific regulation in this subcategory.

Cyanide (121) concentrations appeared on 67 of 69 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.35 mg/l. Only three concentrations are above the level considered to be achievable with available specific treatment methods. Therefore, cyanide is not considered for specific regulation in this subcategory.

Mercury (123) concentrations appeared on 56 of 57 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.015 mg/l. Eighteen concentrations are below the analytically quantifiable limit. All other concentrations are below the level considered to be achievable with available specific treatment methods. Therefore, mercury is not considered for specific regulation in this subcategory.

Selenium (125) concentrations appeared on 25 of 27 process sampling days in the ferrous casting subcategory. The maximum concentration was 2.2 mg/l. Twenty-two concentrations are below the analytically quantifiable limit. Two other concentrations are below the level considered to be achievable with available specific treatment methods. Therefore, selenium is not considered for specific regulation in this subcategory.

Silver (126) concentrations appeared on 14 of 16 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.11 mg/l. Nine concentrations are below the analytically quantifiable limit. All other concentrations are at or below the level considered to be achievable with available

treatment methods. Therefore, silver is not considered for specific regulation in this subcategory.

Thallium (127) concentrations appeared on 14 of 16 process sampling days in the ferrous casting subcategory. The maximum concentration was 7.0 mg/l. Twelve concentrations are below the analytically quantifiable limit. Because this pollutant was found on only two process sampling days, thallium is not considered for specific regulation in this subcategory.

Xylene (130) concentrations appeared on 7 of 28 process sampling days in the ferrous casting subcategory. The maximum concentration was 0.023 mg/l. Six concentration values are below the analytically quantifiable limit. Because this pollutant was found on only one sampling day, xylene is not considered for specific regulation in this subcategory.

Lead Casting Subcategory

Pollutants Considered for Specific Regulation in the Lead Casting Subcategory

Based on sampling results and careful examination of the lead casting subcategory manufacturing processes and raw materials, six pollutants were selected for consideration for specific regulation through effluent limitations and standards for this subcategory. These pollutants were found in raw wastewaters from processes in this subcategory and are amenable to control by identified wastewater treatment practices (e.g., activated carbon adsorption, chemical precipitation-sedimentation). Discussions of these pollutants follow.

Copper was detected at a level of 0.046 mg/l in the process wastewaters sampled in this subcategory. Copper is used for electrical conductors in charging operations and may be present in process equipment. While it is not a primary raw material in this subcategory, copper may be introduced into this subcategory's process wastewaters by corrosion of equipment.

Lead was detected at a level of 0.85 mg/l in the process wastewaters sampled in this subcategory. This value is above the level which can be achieved by specific treatment methods.

Zinc was detected at a level of 0.014 mg/l in the process wastewaters sampled in this subcategory. While it is not a primary raw material in this subcategory, zinc may be introduced into this subcategory's process wastewaters as a constituent of the cast metal.

Oil and grease was detected at a level of <5 mg/l in the process wastewaters sampled in this subcategory. This pollutant can be removed by conventional treatment methods.

Suspended solids was detected at a level of 5 mg/l in the process wastewaters sampled in this subcategory. The TSS generated in this subcategory may consist of large proportions of toxic pollutants.

The pH of the process wastewaters sampled in this subcategory was 7.7. pH can be controlled within the limits of 7.5 to 10.0 with available specific treatment methods.

Pollutants Not Considered for Specific Regulation in the Lead Casting Subcategory

Analytical data for the lead casting subcategory was originally collected as part of a study for the Battery Manufacturing Point Source Category. The screening data for toxic organic pollutants in this category demonstrated that these pollutants need not be considered for specific regulation. As a result, analyses for the toxic organic pollutants were not performed on the sampled process wastewaters of this subcategory. As lead casting operations are associated with the manufacture of lead-acid batteries, data from the battery manufacturing category is considered to be applicable to the lead casting subcategory. The toxic organic pollutant dispositions presented in Tables VI-I through VI-4 for the lead casting subcategory are based upon battery manufacturing category data. Refer to the Battery Manufacturing Point Source Category Development Document for additional details on the sampling carried out at these operations.

A total of one hundred thirty-one pollutants were eliminated from further consideration for specific regulation in the lead casting subcategory. Eighty-three pollutants were dropped from further consideration, because their presence in raw process wastewater was not detected. Thirty-one pollutants were eliminated from further consideration, because the concentrations of these pollutants were less than the analytically quantifiable limits.

The remaining seventeen pollutants were found to be present infrequently, found at levels below those usually achieved by specific treatment methods, or found only once.

The two toxic inorganic pollutants not considered for specific regulation were detected at levels less than 0.003 mg/l in the process wastewaters sampled in this subcategory. These

concentrations are below those levels achievable with specific treatment methods.

The five non-conventional pollutants not considered for specific regulation were detected at the following levels in this subcategory's sampled process wastewaters:

Ammonia(N)	0.05 mg/l
Fluoride	1.1 mg/l
Manganese	0.005 mg/l
Iron	0.32 mg/l
Phenols(4AAP)	0.012 mg/l

These concentrations are below those levels considered to be achievable with specific treatment methods. Therefore, these pollutants are not considered for specific regulation in this subcategory.

Seven of ten toxic organic pollutants not considered for specific regulation were detected at levels considered to be environmentally insignificant. The other three pollutants were detected at levels below those considered to be achievable with specific treatment methods. Refer to the Battery Manufacturing Point Source Category Development Document for additional details.

Magnesium Casting Subcategory

Pollutants Considered for Specific Regulation in the Magnesium Casting Subcategory

Based on sampling results and a careful examination of the magnesium casting subcategory manufacturing processes and raw materials, seven pollutants were selected for consideration for specific regulation through effluent limitations and standards for this subcategory. These pollutants were found in raw wastewaters from processes in this subcategory and are amenable to control by identified wastewater treatment practices (e.g., activated carbon adsorption, oxidation, chemical precipitation-sedimentation). Discussions of these pollutants follow.

Zinc (128) values were detected on all 6 sampling days in this subcategory. The maximum concentration found was 1.7 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available specific treatment methods. Contamination of process wastewaters with this pollutant results from contact of process waters with process equipment and facilities.

Total suspended solids were found on all 6 sampling days in this subcategory. The maximum concentration was 63 mg/l. Several of the TSS concentrations are greater than the treated effluent levels achievable with available treatment technologies. Therefore, this pollutant is considered for specific regulation.

Oil and grease values were found on all 6 sampling days in this subcategory. The maximum concentration was 17 mg/l. As some of the concentrations are greater than the treated effluent levels typically achievable with available specific treatment methods, oil and grease is considered for specific regulation in this subcategory.

pH can be controlled within the limits of 7.5 to 10.0 with available specific treatment methods, and is therefore considered for specific regulation in this subcategory.

Sulfide values were detected on all 6 sampling days in this subcategory. The maximum concentration was 21.0 mg/l. As some of these values are greater than the treated effluent levels attainable with specific treatment methods, sulfide is considered for specific regulation in this subcategory.

Manganese values were detected on all 6 sampling days in this subcategory. The maximum concentration was 0.42 mg/l. As several of these values are greater than the treated effluent levels achievable with available specific treatment in methods, manganese is considered for specific regulation in this subcategory.

Phenols values were detected on all 6 sampling days in this subcategory. The maximum concentration found was 2.15 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant, detected by wet chemistry techniques (4-AAP), encompasses a variety of the individual phenolic compounds. Its presence is related to the various casting sand additives and binders.

Pollutants Not Considered for Specific Regulation in the Magnesium Casting Subcategory

A total of one hundred thirty pollutants that were evaluated were eliminated from further consideration for specific regulation in the magnesium casting subcategory. Seventy-one pollutants were dropped from further consideration because their presence in raw process wastewaters was not detected. Thirty-five pollutants were eliminated from further consideration, because the concentrations of these pollutants were less than the analytically quantifiable limits.

The remaining twenty-four pollutants were found to be present infrequently, found at levels below those usually achieved by specific treatment methods, or were present as artifacts related to sampling procedures. Discussions of these pollutants follow.

Acenaphthene (1) concentrations appeared on 2 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.064 mg/l. One of these two values is below the quantification limit. Therefore, acenaphthene is not considered for specific regulation in this subcategory.

Benzene(4) concentrations appeared on 1 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.014 mg/l. This is lower than the concentration considered to be achievable with available specific treatment methods. Therefore, benzene is not considered for specific regulation in this subcategory.

Chloroform (23) concentrations appeared on all 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.016 mg/l. This is lower than the concentration considered to be achievable with specific treatment methods. Therefore, chloroform is not considered for specific regulation in this subcategory.

2,4-dimethylphenol (34) concentrations appeared on 1 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.016 mg/l. This is lower than the concentration considered to be achievable with available specific treatment methods. Therefore, 2,4-dimethylphenol is not considered for specific regulation in this subcategory.

Methylene chloride (44) concentrations appeared on 4 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.15 mg/l. All concentrations, except the maximum value, were lower than the concentration considered to be achievable with available specific treatment methods. The

maximum concentration is only slightly above this level. Therefore, with only one concentration above the level considered to be achievable with available specific treatment methods, methylene chloride is not considered for specific regulation in this subcategory.

Pentachlorophenol (64) concentrations appeared on 1 of 6 sampling days in the magnesium subcategory. The concentration was 0.033 mg/l. Since this concentration appeared on only one process sampling day, pentachlorophenol is not considered for specific regulation in this subcategory.

Phenol (65) concentrations appeared on 2 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.350 mg/l. All of the concentrations are much lower than the human toxicity level. effects in humans. Therefore, phenol is not considered for specific regulation in this subcategory.

Bis(2-ethylhexyl) phthalate (66) concentrations appeared on 5 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.195 mg/l. All concentrations are much lower than the human toxicity level. Therefore, bis(2-ethylhexyl) phthalate is not considered for specific regulation in this subcategory.

Butyl benzyl phthalate (67) concentrations appeared on 4 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.013 mg/l. Three concentrations are below the quantification limit. The maximum concentration is only slightly above the level considered to be achievable with available specific treatment methods. However, this maximum concentration appeared on only one process sampling day. Therefore, butyl benzyl phthalate is not considered for specific regulation in this subcategory.

Di-n-butyl phthalate (68) concentrations appeared on 5 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.051 mg/l. Only one concentration is above the level considered to be achievable with available specific treatment methods. Therefore, di-n-butyl phthalate is not considered for specific regulation in this subcategory.

Diethyl phthalate (70) concentrations appeared on 3 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.20 mg/l. Two concentrations are below the quantification limit. All of the concentrations are lower than the human toxicity level. Therefore, diethyl phthalate is not considered for specific regulation in this subcategory.

Dimethyl phthalate (71) concentrations appeared on 2 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 1.1 mg/l. All concentrations are lower than the human toxicity level. Therefore, dimethyl phthalate is not considered for specific regulation in this subcategory.

Chrysene (76) concentrations appeared on 3 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.016 mg/l. Two concentrations are below the quantification limit. The maximum concentration appeared on only one process sampling day. Therefore, chrysene is not considered for specific regulation in this subcategory.

Acenaphthylene (77) concentrations appeared on 5 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.124 mg/l. Four concentrations are below the quantification limit. The maximum concentration appeared on only one process sampling day. Therefore, acenaphthylene is not considered for specific regulation in this subcategory.

Anthracene (78) concentrations appeared on 5 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.10 mg/l. Four concentrations are below the quantification limit. The maximum concentration appeared on only one process sampling day. Therefore, anthracene is not considered for specific regulation in this subcategory.

Phenanthrene (81) concentrations appeared on 5 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.10 mg/l. Four concentrations are below the quantification limit. The maximum concentration appeared on only one process sampling day. Therefore, phenanthrene is not considered for specific regulation in this subcategory.

Pyrene (84) concentrations appeared on 4 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.019 mg/l. Three concentrations are below the quantification limit. The maximum concentration appeared on only one process sampling day. Therefore, pyrene is not considered for specific regulation in this subcategory.

Toluene (86) concentrations appeared on 3 of 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.030 mg/l. This is lower than the concentration considered to be achievable with available specific treatment methods. Therefore, toluene is not considered for specific regulation in this subcategory.

Copper (120) concentrations appeared on all 4 process sampling days in the magnesium subcategory. The maximum concentration was 0.08 mg/l. All concentrations are below the level considered to be achievable with available specific treatment methods. Therefore, copper is not considered for specific regulation in this subcategory.

Cyanide (121) concentrations appeared on all 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.01 mg/l. All concentrations are below the level considered to be achievable with available specific treatment methods. Therefore, cyanide is not considered for specific regulation in this subcategory.

Lead (122) concentrations appeared on all 6 process sampling days in the magnesium subcategory. The maximum concentration was 0.13 mg/l. All concentrations are below the level considered to be achievable with available treatment methods. Therefore, lead is not considered for specific regulation in this subcategory.

Ammonia concentrations appeared on all 6 process sampling days in the magnesium subcategory. The maximum concentration was 2.1 mg/l. This concentration is lower than the human toxicity level. Therefore, ammonia is not considered for specific regulation in this subcategory.

Fluoride concentrations appeared on all 6 process sampling days in the magnesium subcategory. The maximum concentration was 2.5 mg/l. All concentrations are below the level considered to be achievable with available treatment methods. Therefore, fluoride is not considered for specific regulation in this subcategory.

Iron concentrations appeared on all 5 process sampling days in the magnesium casting subcategory. The maximum concentration was 0.06 mg/l. Two of the concentration values are below the level considered to be analytically quantifiable. All of the concentration values are below that level considered to be achievable by specific treatment methods. Therefore, iron is not considered for specific regulation in this subcategory.

Zinc Casting Subcategory

Pollutants Considered for Specific Regulation in the Zinc Casting Subcategory

Based upon sampling results and a careful examination of the zinc casting subcategory manufacturing processes and raw materials, seventeen pollutants were selected for consideration for specific regulation through effluent limitations and standards for this

subcategory. These pollutants were found in the raw wastewaters from processes in this subcategory and are amenable to control by wastewater treatment practices (e.g., activated carbon adsorption, chemical precipitation-sedimentation). Discussions of these pollutants follow.

2,4,6-trichlorophenol (21) values were detected on 7 of the 11 sampling days in this subcategory. The maximum concentration found was 2.65 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant's presence can be related to its use as an agent to control biological growth in various process solutions and to the use of "dirty scrap" in the furnace change.

Parachlorometacresol (22) values were detected on 6 of the 11 sampling days in this subcategory. The maximum concentration found was 0.40 mg/l. Some of concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence can be related to the process solutions used in this subcategory.

2,4-dichlorophenol (31) values were detected on 7 of the 11 sampling days in this subcategory. The maximum concentration found was 1.95 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence can be related to the use of "dirty" scrap in the furnace charge.

2,4-dimethylphenol (34) values were detected on 10 of the 11 sampling days in this subcategory. The maximum concentration found was 9.3 mg/l. Some of these concentrations are well above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of this pollutant can be related to its use as a solvent and a biological growth control agent in this subcategory's process solutions, and to the use of "dirty scrap" in the furnace charge.

Naphthalene (55) values were detected on 7 of the 11 sampling days in this subcategory. The maximum concentration found was 4.0 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. The presence of this pollutant can be related to the use of "dirty" scrap in the furnace charge.

Phenol (65) values were detected on 10 of the 11 sampling days in this subcategory. The maximum concentration found was 19.0 mg/l. Some of these concentrations are substantially above the optimum expected 30-day average treated effluent levels achievable with

available treatment methods. This pollutant's presence can be related to various process solutions and to contaminants in the scrap charge to the melting process.

Butyl benzyl phthalate (67) values were detected on 5 of the 11 sampling days in this subcategory. The maximum concentration found was 0.12 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant's presence can be related to the use of contaminated scrap in the furnace charge.

Pyrene (84) values were detected on 8 of the 11 sampling days in this subcategory. The maximum concentration found was 0.018 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. This pollutant can be found in process solutions (e.g., diecasting and casting quench solutions).

Tetrachloroethylene (85) values were detected on 7 of the 11 sampling days in this subcategory. The maximum concentration found was 0.142 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant's presence can be related to solutions used in this subcategory's processes.

Lead (122) values were detected on all 11 sampling days in this subcategory. The maximum concentration found was 0.42 mg/l. Some of these concentrations are above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. The presence of this pollutant is related to its use in process equipment and facilities and to its presence in the cast metal.

Zinc (128) values were detected on all 11 sampling days in this subcategory. The maximum concentration found was 350 mg/l. Some of the concentrations are above the treated effluent levels achievable with available specific treatment methods. Zinc is considered for specific regulation in this subcategory as it is the major metal cast.

Total suspended solids were found on all 11 sampling days in this subcategory. The maximum concentration found was 3,800 mg/l. The TSS concentrations are greater than the treated effluent levels achievable with available specific treatment methods. In addition, control of TSS in process wastewater discharges will result in the control, to a certain extent, of several toxic pollutants.

Oil and grease values were found on all 11 sampling days in this subcategory. The maximum concentration found was 17,100 mg/l. These oils and greases originate as process wastewater pollutants, in the solutions, products, and scrap used in this subcategory's processes. As many of the concentrations are greater than the treated effluent levels typically achievable, oil and grease is considered for specific regulation in this subcategory.

pH can be controlled within the limits of 7.5 to 10.0 with available specific treatment methods and is therefore considered for specific regulation in this subcategory.

Sulfide values were detected on all 11 sampling days in this subcategory. The maximum concentration found was 1.0 mg/l. As several of the concentrations are greater than the treated effluent levels attainable with available specific treatment technologies, sulfide is considered for specific regulation in this subcategory.

Manganese values were detected on all 11 sampling days in this subcategory. The maximum concentration found was 0.29 mg/l. As several of these values are greater than the treated effluent levels achievable with available specific treatment methods, manganese is considered for specific regulation in this subcategory.

Phenols values were detected on all 11 sampling days in this subcategory. The maximum concentration found was 123 mg/l. Some of these concentrations are substantially above the optimum expected 30-day average treated effluent levels achievable with available treatment methods. This pollutant, detected by wet chemistry techniques (4AAP), encompasses a variety of the individual phenolic compounds. This pollutant results from the process solutions used in this subcategory and from contaminants in the furnace scrap charge.

Pollutants Not Considered for Specific
Regulation in the Zinc Casting Subcategory

A total of one hundred twenty pollutants that were evaluated were eliminated from further consideration for specific regulation in the zinc casting subcategory. Fifty pollutants were dropped from further consideration, because their presence in raw process wastewaters was not detected. Thirty-five pollutants were eliminated from further consideration, because the concentrations of these pollutants were less than the analytically quantifiable limits.

The remaining thirty-five pollutants were found to be present infrequently or found at levels below those typically achieved by specific treatment methods. Discussions of these pollutants follow.

Acenaphthene (1) concentrations appeared on 4 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 2.5 mg/l. Two concentrations are less than the analytically quantifiable limit. The maximum concentration is the only value above the level achievable with available specific treatment methods. Because this concentration level is found only on 1 of 11 process sampling days, acenaphthene is not considered for specific regulation in this subcategory.

Benzene concentrations appeared on 5 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.15 mg/l. Four of these concentrations are less then the analytically quantifiable limit. As a quantifiable concentration was found on only one sampling day, benzene is not considered for specific regulation in this subcategory.

Carbon tetrachloride (6) concentrations appeared on 4 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.029 mg/l, which is less than the concentration achievable by specific treatment methods. Three concentrations are below the analytically quantifiable limit. Therefore, this toxic pollutant is not considered for specific regulation in this subcategory.

1,2,4-trichlorobenzene (8) concentrations appeared on 1 of 11 process sampling days in the zinc casting subcategory. The concentration was 3.15 mg/l. Because this toxic pollutant is found at only one plant, it is not considered for specific regulation in this subcategory.

1,1,1-trichloroethane (11) concentrations appeared on 3 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.044 mg/l. This concentration is lower than the concentration considered to be achievable with available specific treatment methods. Two concentrations are below the analytically quantifiable limit. Therefore, this pollutant is not considered for specific regulation in this subcategory.

Chloroform (23) concentrations appeared on all 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.067 mg/l. This concentration is lower than the concentration considered to be achievable with available specific treatment methods. Ten concentrations are below the

analytically quantificable limit. Therefore, this pollutant is not considered for specific regulation in this subcategory.

2-chlorophenol(24) concentrations appeared on 3 of 11 sampling days in the zinc casting subcategory. The maximum concentration was 0.21 mg/l. One concentration is below the analytically quantifiable limit. Another concentration is below the level considered to be achievable with available specific treatment methods. Therefore, 2-chlorophenol is not considered for specific regulation in this subcategory.

1,2-trans-dichloroethylene (30) concentrations appeared on 1 of 11 process sampling days in the zinc casting subcategory. The concentration was 0.043 mg/l. Because this toxic pollutant is found at only one plant, and the concentration is lower than the concentration considered to be achievable with available specific treatment methods, this pollutant is not considered for specific regulation in this subcategory.

2,4-dinitrotoluene (35) concentrations appeared on 1 of 11 process sampling days in the zinc casting subcategory. The concentration was 0.11 mg/l. Because this pollutant is present at only one plant, it is not considered for specific regulation in this subcategory.

2,6-dinitrotoluene (36) concentrations appeared on 1 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.11 mg/l. Because this pollutant is present at only one plant, it is not considered for specific regulation in this subcategory.

Ethylbenzene (38) concentrations appeared on 2 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.018 mg/l. This concentration is lower than the concentration considered to be achievable with available specific treatment methods. One concentration is below the analytically quantifiable limit. Therefore, this pollutant is not considered for specific regulation in this subcategory.

Fluoranthene (39) concentrations appeared on 6 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.029 mg/l. Two concentrations are below the analytically quantifiable limit. Four of the concentrations are slightly greater than the level considered to be achievable by specific treatment methods. However, all of these concentrations are much lower than the human toxicity level. Therefore, fluoranthene is not considered for specific regulation in this subcategory.

Methylene chloride (44) concentrations appeared on 7 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.30 mg/l. Four concentrations are below the analytically quantifiable limit. Another concentration is lower than the concentration considered to be achieved with available specific treatment technology. Therefore, methylene chloride is not considered for specific regulation in this subcategory.

Nitrobenzene (56) concentrations appeared on 1 of 11 process sampling days in the zinc casting subcategory. The concentration was 0.21 mg/l. Because this toxic pollutant is present at only one plant, nitrobenzene is not considered for specific regulation in this subcategory.

4-nitrophenol (58) concentrations appeared on 1 of 11 process sampling days in the zinc casting subcategory. The concentration was 1.6 mg/l. Because this toxic pollutant is present at only one plant, 4-nitrophenol is not considered for specific regulation in this subcategory.

2,4-dinitrophenol (59) concentrations appeared on 2 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.09 mg/l. One concentration is below the analytically quantifiable limit. Therefore, 2,4-dinitrophenol is not considered for specific regulation in this subcategory.

Bis(2-ethylhexyl) phthalate (66) concentrations appeared on all 11 process sampling days in the zinc casting subcategory. The maximum concentration was 4.3 mg/l. Many of the concentrations are greater than those considered to be achievable with available specific treatment methods. However, all of the concentrations are much lower than the human toxicity level. to cause toxic effects in humans. Therefore, bis(2-ethylhexyl) phthalate is not considered for specific regulation in this subcategory.

Di-n-butyl phthalate (68) concentrations appeared on all 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.30 mg/l. Many of the concentrations are greater than those considered to be achievable with available specific treatment methods. However, all of the concentrations are much lower than the human toxicity level. Therefore, di-n-butyl phthalate is not considered for specific regulation in this subcategory.

Di-n-octyl phthalate (69) concentrations appeared on 1 of 11 process sampling days in the zinc casting subcategory. The concentration was 2.8 mg/l. Because this toxic pollutant is

present at only one plant, di-octyl phthalate is not considered for specific regulation in this subcategory.

Diethyl phthalate (70) concentrations appeared on 6 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 13.0 mg/l. Many of the concentrations are greater than those considered to be achievable with available specific treatment methods. Two concentrations are below the analytically quantifiable limit. However, all of the concentrations are much lower than the human toxicity level. Therefore, diethyl phthalate is not considered for specific regulation in this subcategory.

Dimethyl pthalate (71) concentrations appeared on 3 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.13 mg/l. One concentration is below the analytically quantifiable limit. All of the concentrations are much lower than the human toxicity level. Therefore, dimethyl phthalate is not considered for specific regulation in this subcategory.

Benzo(a)anthracene (72) concentrations appeared on 2 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.075 mg/l. One concentration is below the analytically quantifiable limit. Because this toxic pollutant is present at only one plant, benzo(a)anthracene is not considered for specific regulation in this subcategory.

Chrysene (76) concentrations appeared on 2 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.055 mg/l. One concentration is below the analytically quantifiable limit. Because this toxic pollutant was present at only one plant, chrysene is not considered for specific regulation in this subcategory.

Acenaphthylene (77) concentrations appeared on 4 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.12 mg/l. Three concentrations are below the analytically quantifiable limit. Because this toxic pollutant is found on only one process sampling day at a level considered to be achievable with available specific treatment methods, acenaphthylene is not considered for specific regulation in this subcategory.

Fluorene (80) concentrations appeared on 4 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.073 mg/l. Three concentrations are below the analytically quantifiable limit. Because this toxic pollutant is found on only one process sampling day at a level considered to be

achievable with available specific treatment methods, fluorene is not considered for specific regulation in this subcategory.

Toluene (86) concentrations appeared on 4 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.027 mg/l. All concentrations are lower than the concentrations considered to be achievable with available specific treatment methods. Two concentrations are below the analytically quantifiable limit. Therefore, toluene is not considered for specific regulation in this subcategory.

Trichloroethylene (87) concentrations appeared on 5 of 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.23 mg/l. Three concentrations are below the analytically quantifiable limit. One concentration is lower than the level considered achievable with available specific treatment methods. Because this toxic pollutant is found on only one process sampling day at a level considered to be achievable with available specific treatment methods, trichloroethylene is not considered for specific regulation in this subcategory

Cyanide (121) concentrations appeared on all 11 process sampling days in the zinc casting subcategory. The maximum concentration was 0.02 mg/l. All concentrations are lower than level considered to be achievable with available specific treatment methods. Therefore, cyanide is not considered for specific regulation in this subcategory.

Copper (120) concentrations appeared on all 8 process sampling days in the zinc casting subcategory. The maximum concentration was 0.20 mg/l. Two concentrations are lower than the analytically quantifiable limit. Five concentrations are lower than the concentrations considered to be achievable with available specific treatment methods. Because this toxic pollutant is found on only one process sampling day at a level considered to be achievable with available specific treatment methods, copper is not considered for specific regulation in this subcategory.

Mercury (123) concentrations appeared on all 8 process sampling days in the zinc casting subcategory. The maximum concentration was 0.0012 mg/l. All concentrations are lower than the concentrations considered to be achievable with available specific treatment methods. Therefore, cyanide is not considered for specific regulation in this subcategory.

Nickel (124) conentrations appeared on all 8 process sampling days in the zinc casting subcategory. The maximum concentration was 0.04 mg/l. Seven concentrations are lower than the

analytically quantifiable limit. Because this toxic pollutant is found on only one process sampling day at a level considered to be achievable with available specific treatment methods, nickel is not considered for specific regulation in this subcategory.

Xylene (130) concentrations appeared on 2 of 9 process sampling days in the zinc casting subcategory. The maximum concentration was 0.12 mg/l. Three concentrations are below the analytically quantifiable limit. The maximum concentration is less than the human toxicity level. Therefore, xylene is not considered for specific regulation in this subcategory.

Ammonia concentrations appeared on all 11 process sampling days in the zinc casting subcategory. The maximum concentration was 2.4 mg/l. All concentrations are lower than the level considered likely to cause toxic effects in humans. Therefore, ammonia is not considered for specific regulation in this subcategory.

Fluoride concentrations appeared on all 11 process sampling days in the zinc casting subcategory. The maximum concentration was 3.0 mg/l. All concentrations are lower than the level considered be achievable with available specific treatment methods. Therefore, fluoride is not considered for specific regulation in this subcategory.

Iron concentrations appeared on all 11 process sampling days in the zinc casting subcategory. The maximum concentration was 6.9 mg/l. Eight of the concentration values are above the levels considered to be achievable by specific treatment methods. An examination of the melting furnace scrubber and the die casting and casting quench processes, however, indicates that the presence of this pollutant cannot be directly attributed to these processes. Therefore, iron is not considered for specific regulation in this subcategory.

Summary

Table VI-4 presents a summary of the toxic pollutant dispositions, by subcategory, discussed previously in this section. Table VI-5 presents a summary of the conventional and non-conventional pollutant dispositions for each subcategory While these two tables list the various pollutants considered for specific regulation in each subcategory, Table VI-6 presents a summary of those toxic, conventional, and non-conventional pollutants considered for specific regulation in each process segment. These pollutants were considered for regulation on the basis of: plant assessments of a pollutant's presence (refer to Section V); engineering assessments of a pollutant's presence (refer to Section V); and the sampled plant analytical data with

respect to the frequency and concentrations at which each pollutant was found in each process segment. Refer to Sections IX through XIII for discussions of the rationale used to select pollutants for regulation in each subcategory and process segment.

TABLE VI-1

TOXIC POLLUTANTS NOT DETECTED IN THE METAL MOLDING AND CASTING CATEGORY

Pollutant Number	Pollutant Name
002	Acrolein
003	Acrylonitrile
012	Hexachloroethane
016	Chloroethane
017	bis-(chloromethyl) ether
019	2-chloroethyl vinyl ether
028	3,3'-dichlorobenzidine
029	1,1-dichloroethylene
032	1,2-dichloropropane
040	4-chlorophenyl phenyl ether
041	4-bromophenyl phenyl ether
042	bis-(2-chloroisopropyl)ether
046	Methyl bromide
050	Dichlorodifluoromethane
052	Hexachlorobutadiene
053	Hexachlorocyclopentadiene
061	N-nitrosodimethylamine
079	Benzo (g,h,i) perylene
082	Dibenzo (a,h) anthracene
083	Indeno (1,2,3,-cd) pyrene
088	Vinyl chloride
116	Asbestos
129	2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

TABLE VI-2

TOXIC POLLUTANTS DETECTED BELOW QUANTIFIABLE LIMITS IN THE METAL MOLDING AND CASTING CATEGORY

Pollutant Number	Pollutant Name
009	Hexachlorobenzene
020	2-chloronaphthalene
025	1,2-dichlorobenzene
026	1,3-dichlorobenzene
027	1,4-dichlorobenzene
037	1,2-diphenylhydrazine
090	Dieldrin
094	4,4'-DDD
095	a-endosulfan-Alpha
096	b-endosulfan-Beta
097	Endosulfan sulfate
098	Endrin
100	Heptachlor
113	Toxaphene

TABLE VI-3

TOXIC POLLUTANTS PRESENT IN THE
METAL MOLDING AND CASTING CATEGORY

Pollutant Number	Pollutant Name	Pollutant Number	Pollutant Name
001	Acenaphthene	048	Dichlorobromomethane
004	Benzene	049	Trichlorofluoromethane
005	Benzidine	051	Chlorodibromomethane
006	Carbon tetrachloride	054	Isophorone
007	Chlorobenzene	055	Naphthalene
008	1,2,4-trichlorobenzene	056	Nitrobenzene
010	1,2-dichloroethane	057	2-nitrophenol
011	1,1,1-trichloroethane	058	4-nitrophenol
013	1,1-dichloroethane	059	2,4-dinitrophenol
014	1,1,2-trichloroethane	060	4,6-dinitro-o-cresol
015	1,1,2,2-tetrachloroethane	062	N-nitrosodiphenylamine
018	bis-(2-chloroethyl)ether	063	N-nitrosodi-n-propylamine
021	2,4,6-trichlorophenol	064	Pentachlorophenol
022	Parachlorometacresol	065	Phenol
023	Chloroform	066	bis(2-ethylhexyl)phthalate
024	2-chlorophenol	067	Butyl benzyl phthalate
030	1,2-trans-dichloroethylene	068	Di-n-butyl phthalate
031	2,4-dichlorophenol	069	Di-n-octyl phthalate
033	1,3-dichloropropylene	070	Diethyl phthalate
034	2,4-dimethylphenol	071	Dimethyl phthalate
035	2,4-dinitrotoluene	072	Benzo(a)anthracene
036	2,6-dinitrotoluene	073	Benzo(a)pyrene
038	Ethylbenzene	074	3,4-benzofluoranthene
039	Fluoranthene	075	Benzo(k)fluoranthene
043	bis(2-chloroethoxy)methane	076	Chrysene
044	Methylene chloride	077	Acenaphthylene
045	Methyl chloride	078	Anthracene
047	Bromoform	080	Fluorene

TABLE VI-3
TOXIC POLLUTANTS PRESENT IN THE
METAL MOLDING AND CASTING CATEGORY
PAGE 2

Pollutant Number	Pollutant Name	Pollutant Number	Pollutant Name
081	Phenanthrene	110	PCB-1248
084	Pyrene	111	PCB-1260
085	Tetrachloroethylene	112	PCB-1016
086	Toluene	114	Antimony
087	Trichloroethylene	115	Arsenic
089	Aldrin	117	Beryllium
091	Chlordane	118	Cadmium
092	4,4'-DDT	119	Chromium
093	4,4'-DDE	120	Copper
099	Endrin aldehyde	121	Cyanide
101	Heptachlor epoxide	122	Lead
102	a-BHC-Alpha	123	Mercury
103	b-BHC-Beta	124	Nickel
104	r-BHC-Gamma	125	Selenium
105	g-BHC-Delta	126	Silver
106	PCB-1242	127	Thallium
107	PCB-1254	128	Zinc
108	PCB-1221		
109	PCB-1232		

TABLE VI-4

TOXIC POLLUTANT DISPOSITION
METAL MOLDING AND CASTING CATEGORY

Pollutant		Subcategory					
		Aluminum Casting	Copper Casting	Ferrous Casting	Lead Casting	Magnesium Casting	Zinc Casting
001	Acenaphthene	REG	NT	REG	NQ	NT	NT
002	Acrolein	ND	ND	ND	ND	ND	ND
003	Acrylonitrile	ND	ND	ND	ND	ND	ND
004	Benzene	NT	NQ	NT	NQ	NT	NT
005	Benzidine	REG	NQ	NQ	ND	ND	ND
006	Carbon tetrachloride	REG	NT	NT	ND	ND	NT
007	Chlorobenzene	REG	ND	NQ	ND	ND	NQ
008	1,2,4-trichlorobenzene	ND	ND	NT	ND	ND	NT
009	Hexachlorobenzene	ND	ND	NQ	ND	ND	ND
010	1,2-dichloroethane	REG	ND	NQ	ND	ND	ND
011	1,1,1-trichloroethane	REG	NT	NT	NT	ND	NT
012	Hexachloroethane	ND	ND	ND	ND	ND	ND
013	1,1-dichloroethane	REG	ND	ND	ND	ND	ND
014	1,1,2-trichloroethane	NQ	NT	NQ	ND	ND	ND
015	1,1,2,2-tetrachloroethane	NT	ND	ND	ND	ND	NQ
016	Chloroethane	ND	ND	ND	ND	ND	ND
017	bis(chloromethyl)ether	ND	ND	ND	ND	ND	ND
018	bis(2-chloroethyl)ether	NT	ND	NT	ND	ND	ND
019	2-chloroethyl vinyl ether	ND	ND	ND	ND	ND	ND
020	2-chloronaphthalene	ND	ND	NQ	ND	NQ	ND
021	2,4,6-trichlorophenol	REG	NQ	NT	NQ	NQ	REG
022	Parachlorometacresol	REG	NQ	NT	ND	ND	REG
023	Chloroform	REG	NT	NT	NT	NT	NT
024	2-chlorophenol	NT	ND	REG	NQ	NQ	NT
025	1,2-dichlorobenzene	ND	ND	ND	ND	ND	NQ
026	1,3-dichlorobenzene	ND	ND	NQ	NQ	NQ	ND
027	1,4-dichlorobenzene	ND	ND	ND	ND	NQ	ND
028	3,3'-dichlorobenzidine	ND	ND	ND	ND	ND	ND
029	1,1-dichloroethylene	ND	ND	ND	ND	ND	ND
030	1,2-trans-dichloroethylene	NQ	ND	NT	ND	ND	NT

TABLE VI-4
TOXIC POLLUTANT DISPOSITION
METAL MOLDING AND CASTING CATEGORY
PAGE 2

Pollutant		Subcategory					
		Aluminum Casting	Copper Casting	Ferrous Casting	Lead Casting	Magnesium Casting	Zinc Casting
031	2,4-dichlorophenol	REG	ND	REG	NQ	ND	REG
032	1,2-dichloropropane	ND	ND	ND	ND	ND	ND
033	1,3-dichloropropylene	ND	ND	NT	ND	ND	ND
034	2,4-dimethylphenol	NT	NT	REG	ND	NT	REG
035	2,4-dinitrotoluene	ND	ND	NQ	ND	ND	NT
036	2,6-dinitrotoluene	NQ	NT	NQ	ND	ND	NT
037	1,2-diphenylhydrazine	ND	NQ	NQ	ND	ND	NQ
038	Ethylbenzene	NT	ND	NQ	NQ	ND	NT
039	Fluoranthene	REG	NQ	REG	NQ	NQ	NT
040	4-chlorophenyl phenyl ether	ND	ND	ND	ND	ND	ND
041	4-bromophenyl phenyl ether	ND	ND	ND	ND	ND	ND
042	bis(2-chloroisopropyl)ether	ND	ND	ND	ND	ND	ND
043	bis(2-chloroethoxy)methane	ND	ND	NT	ND	ND	ND
044	Methylene chloride	REG	NT	NT	NQ	NT	NT
045	Methyl chloride	ND	NT	NT	ND	ND	ND
046	Methyl bromide	ND	ND	ND	ND	ND	ND
047	Bromoform	NQ	NQ	NT	ND	ND	ND
048	Dichlorobromomethane	NT	ND	NQ	NQ	NQ	ND
049	Trichlorofluoromethane	ND	ND	NT	ND	ND	ND
050	Dichlorodifluoromethane	ND	ND	ND	ND	ND	ND
051	Chlorodibromomethane	NQ	ND	NT	NQ	ND	ND
052	Hexachlorobutadiene	ND	ND	ND	ND	ND	ND
053	Hexachlorocyclopentadiene	ND	ND	ND	ND	ND	ND
054	Isophorone	ND	NT	NT	ND	ND	NQ
055	Naphthalene	REG	NQ	NT	NT	NQ	REG
056	Nitrobenzene	ND	ND	NT	ND	ND	NT
057	2-nitrophenol	NT	NQ	NT	ND	NQ	ND
058	4-nitrophenol	REG	NT	NT	ND	ND	NT
059	2,4-dinitrophenol	NT	NQ	REG	ND	ND	NT
060	4,6-dinitro-o-cresol	NT	NQ	REG	ND	ND	ND

TABLE VI-4
TOXIC POLLUTANT DISPOSITION
METAL MOLDING AND CASTING CATEGORY
PAGE 3

Pollutant		Subcategory					
		Aluminum Casting	Copper Casting	Ferrous Casting	Lead Casting	Magnesium Casting	Zinc Casting
061	N-nitrosodimethylamine	ND	ND	ND	ND	ND	ND
062	N-nitrosodiphenylamine	ND	ND	REG	ND	ND	ND
063	N-nitrosodi-n-propylamine	REG	ND	ND	ND	ND	ND
064	Pentachlorophenol	REG	NT	REG	ND	NT	NQ
065	Phenol	REG	NT	REG	NQ	NT	REG
066	bis(2-ethylhexyl)phthalate	REG	NT	NT	NT	NT	NT
067	Butyl benzyl phthalate	REG	REG	REG	NT	NT	REG
068	Di-n-butyl phthalate	NT	NT	NT	NT	NT	NT
069	Di-n-octyl phthalate	NQ	NQ	NT	NT	ND	NT
070	Diethyl phthalate	NT	NT	NT	ND	NT	NT
071	Dimethyl phthalate	NT	NT	NT	ND	NT	NT
072	Benzo(a)anthracene	REG	NT	REG	NQ	NQ	NT
073	Benzo(a)pyrene	REG	NT	NQ	NQ	NQ	ND
074	3,4-benzofluoranthene	NQ	REG	NT	NQ	ND	ND
075	Benzo(k)fluoranthene	NQ	REG	NT	NQ	NQ	ND
076	Chrysene	REG	NT	REG	NQ	NT	NT
077	Acenaphthylene	REG	NT	REG	ND	NT	NT
078	Anthracene	REG	NT	NQ	NT	NT	NQ
079	Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND
080	Fluorene	REG	NQ	REG	NQ	NQ	NT
081	Phenanthrene	REG	NT	REG	NT	NT	NQ
082	Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND
083	Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND
084	Pyrene	REG	REG	REG	NT	NT	REG
085	Tetrachloroethylene	REG	NT	REG	ND	NQ	REG
086	Toluene	NT	NQ	NT	NQ	NT	NT
087	Trichloroethylene	REG	NT	NT	NQ	ND	NT
088	Vinyl chloride	ND	ND	ND	ND	ND	ND
089	Aldrin	NT	NQ	NQ	ND	ND	NQ
090	Dieldrin	NQ	NQ	NQ	ND	NQ	ND

TABLE VI-4
TOXIC POLLUTANT DISPOSITION
METAL MOLDING AND CASTING CATEGORY
PAGE 4

Pollutant		Subcategory					
		Aluminum Casting	Copper Casting	Ferrous Casting	Lead Casting	Magnesium Casting	Zinc Casting
091	Chlordane	REG	NQ	NQ	ND	ND	NQ
092	4,4'-DDT	NT	NQ	NQ	ND	NQ	NQ
093	4,4'-DDE	NT	NQ	NQ	ND	ND	NQ
094	4,4'-DDD	NQ	ND	NQ	ND	NQ	NQ
095	a-endosulfan-Alpha	NQ	ND	NQ	ND	NQ	NQ
096	b-endosulfan-Beta	NQ	ND	NQ	ND	ND	NQ
097	Endosulfan sulfate	NQ	NQ	NQ	ND	ND	NQ
098	Endrin	NQ	ND	NQ	ND	ND	NQ
099	Endrin aldehyde	NQ	NQ	NT	ND	NQ	NQ
100	Heptachlor	NQ	NQ	NQ	ND	ND	NQ
101	Heptachlor epoxide	NT	NQ	NQ	NQ	NQ	NQ
102	a-BHC-Alpha	NT	NQ	NQ	ND	NQ	NQ
103	b-BHC-Beta	NT	NQ	NT	ND	ND	NQ
104	r-BHC-Gamma	NT	NQ	NQ	ND	NQ	NQ
105	g-BHC-Delta	NT	NQ	NQ	ND	ND	ND
106	PCB-1242	NT	NQ	NQ	ND	NQ	NQ
107	PCB-1254	NT	NQ	NQ	ND	NQ	NQ
108	PCB-1221	NT	NQ	NQ	ND	NQ	NQ
109	PCB-1232	NT	NQ	NQ	ND	NQ	NQ
110	PCB-1248	NT	NQ	NQ	ND	NQ	NQ
111	PCB-1260	NT	NQ	NQ	ND	NQ	NQ
112	PCB-1016	NT	NQ	NQ	ND	NQ	NQ
113	Toxaphene	ND	NQ	NQ	ND	ND	ND
114	Antimony	ND	ND	REG	NT	ND	ND
115	Arsenic	NT	NT	REG	NQ	NQ	NQ
116	Asbestos	ND	ND	ND	ND	ND	ND
117	Beryllium	ND	NQ	NT	NQ	ND	ND
118	Cadmium	ND	NT	REG	NT	ND	ND
119	Chromium	NT	NQ	REG	NQ	ND	NQ

TABLE VI-4
TOXIC POLLUTANT DISPOSITION
METAL MOLDING AND CASTING CATEGORY
PAGE 5

Pollutant	Subcategory					
	Aluminum Casting	Copper Casting	Ferrous Casting	Lead Casting	Magnesium Casting	Zinc Casting
120 Copper	REG	REG	REG	REG	NT	NT
121 Cyanide	NT	NT	NT	NQ	NT	NT
122 Lead	NT	REG	REG	REG	NT	REG
123 Mercury	NT	NT	NT	NQ	NQ	NT
124 Nickel	NT	REG	REG	NQ	ND	NT
125 Selenium	NQ	NQ	NT	NQ	NQ	NQ
126 Silver	NQ	NQ	NT	NQ	NQ	NQ
127 Thallium	NQ	NQ	NT	NQ	NQ	NQ
128 Zinc	NT	REG	REG	REG	REG	REG
129 TCDD	ND	ND	ND	ND	ND	ND

LEGEND:

ND : Not detected
NQ : Not quantifiable
NT : Not treatable by the end-of-pipe technologies considered or found only once.
REG: Considered for regulation

TABLE VI-5

CONVENTIONAL AND NON-CONVENTIONAL POLLUTANT DISPOSITION
METAL MOLDING AND CASTING CATEGORY

Pollutant	Subcategory					
	Aluminum Casting	Copper Casting	Ferrous Casting	Lead Casting	Magnesium Casting	Zinc Casting
TSS	REG	REG	REG	REG	REG	REG
Oil & Grease	REG	REG	REG	REG	REG	REG
pH	REG	REG	REG	REG	REG	REG
Ammonia (N)	REG	NT	REG	NT	NT	NT
Sulfide	REG	NT	REG	NQ	REG	REG
Fluoride	NT	NT	REG	NT	NT	NT
Manganese	NT	REG	REG	NT	REG	REG
Iron	NT	NT	REG	NT	NT	NT
Phenols (4AAP)	REG	REG	REG	NT	REG	REG
Xylene	REG	NT	NT	NT	NT	NT

LEGEND:

ND : Not detected
NQ : Not quantifiable
NT : Not treatable by the end-of-pipe technologies considered or found only once.
REG: Considered for regulation

TABLE VI-6

TOXIC, CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS
CONSIDERED FOR REGULATION IN THE METAL MOLDING AND CASTING CATEGORY

		Aluminum					Copper	
Pollutant		Investment Casting	Melting Furnace Scrubber	Die Casting	Casting Quench	Die Lube	Dust Collection	Mold Cooling And Casting Quench
001	Acenaphthene	-	-	X	-	-	-	-
005	Benzidine	-	-	-	-	X	-	-
006	Carbon tetrachloride	-	-	-	-	X	-	-
007	Chlorobenzene	-	-	-	-	X	-	-
010	1,2-dichloroethane	-	-	-	-	X	-	-
011	1,1,1-trichloroethane	-	-	-	-	X	-	-
013	1,1-dichloroethane	-	-	-	-	X	-	-
021	2,4,6-trichlorophenol	-	X	X	X	X	-	-
022	Parachlorometa cresol	-	-	X	-	-	-	-
023	Chloroform	-	-	X	-	X	-	-
024	2-chlorophenol	-	-	-	-	-	-	-
031	2,4-dichlorophenol	-	-	-	X	-	-	-
034	2,4-dimethylphenol	-	-	-	-	-	-	-
039	Fluoranthene	-	X	X	X	X	-	-
044	Methylene chloride	-	-	-	-	X	-	-
055	Naphthalene	-	-	-	-	X	-	-
058	4-nitrophenol	-	-	-	-	X	-	-
059	2,4-dinitrophenol	-	-	-	-	-	-	-
060	4,6-dinitro-o-cresol	-	-	-	-	-	-	-
062	N-nitrosodiphenylamine	-	-	-	-	-	-	-
063	N-nitrosodi-n-propylamine	-	-	X	-	-	-	-
064	Pentachlorophenol	-	-	-	-	X	-	-
065	Phenol	-	-	X	-	X	-	-
066	bis(2-ethylhexyl)phthalate	-	-	-	-	X	-	-
067	Butyl benzyl phthalate	-	-	X	X	X	X	-
072	Benzo(a)anthracene	-	-	X	-	X	-	-
073	Benzo(a)pyrene	-	X	-	-	-	-	-
074	3,4-benzofluoranthene	-	-	-	-	-	X	-
075	Benzo(k)fluoranthane	-	-	-	-	-	X	-
076	Chrysene	-	-	X	-	-	-	-
077	Acenaphthylene	-	-	-	-	X	-	-
078	Anthracene	-	-	-	-	X	-	-
080	Fluorene	-	-	-	-	X	-	-
081	Phenanthrene	-	-	-	-	X	-	-
084	Pyrene	-	-	X	X	X	X	-
085	Tetrachloroethylene	X	-	X	X	X	-	-
087	Trichloroethylene	X	-	-	-	X	-	-
091	Chlordane	-	-	-	-	X	-	-
114	Antimony	-	-	-	-	-	-	-
115	Arsenic	-	-	-	-	-	-	-
118	Cadmium	-	-	-	-	-	-	-
119	Chromium	-	-	-	-	-	-	-
120	Copper	-	-	-	X	X	X	X
122	Lead	-	-	X	-	X	X	-
124	Nickel	-	-	-	-	-	X	-
128	Zinc	-	X	X	X	X	X	X
	Ammonia (N)	-	X	-	-	X	-	-
	Fluoride	-	-	-	-	-	-	-
	Iron	-	-	-	-	-	-	-
	Manganese	-	-	-	-	-	X	-
	Oil & Grease	X	X	X	X	X	X	X
	Phenols (4AAP)	-	X	X	-	X	X	-
	Sulfide	-	X	-	X	X	-	-
	TSS	X	X	X	X	X	X	X
	Xylene	-	-	X	X	X	-	-
	pH	X	X	X	X	X	X	X

TABLE VI-6
TOXIC, CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS CONSIDERED FOR REGULATION IN THE METAL MOLDING AND CASTING CATEGORY
PAGE 2

		Ferrous					Lead		
Pollutant		Dust Collection	Melting Furnace Scrubber	Slag Quench	Mold Cooling And Casting Quench	Sand Washing	Continuous Strip Casting	Melting Furnace Scrubber	Grid Casting
001	Acenaphthene	X	-	-	-	X	-	-	-
005	Benzidine	-	-	-	-	-	-	-	-
006	Carbon tetrachloride	-	-	-	-	-	-	-	-
007	Chlorobenzene	-	-	-	-	-	-	-	-
010	1,2-dichloroethane	-	-	-	-	-	-	-	-
011	1,1,1-trichloroethane	-	-	-	-	-	-	-	-
013	1,1-dichloroethane	-	-	-	-	-	-	-	-
021	2,4,6-trichlorophenol	-	-	-	-	-	-	-	-
022	Parachlorometa cresol	-	-	-	-	-	-	-	-
023	Chloroform	-	-	-	-	-	-	-	-
024	2-chlorophenol	-	X	-	-	-	-	-	-
031	2,4-dichlorophenol	X	X	-	-	-	-	-	-
034	2,4-dimethylphenol	X	X	X	-	-	-	-	-
039	Fluoranthene	X	X	-	-	-	-	-	-
044	Methylene chloride	-	-	-	-	-	-	-	-
055	Naphthalene	-	-	-	-	-	-	-	-
058	4-nitrophenol	-	-	-	-	-	-	-	-
059	2,4-dinitrophenol	-	X	-	-	-	-	-	-
060	4,6-dinitro-o-cresol	-	X	-	-	-	-	-	-
062	N-nitrosodiphenylamine	X	X	X	-	-	-	-	-
063	n-nitrosodi-n-propylamine	-	-	-	-	-	-	-	-
064	Pentachlorophenol	X	X	-	-	-	-	-	-
065	Phenol	X	X	X	-	X	-	-	-
066	bis(2-ethylhexyl)phthalate	-	-	-	-	-	-	-	-
067	Butyl benzyl phthalate	X	X	-	-	-	-	-	-
072	Benzo(a)anthracene	X	X	-	-	-	-	-	-
073	Benzo(a)pyrene	-	-	-	-	-	-	-	-
074	3,4-benzofluoranthene	-	-	-	-	-	-	-	-
075	Benzo(k)fluoranthane	-	-	-	-	-	-	-	-
076	Chrysene	X	X	-	-	-	-	-	-
077	Acenaphthylene	X	X	-	-	X	-	-	-
078	Anthracene	-	-	-	-	-	-	-	-
080	Fluorene	X	X	-	-	-	-	-	-
081	Phenanthrene	X	X	-	-	-	-	-	-
084	Pyrene	X	X	-	-	X	-	-	-
085	Tetrachloroethylene	X	X	X	-	-	-	-	-
087	Trichloroethylene	-	-	-	-	-	-	-	-
091	Chlordane	-	-	-	-	-	-	-	-
114	Antimony	-	X	-	-	-	-	-	-
115	Arsenic	-	X	-	-	-	-	-	-
118	Cadmium	-	X	X	-	-	-	-	-
119	Chromium	-	X	X	-	X	-	-	-
120	Copper	X	X	X	-	X	X	X	X
122	Lead	X	X	X	-	X	X	X	X
124	Nickel	X	X	X	-	X	-	-	-
128	Zinc	X	X	X	-	X	X	X	X
	Ammonia (N)	X	X	X	-	X	-	-	-
	Fluoride	-	X	X	-	-	-	-	-
	Iron	X	X	X	X	X	-	-	-
	Manganese	X	X	X	-	X	-	-	-
	Oil & Grease	X	X	X	X	X	X	X	X
	Phenols (4AAP)	X	X	X	-	X	-	-	-
	Sulfide	X	X	X	-	X	-	-	-
	TSS	X	X	X	X	X	X	X	X
	Xylene	-	-	-	-	-	-	-	-
	pH	X	X	X	X	X	X	X	X

TABLE VI-6
TOXIC, CONVENTIONAL AND NON-CONVENTIONAL POLLUTANTS CONSIDERED
FOR REGULATION IN THE METAL MOLDING AND CASTING CATEGORY
PAGE 3

		Magnesium		Zinc	
	Pollutant	Dust Collection	Grinding Scrubber	Casting Quench	Melting Furnace Scrubber
001	Acenaphthene	-	-	-	-
005	Benzidine	-	-	-	-
006	Carbon tetrachloride	-	-	-	-
007	Chlorobenzene	-	-	-	-
010	1,2-dichloroethane	-	-	-	-
011	1,1,1-trichloroethane	-	-	-	-
013	1,1-dichloroethane	-	-	-	-
021	2,4,6-trichlorophenol	-	-	X	X
022	Parachlorometacresol	-	-	X	X
023	Chloroform	-	-	-	-
024	2-chlorophenol	-	-	-	-
031	2,4-dichlorophenol	-	-	-	X
034	2,4-dimethylphenol	-	-	-	X
039	Fluoranthene	-	-	-	-
044	Methylene chloride	-	-	-	-
055	Naphthalene	-	-	-	X
058	4-nitrophenol	-	-	-	-
059	2,4-dinitrophenol	-	-	-	-
060	4,6-dinitro-o-cresol	-	-	-	-
062	N-nitrosodiphenylamine	-	-	-	-
063	n-nitrosodi-n-propylamine	-	-	-	-
064	Pentachlorophenol	-	-	-	-
065	Phenol	-	-	-	X
066	bis(2-ethylhexyl)phthalate	-	-	-	-
067	Butyl benzyl phthalate	-	-	-	X
072	Benzo(a)anthracene	-	-	-	-
073	Benzo(a)pyrene	-	-	-	-
074	3,4-benzofluoranthene	-	-	-	-
075	Benzo(k)fluoranthane	-	-	-	-
076	Chrysene	-	-	-	-
077	Acenaphthylene	-	-	-	-
078	Anthracene	-	-	-	-
080	Fluorene	-	-	-	-
081	Phenanthrene	-	-	-	-
084	Pyrene	-	-	X	-
085	Tetrachloroethylene	-	-	X	-
087	Trichloroethylene	-	-	-	-
091	Chlordane	-	-	-	-
114	Antimony	-	-	-	-
115	Arsenic	-	-	-	-
118	Cadmium	-	-	-	-
119	Chromium	-	-	-	-
120	Copper	-	-	-	-
122	Lead	-	-	X	-
124	Nickel	-	-	-	-
128	Zinc	X	X	X	X
	Ammonia (N)	-	-	-	-
	Fluoride	-	-	-	-
	Iron	-	-	-	-
	Manganese	-	X	X	-
	Oil & Grease	X	X	X	X
	Phenols (4AAP)	X	-	X	X
	Sulfide	X	-	X	-
	TSS	X	X	X	X
	Xylene	-	-	-	-
	pH	X	X	X	X

X: Pollutant considered for regulation.
-: Pollutant not considered for regulation.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

INTRODUCTION

This section describes the treatment techniques currently in use or available to remove or recover the wastewater pollutants generated by metal molding and casting processes. Included are discussions of individual treatment technologies and in-plant technologies.

END-OF-PIPE TREATMENT TECHNOLOGIES

This subsection describes individual recovery and treatment technologies which are used or are suitable for use in treating wastewater discharges from metal molding and casting facilities. Each description includes a functional description and discussion of application and performance, advantages and limitations, operational factors (reliability, maintainability, solid waste aspects), and demonstration status. The treatment processes described herein include technologies presently demonstrated within the metal molding and casting category and technologies demonstrated in the treatment of similar wastewaters in other industries.

Metal molding and casting wastewater streams characteristically contain significant levels of toxic organic and inorganic pollutants. Table VI-3 presented a list of the toxic pollutants found in metal molding and casting process wastewater streams in substantial concentrations. These toxic pollutants constitute the most significant wastewater pollutants in this category. In general, these pollutants are removed by chemical precipitation and sedimentation or filtration. Toxic metals may be effectively removed by precipitation of metal hydroxides or carbonates utilizing the reaction with lime, sodium hydroxide, or sodium carbonate. Oil and grease are removed by chemical emulsion breaking and skimming. The sampled plants (12040 and 17089) analytical data also demonstrate a concurrent removal of toxic The removal of oil and grease causes a subsequent removal of some toxic organic pollutants.

The discussion of end-of-pipe treatment technologies is divided into three parts: the major technologies; the effectiveness of the major technologies; and minor end-of-pipe technologies.

MAJOR TECHNOLOGIES

In Sections IX, X, XII, and XIII, the rationale for selecting treatment systems is discussed. The individual technologies used in the system are described here. The major end-of-pipe technologies are: emulsion breaking, oil skimming, oxidation by potassium permanganate, chemical precipitation of dissolved metals, sedimentation of suspended solids, and filtration. In practice, precipitation of metals and settling of the resulting precipitates is often a unified two-step operation. Suspended solids originally present in raw wastewaters are not appreciably affected by the precipitation operation and are removed with the precipitated metals in the settling operations. Settling operations can be evaluated independently of hydroxide or other chemical precipitation operations, but hydroxide and other chemical precipitation operations can only be evaluated in combination with a solids removal operation.

1. Emulsion Breaking

Emulsion breaking is the process of separating an emulsified oil and water mixture. Emulsified oils are used as coolants, lubricants, and antioxidants in many metal molding and casting operations. Discussions of the two methods of emulsion breaking, chemical and thermal, follow.

Chemical emulsion breaking can be accomplished as a batch process or as a continuous process. In the batch process, the mixture of emulsified oil and water is collected in large tanks equipped with agitators and a skimmer or some method of decanting. Decanting can be accomplished with a series of taps positioned pipes at various levels. Using the taps sequentially, the separated material is drawn off of the surface of the tank contents. As an alternate method, water can be drawn off near the bottom of the tank until oil appears in the wastewater line. At this point, the oil is diverted to storage tanks for reprocessing or hauling by a licensed contractor. In the continuous process, a skimmer, skimming through, or similar surface material removal device can be used to remove the material broken out of emulsion. The treated effluent would then be discharged from the separation tank.

The chemical emulsion breaking process involves several steps. First, the pH of the solution is lowered to an acidic state (typically a pH of 3 to 4). The second step involves the addition of an iron or aluminum salt (e.g., ferrous sulfate). ferric chloride, or aluminum sulfate. These salts are used to break the emulsion and free the oils from the water. In conjunction with the addition of these salts, the mixture is

agitated to insure complete contact of the waste water/oil mixture with the de-emulsifying agent. With the addition of the proper amount of metallic salts and thorough agitation, emulsions of 5 percent to 10 percent oil can be reduced to approximately 0.01 percent remaining emulsified oil. In the third step of the emulsion breaking process, sufficient time is allowed for the oil/water mixture to separate. Differences in specific gravity will permit the oil to rise to the surface in approximately 2 to 8 hours. After separation, the normal procedure involves skimming or decanting the oil from the top of the tank. Heat, in the form of steam, can be added to decrease the separation time. The fourth and final step involves the addition of a chemical which desalts by precipitating metals from metals from the remaining wastewater solution. Calcium chloride or lime are normally used as the desalting agents and will precipitate out the metallic ions in the wastewater.

Thermal emulsion breaking can also be operated as a continuous or batch process. In most cases, however, these systems are operated intermittently, due to the batch dump nature of most emulsified oil systems. The emulsified raw waste is collected in a holding tank until sufficient volume has accumulated to warrant operating the Thermal Emulsion Breaker (TEB). The TEB most commonly used is an evaporation-distillation-decantation apparatus which separates the spent emulsion into distilled water, oils and other floating particles, and sludge. Initially, the raw waste flows from the holding tank into the main conveyorized chamber. Warm dry air is passed over a large revolving drum which is partially submerged in the emulsion. Water evaporates from the surface of the drum and is carried upward through a filter and a condensing unit. The condensed water is discharged and can be reused as process makeup, while the air is reheated and returned to the evaporation stage. As the concentration of water in the main conveyorized chamber decreases, oil concentration increases and some gravity separation occurs. The oils and other emulsified wastes which separate flow over a weir into a decanting chamber. A rotating drum skimmer picks up oil from the surface of this chamber and discharges it for possible reprocessing or contractor removal. Meanwhile, oily water is drawn from the bottom of the decanting chamber, reheated, and sent back into the main conveyorized chamber. This aids in increasing the concentration of oil in the main chamber and the amount of oil which floats to the top. Solids which settle out in the main chamber are removed by a conveyor mechanism, called a flight scraper, which moves slowly so as not to disturb the settling action.

Application and Performance - Emulsion breaking technology can be applied to the treatment of emulsified solutions in the metal

molding and casting industry wherever it is necessary to separate oils, fats, soaps, etc. from aqueous solutions.

The performance attainable by a chemical emulsion breaking process is dependent on the addition of the proper amount of de-emulsifying agent, proper agitation and sufficient time for complete separation. For this reason, the effectiveness of chemical emulsion breaking systems is somewhat dependent upon the degree of variability in the raw waste. Since there are several types of emulsified oils, a detailed study should be conducted to determine the most effective treatment techniques and chemicals for a particular application. Emulsified oil concentrations of 50,000 to 100,000 mg/l can be reduced to approximately 100 ppm with proper treatment and adequate rise time.

The performance level of a thermal emulsion breaker is dependent primarily on the characteristics of the raw waste and proper maintenance and functioning of the TEB components. Some emulsions may contain volatile compounds which could escape with the treated effluent. In systems where the water is recycled back to the process, however, this problem is essentially eliminated. Experience in at least two copper forming plants has shown that trace organics or other contaminants found in the TEB effluent will not adversely affect the lubricants when this water is recycled back to process emulsions. In one copper forming plant, typical oil and grease levels were 2872 mg/l in the raw waste and 1 mg/l in the effluent.

Samples were taken before and after chemical emulsion breaking operations at a metal molding and casting operation (12040) and at several metal finishing plants. The raw wastewaters from the metal finishing plants have characteristics (i.e., the oil concentrations and the organic constituents of the emulsions) similar to the emulsified oil wastewaters found in the metal molding and casting industrial category. The analytical results of this sampling are presented in Table VII-1.

TABLE VII-1

EMULSION BREAKING PERFORMANCE DATA (mg/l)

Plant 12040

Pollutant	Day 1 Influent	Day 1 Effluent	Day 2 Influent	Day 2 Effluent	Day 3 Influent	Day 3 Effluent
Oil & Grease	1881	30	7627	29	7480	28
TOC	1530	54	12000	49	9280	47
TSS	1204	23	7918	28	6328	20

Pollutant	Plant 1058 Influent	Plant 1058 Effluent	Plant 30165 Influent	Plant 30165 Effluent
Oil & Grease	3320	42	210	24
TOC	31030	262	210	65
TSS	137	12	520	6

Plant 12095

Pollutant	Day 1 Influent	Day 1 Effluent	Day 2 Influent	Day 2 Effluent	Day 3 Influent	Day 3 Effluent
Oil & Grease	12500	27	2300	52	12800	18
TOC	128-	950	2950	1790	1140	881
TSS	2000	153	1650	187	3470	63

Plant 38040

Pollutant	Day 1 Influent	Day 1 Effluent	Day 2 Influent	Day 2 Effluent
Oil & Grease	192.8	10.6	210	129
TOC	143	139	132	116
TSS	74	37	440	13

	Plant 40836	
Pollutant	Influent	Effluent
Oil & Grease	6060	98
TOC	9360	850
TSS	2612.0	46.0

NOTE: TOC - Total Organic Carbon
TSS - Total Suspended Solids

Summarizing the data presented in the above table, the average and median oil and grease removal rates are 92.2% and 98.4%, respectively. The average and median oil and grease effluent levels are 44.3 mg/l and 29 mg/l, respectively. Additionally, the average and median TOC removal rates are 59.8% and 69.0%, respectively. The average and median TOC effluent levels are 473 mg/l and 139 mg/l, respectively.

As indicated by the TOC removals noted in Table VII-1 (above), chemical emulsion breaking can achieve toxic organic pollutant removal. Chemical emulsion breaking is routinely provided in aluminum subcategory die casting operations. Table VII-2 presents toxic organic pollutant analytical data for the two sampled foundry operations (12040 and 17089) which provide chemical emulsion breaking. Both of these plants have aluminum die casting operations. The pollutants listed in Table VII-2 are those which are considered for regulation in the aluminum die casting process segment.

TABLE VII-2

EMULSION BREAKING PERFORMANCE DATA (mg/l)
TOXIC ORGANIC POLLUTANTS

	Plant 12040			
	Day 1		Day 2	
Pollutant	Influent	Effluent	Influent	Effluent
001 Acenaphthene	3,700	<0.010	ND	ND
021 2,4,6-trichloro-phenol	ND	0.012	ND	ND
022 Parachlorometa-cresol	0.360	0.250	0.150	0.056
023 Chloroform	0.410	0.044	<0.010	0.073
039 Fluoranthene	2.200	<0.010	0.011	ND

063	N-nitrosodi-n-propylamine	ND	ND	ND	ND
065	Phenol	ND	<0.010	<0.010	0.029
067	Butyl benzyl phthalate	0.760	ND	ND	ND
072	Benzo(a)anthracene	0.072	<0.010	ND	0.018
076	Chrysene	0.050	0.015	0.030	ND
084	Pyrene	ND	<0.010	0.062	ND
085	Tetrachloro-ethylene	0.090	0.071	0.270	0.150
	Phenols (4AAP)	0.288	0.182	0.102	0.055

	Plant 12040		
		Day 3	
Pollutant		Influent	Effluent
001	Acenaphthene	ND	<0.010
021	2,4,6-trichloro-phenol	0.044	ND
022	Parachlorometa-cresol	0.096	0.041
023	Chloroform	<0.010	0.050
039	Fluoranthene	0.022	<0.010
063	N-nitrosodi-n-propylamine	ND	ND
065	Phenol	<0.010	<0.010
067	Butyl benzyl phthalate	ND	0.027
072	Benzo(a)anthra-cene	0.030	0.032
076	Chrysene	ND	0.011
084	Pyrene	0.048	ND
085	Tetrachloro-ethylene	0.350	0.058
	Phenols (4AAP)	0.156	0.102

	Plant 17089			
		Day 1		
Pollutant		Influent (Melting Fce. Scrubber)	Influent (Die Casting	Effluent
001	Acenaphthene	ND	ND	0.114
021	2,4,6-trichloro-phenol	0.120	ND	0.260
022	Parachlorometa-cresol	ND	ND	ND

023	Chloroform	0.072	0.460	0.099
039	Fluoranthene	0.023	ND	ND
063	N-nitrosodi-n-propylamine	ND	ND	ND
065	Phenol	0.011	ND	0.027
067	Butyl benzyl phthalate	<0.010	ND	1.264
072	Benzo(a)anthracene	ND	*	ND
076	Chrysene	ND	*	ND
084	Pyrene	0.029	<0.010	ND
085	Tetrachloro-ethylene	ND	<0.010	0.046
	Phenols (4AAP)	1.07	5.430	0.525

	Plant 17089 Day 2		
Pollutant	Influent (Melting Fce. Scrubber)	Influent (Die Casting)	Effluent
001	ND	ND	<0.010
021	0.062	ND	<0.010
022	ND	ND	ND
023	0.098	0.460	0.320
039	0.014	ND	<0.010
063	ND	ND	ND
065	<0.010	ND	0.011
067	ND	ND	<0.010
072	<0.010	*	ND
076	<0.010	*	ND
084	ND	<0.010	<0.010
085	ND	<0.010	<0.010
Phenols	1.28	0.278	0.259

	Plant 17089 Day 3		
Pollutant	Influent (Melting Fce. Scrubber)	Influent (Die Casting)	Effluent
001	<0.010	ND	<0.010
021	0.235	2.000	0.105
022	ND	ND	ND
023	0.054	0.340	0.24
039	ND	<0.010	<0.010
063	ND	ND	ND
065	ND	5.000	0.013
067	ND	ND	ND
072	ND	*	<0.010

076	ND	*	ND
084	ND	0.021	<0.010
085	ND	<0.010	<0.010
Phenols	0.169	4.040	0.18

*: Not Quantifiable
ND: Not Detected

The following summarizes the effluent levels achieved by the above operations.

Pollutant	Effluent Levels (mg/l) Average	Median
001 Acenaphthene	0.019	0.000
021 2,4,6-trichlorophenol	0.063	0.006
022 Parachlorometacresol	0.058	0.020
023 Chloroform	0.138	0.086
039 Fluoranthene	0.000	0.000
063 N-nitrosodi-n-propylamine	0.000	0.000
065 Phenol	0.013	0.012
067 Butyl benzyl phthalate	0.214	0.000
072 Benzo(a)anthracene	0.008	0.000
076 Chrysene	0.004	0.000
084 Pyrene	0.000	0.000
085 Tetrachloroethylene	0.054	0.052
Phenols (4AAA)	0.222	0.181

Advantages and Limitations. The main advantage of the chemical emulsion breaking process is the high percentage of oil removal possible with this system. For proper and economical application of this process, the oily wastes (oil/water mixture) should be segregated from other wastewaters either by storage in a holding tank prior to treatment or by direct inlet to the oil waste removal system from major collection points. Further, if significant quantities of free oils are present, it is advantageous to precede emulsion breaking with gravity sedimentation. Chemical and energy costs can be high, especially if heat is used to accelerate the process.

Advantages of the TEB include an extremely high percentage of oil removal (at least 99 percent in most cases), the separation of floating oil from settleable sludge, and the production of good quality water which is available for process reuse. In addition, no chemical additives are required and the operation is fully

automatic, factors which reduce operating costs and maintenance requirements. Disadvantages of this system are few: the cost of heat to run the small boiler [about $80 a month for natural gas for an 1140 liter/day (300 gallon per day) unit], and the necessary installation of a large storage tank. Some settling may occur in the holding tank, resulting in a more concentrated raw waste load during the first day or two of operation. This higher concentration may result in slightly higher effluent contamination for the day(s) involved. TEB models are currently available to handle loads of 150, 300 and 600 gallons per day.

Operational Factors. Reliability: Chemical emulsion breaking can be highly reliable assuming adequate analysis in the selection of chemicals and proper operator training to ensure that the established procedures are followed.

Thermal emulsion breaking is also a very reliable process for the treatment of emulsified wastes.

Maintainability: For chemical emulsion breaking, routine maintenance is required on pumps, motors, and valves as well as periodic cleaning of the treatment tank to remove any sediment which may accumulate in the tank. The use of acid or acidic conditions will require a lined or coated tank, and the lining or coating should be checked periodically.

A TEB unit requires minimal routine maintenance of the TEB components, and periodic disposal of sludge and oil.

Solid Waste Aspects: Both methods of emulsion breaking generate sludge oils which must receive proper disposal.

Demonstration Status: Emulsion breaking is a common treatment technique used by a number of plants, particularly in the aluminum casting subcategory, in the Metal Molding and Casting Industry. It is a proven method of effectively treating emulsified wastes.

2. Oxidation by Potassium Permanganate

Potassium permanganate ($KMnO_4$) is a powerful oxidizing chemical used to destroy phenolic compounds. It is fed in dry form, and is not corrosive. It keeps indefinitely when stored in a cool, dry, and dark environment. Although it presents no health hazard in its handling, there is some fire hazard which can be controlled with the addition of water.

Application and Performance

Potassium permanganate cleaves the aromatic ring structure of phenol to produce a straight chain aliphatic molecule. The aliphatic is then further oxidized to CO_2 and water. Under actual test conditions on a foundry wastewater, with a flow of 25 million liters/day (6.6 MGD), having an initial phenol concentration of 0.123 mg/l, potassium permanganate was added at concentrations of 1, 5 and 10 mg/l. After a contact time of 20 minutes, the waste was analyzed for residual phenols. Effluent concentrations of <0.010 mg/l were observed. A dosage of 10 mg/l or a ratio of 80:1 permanganate to phenol was required to remove the phenol.

A retention time from one to three hours is sufficient to insure complete oxidation of the phenol. The initial reaction takes place almost immediately, and almost 90 percent of the phenol is oxidized in the first ten minutes. The higher the pH, up to a value of about 9.5, the shorter the reaction time.

Advantages and Limitations

During the oxidation process, an insoluble compound of manganese dioxide (MnO_2) is formed. This inert product exhibits certain sorptive properties, which often render it beneficial to the coagulation and sedimentation of low turbidity waters.

Operational Factors

Reliability: High, assuming proper feed.

Maintainability: Maintenance of chemical feed equipment and mixing is required.

Solid Waste Aspects: The increased solid waste volume is negligible.

Demonstration Status

The use of potassium permanganate to oxidize phenolic compounds has been demonstrated in foundries, refineries, and other industrial wastewater treatment operations.

3. Chemical Precipitation

Dissolved toxic metal ions and certain anions may be chemically precipitated for removal by physical means such as sedimentation, filtration, or centrifugation. Several reagents are commonly used to effect this precipitation.

1) Alkaline compounds such as lime or sodium hydroxide may be used to precipitate many toxic metal ions as metal hydroxides. Lime also may precipitate phosphates as insoluble calcium phosphate and fluorides as calcium fluoride.

2) Both "soluble" sulfides such as hydrogen sulfide or sodium sulfide and "insoluble" sulfides such as ferrous sulfide may be used to precipitate many heavy metal ions as insoluble metal sulfides.

3) Ferrous sulfate, zinc sulfate or both (as is required) may be used to precipitate cyanide as a ferro or zinc ferricyanide complex.

4) Carbonate precipitates may be used to remove metals either by direct precipitation using a carbonate reagent such as calcium carbonate or by converting hydroxides into carbonates using carbon dioxide.

These treatment chemicals may be added to a flash mixer or rapid mix tank, to a presettling tank, or directly to a clarifier or other settling device. Because metal hydroxides tend to be colloidal in nature, coagulating agents may also be added to facilitate settling. After the solids have been removed, final pH adjustment may be required to reduce the high pH created by the alkaline treatment chemicals.

Chemical precipitation as a mechanism for removing metals from wastewater is a complex process of at least two steps - precipitation of the unwanted metals and removal of the precipitate. Some small amount of metal will remain dissolved in the wastewater after complete precipitation. The amount of residual dissolved metal depends on the treatment chemicals used and related factors. The effectiveness of this method of removing any specific metal depends on the fraction of the specific metal in the raw waste (and hence in the precipitate) and the effectiveness of suspended solids removal. In specific instances, a sacrifical ion such as iron or aluminum may be added to aid in the precipitation process and reduce the fraction of a specific metal in the precipitate.

Application and Performance. Chemical precipitation is used in the metal molding and casting industry for precipitation of dissolved metals. It can be used to remove metal ions such as aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, tin and zinc. The process is also applicable to any substance that can be transformed into an insoluble form such as fluorides,

phosphates, soaps, sulfides and others. Because it is simple and effective, chemical precipitation is extensively used for industrial waste treatment.

The performance of chemical precipitation depends on several variables. The most important factors affecting precipitation effectiveness are:

1. Maintenance of an alkaline pH throughout the precipitation reaction and subsequent settling;

2. Addition of a sufficient excess of treatment ions to drive the precipitation reaction to completion;

3. Addition of an adequate supply of sacrifical ions (such as iron or aluminum) to ensure precipitation and removal of specific target ions; and

4. Effective removal of precipitated solids (see appropriate technologies discussed under "Solids Removal").

Control of pH. Regardless of the solids removal technology employed, proper control of pH is absolutely essential for favorable performance of precipitation-sedimentation technologies. This is clearly illustrated by solubility curves for selected metals hydroxides and sulfides shown in Figure VII-1 and by plotting effluent zinc concentrations against pH as shown in Figure VII-2. Figure VII-2 was obtained from Development Document for the Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Zinc Segment of Nonferrous Metals Manufacturing Point Source Category, U.S. E.P.A., EPA 440/1-74/033, November, 1974. Figure VII-2 was plotted from the sampling data from several facilities with metal finishing operations. It is partially illustrated by data obtained from 3 consecutive days of sampling at one metal processing plant (47432) as displayed in Table VII-3. Flow through this system is approximately 49,263 l/h (13,000 gal/hr).

TABLE VII-3
pH CONTROL EFFECT ON METALS REMOVAL

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range	2.4-3.4	8.5-8.7	1.0-3.0	5.0-6.0	2.0-5.0	6.5-8.1
(mg/l)						
TSS	39	8	16	19	16	7
Copper	312	0.22	120	5.12	107	0.66
Zinc	250	0.31	32.5	25.0	43.8	0.66

This treatment system uses lime precipitation (pH adjustment) followed by coagulant addition and sedimentation. Samples were taken before (in) and after (out) the treatment system. The best treatment for removal of copper and zinc was achieved on day one, when the pH was maintained at a satisfactory level. The poorest treatment was found on the second day, when the pH slipped to an unacceptably low level and intermediate values were were achieved on the third day when pH values were less than desirable but in between the first and second days.

Sodium hydroxide is used by one facility (plant 439) for pH adjustment and chemical precipitation, followed by settling (sedimentation and a polishing lagoon) of precipitated solids. Samples were taken prior to caustic addition and following the polishing lagoon. Flow through the system is approximately 22,700 l/hr (6,000 gal/hr).

TABLE VII-4

EFFECTIVENESS OF SODIUM HYDROXIDE FOR METALS REMOVAL

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range (mg/l)	2.1-2.9	9.0-9.3	2.0-2.4	8.7-9.1	2.0-2.4	8.6-9.1
Cr	0.097	0.0	0.057	0.005	0.068	0.005
Cu	0.063	0.018	0.078	0.014	0.053	0.019
Fe	9.24	0.76	15.5	0.92	9.41	0.95

Pb	1.0	0.11	1.36	0.13	1.45	0.11
Mn	0.11	0.06	0.12	0.044	0.11	0.044
Ni	0.077	0.011	0.036	0.009	0.069	0.011
Zn	.054	0.0	0.12	0.0	0.19	0.037
TSS		13		11		11

These data indicate that the system was operated efficiently. Effluent pH was controlled within the range of 8.6-9.3, and, while raw waste loadings were not unusually high, most toxic metals were removed to very low concentrations.

Lime and sodium hydroxide are sometimes used to precipitate metals. Data developed from plant 40063, a facility with a metal bearing wastewater, exemplify efficient operation of a chemical precipitation and settling system. Table VII-5 shows sampling data from this system, which uses lime and sodium hydroxide for pH adjustment, chemical precipitation, polyelectrolyte flocculant addition, and sedimentation. Samples were taken of the raw waste influent to the system and of the clarifier effluent. Flow through the system is approximately 5,000 gal/hr.

TABLE VII-5
EFFECTIVENESS OF LIME AND SODIUM HYDROXIDE FOR METALS REMOVAL

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range (mg/l)	9.2-9.6	8.3-9.8	9.2	7.6-8.1	9.6	7.8-8.2
Al	37.3	0.35	38.1	0.35	29.9	0.35
Co	3.92	0.0	4.65	0.0	4.37	0.0
Cu	0.65	0.003	0.63	0.003	0.72	0.003
Fe	137	0.49	110	0.57	208	0.58
Mn	175	0.12	205	0.012	245	0.12
Ni	6.86	0.0	5.84	0.0	5.63	0.0
Se	28.6	0.0	30.2	0.0	27.4	0.0
Ti	143	0.0	125	0.0	115	0.0
Zn	18.5	0.027	16.2	0.044	17.0	0.01
TSS	4390	9	3595	13	2805	13

At this plant, effluent TSS levels were below 15 mg/l on each day, despite average raw waste TSS concentrations of over 3500 mg/l. Effluent pH was maintained at approximately 8, lime addition was sufficient to precipitate the dissolved metal ions, and the flocculant addition and clarifier retention served to remove effectively the precipitated solids.

Sulfide precipitation is sometimes used to precipitate metals resulting in improved metals removals. Most metal sulfides are less soluble than hydroxides and the precipitates are frequently more dependably removed from water. Solubilities for selected metal hydroxide, carbonate and sulfide precipitates are shown in Table VII-6 (Source: Lange's Handbook of Chemistry). Sulfide precipitation is particularly effective in removing specific metals such as silver and mercury. Sampling data from three industrial plants using sulfide precipitation appear in Table VII-7.

TABLE VII-6

THEORETICAL SOLUBILITIES OF HYDROXIDES AND SULFIDES OF SELECTED METALS IN PURE WATER

Metal	Solubility of Metal Ion, mg/l As Hydroxide	As Carbonate	As Sulfide
Cadmium (Cd^{++})	2.3×10^{-5}	1.0×10^{-4}	6.7×10^{-10}
Chromium (Cr^{+++})	8.4×10^{-4}		No precipitate
Cobalt (Co^{++})	2.2×10^{-1}		1.0×10^{-8}
Copper (Cu^{++})	2.2×10^{-2}		5.8×10^{-18}
Iron (Fe^{++})	8.9×10^{-1}		3.4×10^{-5}
Lead (Pb^{++})	2.1	7.0×10^{-3}	3.8×10^{-9}
Manganese (Mn^{++})	1.2		2.1×10^{-3}
Mercury (Hg^{++})	3.9×10^{-4}	3.9×10^{-2}	9.0×10^{-20}
Nickel (Ni^{++})	6.9×10^{-3}	1.9×10^{-1}	6.9×10^{-8}
Silver (Ag^{+})	13.3	2.1×10^{-1}	7.4×10^{-12}
Tin (Sn^{++})	1.1×10^{-4}		3.8×10^{-8}
Zinc (Zn^{++})	1.1	7.0×10^{-4}	2.3×10^{-7}

TABLE VII-7

SAMPLING DATA FROM SULFIDE PRECIPITATION-SEDIMENTATION SYSTEMS

Treatment	Lime, FeS, Polyelectrolyte, Settle, Filter		Lime, FeS, Polyelectrolyte, Settle, Filter		NaOH, Ferric Chloride, Na_2S Clarify (1 stage)	
	In	Out	In	Out	In	Out
pH (mg/l)	5.0-6.8	8-9	7.7	7.38		
Cr+6	25.6	<0.014	0.022	<0.020	11.45	<.005
Cr	32.3	<0.04	2.4	<0.1	18.35	<.005
Cu	-	-	-	-	0.029	0.003
Fe	0.52	0.10	108	0.6	-	-
Ni	-	-	0.68	<0.1	-	-
Zn	39.5	<0.07	33.9	<0.1	0.060	0.009

These data were obtained from three sources:

Summary Report, Control and Treatment Technology for the Metal Finishing Industry: Sulfide Precipitation, USEPA, EPA No. 625/8/80-003, 1979.

Industrial Finishing, Vol. 35, No. 11, November, 1979.

Electroplating sampling data from plant 27045.

In all cases except iron, effluent concentrations are below 0.1 mg/l and in many cases below 0.01 mg/l for the three plants studied.

Sampling data from several chlorine-caustic manufacturing plants using sulfide precipitation demonstrate effluent mercury concentrations varying between 0.009 and 0.03 mg/l. As shown in Figure VII-1, the solubilities of PbS and Ag_2S are lower at alkaline pH levels than either the corresponding hydroxides or other sulfide compounds. This implies that removal performance for lead and silver sulfides should be comparable to or better than that for the heavy metal hydroxides. Bench scale tests on several types of metal finishing and manufacturing wastewater indicate that metals removal to levels of less than 0.05 mg/l and in some cases less than 0.01 mg/l are common in systems using sulfide precipitation followed by clarification. Some of the bench scale data, particularly in the case of lead, do not support such low effluent concentrations. However, lead is consistently removed to very low levels (less than 0.02 mg/l) in systems using hydroxide and carbonate precipitation and sedimentation.

Based on the available data, Table VII-8 shows the minimum reliably attainable effluent concentrations for sulfide precipitation-sedimentation systems. These values are used to calculate performance predictions of sulfide precipitation-sedimentation systems.

TABLE VII-8

SULFIDE PRECIPITATION-SEDIMENTATION PERFORMANCE

Parameter	Treated Effluent (mg/l)
Cd	0.01
CrT	0.05
Cu	0.05
Pb	0.01
Hg	0.03
Ni	0.05
Ag	0.05
Zn	0.01

Table VII-8 is based on two reports:

Summary Report, Control and Treatment Technology for the Metal Finishing Industry: Sulfide Precipitation, USEPA, EPA No. 625/8/80-003, 1979.

Addendum to Development Document for Effluent Limitations Guidelines and New Source Performance Standards, Major Inorganic products Segment of Inorganics Point Source Category, USEPA., EPA Contract No. EPA=68-01-3281 (Task 7), June, 1978.

Carbonate precipitation is sometimes used to precipitate metals, especially where precipitated metals values are to be recovered. The solubility of most metal carbonates is intermediate between hydroxide and sulfide solubilities; in addition, carbonates form easily filtered precipitates.

Carbonate ions appear to be particularly useful in precipitating lead and antimony. Sodium carbonate has been observed being added at treatment to improve lead precipitation and removal in some industrial plants. The lead hydroxide and lead carbonate solubility curves displayed in Figure VII-3 ("Heavy Metals Removal," by Kenneth Lanovette, Chemical Engineering/Deskbook Issue, Oct. 17, 1977) explain this phenomenon.

Coprecipitation With Iron- The presence of substantial quantites of iron in wastewaters contaminated with toxic metals before treatment has been shown to improve the removal of these toxic metals. In some cases this iron is an integral part of the process wastewater; in other cases iron is deliberately added as a preliminary or first step of treatment. The iron functions to

improve toxic metal removal by three mechanisms: the iron co-precipitates with toxic metals forming a stable precipitate which desolubilizes the toxic metal; the iron improves the settleability of the precipitate; and the large amount of iron reduces the fraction of toxic metal in the precipitate. Co-precipitation with iron has been practiced for many years incidentally, when iron was a substantial consitutent of raw wastewater, and intentionally, when iron salts were added as a coagulant aid. Aluminum or mixed iron-aluminum salt also have been used.

Co-precipitation using large amounts of ferrous iron salts is known as ferrite co-precipitation because magnetic iron oxide or ferrite is formed. The addition of ferrous salts (sulfate) is followed by alkali precipitation and air oxidation. The resultant precipitate is easily removed by filtration and may be removed magnetically. Data illustrating the performance of ferrite co-precipitation is shown in Table VII-9.

Table VII-9

FERRITE CO-PRECIPITATION PERFORMANCE

Metal	Influent(mg/l)	Effluent(mg/l)
Mercury	7.4	0.001
Cadmium	240	0.008
Copper	10	0.010
Zinc	18	0.016
Chromium	10	<0.010
Manganese	12	0.007
Nickel	1,000	0.200
Iron	600	0.06
Bismuth	240	0.100
Lead	475	0.010

NOTE: These data are from:
Sources and Treatment of Wastewater in the Nonferrous Metals Industry, USEPA, EPA No. 600/2-80-074, 1980.

Advantages and Limitations

Chemical precipitation has proven to be an effective technique for removing many pollutants from industrial wastewater. It

operates at ambient conditions and is well suited to automatic control. The use of chemical precipitation may be limited because of interference by chelating agents, because of possible chemical interference of mixed wastewaters and treatment chemicals, or because of the potentially hazardous situation involved with the storage and handling of those chemicals. Lime is usually added as a slurry when used in hydroxide precipitation. The slurry must be kept well mixed and the addition lines periodically checked to prevent blocking of the lines, which may result from a buildup of solids. Also, hydroxide precipitation usually makes recovery of the precipitated metals difficult, because of the heterogeneous nature of most hydroxide sludges.

The major advantage of the sulfide precipitation process is that the extremely low solubility of most metal sulfides promotes very high metal removal efficiencies; the sulfide process also has the ability to remove chromates and dichromates without preliminary reduction of the chromium to its trivalent state. In addition, sulfide can precipitate metals complexed with most complexing agents. The process demands care, however, in maintaining the pH of the solution at approximately 10 in order to prevent the generation of toxic hydrogen sulfide gas. For this reason, ventilation of the treatment tanks may be a necessary precaution in most installations. The use of insoluble sulfides reduces the problem of hydrogen sulfide evolution. As with hydroxide precipitation, excess sulfide ion must be present to drive the precipitation reaction to completion. Since the sulfide ion itself is toxic, sulfide addition must be carefully controlled to maximize heavy metals precipitation with a minimum of excess sulfide to avoid the necessity of post treatment. At very high excess sulfide levels and high pH, soluble mercury-sulfide compounds may also be formed. Where excess sulfide is present, aeration of the effluent stream can aid in oxidizing residual sulfide to the less harmful sodium sulfate (Na_2SO_4). The cost of sulfide precipitants is high in comparison with hydroxide precipitants, and disposal of metallic sulfide sludges may pose problems. An essential element in effective sulfide precipitation is the removal of precipitated solids from the wastewater and proper disposal in an appropriate site. Sulfide precipitation will also generate a higher volume of sludge, than hydroxide precipitation, resulting in higher disposal and dewatering costs. This is especially true when ferrous sulfide is used as the precipitant.

Sulfide precipitation may be used as a polishing treatment after hydroxide precipitation-sedimentation. This treatment configuration may provide the better treatment effectiveness of sulfide precipitation while minimizing the variability caused by

changes in raw waste and reducing the amount of sulfide precipitant required.

Operational Factors. Reliability: Alkaline chemical precipitation is highly reliable, although proper monitoring and control are required. Sulfide precipitation systems provide similar reliability.

Maintainability: The major maintenance needs involve periodic upkeep of monitoring equipment, automatic feeding equipment, mixing equipment, and other hardware. Removal of accumulated sludge is necessary for efficient operation of precipitation-sedimentation systems.

Solid Waste Aspects: Solids which precipitate out are removed in a subsequent treatment step. Ultimately, these solids require proper disposal.

Demonstration Status. Chemical precipitation of metal hydroxides is a classic waste treatment technology used by most industrial waste treatment systems. Full scale commercial sulfide precipitation units are in operation at numerous industrial wastewater treatment systems. As noted earlier, sedimentation to remove precipitates is discussed separately.

Use in the Metal Molding and Casting Category. Chemical precipitation is used widely in each subcategory of the metal molding and casting industry. The quality of treatment provided, however, is variable. As a result, treatment performance at metals casting industry plants nominally practicing the same wastewater treatment procedures can vary widely.

4. Granular Bed Filtration

Filtration occurs in nature as groundwaters are cleansed by passage through the soil. Silica sand, anthracite coal, and garnet are common filter media used in water treatment plants. These are usually supported by gravel. The media may be used singly or in combination. The multi-media filters may be arranged to maintain relatively distinct layers by virtue of balancing the forces of gravity, flow, and buoyancy on the individual particles. This is accomplished by selecting appropriate filter flow rates (gpm/sq-ft), media grain size, and density.

Granular bed filters may be classified in terms of filtration rate, filter media, flow pattern, or method of pressurization. Traditional rate classifications are slow sand, rapid sand, and high rate mixed media. In the slow sand filter, flux or

hydraulic loading is relatively low, and removal of collected solids to clean the filter is therefore relatively infrequent. The filter is often cleaned by scraping off the inlet face (top) of the sand bed. In the higher rate filters, cleaning is frequent and is accomplished by a periodic backwash, opposite to the direction of normal flow.

A filter may use a single medium such as sand or diatomaceous earth, but dual and mixed (multiple) media filters allow higher flow rates and efficiencies. The dual media filter usually consists of a fine bed of sand under a coarser bed of anthracite coal. The coarse coal removes most of the influent solids, while the fine sand performs a polishing function. At the end of the backwash, the fine sand settles to the bottom because it is denser than the coal, and the filter is ready for normal operation. The mixed media filter operates on the same principle, with the finer, denser media at the bottom and the coarser, less dense media at the top. The usual arrangement is garnet at the bottom (outlet end) of the bed, sand in the middle, and anthracite coal at the top. Some mixing of these layers occurs and is, in fact, desirable.

The flow pattern is usually top-to-bottom, but other patterns are sometimes used. Upflow filters are sometimes used, and in a horizontal filter the flow is horizontal. In a biflow filter, the influent enters both the top and the bottom and exits laterally. The advantage of an upflow filter is that with an upflow backwash the particles of a single filter medium are distributed and maintained in the desired coarse-to-fine (bottom-to-top) arrangement. The disadvantage is that the bed tends to become fluidized, which ruins filtration efficiency. The biflow design is an attempt to overcome this problem.

The classic granular bed filter operates by gravity flow; however, pressure filters are fairly widely used. They permit higher solids loadings before cleaning and are advantageous when the filter effluent must be pressurized for further downstream treatment. In addition, pressure filter systems are often less costly for low to moderate flow rates.

Figure VII-4 depicts a high rate, dual media, gravity downflow granular bed filter, with self-stored backwash. Both filtrate and backwash are piped around the bed in an arrangement that permits gravity upflow of the backwash, with the stored filtrate serving as backwash. Addition of the indicated coagulant and polyelectrolyte usually results in a substantial improvement in filter performance.

Auxilliary filter cleaning is sometimes employed in the upper few inches of filter beds. This is conventionally referred to as surface wash and is accomplished by water jets just below the surface of the expanded bed during the backwash cycle. These jets enhance the scouring action in the bed by increasing the agitation.

An important feature for successful filtration and backwashing is the underdrain. This is the support structure for the bed. The underdrain provides an area for collection of the filtered water without clogging from either the filtered solids or the media grains. In addition, the underdrain prevents loss of the media with the water, and during the backwash cycle it provides even flow distribution over the bed. Failure to dissipate the velocity head during the filter or backwash cycle will result in bed upset and the need for major repairs.

Several standard approaches are employed for filter underdrains. The simplest one consists of a parallel porous pipe imbedded under a layer of coarse gravel and manifolded to a header pipe for effluent removal. Other approaches to the underdrain system are known as the Leopold and Wheeler filter bottoms. Both of these incorporate false concrete bottoms with specific porosity configurations to provide drainage and velocity head dissipation.

Filter system operation may be manual or automatic. The filter backwash cycle may be on a timed basis, a pressure drop basis with a terminal value which triggers backwash, or a solids carry-over basis from turbidity monitoring of the outlet stream. All of these schemes have been used successfully.

Application and Performance. Wastewater treatment plants often use granular bed filters for polishing after clarification, sedimentation, or other similar operations. Granular bed filtration thus has potential application to nearly all industrial plants. Chemical additives which enhance the upstream treatment equipment may or may not be compatible with or enhance the filtration process. Normal operating flow rates for various types of filters are as follows:

Slow Sand	2.04 - 5.30 l/sq m-hr
Rapid Sand	40.74 - 51.48 l/sq m-hr
High Rate Mixed Media	81.48 - 122.22 l/sq m-hr

Suspended solids are commonly removed from wastewater streams by filtering through a deep 0.3-0.9 m (1-3 feet) granular filter bed. The porous bed formed by the granular media can be designed to remove practically all suspended particles. Even colloidal suspensions (roughly 1 to 100 microns) are adsorbed on the

surface of the media grains as they pass in close proximity in the narrow bed passages.

Properly operated filters, following some pretreatment to reduce suspended solids concentrations to less than 200 mg/l, should produce water with less than 10 mg/l TSS. For example, multimedia filters produced the effluent qualities shown in Table VII-10 below.

Table VII-10

MULTIMEDIA FILTER PERFORMANCE

Plant ID #	TSS Effluent Concentration, mg/l
06097	0.0, 0.0, 0.5
13924	1.8, 2.2, 5.6, 4.0, 4.0, 3.0, 2.2, 2.8, 3.0, 2.0, 5.6, 3.6, 2.4, 3.4
18538	1.0
30172	1.4, 7.0, 1.0
36048	2.1, 2.6, 1.5
mean	2.61

Advantages and Limitations. The principal advantages of granular bed filtration are its comparatively (to other filters) low initial and operating costs, reduced land requirements over other methods to achieve the same level of solids removal, and elimination of chemical additions to the discharge stream. However, the filter may require pretreatment if the solids level is high (over 100 mg/l). Operator training must be somewhat extensive due to the controls and periodic backwashing involved, and backwash must be stored and dewatered for economical disposal.

Operational Factors. Reliability: The recent improvements in filter technology have significantly improved filtration reliability. Control systems, improved designs, and good operating procedures have made filtration a highly reliable method of water treatment.

Maintainability: Deep bed filters may be operated with either manual or automatic backwash. In either case, they must be periodically inspected for media attrition, partial plugging, and leakage. Where backwashing is not used, collected solids must be removed by shoveling, and filter media must be at least partially replaced.

Solid Waste Aspects: Filter backwash is generally recycled within the wastewater treatment system, so that the solids ultimately appear in the clarifier sludge stream for subsequent dewatering. Alternatively, the backwash stream may be dewatered directly or, if there is no backwash, the collected solids may be disposed of in a suitable landfill. In either of these situations there is a solids disposal problem similar to that of clarifiers.

Demonstration Status. Deep bed filters are in common use in a number of foundry operations, particularly in the lead casting subcategory. Their use in polishing industrial clarifier effluent is increasing, and the technology is proven and conventional. Granular bed filtration is used in many manufacturing plants. However, little data is available to characterize the effectiveness of filters presently in use within this industry.

5. Pressure Filtration

Pressure filtration works by pumping the liquid through a filter material which is impenetrable to the solid phase. The positive pressure exerted by the feed pumps or other mechanical means provides the pressure differential which is the principal driving force. Figure VII-5 represents the operation of one type of pressure filter.

A typical pressure filtration unit consists of a number of plates or trays which are held rigidly in a frame to ensure alignment and which are pressed together between a fixed end and a traveling end. On the surface of each plate is mounted a filter made of cloth or a synthetic fiber. The feed stream is pumped into the unit and passes through holes in the trays along the length of the press until the cavities or chambers between the trays are completely filled. The solids are then entrapped, and a cake begins to form on the surface of the filter material. The water passes through the fibers, and the solids are retained.

At the bottom of the trays are drainage ports. The filtrate is collected and discharged to a common drain. As the filter medium becomes coated with sludge, the flow of filtrate through the filter drops sharply, indicating that the capacity of the filter has been exhausted. The unit must then be cleaned of the sludge. After the cleaning or replacement of the filter media, the unit is again ready for operation.

Application and Performance. Pressure filtration is used in coil coating for sludge dewatering and also for direct removal of precipitated and other suspended solids from wastewater.

Because dewatering is such a common operation in treatment systems, pressure filtration is a technique which can be found in many industries concerned with removing solids from their waste stream.

In a typical pressure filter, chemically preconditioned sludge detained in the unit for one to three hours under pressures varying from 5 to 13 atmospheres exhibited final solids content between 25 and 50 percent.

Advantages and Limitations. The pressures which may be applied to a sludge for removal of water by filter presses that are currently available range from 5 to 13 atmospheres. As a result, pressure filtration may reduce the amount of chemical pretreatment required for sludge dewatering. Sludge retained in the form of the filter cake has a higher percentage of solids than that from centrifuge or vacuum filter. Thus, it can be easily accommodated by materials handling systems.

As a primary solids removal technique, pressure filtration requires less space than clarification and is well suited to streams with high solids loadings. The sludge produced may be disposed without further dewatering, but the amount of sludge is increased by the use of filter precoat materials (usually diatomaceous earth). Also, cloth pressure filters often do not achieve as high a degree of effluent clarification as clarifiers or granular media filters.

Two disadvantages associated with pressure filtration in the past have been the short life of the filter cloths and lack of automation. New synthetic fibers have largely offset the first of these problems. Also, units with automatic feeding and pressing cycles are now available.

For larger operations, the relatively high space requirements, as compared to those of a centrifuge, could be prohibitive in some situations.

Operational Factors. Reliability: With proper pretreatment, design, and control, pressure filtration is a highly dependable system.

Maintainability: Maintenance consists of periodic cleaning or replacement of the filter media, drainage grids, drainage piping, filter pans, and other parts of the system. If the removal of

the sludge cake is not automated, additional time is required for this operation.

Solid Waste Aspects: Because it is generally drier than other types of sludges, the filter sludge cake can be handled with relative ease. The accumulated sludge may be disposed by any of the accepted procedures depending on its chemical composition. The levels of toxic metals present in sludge from treating metal molding and casting wastewaters necessitates proper disposal.

Demonstration Status. Pressure filtration is a commonly used technology in a great many commercial applications.

6. Settling

Settling is a process which removes solid particles from a liquid matrix by gravitational force. This is done by reducing the velocity of the feed stream in a large volume tank or lagoon so that gravitational settling can occur. Figure VII-6 shows two typical settling devices.

Settling is often preceded by chemical precipitation, which converts dissolved pollutants to a solid form, and by coagulation, which enhances settling by coagulating suspended precipitates into larger, faster settling particles.

If no chemical pretreatment is used, the wastewater is fed into a tank or lagoon where it loses velocity and the suspended solids are allowed to settle out. Long retention times are generally required. Accumulated sludge can be collected either periodically or continuously and either manually or mechanically. Simple settling, however, may require excessively large catchments, and long retention times (days as compared with hours) to achieve high removal efficiencies. Because of this, the addition of settling aids such as alum or polymeric flocculants is often economically attractive.

In practice, chemical precipitation often precedes settling, and inorganic coagulants or polyelectrolytic flocculants are usually added as well. Common coagulants include sodium sulfate, sodium aluminate, ferrous or ferric sulfate, and ferric chloride. Organic polyelectrolytes vary in structure, but all usually form larger floc particles than coagulants used alone.

Following this pretreatment, the wastewater can be fed into a holding tank or lagoon for settling, but is more often piped into a clarifier for the same purpose. A clarifier reduces space requirements, reduces retention time, and increases solids removal efficiency. Conventional clarifiers generally consist of

a circular or rectangular tank with a mechanical sludge collecting device or with a sloping funnel-shaped bottom designed for sludge collection. In advanced settling devices inclined plates, slanted tubes, or a lamellar network may be included within the clarifier tank in order to increase the effective settling area, increasing capacity. A fraction of the sludge stream is often recirculated to the inlet, promoting formation of a denser sludge.

Application and Performance. Settling and clarification are used in the coil coating category to remove precipitated metals. Settling can be used to remove most suspended solids in a particular waste stream; thus it is used extensively by many different industrial waste treatment facilities. Because most metal ion pollutants are readily converted to solid metal hydroxide precipitates, settling is of particular use in those industries associated with metal production (casting), metal finishing, and metal working. In addition to toxic metals, the suitably precipitated materials effectively removed by settling include aluminum, iron, manganese, and fluoride.

A properly operating settling system can efficiently remove suspended solids, precipitated metal hydroxides, and other impurities from wastewater. The performance of the process depends on a variety of factors, including the density and particle size of the solids, the effective charge on the suspended particles, and the types of chemicals used in pretreatment. The site of flocculant or coagulant addition also may significantly influence the effectiveness of clarification. If the flocculant is subjected to too much mixing before entering the clarifier, the complexes may be sheared and the settling effectiveness diminished. At the same time, the flocculant must have sufficient mixing and reaction time in order for effective set-up and settling to occur. Plant personnel have observed that the line or trough leading into the clarifier is often the most efficient site for flocculant addition. The performance of simple settling is a function of the retention time, particle size and density, and the surface area of the basin.

The data displayed in Table VII-11 indicate suspended solids removal efficiencies in settling systems.

TABLE VII-11
PERFORMANCE OF SELECTED SETTLING SYSTEMS

PLANT ID	SETTLING DEVICE	SUSPENDED SOLIDS CONCENTRATION (mg/l) Day 1		Day 2		Day 3	
		In	Out	In	Out	In	Out
01057	Lagoon	54	6	56	6	50	5
09025	Clarifier	1100	9	1900	12	1620	5
11058	Clarifier	451	17	-	-	-	-
12075	Settling Pond	284	6	242	10	520	14
19019	Settling Tank	170	1	50	1	-	-
33617	Clarifier & Lagoon	-	-	1662	16	1298	4
40063	Clarifier	4390	9	3595	12	2805	13
44062	Clarifier	182	13	118	14	174	23
46050	Settling Tank	295	10	42	10	153	8

The mean effluent TSS concentration obtained by the plants shown in Table VII-11 is 10.1 mg/l. Influent concentrations averaged 838 mg/l. The maximum effluent TSS value reported is 23 mg/l. These plants all use alkaline pH adjustment to precipitate metal hydroxides, and most add a coagulant or flocculant prior to settling.

Advantages and Limitations. The major advantage of simple settling is its simplicity as demonstrated by the gravitational settling of solid particulate waste in a holding tank or lagoon. The major problem with simple settling is the long retention time necessary to achieve complete settling, especially if the specific gravity of the suspended matter is close to that of water. Some materials cannot be practically removed by simple settling alone.

Settling performed in a clarifier is effective in removing slow-settling suspended matter in a shorter time and in less space than a simple settling system. Also, effluent quality is often better from a clarifier. The cost of installing and maintaining a clarifier, however, is substantially greater than the costs associated with simple settling.

Inclined plate, slant tube, and lamella settlers have even higher removal efficiencies than conventional clarifiers, and greater capacities per unit area are possible. Installed costs for these advanced clarification systems are claimed to be one half the cost of conventional systems of similar capacity.

Operational Factors. Reliability: Settling can be a highly reliable technology for removing suspended solids. Sufficient retention time and regular sludge removal are important factors affecting the reliability of all settling systems. Proper control of pH adjustment, chemical precipitation, and coagulant or flocculant addition are additional factors affecting settling efficiencies in systems (frequently clarifiers) where these methods are used.

Those advanced settlers using slanted tubes, inclined plates, or a lamellar network may require pre-screening of the waste in order to eliminate any fibrous materials which could potentially clog the system. Some installations are especially vulnerable to shock loadings, as by storm water runoff, but proper system design will prevent this.

Maintainability: When clarifiers or other advanced settling devices are used, the associated system utilized for chemical pretreatment and sludge dragout must be maintained on a regular basis. Routine maintenance of mechanical parts is also necessary. Lagoons require little maintenance other than periodic sludge removal.

Demonstration Status

Settling represents the typical method of solids removal and is employed extensively in industrial waste treatment. The advanced clarifiers are just beginning to appear in significant numbers in commercial applications. Sedimentation or clarification is used in the majority of foundry operations.

Settling is used both as part of end-of-pipe treatment and within the process (i.e., air pollution control devices and casting quench).

7. Skimming

Pollutants with a specific gravity less than water will often float unassisted to the surface of the wastewater. Skimming removes these floating wastes. Skimming normally takes place in a tank designed to allow the floating debris to rise and remain on the surface, while the liquid flows to an outlet located below the floating layer. Skimming devices are therefore suited to the removal of non-emulsified oils from raw waste streams. Common skimming mechanisms include the rotating drum type, which picks up oil from the surface of the water as it rotates. A doctor blade scrapes oil from the drum and collects it in a trough for disposal or reuse. The water portion is allowed to flow under the rotating drum. Occasionally, an underflow baffle is

installed after the drum; this has the advantage of retaining any floating oil which escapes the drum skimmer. The belt type skimmer is pulled vertically through the water, collecting oil which is scraped off from the surface and collected in a drum. Gravity separators, such as the API type, utilize overflow and underflow baffles to skim a floating oil layer from the surface of the wastewater. An overflow-underflow baffle allows a small amount of wastewater (the oil portion) to flow over into a trough for disposition or reuse while the majority of the water flows underneath the baffle. This is followed by an overflow baffle, which is set at a height relative to the first baffle such that only the oil bearing portion will flow over the first baffle during normal plant operation. A diffusion device, such as a vertical slot baffle, aids in creating a uniform flow through the system and increasing oil removal efficiency.

Application and Performance. Oil cleaned from the strip is a principal source of oil. Skimming is applicable to any waste stream containing pollutants which float to the surface. It is commonly used to remove free oil, grease, and soaps. Skimming is often used in conjunction with air flotation or clarification in order to increase its effectiveness.

The removal efficiency of a skimmer is partly a function of the retention time of the water in the tank. Larger, more buoyant particles require less retention time than smaller particles. Thus, the efficiency also depends on the composition of the waste stream. The retention time required to allow phase separation and subsequent skimming varies from 1 to 15 minutes, depending on the wastewater characteristics.

API or other gravity-type separators tend to be more suitable for use where the amount of surface oil flowing through the system is consistently significant. Drum and belt type skimmers are applicable to waste streams which evidence smaller amounts of floating oil and where surges of floating oil are not a problem. Using an API separator system in conjunction with a drum type skimmer would be a very effective method of removing floating contaminants from non-emulsified oily waste streams. Sampling data shown below illustrate the capabilities of the technology with both extremely high and moderate oil influent levels.

Table VII-12

SKIMMING PERFORMANCE

Plant	Skimmer Type	Oil & Grease mg/l In	Out
06058	API	224,669	17.9
06058	Belt	19.4	8.3

This data is intended to be illustrative of the very high level of oil and grease removals attainable in a simple two stage oil removal system. Based on the performance of installations in a variety of manufacturing plants and permit requirements that are constantly achieved, it is determined that effluent oil levels may be reliably reduced below 10 mg/l with moderate influent concentrations. Very high concentrations of oil such as the 22 percent shown above may require two step treatment to achieve this level.

Skimming which removes oil may also be used to remove base levels of organics. Plant sampling data show that many organic compounds tend to be removed in standard wastewater treatment equipment. Oil separation not only removes oil but also organics that are more soluble in oil than in water. Clarification removes organic solids directly and probably removes dissolved organics by adsorption on inorganic solids.

The source of these organic pollutants is not always known with certainty, although in metal forming operations they seem to derive mainly from various process lubricants. They are also sometimes present in the plant water supply, as additives to proprietary formulations of cleaners, or due to leaching from plastic lines and other materials.

High molecular weight organics in particular are much more soluble in organic solvents than in water. Thus they are much more concentrated in the oil phase that is skimmed than in the wastewater. The ratio of solubilities of a compound in oil and water phases is called the partition coefficient. The logarithm of the partition coefficients for fifteen polynuclear aromatic hydrocarbon (PAH) compounds in octanol and water are listed below.

PAH Priority Pollutant		Log Octanol/Water Partition Coefficient
001	Acenaphthene	4.33
039	Fluoranthene	5.33
072	Benzo(a)anthracene	5.61
073	Benzo(a)pyrene	6.04
074	3,4-benzofluoranthene	6.57
075	Benzo(k)fluoranthene	6.84
076	Chrysene	5.61
077	Acenaphthylene	4.07
078	Anthracene	4.45
079	Benzo(ghi)perylene	7.23
080	Fluorene	4.18
081	Phenanthrene	4.46
082	Dibenzo(a,h)anthracene	5.97
083	Indeno(1,2,3,cd)pyrene	7.66
084	Pyrene	5.32

A study of priority organic compounds commonly found in metal forming operations waste streams indicated that incidental removal of these compounds often occurs as a result of oil removal or clarification processes. When all organics analyses from these plants are considered, removal of organic compounds by other waste treatment technologies appears to be marginal in many cases. However, when only raw waste concentrations of 0.05 mg/l or greater are considered incidental organics removal becomes much more apparent. Lower values, those less than 0.05 mg/l, are much more subject to analytical variation, while higher values indicate a significant presence of a given compound. When these factors are taken into account, analysis data indicate that most clarification and oil removal treatment systems remove significant amounts of the organic compounds present in the raw waste. The API oil-water separation system and the thermal emulsion breaker (TEB) performed notably in this regard, as shown in the following table (all values in mg/l).

TABLE VII-13

TRACE ORGANIC REMOVAL BY SKIMMING
API PLUS BELT SKIMMERS
(From Plant 06058)

	Concentration (mg/l)	
	Inf.	Eff.
Oil & Grease	225,000	14.6
Chloroform	0.023	0.007
Methylene Chloride	0.013	0.012
Naphthalene	2.31	0.004
N-nitrosodiphenylamine	59.0	0.182
Bis-2-ethylhexylphthalate	11.0	0.027
Diethyl phthalate	-	-
Butylbenzylphthalate	0.005	0.002
Di-n-octyl phthalate	0.019	0.002
Anthracene - phenanthrene	16.4	0.014
Toluene	0.02	0.012

Data from five plant days demonstrate removal of organics by the combined oil skimming and settling operations performed on coil coating wastewaters. Days were chosen where treatment system influent and effluent analyses provided paired data points for oil and grease and the organics present. All organics found at quantifiable levels on those days were included. Further, only those days were chosen where oil and grease raw wastewater concentrations exceeded 10 mg/l and where there was reduction in oil and grease going through the treatment system. All plant sampling days which met the above criteria are included below. The conclusion is that when oil and grease are removed, organics are removed, also.

	Percent Removal	
Plant-Day	Oil & Grease	Organics
1054-3	95.9	98.2
13029-2	98.3	78.0
13029-3	95.1	77.0
38053-1	96.8	81.3
38053-2	98.5	86.3
Mean	96.9	84.2

The unit operation most applicable to removal of trace priority organics is adsorption, while chemical emulsion breaking and chemical oxidation are other possibilities. Biological degradation is not generally applicable because the organics are

not present in sufficient concentration to sustain a biomass and because most of the organics are resistant to biodegradation.

Advantages and Limitations. Skimming as a pretreatment is effective in removing naturally floating waste material. It also improves the performance of subsequent downstream treatments.

Many pollutants, particularly dispersed or emulsified oil, will not float "naturally" but require additional treatments. Therefore, skimming alone may not remove all the pollutants capable of being removed by air flotation or other more sophisticated technologies.

Operational Factors. Reliability: Because of its simplicity, skimming is a very reliable technique.

Maintainability: The skimming mechanism requires periodic lubrication, adjustment, and replacement of worn parts.

Solid Waste Aspects: The collected layer of debris must be disposed of by contractor removal, landfill, or incineration. Because relatively large quantities of water are present in the collected wastes, incineration is not always a viable disposal method.

Demonstration Status. Skimming is a common operation utilized extensively by industrial waste treatment systems. Oil skimming is used in foundry operations.

MAJOR TECHNOLOGY EFFECTIVENESS

The performance of individual treatment technologies was presented above. Performance of operating systems is discussed here. Two different systems are considered: L&S (hydroxide precipitation and sedimentation or lime and settle) and LS&F (hydroxide precipitation, sedimentation and filtration or lime, settle, and filter). Subsequently, an analysis of effectiveness of such systems is made to develop one-day maximum, and ten-day and thirty-day average concentration levels to be used in regulating pollutants. Evaluation of the L&S and the LS&F systems is carried out on the assumption that oil skimming is installed and operating properly where appropriate.

L&S Performance -- Combined Metals Data Base

Before proposal, chemical analysis data were collected of raw waste (treatment influent) and treated waste (treatment effluent) from 55 plants (126 data days) sampled by EPA (or its contractor)

using EPA sampling and chemical analysis protocols. These data are the data base for determining the effectiveness of L&S technology. Each of these plants belongs to at least one of the following industry categories: aluminum forming, battery manufacturing, coil coating, copper forming, electroplating and porcelain enameling. All of the plants employ pH adjustment and hydroxide precipitation using lime or caustic, followed by settling (tank, lagoon or clarifier) for solids removal. Most also add a coagulant or flocculant prior to solids removal.

An analysis of this data was presented in the development documents for the proposed regulations for coil coating and porcelain enameling (January 1981). In response to the proposal, some commenters claimed that it was inappropriate to use data from some categories for regulation of other categories. In response to these comments, the Agency reanalyzed the data. An analysis of variance was applied to the data for the 126 days of sampling to test the hypothesis of homogeneous plant mean raw and treated effluent levels across categories by pollutant. This analysis is described in the report "A Statistical Analysis of the Combined Metals Industries Effluent Data" which is in the administrative record supporting this rulemaking.

The main conclusion drawn from the analysis of variance is that, with the exception of electroplating, the categories are generally homogeneous with regard to mean pollutant concentrations in both raw and treated effluent. That is, when data from electroplating facilities are included in the analysis, the hypothesis of homogeneity across categories is rejected. When the electroplating data are removed from the analysis the conclusion changes substantially and the hypothesis of homogeneity across categories is not rejected. On the basis of this analysis, the electroplating data were removed from the data base used to determine limitations. Cases that appeared to be marginally different were not unexpected (such as copper in copper forming and lead in lead battery manufacturing) were accommodated in developing limitations by using the larger values obtained from the marginally different category to characterize the entire data set.

The statistical analysis provides support for the technical engineering judgment that electroplating wastewaters are different from most metal processing wastewaters. These differences may be further explained by differences in the constituents and relative amounts of pollutants in the raw wastewaters. Therefore, the wastewater data derived from plants that only electroplate are not used in developing limitations for the coil coating category.

After removing the electroplating data, data from 21 plants and 52 days of sampling remained. Eleven of these plants and 25 days of sampling are from coil coating operations.

For the purpose of developing treatment effectiveness, certain data were deleted from the data base before examination for homogeneity. These deletions were made to ensure that the data reflect properly operated treatment systems and actual pollutant removal. The following criteria were used in making these deletions:

- Plants where malfunctioning processes or treatment systems at time of sampling were identified.
- Data days where pH was less than 7.0 or TSS was greater than 50 mg/l. (This is a prima facie indication of poor operation).
- Data points where the raw waste value was too low to assure actual pollutant removal occurred (i.e., less than 0.1 mg/l of pollutant in raw waste).

Collectively, these selection criteria insure that the data are from properly operating lime and settle treatment facilities. The remaining data are displayed graphically in Figures VII-7 to VII-15. This common or combined metals data base provides a more sound and usable basis for estimating treatment effectiveness and statistical variability of lime and settle technology than the available data from any one category.

One-day Effluent Values

The basis assumption underlying the determination of treatment effectiveness is that the data for a particular pollutant are lognormally distributed by plant. The lognormal has been found to provide a satisfactory fit to plant effluent data in a number of effluent guidelines categories. In the case of the combined metal categories data base, there are too few data from any one plant to verify formally the lognormal assumption. Thus, we assumed measurements of each pollutant from a particular plant, denoted by X, followed a lognormal distribution with log mean μ and log variance o^2. The mean, variance and 99th percentile of X are then:

$$\text{mean of } X = E(X) = \exp(\mu + \sigma^2/2)$$

$$\text{variance of } X = V(X) = \exp(2u + o^2)[\exp(o^2) - 1]$$

$$99\text{th percentile} = X_{.99} = \exp(u + 2.33\,o)$$

where exp is e, the base of the natural logarithm. The term lognormal is used because the logarithm of X has a normal distribution with mean u and variance o^2. Using the basis assumption of lognormality the actual treatment effectiveness was determined using a lognormal distribution that, in a sense, approximates the distribution of an average of the plants in the data base, i.e., an "average plant" distribution. The notion of an "average plant" distribution is not a strict statistical concept but is used here to determine limits that would represent the performance capability of an average of the plants in the data base.

This "average plant" distribution for a particular pollutant was developed as follows: the log mean was determined by taking the average of all the observations for the pollutant across plants. The log variance was determined by the pooled within plant variance. This is the weighted average of the plant variances. Thus, the log mean represents the average of all the data for the pollutant and the log variance represents the average of the plant log variances or average plant variability for the pollutant.

The one day effluent values were determined as follows:

Let Xij = the jth observation on a particular pollutant at plant i where

$i = 1, \ldots, I$
$j = 1, \ldots, Ji$
I = total number of plants
Ji = number of observations at plant i.

Then $Yij = \ln Xij$

where ln means the natural logarithm.

Then $y = \text{log mean over all plants} = \frac{1}{n} \sum_{i=1}^{I} \sum_{j=1}^{Ji} Yij$

where $n = \text{total number of observations} = \sum_{i=1}^{I} Ji$

and $V(y) = \text{pooled log variance} = \sum_{I} (Ji - 1)\, Si2$

$$\sum_{i=1}^{I} (Ji - 1)$$

where $Si2$ = log variance at plant i

$$= \sum_{Ji} (yij - yi)^2/(Ji - 1)$$

yi = log mean at plant i.

Thus, y and V(y) are the log mean and log variance, respectively, of the lognormal distribution used to determine the treatment effectiveness. The estimated mean and 99th percentile of this distribution form the basis for the long term average and daily maximum effluent limitations, respectively. The estimates are

$$\text{mean} = E(X) = \exp(y) \quad n\ (0.5\ V(y))$$

$$99\text{th percentile} = X._{99} = \exp [y + 2.33\ V(y)\ ]$$

where y (.) is a Bessel function and exp is e, the base of the natural logarithms (See Aitchison, J. and J.A.C. Brown, The Lognormal Distribution, Cambridge University Press, 1963). In cases where zeros were present in the data, a generalized form of the lognormal, known as the delta distribution was used (See Aitchison and Brown, op. cit., Chapter 9).

For certain pollutants, this approach was modified slightly to accommodate situations in which a category or categories stood out as being marginally different from the others. For instance, after excluding the electroplating data and other data that did not reflect pollutant removal or proper treatment, the effluent copper data from the copper forming plants were statistically significantly greater than the copper data from the other plants. Thus, copper effluent values shown in Table VII-14 are based only on the copper effluent data from the copper forming plants. That is, the log mean for copper is the mean of the logs of all copper values from the copper forming plants only and the log variance is the pooled log variance of the copper forming plant data only.

In the case of cadmium, after excluding the electroplating data and data that did not reflect removal or proper treatment, there were insufficient data to estimate the log variance for cadmium. The variance used to determine the values shown in Table VII-14 for cadmium was estimated by pooling the within plant variances for all the other metals. Thus, the cadmium variability is the average of the plant variability averaged over all the other metals. The log mean for cadmium is the mean of the logs of the cadmium observations only. A complete discussion of the data and

calculations for all the metals is contained in the administrative record for this rulemaking.

Average Effluent Values

Average effluent values that form the basis for the monthly limitations were developed in a manner consistent with the method used to develop one day treatment effectiveness in that the lognormal distribution used for the one-day effluent values was also used as the basis for the average values. That is, we assume a number of consecutive measurements are drawn from the distribution of daily measurements. The approach used for the 10 measurements values was employed previously for the electroplating category (see "Development document for Existing Sources Pretreatment Standards for the Electroplating Point Source Category" EPA 440/1-79/003, U.S. Environmental Protection Agency, Washington, D.C., August, 1979). That is, the distribution of the average of 10 samples from a lognormal was approximated by another lognormal distribution. Although the approximation is not precise theoretically, there is empirical evidence based on effluent data from a number of categories that the lognormal is an adequate approximation for the distribution of small samples. In the course of previous work the approximation was verified in a computer simulation study. We also note that the average values were developed assuming independence of the observations although no particular sampling scheme was assumed.

Ten-Sample average:

The formulas for the 10-sample limitations were derived on the basis of simple relationships between the mean and variance of the distributions of the daily pollutant measurements and the average of 10 measurements. We assume the daily concentration measurements for a particular pollutant, denoted by X, follow a lognormal distribution with log mean and log variance denoted by xx and o^2, respectivey. Let X_{10} denote the mean of 10 consecutive measurements. The following relationships then hold assuming the daily measurements are independent:

$$\text{mean of } X_{10} = E(X_{10}) = E(X)$$

$$\text{variance of } X_{10} = V(X_{10}) = V(X) + 10.$$

Where E(X) and V(X) are the mean and variance of X, respectively, defined above. We then assume that X_{10} follows a lognormal distribution with log mean U_{10} and log standard deviation o_{10}. The mean and variance of X_{10} are then

$$E(X_{10}) = \exp (10 + 0.5 \sigma^2_{10})$$
$$V(X_{10}) = \exp (2\ 10 + \sigma^2_{10}) [\exp(\sigma^2_{10})-1]$$

Now, 10 and σ^2_{10} can be derived in terms of xx and σ^2 as

$$10 = xx + \sigma^2 /2 + 0.5 \ln [1+(\exp(\sigma^2 -1)/N]$$
$$\sigma^2 = \ln [1+(\exp(\sigma^2) -1)/N]$$

Therefore, U10 and σ^2_{10} can be estimated using the above relationships and the estimates of U and σ^2 obtained for the underlying lognormal distribution. The 10 sample limitation value was determined by the estimate of the approximate 99th percentile of the distribution of the 10 sample average given by

$$X_{10} (.99) = \exp (_{10} + 2.33\ \sigma _{10}).$$

where 10 and $\sigma _{10}$ are the estimates of μ_{10} and σ_{10}, respectively.

30 Sample Average:

The average values based on 30 measurements are determined on the basis of a statistical result known as the Central Limit Theorem. This Theorem states that, under general and nonrestrictive assumptions, the distribution of a sum of a number of random variables, say n, is approximated by the normal distribution. The approximation improves as the number of variables, n, increases. The Theorem is quite general in that no particular distributional form is assumed for the distribution of the individual variables. In most applications (as in approximating the distribution of 30-day averages) the Theorem is used to approximate the distribution of the average of n observations of a random variable. The result makes it possible to compute approximate probability statements about the average in a wide range of cases. For instance, it is possible to compute a value below which a specified percentage (e.g., 99 percent) of the averages of n observations are likely to fall. Most textbooks state that 25 or 30 observations are sufficient for the approximation to be valid. In applying the Theorem to the distribution of the 30 day average effluent values, we approximate the distribution of the average of 30 observations drawn from the distribution of daily measurements and use the estimated 99th percentile of this distribution. The monthly limitations based on 10 consecutive measurements were determined using the lognormal approximation described above because 10 measurements was, in this case, considered too small a number for use of the Central Limit Theorem.

30 Sample Average Calculation

The formulas for the 30 sample average were based on an application of the Central Limit Theorem. According to the Theorem, the average of 30 observations drawn from the distribution of daily measurements, denoted by X_{30}, is approximately normally distributed. The mean and variance of X_{30} are:

$$\text{mean of } X_{30} = E(X_{30}) = E(X)$$
$$\text{variance of } X_{30} = V(X_{30}) = V(X)\ 30.$$

The 30 sample average value was determined by the estimate of the approximate 99th percentile of the distribution of the 30 sample average given by

$$X_{30}(.99) = E(X) = 2.33\ V(X)/30$$

where

$$E(X) = \exp(y)\ n\ (0.5v(y))$$

and

$$V(X) = \exp(2y)\ [\ n(2V(y)) = n\ \frac{n-2}{n-1}\ V(y))]$$

The formulas for E(X) and V(X) are estimates of E(X) and V(X) respectively given in Aitchison, J. and J.A.C. Brown, The Lognormal Distribution, Cambridge University Press, 1963, page 45.

Table VII-14

COMBINED METALS DATA EFFLUENT VALUES (mg/l)

	Mean	One Day Max.	10 Day Avg. Max.	30 Day Avg. Max.
Cd	0.079	0.32	0.15	0.13
Cr	0.08	0.42	0.17	0.12
Cu	0.58	1.90	1.00	0.73
Pb	0.12	0.15	0.13	0.12
Ni	0.57	1.41	1.00	0.75
Zn	0.30	1.33	0.56	0.41
Fe	0.41	1.23	0.63	0.51
Mn	0.21	0.43	0.34	0.27
TSS	12.0	41.0	20.0	15.5

Application

The Agency received comments, in response to proposed coil coating and porcelain enameling regulations, pointing out that permits usually required less than 30 samples to be taken during a month while the monthly average used as the basis for permits and pretreatment requirements usually is based on the average of 30 samples.

In applying the treatment effectiveness values to regulations we have considered the comments, examined the sampling frequency required by many permits and considered the change in values of averages depending on the number of consecutive sampling days in the averages. The most common frequency of sampling required in permits is about ten samples per month or slightly greater than twice weekly. The 99th percentiles of the distribution of averages of ten consecutive sampling days are not substantially different from the 99th percentile of the distribution's 30 day average. (Compared to the one-day maximum, the ten-day average is about 80 percent of the difference between one and 30 day values). Hence the ten day average provides a reasonable basis for a monthly average limitation and is typical of the sampling frequency required by existing permits.

The monthly average limitation is to be achieved in all permits and pretreatment standards regardless of the number of samples required to be analyzed and averaged by the permit or the pretreatment authority.

Additional Pollutants

A number of other pollutant parameters were considered with regard to the performance of lime and settle treatment systems in removing them from industrial wastewater. Performance data for these parameters is not readily available, so data available to the Agency in other categories has been selectively used to determine the long term average.

Performance of lime and settle technology for each pollutant. These data indicate that the concentrations shown in Table VII-15 are reliably attainable with hydroxide precipitation and settling. The precipitation of silver appears to be accomplished by alkaline chloride precipitation and adequate chloride ions must be available for this reaction to occur.

TABLE VII-15
L&S PERFORMANCE
ADDITIONAL POLLUTANTS

Pollutant	Average Performance (mg/l)
Sb	0.7
As	0.51
Be	0.30
Hg	0.06
Se	0.30
Ag	0.10
Th	0.50
Al	1.11
Co	0.05
F	14.5

In establishing which data were suitable for use in Table VII-15 two factors were heavily weighed; (1) the nature of the wastewater; (2) and the range of pollutants or pollutant matrix in the raw wastewater. These data have been selected from processes that generate dissolved metals in the wastewater and which are generally free from complexing agents. The pollutant matrix was evaluated by comparing the concentrations of pollutants found in the raw wastewaters with the range of pollutants in the raw wastewaters of the combined metals data set. These data are displayed in Tables VII-16 and VII-17 and indicate that there is sufficient similarity in the raw wastes to logically assume transferability of the treated pollutant concentrations to the combined metals data base. The available date on these added pollutants do not allow homogeneity analysis as was performed on the combined metals data base. The data source for each added pollutant is discussed separately.

TABLE VII-16

COMBINED METALS DATA SET - UNTREATED WASTEWATER

Pollutant	Min. Conc (mg/l)	Max. Conc. (mg/l)
Cd	<0.1	3.83
Cr	<0.1	116
Cu	<0.1	108
Pb	<0.1	29.2
Ni	<0.1	27.5
Zn	<0.1	337.
Fe	<0.1	263
Mn	<0.1	5.98
TSS	4.6	4390

TABLE VII-17
MAXIMUM POLLUTANT LEVEL IN UNTREATED WASTEWATER

ADDITIONAL POLLUTANTS
(mg/l)

Pollutant	As & Se	Be	Ag	F
As	4.2	-	-	-
Be	-	10.24	-	-
Cd	<0.1	-	<0.1	<0.1
Cr	0.18	8.60	0.23	22.8
Cu	33.2	1.24	110.5	2.2
Pb	6.5	0.35	11.4	5.35
Ni	-	-	100	0.69
Ag	-	-	4.7	-
Zn	3.62	0.12	1512	<0.1
F	-	-	-	760
Fe	-	646	-	-
O&G	16.9	-	16	2.8
TSS	352	796	587.8	5.6

Antimony (Sb) - The achievable performance for antimony is based on data from a battery and secondary lead plant. Both EPA sampling data and recent permit data (1978-1982) confirm the achievability of 0.7 mg/l in the battery manufacturing wastewater matrix included in the combined data set.

Arsenic (As) - The achievable performance of 0.5 mg/l for arsenic is based on permit data from two nonferrous metals manufacturing plants. The untreated wastewater matrix shown in Table VII-17 is comparable with the combined data set matrix.

Aluminum (Al) - The 1.11 mg/l treatability of aluminum is based on the mean performance of one aluminum forming plant and one coil coating plant. Both of the plants are from categories considered in the combined metals data set, assuring untreated wastewater matrix comparability.

Cobalt (Co) - The 0.05 mg/l treatability is based on nearly complete removal of cobalt at a porcelain enameling plant with a mean untreated wastewater cobalt concentration of 4.31 mg/l. In this case, the analytical detection using aspiration techniques for this pollutant is used as the basis of the treatability. Porcelain enameling was considered in the combined metals data base, assuring untreated wastewater matrix comparability.

Fluoride (F) - The 14.5 mg/l treatability of fluoride is based on the mean performance of an electronics and electrical component manufacturing plant. The untreated wastewater matrix for this plant shown in Table VII-17 is comparable to the combined metals data set.

LS&F Performance

Tables VII-18 and VII-19 show long term data from two plants which have well operated precipitation-settling treatment followed by filtration. The wastewaters from both plants contain pollutants from metals processing and finishing operations (multi-category). Both plants reduce hexavalent chromium before neutralizing and precipitating metals with lime. A clarifier is used to remove much of the solids load and a filter is used to "polish" or complete removal of suspended solids. Plant A uses a pressure filter, while Plant B uses a rapid sand filter.

Raw waste data was collected only occasionally at each facility and the raw waste data is presented as an indication of the nature of the wastewater treated. Data from plant A was received as a statistical summary and is presented as received. Raw laboratory data was collected at plant B and reviewed for

spurious points and discrepancies. The method of treating the data base is discussed below under lime, settle, and filter treatment effectiveness.

Table VII-20 shows long-term data for zinc and cadmium removal at Plant C, a primary zinc smelter, which operates a LS&F system. This data represents about 4 months (103 data days) taken immediately before the smelter was closed. It has been arranged similarily to Plants A and B for comparison and use.

TABLE VII-18

PRECIPITATION-SETTLING-FILTRATION (LS&F) PERFORMANCE
Plant A

Parameters	No Pts.	Range mg/l	Mean ± std. dev.	Mean + 2 std. dev.
For 1979-Treated Wastewater				
Cr	47	0.015 - 0.13	0.045 ±0.029	0.10
Cu	12	0.01 - 0.03	0.019 ±0.006	0.03
Ni	47	0.08 - 0.64	0.22 ±0.13	0.48
Zn	47	0.08 - 0.53	0.17 ±0.09	0.35
Fe				
For 1978-Treated Wastewater				
Cr	47	0.01 - 0.07	0.06 ±0.10	0.26
Cu	28	0.005 - 0.055	0.016 ±0.010	0.04
Ni	47	0.10 - 0.92	0.20 ±0.14	0.48
Zn	47	0.08 - 2.35	0.23 ±0.34	0.91
Fe	21	0.26 - 1.1	0.49 ±0.18	0.85
Raw Waste				
Cr	5	32.0 - 72.0		
Cu	5	0.08 - 0.45		
Ni	5	1.65 - 20.0		
Zn	5	33.2 - 32.0		
Fe	5	10.0 - 95.0		

TABLE VII-19

PRECIPITATION-SETTLING-FILTRATION (LS&F) PERFORMANCE
Plant B

Parameters	No Pts.	Range mg/l	Mean ± std. dev.	Mean + 2 std. dev.
For 1979-Treated Wastewater				
Cr	175	0.0 - 0.40	0.068 ±0.075	0.22
Cu	176	0.0 - 0.22	0.024 ±0.021	0.07
Ni	175	0.01 - 1.49	0.219 ±0.234	0.69
Zn	175	0.01 - 0.66	0.054 ±0.064	0.18
Fe	174	0.01 - 2.40	0.303 ±0.398	1.10
TSS	2	1.00 - 1.00		
For 1978-Treated Wastewater				
Cr	144	0.0 - 0.70	0.059 ±0.088	0.24
Cu	143	0.0 - 0.23	0.017 ±0.020	0.06
Ni	143	0.0 - 1.03	0.147 ±0.142	0.43
Zn	131	0.0 - 0.24	0.037 ±0.034	0.11
Fe	144	0.0 - 1.76	0.200 ±0.223	0.47
Total 1974-1979-Treated Wastewater				
Cr	1288	0.0 - 0.56	0.038 ±0.055	0.15
Cu	1290	0.0 - 0.23	0.011 ±0.016	0.04
Ni	1287	0.0 - 1.88	0.184 ±0.211	0.60
Zn	1273	0.0 - 0.66	0.035 ±0.045	0.13
Fe	1287	0.0 - 3.15	0.402 ±0.509	1.42
Raw Waste				
Cr	3	2.80 - 9.15	5.90	
Cu	3	0.09 - 0.27	0.17	
Ni	3	1.61 - 4.89	3.33	
Zn	2	2.35 - 3.39		
Fe	3	3.13 -35.9	22.4	
TSS	2	177 -466.		

TABLE VII-20

PRECIPITATION-SETTLING-FILTRATION (LS&F) PERFORMANCE
Plant C

Parameters	No Pts.	Range mg/l	Mean ± std. dev.	Mean + 2 std. dev.
For Treated Wastewater				
Cd	103	0.010 - 0.500	0.049 ±0.049	0.147
Zn	103	0.039 - 0.899	0.290 ±0.131	0.552
TSS	103	0.100 - 5.00	1.244 ±1.043	3.33
pH	103	7.1 - 7.9	9.2*	
For Untreated Wastewater				
Cd	103	0.039 - 2.319	0.542 ±0.381	1.304
Zn	103	0.949 -29.8	11.009 ±6.933	24.956
Fe	3	0.107 - 0.46	0.255	
TSS	103	0.80 -19.6	5.616 ±2.896	11.408
pH	103	6.8 - 8.2	7.6*	

* pH value is median of 103 values.

These data are presented to demonstrate the performance of precipitation-settling-filtration (LS&F) technology under actual operating conditions and over a long period of time.

It should be noted that the iron content of the raw waste of plants A and B is high while that for Plant C is low. This results, for plants A and B, in coprecipitation of toxic metals with iron. Precipitation using high-calcium lime for pH control yields the results shown above. Plant operating personnel indicate that this chemical treatment combination (sometimes with polymer assisted coagulation) generally produces better and more consistant metals removal than other combinations of sacrificial metal ions and alkalis.

The LS&F performance data presented here are based on systems that provide polishing filtration after effective L&S treatment. We have previously shown that L&S treatment is equally applicable to wastewaters from the five categories because of the homogeneity of its raw and treated wastewaters, and other factors. Because of the similarity of the wastewaters after L&S treatment, the Agency believes these wastewaters are equally amenable to treatment using polishing filters added to the L&S treatment system. The Agency concludes that LS&F data based on porcelain enameling and non-ferrous smelting and refining is directly applicable to the aluminum forming, copper forming,

battery manufacturing, coil coating, and metal molding and casting categories, as well as to the porcelain enameling and nonferrous smelting and refining.

Analysis of Treatment System Effectiveness

Data are presented in Table VII-14 showing the mean, one day, 10 day, and 30 day values for nine pollutants examined in the L&S metals data base. The mean variability factor for eight pollutants (excluding cadmium because of the small number of data points) was determined and is used to estimate one day, 10 day and 30 day values. (The variability factor is the ratio of the value of concern to the mean: the average variability factors are: one day maximum - 4.051; ten day average - 1.899; and 30 day average - 1.646.) For values not calculated from the common data base as previously discussed, the mean value for pollutants shown in Table VII-15 were multiplied by the variability factors to derive the value to obtain the one, ten and 30 day values. These are tabulated in Table VII-21.

LS&F technology data are presented in Tables VII-18 and VII-19. These data represent two operating plants (A and B) in which the technology has been installed and operated for some years. Plant A data was received as a statistical summary and is presented without change. Plant B data was received as raw laboratory analysis data. Discussions with plant personnel indicated that operating experiments and changes in materials and reagents and occasional operating errors had occured during the data collection period. No specific information was available on those variables. To sort out high values probably caused by methodological factors from random statistical variability, or data noise, the plant B data were analyzed. For each of four pollutants (chromium, nickel, zinc, and iron), the mean and standard deviation (sigma) were calculated for the entire data set. A data day was removed from the complete data set when any individual pollutant concentration for that day exceeded the sum of the mean plus three sigma for that pollutant. Fifty-one data days (from a total of about 1300) were eliminated by this method.

Another approach was also used as a check on the above method of eliminating certain high values. The minimum values of raw wastewater concentrations from Plant B for the same four pollutants were compared to the total set of values for the corresponding pollutants. Any day on which the pollutant concentration exceeded the minimum value selected from raw wastewater concentrations for that pollutant was discarded. Forty-five days of data were eliminated by that procedure. Forty-three days of data in common were eliminated by either procedures. Since common engineering practice (mean plus 3

sigma) and logic (treated waste should be less than raw waste) seem to coincide, the data base with the 51 spurious data days eliminated is the basis for all further analysis. Range, mean, standard deviation and mean plus two standard deviations are shown in Tables VII-18 and VII-19 for Cr, Cu, Ni, Zn and Fe.

The Plant B data was separated into 1979, 1978, and total data base (six years) segments. With the statistical analysis from Plant A for 1978 and 1979 this in effect created five data sets in which there is some overlap between the individual years and total data sets from Plant B. By comparing these five parts it is apparent that they are quite similar and all appear to be from the same family of numbers. The largest mean found among the five data sets for each pollutant was selected as the long term mean for LS&F technology and is used as the LS&F mean in Table VII-21.

Plant C data was used as a basis for cadmium removal performance and as a check on the zinc values derived from Plants A and B. The cadmium data is displayed in Table VII-18 and is incorporated into Table VII-21 for LS&F. The zinc data was analyzed for compliance with the 1-day and 30-day values in Table VII-21; no zinc value of the 103 data points exceeded the 1-day zinc value of 1.02 mg/l. The 103 data points were separated into blocks of 30 points and averaged. Each of the 3 full 30-day averages was less than the Table VII-21 value of 0.31 mg/l. Additionally the Plant C raw wastewater pollutant concentrations (Table VII-20) are well within the range of raw wastewater concentrations of the combined metals data base (Table VII-16); further supporting the conclusion that Plant C wastewater data is compatible with similar data from Plants A and B.

Concentration values for regulatory use are displayed in Table VII-21. Mean one day, ten day and 30 day values for L&S for nine pollutants were taken from Table VII-14; the remaining L&S values were developed using the mean values in Table VII-15 and the mean varaiability factors discussed above.

LS&F mean values for Cd, Cr, Ni, Zn and Fe are derived from plants A, B, and C as discussed above. One, ten and thirty day values are derived by applying the variability factor developed from the pooled data base for the specific pollutant to the mean for that pollutant. Other LS&F values are calculated using the long term average or mean and the appropriate variability factors. Mean values for LS&F for pollutants not already discussed are derived by reducing the L&S mean by one-third. The one-third reduction was established after examining the percent reduction in concentrations going from L&S to LS&F data for Cd,

Cr, Ni, Zn, and Fe. The average reduction is 0.3338 or one third.

Copper levels achieved at Plants A and B may be lower than generally achievable because of the high iron content and low copper content of the raw wastewaters. Therefore, the mean concentration value achieved is not used; LS&F mean used is derived from the L&S technology.

The mean concentration of lead is not reduced from the L&S value because of the relatively high solubility of lead carbonate.

The filter performance for removing TSS as shown in Table VII-10 yields a mean effluent concentration of 2.61 mg/l and calculates to a 10 day average of 4.33, 30 day average of 3.36 mg/l; a one day maximum of 8.88. These calculated values more than amply support the classic values of 10 and 15, respectively, which are used for LS&F.

Although iron was reduced in some LS&F operations, some facilities using that treatment introduce iron compounds to aid settling. Therefore, the one day, ten day and 30 day values for iron at LS&F were held at the L&S level so as to not unduly penalize the operations which use the relatively less objectionable iron compounds to enhance removals of toxic metals.

TABLE VII-21

SUMMARY OF TREATMENT EFFECTIVENESS
(mg/l)

Pollutant Parameter	L&S Technology System			
	Mean	One Day Max.	Ten Day Avg.	Thirty Day Avg.
114 Sb	0.05	0.21	0.09	0.08
115 As	0.51	2.09	0.86	0.83
117 Be	0.30	1.23	0.51	0.49
118 Cd	0.079	0.32	0.15	0.13
119 Cr	0.080	0.42	0.17	0.12
120 Cu	0.58	1.90	1.00	0.73
121 CN	0.07	0.29	0.12	0.11
122 Pb	0.12	0.15	0.13	0.12
123 Hg	0.06	0.25	0.10	0.10
124 Ni	0.57	1.41	1.00	0.75
125 Se	0.01	0.04	0.02	0.02
126 Ag	0.1	0.41	0.17	0.16
127 Th	0.50	2.05	0.84	0.81
128 Zn	0.30	1.33	0.56	0.41
Al	1.11	4.55	1.86	1.80
Co	0.07	0.29	0.12	0.11
F	14.2	58.2	23.8	23.0
Fe	0.41	1.23	0.63	0.51
Mn	0.21	0.43	0.34	0.27
P	4.08	16.7	6.83	6.60
O&G		20.0	12.0	10.0
TSS	12.0	41.0	20.0	15.5

Pollutant Parameter		LS&F Technology System			
		Mean	One Day Max.	Ten Day Avg.	Thirty Day Avg.
114	Sb	0.034	0.14	0.06	0.06
115	As	0.34	1.39	0.57	0.55
117	Be	0.20	0.82	0.34	0.32
118	Cd	0.049	0.20	0.08	0.08
119	Cr	0.07	0.37	0.15	0.10
120	Cu	0.39	1.28	0.61	0.49
121	CN	0.047	0.20	0.08	0.08
122	Pb	0.08	0.10	0.09	0.08
123	Hg	0.036	0.15	0.06	0.06
124	Ni	0.22	0.55	0.37	0.29
125	Se	0.007	0.03	0.01	0.01
126	Ag	0.07	0.29	0.12	0.10
127	Th	0.34	1.40	0.57	0.55
128	Zn	0.23	1.02	0.42	0.31
	Al	0.74	3.03	1.24	1.20
	Co	0.05	0.21	0.09	0.08
	F	9.46	38.8	15.8	15.3
	Fe	0.28	1.23	0.63	0.51
	Mn	0.14	0.30	0.23	0.19
	P	2.72	11.2	4.6	4.4
	O&G		10.0	10.0	10.0
	TSS	2.6	15.0	12.0	10.0

MINOR TECHNOLOGIES

Several other treatment technologies were considered for possible application in BPT or BAT. These technologies are presented here with a full discussion for most of them. A few are described only briefly because of limited technical development.

8. Carbon Adsorption

The use of activated carbon to remove dissolved organics from water and wastewater is a long demonstrated technology. It is one of the most efficient organic removal processes available. This sorption process is reversible, allowing activated carbon to be regenerated for reuse by the application of heat and steam or solvent. Activated carbon has also proved to be an effective adsorbent for many toxic metals, including mercury. Regeneration of carbon which has adsorbed significant metals, however, may be difficult.

The term activated carbon applies to any amorphous form of carbon that has been specially treated to give high adsorption capacities. Typical raw materials include coal, wood, coconut shells, petroleum base residues and char from sewage sludge pyrolysis. A carefully controlled process of dehydration, carbonization, and oxidation yields a product which is called activated carbon. This material has a high capacity for adsorption due primarily to the large surface area available for adsorption, 500-1500 m^2/sq m resulting from a large number of internal pores. Pore sizes generally range from 10-100 angstroms in radius.

Activated carbon removes contaminants from water by the process of adsorption, or the attraction and accumulation of one substance on the surface of another. Activated carbon preferentially adsorbs organic compounds and, because of this selectivity, is particularly effective in removing organic compounds from aqueous solution.

Carbon adsorption requires pretreatment to remove excess suspended solids, oils, and greases. Suspended solids in the influent should be less than 50 mg/l to minimize backwash requirements; a downflow carbon bed can handle much higher levels (up to 2000 mg/l), but requires frequent backwashing. Backwashing more than two or three times a day is not desirable; at 50 mg/l suspended solids one backwash will suffice. Oil and grease should be less than about 10 mg/l. A high level of dissolved inorganic material in the influent may cause problems with thermal carbon reactivation (i.e., scaling and loss of activity) unless appropriate preventive steps are taken. Such

steps might include pH control, softening, or the use of an acid wash on the carbon prior to reactivation.

Activated carbon is available in both powdered and granular form. An adsorption column packed with granular activated carbon is shown in Figure VII-16. Powdered carbon is less expensive per unit weight and may have slightly higher adsorption capacity, but it is more difficult to handle and to regenerate.

Application and Performance. Carbon adsorption is used to remove mercury from wastewaters. The removal rate is influenced by the mercury level in the influent to the adsorption unit. Removal levels found at three manufacturing facilities are:

Table VII-22

ACTIVATED CARBON PERFORMANCE (MERCURY)

	Mercury levels - mg/l	
Plant	In	Out
A	28.0	0.9
B	0.36	0.015
C	0.008	0.0005

In the aggregate these data indicate that very low effluent levels could be attained from any raw waste by use of multiple adsorption stages. This is characteristic of adsorption processes.

Isotherm tests have indicated that activated carbon is very effective in adsorbing 65 percent of the organic priority pollutants and is reasonably effective for another 22 percent. Specifically, for the organics of particular interest, activated carbon was very effective in removing 2,4-dimethylphenol, fluoranthene, isophorone, naphthalene, all phthalates, and phenanthrene. It was reasonably effective on 1,1,1-trichloroethane, 1,1-dichloroethane, phenol, and toluene. Table VII-23 summarizes the treatability effectiveness for most of the organic priority pollutants by activated carbon as compiled by EPA. Table VII-24 summarizes classes of organic compounds together with examples of organics that are readily adsorbed on carbon.

Advantages and Limitations. The major benefits of carbon treatment include applicability to a wide variety of organics, and high removal efficiency. Inorganics such as cyanide, chromium, and mercury are also removed effectively. Variations in concentration and flow rate are well tolerated. The system is

compact, and recovery of adsorbed materials is sometimes practical. However, destruction of adsorbed compounds often occurs during thermal regeneration. If carbon cannot be thermally desorbed, it must be disposed of along with any adsorbed pollutants. The capital and operating costs of thermal regeneration are relatively high. Cost surveys show that thermal regeneration is generally economical when carbon usage exceeds about 1,000 lb/day. Carbon cannot remove low molecular weight or highly soluble organics. It also has a low tolerance for suspended solids, which must be removed to at least 50 mg/l in the influent water.

Operational Factors. Reliability: This system should be very reliable with upstream protection and proper operation and maintenance procedures.

Maintainability: This system requires periodic regeneration or replacement of spent carbon and is dependent upon raw waste load and process efficiency.

Solid Waste Aspects: Solid waste from this process is contaminated activated carbon that requires disposal. Carbon undergoes regeneration, reduces the solid waste problem by reducing the frequency of carbon replacement.

Demonstration Status. Carbon adsorption systems have been demonstrated to be practical and economical in reducing COD, BOD and related parameters in secondary municipal and industrial wastewaters; in removing toxic or refractory organics from isolated industrial wastewaters; in removing and recovering certain organics from wastewaters; and in the removing and some times recovering, of selected inorganic chemicals from aqueous wastes. Carbon adsorption is a viable and economic process for organic waste streams containing up to 1 to 5 percent of refractory or toxic organics. Its applicability for removal of inorganics, such as certain metals, has also been demonstrated.

9. Centrifugation

Centrifugation is the application of centrifugal force to separate solids and liquids in a liquid-solid mixture or to effect concentration of the solids. The application of centrifugal force is effective because of the density differential normally found between the insoluble solids and the liquid in which they are contained. As a waste treatment procedure, centrifugation is applied to dewatering of sludges. One type of centrifuge is shown in Figure VII-17.

There are three common types of centrifuges: the disc, basket, and conveyor type. All three operate by removing solids under the influence of centrifugal force. The fundamental difference between the three types is the method by which solids are collected in and discharged from the bowl.

In the disc centrifuge, the sludge feed is distributed between narrow channels that are present as spaces between stacked conical discs. Suspended particles are collected and discharged continuously through small orifices in the bowl wall. The clarified effluent is discharged through an overflow weir.

A second type of centrifuge which is useful in dewatering sludges is the basket centrifuge. In this type of centrifuge, sludge feed is introduced at the bottom of the basket, and solids collect at the bowl wall while clarified effluent overflows the lip ring at the top. Since the basket centrifuge does not have provision for continuous discharge of collected cake, operation requires interruption of the feed for cake discharge for a minute or two in a 10 to 30 minute overall cycle.

The third type of centrifuge commonly used in sludge dewatering is the conveyor type. Sludge is fed through a stationary feed pipe into a rotating bowl in which the solids are settled out against the bowl wall by centrifugal force. From the bowl wall, they are moved by a screw to the end of the machine, at which point whey are discharged. The liquid effluent is discharged through ports after passing the length of the bowl under centrifugal force.

Application And Performance. Virtually all industrial waste treatment systems producing sludge can use centrifugation to dewater it. Centrifugation is currently being used by a wide range of industrial concerns.

The performance of sludge dewatering by centrifugation depends on the feed rate, the rotational velocity of the drum, and the sludge composition and concentration. Assuming proper design and operation, the solids content of the sludge can be increased to 20-35 percent.

Advantages And Limitations. Sludge dewatering centrifuges have minimal space requirements and show a high degree of effluent clarification. The operation is simple, clean, and relatively inexpensive. The area required for a centrifuge system installation is less than that required for a filter system or sludge drying bed of equal capacity, and the initial cost is lower.

Centrifuges have a high power cost that partially offsets the low initial cost. Special consideration must also be given to providing sturdy foundations and soundproofing because of the vibration and noise that result from centrifuge operation. Adequate electrical power must also be provided since large motors are required. The major difficulty encountered in the operation of centrifuges has been the disposal of the concentrate which is relatively high in suspended, non-settling solids.

Operational Factors. Reliability: Centrifugation is highly reliable with proper control of factors such as sludge feed, consistency, and temperature. Pretreatment such as grit removal and coagulant addition may be necessary, depending on the composition of the sludge and on the type of centrifuge employed.

Maintainability: Maintenance consists of periodic lubrication, cleaning, and inspection. The frequency and degree of inspection required varies depending on the type of sludge solids being dewatered and the maintenance service conditions. If the sludge is abrasive, it is recommended that the first inspection of the rotating assembly be made after approximately 1,000 hours of operation. If the sludge is not abrasive or corrosive, then the initial inspection might be delayed. Centrifuges not equipped with a continuous sludge discharge system require periodic shutdowns for manual sludge cake removal.

Solid Waste Aspects: Sludge dewatered in the centrifugation process may be disposed of by landfill. The clarified effluent (centrate), if high in dissolved or suspended solids, may require further treatment prior to discharge.

Demonstration Status. Centrifugation is currently used in a great many commercial applications to dewater sludge. Work is underway to improve the efficiency, increase the capacity, and lower the costs associated with centrifugation.

10. Coalescing

The basic principle of coalescence involves the preferential wetting of a coalescing medium by oil droplets which accumulate on the medium and then rise to the surface of the solution as they combine to form larger particles. The most important requirements for coalescing media are wettability for oil and large surface area. Monofilament line is sometimes used as a coalescing medium.

Coalescing stages may be integrated with a wide variety of gravity oil separation devices, and some systems may incorporate

several coalescing stages. In general a preliminary oil skimming step is desirable to avoid overloading the coalescer.

One commercially marketed system for oily waste treatment combines coalescing with inclined plate separation and filtration. In this system, the oily wastes flow into an inclined plate settler. This unit consists of a stack of inclined baffle plates in a cylindrical container with an oil collection chamber at the top. The oil droplets rise and impinge upon the undersides of the plates. They then migrate upward to a guide rib which directs the oil to the oil collection chamber, from which oil is discharged for reuse or disposal.

The oily water continues on through another cylinder containing replaceable filter cartridges, which remove suspended particles from the waste. From there the wastewater enters a final cylinder in which the coalescing material is housed. As the oily water passes through the many small, irregular, continuous passages in the coalescing material, the oil droplets coalesce and rise to an oil collection chamber.

Application and Performance. Coalescing is used to treat oily wastes (e.g., die casting or casting quench) which do not separate readily in simple gravity systems. The three stage system described above has achieved effluent concentrations of 10-15 mg/l oil and grease from raw waste concentrations of 1000 mg/l or more.

Advantages and Limitations. Coalescing allows removal of oil droplets too finely dispersed for conventional gravity separation-skimming technology. It also can significantly reduce the residence times (and therefore separator volumes) required to achieve separation of oil from some wastes. Because of its simplicity, coalescing provides generally high reliability and low capital and operating costs. Coalescing is not generally effective in removing soluble or chemically stabilized emulsified oils. To avoid plugging, coalescers must be protected by pretreatment from very high concentrations of free oil and grease and suspended solids. Frequent replacement of prefilters may be necessary when raw waste oil concentrations are high.

Operational Factors. Reliability: Coalescing is inherently highly reliable since there are no moving parts, and the coalescing substrate (monofilament, etc.) is inert in the process and therefore not subject to frequent regeneration or replacement requirements. Large loads or inadequate pretreatment, however, may result in plugging or bypass of coalescing stages.

Maintainability: Maintenance requirements are generally limited to replacement of the coalescing medium on an infrequent basis.

Solid Waste Aspects: No appreciable solid waste is generated by this process.

Demonstration Status. Coalescing has been fully demonstrated in industries generating oily wastewaters.

11. Evaporation

Evaporation is a concentration process. Water is evaporated from a solution, increasing the concentration of solute in the remaining solution. If the resulting water vapor is condensed back to liquid water, the evaporation-condensation process is called distillation. However, to be consistent with industry terminology, evaporation is used in this report to describe both processes. Both atmospheric and vacuum evaporation are commonly used in industry today. Specific evaporation techniques are shown in Figure VII-18 and discussed below.

Atmospheric evaporation could be accomplished simply by boiling the liquid. However, to aid evaporation, heated liquid is sprayed on an evaporation surface, and air is blown over the surface and subsequently released to the atmosphere. Thus, evaporation occurs by humidification of the air stream, similar to a drying process. Equipment for carrying out atmospheric evaporation is quite similar for most applications. The major element is generally a packed column with an accumulator bottom. Accumulated wastewater is pumped from the base of the column, through a heat exchanger, and back into the top of the column, where it is sprayed into the packing. At the same time, air drawn upward through the packing by a fan is heated as it contacts the hot liquid. The liquid partially vaporizes and humidifies the air stream. The fan then blows the hot, humid air to the outside atmosphere. A scrubber is often unnecessary because the packed column itself acts as a scrubber.

Another form of atmospheric evaporator also works on the air humidification principle, but the evaporated water is recovered for reuse by condensation. These air humidification techniques operate well below the boiling point of water and can utilize waste process heat to supply the energy required.

In vacuum evaporation, the evaporation pressure is lowered to cause the liquid to boil at reduced temperature. All of the water vapor is condensed and, to maintain the vacuum condition, noncondensible gases (air in particular) are removed by a vacuum pump. Vacuum evaporation may be either single or double effect.

In double effect evaporation, two evaporators are used, and the water vapor from the first evaporator (which may be heated by steam) is used to supply heat to the second evaporator. As it supplies heat, the water vapor from the first evaporator condenses. Approximately equal quantities of wastewater are evaporated in each unit; thus, the double effect system evaporates twice the amount of water that a single effect system does, at nearly the same cost in energy but with added capital cost and complexity. The double effect technique is thermodynamically possible because the second evaporator is maintained at lower pressure (higher vacuum) and, therefore, lower evaporation temperature. Another means of increasing energy efficiency is vapor recompression (thermal or mechanical), which enables heat to be transferred from the condensing water vapor to the evaporating wastewater. Vacuum evaporation equipment may be classified as submerged tube or climbing film evaporation units.

In the most commonly used submerged tube evaporator, the heating and condensing coil are contained in a single vessel to reduce capital cost. The vacuum in the vessel is maintained by an eductor-type pump, which creates the required vacuum by the flow of the condenser cooling water through a venturi. Waste water accumulates in the bottom of the vessel, and it is evaporated by means of submerged steam coils. The resulting water vapor condenses as it contacts the condensing coils in the top of the vessel. The condensate then drips off the condensing coils into a collection trough that carries it out of the vessel. Concentrate is removed from the bottom of the vessel.

The major elements of the climbing film evaporator are the evaporator, separator, condenser, and vacuum pump. Waste water is "drawn" into the system by the vacuum so that a constant liquid level is maintained in the separator. Liquid enters the steam-jacketed evaporator tubes, and part of it evaporates so that a mixture of vapor and liquid enters the separator. The design of the separator is such that the liquid is continuously circulated from the separator to the evaporator. The vapor entering the separator flows out through a mesh entrainment separator to the condenser, where it is condensed as it flows down through the condenser tubes. The condensate, along with any entrained air, is pumped out of the bottom of the condenser by a liquid ring vacuum pump. The liquid seal provided by the condensate keeps the vacuum in the system from being broken.

Application and Performance. Both atmospheric and vacuum evaporation are used in many industrial plants, mainly for the concentration and recovery of process solutions. Many of these evaporators also recover water for rinsing. Evaporation has also been applied to recovery of phosphate metal cleaning solutions.

In theory, evaporation should yield a concentrate and a deionized condensate. Actually, carry-over has resulted in condensate metal concentrations as high as 10 mg/l, although the usual level is less than 3 mg/l, pure enough for most final rinses. The condensate may also contain organic brighteners and antifoaming agents. These can be removed with an activated carbon bed, if necessary. Samples from one plant showed 1,900 mg/l zinc in the feed, 4,570 mg/l in the concentrate, and 0.4 mg/l in the condensate. Another plant had 416 mg/l copper in the feed and 21,800 mg/l in the concentrate. Chromium analysis for that plant indicated 5,060 mg/l in the feed and 27,500 mg/l in the concentrate. Evaporators are available in a range of capacities, typically from 15 to 75 gph, and may be used in parallel arrangements for processing of higher flow rates.

Advantages and Limitations. Advantages of the evaporation process are that it permits recovery of a wide variety of process chemicals, and it is often applicable to concentration or removal of compounds which cannot be accomplished by any other means. The major disadvantage is that the evaporation process consumes relatively large amounts of energy for the evaporation of water. However, the recovery of waste heat from many industrial processes (e.g., diesel generators, incinerators, boilers and furnaces) should be considered as a source of this heat for a totally integrated evaporation system. Also, in some cases solar heating could be inexpensively and effectively applied to evaporation units.

For some applications, pretreatment may be required to remove solids or bacteria which tend to cause fouling in the condenser or evaporator. The buildup of scale on the evaporator surfaces reduces the heat transfer efficiency and may present a maintenance problem or increase operating cost. However, it has been demonstrated that fouling of the heat transfer surfaces can be avoided or minimized for certain dissolved solids by maintaining a seed slurry which provides preferential sites for precipitate deposition. In addition, low temperature differences in the evaporator will eliminate nucleate boiling and supersaturation effects. Steam distillable impurities in the process stream are carried over with the product water and must be handled by pre or post treatment.

Operational Factors. Reliability: Proper maintenance will ensure a high degree of reliability for the system. Without such attention, rapid fouling or deterioration of vacuum seals may occur, especially when handling corrosive liquids.

Maintainability: Operating parameters can be automatically controlled. Pretreatment may be required, as well as periodic cleaning of the system. Regular replacement of seals, especially in a corrosive environment, may be necessary.

Solid Waste Aspects: With only a few exceptions, the process does not generate appreciable quantities of solid waste.

Demonstration Status. Evaporation is a fully developed, commercially available wastewater treatment system. It is used extensively to recover plating chemicals in the electroplating industry and a pilot scale unit has been used in connection with phosphating of aluminum. Proven performance in silver recovery indicates that evaporation could be a useful treatment operation for the photographic industry, as well as for metal finishing. No data have been reported showing the use of evaporation in metal molding and casting industry operations.

12. Flotation

Flotation is the process of causing particles such as metal hydroxides or oil to float to the surface of a tank where they can be concentrated and removed. This is accomplished by releasing gas bubbles which attach to the solid particles, increasing their buoyancy and causing them to float. In principle, this process is the opposite of sedimentation. Figure VII-19 shows one type of flotation system.

Flotation is used primarily in the treatment of wastewater streams that carry heavy loads of finely divided suspended solids or oil. Solids having a specific gravity only slightly greater than 1.0, which would require abnormally long sedimentation times, may be removed in much less time by flotation.

This process may be performed in several ways: foam, dispersed air, dissolved air, gravity, and vacuum flotation are the most commonly used techniques. Chemical additives are often used to enhance the performance of the flotation process.

The principal difference among types of flotation is the method of generating the minute gas bubbles (usually air) in a suspension of water and small particles. Chemicals may be used to improve the efficiency with any of the basic methods. The

following paragraphs describe the different flotation techniques and the method of bubble generation for each process.

Froth Flotation - Froth flotation is based on differences in the physiochemical properties in various particles. Wettability and surface properties affect the particles' ability to attach themselves to gas bubbles in an aqueous medium. In froth flotation, air is blown through the solution containing flotation reagents. The particles with water repellant surfaces stick to air bubbles as they rise and are brought to the surface. A mineralized froth layer, with mineral particles attached to air bubbles, is formed. Particles of other minerals which are readily wetted by water do not stick to air bubbles and remain in suspension.

Dispersed Air Flotation - In dispersed air flotation, gas bubbles are generated by introducing the air by means of mechanical agitation with impellers or by forcing air through porous media. Dispersed air flotation is used mainly in the metallurgical industry.

Dissolved Air Flotation - In dissolved air flotation, bubbles are produced by releasing air from a supersaturated solution under relatively high pressure. There are two types of contact between the gas bubbles and particles. The first type is predominant in the flotation of flocculated materials and involves the entrapment of rising gas bubbles in the flocculated particles as they increase in size. The bond between the bubble and particle is one of physical capture only. The second type of contact is one of adhesion. Adhesion results from the intermolecular attraction exerted at the interface between the solid particle and gaseous bubble.

Vacuum Flotation - This process consists of saturating the waste water with air either directly in an aeration tank, or by permitting air to enter on the suction of a wastewater pump. A partial vacuum is applied, which causes the dissolved air to come out of solution as minute bubbles. The bubbles attach to solid particles and rise to the surface to form a scum blanket, which is normally removed by a skimming mechanism. Grit and other heavy solids that settle to the bottom are generally raked to a central sludge pump for removal. A typical vacuum flotation unit consists of a covered cylindrical tank in which a partial vacuum is maintained. The tank is equipped with scum and sludge removal mechanisms. The floating material is continuously swept to the tank periphery, automatically discharged into a scum trough, and removed from the unit by a pump also under partial vacuum. Auxilliary equipment includes an aeration tank for saturating the

wastewater with air, a tank with a short retention time for removal of large bubbles, vacuum pumps, and sludge pumps.

Application and Performance. The primary variables for flotation design are pressure, feed solids concentration, and retention period. The suspended solids in the effluent decrease, and the concentration of solids in the float increases with increasing retention period. When the flotation process is used primarily for clarification, a retention period of 20 to 30 minutes is adequate for separation and concentration.

Advantages and Limitations. Some advantages of the flotation process are the high levels of solids separation achieved in many applications, the relatively low energy requirements, and the adaptability to meet the treatment requirements of different waste types. Limitations of flotation are that it often requires addition of chemicals to enhance process performance and that it generates large quantities of solid waste.

Operational Factors. Reliability: Flotation systems normally are very reliable with proper maintenance of the sludge collector mechanism and the motors and pumps used for aeration.

Maintainability: Routine maintenance is required on the pumps and motors. The sludge collector mechanism is subject to possible corrosion or breakage and may require periodic replacement.

Solid Waste Aspects: Chemicals are commonly used to aid the flotation process by creating a surface or a structure that can easily adsorb or entrap air bubbles. Inorganic chemicals, such as the aluminum and ferric salts, and activated silica, can bind the particulate matter together and create a structure that can entrap air bubbles. Various organic chemicals can change the nature of either the air-liquid interface or the solid-liquid interface, or both. These compounds usually collect on the interface to bring about the desired changes. The added chemicals plus the particles in solution combine to form a large volume of sludge which must be further treated or properly disposed.

Demonstration Status. Flotation is a fully developed process, which demonstrated in this industry, is readily available for the treatment of a wide variety of industrial waste streams.

13. Gravity Sludge Thickening

In the gravity thickening process, dilute sludge is fed from a primary settling tank or clarifier to a thickening tank where

rakes stir the sludge gently to densify it and to push it to a central collection well. The supernatant is returned to the primary settling tank. The thickened sludge that collects on the bottom of the tank is pumped to dewatering equipment or hauled away. Figure VII-20 shows the construction of a gravity thickener.

Application and Performance. Thickeners are generally used in facilities where the sludge is to be further dewatered by a compact mechanical device such as a vacuum filter or centrifuge. Doubling the solids content in the thickener substantially reduces capital and operating cost of the subsequent dewatering device and also reduces cost for hauling. The process is potentially applicable to almost any industrial plant.

Organic sludges from sedimentation units of one to two percent solids concentration can usually be gravity thickened to six to ten percent; chemical sludges can be thickened to four to six percent.

Advantages and Limitations. The principal advantage of a gravity sludge thickening process is that it facilitates further sludge dewatering. Other advantages are high reliability and minimum maintenance requirements.

Limitations of the sludge thickening process are its sensitivity to the flow rate through the thickener and the sludge removal rate. These rates must be low enough not to disturb the thickened sludge.

Operational Factors. Reliability: Reliability is high with proper design and operation. A gravity thickener is designed on the basis of square feet per pound of solids per day, in which the required surface area is related to the solids entering and leaving the unit. Thickener area requirements are also expressed in terms of mass loading, grams of solids per square meter per day (lbs/sq ft/day).

Maintainability: Approximately twice a year a thickener must be shut down for lubrication of the drive mechanisms. Occasionally, water must be pumped back through the system in order to clear sludge pipes.

Solid Waste Aspects: Thickened sludge from a gravity thickening process will usually require further dewatering prior to disposal, incineration, or drying. The clear effluent may be recirculated in part, or it may be subjected to further treatment prior to discharge.

Demonstration Status. Gravity sludge thickeners are used throughout this industry to reduce water content to a level where the sludge may be efficiently handled. Further dewatering is usually practiced to minimize the costs of hauling the sludge to approved landfill areas.

14. Sludge Bed Drying

As a waste treatment procedure, sludge bed drying is employed to reduce the water content of a variety of sludges to the point where they are amenable to mechanical collection and removal to landfill. These beds usually consist of 15 to 45 cm (6 to 18 in.) of sand over a 30 cm (12 in.) deep gravel drain system made up of 3 to 6 mm (1/8 to 1/4 in.) graded gravel overlying drain tiles. Figure VII-21 (page 289) shows the construction of a drying bed.

Drying beds are usually divided into sectional areas approximately 7.5 meters (25 ft) wide x 30 to 60 meters (100 to 200 ft) long. The partitions may be earth embankments, but more often are made of planks and supporting grooved posts.

To apply liquid sludge to the sand bed, a closed conduit or a pressure pipeline with valved outlets at each sand bed section is often employed. Another method of application is by means of an open channel with appropriately placed side openings which are controlled by slide gates. With either type of delivery system, a concrete splash slab should be provided to receive the falling sludge and prevent erosion of the sand surface.

Where it is necessary to dewater sludge continuously throughout the year regardless of the weather, sludge beds may be covered with a fiberglass reinforced plastic or other roof. Covered drying beds permit a greater volume of sludge drying per year in most climates because of the protection afforded from rain or snow and because of more efficient control of temperature. Depending on the climate, a combination of open and enclosed beds will provide maximum utilization of the sludge bed drying facilities.

Application and Performance. Sludge drying beds are a means of dewatering sludge from clarifiers and thickeners. They are widely used both in municipal and industrial treatment facilities.

Dewatering of sludge on sand beds occurs by two mechanisms: filtration of water through the bed and evaporation of water as a result of radiation and convection. Filtration is generally complete in one to two days and may result in solids

concentrations as high as 15 to 20 percent. The rate of filtration depends on the drainability of the sludge.

The rate of air drying of sludge is related to temperature, relative humidity, and air velocity. Evaporation will proceed at a constant rate to a critical moisture content, then at a falling rate to an equilibrium moisture content. The average evaporation rate for a sludge is about 75 percent of that from a free water surface.

Advantages and Limitations. The main advantage of sludge drying beds over other types of sludge dewatering is the relatively low cost of construction, operation, and maintenance.

Its disadvantages are the large area of land required and long drying times that depend, to a great extent, on climate and weather.

Operational Factors. Reliability: Reliability is high with favorable climactic conditions, proper bed design and care to avoid excessive or unequal sludge application. If climatic conditions in a given area are not favorable for adequate drying, a cover may be necessary.

Maintainability: Maintenance consists basically of periodic removal of the dried sludge. Sand removed from the drying bed with the sludge must be replaced and the sand layer resurfaced.

The resurfacing of sludge beds is the major expense item in sludge bed maintenance, but there are other areas which may require attention. Underdrains occasionally become clogged and have to be cleaned. Valves or sludge gates that control the flow of sludge to the beds must be kept watertight. Provision for drainage of lines in winter should be provided to prevent damage from freezing. The partitions between beds should be tight so that sludge will not flow from one compartment to another. The outer walls or banks around the beds should also be watertight.

Solid Waste Aspects: The full sludge drying bed must either be abandoned or the collected solids must be removed to a landfill. These solids contain whatever metals or other materials were settled in the clarifier. Metals will be present as hydroxides, oxides, sulfides, or other salts. They have the potential for leaching and contaminating ground water, whatever the location of the semidried solids. Thus the abandoned bed or landfill should include provisions for runoff control and leachate monitoring.

Demonstration Status. Sludge beds have been in common use in both municipal and industrial (including foundries) facilities for many years. However, protection of ground water from contamination is not always adequate.

15. Ultrafiltration

Ultrafiltration (UF) is a process which uses semipermeable polymeric membranes to separate emulsified or colloidal materials suspended in a liquid phase by pressurizing the liquid so that it permeates the membrane. The membrane of an ultrafilter forms a molecular screen which retains molecular particles based on their differences in size, shape, and chemical structure. The membrane permits passage of solvents and lower molecular weight molecules. At present, an ultrafilter is capable of removing materials with molecular weights in the range of 1,000 to 100,000 and particles of comparable or larger sizes.

In an ultrafiltration process, the feed solution is pumped through a tubular membrane unit. Water and some low molecular weight materials pass through the membrane under the applied pressure of 10 to 100 psig. Emulsified oil droplets and suspended particles are retained, concentrated, and removed continuously. In contrast to ordinary filtration, retained materials are washed off the membrane filter rather than held by it. Figure VII-22 represents the ultrafiltration process.

Application and Performance. Ultrafiltration has potential application to metals casting industry plants for separation of emulsified oils from casting quench, die casting and die lube waste streams. Over one hundred such units now operate in the United States, treating emulsified oils from a variety of industrial processes. Capacities of currently operating units range from a few hundred gallons a week to 50,000 gallons per day. Concentration of oily emulsions to 60 percent oil or more are possible. Oil concentrates of 40 percent or more are generally suitable for incineration, and the permeate can be treated further and in some cases recycled back to the process. In this way, it is possible to eliminate contractor removal costs for oil from some oily waste streams.

The following test data indicate ultrafiltration performance (note that UF is not intended to remove dissolved solids):

TABLE VII-23

TREATABILITY RATING OF PRIORITY POLLUTANTS UTILIZING CARBON ADSORPTION

Priority Pollutant		*Removal Rating	Priority Pollutant		*Removal Rating
001	Acenaphthene	H	049	Trichlorofluoromethane	M
002	Aroclein	L	050	Dichlorodifluoromethane	L
003	Acrylonitrile	L	051	Chlorodibromomethane	M
004	Benzene	M	052	Hexachlorobutadiene	H
005	Benzidine	H	053	Hexachlorocyclopentadiene	H
006	Carbon tetrachloride	M	054	Isophorone	H
007	Chlorobenzene	H	055	Naphthalene	H
009	Hexachlorobenzene	H	057	2-nitrophenol	H
010	1,2-dichloroethane	M	058	4-nitrophenol	H
011	1,1,1-trichloroethane	M	059	2,4-dinitrophenol	H
012	Hexachloroethane	H	060	4,6-dinitro-o-cresol	H
013	1,1-dichloroethane	M	061	N-nitrosodimethylamine	M
014	1,1,2-trichloroethane	M	062	N-nitrosodiphenylamine	H
015	1,1,2,2-tetrachloroethane	H	063	N-nitrodosi-n-propylamine	M
016	Chloroethane	L	064	Pentachlorophenol	H
017	Bis(chloromethyl)ether	-	065	Phenol	M
018	Bis(2-chloroethyl)ether	M	066	Bis(2-ethylhexyl)phthalate	H
019	2-chloroethyl vinyl ether	L	067	Butyl benzyl phthalate	H
020	2-chloronaphthalene	H	068	Di-n-butyl phthalate	H
021	2,4,6-trichlorophenol	H	069	Di-n-octyl phthalate	H
022	Parachlormeta cresol	H	070	Diethyl phthalate	H
023	Chloroform	L	071	Dimethyl phthalate	H
024	2-chlorophenol	H	072	(a) Antharacene	H
025	1,2-dichlorobenzene	H	073	Benzo(a)pyrene	H
026	1,3-dichlorobenzene	H	074	3,4-benzofluoranthene	H
027	1,4-dichlorobenzene	H	075	Benzo(k)fluoranthene	H
028	3,3'-dichlorobenzidine	H	076	Chrysene	H
029	1,1-dichlroehtylene	L	077	Acenaphthylene	H
030	1,2-trans-dichloroehtylene	L	078	Anthracene	H
031	2,4-dichlorophenol	H	079	Benzo(ghi)-perylene	H
032	1,2-dichloropropane	M	080	Fluorene	H
033	1,2-dichloropropylene	M	081	Phenanthrene	H
034	2,4-dimethylphenol	H	082	Dibenzo(a,h)anthracene	H
035	2,4-dinitrotoluene	H	083	Ideno(1,2,3-cd)pyrene	H
036	2,6-dinitrotoluene	H	084	Pyrene	-
037	1,2-diphenylhydrazine	H	085	Tetrachloroethylene	M
038	Ethylbenzene	M	086	Toluene	M
039	Fluoranthene	H	087	Trichloroethylene	L
040	4-chlorophenyl phenyl ether	H	088	Vinyl chloride	L
041	4-bromophenyl phenyl ether	H	106	PCB-1242	H
042	Bis(2-chloroisopropyl)ether	M	107	PCB-1254	H
043	Bis(2-chloroethoxy)methane	M	108	PCB-1221	H
044	Methylene chloride	L	109	PCB-1232	H
045	Methyl chloride	L	110	PCB-1248	H
046	Methyl bromide	L	111	PCB-1260	H
047	Bromoform	H	112	PCB-1016	H
048	Dichlorobromomethane	M			

*Explanation of Removal Ratings:

Category H (high removal)

Adsorbs at levels $\geq$100 mg/g carbon at C_f = .10 mg/l
Adsorbs at levels $\geq$100 mg/g carbon at C_f <1.0 mg/l

Category M (moderate removal)

Adsorbs at levels >100 mg/g carbon at C_f = 10 mg/l
Adsorbs at levels $\leq$100 mg/g carbon at C_f >1.0 mg/l

Category L (low removal)

Adsorbs at levels >100 mg/g carbon at C_f = 10 mg/l
Adsorbs at levels >10 mg/g carbon at C_f<1.0 mg/l

C_f = final concentrations of priority pollutant at equilibrium

TABLE VII-24

CLASSES OF ORGANIC COMPOUNDS ADSORBED ON CARBON

Organic Chemical Class	Examples of Chemical Class
Aromatic Hydrocarbons	benzene, toluene, xylene
Polynuclear Aromatics	naphthalene, anthracene biphenyls
Chlorinated Aromatics	chlorobenzene, polychlorinated biphenyls, aldrin, endrin, toxaphene, DDT
Phenolics	phenol, cresol, resourcinol and polyphenyls
Chlorinated Phenolics	trichlorophenol, pentachlorophenol
High Molecular Weight Aliphatic and	gasoline, kerosene Branch Chain Hydrocarbons
Chlorinated Aliphatic Hydrocarbons	carbon tetrachloride, perchloroethylene
High Molecular Weight Aliphatic Acids	tar acids, benzoic acid and Aromatic Acids
High Molecular Weight Aliphatic Amines	aniline, diamines and Aromatic Amines
High Molecular Weight Ketones, Esters,	hydroquinone, polyethylene Ethers and Alcoholsglycol
Surfactants	alkyl benzene sulfonates
Soluble Organic Dyes	methylene blue, indigo carmine

High Molecular Weight includes compounds in the range of from 4 to 20 carbon atoms.

Table VII-25

ULTRAFILTRATION PERFORMANCE

Parameter	Feed (mg/l)	Permeate (mg/l)
Oil (freon extractable)	1230	4
COD	8920	148
TSS	1380	13
Total Solids	2900	296

The removal percentages shown are typical, but they can be influenced by pH and other conditions. The high TSS level is unusual for this technology and ultrafiltration is assumed to reduce the TSS level by one-thrid after mixed media filtration.

The permeate or effluent from the ultrafiltration unit is normally of a quality that can be reused in industrial applications or discharged directly. The concentrate from the ultrafiltration unit can be disposed of as any oily or solid waste.

Advantages and Limitations. Ultrafiltration is sometimes an attractive alternative to chemical treatment because of lower capital equipment, installation, and operating costs, very high oil removal, and little required pretreatment. It places a positive barrier between pollutants and effluent which reduces the possibility of extensive pollutant discharge due to operator error or upset in settling and skimming systems. Alkaline values in alkaline cleaning solutions can be recovered and reused in process.

A limitation of ultrafiltration for the treatment of process effluents is its narrow temperature range (18° to 45°C) for satisfactory operation. Membrane life decreases with higher temperatures, but flux increases at elevated temperatures. Therefore, surface area requirements are a function of temperature and become a tradeoff between initial costs and replacement costs for the membrane. In addition, ultrafiltration cannot handle certain solutions. Strong oxidizing agents, solvents, and other organic compounds can dissolve the membrane. Fouling is sometimes a problem, although the high velocity of the wastewater normally creates enough turbulence to keep fouling at a minimum. Large solids particles can sometimes puncture the membrane and must be removed by gravity settling or filtration prior to the ultrafiltration unit.

Operational Factors. Reliability: The reliability of an ultrafiltration system is dependent on the proper filtration, settling or other treatment of incoming waste streams to prevent damage to the membrane. Careful pilot studies should be done in each instance to determine necessary pretreatment steps and the exact membrane type to be used.

Maintainability: A limited amount of regular maintenance is required for the pumping system. In addition, membranes must be periodically changed. Maintenance associated with membrane plugging can be reduced by selection of a membrane with optimum physical characteristics and sufficient velocity of the waste stream. It is often necessary to occasionally pass a detergent solution through the system to remove an oil and grease film which accumulates on the membrane. With proper maintenance membrane life can be greater than twelve months.

Solid Waste Aspects: In this category ultrafiltration is used primarily to remove or recover liquid constituents of process wastewaters. The system reject (concentrated oils) could be recovered, reprocessed, or removed for disposal.

Demonstration Status. The ultrafiltration process is well developed and commercially available for treatment of wastewater or recovery of certain high molecular weight liquid and solid contaminants. This technology is demonstrated in the aluminum die lube process segment.

16. Vacuum Filtration

In wastewater treatment plants, sludge dewatering by vacuum filtration generally uses cylindrical drum filters. These drums have a filter medium which may be cloth made of natural or synthetic fibers or a wire-mesh fabric. The drum is suspended above and dips into a vat of sludge. As the drum rotates slowly, part of its circumference is subject to an internal vacuum that draws sludge to the filter medium. Water is drawn through the porous filter cake to a discharge port, and the dewatered sludge, loosened by compressed air, is scraped from the filter mesh. Because the dewatering of sludge on vacuum filters is relativley expensive per kilogram of water removed, the liquid sludge is frequently thickened prior to processing. A vacuum filter is shown in Figure VII-23.

Application and Performance. Vacuum filters are frequently used both in municipal treatment plants and in a wide variety of industries. They are most commonly used in larger facilities, which may have a thickener to double the solids content of clarifier sludge before vacuum filtering.

The function of vacuum filtration is to reduce the water content of sludge, so that the solids content increases from about 5 percent to about 30 percent.

Advantages and Limitations. Although the initial cost and area requirement of the vacuum filtration system are higher than those of a centrifuge, the operating cost is lower, and no special provisions for sound and vibration protection need be made. The dewatered sludge from this process is in the form of a moist cake and can be conveniently handled.

Operational Factors. Reliability: Vacuum filter systems have proven reliable at many industrial and municipal treatment facilities. At present, the largest municipal installation is at the West Southwest waste water treatment plant of Chicago, Illinois, where 96 large filters were installed in 1925, functioned approximately 25 years, and then were replaced with larger units. Original vacuum filters at Minneapolis-St. Paul, Minnesota now have over 28 years of continuous service, and Chicago has some units with similar or greater service life.

Maintainability: Maintenance consists of the cleaning or replacement of the filter media, drainage grids, drainage piping, filter pans, and other parts of the equipment. Experience in a number of vacuum filter plants indicates that maintenance consumes approximately 5 to 15 percent of the total time. If carbonate buildup or other problems are unusually severe, maintenance time may be as high as 20 percent. For this reason, it is desirable to maintain one or more spare units.

If intermittent operation is used, the filter equipment should be drained and washed each time it is taken out of service. An allowance for this wash time must be made in filtering schedules.

Solid Waste Aspects: Vacuum filters generate a solid cake which is usually trucked directly to landfill. All of the metals extracted from the plant wastewater are concentrated in the filter cake as hydroxides, oxides, sulfides, or other salts.

Demonstration Status. Vacuum filtration has been widely used for many years. It is a fully proven, conventional technology for sludge dewatering.

IN-PLANT TECHNOLOGY

The intent of in-plant technology (i.e., recycle or reuse) for the metal molding and casting industry point source category is to reduce or eliminate the waste load requiring end-of-pipe treatment or to reduce or eliminate the discharge of process or

treated wastewaters. By incorporating recycle prior to treatment, the efficiency of an existing wastewater treatment system is improved or the requirements of a new treatment system are reduced.

The recycle or reuse of process wastewater is a particularly effective technique for the reduction of both pollutant discharges and treatment costs. The term "recycle" is used to designate the return of process wastewater to the process or processes from which it originated, while "reuse" refers to the use of wastewater from one process in another. Both recycle and reuse of process wastewater are presently practiced at battery manufacturing plants although recycle is more extensively used. The most frequently recycled waste streams are the air pollution control scrubber discharges, and wastewater from equipment and area cleaning.

Both recycle and reuse are frequently ppossible with only simple treatment (i.e., primary sedimentation. Recycle or reuse in these instances yields cost savings by reducing the volume of wastewater requiring treatment. Where treatment is required for recycle or reuse, it is frequently simpler than the treatment necessary to achieve effluent quality suitable for release to the environment. Treatment prior to recycle or reuse observed in present practice is generally restricted to simple settling or neutralization. Since these treatment practices can be less costly than those used prior to discharge, economic as well as environmental benefits are usually realized. In addition to these in-process recycle and reuse practices, some plants are observed to return part or all of the treated effluent from an end-of-pipe treatment system for further process use.

The extent of recycle possible in most process water uses is ultimately limited by the increasing concentrations of dissolved solids in the water. The buildup of dissolved salts generally necessitates some small discharge or "blowdown" from the process to treatment. In some cases, the rate of addition of dissolved salts may be sufficiently low to be balanced by removal of dissolved solids in water entrained in settled solids. In these cases, complete recycle with no wastewater discharge can be achieved. In other cases, a accumulated scale may be abraded by the particulate matter suspended in the recycled wastewaters.

Water Use Reduction - The volume of wastewater discharged from a plant or specific process operation may be reduced by simply eliminating excess flow and unnecessary water use. Often this may be accomplished with little or no change in the manufacturing process or equipment and without any capital expenditure. A comparison of the volumes of process water used in and discharged

from equivalent process operations at different foundries or on different days at the same foundry indicates numerous opportunities for water use reductions. Additional reductions in process water use and discharge may be achieved by modifications to process techniques and equipment.

Many production units in foundry operations were observed to operate intermittently or at highly variable production rates. The practice of shutting off process water flow during periods when the unit is not operating and of adjusting flow rates during periods of low production can prevent much unnecessary water use. Water may be shut off and controlled manually or through automatically controlled valves. Manual adjustment involves the human factor and has been found to be somewhat unreliable in practice; production personnel often fail to turn off manual valves when production units are shut down and tend to increase water flow rates to maximum levels "to ensure good operation" regardless of production activity. Automatic shut off valves may be used to turn off water flows when production units are inactive. Automatic adjustment of flow rates according to production levels requires more sophisticated control systems.

Additional flow reductions may be achieved by the implementation of more effective water use in some process operations. These measures generally require the purchase or modification of some process equipment and involve larger capital investment than the simple flow control measures discussed above.

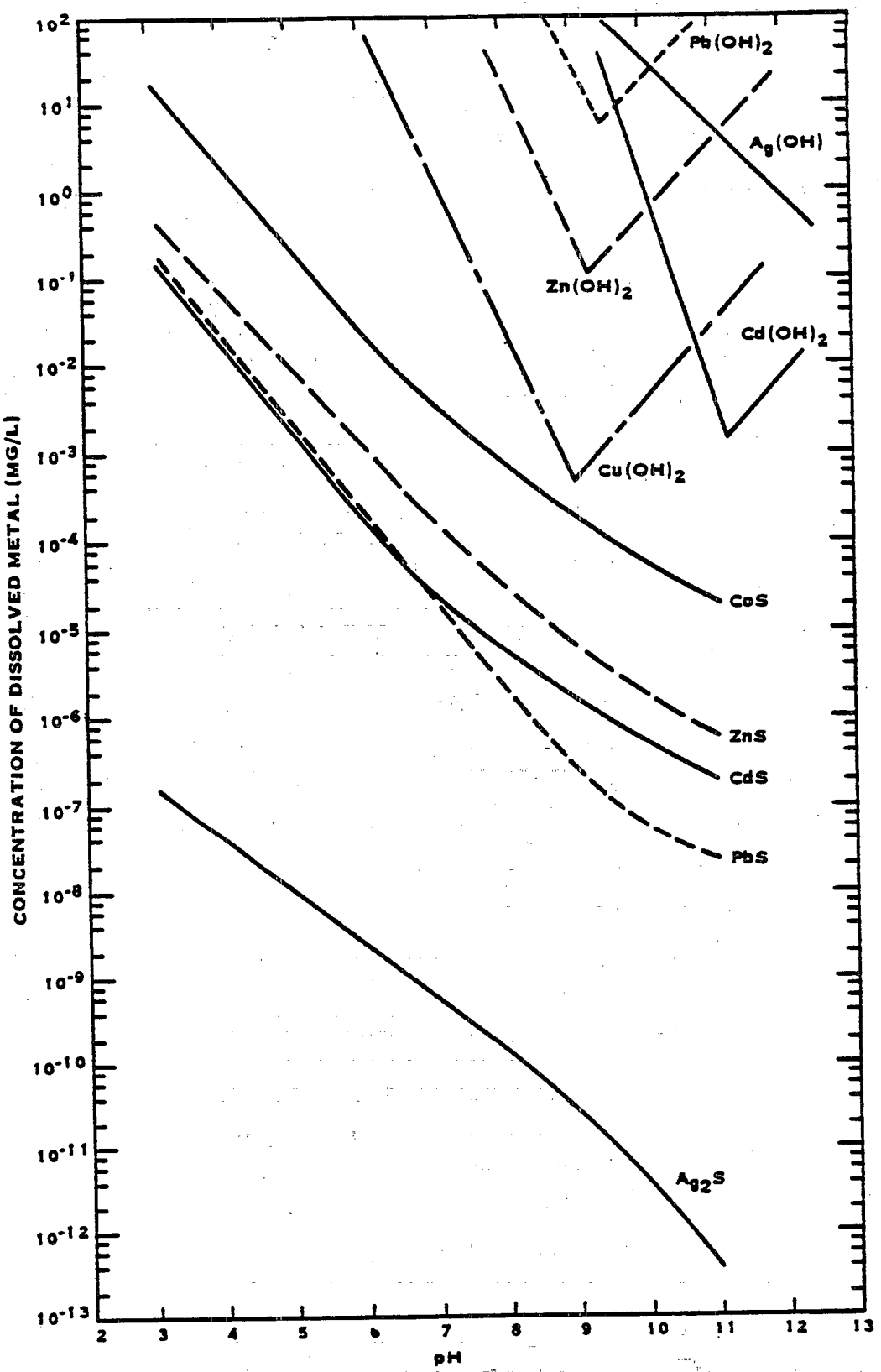


FIGURE VII-1 COMPARATIVE SOLUBILITIES OF METAL HYDROXIDES AND SULFIDE AS A FUNCTION OF pH

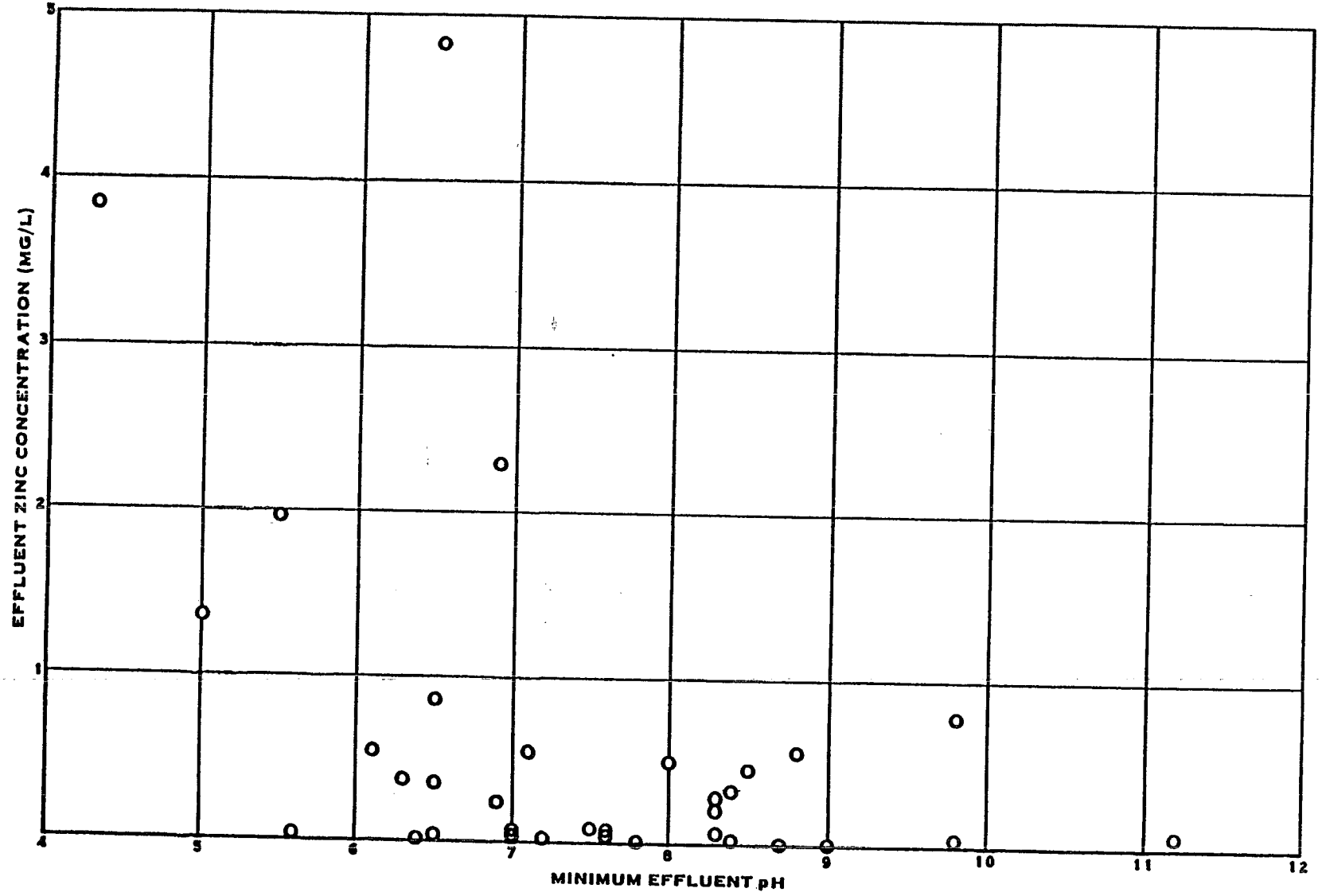


FIGURE VII-2 EFFLUENT ZINC CONCENTRATION VS. MINIMUM EFFLUENT pH

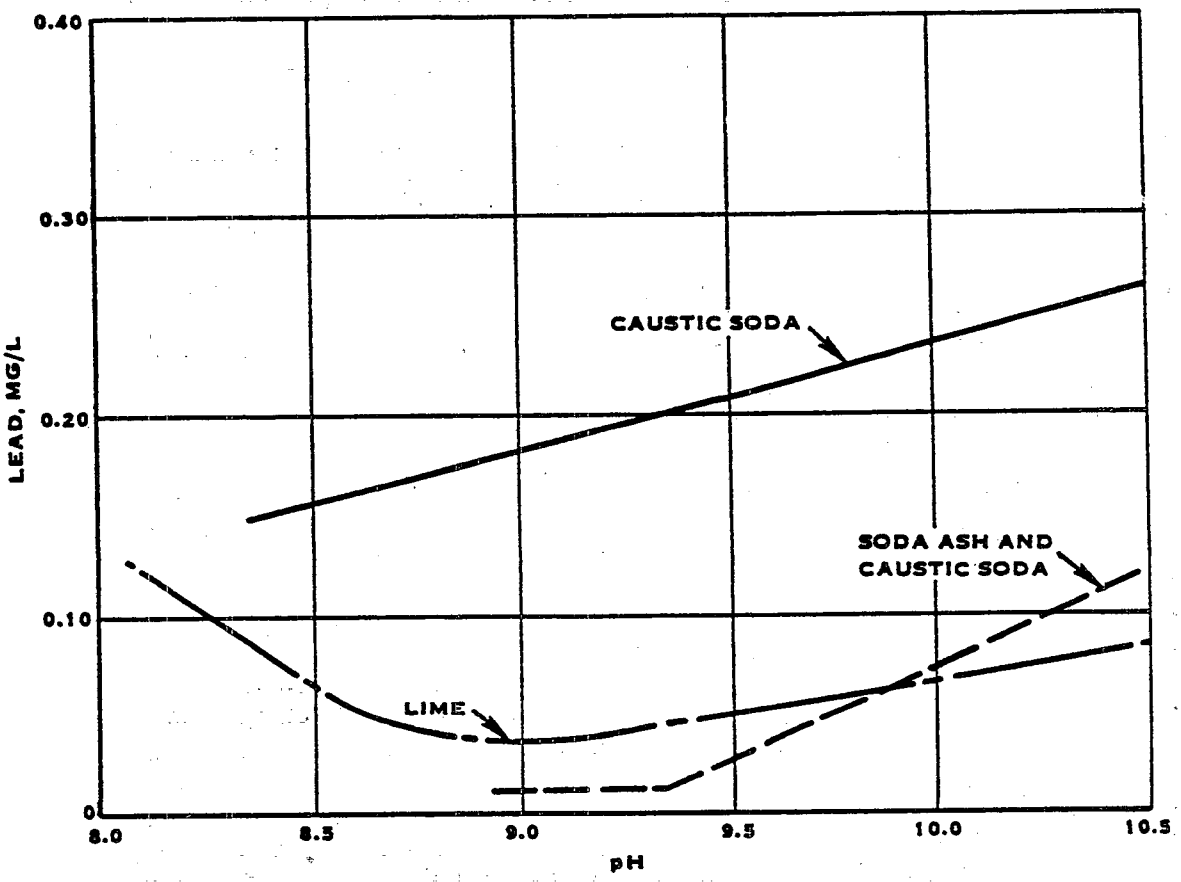


FIGURE VII-3 LEAD SOLUBILITY IN THREE ALKALIES

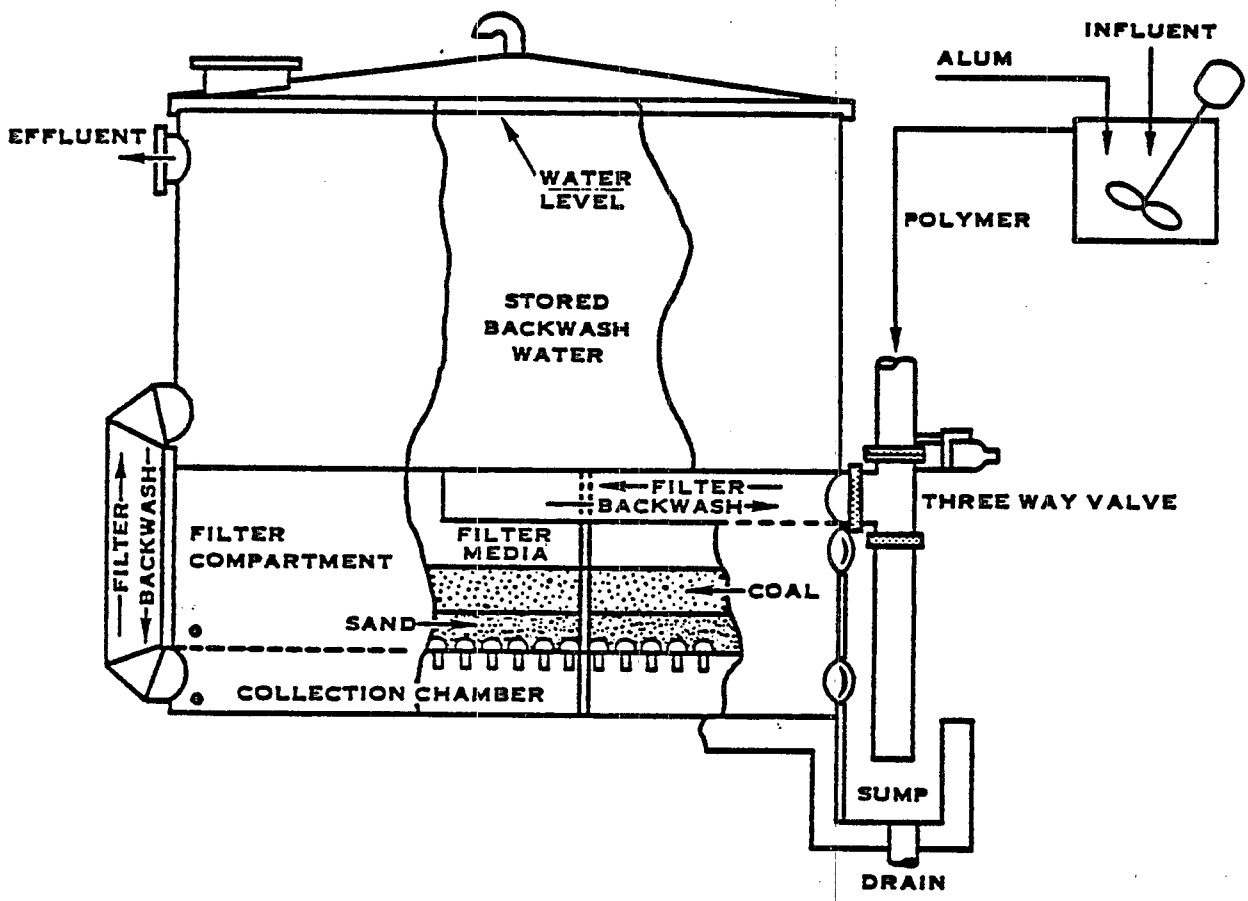


FIGURE VII4 GRANULAR BED FILTRATION

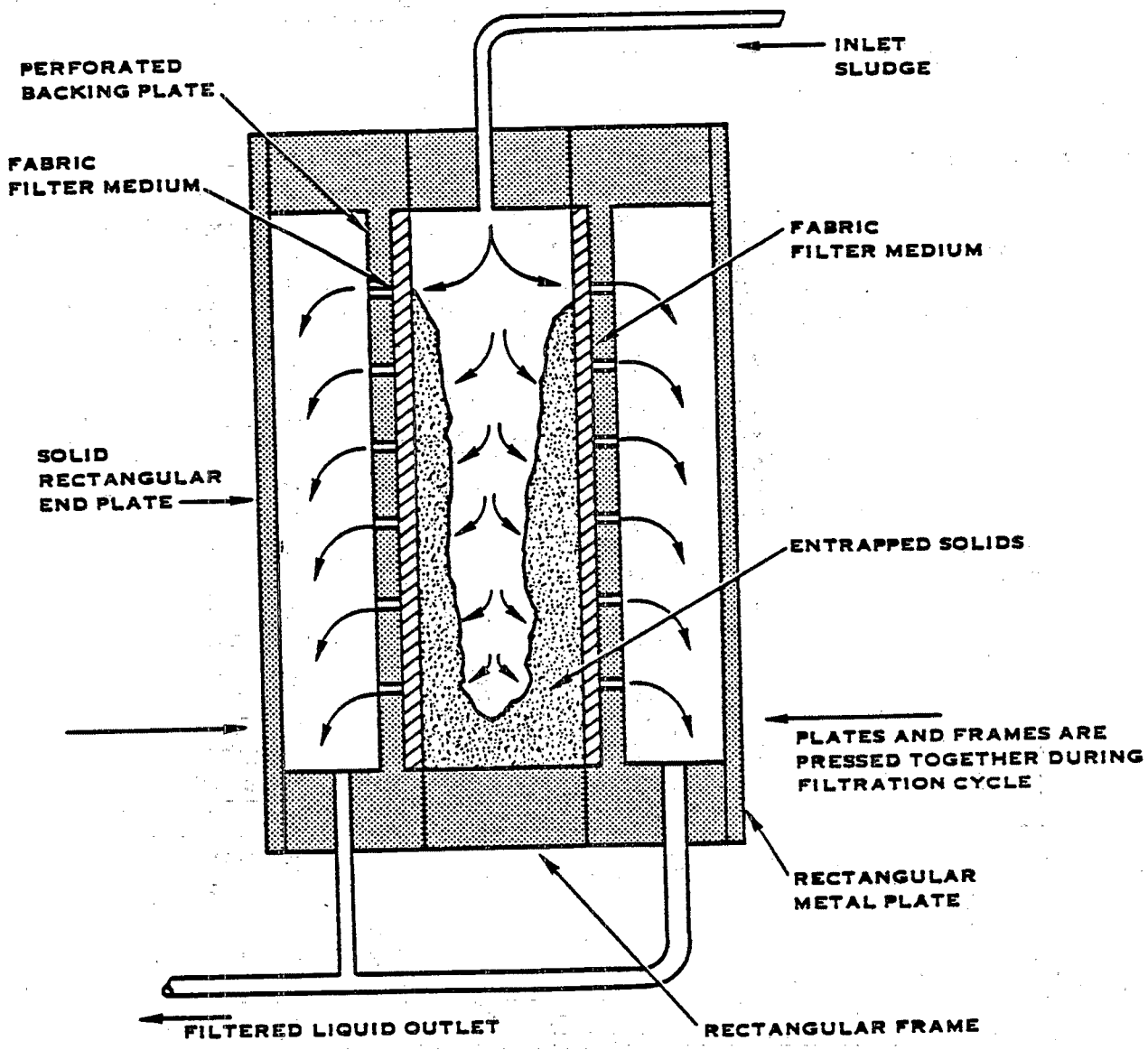


FIGURE VII-5 PRESSURE FILTRATION

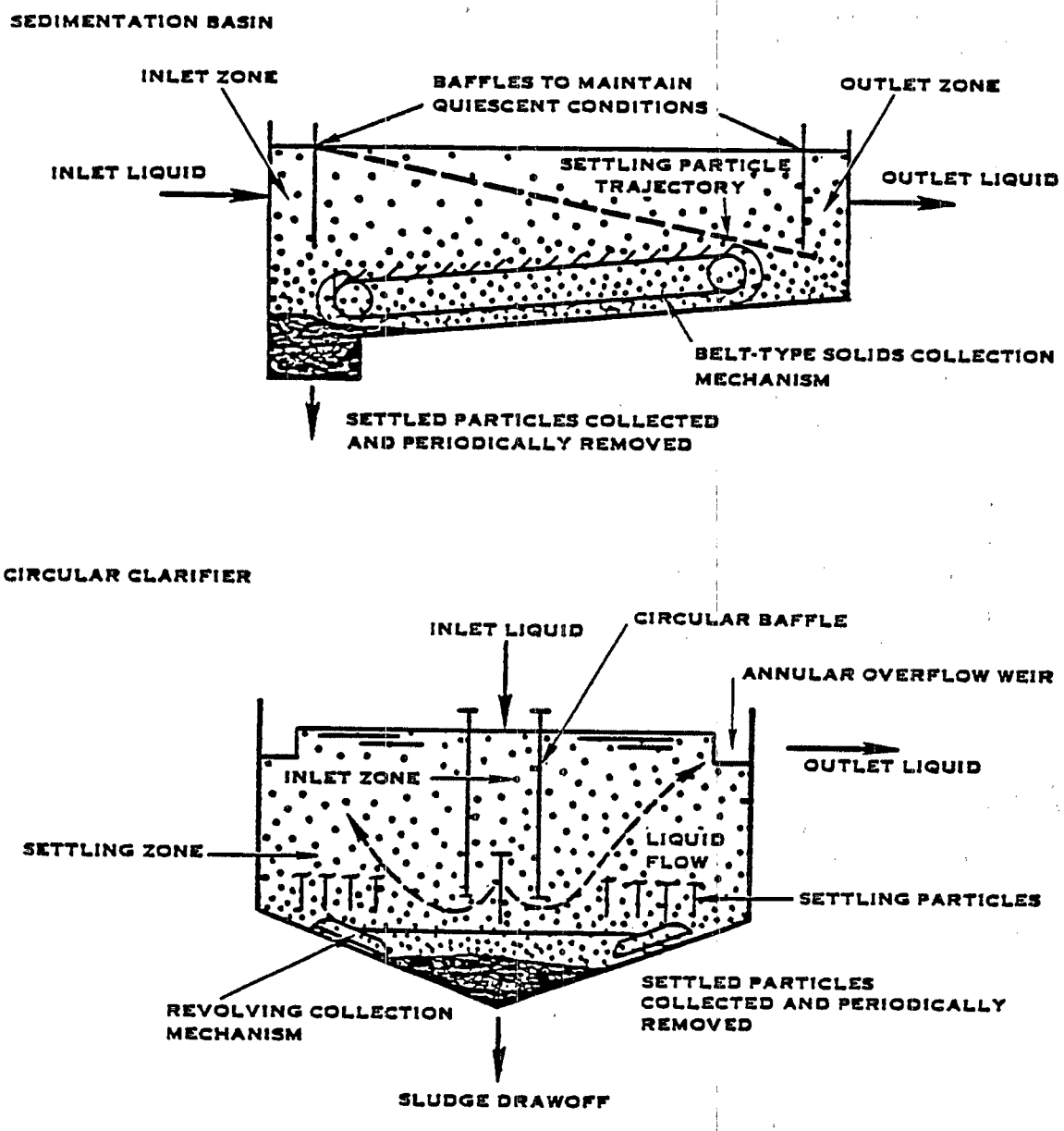
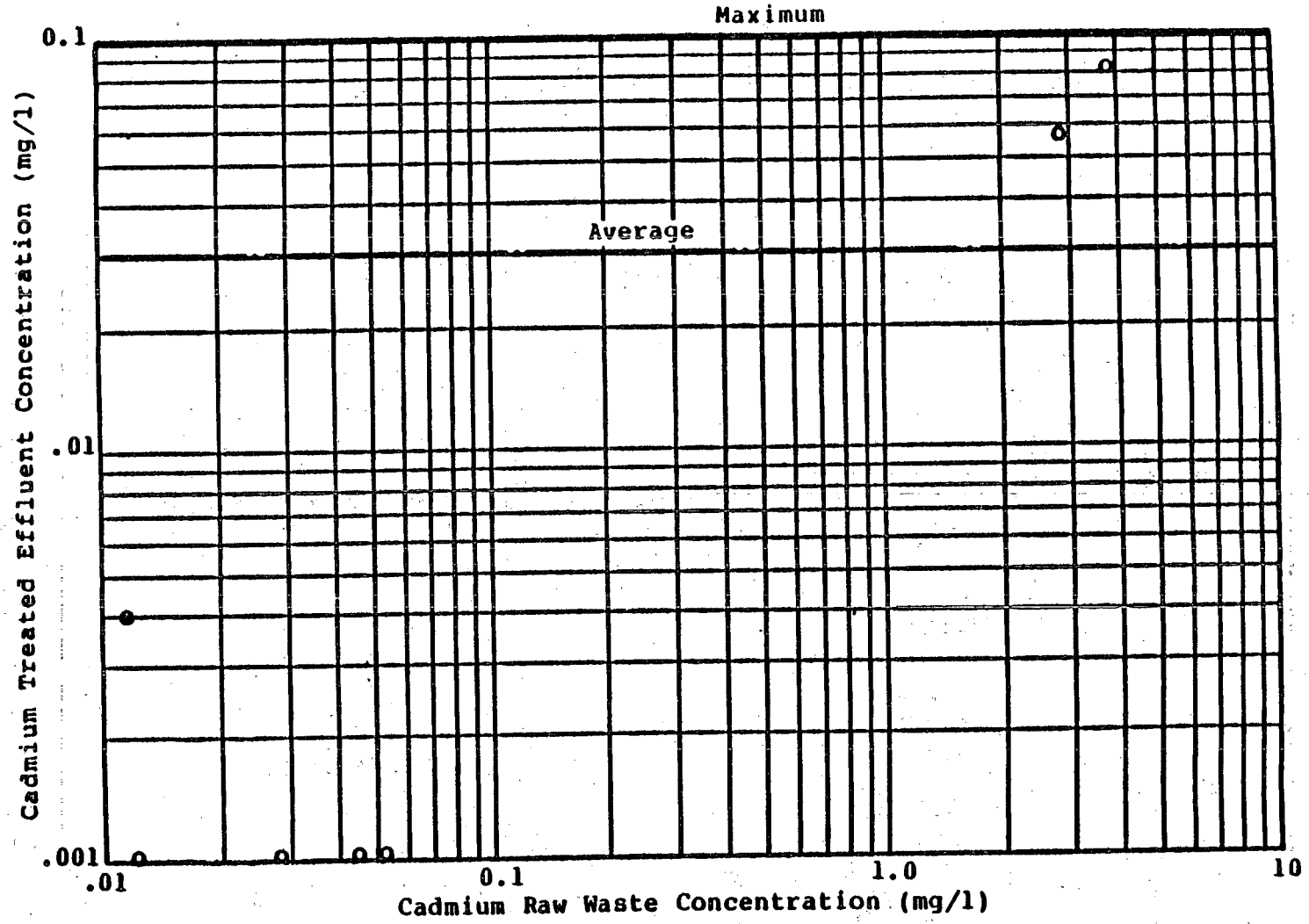


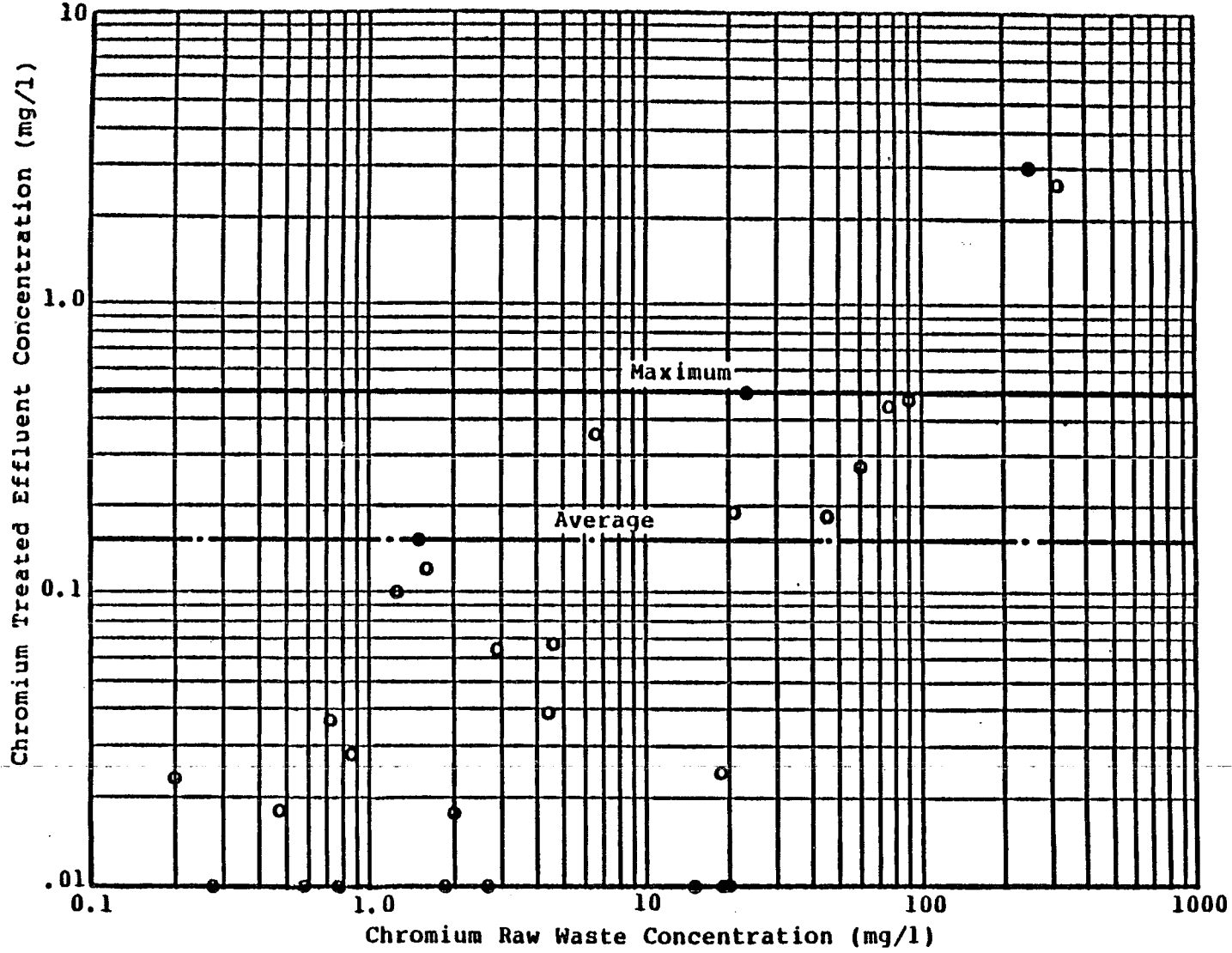
FIGURE VII- 6 REPRESENTATIVE TYPES OF SEDIMENTATION



(Number of observations=7)

FIGURE VII-7

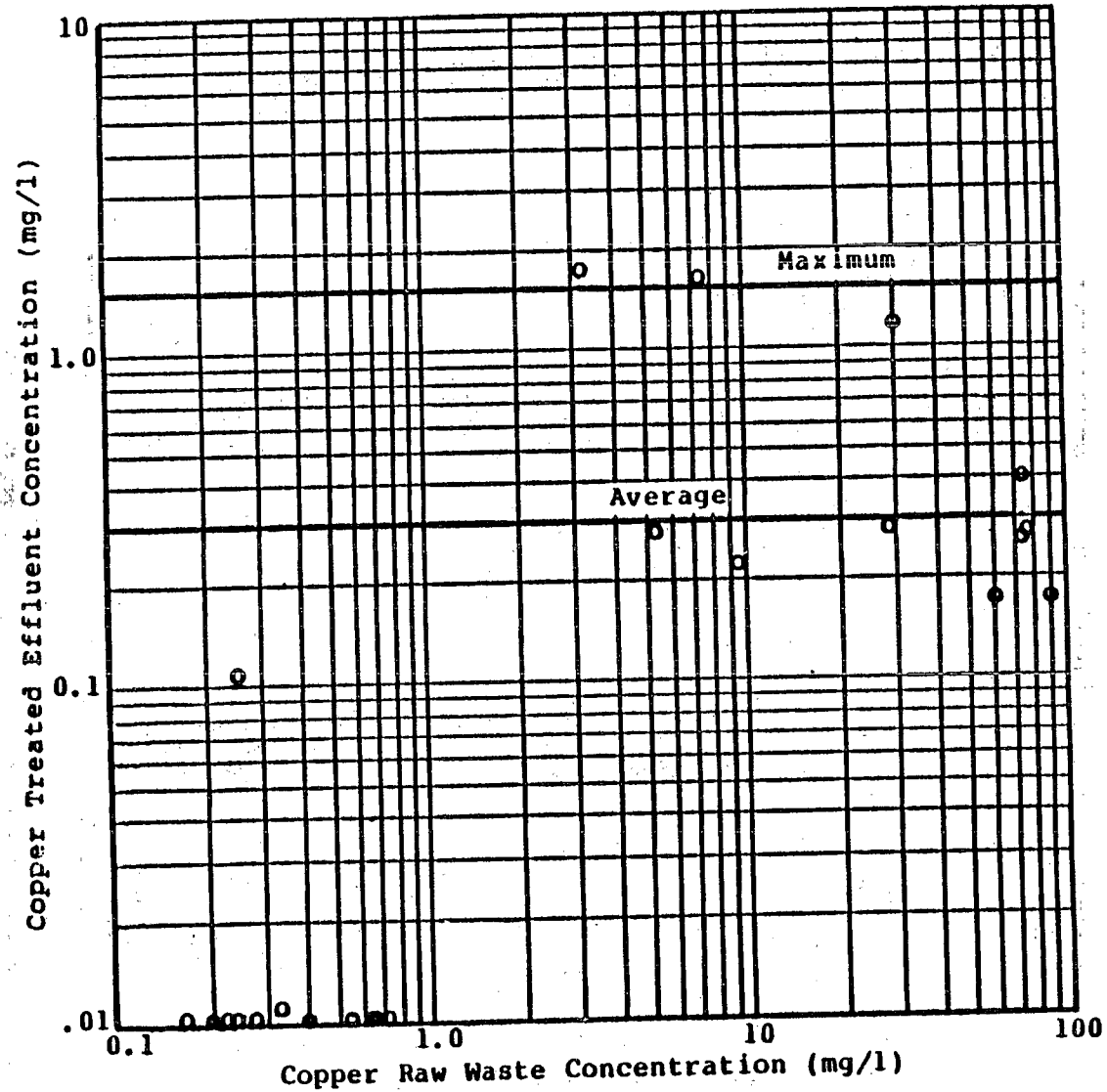
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
CADMIUM



(Number of observations=29)

FIGURE VII- 8

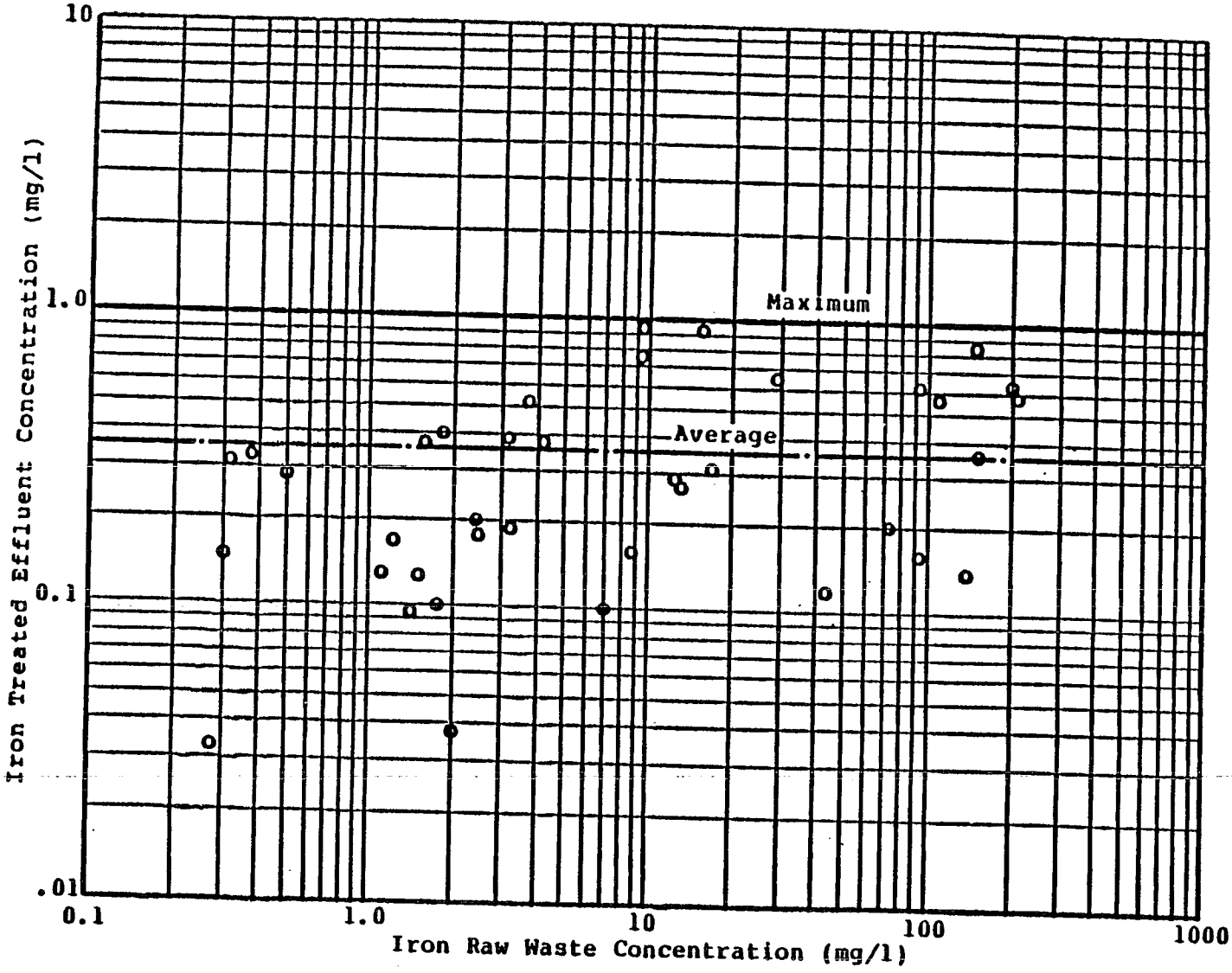
HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
CHROMIUM



(Number of observations=23)

FIGURE VII-9

HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
COPPER



(Number of observations=38)

FIGURE VII-10

HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
IRON

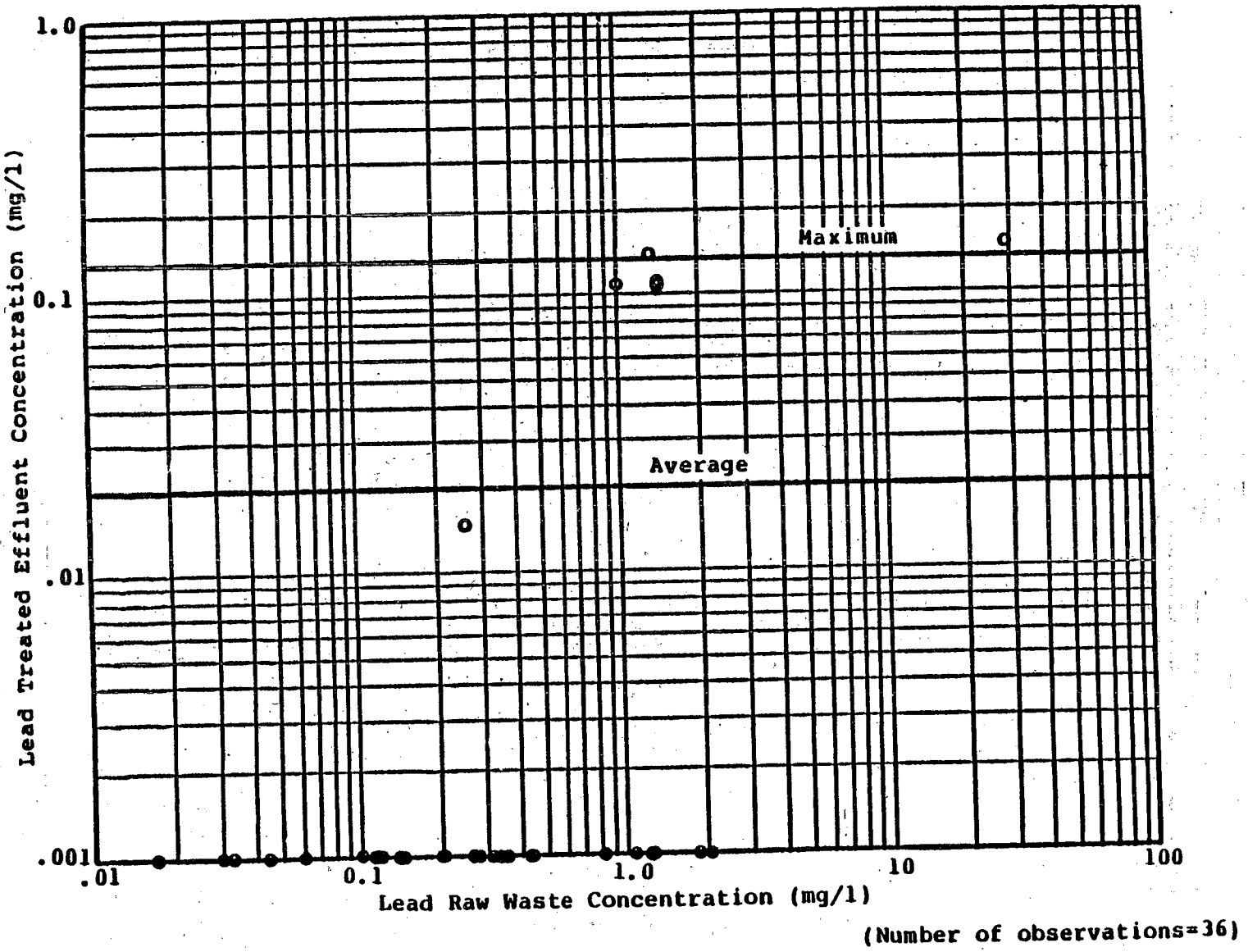
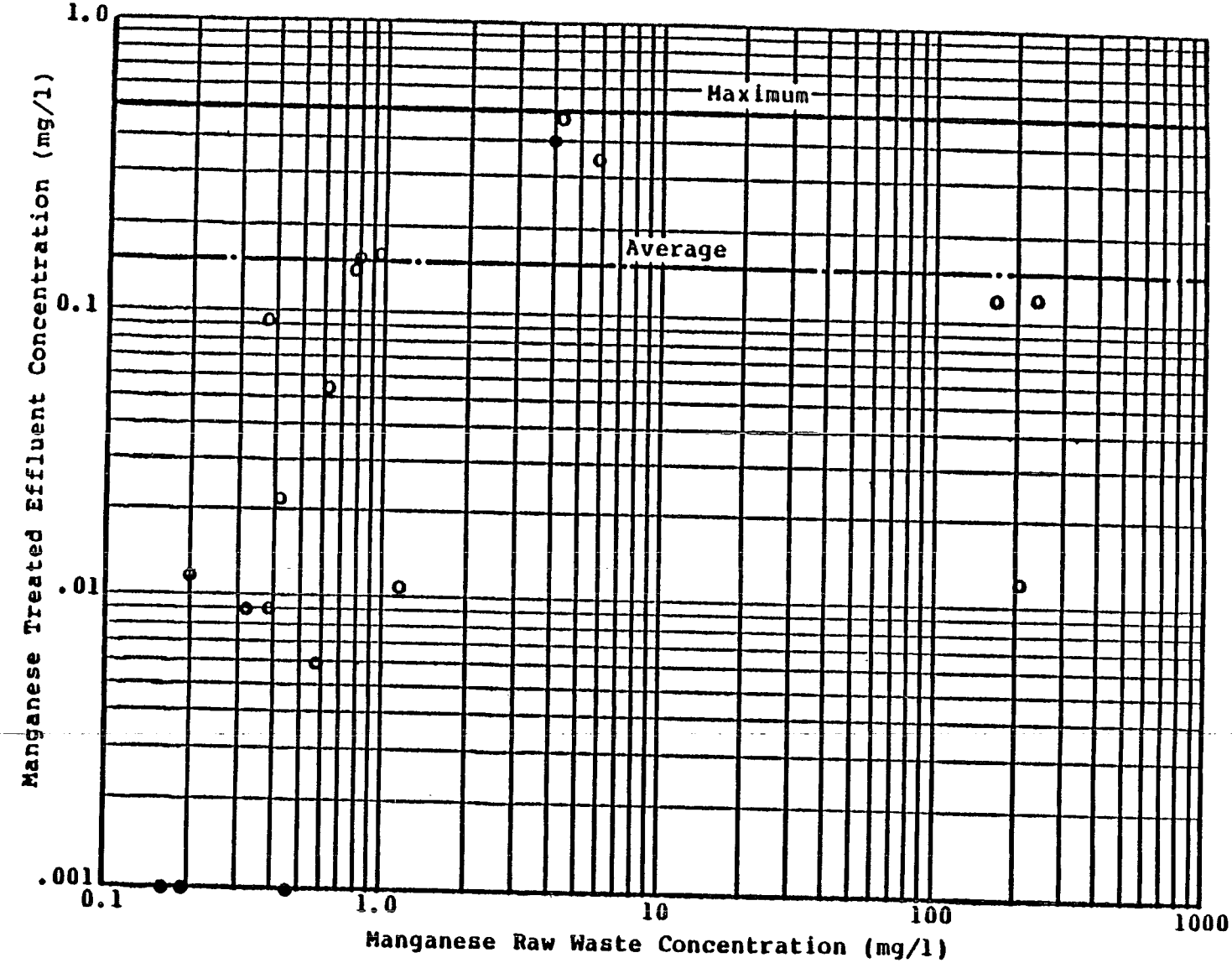


FIGURE VII-11

HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
LEAD



(Number of observations=20)

FIGURE VII-12

HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
MANGANESE

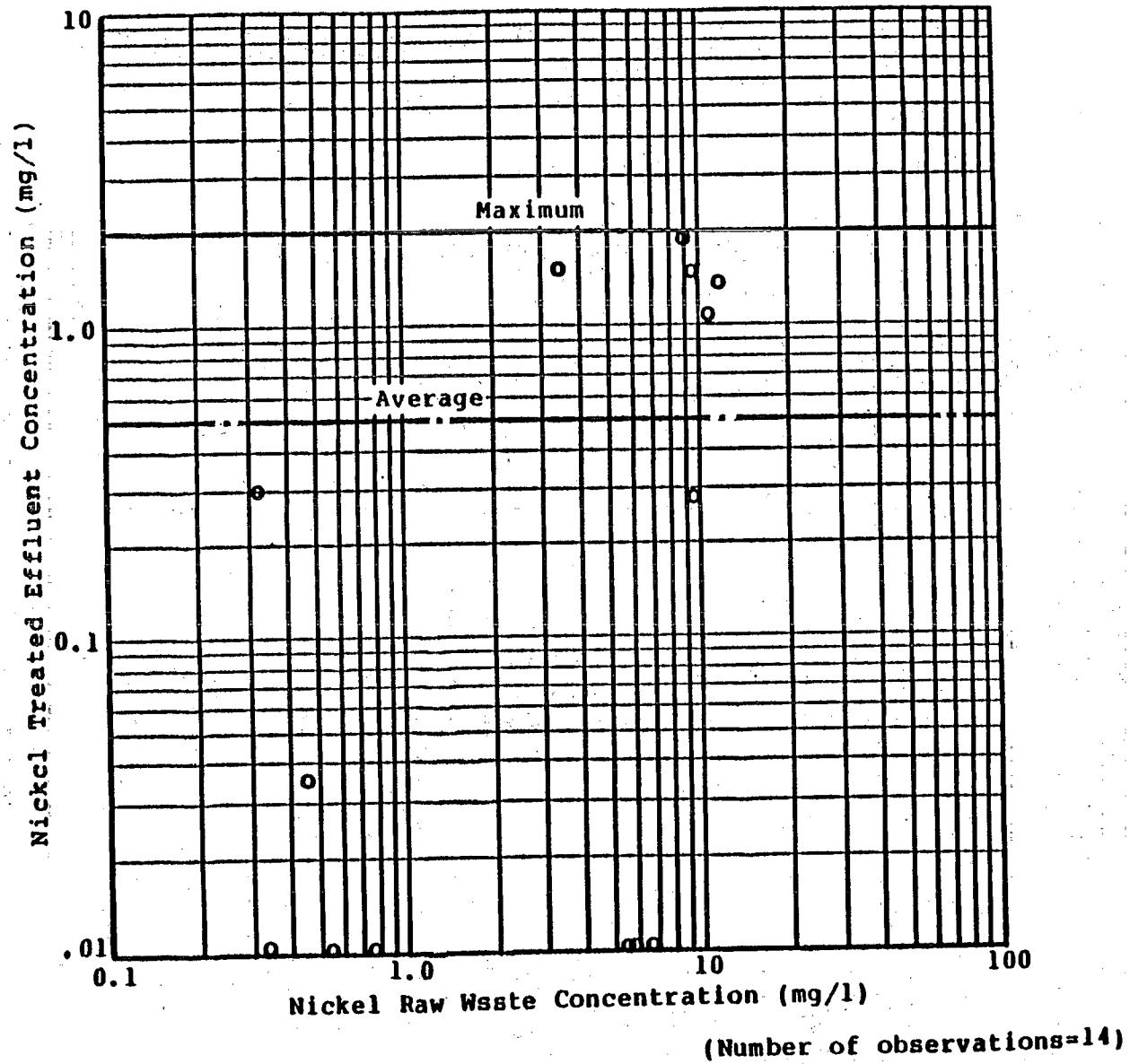
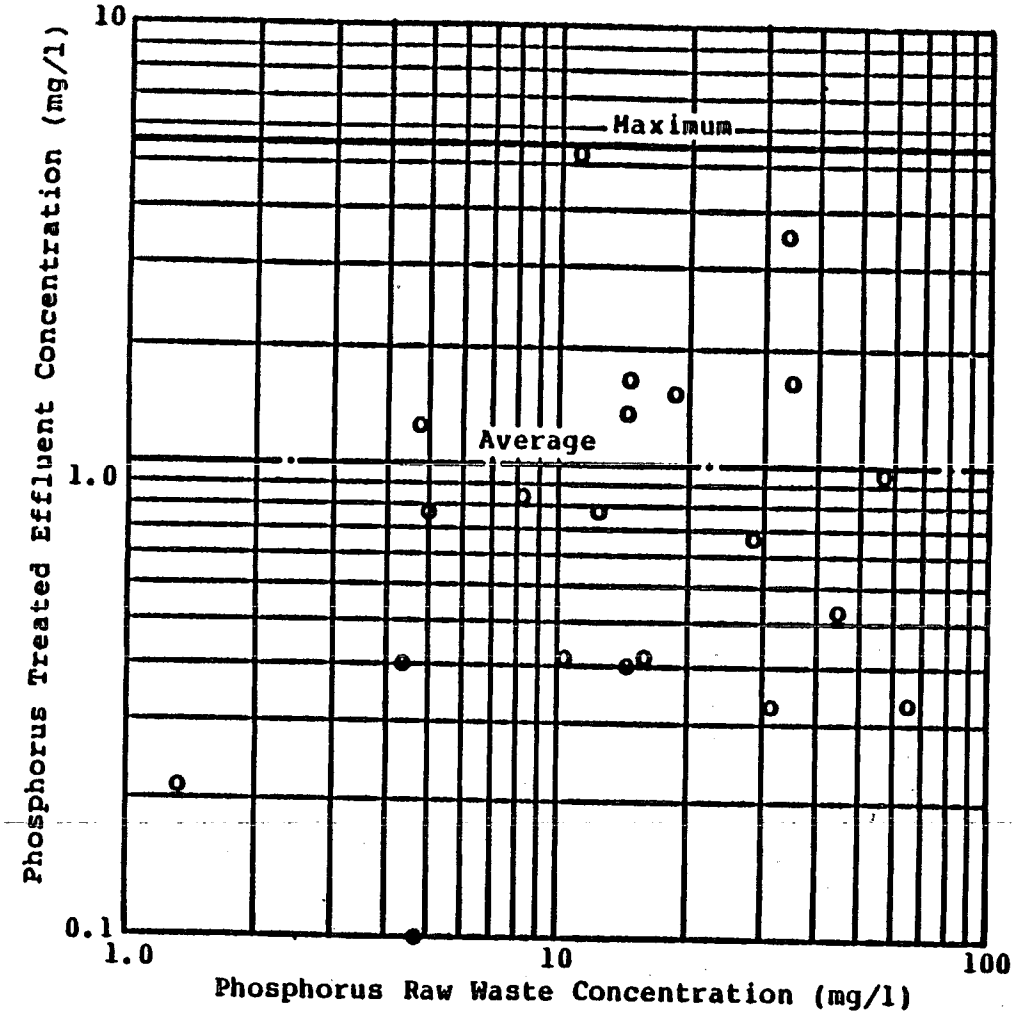


FIGURE VII-13

HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
NICKEL



(Number of observations=21)

FIGURE VII- 14

HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
PHOSPHORUS

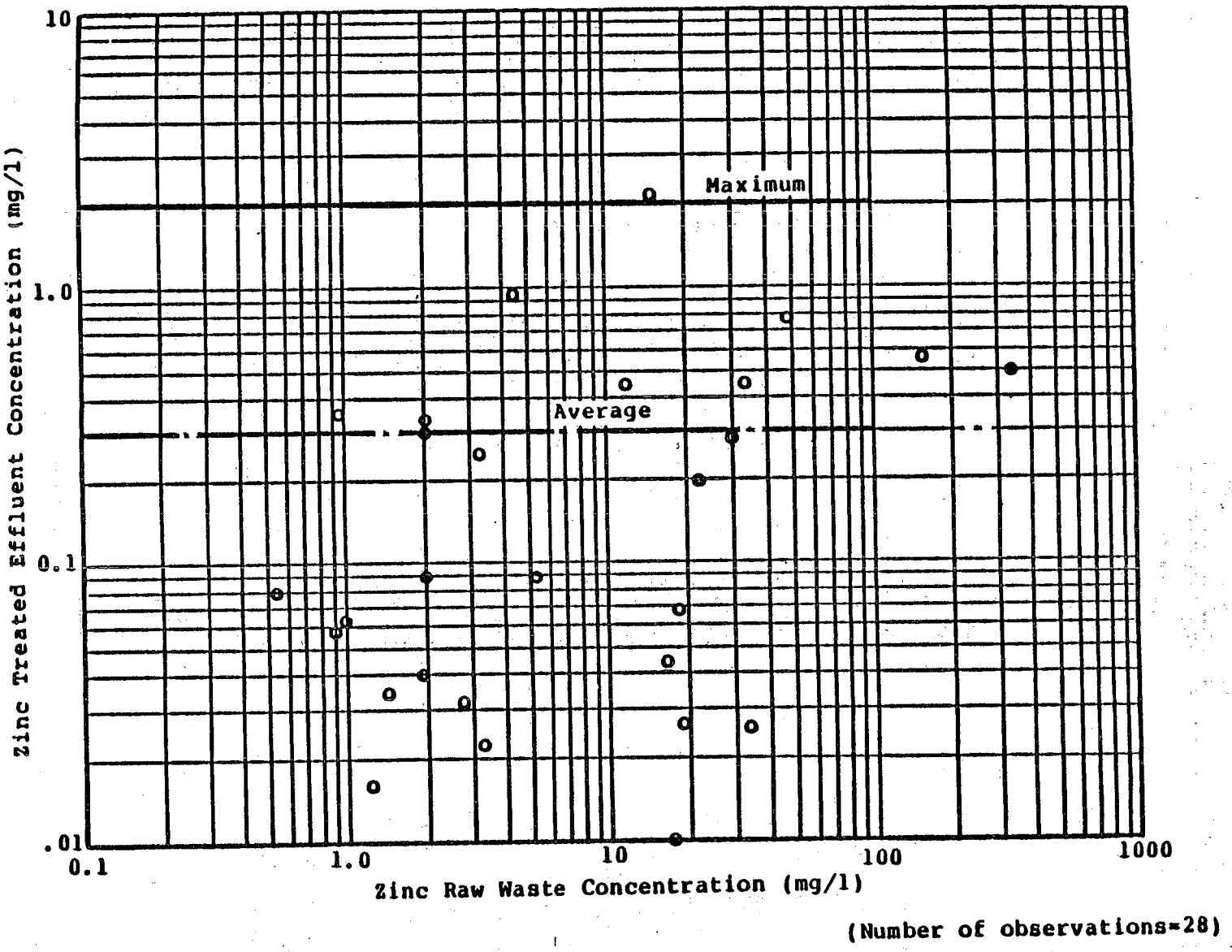


FIGURE VII- 15

HYDROXIDE PRECIPITATION SEDIMENTATION EFFECTIVENESS
ZINC

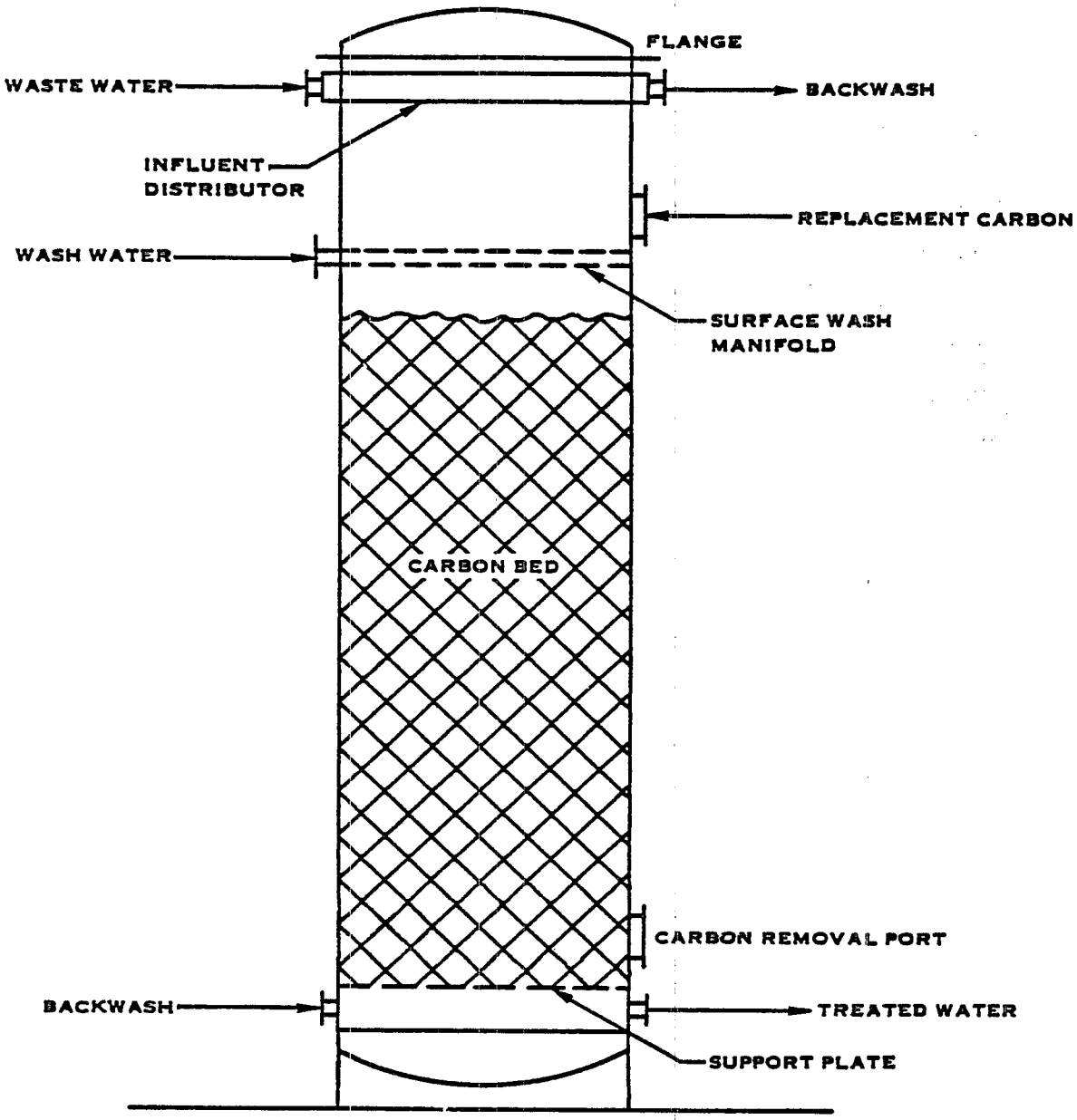


FIGURE VII-16 ACTIVATED CARBON ADSORPTION COLUMN

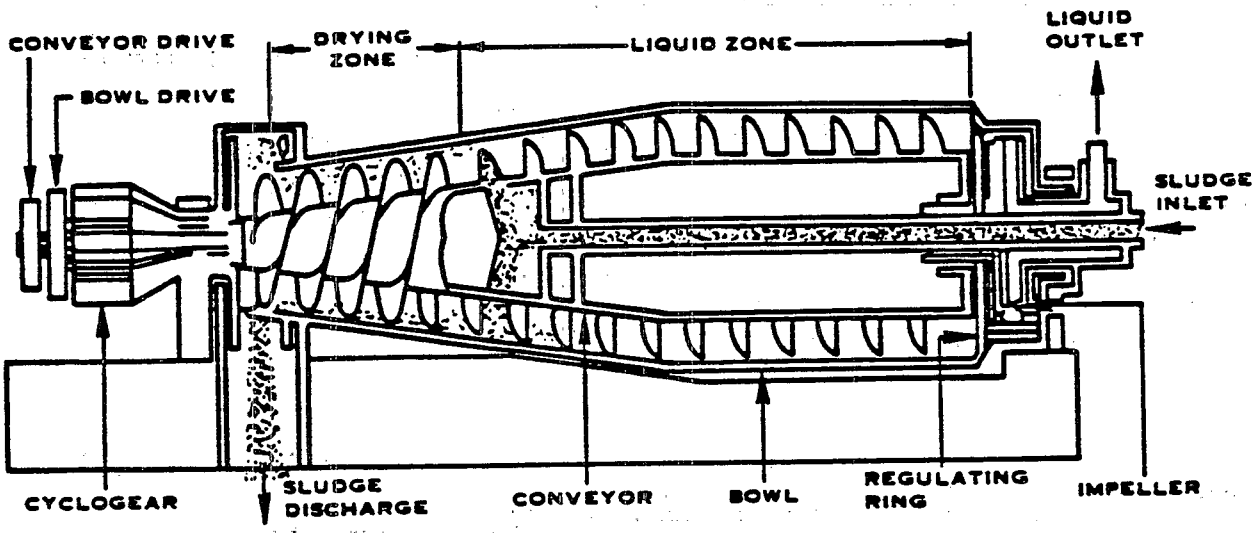


FIGURE VII- 17

CENTRIFUGATION

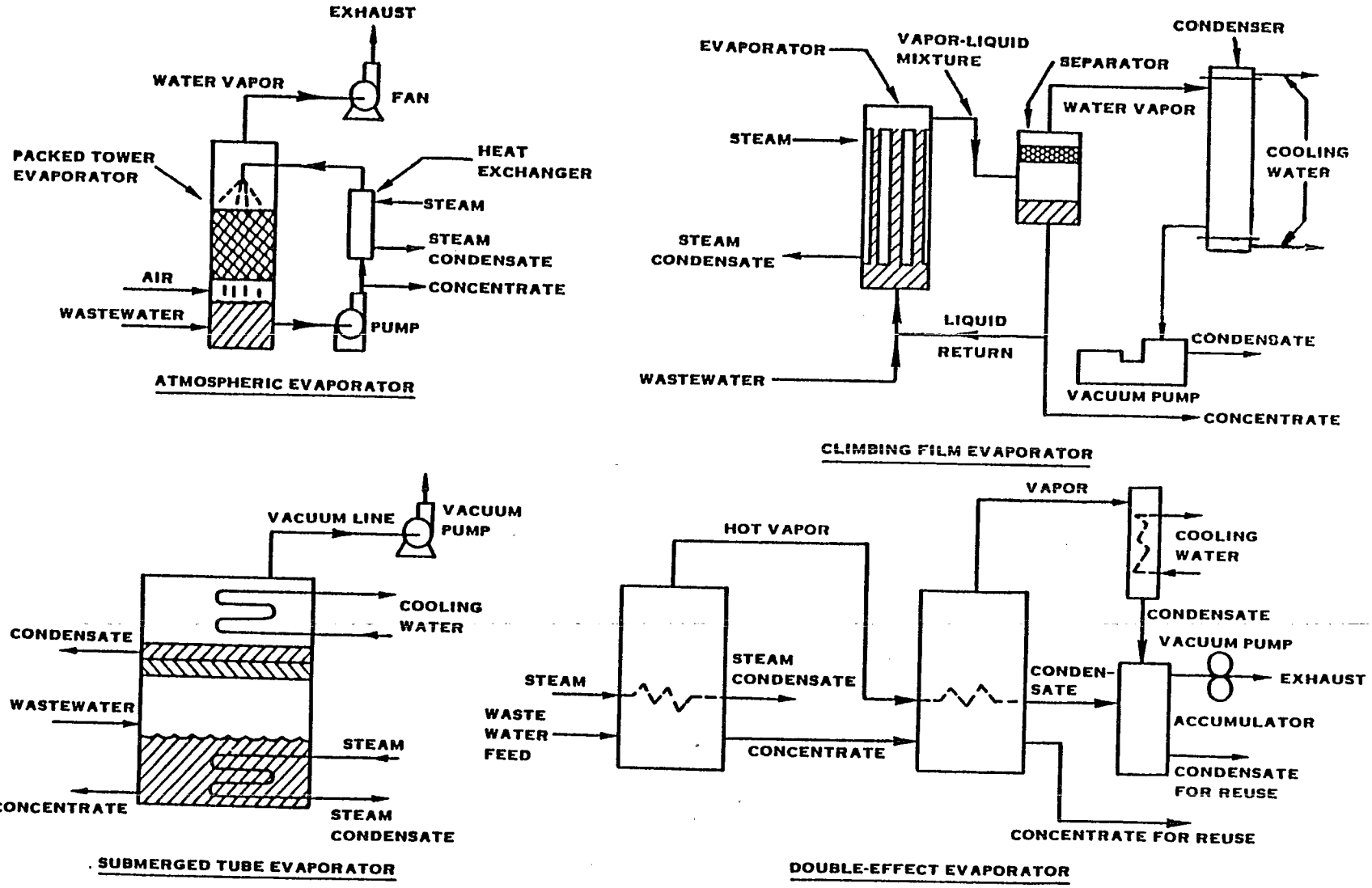


FIGURE VII- 18 TYPES OF EVAPORATION EQUIPMENT

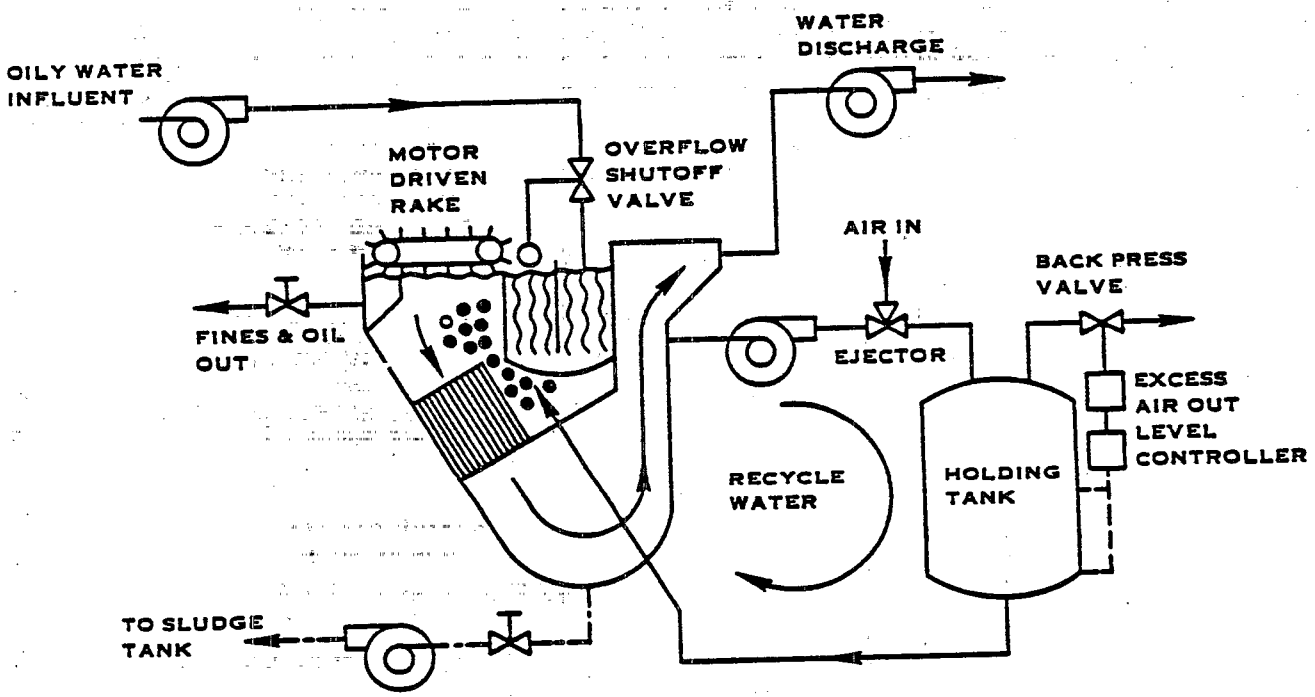


FIGURE VII-19 DISSOLVED AIR FLOTATION

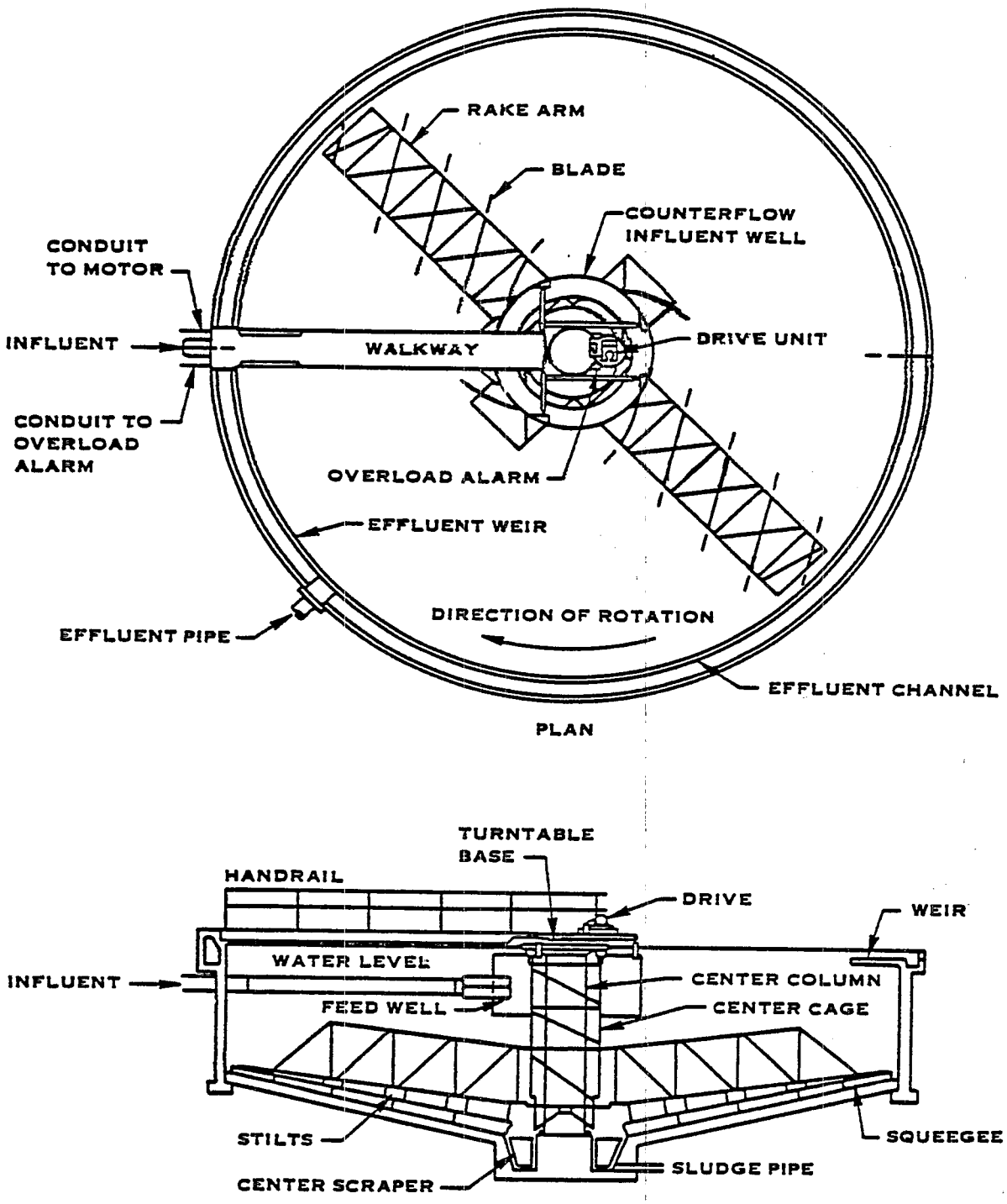


FIGURE VII-20 GRAVITY THICKENING

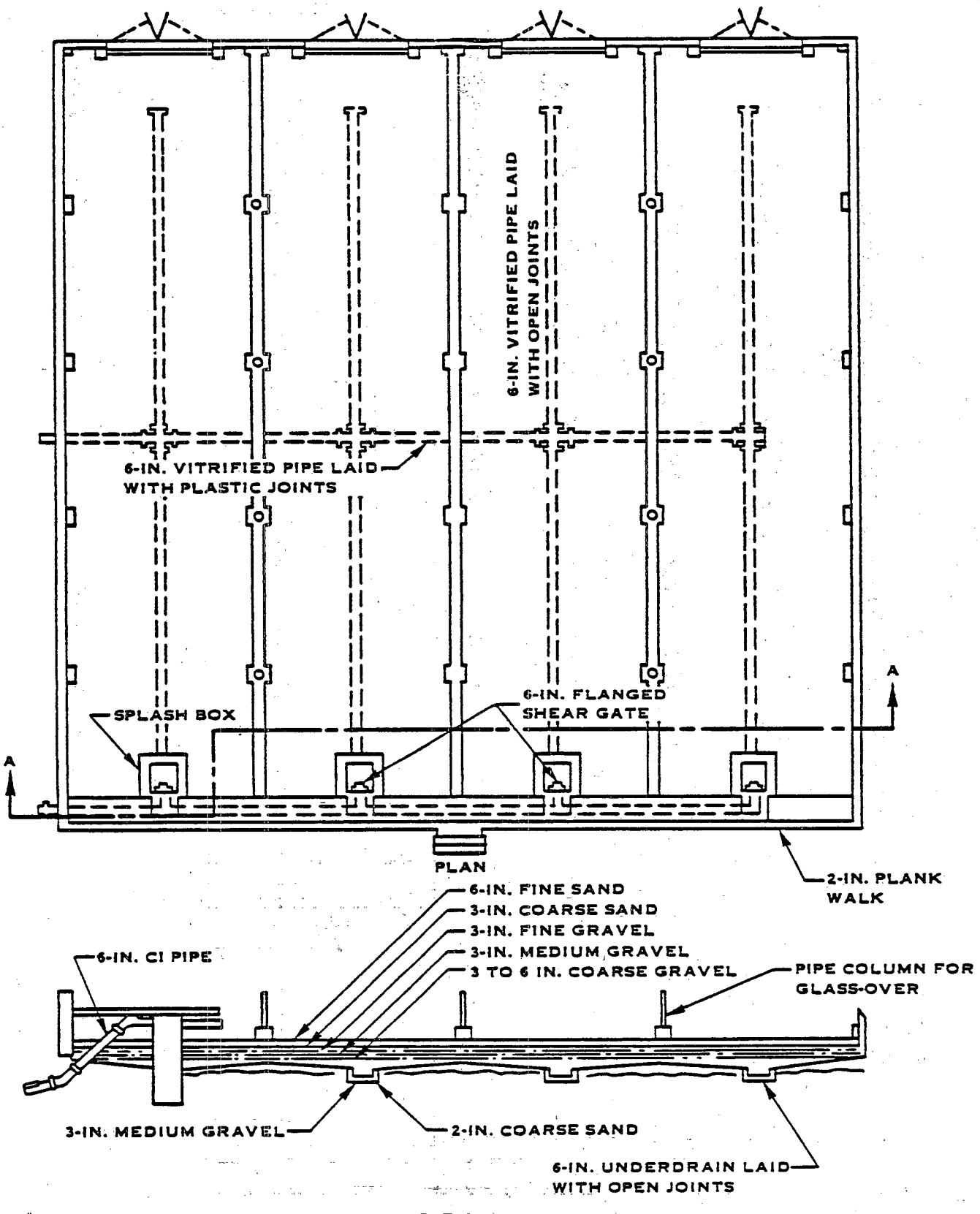


FIGURE VII-21 SLUDGE DRYING BED

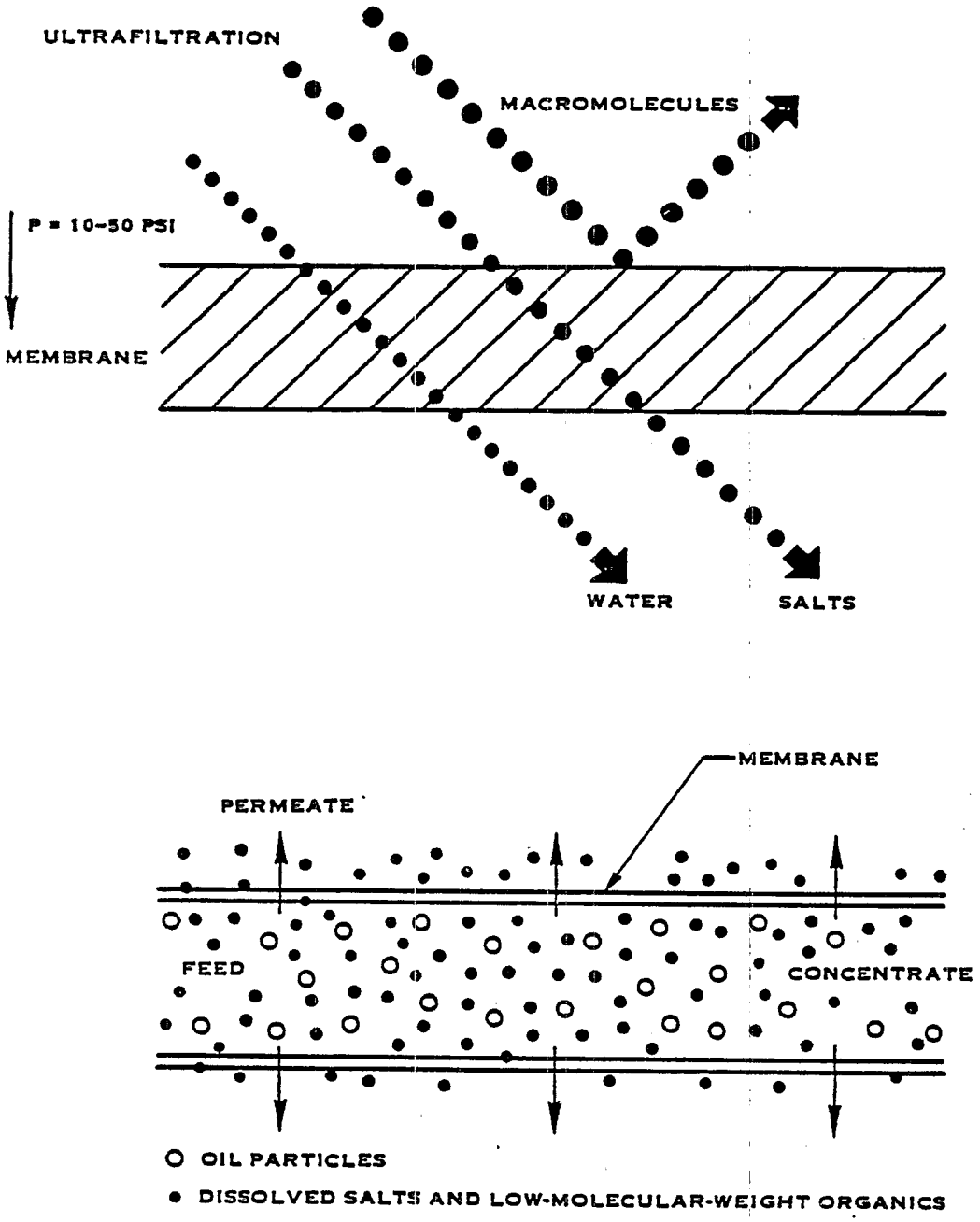


FIGURE VII-22 SIMPLIFIED ULTRAFILTRATION FLOW SCHEMATIC

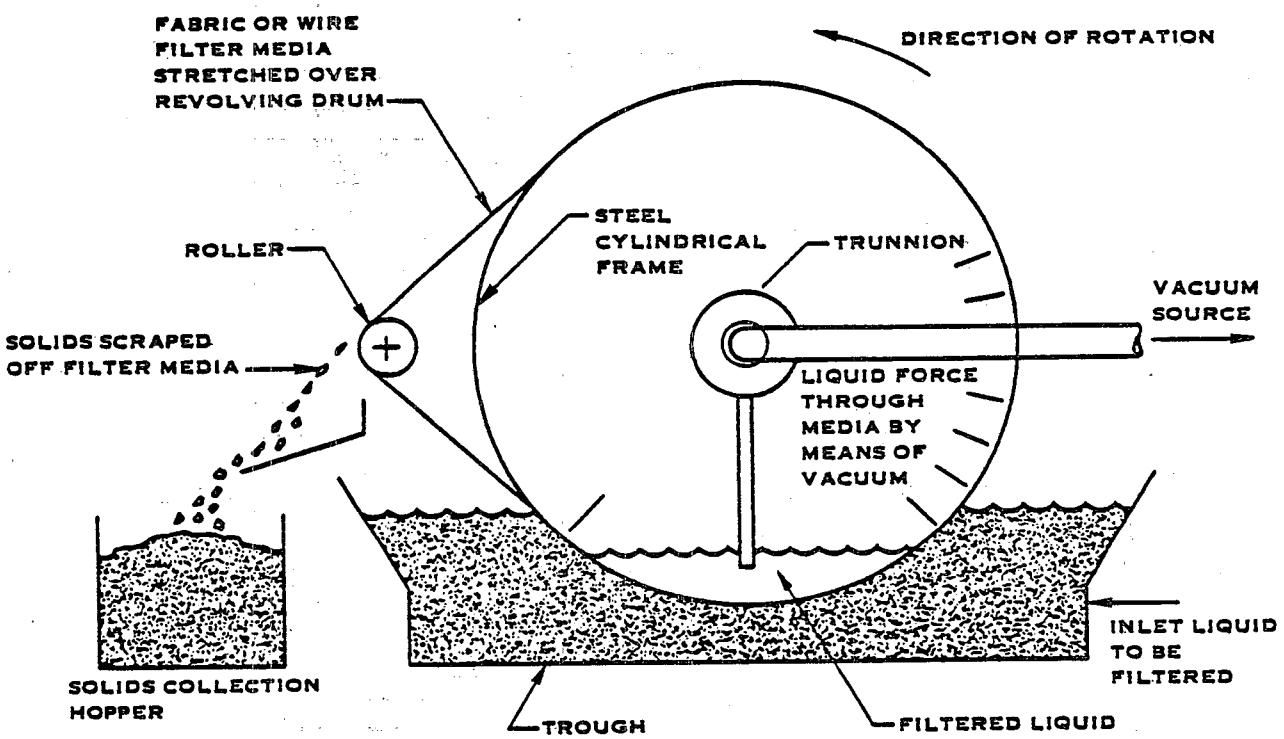


FIGURE VII-23 VACUUM FILTRATION

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