United States
Environmental Protection
Agency

Effluent Guidelines Division
WH-552
Washington DC 20460

EPA 440/1-82/072
November 1982

Water and Waste Management

EPA

Development Document for Effluent Limitations Guidelines and Standards for the Porcelain Enameling

Final

Point Source Category

DEVELOPMENT DOCUMENT

for the

PORCELAIN ENAMELING POINT SOURCE CATEGORY

Anne M. Burford
Administrator

Frederic A. Eidsness, Jr.
Assistant Administrator, Office of Water

Steven Schatzow
Director, Office of
Water Regulations and Standards

Jeffery D. Denit
Director, Effluent Guidelines Division

Ernst P. Hall, P.E.
Chief, Metals and Machinery Branch

Ben J. Honaker
Project Officer

November, 1982

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

CONTENTS

TABLES

TABLES

TABLES

TABLES

TABLES

TABLES

TABLES

FIGURES

FIGURES

FIGURES

FIGURES

SECTION I

SUMMARY

Industry and Operations

Porcelain enameling is the application of glass-like coatings to metals such as steel, cast iron, aluminum or copper. The purpose of the coating is to improve resistance to chemicals, abrasion and water and to improve thermal stability, electrical resistance and appearance. The coating applied to the workpiece is a water based slurry called a "slip" and is composed of one of many combinations of frit (glassy like material), clays, coloring oxides, water and special additives such as suspending agents. These vitreous inorganic coatings are applied to the metal by a variety of methods such as spraying, dipping, and flow coating, and are bonded to the base metal at temperatures in excess of 500 degrees C (over 1000F). At these temperatures, finely ground enamel frit particles fuse and flow together to form the permanently bonded, hard procelain coating.

Porcelain enameling began in the United States in the late 1800's. Following the Depression, the manufacture of porcelain enameled refrigerators, stoves, and other household items expanded many times. The demand for procelain enamel products and finishes remained at a peak until the early 1960's, when substitute finishes began to replace many uses of the more costly porcelain enamel surfaces. EPA estimates that currently there are approximately 116 procelain enameling plants in the United States; the majority are located east of the Mississippi River.

There are two major groups of standard process steps used in manufacturing procelain enameled materials. These are: (1) surface preparation and (2) coating. Surface preparation is for removal of soil, oil, corrosion and similar dirt from the basis material. Surface preparation cleaning processes includes water based alkaline cleaners for removing oil and dirt; employ acid pickling solutions to remove oxides and corrosion and to etch the surface of the workpiece; and water rinses of the basis material after alkaline cleaning or acid pickling.

The steel subcategory also uses a fourth metal preparation step, water solution of nickel salts (nickel flash) is used to improve adhesion of the slip to the basis metal.

Coating includes both ball milling and enamel application. Ball milling is performed to mix and grind frit and other raw materials, forming an enamel slip of appropriate consistency for the intended use of the product. The steel subcategory also uses a fourth metal preparation step, The ball milling operation uses water for washing out the ball mills between mixing batches and for cooling the ball mills. During application of the porcelain enamel slip, water also may be used in a curtain device to capture waste slip in overspray.

The most important pollutants or pollutant parameters are: (1) toxic metal pollutants--antimony, cadmium, chromium, copper, lead, nickel, selenium and, zinc; (2) conventional pollutants--total suspended solids, pH, and oil and grease, and (3) nonconventional pollutants--aluminum and iron. Toxic organic pollutants, however, were not found with any frequency and are not considered to be significant in this industry.

Data Base and Information Used

In developing this regulation, EPA studied the porcelain enameling category to determine whether differences in raw materials, final products, manufacturing processes, equipment, age and size of plants, water use, wastewater constituents, or other factors required the development of separate effluent limitations and standards for different segments of the industry.

EPA has subcategorized the porcelain enameling industry based on the basis material coated. The subcategories are defined as procelain enameling on: steel, cast iron, aluminum, and copper. No limitations are established for porcelain enameling on precious metals (gold, silver and platinum group metals) because they are believed to be very small sources and virtually all would be excluded from regulation by the small indirect discharger exemption.

This study included the identification of raw waste and treated effluent characteristics, including: (1) the sources and volume of water used, the processes employed, and the sources of pollutants and wastewaters in the plant, and (2) the constituents of wastewaters. Such analysis enabled EPA to determine the presence and concentration of toxic pollutants in wastewater discharges.

EPA also identified both actual and potential control and treatment technologies, including both in-plant and end-of-process technologies. The Agency analyzed both historical and newly generated data on the performance of these technologies including performance, operational limitations, and reliability.

Current wastewater treatment practices in the porcelain enameling category range from no treatment by about 72 percent of the plants to a high level of physical-chemical treatment combined with water conservation practices. Of the 116 porcelain enameling plants for which data are available, 33 percent have sedimentation or clarification devices, 24 percent have alkaline addition pH adjustment systems, and 9 percent have acid addition pH adjustment systems. There is no apparent difference between direct or indirect dischargers in the nature or degree of treatment employed.

The control and treatment technologies available for this category include both in-process and end-of-pipe treatment. In-process treatment includes a variety of water flow reduction steps and major process changes such as cascade rinsing to reduce the amount of water used to remove unwanted materials from the workpiece surface, the use of flow control equipment and the recycle of treated coating wastewaters. End-of-pipe treatment includes: hexavalent chromium reduction (where applicable), oil skimming, chemical precipitation of metals using hydroxides or carbonates and removal of precipitated metals and other materials using settling, sedimentation, filtration, and combinations of these technologies.

The effectiveness of these treatment technologies has been evaluated and established by examining the performance of these technologies on porcelain enameling and other similar wastewaters. The primary data base for hydroxide precipitation--sedimentation technology is a composite of data drawn from EPA sampling and analysis of copper and aluminum forming, battery manufacturing, porcelain enameling, and coil coating. These wastewaters are judged to be similar in treatability because they contain similar ranges of dissolved metals which can be removed by precipitation and solids removal. Similarly, the precipitation--sedimentation and filtration technology performance is based on the performance of full scale commerical systems treating multicategory wastewaters which also are essentially similar to porcelain enameling wastewaters.

The Agency estimated the costs of each control and treatment technology using a computer program developed by standard engineering analysis. EPA derived unit process costs for each of 116 plants using data and characteristics (production and flow) applied to each treatment process (i.e.,hexavalent chromium reduction, metals precipitation, sedimentation, granular bed-multimedia filtration, etc.). These unit process costs were added to yield total cost at each treatment level. After confirming the reasonableness of this methodology by comparing EPA cost estimates to treatment system costs supplied by the industry, the Agency evaluated the economic impacts of these costs.

Regulation

On the basis of these factors, EPA identified various control and treatment technologies as the basis for BPT, NSPS, PSES and PSNS. The regulation, however, does not require the installation of any particular technology. Rather, it requires achievement of effluent limitations equivalent to those achieved by the proper operation of these or equivalent technologies.

The effluent limitations for BPT, BAT, and NSPS are expressed as mass limitations (mg/m^2) and are calculated by multiplying three elements: (1) effluent concentrations determined from analysis of control technology performance data; (2) allowable wastewater flow determined by an analysis of flow data at plants in each subcategory with adequate water use practices; and (3) the relevant process or treatment variability factor (e.g., maximum monthly average vs. maximum day).

Pretreatment standards for existing sources (PSES) are expressed as concentration standards. The equivalent mass standards are also presented for use when POTW find it necessary to impose mass pretreatment standards. Pretreatment standards for new sources (PSNS) are expressed as mass standards to assure the pollutant reduction benefits of the 90 percent flow reduction included as the basis of PSNS.

BPT

In general, the BPT level represents the average of the best existing performances of plants of various ages, sizes, processes or other common characteristics. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category.

In balancing costs in relation to effluent reduction benefits, EPA considers the volume and nature of existing discharges, the volume and nature of discharges expected after application of BPT, the general environmental effects of the pollutants, and cost and economic impacts of the required pollution control level. .

This regulation imposes BPT requirements on the steel, cast iron, and aluminum subcategories. The technology basis for the BPT limitations being promulgated is the same as for the proposed limitations and includes flow normalization, hexavalent chromium reduction (for facilities which perform porcelain enameling on aluminum), oil skimming, pH adjustment, and sedimentation to remove the resultant precipitate and other suspended solids. Zero discharge for metal preparation is required in the cast iron subcategory because the metal preparation method usually employed does not result in a discharge of process wastewater. BPT (as well as BAT and PSES) limitations are not being promulgated for the copper subcategory because there are no existing direct dischargers and no large indirect dischargers in this subcategory.

The BPT technology outlined above applies all three regulated porcelain enameling subcategories and the effluent concentrations resulting from the application of the technology are identical. However, the mass limitations vary due to different water uses among the subcategories and the absence of some pollutants in some subcategories.

The pollutants selected for regulation at BPT are: chromium, lead, nickel, zinc, aluminum, iron, oil and grease, TSS, and pH.

Implementation of the BPT limitations will remove annually an estimated 96,700 kg of toxic pollutants and 7,640,000 kg of other pollutants (from estimated current discharge) at a capital cost above equipment in place of $5.4 million and an annual cost of $2.8 million (based on January 1978 dollars).

BAT

The BAT technology level represents, the best economically achievable performance of plants of various ages, sizes, processes or other shared characteristics. As with BPT, where existing performance is uniformly inadequate, BAT may be transferred from a different subcategory or category. BAT may include feasible process changes or internal controls, even when not common industry practice.

In developing BAT, EPA has given substantial weight to the reasonableness of costs. The Agency considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels.

Despite this consideration of costs, the primary determinant of BAT is still effluent reduction capability.

The Agency considered three major sets of technology options which might be applied at the BAT level. The effectiveness and costs of the BAT options were evaluated and considered in selecting BAT. This regulation imposes BAT requirements on the steel, cast iron and aluminum subcategories. The technology basis for BAT or the final regulation is flow normalization, chromium reduction, oil & grease removal and lime and settle end-of-pipe treatment. Flow reduction by reusing treated wastewater for all coating water needs except ball mill washout also is included as part of the BAT model technology. This will reduce wastewater discharge from coating operations by about 95 percent (compared to BPT) and the overall wastewater discharge by about 15-18 percent.

This technology basis for BAT eliminates filtration from the proposed BAT model treatment system and added reuse of process wastewaters. Industry comments opposed filtration as a basis for BAT because of its cost and because it could present technological problems for porcelain enamelers whose operations are integrated with operations covered by other regulations. Comments on an the alternative flow reduction option presented in the proposed regulation stated that the ball mill allowance should be higher than the amount specified. The final regulation includes a substantial increase in the ball mill washout allowance which is used as the basis for the mass based discharge limitations.

The pollutants selected for regulation at BAT are: chromium, lead, nickel, zinc, aluminum and iron. The toxic pollutants considered for regulation at proposal, but not selected for regulation, are arsenic, antimony, cadmium, copper, cyanide and selenium. The technology that would be necessary to meet the limitations for the regulated pollutants will effectively control the unregulated pollutants.

The direct dischargers are expected to move directly to compliance with BAT limitations from existing treatment because the flow reduction used to meet BAT limitations will allow the use of smaller -- and less expensive -- lime and settle equipment than would be used to meet BPT limitations without flow reduction.

Implementation of the BAT limitations will remove annually an estimated 97,350 kg/yr of toxic pollutants and 7,650,000 kg/yr of other pollutants (from estimated current discharge) at a capital cost above equipment in place of $5.7 million and an annual cost of $2.9 million (based on January 1978 dollars).

BAT will remove 650 kg/yr of toxic pollutants and 10,000 kg/yr of other pollutants incrementally above BPT; the incremental investment cost is $0.3 million and the additional total annual cost is $0.1 million (January 1978 dollar basis).

NSPS

NSPS (new source performance standards) are based on the best available demonstrated technology (BDT), including process changes, in-plant control, and end-of-pipe treatment technologies which reduce pollution to the maximum extent feasible. EPA considered three options for selection of NSPS technology. This regulation establishes NSPS for all four subcategories.

The proposed NSPS were based on the following technology: 90 percent reduction of metal preparation wastewater by countercurrent rinsing followed by lime, settle and filter end-of-pipe treatment. Elimination of all coatings wastewater was part of the model treatment technology and was to be achieved by use of electrostatic dry powder coatings, a dry process that eliminates the generation of wastewater. Industry comments opposed eliminating coating wastewater. Many companies stated that powder coatings are not appropriate for their products because of problems associated with enameling complex shapes and aluminum materials.

After consideration of these options we are promulgating a modified NSPS based on multi-stage countercurrent cascade rinsing after each metal preparation operation, reuse of most coating operation water as in BAT and lime, settle and filter end-of-pipe treatment technology for all wastewaters. The Agency has eliminated dry electrostatic powder coating as a technology basis for NSPS because this coating is not universally applicable.

Filtration has been retained in the NSPS model because filters are substantially less costly for new sources after substantial flow reduction than for existing sources. Filtration and flow reduction will remove an estimated 94 percent of the toxic pollutants discharged after BAT.

The pollutants regulated are: chromium, lead, nickel, zinc, aluminum, oil and grease, iron, TSS and pH. The capital investment for new sources to meet NSPS is about 7 percent above that needed by existing sources to comply with BAT.

PSES

PSES (pretreatment standards for existing sources) are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Pretreatment standards are to be technology-based and analogous to the best available technology for removal of toxic pollutants.

This regulation establishes PSES for the steel, cast iron and aluminum subcategories.

EPA determined there is pass-through of toxic metal pollutants because POTW removals of major toxic pollutants found in porcelain enameling wastewater average about 50 percent (Cr-18%, Cu-58%, CN-52%, Zn-65%) while BAT technology treatment removes more than 99 percent of these pollutants. This difference in removal effectiveness clearly indicates pass-through of pollutants will occur unless porcelain enameling wastewaters are adequately pretreated. The pollutants to be regulated by PSES include chromium, copper, lead, nickel and zinc.

The Agency proposed PSES using technology analogous to the proposed BAT: flow normalization, chromium reduction, and lime, settle and filter end-of-pipe treatment. For the reasons discussed under BAT, we are removing filtration from the PSES model technology and adding reuse of process wastewater. The model technology on which the promulgated PSES is based is analogous to the promulgated BAT model technology except that oil skimming is not included. This PSES model technology consists of flow reduction by reuse of treated process wastewater, chromium reduction, and lime and settle end-of-pipe treatment.

The Agency determined that PSES are not not economically achievable for small plants. Plants which produce less than 1600 m^2/day product and discharge less than 60,000 l/day wastewater are not controlled by the categorical PSES established by this regulation. The two copper subcategory plants in the data base are excluded from regulation by this provision. Indirect discharging plants not controlled by this PSES must, however, conform to the provisions of 40 CFR Part 403. The exclusion point is reasonable since the next projected plant closure is about twice the cutoff level. This cut-off exempts from the categorical PSES regulation 38 small indirect discharges which represent about 4.6 percent of the total industry production and 6.8 percent of the production by indirect dischargers. Further details of the small plant analysis are presented in the economic analysis document.

The Agency has determined that there is no less stringent technology that could be the basis of pretreatment standards for small plants. EPA evaluated a less expensive, sump settling technology suggested by public comments for small indirect dischargers. However, the Agency determined that this technology has not been adequately demonstrated in the industry and probably would not appreciably reduce the discharge of toxic pollutants.

The 38 small indirect dischargers not regulated by this PSES generate 21,800 kg/yr toxic pollutants and 1,426,000 kg/yr other pollutants. If PSES applied to these facilities they would introduce into POTW only 605 kg/yr toxic pollutants and 8,500 kg/yr other pollutants.

Concentration based standards, rather than the proposed mass-based standards, are promulgated for PSES with mass-based alternate standards made available for use where desired by the POTW.

Implementation of the PSES standards will remove annually an estimated 179,500 kg of toxic pollutants and 14,200,000 kg of other pollutants (from estimated current discharge) at a capital cost above equipment in place of $13.5 million and an annual cost of $6.6 million (January 1978 dollar basis)

The Agency has set the PSES compliance date at three years after promulgation of this regulation: November, 1985.

PSNS

Like PSES, PSNS (pretreatment standards for new sources) are to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatable with the operation of the POTW. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies including process changes, in-plant controls, and end-of-pipe treatment technologies, and to use plant site selection to ensure adequate treatment system installation.

This regulation establishes mass-based PSNS for all four subcategories. The treatment technology basis for the PSNS being promulgated is identical to the treatment technology set forth as the basis for the NSPS being promulgated: multi-stage countercurrent cascade rinsing, coating wastewater recycle and lime, settle and filter end-of-pipe treatment.

Although mass-based standards may be somewhat more difficult for a POTW to enforce, mass-based standards are necessary for PSNS to ensure that the considerable effluent-reduction benefits of flow reduction techniques are obtained. Overall flow and pollutant reduction of about 90 percent can be achieved by countercurrent cascade rinsing, and countercurrent cascade rinsing is not excessively costly in new plants. Since POTW removal of toxic pollutants is only about 50 percent, pass-through of toxic pollutants will occur.

The incremental capital investment (above the capital that would have been required if PSES requirements applied) for new source standards is less than 0.5 percent of expected revenues and is not expected to result in any barrier to entry into the category. Regulated pollutants at PSNS are antimony, chromium, lead, nickel and zinc.

Non-Water Quality Environmental Impacts

Eliminating or reducing one form of pollution may cause other environmental problems. Sections 304(b) and 306 of the Act require EPA to consider the non-water quality environmental impacts (including energy requirements) of certain regulations. In compliance with these provisions, we considered the effect of this regulation on air pollution, solid waste generation, water scarcity, and energy consumption.

This regulation was reviewed by EPA personnel responsible for non-water quality programs. While it is difficult to balance pollution problems against each other and against energy use, we believe that this regulation will best serve often competing national goals.
Wastewater treatment sludges from this category are expected to be non-hazardous under RCRA when generated using the model technology. Treatment of similar wastewaters from other categories using this technology has resulted in non-hazardous sludges. Costs for disposal of non-hazardous wastes are included in the annual costs.

To achieve the BPT and BAT effluent limitation, a typical direct discharger will increase total energy consumption by less than one percent of the energy consumed for production purposes.

SECTION II

RECOMMENDATIONS

1. EPA has divided the porcelain enameling category into four subcategories for the purpose of effluent limitations and standards. These subcategories are:

steel
cast iron
aluminum
copper

2. The following effluent limitations are being promulgated for existing sources:

A. <u>Subcategory A - Steel Basis Material</u>

(a) <u>BPT Limitations</u>

BPT Effluent Limitations

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m^2 of Area Processed or Coated				
Chromium	16.82	3.41	6.81	1.38
Lead	6.01	1.21	5.21	1.06
Nickel	56.46	11.43	40.05	8.11
Zinc	53.26	10.78	22.43	4.54
Aluminum	182.20	36.87	74.47	15.07
Iron	49.26	9.97	25.23	5.11
Oil & Grease	800.84	162.10	480.51	97.23
TSS	1642.00	332.20	800.90	162.00
pH	(1)	(1)	(1)	(1)
English Units--lbs/1 million ft^2 of Area Processed or Coated				
Chromium	3.45	0.70	1.40	0.29
Lead	1.23	0.25	1.07	0.22
Nickel	11.57	2.34	8.20	1.66
Zinc	10.91	2.21	4.60	0.93

Aluminum	37.32	7.55	15.26	3.09
Iron	10.09	2.04	5.17	1.05
Oil & Grease	164.03	33.19	98.42	19.92
TSS	337.00	68.10	164.00	33.20
pH	(1)	(1)	(1)	(1)

(1) Within the range 7.5 to 10.0 at all times.

(b) BAT Limitations

Pollutant or Pollutant Property	BAT Effluent Limitations			
	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m^2 of Area Processed or Coated				
Chromium	16.82	0.27	6.81	0.11
Lead	6.01	0.10	5.21	0.09
Nickel	56.50	0.90	40.05	0.64
Zinc	53.30	0.85	22.43	0.36
Aluminum	182.00	2.90	74.48	1.19
Iron	49.30	0.79	25.23	0.41
English Units--lbs/1 million ft^2 of Area Processed or Coated				
Chromium	3.45	0.06	1.4	0.022
Lead	1.23	0.02	1.07	0.017
Nickel	11.57	0.19	8.20	0.13
Zinc	10.91	0.18	4.60	0.08
Aluminum	37.32	0.6	15.26	0.25
Iron	10.09	0.16	5.17	0.09

B. Subcategory B - Cast Iron Basis Material

(1) There shall be no discharge of process wastewater pollutants from metal preparation operations.

(2) The discharge of process wasterwater pollutants from all porcelain enameling coating operations shall not exceed the values set forth below:

(a) BPT Limitations

BPT Effluent Limitations

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	mg/m^2 (lbs/1 million ft^2) of Area Coated			
Chromium	0.29	(0.06)	0.12	(0.024)
Lead	0.11	(0.02)	0.09	(0.02)
Nickel	0.98	(0.20)	0.7	(0.15)
Zinc	0.93	(0.19)	0.39	(0.08)
Aluminum	3.16	(0.65)	1.29	(0.27)
Iron	0.86	(0.18)	0.44	(0.09)
Oil & Grease	13.86	(2.84)	8.32	(1.71)
TSS	28.42	(5.82)	13.86	(2.84)
pH	(1)	(1)	(1)	(1)

(1) Within the range 7.5 to 10. 0 at all times.

(b) BAT Limitations

BAT Effluent Limitations

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	mg/m^2 (lbs/1 million ft^2) of Area Coated			
Chromium	0.27	(0.06)	0.11	(0.022)
Lead	0.10	(0.02)	0.09	(0.017)
Nickel	0.90	(0.19)	0.64	(0.13)
Zinc	0.85	(0.18)	0.36	(0.08)
Aluminum	2.90	(0.60)	1.19	(0.25)
Iron	0.79	(0.16)	0.40	(0.09)

C. Subcategory C - Aluminum Basis Material

(a) BPT Limitations

BPT Effluent Limitations

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m^2 of Area Processed or Coated				
Chromium	16.34	6.32	6.63	2.56
Lead	5.84	2.26	5.06	1.96
Nickel	54.85	21.21	38.90	15.04
Zinc	51.73	20.01	21.79	8.43
Aluminum	176.98	68.44	72.35	27.98
Iron	47.85	18.50	24.51	9.48
Oil & Grease	777.92	300.84	466.76	108.50
TSS	1594.74	616.68	777.92	300.82
pH	(1)	(1)	(1)	(1)
English Units--lbs/1 million ft^2 of Area Processed or Coated				
Chromium	3.35	1.30	1.37	0.53
Lead	1.20	0.47	1.04	0.40
Nickel	11.24	4.35	7.97	3.08
Zinc	10.6	4.10	4.46	1.73
Aluminum	36.25	14.02	14.82	5.73
Iron	9.80	3.79	5.02	1.94
Oil & Grease	159.33	61.61	95.60	36.97
TSS	326.63	126.33	159.33	61.61
pH	(1)	(1)	(1)	(1)

(1) Within the range 7.5 to 10.0 at all times.

(b) BAT Limitations

Pollutant or Pollutant Property	BAT Effluent Limitations			
	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m^2 of Area Processed or Coated				
Chromium	16.34	0.27	6.62	0.11
Lead	5.84	0.10	5.06	0.09
Nickel	54.85	0.90	38.90	0.64
Zinc	51.74	0.85	21.79	0.36
Aluminum	176.98	2.9	72.35	1.19
Iron	47.85	0.79	24.51	0.40
English Units--lbs/1 million ft^2 of Area Processed or Coated				
Chromium	3.35	0.06	1.36	0.022
Lead	1.20	0.02	1.04	0.02
Nickel	11.24	0.19	7.97	0.13
Zinc	10.60	0.18	4.46	0.08
Aluminum	36.25	0.60	14.82	0.25
Iron	9.80	0.16	5.02	0.09

D. Subcategory D - Copper Basis Material

(a) No BPT effluent limitation are being promulgated.

(b) No BAT effluent limitations are being promulgated.

3. The following effluent standards are being promulgated for new sources.

A. Subcategory A - Steel Basis Material

NSPS

§466.13 New source performance standards.

Any new source subject to this subpart must achieve the following new source performance standards:

Subpart A. NSPS

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m² of Area Processed or Coated				
Chromium	1.33	0.24	0.54	0.1
Lead	0.36	0.70	0.33	0.06
Nickel	1.97	0.35	1.32	0.24
Zinc	3.65	0.65	1.51	0.27
Aluminum	10.90	1.93	4.44	0.79
Iron	4.40	0.79	2.26	0.40
Oil & Grease	35.75	6.36	35.75	6.36
TSS	53.7	9.54	39.4	7.0
pH	(1)	(1)	(1)	(1)
English Units--lbs/1 million ft² of Area Processed or Coated				
Chromium	0.27	0.05	0.11	0.02
Lead	0.08	0.013	0.07	0.012
Nickel	0.41	0.08	0.27	0.05
Zinc	0.75	0.14	0.31	0.06
Aluminum	2.22	0.4	0.91	0.17

Iron	0.90	0.16	0.46	0.09
Oil & Grease	7.33	1.31	7.33	1.31
TSS	10.99	1.96	8.06	1.44
pH	(1)	(1)	(1)	(1)

(1) Within the range 7.5 to 10.0 at all times.

B. Subcategory B - Cast Iron Basis Material

(a) There shall be no discharge of process wastewater pollutants from metal preparation operations.

(b) The discharge of process wastewater pollutants from all porcelain enameling coating operations shall not exceed the values set forth below:

Subpart B. NSPS

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	mg/m² (lb/1 million ft²) of area Coated			
Chromium	0.24	(0.05)	0.10	(0.02)
Lead	0.07	(0.013)	0.06	(0.012)
Nickel	0.35	(0.08)	0.24	(0.05)
Zinc	0.65	(0.14)	0.27	(0.06)
Aluminum	1.93	(0.4)	0.79	(0.17)
Iron	0.79	(0.16)	0.40	(0.09)
Oil & Grease	6.36	(1.31)	6.36)	(1.31)
TSS	9.54	(1.95)	7.00	(1.44)
pH	(1)	(1)	(1)	(1)

(1) Within the range 7.5 to 10.0 at all times.

C. Subcategory C - Aluminum Basis Material

NSPS

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation

Metric Units--mg/m^2 of Area Processed or Coated

Chromium	1.29	0.24	0.52	0.1
Lead	0.35	0.07	0.32	0.05
Nickel	1.91	0.35	1.29	0.24
Zinc	3.55	0.65	1.46	0.27
Aluminum	10.53	1.93	4.31	0.79
Iron	4.28	0.79	2.19	0.40
Oil & Grease	34.73	6.36	34.73	6.36
TSS	52.1	9.54	38.21	7.00
pH	(1)	(1)	(1)	(1)

English Units--lbs/1 million ft^2 of Area Processed or Coated

Chromium	0.27	0.05	0.11	0.02
Lead	0.07	0.013	0.07	0.012
Nickel	0.39	0.08	0.27	0.05
Zinc	0.723	0.14	0.3	0.06
Aluminum	2.16	0.4	0.89	0.17
Iron	0.88	0.16	0.45	0.09
Oil & Grease	7.12	1.31	7.12	1.31
TSS	10.67	1.96	7.83	1.44
pH	(1)	(1)	(1)	(1)

(1) Within the range 7.5 to 10.0 at all times.

D. Subcategory D - Copper Basis Material

NSPS

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m^2 of Area Processed or Coated				
Chromium	2.23	0.24	0.90	0.1
Lead	0.60	0.07	0.54	0.06
Nickel	3.31	0.35	2.23	0.24

Zinc	6.13	0.65	2.53	0.27
Aluminum	18.21	1.93	7.46	0.79
Iron	7.4	0.79	3.79	0.40
Oil & Grease	60.1	6.36	60.1	6.36
TSS	90.15	9.54	66.11	7.0
pH	(1)	(1)	(1)	(1)
English Units--lbs/1 million ft² of Area Processed or Coated				
Chromium	0.46	0.05	0.19	0.02
Lead	0.13	0.013	0.11	0.012
Nickel	0.68	0.08	0.46	0.05
Zinc	1.26	0.14	0.52	0.06
Aluminum	3.73	0.4	1.53	0.17
Iron	1.52	0.16	0.78	0.09
Oil & Grease	12.31	1.31	12.31	1.31
TSS	18.47	1.96	13.54	1.44
pH	(1)	(1)	(1)	(1)

(1) Within the range 7.5 to 10.0 at all times.

4. The following pretreatment standards are being promulgated for existing sources and new sources.

A. Subcategory A - Steel Basis Material

(a) Pretreatment Standards for Existing Source

PSES

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Milligrams per liter (mg/l)				
Chromium	0.42		0.17	
Lead	0.15		0.13	
Nickel	1.41		1.00	
Zinc	1.33		0.56	

(b) In cases where POTW find it necessary to impose mass effluent pretreatment standards the following equivalent mass standards are provided:

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m² of Area Processed or Coated				
Chromium	16.82	0.27	6.81	0.11
Lead	6.01	0.10	5.21	0.09
Nickel	56.5	0.90	40.1	0.64
Zinc	53.3	0.85	22.9	0.36
English Units--lbs/1 million ft² of Areas Process or Coated				
Chromium	3.45	0.06	1.4	0.022
Lead	1.23	0.19	1.07	0.02
Nickel	11.6	0.19	8.20	0.13
Zinc	10.9	0.18	4.6	0.08

(b) Pretreatment Standards for New Sources

PSNS Effluent Limitations

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m^2 of Area Processed or Coated				
Chromium	1.33	0.24	0.54	0.10
Lead	0.36	0.07	0.33	0.06
Nickel	1.97	0.35	1.33	0.24
Zinc	3.65	0.65	1.51	0.27
English Units--lbs/1 million ft^2 of Area Processed or Coated				
Chromium	0.27	0.05	0.11	0.02
Lead	0.07	0.013	0.07	0.012
Nickel	0.41	0.08	0.27	0.05
Zinc	0.75	0.14	0.31	0.06

B. Subcategory B - Cast Iron Basis Material

Pretreatment Standards for Existing Sources

(a) There shall be no discharge of process wastewater pollutants from metal preparation operations.

(b) The discharge of process wastewater pollutants from all porcelain enameling coating operations shall not exceed the values set forth below:

Pollutant or Pollutant Property	PSES Effluent Limitations Maximum for any 1 day	 Maximum for Monthly average
	milligrams per liter (mg/l)	
Chromium	0.42	0.17
Lead	0.15	0.13
Nickel	1.41	1.00
Zinc	1.33	0.56

b) In cases when POTW find it necessary to impose mass pretreatment standards the following equivalent mass standards are provided.

(a) There shall be no discharge of process wastewater pollutants from metal preparation operations.

(b) The discharge of process wastewater pollutants from all porcelain enameling coating operations shall not exceed the values set forth below:

Subpart B. PSES

Pollutant or Pollutant Property	Maximum for any 1 day·		Maximum for Monthly average	
Metric Units - mg/m² (English Units - lb/1 million ft²) of area Coated				
Chromium	0.27	(0.06)	0.11	(0.022)
Lead	0.10	(0.02)	0.09	(0.017)
Nickel	0.90	(0.19)	0.64	(0.13)
Zinc	0.85	(0.18)	0.36	(0.08)

(b) Pretreatment Standards for New Sources

(a) There shall be no discharge of process wastewater pollutants from metal preparation operations.

(b) The discharge of process wastewater pollutants from all porcelain enameling coating operations shall not exceed the values set forth below:

Subpart B. PSNS

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	mg/m² (lb/1 million ft²) of Area Coated			
Chromium	0.24	(0.05)	0.10	(0.02)
Lead	0.07	(0.02)	0.06	(0.012)
Nickel	0.35	(0.08)	0.24	(0.05)
Zinc	0.65	(0.14)	0.27	(0.06)

C. Subcategory C - Aluminum Basis Material

(a) Pretreatment Standards for Existing Sources

Subpart B. PSES

Pollutant or Pollutant Property	Maximum for any 1 day	Maximum for Monthly average
	milligrams per liter (mg/l)	
Chromium	0.42	0.17
Lead	0.15	0.13
Nickel	1.41	1.00
Zinc	1.33	0.56

b) In cases when POTW find it necessary to impose mass pretreatment standards the following equivalent mass standards are provided:

Subpart C. PSES

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
	Metric Units--mg/m² of Area Processed or Coated			
Chromium	16.34	0.28	6.62	0.11
Lead	5.84	0.10	5.06	0.09
Nickel	54.85	0.90	38.9	0.64
Zinc	51.74	0.85	21.79	0.36
	English Units--lbs/1 million ft² of Area Processed or Coated			
Chromium	3.35	0.06	1.36	0.022
Lead	1.20	0.02	1.04	0.017
Nickel	11.24	1.19	7.97	0.13
Zinc	10.6	0.18	4.46	0.08

(b) Pretreatment Standards for New Sources

Pollutant or Pollutant Property	PSNS			
	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m² of Area Processed or Coated				
Chromium	1.29	0.24	0.52	0.1
Lead	0.35	0.07	0.32	0.06
Nickel	1.91	0.35	1.29	0.24
Zinc	3.55	0.65	1.46	0.27
English Units--lbs/1 million ft² of Area Processed or Coated				
Chromium	0.27	0.05	0.11	0.12
Lead	0.07	0.013	0.07	0.012
Nickel	0.39	0.08	0.27	0.05
Zinc	0.73	0.14	0.13	0.06

D. Subcategory D - Copper Basis Material

No Pretreatment Standards for Existing Sources are being promulgated

(b) Pretreatment Standards for New Source

PSNS

Pollutant or Pollutant Property	Maximum for any 1 day		Maximum for Monthly average	
	Metal preparation	Coating operation	Metal preparation	Coating operation
Metric Units--mg/m² of Area Processed or Coated				
Chromium	2.23	0.24	0.90	0.1
Lead	0.6	0.07	0.54	0.06
Nickel	3.31	0.35	2.23	0.24
Zinc	6.13	0.65	2.53	0.27
English Units--lbs/1 million ft² of Area Processed or Coated				
Chromium	0.46	0.05	0.19	0.02
Lead	0.13	0.013	0.11	0.012
Nickel	0.68	0.08	0.46	0.05
Zinc	1.26	0.14	0.52	0.06

5. No effluent limitations based on the best conventional treatment are being promulgated at this time.

SECTION III

INTRODUCTION

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, 1983, these dischargers are required to achieve effluent limitations requiring the application of the best available technology economically achievable --- which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants (BAT), Section 301(b)(2)(A). New industrial direct dischargers are 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 ((POTW) are subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers are to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards are 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 authorizes 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 requires 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 requires promulgation of regulations for NSPS. Sections 304(f), 307(b), and 307(c) requires promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) of the Act requires the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorizes 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 guidelines, pretreatment standards, and new source performance standards for 65 priority pollutants and classes of pollutants. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified March 9, 1979. Porcelain Enameling is included in the 21 industries in the Agreement.

On December 27, 1977, the President signed into law the Clean Water Act of 1977. Although this law makes several important changes in the Federal water pollution control program, its most significant feature is its incorporation into the Act of 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 "priority" 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 controls. Moreover, to strengthen the toxics control program, Section 304(e) of the Act authorizes 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.

The 1977 Amendments added Section 301(b)(2)(E) to the Act establishing "best conventional pollutant control technology" (BCT) for discharges of conventional pollutants from existing industrial point sources.

BCT is not an additional limitation but replaces BAT for the control of conventional pollutants, TSS, BOD, oil and grease, pH and fecal coliforms. In addition to other factors specified in section 304(b)(4)(B), the Act requires that BCT limitations be assessed in light of a two part "cost-reasonableness" test. American Paper Institute v. EPA, 660 F.2d 954 (4th Cir. 1981). The first test compares the cost for private industry to reduce its conventional pollutants with the costs to publicly owned treatment works for similar levels of reduction in their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find that limitations are "reasonable" under both tests before establishing them as BCT. In no case may BCT be less stringent than BPT.

EPA published its methodology for analyzing BCT costs on August 29, 1979 (44 FR 50732). In the case noted above, the Court of Appeals ordered EPA to correct data errors underlying EPA's calculation of the first test, and to apply the second cost test. (EPA had argued that a second cost test was not required.)

EPA has determined that the technology which is the basis for porcelain enameling BAT can remove significant amounts of conventional pollutants. However, EPA has not yet developed a revised BCT methodology in response to the American Paper Institute v. EPA decision mentioned earlier. Accordingly, EPA is deferring a decision on the appropriate final BCT limitations.

NSPS are based on the best available demonstrated technology (BDT). New plants have the opportunity to install the best and most efficient production processes and wastewater treatment technologies.

PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of publicly owned treatment works.

GUIDELINES DEVELOPMENT SUMMARY

The proposed effluent limitations and standards (January 27, 1981) for porcelain enameling were developed from data obtained from previous EPA studies, literature searches, and a plant survey and evaluation. Initially, information from EPA records was collected and a literature search was conducted. This information was then catalogued in the form of individual plant summaries describing processes performed, production rates, raw materials utilized, wastewater treatment practices, water uses and wastewater characteristics.

In addition to providing a quantitative description of the porcelain enameling category, this information was used to determine if the characteristics of plants in the category as a whole were uniform and thus amenable to one set of effluent limitations and standards. Since the characteristics of the plants in the data base and the wastewater generation and discharge varied widely, the establishment of subcategories was determined to be necessary. The subcategorization of the category was made by using basis material processed as the subcategory descriptor. The subcategorization process is fully discussed in Section IV of this Development Document.

To supplement existing data, data collection portfolios (dcp's) under authority of Section 308 of the Federal Water Pollution Control Act, as amended, were transmitted by EPA to all known porcelain enameling companies. In addition to existing and plant supplied information (via dcp), data were obtained through a sampling program carried out at selected sites. Sampling consisted of a screening program at one plant for each basis material type plus verification at up to 5 plants for each type. Screen sampling was utilized to select pollutant parameters for analysis in the second or verification phase of the program. The designated priority pollutants (65 toxic pollutants) and typical porcelain enameling pollutants formed the basic list for screening. Verification sampling and analysis was conducted to determine the source and quantity of the selected pollutant parameters in each subcategory.

Available data were analyzed to determine wastewater generation and mass discharge rates for each basis material subcategory. In addition to evaluating pollutant generation and discharges, the full range of control and treatment technologies existing within the porcelain enameling category was identified. This was done by taking into consideration the pollutants to be treated and the chemical, physical, and biological characteristics of these pollutants. Special attention was paid to in-process technology such as the recovery and reuse of process solutions, the recycle of process water and the curtailment of water use.

The information as outlined above was then evaluated in order to determine what levels of technology were appropriate as a basis for effluent limitations for proposed existing sources based on the best practicable control technology currently available (BPT) and based on best available technology economically achievable (BAT). Levels of technology appropriate for pretreatment of wastewater introduced into a publicly owned treatment works (POTW) from both new and existing sources were also identified as were the new source performance standards (NSPS) based on best demonstrated control technology, processes, operating methods, or other alternatives (BDT) for the control of direct discharges from new sources. In evaluating these technologies various factors were considered. These included treatment technologies from other industries, any pretreatment requirements, the total cost of application of the technology in relation to the effluent reduction benefits to be achieved, the age of equipment and facilities involved, the processes employed, the engineering aspects of the application of various types of control technique process changes, and non-water quality environmental impact (including energy requirements). This information is summarized in the proposed regulation development document for porcelain enameling (EPA 440/1-81/072-b).

Sources of Industry Data

Before proposal of limitations, data on the porcelain enameling category were gathered from previous EPA studies, literature studies, inquiries to federal and state environmental agencies, raw material manufacturers and suppliers, trade association contacts and the porcelain enameling manufacturers themselves. Additionally, meetings were held with industry representatives and the EPA. All known porcelain enamelers were sent a data collection portfolio (dcp) to solicit specific information concerning each facility. Finally, a sampling program was carried out at plants consisting of screen sampling and analysis at five facilities to determine the presence of a broad range of pollutants and verification sampling and analysis at 15 plants (at two plants two subcategories were sampled) to quantify the pollutants present in porcelain enameling wastewater. Specific details of the sampling program and information from the above data sources are presented in Section V of this Document.

Literature Study - Published literature in the form of books, reports, papers, periodicals, and promotional materials was examined. The most informative sources are listed in Section XV.

EPA Studies - A previous preliminary and unpublished EPA study of the porcelain enameling segment was reviewed. The information included a summary of the industry describing: the manufacturing processes; the waste characteristics associated with these processes; recommended pollutant parameters requiring control; applicable end-of-pipe treatment technologies for wastewaters; effluent characteristics resulting from this treatment; and a background bibliography. Also included in these data were detailed production and sampling information on approximately 19 manufacturing plants.

Plant Survey and Evaluation - The collection of data pertaining to facilities that perform porcelain enameling was a two-phased operation. First, a mail survey was conducted by EPA. A dcp was mailed to each company in the country known or believed to perform porcelain enameling. This dcp included sections for general plant data, specific production process data, waste management process data, raw and treated wastewater data, waste treatment cost information, and priority pollutant information based on 1976 production records. Nearly 250 requests for information were mailed. From this mailing, it was determined that 103 companies operate 123 porcelain enameling facilities. Of the total data requests, 117 submitted a completed dcp for porcelain enameling, 2 plants that did no porcelain enameling submitted dcps, 95 reported no porcelain enameling, three were dry processors, six were not deliverable, 17 mailings went to corporate addresses, 10 were duplicate mailings, and there was no response from three. Some plants responded with 1977 or 1978 data, while most provided 1976 data. Table III-1 (Page 43) summarizes the survey responses received. It was subsequently learned in a telephone survey of several plants that plant 36069 had ceased operations. This reduced the number of porcelain enameling plants identified to 116.

Utilization of Industry Data

Data collected from the previously listed sources are used throughout this report in the development of a base for BPT and BAT limitations and NSPS and pretreatment standards. The EPA studies as well as the available literature provided the basis for the porcelain enameling subcategorization discussed in Section IV. Raw wastewater characteristics for each subcategory presented in Section V were obtained from the screening and verification sampling. Dcp information on wastewater characteristics was incomplete. Selection of pollutant parameters for control (Section VI) was based on both dcp responses and verification and screening results. These provided information on both the pollutants which the plant personnel felt were in their wastewater discharges and those pollutants specifically found in porcelain enameling wastewaters as the result of sampling. Based on the selection of pollutants requiring control and their levels, applicable treatment technologies were identified and are described in Section VII of this document. Actual waste treatment technologies utilized by porcelain enameling plants (as identified in the dcp responses and observed at the sampled plants) were also used to identify applicable treatment technologies. The cost of treatment (both individual technologies and systems) is based primarily on data from equipment manufacturers and is contained in Section VIII of this document. Finally, dcp data, sampling data and estimated treatment system performance are utilized in Sections IX, X, XI, and XII (BPT, BAT, NSPS, and pretreatment respectively) in the selection of applicable treatment systems, the presentation of achievable effluent levels, and the presentation of actual effluent levels obtained for each porcelain enameling subcategory. Cost of treatment systems and environmental benefits are presented for BPT, BAT, NSPS, and pretreatment in Sections IX, X, XI, and XII, respectively. The technical development document was published with the proposed regulation for Effluent Limitations Guidelines and Standards for Porcelain

Enameling, and public comments were invited. In response to public comments, changes were made in this document before the final regulation was published. The two most important changes to the proposed regulation are reanalysis of the combined metals data base (described in Section VII) and recalculation of the estimated compliance costs (described Section VIII). Other changes include reevaluation of the feasibility of filtration, dry powder coatings and a sump settling technologies (described in Section VII), a reconsideration of the pollutants requiring limitation (Sections VI and IX) and modifications of the production normalized water use data base in Section V, IX, X, XI).

DESCRIPTION OF THE PORCELAIN ENAMELING INDUSTRIAL SEGMENT

Background

Porcelain enameling is the application of glass-like coatings to metals such as steel, cast iron, aluminum or copper. The purpose of the coating is to improve surface characteristics of the product such as; chemical resistance, abrasion resistance, thermal stability, electrical resistance and appearance. Most coatings are applied to the workpiece as "slip" which is composed of frit (glassy-like raw material), clays, coloring oxides, metal salts, water, and special additives such as suspending agents. The vitreous inorganic coating is produced by applying the slip to the metal by a variety of methods such as spraying, dipping, and flow coating, and then bonding the coating to the base metal at temperatures in excess of 500°C (1,000°F). At these temperatures, finely ground enamel frit particles fuse and flow together entrapping the other solid constituents of the slip to form the permanently bonded, hard porcelain coating. Some enamel coating is applied as a dry powder. The powder is prepared from frit, fluxes, and other components. The dry powder is applied by electrostatic powder spraying or by dusting the powder onto the hot object (usually cast iron plumbing ware).

The facilities regulated by this category may be listed under SIC codes 3469 (porcelain enameled products, except plumbing supplies), 3431 (enameled iron and metal sanitary ware), 3479 (porcelain enameling for the trade), 3631 (household cooking equipment), 3632 (household refrigerators and home and farm freezers), 3633 (household laundry equipment), and 3639 (household appliances, not elsewhere classified). Included among these areas are the large appliance, cookware, architectural panel, and plumbingware industries.

The porcelain enameling category is estimated to consist of 116 plants of various sizes. Included in this total are many plants that also perform metal finishing, aluminum forming or other processes included in other point source categories. Independent shops obtain raw untreated metal, and produce a wide variety of porcelain enameled products for specific customers. Sometimes the independent porcelain enameler performs a toll function, coating basis materials owned by the customer. A captive porcelain enameling operation is usually an integral part of a large corporation engaged in many phases of metal production and finishing. The annual square footage for most independent shops is lower than captive porcelain enameling operations.

Porcelain enameling facilities generally clean, etch and apply porcelain enamel to one of four basis materials which are steel (sometimes called sheet iron), cast iron, aluminum, and copper. Special low-carbon steels, generally referred to as enameling iron, are used extensively because of their superior performance in enameling operations. A few facilities coat more than one basis material, usually steel and cast iron. The basis metal is prepared for enamel application on both sides of the work piece, but the number of coats applied varies according to product specifications. A ground coat is usually applied to the whole work piece with the additional coatings applied to one side or again to both sides as necessary.

Most porcelain enameling facilities purchase coating materials and metal preparation chemicals including alkaline cleaners, acids, neutralizers, etc. Virtually all porcelain enameling facilities blend and grind purchased materials in a ball mill to make slip, a viscous fluid to be coated on the work piece.

Slip ingredients are manufactured and sold by only a few specialized chemical firms. Many formulations of slip may be used in any plant so that the finished porcelain enamel surface will meet individual product specifications. In general, porcelain enamel facilities depend heavily on their individual vendors for technical advice for optimum use of purchased chemicals.

Description of Porcelain Enameling Process

Regardless of the basis metal being coated, the porcelain enameling process involves the preparation of the enamel slip or powder, surface preparation of the basis material, application of the enamel, drying, and firing to fuse the coating to the metal. The following sections describe the various production processes involved in porcelain enameling. They are, ball milling, metal surface preparations, enamel application methods, and process sequences for each basis metal coated.

Ball Milling

Ball milling is the process of mixing and grinding frit and other raw materials to form an enamel slip of the appropriate consistency for a particular application. The components of the enamel are loaded into a revolving drum (ball mill) with water and grinding balls made of porcelain or alumina. The revolving motion of the ball mill causes the balls to impact, trapping raw materials in between them. This action, over a period of time, breaks the individual particles into very small fragments and forms a homogeneous mixture suitable for spraying, dipping or flow coating. The very fine particle size achieved in a ball mill (about 99 percent will pass through a 325 mesh screen) provides a very large surface area making metal components more available for leaching into water.

A typical enamel slip is comprised of a combination of the following:

1. Frit or a combination of frits - These make up the major portion of the slip.
2. Clays - Clays are used as floating agents to suspend the frit particles in the slip.
3. Gums - Compounds such as gum arabic and gum tragacanth are used as floating agents in some enamels and in other cases are used as hardness controllers.
4. Suspending agents such as bentonites and colloidal silica.
5. Opacifiers such as tin oxide, zirconium oxide or "uverite".
6. Coloring oxides which impart desired color to the enamel.
7. Electrolytes such as borax, sodium carbonate and magnesium sulfate which control the properties of the slip.
8. Water, which is the vehicle for the coating.

Basis Material Preparation

In order for the porcelain enamel to form a good bond with the workpiece, the base metal to be coated must be properly prepared. Depending on the type of metal being finished, one or more surface preparation processes are performed. These processes may include solvent cleaning, alkaline cleaning, acid etch, grit blasting, nickel strike, neutralization, and chromate cleaning.

Solvent Cleaning is used to remove oily dirt, grease, smears and fingerprints from metal workpieces. Solvent cleaning is classified as either hot cleaning such as vapor degreasing or cold cleaning which covers all solvent cleaning performed at or near room temperature. Vapor degreasing, which is carried out in specifically designed equipment that maintains a nonflammable solvent such as trichloroethylene or 1,1,2-trichloroethane at its boiling point, is used to clean metal parts. It is very effective in removing non-saponifiable oils, and sulfurized or chlorinated components. It is also used to flush away soluble soil. In cold cleaning, the solvent or mixture of solvents is selected based on the type of soil to be removed. For some parts, diphase cleaning provides the best method of cleaning where soil removal requires the action of water and organic compounds. This approach uses a two layer system of water soluble and water insoluble solvents. Diphase cleaning is particularly useful where both solvent-soluble and water-soluble lubricants are used.

Alkaline Cleaning is used to remove oils, soils or solid soil from workpieces. The detergent nature of the cleaning solution provides most of the cleaning action with agitation of the solution and movement of the workpiece being of secondary importance. Alkaline cleaners are classified into three types: soak, spray, and electrolytic. Soak cleaners are used on easily removed soil. This type of cleaner is less efficient than spray or electrolytic cleaners.

Spray cleaners combine the detergent properties of the solution with the impact force of the spray which mechanically loosens the soil. A difficulty with spray cleaning is that to be effective the spray must reach all surfaces. Another problem is that the detergent concentration is often lessened because of foaming.

When aluminum is the metal being porcelain enameled, a stronger alkaline solution is often used to bring about a mild etch or micro etch of the metal. The purpose of the etch is to remove a thin layer of aluminum, thereby ensuring that surface oxides are removed.

Electrolytic cleaning produces the cleanest surfaces available from conventional methods of cleaning. The effectiveness of this method results from the strong agitation of the solution by gas evolution and oxidation-reduction reactions that occur during electrolysis. Also, certain dirt particles become electrically charged and are repelled from the surface. Direct current (cathodic), the most common electrolytic cleaning, uses the workpiece as the cathode, while reverse current (anodic) cleaning uses the workpiece is the anode. Periodic reverse current cleaning is a combination of anodic and cathodic cleaning in which the current is periodically reversed. Periodic reverse cleaning gives improved smut removal, accelerated cleaning and a more active surface for subsequent coating.

Acid Etch - Acid may be utilized to remove rust, scale and oxides that form on a part and to provide desired surface characteristics prior to porcelain enameling. Acid etch may include acid cleaning, acid pickling or acid etching. Acid cleaning involves a mild acid solution which dissolves surface oxides; acid pickling uses a stronger solution which dissolves and attacks the metal, liberating hydrogen gas which forces scale from the surface. Acid etching makes use of a strong acid solution for the controlled removal of surface metal. The result of this is a clean, bare and etched basis material.

As a rule, sulfuric acid is used for acid etching in the porcelain enameling industry, although hydrochloric (muriatic) acid, phosphoric acid and nitric acid are also employed. In many cases, an acid ferric sulfate solution is used in conjunction with a sulfuric acid dip for pickling of steel. The ferric sulfate solution attacks or etches the metal much (four to six times) faster than acid alone. However, since it does not remove rust, smut and scale as efficiently as sulfuric acid, a sulfuric acid dip is also required.

Nickel Flash - Prior to the porcelain enameling of many steels, a nickel plating step is performed. This deposition of nickel is a form of immersion plating in which a thin, metal deposit is obtained by chemical displacement on the surface of the basis metal. In immersion plating, a metal displaces from solution any other metal that is below it in the electromotive series of elements. The more noble metal is deposited from solution while the more active is dissolved. In this particular case, nickel comes out of solution and deposits on the steel while iron ions go into solution.

Nickel flash is employed in order to improve the bond between the porcelain enamel and the metal. It is normally deposited after the part has been etched and rinsed. The solution can consist of single ($NiSO_4 \bullet 6H_2O$) or double ($NiSO_4 \bullet (NH_3)_2SO_4 \bullet 6H_2O$) nickel salts with nickel sulfate being the predominant component.

Neutralization - The neutralization step follows the acid etch and nickel flash (if present) steps prior to the porcelain enameling of steel. Its function is to remove the last traces of acid left on the metal surface. Neutralization may or may not be followed by a rinse.

The alkali neutralizer solution may be made up of soda ash, borax or trisodium phosphate and water. The alkalinity of these compounds neutralizes any remaining acid.

Chromate Cleaning - When certain aluminum alloys (such as high magnesium alloys) are being porcelain enameled, a chromate cleaning or pickling solution is usually used to enhance adherence of the enamel. Typical solutions contain a source of chromate (potassium chromate or sodium bichromate), sodium hydroxide and water. This step, when used, is the final preparation step performed on aluminum prior to porcelain enameling. Data received indicate that four aluminum porcelain enameling plants utilize the chromate cleaning process.

Grit Blasting is a mechanical surface preparation in which an abrasive impacts the metal to be processed in order to produce a roughened, matte surface. The mold chilled surface of cast iron must be altered to achieve a good bond with porcelain enamel and grit blasting has proven to be effective in producing a suitable surface. Sand, steel grit, and steel shot are the abrasives used in blasting, though steel grit appears to be most widely used in porcelain enameling. The parts which are grit blasted require no additional surface preparation since they are essentially clean and their roughened surfaces provide a good 'tooth' for porcelain enamel adherence.

Coating Application Methods

Once the workpiece has undergone the proper basis metal preparation and the enamel slip has been prepared, the next step is the actual application of the porcelain enamel. Included among the application methods used are air spraying, electrostatic spraying, dip coating, electrostatic powder coating, flow coating, powder coating, and silk screening. After each coating is applied, the part is dried if a wet coating is used, then fired in a furnace to fuse the enamel coating to the basis metal or substrate.

Air Spraying - The most widely used method of enamel application is air spraying. In this process, enamel slip is atomized and propelled by air into a conical pattern, which can be directed over the article to be coated by an operator or machine. The atomization of the coating material occurs due to the expansion and turbulence of compressed air, which tears the slip into tiny droplets.

Air spraying operates with controlled air pressure supplied to the slip container from a compressed air supply line and finishing material supplied from a flexible fluid hose. This type of spraying is especially good if there are frequent color changes or if parts of random shape and size are to be coated.

Electrostatic Spray Coating incorporates the principles of air atomized spray coating with the attraction of unlike electric charges. In electrostatic spray coating, atomized slip particles are charged at 70,000-100,000 volts and directed toward a grounded part. The electrostatic forces push the particles away from the atomizer and away from each other. The charged particles are attracted to the grounded workpiece and adhere to it.

Dip Coating consists of submerging a part in a tank of slip, withdrawing the part, and permitting it to drain or centrifuging it to remove excess slip. There are several instances for which dip coating is well suited:

1. Large parts too bulky to be spray coated.
2. Parts with complex shapes or deep recesses.
3. Parts that require metal protection, but uniformity of coating and appearance are not important
4. Large numbers of small parts such as hardware.
5. Small objects that require coating on only one end.

Flow Coating - In the flow coating process, enamel slip is pumped from a storage tank to nozzles that are positioned according to the shape and size of the parts so as to direct the flow of enamel onto the surface of the parts as the parts are conveyed past the nozzles. The excess enamel drains back to the storage tank for recirculation.

Powder Coating is an application method employed for cover coating cast iron. It is a dry process which requires no water. After a ground coat is applied and fused, the hot or reheated cast iron part, in a red hot condition, is dusted with porcelain enamel in the form of a dry powder. The glass powder melts as it strikes the hot surface. The dusting is carried out as long as the temperature of the part is higher than the melting point of the powder. If necessary, the casting can be reheated and dusted several times to achieve the desired finish.

Electrostatic Powder Coating is a combination of electrostatic spray coating and powder coating. Charged dry powder particles are sprayed toward the workpiece and are attracted to the cold grounded workpiece by electrostatic attraction. The process is dry, neither using process water nor generating process wastewater.

Silk Screening is utilized by some companies to impart a decorative pattern onto a porcelain enameled piece. This is accomplished through the use of an oil based porcelain enamel which is applied to the part through a stencil constructed of silk. The enamel is spread on in a thin layer with a squeegee. After application, the workpiece is baked to achieve fusion of the enamel. It should be noted that only one color can be applied and baked at one time.

INDUSTRY SUMMARY

The porcelain enameling industry in the United States is estimated to consist of at least 116 porcelain enameling plants. The basis materials enameled are steel, cast iron, aluminum and copper. Products manufactured are varied, ranging from large cooking appliances (porcelain on steel) to smaller, more specialized items such as jewelry (porcelain on copper). Of the 116 plants known to apply porcelain enamel, 100 facilities enamel on steel, 12 enamel on cast iron 16 enamel on aluminum, and two enamel on copper. Several facilities coat two different basis materials.

General Information

- Plants range in age from new to almost 100 years old. Most plants were built or modified significantly after 1960.
- Employment in plants engaged in porcelain enameling ranges from 3 to almost 3,000 people. These figures represent total plant employment and do not necessarily represent only employees engaged in porcelain enameling for captive operations. The average employment is 173 people.
- 88 facilities discharge to municipal treatment systems; 28 discharge to streams or rivers.

Production Profile

- The average (mean) porcelain enamel plant applies
  1.08×10^6 m^2/yr (11.6×10^6 ft^2/yr). metal preparation
  1.18×10^6 m^2/yr (12.7×10^6 ft^2/yr). porcelain enamel coated
- Total porcelain enamel applied each year by all plants is estimated at 153×10^6 m^2 (1610×10^6 ft^2).
- The average production rate of a plant in each basis metal subcategory is:

	Metal Prep		Coating	
(Millions)	m^2/yr	ft^2/yr	m^2/yr	ft^2/yr
Steel	1.230	13.23	1.400	15.06
Cast Iron			0.796	8.56
Aluminum	0.257	2.765	0.207	2.227
Copper	0.052	0.560	0.054	0.581

Porcelain enameling operations generate wastewater from surface preparation of the basis material and from the enamel application process. The rate of process water discharge varies from five to almost 15,000 gallons per hour.

The porcelain enameling industrial segment has various types of end-of-pipe treatment systems but only limited in-process treatment to handle wastewater streams. Seventy-two percent of the plants have no treatment in-place. Dcp's indicate that the following waste treatment components are commonly found in this industrial segment.

Treatment in Place	Percent of Plants
pH Adjust-Lime or Caustic	28
pH Adjust-Acid	9
Chemical Precipitation and Sedimentation	28
Sedimentation Lagoon	11
Contract Removal of Sludge	7
Landfill of Sludge	21

Industry Outlook

Porcelain enameling as an industry in this country is about 100 years old. During the first half of the 20th century porcelain enameling was a vigorous industry segment as it supplied a low cost weather resistant surface of great durability. Products ranged from household pots and plumbingware to outdoor signs and building surface panels. The advent of stainless and aluminum ware, improved characteristics of painted metals, molded and formed plastic parts and changes in architectural taste have combined to reduce the relative demand for porcelain enameling. Despite the fact that lower cost competitive materials are eroding some porcelain enamel markets, it appears to be a stable industry. Additional consideration of the industry economic outlook is provided in the Agency's Economic Analysis of the Industry (EPA 440/2-82-005).

TABLE III-1

PORCELAIN ENAMELING INDUSTRY PROFILE SUBCATEGORIZATION AND DISCHARGE INFORMATION

			PROCELAIN ENAMELING SUBCATEGORY AND DIRECT (a) OR INDIRECT (b) DISCHARGE							
PLANT ID	DATE BUILT OR MODIFIED	NUMBER OF EMPLOYEES	STEEL		CAST IRON		ALUMINUM		COPPER	
			DIR	IND	DIR	IND	DIR	IND	DIR	IND
01059	1978	22		X						
01061	1978	500	X	X						
01062	1972	10		X						
03032	1976	50	X							
03033	1972	9						X		
04066	1946	20		X						
04098	1976	30	X							
04099	1978	12		X	X					
04101	1952	30		X						
04102	1975	40		X						
04122	1964	65		X						
04126	1946	160		X				X		
04138	1966	32		X		X				
06030	1971	8						X		
06031	1970	10								X
09031	1977	66		X						
09032	1973	55		X						
09037	1967	600						X		
11045	1965	12						X		
11052	1975	160		X						
11053	1976	1084		X						
11082	1974	1237		X						
11089	1976	53		X						
11090	1976	75		X						
11091	1977	45		X						
11092	1950	100	X		X					
11105	1966	22		X						
11106	1967	10		X						
11107	1962	1080		X						
11117	1965	1300		X						
11923	1973	1200		X						
12035	1955	154		X						
12037	1946	40		X						
12038	1968	86		X						
12039	1968	185	X		X					
12040	1946	125	X	X						
12043	1929	390		X						
12044	1958	538		X						
12045	1975	20		X				X		

(a) Direct: Discharge of PE Process Wastewater to Surface Water Course.

(b) Indirect: Discharge of PE Process Wastewater to POTW

TABLE III-1 (Continued)

PORCELAIN ENAMELING INDUSTRY PROFILE
SUBCATEGORIZATION AND DISCHARGE INFORMATION

			PROCELAIN ENAMELING SUBCATEGORY AND DIRECT (a) OR INDIRECT (b) DISCHARGE							
			STEEL		CAST IRON		ALUMINUM		COPPER	
PLANT ID	DATE BUILT OR MODIFIED	NUMBER OF EMPLOYEES	DIR	IND	DIR	IND	DIR	IND	DIR	IND
12064	1977	750		X						
12234	1974	65		X						
12235	1977	290		X						
13321	1964	–		X						
13330	1977	175		X						
15031	1970	75		X						
15032	1976	15	X							
15033	1968	175		X						
15051	1967	275		X						
15194	1971	79	X							
15712	1959	1080				X				
15949	1978	160		X						
18538	1970	1400	X							
19049	1976	15		X						
20015	1976	80		X						
20059	1978	7		X						
20067	1969	50	X							
20090	1964	14		X						
20091	1970	76		X						
21060	1965	500						X		
22024	1977	13		X						
23089	1949	–		X		X				
30043	1970	138		X						
30062	1967	46	X							
33053	1960	8					X			
33054	1968	2800	X							
33076	1958	38				X				
33077	1967	14					X			
33083	1971	373						X		
33084	1957	56		X						
33085	1960	1155		X						
33086	1954	155	X							
33088	1965	4		X						
33089	1977	–		X						
33092	1973	40		X						
33097	1957	70	X							
33098	1969	27		X						

(a) Direct: Discharge of PE Process Wastewater to Surface Water Course.
(b) Indirect: Discharge of PE Process Wastewater to POTW

TABLE III-1 (Continued)

PORCELAIN ENAMELING INDUSTRY PROFILE
SUBCATEGORIZATION AND DISCHARGE INFORMATION

			PROCELAIN ENAMELING SUBCATEGORY AND DIRECT (a) OR INDIRECT (b) DISCHARGE							
PLANT ID	DATE BUILT OR MODIFIED	NUMBER OF EMPLOYEES	STEEL		CAST IRON		ALUMINUM		COPPER	
			DIR	IND	DIR	IND	DIR	IND	DIR	IND
33104	1975	200	X							
33617	1977	516	X							
34031	1974	35	X				X			
36030	1978	50		X						X
36039	1964	30		X		X				
36052	1978	110	X							
36069	1973	6		X		X				
36072	1977	28		X		X				
36077	1957	11	X				X			
36078	1956	3		X						
40031	1969	47		X						
40032	1972	245	X							
40033	1977	1500	X							
40034	1976	51		X						
40035	1977	25		X						
40036	1968	6		X						
40039	1977	75		X						
40040	1953	20	X							
40041	1977	28		X						
40042	1964	11	X							
40043	1976	11		X						
40050	1972	50		X						
40053	1966	75		X		X				
40055	1973	210	X	X						
40063	–	216	X							
40540	1971	9	X							
41062	1971	59	X							
41076	1977	70		X						
41078	1958	55		X						
44031	1967	28		X						
45030	1974	79		X						
47032	1965	28						X		
47033	1977	35		X						
47034	1960	42		X						
47036	1978	12						X		
47037	1953	32		X						
47038	1965	38		X						
47050	1951	40		X		X				
47051	1971	46						X		
47111	1948	306			X					
47670	1978	48						X		

(a) Direct: Discharge of PE Process Wastewater to Surface Water Course.
(b) Indirect: Discharge of PE Process Wastewater to POTW

SECTION IV

INDUSTRY SUBCATEGORIZATION

INTRODUCTION

Subcategorization should take into account pertinent industry characteristics, manufacturing process variations, water use, wastewater characteristics, and other factors which do or could compel a specific grouping of segments of industry for the purpose of regulating wastewater pollutants. Effluent limitations and standards establish mass limitations on the discharge of pollutants which are applied, through the permit issuance process, to specific dischargers. Division of the industry segment into subcategories provides a mechanism for addressing process and product variations which result in distinct wastewater characteristics. To allow the national limitations and standards to be applied to a wide range of sizes of production units, the mass of pollutant discharge must be referenced to a unit of production. This factor is referred to as a production normalizing parameter and is developed in conjunction with subcategorization.

SUBCATEGORIZATION BASIS

Factors Considered

After considering the nature of the various segments of the porcelain enameling industry and the operations performed therein, the following subcategorization bases were selected for evaluation.

1. Basis Material Used
2. Manufacturing Processes
3. Wastewater Characteristics
4. Products Manufactured
5. Water Use
6. Water Pollution Control Technology
7. Treatment Costs
8. Solid Waste Generation and Disposal
9. Size of Plant
10. Age of Plant
11. Number of Employees
12. Total Energy Requirements (Manufacturing Process and Waste Treatment and Control)
13. Non-Water Quality Characteristics
14. Unique Plant Characteristics

Subcategory Selection

A review of each of the potential subcategorization factors reveals that the basis material used and the processes performed on these basis materials are the principal factors affecting the wastewater characteristics of plants in the porcelain enameling category. This is because both the process chemicals and the basis material constituents can appear in wastewaters. The major manufacturing processes in the porcelain enameling industry are cleaning, etching, and enamel application. Wastewaters from cleaning and etching are dependent on the basis material processed, while wastewaters from the enamel application step are relatively independent of the basis material. Therefore, subcategorization by basis material inherently accounts for the process chemicals used. Such a subcategorization is:

A. Porcelain enameling on steel
B. Porcelain enameling on cast iron
C. Porcelain enameling on aluminum
D. Porcelain enameling on copper

In addition to the above subcategorization, the steel and aluminum base metals could be further divided into two segments, sheet and strip to account for the significant water saving potential of continuous operations relative to individual sheet processing. However, because there are only two known porcelain enamelers on strip, it was not selected as a separate subcategory.

Other Factors Considered

Other categorization bases considered but not selected for categorization are presented in the following subsections along with the reasons why they are not considered as appropriate as the basis selected.

Products Manufactured. The products porcelain enameled are varied ranging from pots and pans to washing machine drums. While there are specific manufacturing differences from product to product (and hence, wastewater differences), subcategorization by the discrete process differences associated with each basis metal inherently accounts for product variation in terms of wastewater characteristics.

Water Use. Water use alone is not a comprehensive enough factor for subcategorization. While water use is a key element in the limitations established, it does not inherently relate to the source or to the type and quantity of the waste. Water use must be related to the manufacturing process utilizing the water since it dictates the water use and cannot be used alone as an effective subcategorization base.

Water Pollution Control Technology and Treatment Costs. The necessity for a subcategorization factor to relate to the raw wastewater characteristics of a plant automatically eliminates certain factors from consideration as potential bases for subdividing the category. Water pollution control technology, treatment costs, and effluent discharge destination have no effect on the raw waste water generated in a plant. The water pollution control technology employed at a plant and its cost are the result of a requirement to achieve a particular effluent level for a given raw wastewater load. It does not affect the raw wastewater characteristics.

Solid Waste Generation and Disposal. Physical and chemical characteristics of solid waste generated by the porcelain enamel category are inherently accounted for by subcategorization according to basis metal or manufacturiing process used, since these factors determine the resultant solid waste from a plant. Solid waste characteristics as well as wastewater characteristics are a function of the basis metal and process employed in a plant. Solid waste disposal techniques may be identical for a wide variety of solid wastes and do not provide a sufficient basis for subcategorization.

Size of Plant. The nature of the processes for the porcelain enameling industry are the same in all facilities regardless of size. The size of a plant is not an appropriate basis for subcategorization parameter since the waste characteristics of a plant per unit of production are essentially the same for plants of all sizes when processing the same basis material. Thus, size alone is not an adequate technical subcategorization parameter since the wastewater characteristics of plants are dependent on the type of products produced.

While size is not adequate as the technical subcategorization parameter, it is recognized that the capital investment for installing wastewater control facilities may be greater for small plants relative to the investment in their production facilities than for larger plants. Consequently, the size distribution of plants was investigated during the development of limitations and wastewater treatment technology recommendations were reviewed to determine if special considerations are required for small plants.

Age of Plant. While the relative age of a plant is important in considering the economic impact of a guideline, it is not an appropriate basis for grouping the porcelain enamel industry into subcategories because it does not take into consideration the significant parameters which affect the raw wastewater characteristics. The basis material enameled dictates the processes employed and these have a much more significant impact on the raw wastewater generated than the age of the plant. In addition, subcategorization would have to allow for old plants with new equipment, new plants with old equipment and other possible combinations.

Number of Employees. The number of employees in a plant does not directly provide a basis for subcategorization since the number of employees does not necessarily reflect the production or water use at any plant. A plant manually controlled and operated by six people may produce less than an automated plant with two employees that has extensive automated equipment. Since the amount of wastewater generated is related to the production rates, the number of employees does not provide a definitive relationship to wastewater generation.

Total Energy Requirements. Total energy requirements were excluded as a subcategorization parameter primarily because of the difficulty in obtaining reliable energy estimates specifically for production and waste treatment. When energy consumption data are available, they are likely to include other energy requirements such as lighting, process, air conditioning, and heating or cooling energy figures.

Non-Water Quality Aspects. Non-water quality aspects may have an effect on the wastewater generated in a plant. A non-water quality area such as air pollution discharges may be under regulation and water scrubbers may be used to satisfy such a regulation. This could result in an additional contribution to the plant's wastewater. However, it is not the prime cause of wastewater generation in the porcelain enamel category, and therefore not useful as an overall subcategorization factor.

Unique Plant Characteristics. Unique plant characteristics such as geographical location, space availability, and water availability do not provide a proper basis for subcategorization since they do not necessarily affect the raw wastewater characteristics of the plant. Plants in the same geographical area have different wastewater characteristics. Process water availability may be a function of the geography of a plant, and the price of water determines any necessary modifications to water use procedures employed in each plant. However, required procedural changes to account for water availability only affect the volume of pollutants discharged, not the characteristics of the constituents. Waste treatment procedures can be utilized in most geographical locations.

A limitation in the availability of land space for constructing a waste treatment facility may in some cases affect the economic impact of an effluent limitation. However, in-process controls and rinse water conservation can be adopted to minimize the size - and thus land space required - for the end-of-process treatment facility. Often, a compact treatment unit can easily handle end-of-process waste if good in-process techniques are utilized to conserve raw materials and water.

Summary of Subcategorization

For this study, it was determined that the principal factor affecting the wastewater characteristics of plants in the porcelain enamel category is the basis metal enameled. This dictates the type of preparation required, thus affecting the waste characteristics. The coating operations were considered as a separate subcategory because these wastewaters are basically homogeneous regardless of basis metal to which the enamel is applied. Because of the different subcategory flows observed, the coating wastewaters are subcategorized according to basis metal.

PRODUCTION NORMALIZING PARAMETERS

The relation of the pollution generation rate to spent solution and slip generation rates is directly dependent on the amount of porcelain enameling performed, i.e., the processed area. This leads naturally to the selection of processed area as a production related pollutant discharge rate parameter. Processed area might be different for surface preparation operations and enamel application. This results from the application of multiple coats of porcelain enamel to a part, or enamel application on only one side of a part that has had both sides prepared by a dip operation. Therefore, area processed must consider both the area prepared (each side) and the area coated.

Weight of material being porcelain enameled is a direct and readily identifiable production normalizing parameter. However, the thickness of the basis material can vary. This can result in a variation in surface area for products of identical weights. This variation in surface area affects the quantity of spent solutions and process baths. Thus, the weight of product is not sufficient for determining a quantitative prediction of pollutant discharge rate. The processed area must be used.

Raw materials consumed was also considered for a production normalizing parameter. The amount of chemicals and other materials used in production is not an accurate measure of the production rate because some plants are more efficient in their use of porcelain enamels and chemicals. Reduction of dragout is an important production feature that can extend the life of various solutions. As bath dragout is reduced, the amount of solution makeup required is also reduced. Thus, the amount of raw materials consumed for identical processed areas can vary widely. For these reasons, the amount of raw materials consumed is not appropriate as a production normalizing parameter. In summary, area of basis material cleaned and area coated were determined to be the most logical and useful production normalizing parameters.

SECTION V

WATER USE AND WASTEWATER CHARACTERIZATION

This section presents supportive data which describe porcelain enameling water use and wastewater characteristics. Data collection and data analysis methodologies are discussed. Raw waste and effluent concentrations, flows and pollutant mass per unit of production area are presented for the four basis material subcategories and for specific functional operations in each.

DATA COLLECTION

Data on the porcelain enameling category segment were gathered from previous EPA studies, literature studies, inquiries to federal and state environmental agencies, raw material manufacturers and suppliers, trade association contacts and the porcelain enamelers themselves via a mail survey and plant visits. Additionally, meetings were held with industry representatives.

Literature Study:

Published literature in the form of books, reports, papers, periodicals, and promotional materials was examined; the most informative sources are listed in Section XV. The material researched covered the manufacturing processes utilized in porcelain enameling, water used, wastewater treatment technology and economic data.

Previous EPA Studies:

Previous EPA studies of the porcelain enameling industry segment were examined. From these studies information was gathered on manufacturing processes, wastewater treatment technology, and some preliminary raw wastewater characteristics at specific plants.

Federal and State Contacts:

Federal EPA regional offices and several state environmental agencies were contacted to obtain permit and monitoring data on specific porcelain enameling plants.

Raw Material Manufacturers and Suppliers:

Eight manufacturers of porcelain enamel slip ingredients were contacted by the EPA and requested to supply priority pollutant information concerning their formulations. This information was tabulated and is discussed later in this section.

Trade Association Contacts:

In preparation for a survey of the industry, a meeting with representatives of the Porcelain Enamel Institute (PEI) and the Agency was held to discuss conclusions from previous EPA data gathering efforts and to discuss the information to be gathered in the data collection portfolio employed in the study. Each dcp question was reviewed to assure that it was necessary and appropriate. Several additional meetings with the PEI took place during the data collection period at their request to review the progress of the Agency. The Agency specifically requested that PEI assist the Agency by providing a mailing list of PEI members who perform porcelain enameling. PEI refused to comply with this request.

Dcp Survey Data:

The collection of information and data pertaining to individual manufacturing facilities that perform porcelain enameling consisted of a mail survey conducted by the EPA. A search through the Dun and Bradstreet index and discussions with industry personnel provided a list of the possible porcelain enamelers in the U.S. Dcps were mailed to all of the companies believed to do porcelain enameling. The dcp requested general plant data, specific production information, waste treatment information, process and treated wastewater data, waste treatment cost information, and priority pollutant information. The Agency mailed 250 dcp's to companies presumed to perform porcelain enameling and received data and information on 117 plants. Of the 117 portfolios received, only 2 contained data on raw wastewater streams and only 31 contained any effluent stream data. Approximately 75 percent of the portfolios received were relatively complete and provided information regarding production, size, process descriptions, wastewater treatment systems, and water use. This information was used to provide a good profile of the porcelain enameling industry. Of the remaining portfolios: 95 facilities reported they were no longer engaged in porcelain enameling, 17 went to corporate addresses, six were undeliverable, 10 were duplicate mailings, the remainder used no water (dry process) and three were never returned. It was learned that one plant 36069 had subsequently ceased operations. The reduced the number of plants identified as generating wastewater in procelain enameling operations to 116.

PLANT SAMPLING

The data collection effort also included engineering visits and wastewater sampling at porcelain enameling facilities. A two phased sampling program was conducted to collect technical and chemical information about specific plants. The first phase - called screening - was intended to collect incoming water, raw wastewater and treated wastewater samples and determine the presence or absence of pollutants with special emphasis on the Agency list of 65 (129 specific) toxic pollutants. The second phase, verification, was intended to further confirm (or refute) the toxic pollutants found in the screening of each subcategory. The presence of conventional pollutants and other pollutants was determined as appropriate.

The principal difference between screening and verification sampling and analysis is the chemical analysis method used for analyzing toxic organic pollutants. Verification analysis more extensive procedures to assure accurate quantification of pollutants. For plants which were used for screening, a screening analysis was performed on the first sampling day. Verification analysis was performed on the remaining two days of sampling. Usually, three consecutive days of sampling were conducted at each sampled plant.

Site Selection - The dcp served as a primary information source in the selection of plants for visitation and sampling. Specific criteria used to select plant visit sites for sampling included:

1. Assuring visits to plants using each basis metal.

2. Providing a mixture of plants with relatively large and small production. Production was judged a more important factor than flow since a plant with poor housekeeping practice can have large discharge, regardless of its size.

3. Selecting plants whose production processes are typical of the processes performed for each basis material. Consideration was also given to selection of plants with unique processes or treatment not universally practiced but applicable to the industry in general as a potential pollutant reduction alternative.

4. Evidence of a company's knowledge of its production processes, water use, wastewater generation and treatment system as indicated in the dcp's received. This knowledge is important

in establishing the degree to which sampling data from the plant is representative of the industry.

5. The presence of wastewater treatment or water conservation practices. If a plant meets the first four criteria, it is cost efficient for EPA to sample plants that will provide untreated wastewater data as well as treatment performance data. Included in this criteria was a consideration of dcp data that might indicate proper design and operation of the treatment technology.

6. Any problems or situations peculiar to the plant being visited. In particular, consideration of accessibility of wastewater streams or availability of transportation to convey samples to laboratories within protocol requirements also impacted the selection of sampling sites.

Table V-1 (Page 73) presents a summary of the sampling sites selected.

Sampling Program - The wastewater sampling program conducted at each plant consisted of screening and verification, or just verification. The object of screening was to determine, by sampling, analysis and flow measurements the identity and quantity of pollutants present in plant wastewater for each basis material porcelain enameled. Screening involved sampling, flow measurement and full spectrum analysis of one plant in each basis material subcategory. Once the screening data were obtained, parameters were chosen for verification analysis based on the pollutants detected during screening, information reported in the dcp, and technical judgment concerning the probable presence or absence of each pollutant. The samples collected during verification were then analyzed for those selected parameters.

Prior to each sampling visit, all available data, such as layouts and diagrams of the selected plant's production processes and wastewater treatment facilities, were reviewed. Often a visit to the plant to be sampled was made prior to the actual sampling visit to finalize the sampling approach. Representative sample points were then selected to provide coverage of discrete raw wastewater sources, total raw wastewater entering a wastewater treatment system, and final effluents. Finally, before conducting a visit, a detailed sampling plan showing the selected sample points and all pertinent sample data to be obtained was generated and reviewed.

For all sampling programs, flow proportioned composite samples or the equivalent (for batch operations) were taken over the time period that the plant was in operation - one day for screening and three consecutive days for verification. On a screening visit, a total raw wastewater sample was taken to determine what pollutants were generated by the production processes, a final effluent sample was collected to determine which pollutants were removed or contributed by the wastewater treatment system, and a plant incoming water sample was taken to determine if there were any significant pollutants in the water source.

For the verification sampling visits, samples were taken of the plant incoming water, final effluent and discrete raw wastewater sources. Individual process operations were sampled at most plants, these data were subsequently combined into two basic functions: coating operations and metal preparation operations. Figure V-1 (Page 111) presents typical porcelain enameling on steel process operations and raw wastewater sampling points. These points generally included incoming water, metal preparation (i.e., alkaline cleaning rinse, acid etch rinse, nickel flash rinse, neutralization rinse) and coating (i.e., ball milling wastewater and spray booth wastewater). Table V-2 (Page 74) presents the number of days verification sampling was performed on metal preparation and coating raw wastewater sources for the sampling program.

Figure V-2 (Page 112) presents a process line diagram of a typical porcelain enameling on cast iron facility. Raw wastewater sampling points included incoming water and ball milling and enamel application wastewater.

Figure V-3 (Page 113) presents typical porcelain enameling on aluminum process operations and raw wastewater sampling points. Sampling points for sampled facilities within this subcategory included incoming water, metal preparation, (i.e., alkaline cleaning rinse water), and coating (i.e., ball milling and enamel application wastewater). All sampled porcelain enameling on aluminum facilities performed the same process operations. Table V-2 shows the number of sampling days for metal preparation and coating raw wastewater at each sampled facility.

Figure V-4 (Page 114) presents typical porcelain enameling on copper process operations and raw wastewater sampling points. Sampling points for facilities within this subcategory included incoming water, metal preparation (i.e., acid etch rinse water), and coating (i.e., ball milling and enamel application wastewater). Solvent cleaning was used at one sampled facility (06031); however, no wastewater was discharged from this operation. Alkaline cleaning, while being reported in the dcp's as used, was not observed at any plants visited. Table V-2 presents the number of sampling days for metal preparation and coating raw wastewater at sampled facilities.

All of the samples collected were kept on ice throughout each day of sampling. At the end of the sampling day, the composite samples were divided into several bottles and preserved according to EPA protocol.

All samples were subjected to three levels of analysis depending on the stability of the parameters to be analyzed. On-site analysis, performed by the sampler at the facility, measured flow rate, pH, and temperature. Four liters of water from each sample point for each of the three sampling days were delivered to a laboratory in the vicinity of the subject plant and analyzed for total cyanide, cyanide amenable to chlorination, oil and grease, phenols (4AAP method), and total suspended solids. This analysis was performed by these local laboratories within a six hour period after each day's composite sample was prepared. Because of the sensitive nature of the cyanide analysis procedure, a quality assurance questionnaire intended to document conformance of the procedures used by the laboratories with EPA (Part 136) analysis methods was completed by all laboratories performing this analysis.

The remainder of the composite samples prepared each day were analyzed by three different laboratories: a central laboratory for verification samples and some screening analysis, the EPA Chicago Regional Laboratory for metals screening analysis, and a laboratory which specialized in gas chromatograph-mass spectroscopy (GCMS) analysis for screening of organic priority pollutants. The EPA Chicago Regional Laboratory employed an inductively coupled argon plasma unit (ICAP) to analyze the samples for metals.

On a verification sampling visit, the central laboratory only analyzed for those parameters which were selected after screening for verification analyses. In addition, special samples were taken of various process solutions to determine their organic or metals content and these samples were analyzed at the central laboratory.

Screening and verification parameters and laboratory methodologies are listed in Table V-3 (Page 75).

Verification Parameter Selection - In order to reduce the volume of data which must be handled, to avoid unnecessary expense, and to limit the scope of the sampling program, a number of the pollutant parameters analyzed for during the screen sampling are not analyzed for during the verification sampling. The pollutant parameters which are chosen for further analysis are called verification pollutant parameters. Because there are different pollutants present in each subcategory, verification pollutant parameter selection is done separately for each subcategory. Three sources of information are used for their selection: the pollutants the industry believes are present in their wastewater as reported in dcp responses, the screen sampling analyses, and the pollutants the Agency believes should be present after studying the processes and materials used by the industry.

The absence or presence of priority pollutants in plant wastewaters was also investigated as part of the data collection portfolio survey transmitted to all known porcelain enamel plants. Specifically, a list of the priority pollutants was attached to all data collection portfolios to determine which of the priority pollutants should be investigated further. Table V-4 (Page 81) is a tabulation of the responses to this survey and presents raw wastewater concentration ranges. For each priority pollutant, it lists the number of plants that knew, or believed, it was absent or present in their wastewater.

Supplementing the above information are the sampling data supplied by porcelain enamelers in their dcp responses. The information received is presented in Table V-5 (Page 85) for the plants that supplied analytical data. These data are only from effluent streams since no significant raw waste data were received in the responses. In addition to those reported in Table V-5, long term effluent data were received from two facilities (18538 and 13330). These data are presented in Section VII of this report, in Tables VII-14 and VII-15 (Pages 98 to 99).

Table V-6 (Page 88) presents screening results tabulated from all screening visits.

Table V-7 (Page 89) presents the selected verification parameters for each subcategory based on the above mentioned sampling dcp information and engineering judgment.

In the final analysis a number of metals other than the basis material processed or major process bath constituents were found in raw wastewaters in measurable concentrations. These included antimony, barium, cadmium, chromium, cobalt, lead, manganese, selenium, titanium, and zinc. These metals may be found in the following areas:

- The metals are components resulting from direct addition or contamination of porcelain enamel slips used within each subcategory.

- The metals are present in incoming water.

- The metals are associated with the basis metal as contaminants. These metals can be contaminants resulting from the original ore reduction and smelting operations. Some of these metals are present in the applied oils and greases used during forming or to protect the workpiece. Metallic fumes and other contaminants, often present in shop atmospheres, can dissolve into the applied oil film.

- Metals from the tanks, pipes and soldered connections can be dissolved by the process solutions.

As can be seen from Table V-7 a number of organic pollutant parameters were also detected. Trichloroethylene and 1,1,2-trichloroethane were detected in the copper subcategory since vapor degreasing is sometimes used to prepare copper for the application of slip. Bis(2-ethylhexyl)phthalate and di-n-octyl phthalate were detected in the aluminum subcategory. However, these organic pollutants were detected only in relatively few samples and were present at or near detection limits of 10 mg/l.

Incoming Water Analysis - Incoming water samples were collected for each sampled plant and analyzed for verification (and screening where applicable) parameters. Overall, these analyses revealed very few parameters whose concentrations were above the minimum detectable or analytically quantifiable limit of the specific method. The concentration levels found in the incoming water of parameters common to process discharges were not significant enough to affect the anticipated design of a wastewater treatment system.

DATA ANALYSIS

Porcelain enameling wastewater characteristics are presented for each basis material in terms of water use, raw wastewater stream concentrations and final effluent stream concentrations.

Water Use and Wastewater Generation - Water is used in most porcelain enameling operations. It provides the mechanism for removing undesirable material from the ware surface, is the medium for the chemical reactions that occur on the basis metal, is a vehicle for coating application, is used as cooling water for ball milling operations and is used for plant clean-up and maintenance. The nature of porcelain enamel operations, the area of basis material processed, and the quantity of and types of chemicals used produce a large volume of wastewater that requires treatment before discharge, recycle or reuse. Sampled plant water use by subcategory and process operation is shown on Table V-24 (Page 108). The mean water use of these sampled plants is used in calculating BPT limitations. In response to a comment on the proposed regulation data for plant ID# 33617 are excluded from the existing source analysis because this plant uses countercurrent rinsing and other in-process flow reduction technology which is not part of BPT or BAT. However, the flow data for # 33617 are used in Section XI as a basis for NSPS. (Plant ID# 33617 effluent characteristics are used for comparison with BPT limitations in Section IX).

Wastewater is generated in each subcategory (steel, cast iron, aluminum, and copper). The wastewater generated by basis material preparation and coating may (1) flow directly to a municipal sewage treatment system or to surface water, (2) flow to an onsite waste treatment system and then to a municipal sewage treatment system or surface water, (3) be recirculated or recycled following intermediate treatment, or (4) a combination of the above. Table III-1 (Page 43) presented effluent destinations as reported in the dcp's for each basis material subcategory.

<u>Specific Wastewater Sources</u> - Specific wastewater sources in porcelain enameling may vary from basis material to basis material. Wastewaters generated from the coating operations are uniform in their origin and are listed below only once although they are applicable to each subcategory.

<u>Coating Operations</u>

1) wastewater generated by spraying the outside of ball mills for cooling

2) wastewater from overspray during application which is either caught in water curtains or results from floor and booth area washdowns

3) wastewater from cleaning operations associated with the ball mills themselves.

4) wastewater from cleaning of fixtures used to hold work pieces during application of porcelain enamel slip.

<u>Steel Subcategory</u> - Potential wastewater sources from basis material preparation are:

1) alkaline cleaning wastewater including process bath batch dumps and rinsing operations

2) acid etch wastewater including process bath batch dumps and rinsing operations

3) nickel flash wastewater including process bath batch dumps, rinsing operations and filter discharges (filters remove iron from the process bath to extend the bath life).

4) neutralization of remaining acid wastewater including process bath batch dumps and subsequent rinsing operations.

Cast Iron Subcategory - There is no water used for cast iron basis material preparation. Dry, mechanical cleaning processes are used.

Aluminum Subcategory - Potential wastewater sources from basis material preparation are:

1) alkaline cleaning wastewater including process bath batch dumps and discharges from rinsing operations

2) acid etch and chromate conversion coating wastewater.

Copper Subcategory - Potential wastewater sources from basis material preparation are:

1) alkaline cleaning wastewater that includes process bath batch dumps and rinsing operations (some porcelain enamelers on copper may substitute vapor degreasing)

2) acid etching wastewater that includes process bath batch dumps and rinsing operations.

Dcp flow data were not used because EPA plant visits revealed lack of attention to water use at several plants. Only careful analysis of plant operations during sampling visits provided an adequate basis for determining whether adequate in-plant flow control exists at any plant. Dcp data was inadequate for this purpose.

Metal preparation water use and coating and enamel water use and production rates obtained from dcp's for the steel and aluminum subcategories are shown in Tables V-8 and V-9 (Pages 90-91). These tables present the hourly flow rate (l/hr), hourly production rate (m^2/hr), and production normalized flow (l/m^2) for both streams for all plants within these subcategories for which dcp data were provided. Dcp data for the cast iron and copper subcategories relative to water use were limited and plants reporting such information were also visited. The production from the dcp's is average hourly production since it was calculated as the annual production divided by the number of hours per year the facility operated. These reported production rates represent the area which undergoes basis material preparation and the area that receives porcelain enamel as applicable. Where multiple coats of enamel are applied, they are counted individually.

Raw Waste Characteristics

Wastewater from porcelain enameling operations is characterized by the chemicals associated with each operation and the basis metal. During verification sampling, discrete samples of each wastewater-producing operation were obtained. The pollutants in the wastewater streams sampled included the basis metal, oil and grease, and a variety of other pollutants associated with individual process solutions or porcelain enamel slips. Oil and grease for the porcelain enameling subcategories is free oil and emulsified oil, not soluble oil. Free oil and emulsified oils are typically milling oils or rust inhibitors, and can be removed by the application of coalescing agents, sedimentation, separation and skimming.

Following is a detailed discussion of the raw wastewater sources and characteristics for each basis material subcategory. Coating wastewater characteristics are discussed first since these operations contribute by far the largest quantity of pollutants in comparison to basis material preparation operations. Included is an explanation of ball milling operations and how they can generate wastewater. Following the ball milling discussion, the various methods of application of the porcelain enamel slip are presented along with their respective contributions to wastewater. Raw wastewater sampling data from the wastewater streams are then presented. Finally, the result of an extensive study done by the Agency to quantify and discern the environmental impact of the toxic pollutants discharged by these processes is presented.

Following the discussion of coating wastewater, basis metal preparation operations and the resultant wastewater generated are presented. In this presentation each basis material subcategory is discussed separately since these operations, unlike coating operations, vary significantly from subcategory to subcategory.

Ball Milling and Enamel Application

The first operation involved with application of porcelain enamel is the grinding and mixing of all the various ingredients. The constituents of porcelain enamel usually include a mixture of frits (glassy raw material), clays and coloring oxides. Specific additions to this basic mixture can include borax, feldspar, quartz, cobalt oxide and manganese dioxide. A wide range of other additions can also be made depending on color, whitening and opacification requirements. The constituents are weighed and poured into the ball mill with a carefully measured amount of water if the enamel is to be applied in a wet or slip form.

The ball mills are cylindrical drums of different sizes and are usually up to 2/3 full of ceramic balls. The ceramic balls serve to grind and throughly mix all the ingredients. The raw materials are milled and this produces a potentially detrimental amount of heat caused by friction. To control the temperature, a fine mist of water is constantly sprayed onto the outer surface of the mill. In the majority of cases this cooling water is a source of wastewater since it usually comes into contact with wasted slip when it falls onto the floor areas around the ball mill and mixes with spilled slip. After several hours of grinding, the slip is poured through a screen to trap oversized particles, and is then placed in containers. Wastewater may be generated by equipment cleaning, which is done to prevent color contamination of this screening and holding equipment.

The procedures used for cleaning out ball mills vary greatly from facility to facility. If space and finances permit, some facilities have separate ball mills for each color they use and the mills are rarely cleaned. In other cases close attention is paid to scheduling of mill runs so the colors milled get progressively darker making only occasional cleaning necessary. It is a rule of thumb in most facilities to wash out ball mills as infrequently as possible to avoid wasting the significant amount of slip which adheres to interior walls and the ceramic balls within the mill. The actual amount of wastewater generated by ball mill washouts was determined in the proposed regulation by evaluation of data gathered at six porcelain enameling facilities (ID's 12038, 15712, 33076, 33617, 33076, 40053). However, several comments on the proposed regulation indicated that some of the data was not correct. Upon close examination it was found that plant ID 12038 supplied data in the dcp which was inconsistent. Two possible flows--differing by a factor of five--could be calculated for ball mill washout. Plant ID 33076 recycles ball mill wash out water from a sump, therefore the water used for one wash out cannot be calculated. Plant ID 33617 water use data from plant visit did not identify separate ball mill washout flow; information obtained subsequent to the visit was inadequate to provide uniquely defined ball mill washout water usage. Plant ID 36077 sampled water flow data were not definitive enough to calculate ball mill wash out water use. The water use for the remaining two plants ID 15712 (0.0107 l/sq.m.) and ID 40053 (1.2603 l/sq.m.) were used to calculate a mean production normalized wastewater usage of 0.636 l/sq.m. of area coated for ball mill wash out this revised mean is used in the calculation of BPT and BAT limitations as well as new source and pretreatment standards.

Porcelain enamel slip is applied by several different methods that generate wastewater. Each method is described below.

- Air Spraying - The most widely used method of enamel application is air spraying. In this process enamel slip is atomized and propelled by air into a conical pattern, which can be directed over the article to be coated by an operator or machine.

- Electrostatic Spray Coating - Electrostatic spray coating incorporates the principles of air atomized spray coating with the attraction of unlike electric charges. In electrostatic spray coating, atomized enamel slip particles are charged at 70,000-100,000 volts and directed toward a grounded part. The electrostatic forces push the particles away from the atomizer and away from each other. The charged particles are attracted to the grounded workpiece and adhere to it.

- Dip Coating - In dip coating a part is submerged in a tank of enamel slip, withdrawn, and permitted to drain or is centrifuged to remove excess slip.

- Flow Coating - In this process, enamel slip is pumped from a storage tank to nozzles that are positioned according to the shape and size of the ware to direct the flow of enamel onto the surface as the parts are conveyed past the nozzles.

- Powder Coating - The ground (first) coat is applied. The part is heated to red heat, the powdered enamel is dusted on the part, and the part is re-fired. The most prevalent use of powder coating is for the application of a cover (second) coat of enamel to cast iron workpieces. Three porcelain enameling plants use the dry process exclusively on cast iron, and therefore generate no coating process wastewater.

All of these methods of porcelain enamel application generate wastewater. Air spraying usually generates the largest quantities of wastewater since overspray must be strictly controlled. This is usually accomplished by the use of a water curtain behind the spraybooth. Significant quantities of wastewater are generated when the water curtains are dumped or cleaned. Electrostatic, dip, and flow coating operations generate wastewater when application equipment and floor areas are cleaned. Powder coating operations generate the smallest quantity of wastewater since little or no clean-up is necessary.

A sixth enamel application method, electrostatic dry powder coating, also exists and is described in Section III. However it does not generate wastewater and is not discussed further in this section.

For the purposes of sampling, wastewaters associated with ball milling and enamel application at each plant were usually mixed. This mixed sample generally included wastewater from the following sources: ball mill cooling water, ball mill wash out water, water curtain batch dumps, and general clean-up water from drain board, spray equipment and floor areas. Table V-10 (Page 92) presents the raw wastewater concentrations (mg/l) of the 36 sampled coating streams for all subcategories. The mean concentration of these streams is used in calculating the normal plant and subcategory totals for the amount of pollutants removed and discharged. These wastewater streams contain significant amounts of toxic metals regardless of subcategory. To verify this, an experiment comparing total metals analysis and dissolved metals analysis on coating wastewater was conducted. Tables V-11 through V-14 (Pages 95-98) show the results of this comparison of wastewater streams from typical plants in each subcategory.

For the dissolved metals analysis, samples were first settled and then passed through a 0.45 micron filter. Total metals analysis was performed on an aliquot sample of a well mixed and unfiltered sample.

In response to industry comments questioning the need to control discharges from coating operations a study was also performed to determine the short term leaching characteristics of enamel coating wastewaters at various pH levels over a 24 hour period. The results of this experiment are shown in Table V-15 (page 99) and indicate that at acidic pH levels, a significant amount of toxic metals are dissolved from the coating solids into the wastewater matrix.

From these studies EPA also was concluded that the toxic metals contained in the wastewater of ball milling and enamel application operations are variable, depending upon specific formulations that may change hourly. Although a high concentration of toxic metals is certain, it is virtually impossible to predict the exact composition and specific metals to be found at any specific time. Because of this extreme variability and potential toxicity, EPA has focused its attention on minimization of wastewater discharges from coating operations. To further quantify the amounts of these metals that are discharged to the environment, coating wastewater streams were sampled at fourteen porcelain enameling facilities. Sample location and potential sample contamination problems were checked to verify that the sample was gathered before any settling had occurred and that no other waste streams were mixed with the coating wastewater streams. Of these fourteen plants, five facilities could be used to quantify the amount of toxic metals discharged. These five facilities were plants 11045, 33077, 33617, 40053 and 40063. EPA also quantified the amount of toxic metals contained in the raw materials supplied as slip ingredients. Dcp supplied raw material data often contained amounts and brand names of frits and coloring oxides used by the facility, however, no data were available on the actual amount of toxic metals contained in each of these products. In order to gather these data, the Agency contacted the eight largest manufacturers of frit and coloring oxides and asked them to supply the percent of selected elements, including all of the toxic metals, contained in each of their products and the amounts of these products that were manufactured in 1976. The results of this inquiry indicated that the toxic metals contained in the frits were antimony, arsenic, cadmium, chromium, copper, lead, nickel, and zinc. In addition, cobalt, manganese, and trace quantities of several rare earth metals were reported. The coloring oxides contained significant quantities of all of the above with the exception of arsenic and the rare earth metals. Selenium, vanadium and trace quantities of silver were present in coloring oxides but not in the frits.

Using this information the amount of toxic metals in the raw materials was calculated for the six visited plants previously identified. These figures were compared to the quantitative analysis of the raw wastewater streams of these six facilities and a percent toxic metals discharged was calculated. The percent discharge (not applied to workpiece or reclaimed) ranged from 0.3 percent to 21 percent.

To determine the full magnitude of these discharges, these percentages were applied to the entire porcelain enameling category. Useful dcp data, gathered from 56 of these 116 facilities resulted in an EPA estimate that these 56 plants used 45,600,000 pounds of frit and 813,000 pounds of oxides. The data for 56 plants represented approximately 75 percent of the total raw materials used by the industry since all of the largest porcelain enamelers were accounted for in this data base. To depict the entire porcelain enameling industrial segment, these amounts were extrapolated to represent the entire 116 facility data base. This resulted in a total of approximately 57,000,000 pounds of frit and 1,000,000 pounds of oxides used by the entire porcelain enameling category. The total amount of toxic metals contained in these frits and oxides is 1,900,000 pounds.

The discharge percentages calculated for the six visited facilities were then applied to the extrapolated amount of frit and oxide consumed by the 116 facilities in the data base. Table V-16 (Page 100) presents the estimated total amount of toxic metals discharged by the entire porcelain enameling category. These totals emphasize the need for control of toxic discharges from coating discharges.

Metal Preparation

Raw wastewater sample concentration data for metal preparation for each subcategory are shown in Tables V-17, V-18 and V-19 (Pages 101-103). Each table lists the minimum, maximum, mean, median and flow proportioned average concentration of verification and screening sample data for parameters whose concentrations were greater than 0.010 mg/l. This concentration was selected for toxic organics because at 0.010 mg/l and below the organic priority pollutants cannot be quantified accurately. The 0.010 mg/l cutoff was also selected for metals since existing control technologies cannot effectively reduce the concentration of most metals below this concentration. The number of data points defines the total number of positive values used for the mean, median and flow proportioned average concentration presentations. The "number of zeros" column reflects the number of samples analyzed for each parameter where no detectable concentration was measured.

Steel Subcategory Metal Preparation - Wastewater in this subcategory results from alkaline cleaning, acid etch, nickel flash, neutralization and coating operations.

Alkaline Cleaning solutions usually contain one or more of the following chemicals: sodium hydroxide, sodium carbonate, sodium metasilicate, sodium phosphate, (di-or trisodium) sodium silicate, sodium tetra phosphate, and a wetting agent. The specific content of cleaners varies with the type of soil being removed, the cleaners for steel being more alkaline and active than other cleaners. Wastewaters from alkaline cleaning operations contain not only the consitituents of the cleaning bath, but also oils and greases which have been removed from the part. The wastewaters also contain iron removed from the base metal, but the amount is small in relation to the iron removed in the acid etching process.

Alkaline cleaning wastes enter the waste stream in three ways:

1. Rinsing directly following the alkaline cleaning step.
2. Continuous overflow of the rinse tanks.

3. Batch dump of a spent alkaline cleaning bath.

Acid Etch typically utilizes either sulfuric acid, or ferric sulfate in combination with sulfuric acid. Hydrochloric (muriatic), phosphoric, and nitric acids are also reportedly in use. The components of the acids enter the waste stream but they are of little consequence in comparison to the metals that are contributed by the acid etching operation. Acid solutions after a period of use have a high metallic content due to the dissolution of the surface of the steel when it is etched. As a result, large amounts of iron enter by way of dragout from the acid solutions into rinse waters and also when the baths are dumped. Also present at significant levels are components of steel such as phosphorus and manganese.

Nickel Flash, either through dragout into the rinsewaters or batch dumping of the spent bath, contributes metals to the raw waste stream. The process solutions contain nickel salts, nickel sulfate in particular. After a period of use the nickel bath also contains high concentrations of iron due to the displacement reaction of the nickel ions on the steel surface. Thus the nickel flash raw wastewater streams show high levels of nickel and iron.

Neutralization is designed to remove the last traces of acid from the steel workpiece. The neutralizing bath consists of an alkali such as soda ash, borax, or trisodium phosphate and water. The contents of the bath enter the wastewater stream either through dragout into subsequent rinses or batch dumping of the process solution tanks.

Coating Operations are the main source of pollution in the porcelain enameling industry and were discussed previously in this section.

Cast Iron Subcategory - The only waterborne wastes found at sampled plants in this subcategory were from coating operations and have been discussed previously in this section.

Aluminum Subcategory - Wastewater in this subcategory results from alkaline cleaning, acid treatment, chromate treatment and coating operations.

Alkaline Cleaning waters contain dirt and grease removed in the cleaning process as well as the contents of the cleaning solution. Depending on the strength of the solution, some amount of aluminum is removed from the workpiece and is in solution. In the case of an alkaline etch, a considerable amount of aluminum can accumulate in a bath prior to dumping. The typical alkaline cleaning stream in this subcategory contains suspended solids and phosphorus as well as aluminum.

Acid solutions are sometimes utilized in the preparation of aluminum for the purpose of deoxidizing the surface of the workpiece. This operation is not practiced frequently; a nitric acid solution is used when this step is performed. The nitric acid causes the dissolution of some metal, resulting in the presence of aluminum in the waste stream. None of the sampled facilities performed acid treatment.

Chromate Treatment is employed by some facilities to promote adhesion and good enameling properties. This step is performed last on the metal preparation line, after alkaline cleaning and acid treatment. The chromate solution is composed of potassium chromate and sodium hydroxide; these chemicals enter the wastewater stream from rinsing or batch dumps of the chromate bath. None of the visited facilities performed chromate treatment.

Coating Operations are the major source of pollutants in this subcategory and were discussed previously in this section.

Copper Subcategory - Wastewater in this subcategory results from surface preparation and coating operations.

Surface Preparation is accomplished by alkaline cleaning and acid etching solutions. These materials can enter the wastewater stream either from rinsing or through batch dumps of the process solutions. The alkaline cleaning step produces wastewater containing oil and soils that have been removed from the workpieces. Specific raw wastewater data on alkaline cleaning of copper is not available because it was not reported in dcp responses and the two copper porcelain enameling plants sampled did not employ this process. Acid etching adds to the wastewater stream copper that has been dissolved from the surface of the part to be coated. If a vapor degreasing step is used, trace amounts of the degreasing solvent may be found in the wastewater stream. These solvents are so volatile that the amount present is likely to be negligible.

Coating wastewater is the major source of pollutants within this subcategory and was discussed previously in this section.

Effluent Characteristics

A summary of treated effluents from 15 sampled plants with various levels of treatment is presented in Tables V-20 through V-23 (Pages 104-107). The sampled results are presented by subcategory for the pollutant parameters considered for regulatory control (Reference Section VI). Each of these tables also lists the treatment components at each plant. Limited dcp effluent data are available and were presented previously in Table V-5.

Data Summary

Comparison of wastewaters from the different subcategories within the porcelain enameling industry segment is difficult because of widely varying basis material preparation operations from subcategory to subcategory. A comparison between subcategories can best be made if subcategory wastewater characteristics are split in terms of wastewater generated by metal preparation and wastewater generated by coating.

Tables V-17, V-18, and V-19 (Pages 101-103) present wastewater characteristics for the basis material preparation stream for each subcategory. Specific information derived from these tables follows:

Oil and grease concentrations in basis metal preparation streams were highest in the copper subcategory and lowest in the aluminum subcategory. This is caused by large amounts of drawing oils and waxes applied to copper parts to prevent oxidation.

The basis metal preparation streams for all three subcategories (steel, aluminum and copper) contain similar levels of total suspended solids, with slightly higher levels in the steel and aluminum subcategories. Steel and aluminum workpieces generally undergo a larger number of forming operations than copper parts and thus are likely to have more dirt and grease on the surface.

The basis metal preparation stream of the steel subcategory shows the highest concentrations of basis material. This indicates that steel workpieces undergo more severe basis material preparation operations.

Concentrations of lead are significantly higher in the basis metal preparation streams for the copper and aluminum subcategories. This is attributable to higher lead levels in these basis materials.

Concentrations of nickel in the basis material preparation streams are highest in the steel subcategory. This significant difference is attributed to the discharge from nickel deposition operations used in basis material preparation for steel.

In general, wastewater constituents associated with coating wastewater streams vary only slightly according to bonding and color requirements associated with the basis metal. These requirements are reflected in the slip ingredients used, which were previously discussed.

TABLE V-1

SUMMARY OF SAMPLING SITES AND DAYS SAMPLED

	BASIS MATERIAL							
	Steel		Iron		Aluminum		Copper	
Plant ID	Screen	Verif	Screen	Verif	Screen	Verif	Screen	Verif
06031								1
11045						3		
15051	1	2						
15712			1	2				
18538		3						
33076				1				
33077					1	2		
33617		3						
36030		3					1	2
36077	1	2						
40053		3		3				
40063		3						
41062		3						
47033		3						
47051						3		
Totals	2	25	1	6	1	8	1	3

TABLE V-2
NUMBER OF SAMPLING DAYS FOR EACH OPERATION AT EACH SAMPLED FACILITY

	15051	18538	33617	36030	36077	40053	40063	41062	47033	15712	33076	11045	33077	47051	06031
Subcategory	Steel	Steel	Steel	Steel Copper	Steel	Steel Cast Iron	Steel	Steel	Steel	Cast Iron	Cast Iron	Aluminum	Aluminum	Aluminum	Copper
Process Operation															
Alkaline Clean	3	3	3	3		3	3	3	3			3	3	3	
Acid Treatment	3	3	3	3		3	3	3	3						1
Nickel Deposition	3	3	3	(a)		(a)	3		3						
Neutralization	3	3	1	3		(a)	3	(a)	3						
Ball Milling and Enamel Application	3	3	3	3	3	3	3	3	3	3	1	3	3	3	1(b)

(a) No discharge at time of visit. However, batch dumps do occur.

(b) Essentially a dry operation with a minor discharge from rack washing.

TABLE V-3

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Priority Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
1. Acenaphthene	SP	
2. Acrolein	SP	
3. Acrylonitrile	SP	
4. Benzene	SP	
5. Benzidine	SP	
6. Carbon Tetrachloride (Tetrachloromethane)	SP	
7. Chlorobenzene	SP	
8. 1,2,4-Trichlorobenzene	SP	
9. Hexachlorobenzene	SP	
10. 1,2-Dichloroethane	SP	
11. 1,1,1-Trichloroethane	SP	
12. Hexachloroethane	SP	
13. 1,1-Dichloroethane	SP	VP: L-L Extract; GC,ECD
14. 1,1,2-Trichloroethane	SP	VP: L-L Extract; GC,ECD
15. 1,1,2,2-Tetrachloroethane	SP	
16. Chloroethane	SP	
17. Bis(Chloromethyl) Ether	SP	
18. Bis(2-Chloroethyl) Ether	SP	
19. 2-Chloroethyl Vinyl Ether (Mixed)	SP	
20. 2-Chloronaphthalene	SP	
21. 2,4,6-Trichlorophenol	SP	
22. Parachlorometa Cresol	SP	
23. Chloroform (Trichloromethane)	SP	
24. 2-Chlorophenol	SP	
25. 1,2-Dichlorobenzene	SP	
26. 1,3-Dichlorobenzene	SP	
27. 1,4-Dichlorobenzene	SP	
28. 3,3-Dichlorobenzidine	SP	
29. 1,1-Dichloroethylene	SP	
30. 1,2-Trans-Dichloroethylene	SP	VP: L-L Extract; GC,ECD

TABLE V-3 (Continued)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Priority Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
31. 2,4-Dichlorophenol	SP	
32. 1,2-Dichloropropane	SP	
33. 1,2-Dichloropropylene (1,3-Dichloropropene)	SP	
34. 2,4-Dimethylphenol	SP	VP: GC - FID
35. 2,4-Dinitrotoluene	SP	
36. 2,6-Dinitrotoluene	SP	
37. 1,2-Diphenylhydrazine	SP	
38. Ethylbenzene	SP	
39. Fluoranthene	SP	SP
40. 4-Chlorophenyl Phenyl Ether	SP	
41. 4-Bromophenyl Phenyl Ether	SP	
42. Bis(2-Chloroisopropyl) Ether	SP	
43. Bis(2-Chloroethoxy) Methane	SP	
44. Methylene Chloride (Dichloromethane)	SP	
45. Methyl Chloride (Chloromethane)	SP	
46. Methyl Bromide (Bromomethane)	SP	
47. Bromoform (Tribromomethane)	SP	
48. Dichlorobromomethane	SP	
50. Dichlorodifluoromethane	SP	
51. Chlorodibromomethane	SP	
52. Hexachlorobutadiene	SP	
53. Hexachlorocyclopentadiene	SP	
54. Isophorone	SP	SP
55. Naphthalene	SP	SP
56. Nitrobenzene	SP	
57. 2-Nitrophenol	SP	
58. 4-Nitrophenol	SP	
59. 2,4-Dinitrophenol	SP	
60. 4,6-Dinitro-O-Cresol	SP	

TABLE V-3 (Continued)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Priority Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
61. N-Nitrosodimethylamine	SP	
62. N-Nitrosodiphenylamine	SP	
63. N-Nitrosodi-N-Propylamine	SP	
64. Pentachlorophenol	SP	
65. Phenol	SP	VP: GC,ID
66. Bis(2-Ethylhexyl) Phthalate	SP	SP
67. Butyl Benzyl Phthalate	SP	SP
68. Di-N-Butyl Phthalate	SP	SP
69. Di-N-Octyl Phthalate	SP	SP
70. Diethyl Phthalate	SP	SP
71. Dimethyl Phthalate	SP	SP
72. 1,2-Benzanthracene (Benzo (a) Anthracene)	SP	SP
73. Benzo (a) Pyrene (3,4-Benzo-Pyrene)	SP	SP
75. 11,12-Benzofluoranthene (Benzo (k) Fluoranthene)	SP	SP
76. Chrysene	SP	SP
77. Acenaphthylene	SP	SP
78. Anthracene	SP	SP
79. 1,12-Benzoperylene (Benzo (ghi)-Perylene)	SP	SP
80. Fluorene	SP	SP
81. Phenanthrene	SP	SP
82. 1,2,5,6-Dibenzathracene (Dibenzo (a,h) Anthracene)	SP	SP
83. Indeno (1,2,3-cd) Pyrene (s,3-0-Phenylene Pyrene)	SP	SP
84. Pyrene	SP	SP
85. Tetrachloroethylene	SP	
86. Toluene	SP	VP: L-L Extract; GC,FID
87. Trichloroethylene	SP	VP: L-L Extract; GC,ECD
88. Vinyl Chloride (Chloroethylene)	SP	
89. Aldrin	SP	
90. Dieldrin	SP	

TABLE V-3 (Continued)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Priority Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
91. Chlordane (Technical Mixture and Metabolites)	SP	
92. 4,4-DDT	SP	
93. 4,4-DDE (p,p'-DDX)	SP	
94. 4,4-DDD (p,p'-TDE)	SP	
95. Alpha-Endosulfan	SP	
96. Beta-Endosulfan	SP	
97. Endosulfan Sulfate	SP	
98. Endrin	SP	
99. Endrin Aldehyde	SP	
100. Heptachlor	SP	
101. Heptachlor Epoxide		
(BHC=Hexachlorocyclohexane)	SP	
102. Alpha-BHC	SP	
103. Beta-BHC	SP	
104. Gamma-BHC (Lindane)	SP	
105. Delta-BHC		
(PCB-Polychlorinated Biphenyls)	SP	
106. PCB-1242 (Arochlor 1242)	SP	
107. PCB-1254 (Arochlor 1254)	SP	
108. PCB-1221 (Arochlor 121)	SP	
109. PCB-1332 (Arochlor 1232)	SP	
110. PCB-1248 (Arochlor 1248)	SP	
111. PCB-1260 (Arochlor 1260)	SP	
112. PCB-1016 (Arochlor 1016)	SP	
113. Toxaphene	SP	
114. Antimony	SP	
115. Arsenic	SP	
116. Asbestos	-	
117. Beryllium	ICAP	
118. Cadmium	ICAP	40CFR 136: AA
119. Chromium	ICAP	40CFR 136: AA
120. Copper	ICAP	40CFR 136: AA

TABLE V-3 (Continued)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Priority Pollutants	Screening Analysis Methodology	Verification Analysis Methodology
121. Cyanide	40 CFR 136: Dist./Col. Mea.	40CFR 136: Dist./Col. Mea.
122. Lead	ICAP	40CFR 136: AA
123. Mercury	SP	
124. Nickel	ICAP	40CFR 136: AA
125. Selenium	SP	
126. Silver	SP	
127. Thallium	SP	
128. Zinc	ICAP	40CFR 136: AA
129. 2,3,4,8-Tetrachlorodibenzo-P-Dioxin (TCDD)	SP	
pH Minimum	-	Electrochemical
pH Maximum	-	Electrochemical
Temperature	-	-
Oil & Grease	-	40CFR 136: Dist./I.E.
Flourides	-	Dist./I.E.
Phosphorous Total	-	SM: Dig/SnCl
TSS	-	40CFR 136
TDS	-	40CFR 136
Cyanide Amenable to Chlorination		40CFR 136: Dist./Col. Mea.
Phenols	-	40CFR 136
Aluminum	-	40CFR 136: AA
Hexavalent Chromium	-	40CFR 136: Colorimetric
Iron	-	40CFR 136: AA
Manganese	-	40CFR 136: AA

TABLE V-3 (Continued)

SCREENING AND VERIFICATION ANALYSIS TECHNIQUES

Notes

40 CFR 136: Code of Federal Regulations, Title 40, Part 136
SP - Sampling and Analysis Procedures for Screening of Industrial Effluents for Priority Pollutants, U.S. EPA, March, 1977, Revised April, 1977.
VP - Analytical Methods for the Verification Phase of BAT Review, U.S. EPA, June, 1977.
SM - Standard Methods, 14th Edition.
ICAP - Inductively Coupled Argon Plasma.
AA - Atomic Absorption.
L-L Extract; GC,ECD-Liquid - Liquid Extraction/Gas Chromatography, Electron Capture Detection.
Dig/$SnCl_2$ - Digestion/Stannous Chloride.
Filt./Grav. - Filtration/Gravimetric
Freon Ext. - Freon Extraction
Dist./Col. Mea. - Distillation/pyridine pyrazolone colorimetric
Dist./I.E. - Distillation/Ion Electrode
GC-FID - Gas Chromatography - Flame Ionization Detection
SIE - Selective Ion Electrode

TABLE V-4

SUMMARY OF RESPONSES TO DCP
(NUMBER OF PLANTS RESPONDING IN EACH AREA)

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Raw Wastewater Concentration Range mg/l
1. acenaphthene	0	0	58	14	0
2. acrolein	0	0	58	14	0
3. acrylonitrile	0	0	59	13	0
4. benzene	0	4	58	10	0
5. benzidine	0	0	57	15	0
6. carbon tetrachloride (tetrachloromethane)	0	0	57	15	0
7. chlorobenzene	0	0	58	14	0
8. 1,2,4-trichlorobenzene	0	0	57	15	0
9. hexachlorobenzene	0	0	57	15	0
10. 1,2-dichloroethane	0	0	58	14	0
11. 1,1,1-trichloroethane	2	2	56	12	0
12. hexachloroethane	0	1	58	13	0
13. 1,1-dichloroethane	0	0	58	14	0
14. 1,1,2-trichloroethane	0	0	56	13	0.007
15. 1,1,2,2-tetrachloroethane	0	0	58	14	0
16. chloroethane	1	1	58	12	0
17. bis(chloroemthyl) ether	0	0	59	13	0
18. bis(2-chloroethyl) ether	0	0	59	13	0
19. 2-chloroethyl vinyl ether (mixed)	0	0	58	14	0
20. 2-chloronaphthalene	0	0	60	12	0
21. 2,4,6-trichlorophenol	0	0	59	13	0
22. parachlorometa cresol	0	0	58	14	0
23. chloroform (trichloromethane)	0	1	59	12	0.002-0.005
24. 2-chlorophenol	0	0	59	13	0
25. 1,2-dichlorobenzene	0	0	58	14	0
26. 1,3-dichlorobenzene	0	0	58	14	0
27. 1,4-dichlorobenzene	0	0	58	14	0
28. 3,3'-dichlorobenzidine	0	0	57	15	0
29. 1,1-dichloroethylene	0	0	58	14	0
30. 1,2-trans-dichloroethylene	0	0	58	14	0.002
31. 2,4-dichlorophenol	0	0	58	14	0
32. 1,2-dichloropropane	0	0	57	15	0
33. 1,2-dichloropropylene (1,3-dichloropropene)	0	0	59	13	0
34. 2,4-dimethylphenol	0	0	59	13	0
35. 2,4-dinitrotoluene	0	0	59	13	0
36. 2,6-dinitrotoluene	0	0	59	13	0
37. 1,2-diphenylhydrazine	0	0	58	14	0
38. ethylbenzene	0	2	61	9	0
39. fluoranthene	0	0	59	13	0
40. 4-chlorophenyl phenyl ether	0	0	59	13	0
41. 4-bromophenyl phenyl ether	0	0	58	13	0
42. bis(2-chloroisopropyl) ether	0	0	58	13	0
43. bis(2-chloroethoxy) methane	0	0	58	13	0
44. methylene chloride (dichloromethane)	1	4	54	12	0.002-0.005

TABLE V-4 (CON T)

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Raw Wastewater Concentration Range mg/l
45. methyl chloride (chloromethane)	0	0	58	13	0
46. methyl bromide (bromomethane)	0	0	58	13	0
47. bromoform (tribromomethane)	0	0	58	13	0.002*
48. dichlorobromomethane	0	0	58	13	0.002-0.007*
49. trichlorofluoromethane	0	1	57	13	0
50. dichlorodifluoromethane	0	2	56	13	0
51. chlorodibromomethane	0	0	57	14	0.002-0.003*
52. hexachlorobutadiene	0	0	57	14	0
53. hexachlorocyclopentadiene	0	0	57	14	0
54. isophorone	0	3	57	11	0
55. naphthalene	0	0	56	15	0
56. nitrobenzene	0	0	56	15	0
57. 2-nitrophenol	0	0	56	15	0.001
58. 4-nitrophenol	0	0	56	15	0
59. 2,4-dinitrophenol	0	0	56	15	0
60. 4,6-dinitro-o-cresol	0	0	57	14	0
61. N-nitrosodimethylamine	0	0	57	14	0
62. N-nitrosodiphenylamine	0	0	57	14	0
63. N-nitrosodi-n-propylamine	0	0	58	13	0
64. pentachlorophenol	0	0	57	14	0
65. phenol	2	1	56	12	0
66. bis(2-ethylhexyl) phthalate	0	0	59	12	0.002-0.022
67. butyl benzyl phthalate	0	0	56	15	0
68. di-n-butyl phthalate	0	0	57	14	0.002-0.005
69. di-n-octyl phthalate	0	1	56	14	0.011
70. diethyl phthalate	0	0	57	14	0.002*
71. dimethyl phthalate	0	1	56	14	0
72. 1,2-benzanthracene (benzo(a)anthracene)	0	1	57	13	0
73. benzo (a) pyrene (3,4-benzo-pyrene)	0	0	58	13	0
74. 3,4-benzofluoranthene (benzo(b)fluoranthene)	0	0	57	14	0
75. 11,12-benzofluoranthene (benzo(k)fluoranthene)	0	0	57	14	0
76. chrysene	0	0	58	13	0
77. acenaphthylene	0	0	57	14	0
78. anthracene	0	0	57	14	0
79. 1,12-benzoperylene (benzo(ghi)-perylene)	0	3	56	15	0
80. fluorene	0	0	55	13	0
81. phenanthrene	0	0	59	13	0
82. 1,2,5,6-dibenzanthracene (dibenzo(a,h)anthracene)	0	0	58	14	0
83. indeno(1,2,3-cd) pyrene (2,3-o-phenylene pyrene)	0	1	57	14	0
84. pyrene	0	1	58	13	0

* The same or a higher concentration was found in the incoming water

TABLE V-4 (CONT)

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Raw Wastewater Concentration Range mg/l
85. tetrachloroethylene	1	2	57	12	0
86. toluene	2	9	52	9	0.018
87. trichloroethylene	1	4	55	12	0.004
88. vinyl chloride (chloroethylene)	0	2	58	12	0
89. aldrin	0	0	60	12	0
90. dieldrin	0	0	58	14	0
91. chlordane (technical mixture and metabolites)	0	0	60	12	0
92. 4,4'-DDT	0	0	59	13	0
93. 4,4'-DDE (p,p'-DDX)	0	0	59	13	0
94. 4,4'-DDD (p,p'-TDE)	0	0	59	13	0
95. alpha-endosulfan	0	0	60	12	0
96. beta-endosulfan	0	0	59	13	0
97. endosulfan sulfate	0	1	59	12	0
98. endrin	0	0	59	13	0
99. endrin aldehyde	0	0	60	12	0
100. heptachlor	0	0	59	13	0
101. heptachlor epoxide	0	0	59	13	0
(BHC=hexachlorocyclohexane)					
102. alpha-BHC	0	0	60	12	0
103. beta-BHC	0	0	60	12	0
104. gamma-BHC (lindane)	0	0	60	12	0
105. delta-BHC	0	0	59	13	0
(PCB-polychlorinated biphenyls)					
106. PCB-1242 (Arochlor 1242)	0	0	59	13	0
107. PCB-1254 (Arochlor 1254)	0	0	59	13	0
108. PCB-1221 (Arochlor 1221)	0	0	59	13	0
109. PCB-1232 (Arochlor 1232)	0	0	59	13	0
110. PCB-1248 (Arochlor 1248)	0	0	59	13	0
111. PCB-1260 (Arochlor 1260)	0	0	59	13	0
112. PCB-1016 (Arochlor 1016)	0	0	60	12	0
113. Toxaphene	0	0	59	13	0
114. Antimony	13	31	22	6	0.150
115. Arsenic	8	14	39	11	0
116. Asbestos	0	2	59	11	--
117. Beryllium	2	3	54	13	0.002
118. Cadmium	17	26	19	10	0.03-20.0
119. Chromium	29	21	15	7	0.06-0.2
120. Copper	28	21	19	4	0.02-20.0
121. Cyanide	4	1	53	14	0.007
122. Lead	23	24	17	8	0.5-30.0
123. Mercury	3	1	54	13	0.0002
124. Nickel	32	19	15	5	1.0-3.0
125. Selenium	7	26	30	9	0.72-13.84
126. Silver	4	2	54	12	0.02
127. Thallium	1	1	58	12	0
128. Zinc	29	21	16	6	0.4-0.7
129. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	0	0	58	13	0
NON-CONVENTIONAL POLLUTANTS	0	2	23	3	--
Xylenes	2	5	20	3	--
Alkyl epoxides	0	2	23	3	--

TABLE V-4 (Cont)

Priority Pollutant	Known To Be Present	Believed To Be Present	Believed To Be Absent	Known To Be Absent	Raw Wastewater Concentration Range mg/l
Aluminum	Not Applicable				1.0-7.0
Barium	Not Applicable				1.0-6.0
Boron	Not Applicable				4.0-10.0
Chromium, Hexavalent	Not Applicable				.2
Cobalt	Not Applicable				.9-1.0
Fluoride	Not Applicable				0
Iron	Not Applicable				.3-100.0
Magnesium	Not Applicable				7.4-12.0
Manganese	Not Applicable				.08-3.0
Molybdenum	Not Applicable				.2-.4
Phenol, Total	Not Applicable				0-.012
Phosphorus	Not Applicable				4.14-80.1
Sodium	Not Applicable				57.-400.0
Tin	Not Applicable				.02-.04
Titanium	Not Applicable				2.0-20.0
Vanadium	Not Applicable				.02
Yttrium	Not Applicable				0
Oil & Grease	Not Applicable				1.0
TSS	Not Applicable				32-364

TABLE V-5

DCP EFFLUENT (mg/l)

ID	DESTINATION	FLOW (gph)	F	TSS	AL	SB	CD	CR-T	CU	FE	PB	MN	NI	SE	TI	ZN
1059	POTW															
1061	POTW/SURF															
1062	POTW															
3032	POTW	46.000		14.000	4.3		0.010	0.020		0.300	0.080		0.040			0.870
3033	POTW	86100		492.000			0.16	0.08	0.03	0.8	4.1	0.05	0.01			0.09
4066	POTW			520.000			0.000	0.01	0.080		0.000		0.020			0.100
4098	POTW															
4099	POTW															
4101	POTW															
4102	POTW	4500		1130				0.580			1.400		4.200			6.240
4122	POTW							1.320	0.160		0.120					0.930
4126	POTW															
4138	POTW															
6030	POTW															
6031	POTW															
9032	POTW															
9037	POTW															
11045	POTW															
11052	POTW	3900		1396			0.004			14.000	18.400	5.2	24.000			
11053	POTW															
11082	POTW	4500	2.000	750.000			0.010				1.960		2.300			3.600
11089	POTW															
11090	POTW	741.000					0.040		0.100		0.320		0.100			2.600
11091	POTW	2400		233.000	0.055		0.050	0.050	0.230	14.950	0.050		5.320			0.270
11092	SURF															
11105	POTW															
11106	POTW															
11107	POTW															
11117	POTW															
11923	POTW															
12035	POTW															
12037	POTW	120.000														
12038	POTW															
12039	POTW															
12040	RIVR	5610		1108						150.000		1.100	1.600			
12043	POTW															
12044	POTW															
12045	POTW															
12064	POTW			1.700			0.000		1.300	0.810	0.000		0.130			0.470
12064	POTW			56.000			0.010		1.800	0.430	0.010		0.170			0.580
12234	POTW	68460		673.000	19.000			1.870		144.000			2.400			4.820
12235	POTW															
13321	POTW															
13330	POTW	84000					0.009	0.053	0.012	0.373	0.020		0.262			0.270

TABLE V-5 Con t.

DCP EFFLUENT (mg/l)

ID	DESTINATION	FLOW (gph)	F	TSS	AL	SB	CD	CR-T	CU	FE	PB	MN	NI	SE	TI	ZN
15031	POTW		2.500	264.000			0.002	0.078	0.003	27.000	0.320	0.145	2.130			0.074
15031	POTW		1.900	96.000			0.001	0.199	0.023	58.000	0.030	0.183	1.150			0.027
15032	RIVR	1.000														
15033	POTW			274.000				1.975	0.110	15.000	0.170		1.550			2.010
15194	RIVR	12000														
15712	POTW															
15949	POTW			274.000				1.975	0.110	15.000	0.170		0.155			2.010
19049	POTW															
20015	POTW															
20059	POTW	1458														
20067	RIVR	500.000		20.000									900.000			0.710
20090	POTW															
20091	POTW															
21060	POTW															
22024	POTW	1072								0.500			0.020			
23089	POTW															
30043	POTW															
30062	SURF															
33053	SURF															
33054	RIVR	1950		26.000				0.150		0.59			0.71			0.59
33054	RIVR	2000		18.000				0.150		0.590			0.710			0.590
33076	POTW	1.000														
33076	POTW	0.000														
33077	LFLD	7200		20.000												
33083	POTW															
33084	POTW															
33085	POTW															
33086	SURF															
33088	POTW															
33089	POTW															
33092	POTW	21000		10.000						50.000			0.300			0.160
33092	POTW	24125		72.000						4.000						
33092	POTW	26750		14.000						4.800						
33092	POTW	26688		16.000				0.006		1.000			0.870			
33092	POTW	29688		90.000						5.000						
33092	POTW	28500		22.000						2.000						
33092	POTW	30125		74.000						1.800						
33092	POTW	34625		19.000						1.040			0.430			
33092	POTW	31750		12.000						0.490						
33092	POTW	38938		12.000					0.000	1.400						0.470
33092	POTW	28000		22.000						2.000						
33092	POTW	25250		11.000						3.200						
33092	POTW	29188		4.000						2.800						
33092	POTW	21198		66.000						1.600						
33092	POTW	23812		222.000						2.000						
33092	POTW	29125		9.000					0.000	1.800			0.200			0.180

TABLE V-5 Con t.

DCP EFFLUENT (mg/l)

ID	DESTINATION	FLOW (gph)	F	TSS	AL	SB	CD	CR-T	CU	FE	PB	MN	NI	SE	TI	ZN
33097	NONE			15.000					0.050				0.500			
33098	POTW															
33104	SURF															
33617	SURF															
34031	POTW	2280				0.014	0.005		0.000		0.027		0.040	0.020		0.000
36030	POTW						0.010		0.010	14.000	0.010	0.020	1.000			0.010
36039	POTW			40.000												
36052	RIVR			400.000				1.200		200.000			0.500			0.500
36069	POTW															
36072	POTW	1980		34.000				0.200	6.700	0.170	0.060		0.680			0.200
36072	POTW	1980		22.000				0.010	0.050	0.590	0.060		0.120			0.200
36072	POTW	1980		38.000				0.050	0.100	0.530	0.120		1.200			0.290
36072	POTW	1980		14.000				0.010	0.030	1.700	0.480		0.280			0.200
36072	POTW	1980		124.000				124.000	0.080	100.000	0.480		6.250			2.250
36072	POTW	1980		84.000				0.200	0.100	11.500	0.250		3.250			
36072	POTW	1980		16.000				0.150	0.080	32.000	0.200		22.000			0.150
36077	SURF															
36078	POTW															
40031	RIVR	0.000		1160				0.140	2.000	6.500	1.400	3.900	1.900			6.900
40032	RIVR	18000		2.500				0.300		0.140			0.190			0.060
40033	RIVR	200.000	5.460	103.570				0.020	0.040	7.430	0.150		0.120			0.040
40034	POTW	3840		150.000						0.400						
40035	POTW	1560	2.200	44.000		0.001	0.002	0.012	0.035	9.300	0.022	0.110	0.291	0.001	0.220	0.200
40036	POTW	17.000														
40039	POTW	1121	15.000	212.000						44.000						
40040	RIVR	374.000		10.000												0.090
40041	POTW															
40042	POTW	1086					0.003	0.020	0.040	0.860			0.040			
40043	NONE															
40050	POTW															
40053	POTW															
40055	POTW	4800			0.051	0.001	0.007	0.005		3.550	0.011		0.186			0.055
40063	RIVR	1000		1400						4.000			0.800			
40540	POTW	72.000						0.005	0.000	2.420			0.285			0.036
41062	LAKE	232.000		19.000			0.020	0.001								0.046
41076	POTW															
41078	RIVR	2704		560.000												
41078	RIVR	2704		160.000												
41078	RIVR	2704		190.000												
41078	RIVR	2704		310.000												
41078	RIVR	2704		370.000												
44031	POTW															
45030	POTW	1577		1.000			0.008	0.040	0.250		0.180		0.100			0.540
47032	POTW			129.000			0.130	0.010	0.010		0.220	0.020	0.050			
47033	POTW							1.800	0.190		0.060					0.040
47034	POTW	3120		41.300									0.800			0.020
47036	POTW	4800		232.000			0.550	0.920	0.100		3.560		0.010			0.766
47037	POTW			282.000			0.750	0.220	0.090		5.450					0.350
47038	POTW															
47050	POTW	858.000														
47051	LAKE	11648		388.000				0.020	0.070		0.130	0.150	0.360			
47111	POTW	7083	1.800	9.800				2.300			0.300		1.600			0.200
47670	POTW	51300		242.000				1.450	0.050		0.500		0.020			0.430

TABLE V-6
PARAMETERS FOUND IN SCREENING ANALYSIS

Parameter	Concentration Range (mg/l) Inlet Water	Raw Wastewater	Effluent	Blank
14 1,1,2-Trichloroethane	*	.007	*	*
23 Chloroform	.002-.068	.002-.005	*	.004-.005
30 1,2-transdichloroethylene	*	.002	*	*
44 Methylene chloride	.001-.012	.002-.005	.003	.014-.024
47 Bromoform	.002-.010	.002	*	*
48 Dichlorobromomethane	.003-.008	.002-.007	*	.003
51 Chlorodibromomethane	.001-.010	.002-.003	*	*
57 2-nitrophenol	*	.001	*	*
66 Bis(2-ethylhexyl)phthalate	.001-.008	.002-.022	*	*
68 Di-n-butyl phthalate	.002-.003	.002-.005	*	*
69 Di-n-octyl phthalate	*	.011	*	*
70 Diethyl phthalate	.002	.002-.024	*	*
86 Toluene	.001	.018	*	*
87 Trichloroethylene	*	.004	*	*
114 Antimony	*	.150	*	*
117 Beryllium	*	.002	*	*
117 Cadmium	.01	.03-20.0	.014-.9	*
119 Chromium, Total	.006-.043	.06-.2	.06-.4	*
Chromium, Hexavalent	*	.02	*	*
120 Copper	.018-.05	.02-20.0	.024-.5	*
121 Cyanide	.006-.13	.007	.03	*
122 Lead	.04-.16	.5-30.0	.2-.5	*
123 Mercury	*	.0002	.0008	*
124 Nickel	.192	1.0-3.0	.25-4.0	*
125 Selenium	*	.72-3.84	.084-11.8	*
126 Silver	.033	.02	.01	*
128 Zinc	.10	.4-.7	.07-2.0	*
Aluminum	.16-.3	1.0-7.0	.2-2.0	*
Barium	.01-.08	1.0-6.0	.3-2.0	*
Boron	.07	4.0-10.0	.157-20.0	*
Calcium	19.6-24.0	17.0-80.0	26.0-87.0	*
Cobalt	.027	.9-1.0	.044-.8	*
Fluorides	1.1	*	2.0	*
Iron	.2	.3-100.0	100.0	*
Magnesium	4.5-15.0	7.4-12.0	3.1-13.0	*
Manganese	.007-.009	.008-3.0	.009-2.0	*
Molybdenum	.03	.02-.03	.02-.04	*
Phenols, Total	.020-.054	.005-.012	.009-.038	*
Phosphorus	.410-.6	4.14-80.1	2.06-5.14	*
Sodium	16-24	57.0-400.0	36.0-250.0	*
Tin	.009-.05	.02-.04	.03	*
Titanium	.02	2.0-20.0	.02-9.0	*
Vanadium	.036	.02	.03-.042	*
Yttrium	0.4	*	.05	*

* Not detected in analysis

TABLE V - 7

POLLUTANT PARAMETERS SELECTED FOR VERIFICATION SAMPLING AND ANALYSIS FOR THE PORCELAIN ENAMELING CATEGORY*

Pollutant Parameter		Subcategory			
		Steel	Cast Iron	Aluminum	Copper
14	1,1,2-Trichloroethane	-	-	-	x
66	Bis(2-ethylhexyl)phthalate	-	-	x	-
69	Di-n-octyl phthalate	-	-	x	-
86	Toluene	-	-	-	x
87	Trichloroethylene	-	-	-	x
114	Antimony	x	x	x	x
115	Arsenic	x	x	x	x
117	Beryllium	x	-	x	-
118	Cadmium	x	x	x	x
119	Chromium, Total	x	x	x	x
119	Chromium, Hexavalent	-	-	x	-
120	Copper	x	x	x	x
122	Lead	x	x	x	x
124	Nickel	x	x	x	x
125	Selenium	x	x	x	x
128	Zinc	x	x	x	x
	Aluminum	x	x	x	x
	Barium	-	-	x	x
	Cobalt	x	x	x	x
	Fluoride	x	x	x	x
	Iron	x	x	x	x
	Manganese	x	x	x	x
	Phenols, Total	x	x	x	x
	Phosphorus	x	x	x	x
	Titanium	x	x	x	x
	Oil & Grease	x	-	x	x
	Total Suspended Solids	x	x	x	x
	pH	x	x	x	x

*A dash (-) indicates the parameter was not selected for verification; an x indicates the parameter was selected for verification. Selection of parameters was made prior to the determination that coating wastewaters are essentialy similar for each subcategory.

TABLE V-8

WATER USE RATES REPORTED IN DCP's
STEEL SUBCATEGORY

	METAL PREPARATION			COATING AND BALL MILLING		
PLANT ID	l/hr	m^2/hr	l/m^2	l/hr	m^2/hr	l/m^2
01059	397.43	245.75	1.62	227.48	245.75	0.926
03032	14534	1492.8	9.74	682.06	783.7	0.87
04098	3028	96.8	31.28	378.9	48.4	7.83
04102	6797.9	224.38	30.3	10291	355.28	28.97
09032	71536	746.8	95.79	3209.7	746.8	4.30
11052	3633.98	466	7.80	113.17	466	0.243
11090	1911.05	222	8.61	894.02	224	3.99
11105	26571	87.13	304.96	14307	131.47	108.82
11107	339.89	455	0.75	1363	455	3.0
12038	49205	1626	30.26	3785	1626	2.33
12043	5744.9	154.55	37.17	3093	201.66	15.34
15031	10366.7	321.8	32.21	8565	943	9.08
15033	14079.8	1385	10.17	44852	1385	32.38
15194	53368.1	259	206.05	11355	279	40.70
15949	38607	1061	36.39	112793	1185	95.18
20059	10763.4	42.82	251.36	5693.4	42.82	132.96
20067	1229.7	164.2	7.49	757	164.2	4.61
22024	5376	41.82	128.55	18.925	24.88	0.76
33054	22710	906.13	25.06	29523	824.8	35.79
33084	5905.0	349.34	16.9	6131.3	572.92	10.7
33086	14761.9	515	28.66	578	339	1.70
33092	31794	536	59.32	10787	586	18.41
33617	4769.1	1990.3	2.396	18320	2692	6.80
36030	465.9	31.65	14.72	1691.9	40.36	41.92
36052	14288	234.5	60.93	2271	109.6	20.72
40031	7721.4	246	31.39	3406.5	467	7.29
40034	14306.9	149	96.02	2953.1	292	10.11
40035	1135.88	103.5	10.97	1267.2	51.76	24.48
40039	11808.8	569.0	20.75	2952.3	569.0	5.19
40040	923.16	10	92.32	265.7	18	14.76
40043	49.92	191	0.26	33.28	191	0.174
40055	13970	557.17	25.07	3970.8	1446.7	2.74
40063	8858.9	204	43.43	5906	292	20.23
40540	3814.9	286	13.34	2089.7	286	7.31
44031	7608	148	51.41	5072	207	24.5
47033	14429.2	88	163.97	9619.4	40	240.49
47034	2725.2	217	12.56	4768.7	128	37.26
47037	5677.5	274	20.72	4911.4	164	29.95
11089	3406.5	273	12.48	1135.5	258	4.40
11106	40878	263	155.43	757	229	3.3
20015	5450.4	561.21	9.71	1173.7	902.47	1.30
20091	7948.5	209	38.03	18168.4	209	86.93
33085	1457.2	157.06	9.28	3141.9	236.5	13.28
33098	49345	151	326.79	6294.8	155	40.61
40042	2157.5	61	35.37	654.4	91	7.19
41062	734.29	11	66.75	143.8	40	3.60
11091	5954.2	215	27.69	3205.5	324	9.89
12039	9084	254	35.76	8403	356	23.6

TABLE V- 9

WATER USE RATES REPORTED IN DCP's
ALUMINUM SUBCATEGORY

	METAL PREPARATION			COATING AND BALL MILLING		
PLANT ID	l/hr	m^2/hr	l/m^2	l/hr	m^2/hr	l/m^2
09037	5205.9	520.75	10.0	2803.2	412.46	6.8
06030	6813	55.76	122.2	700.2	37.17	18.84
11045	1328.2	46.47	28.58	715.7	46.47	15.40
33077	8119.2	113.67	71.43	4371.7	113.67	38.46
33083	3633.6	107.11	33.92	567.75	53.55	10.60
47032	13626	73.37	185.72	1816.8	73.37	24.76
47036	3406.5	55.73	61.125	1286.5	55.73	23.08
47051	12490.5	88.87	140.55	1589.3	88.87	17.88
47670	11355	351.72	32.28	11177	175.86	63.56
33053	20.06	36.83	0.54	10.6	69.03	0.154

TABLE V- 10
COATING RAW WASTEWATER SUMMARY
(mg/l)

	ID#	40053	40053	40063	40063	40063	47033	47033	47033
		151	152	150	152	154	150	151	152
114	Antimony	0.0	0.0	4.226	8.983	12.190	0.0	1020.000	3.350
115	Arsenic	0.0	0.0	0.0	2.845	3.471	0.280	0.250	0.0
117	Beryllium	0.0	0.120	0.0	0.0	0.0	0.0	0.044	0.0
118	Cadmium	9.570	0.760	0.0	0.0	0.0	4.110	6.100	1.080
119	Chromium	0.210	1.070	0.036	0.005	0.460	1.190	37.400	0.110
120	Copper	2.245	8.750	0.314	1.139	2.976	55.000	12.100	0.520
122	Lead	3.030	7.580	0.285	0.0	0.0	10.800	1.470	0.840
124	Nickel	22.500	67.000	3.319	10.188	21.593	358.000	2.900	3.630
125	Selenium	0.430	0.820	0.0	17.290	16.321	2.030	0.0	0.120
128	Zinc	95.000	645.000	10.425	30.457	61.448	1320.000	77.000	1.980
	Aluminum	95.000	290.000	23.633	85.054	287.203	1525.000	365.000	5.240
	Barium								
	Cobalt	8.910	95.000	0.310	6.502	12.598	350.000	90.000	6.240
	Fluorides	38.000	105.000	46.373	33.251	34.449	74.000	60.000	14.500
	Iron	52.000	150.000	2.903	24.371	41.403	152.000	620.000	3.330
	Manganese	11.400	65.000	12.780	29.296	82.754	400.000	275.000	11.800
	Phosphorus	0.490	0.940	0.856	0.600	0.692	9.810	2.060	1.640
	Titanium	19.100	102.000	41.190	184.058	1641.450	1500.000	138.000	5.750
	Oil & Grease			54.274	3.820	3.360			
	Total Suspended Solids	6629.996	27899.988	2218.809	21708.258	21709.882	319599.937	10669.996	
	pH - Minimum	8.3	8.3	7.0	7.2	7.4	8.3	8.3	8.1
	pH - Maximum	9.0	9.0	11.5	11.4	12.5	8.9	8.9	8.4

	ID#	33077	36077	36077	36077	47051	47051	47051	
		151	150	151	152	150	151	152	Mean
114	Antimony	0.0	16.500	3.030	6.180	0.0	0.0	0.0	77.7472
115	Arsenic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7924
117	Beryllium	0.0	0.060	0.0	0.0	0.0	0.0	0.0	0.049
118	Cadmium	11.300	8.000	3.300	22.400	0.580	0.290	0.310	6.7405
119	Chromium	0.030	3.000	0.320	0.220	0.039	0.039	0.032	1.5728
120	Copper	0.0	3.000	0.240	0.430	0.006	0.005	0.010	4.0283
122	Lead	37.900	40.000	20.100	22.600	8.720	4.980	9.550	51.4413
124	Nickel	0.0	30.000	1.160	1.160	0.0	0.0	0.0	36.6847
125	Selenium	0.530	0.720	0.540	1.710	0.0	0.0	0.0	11.8858
128	Zinc	1.970	400.000	203.000	92.000	0.750	1.030	0.920	113.9000
	Aluminum	2.080	200.000	29.700	43.800	0.380	0.330	0.500	184.0688
	Barium	0.110	90.000			1.370	1.140	0.970	10.5239
	Cobalt	0.029	30.000	1.200	2.680	0.0	0.0	0.0	36.4673
	Fluorides	0.920		8.800	15.000	1.850	1.450	1.400	27.9779
	Iron	0.200	20.000	7.880	8.830	0.150	0.110	0.180	43.9262
	Manganese	0.0	5.000	0.580	0.660	0.0	0.0	0.0	54.3345
	Phosphorus	65.300	0.0	0.850	1.130	4.140	0.380	0.710	4.6307692
	Titanium	30.400	100.000	198.000	280.000	6.910	3.130	4.780	5357.257
	Oil & Grease	0.0	7.900	5.00	2.640	0.0	0.0	0.0	15.8652
	Total Suspended Solids	650.000	22095.992	6019.996	5209.996	529.000	383.000	469.000	15291.658
	pH - Minimum	9.2	8.4	8.7	8.2	8.2	9.1	8.5	
	pH - Maximum	9.5	9.3	9.4	8.5	9.3	10.0	10.0	

NOTE: The number immediately below each plant ID# indicates either screening or verification sampling and the sampling day on which these results were obtained. Numbers beginning with 14 indicate screening; numbers beginning with 15 indicate verification sampling. The third digit represents a specific sampling day in relation to other sampling days at the same plant.

TABLE V-10 (Continued)
COATING RAW WASTEWATER SUMMARY
(mg/l)

	ID#	33617 140	33617 153	33617 155	36030 140	36030 151	36030 152	40053 150
114	Antimony	0.0	0.0	0.0	1.580	3.500	2.350	0.0
115	Arsenic	0.0	0.0	0.0	0.0	0.0	0.420	0.0
117	Beryllium	0.0	0.0	0.0	0.059	0.0	0.035	0.069
118	Cadmium	0.0	0.0	0.0	0.260	0.097	0.220	0.410
119	Chromium	0.060	0.040	0.033	0.300	0.200	0.630	0.910
120	Copper	0.260	0.280	0.260	5.880	4.730	7.070	6.610
122	Lead	0.630	0.290	0.180	4.760	2.320	4.820	6.050
124	Nickel	2.000	1.810	2.000	38.200	39.800	49.000	42.500
125	Selenium	0.0	0.0	0.0	0.510	0.770	0.810	0.530
128	Zinc	3.360	1.090	1.520	57.500	82.000	196.000	3.600
	Aluminum	41.500	32.600	27.900	182.000	100.000	196.000	180.000
	Barium							
	Cobalt	1.980	1.490	2.270	48.400	51.000	64.000	46.800
	Fluorides	19.000	23.000	18.000	46.000	66.000	56.000	115.000
	Iron	3.130	2.850	2.600	16.000	14.900	28.800	37.700
	Manganese	2.300	1.750	2.250	64.000	85.000	118.000	28.900
	Phosphorus	5.140	4.860	6.780	1.000			1.500
	Titanium	45.800	20.800	23.700	120.000	220.000	554.999	54.000
	Oil & Grease	34.000	28.000	12.000	10.000	98.000	2.000	
	Total Suspended Solids	488.000	2630.000	360.000	13799.996	31249.992	93899.937	26999.996
	pH - Minimum	8.4	8.9	8.1	7.6	8.1	8.0	8.3
	pH - Maximum	8.9	9.1	8.3	9.5	9.7	10.100	9.0

	ID#	11045 150	11045 151	11045 152	15712 140	15712 151	15712 152	33076 150	33077 150
114	Antimony	0.362	0.208	0.0	0.0	0.0	0.0	6.002	0.0
115	Arsenic	0.0	0.0	0.0	0.0	2.800	2.401	1.872	0.0
117	Beryllium	0.0	0.0	0.0	0.0	0.003	0.002	0.0	0.0
118	Cadmium	0.0	6.984	5.025	0.014	0.0	0.0	0.0	54.000
119	Chromium	0.008	0.011	0.010	0.057	0.001	0.0004	0.740	0.024
120	Copper	0.039	0.181	0.050	0.024	0.001	0.001	0.415	0.0
122	Lead	3.467	6.215	20.319	0.490	130.145	188.242	876.242	28.300
124	Nickel	0.0	0.0	0.0	0.250	0.0	0.0	0.0	0.0
125	Selenium	0.0	0.747	0.543	11.800	15.851	161.189	9.270	7.070
128	Zinc	0.153	0.202	0.564	0.0	0.681	0.732	14.405	0.300
	Aluminum	0.253	0.270	0.292	0.376	144.209	342.873	1220.012	0.860
	Barium	0.310	0.303	0.402	0.0				0.110
	Cobalt	0.0	0.0	0.0	0.044	7.585	11.283	0.118	0.0
	Fluorides	0.920	0.932	0.946	2.000	2.241	2.541	22.846	0.940
	Iron	0.563	0.940	0.385	0.0	18.408	20.222		0.180
	Manganese	0.003	0.011	0.0	0.009	0.004	0.003	2.227	0.0
	Phosphorus	1.091	1.044	1.423	2.060	0.910	0.734	0.0	4.260
	Titanium	3.680	5.176	9.812	0.022	0.0	0.0	0.0	17.500
	Oil & Grease	2.335	4.698	3.304	1.000	3.718	9.525		0.0
	Total Suspended Solids	121.630	249.146	161.861	11949.996	16971.363	18598.203	81337.875	55.000
	pH - Minimum	6.950	7.7	8.0	7.9	9.2	9.3	11.1	9.2
	pH - Maximum	8.800	8.8	9.7	10.7	10.8	10.5	11.4	10.0

TABLE V-10 (Continued)
COATING RAW WASTEWATER SUMMARY
(mg/l)

	18538 140	18538 152	18538 154	41062 150	41062 151	41062 152	Mean
114 Antimony	0.0	0.0	0.0	0.920	1.080	0.0	68.1538
115 Arsenic	0.0	0.130	0.0	0.060	0.060	0.052	1.2201
117 Beryllium	0.0	0.0	0.0	0.014	0.034	0.028	0.0425
118 Cadmium	0.004	0.0	0.0	4.640	4.760	54.00	8.2589
119 Chromium	0.031	0.260	0.013	0.410	1.240	0.180	1.3699
120 Copper	3.210	1.920	0.160	0.190	0.200	0.270	3.4924
122 Lead	1.280	0.750	0.047	3.590	6.490	3.180	42.8145
124 Nickel	19.300	7.610	0.600	0.750	0.680	0.390	28.3336
125 Selenium	0.0	0.150	0.0	0.680	0.460	0.290	10.0473
128 Zinc	34.700	14.100	16.400	14.700	16.400	31.800	98.0343
Aluminum	22.500	12.500	5.330	24.000	49.700	225.000	162.8082
Barium	-	-	-	-	-	-	10.5239
Cobalt	8.000	3.090	0.440	2.950	3.740	2.070	29.6220
Fluorides	8.400	6.400	1.900	6.200	3.400	7.000	24.1331
Iron	1.920	1.530	0.450	2.420	6.600	12.500	36.9222
Manganese	11.800	4.550	0.720	0.610	0.660	0.450	44.0939
Phosphorus	1.690	2.250	1.350	2.710	4.170	3.400	4.2491
Titanium	107.000	72.000	23.300	4.330	43.300	799.999	4415.0263
Oil & Grease	2.000	2.000	3.000	90.000	3.000	1.000	16.1072
Total Suspended Solids	4272.000	2829.999	367.000	1560.000	1840.000	11599.996	21918.1669
pH - Minimum	6.2	5.8	6.4	8.2	8.2	7.5	
pH - Maximum	7.9	5.9	7.6	8.4	8.6	8.2	

TABLE V-11

TOTAL & DISSOLVED METALS ANALYSIS
STEEL SUBCATEGORY

Coating Waste Stream

PARAMETER	TOTAL mg/l	DISSOLVED mg/l
pH range	11.2-11.5	
Aluminum	136.00	0.95
Antimony	14.10	0.00
Arsenic	4.690	0.00
Cobalt	10.40	0.00
Copper	1.80	0.019
Iron	39.40	0.029
Manganese	46.70	0.0
Nickel	16.30	0.0
Selenium	28.50	0.0
Titanium	300.00	0.0
Zinc	49.10	0.017

TABLE V-12
TOTAL & DISSOLVED METALS ANALYSIS
CAST IRON SUBCATEGORY
Coating Waste Stream

PARAMETER	TOTAL mg/l	DISSOLVED mg/l
pH range	10.3-10.5	
Aluminum	254.0	0.0
Arsenic	2.930	0.0
Cobalt	7.860	0.0
Iron	18.900	0.007
Lead	135.00	2.10
Selenium	16.600	0.0
Zinc	0.710	0.011

TABLE V-13
TOTAL & DISSOLVED METALS ANALYSIS
ALUMINUM SUBCATEGORY
Coating Waste Stream

PARAMETER	TOTAL mg/l	DISSOLVED mg/l
pH Range	9.2-9.5	
Aluminum	0.86	0.0
Barium	0.110	0.0
Cadmium	54.00	0.003
Chromium, total	0.024	0.008
Iron	0.180	0.0
Lead	28.30	0.0
Selenium	7.070	0.07
Titanium	17.50	0.0
Zinc	0.30	0.010

TABLE V-14
TOTAL & DISSOLVED METALS ANALYSIS
COPPER SUBCATEGORY
Coating Waste Stream

PARAMETER	TOTAL mg/l	DISSOLVED mg/l
pH range	8.0-10.1	
Aluminum	196.00	0.49
Antimony	2.350	0.27
Arsenic	0.420	0.0
Beryllium	0.035	0.0
Cadmium	0.220	0.0
Chromium, total	0.630	0.30
Cobalt	64.00	0.016
Copper	7.070	0.028
Iron	28.80	0.12
Lead	4.82	0.0
Manganese	118.00	0.043
Nickel	49.00	0.026
Selenium	0.810	0.0
Titanium	555.00	0.0
Zinc	196.00	0.018

TABLE V-15
SHORT TERM LEACHING CHARACTERISTICS OF COATING WASTEWATER

Dissolved Parameter Analysis

	CONCENTRATION (mg/l)		
PARAMETER	pH=4	pH=7	pH=10
Arsenic	<1	<1	<1
Cadmium	0.70	0.00	0.00
Chromium	<1	<1	<1
Cobalt	19.0	2.68	<1
Copper	1.13	<1	<1
Fluoride	110	50	13
Iron	1.38	<1	<1
Lead	1	<1	<1
Manganese	24.8	1.58	<1
Nickel	47.0	4.70	<1
Zinc	26.1	<1	<1

TABLE V- 16
TOXIC METALS DISCHARGED FROM THE COATING WASTE STREAM PER YEAR

Parameter	lbs/yr Discharged	Fraction of Total Metals Discharged (Percent)
Antimony	8,000	5.8
Arsenic	2,200	1.59
Cadmium	1,600	1.16
Chromium	425	0.31
Copper	6,000	4.35
Lead	3,000	2.17
Nickel	16,500	11.96
Selenium	225	0.16
Zinc	100,000	72.49

TABLE V-17

SAMPLED PLANTS
EFFLUENT CONCENTRATION (mg/l)
STEEL SUBCATEGORY

	PLANT 36030			PLANT 36077		
	DAY 1	DAY 2	DAY 3	DAY 1	DAY 2	DAY 3
Aluminum	1.760	166.	210.	10.0	4.29	8.08
Antimony	0	16.3	3.140	0.0	4.55	3.4
Arsenic	-	0.780	0.520	-	0.0	0.0
Cadmium	0.079	0.480	1.090	2.000	1.34	2.83
Chromium, Total	0.061	1.330	1.910	.080	0.024	0.0
Cobalt	.590	50.	43.5	.300	.270	.300
Copper	0.530	5.880	4.180	.200	0.115	0.0
Fluoride	6.80	66.	100.	-	8.3	13.0
Iron	110.	770.	1010.	2.000	1.08	2.39
Lead	0.530	5.880	4.180	2.000	1.57	1.51
Manganese	1.550	82.0	69.	.300	0.185	0.21
Nickel	0	46.80	40.50	1.000	0.76	0.71
Phenols, Total	-	0.062	-	0.014	0.006	0.007
Phosphorus	0.800	3.0	7.020	1.98	0.8	1.23
Selenium	0	0.570	1.190	0.0	0.0	0.37
Titanium	4.630	970.	1025.	10.00	6.66	11.80
Zinc	1.790	257	279	5.00	5.13	26.9
Oil and Grease	-	12.0	242.	0.0	7.0	9.0
Total Suspended Solids	740.	60100.	113300.	336.0	90.	198.0
pH	-	6.2-8.2	6.4-10.5	7.9-8.4	8.4-9.2	8.2-8.6

TREATMENT IN PLACE	PLANT 36030	PLANT 36077
Equalization		
Chromium Reduction		
Chemical Precipitation		
Clarification/Settling	x	
Sludge Dewatering		

	PLANT 40053			PLANT 41062		
	DAY 1	DAY 2	DAY 3	DAY 1	DAY 2	DAY 3
Aluminum	.300	0.0	.270	1.37	1.93	3.08
Antimony	-	-	-	0	0	-
Arsenic	-	-	-	0	0	0
Cadmium	0	0	0	0.055	0.011	0.160
Chromium, Total	0.011	0.014	0.012	0.009	0.009	0.011
Cobalt	0.0	.029	.036	0.0	0.0	0.0
Copper	0.056	0.046	0.055	0.010	0.013	0.016
Fluoride	1.050	0.980	0.720	2.80	1.60	2.40
Iron	180.	275.	300.	0.050	0.069	0.600
Lead	0	0	0	0	0	0
Manganese	0.620	1.0	1.1	0	0	0.010
Nickel	3.800	2.970	4.620	0.021	0	0.020
Phenols, Total	0.019	0.037	0.015	0.048	0.012	0.048
Phosphorus	7.95	11.90	12.0	0.48	0.730	1.10
Selenium	0	0	0	0	0	0
Titanium	0.0	0.0	0.0	0.0	0.0	.480
Zinc	0.120	0.130	0.160	0.480	0.130	0.088
Oil and Grease	-	-	-	1.0	3.0	1.0
Total Suspended Solids	3.0	10.0	141	6.0	13.0	18.0
pH	2.1-3.2	2.1-3.2	2.1-3.2	7.5-8.9	8.4-9.4	8.4-8.9

TREATMENT IN PLACE	PLANT 40053	PLANT 41062
Equalization		
Chromium Reduction		
Chemical Precipitation		
Clarification/Settling		x
Sludge Dewatering		x
Filtration		x

-indicates no data available.

TABLE V-18
SAMPLED PLANTS
EFFLUENT CONCENTRATION (mg/l)
CAST IRON SUBCATEGORY

	PLANT 15712			PLANT 33076	PLANT 40053		
PARAMETER	DAY 1	DAY 2	DAY 3	DAY 1	DAY 1	DAY 2	DAY 3
Aluminum	.376	244.209	342.873	1220.012	180.	95.0	290.0
Antimony	-	-	-	6.002	-	-	-
Arsenic	-	2.8	2.401	1.872	-	-	-
Cadmium	0.014	-	-	-	0.41	9.57	0.76
Chromium, Total	0.057	0.001	0.0	0.74	0.91	0.21	1.07
Cobalt	.044	7.585	11.283	.118	46.8	8.91	95.0
Copper	0.024	0.001	0.001	0.415	6.61	2.45	8.75
Fluoride	2.0	2.241	2.541	22.846	115.0	38.0	105.0
Iron	0.0	18.408	20.222		37.7	52.0	150.0
Lead	0.49	130.145	188.242	876.272	6.05	3.03	7.58
Manganese	0.009	0.004	0.003	2.227	28.9	11.4	65.0
Nickel	0.25	-	-	-	42.5	22.5	67.0
Phenols, Total	.038	.008	.014	-	.025	.016	.019
Phosphorus	2.06	.910	.734	-	1.5	.49	.940
Selenium	11.8	15.851	161.189	9.27	0.53	0.43	0.82
Titanium	.022	-	-	-	54.0	19.1	102.
Zinc	0.0	0.681	0.732	14.405	3.6	95.0	645.0
Total Suspended Solids	11950	16971.363	18598.203	81337.87	26999.99	6629.99	27899.98
pH	7.9-10.7	9.2-10.8	9.3-10.5	11.1-11.4	8.3-9.0	8.3-9.0	8.3-9.0

TREATMENT IN PLACE

	PLANT 15712 DAY 1	PLANT 15712 DAY 2	PLANT 15712 DAY 3	PLANT 33076 DAY 1	PLANT 40053 DAY 1	PLANT 40053 DAY 2	PLANT 40053 DAY 3
Equalization							
Chromium Reduction							
Chemical Precipitation							
Clarification/Settling	X			X			
Sludge Dewatering							

TABLE V-19
SAMPLED PLANTS
EFFLUENT CONCENTRATION (mg/l)
ALUMINUM SUBCATEGORY

	PLANT 11045			PLANT 33077			PLANT 47051		
	DAY 1	DAY 2	DAY 3	DAY 1	DAY 2	DAY 3	DAY 1	DAY 2	DAY 3
Aluminum	.381	.410	10.450	.200	0.0	-0.027	2.86	8.8	8.6
Antimony	0.26	0.154	-	0.0	0.0	0.0	-	-	-
Arsenic	-	-	-	0.0	0.0	0.0	-	-	-
Barium	.228	.250	.243	.300	.200	.110	.340	.400	0.170
Cadmium	0.002	0.0	3.299	0.9	0.057	0.083	0.003	0.024	0.0
Chromium, Total	0.003	0.009	0.014	0.006	0.0	0.0	0.012	0.019	0.14
Chromium, Hexavalent	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Cobalt	-	-	-	-	-	-	0.0	.015	0.0
Copper	.092	.118	.040	0.0	0.0	0.0	.009	.088	.060
Fluoride	.910	.950	.936	1.50	2.0	1.8	.082	.082	1.00
Iron	.506	.622	.252	0.0	.038	.033	.100	.590	0.390
Lead	2.765	2.733	12.706	0.5	0.0	0.12	0.12	0.17	0.0
Manganese	.007	.007	.071	0.0	0.0	0.0	.04	.130	0.07
Nickel	-	-	-	-	-	-	.028	5.61	.165
Phenols, Total	.008	.013	.006	.009	0.0	0.0	.005	0.01	0.0
Phosphorus	0.811	0.435	4.425	3.57	0.89	1.14	8.93	-	-
Selenium	-	0.186	0.345	0.084	0.0	0.0	-	-	-
Titanium	1.824	3.484	6.395	.400	0.0	0.0	0.0	0.0	0.0
Zinc	0.1	0.175	0.344	0.07	0.54	0.57	0.69	0.091	0.078
Oil and Grease	3.116	3.483	3.184	0.0	0.0	0.0	10.0	172.0	35.0
Total Suspended Solids	138.025	159.812	120.143	5.0	0.0	33.0	303.0	256.0	366.0
pH	6.95-8.8	7.0-8.8	8.0-10.4	8.7-8.8	9.4-10.0	8.9-9.0	7.0-11.0	7.3-8.5	7.0-11.2
TREATMENT IN PLACE									
Equalization									
Chromium Reduction									
Chemical Precipitation					X				
Clarification/Settling		X			X			X	
Sludge Dewatering									

-indicates no data available

*indicates effluent contains pollutant from other Point Source Categories.

TABLE V-20
SAMPLED PLANTS
EFFLUENT CONCENTRATION (mg/l)
COPPER SUBCATEGORY

PARAMETERS	PLANT 06031	PLANT 36030 DAY 1	PLANT 36030 DAY 2	PLANT 36030 DAY 3
Aluminum	.208	1.76	166	210
Antimony	0.002	0.0	16.3	3.14
Arsenic	0.081	-	0.78	0.52
Cadmium	0.003	0.079	0.48	1.09
Chromium, Total	0.013	0.061	1.33	1.91
Cobalt	.024	.590	50.0	43.50
Copper	0.751	0.53	5.88	4.18
Fluoride	-	6.8	66.0	100.0
Iron	.345	110.0	770.0	1010.
Lead	0.542	0.085	1.69	4.58
Manganese	0.008	1.55	82.0	69.0
Nickel	0.025	0.0	46.8	40.5
Phenols, Total	-	-	.062	-
Phosphorus	-	.800	3.0	7.02
Selenium	0.16	0.0	0.57	1.19
Titanium	.004	4.63	970.	1025.
Trichloroethylene	.011	-	-	-
Zinc	0.012	1.79	257.0	279.0
Oil and Grease	-	-	12.0	242
Total Suspended Solids	-	740.0	60100	113300
pH	6.0-11.2	-	6.2-8.2	6.4-10.5

TREATMENT IN PLACE

Equalization				
Chromium Reduction				
Clarification/Settling	X	X		
Sludge Dewatering				

-indicates no data available.

TABLE V-21

RAW WASTE: PREPARATION OF STEEL (mg/l)

		AVERAGE DAILY VALUES				#	#
		MINIMUM	MAXIMUM	MEAN	MEDIAN	PTS	ZEROS
	Flow . l/day	9910.	206500.	91600.	57500.	18	0
	Minimum pH	2.000	6.80	2.472	2.100	18	0
	Maximum pH	5.40	11.70	8.34	9.50	18	0
	Temperature Deg C	27.43	121.0	41.57	33.00	20	0
86	Toluene	0.00	0.00	0.00	0.00	0	2
114	Antimony	0.000	0.000	0.000	0.000	0	20
115	Arsenic	0.000	0.000	0.000	0.000	0	20
117	Beryllium	0.000	0.000	0.000	0.000	0	20
118	Cadmium	0.00169	0.02307	0.00892	0.00594	5	15
119	Chromium, Total	0.00742	0.3478	0.1088	0.0549	20	0
	Chromium, Hexavalent	0.000	0.000	0.000	0.000	0	20
120	Copper	0.01944	0.1193	0.0574	0.4995	20	0
121	Cyanide, Total	0.000	0.000	0.000	0.000	0	7
	Cyanide Amn. to Chlor.	0.000	0.000	0.000	0.000	0	7
122	Lead	0.01583	0.03537	0.02405	0.0225	4	16
124	Nickel	0.0751	67.2	14.51	1.367	15	3
125	Selenium	0.00201	0.1898	0.0959	0.0959	2	18
128	Zinc	0.02002	0.3478	0.1002	0.0811	19	0
	Aluminum	0.04577	3.150	0.3449	0.1633	17	3
	Cobalt	0.01004	0.1267	0.0521	0.0243	17	3
	Fluorides	0.2040	1.250	0.696	0.786	20	0
	Iron	0.797	1357.	535.	488.5	17	0
	Manganese	0.00326	6.24	1.938	1.247	18	0
	Phenols, Total	0.00667	0.4727	0.0752	0.03426	17	1
	Phosphorus	0.3618	14.10	5.43	4.395	9	0
	Titanium	0.04337	0.04337	0.04337	0.04337	1	19
	Oil & Grease	1.2746	44.81	12.35	5.05	10	0
	Total Suspended Solids	4.768	287.9	84.0	32.74	18	0

TABLE V-22

RAW WASTE: PREPARATION OF ALUMINUM (mg/l)

		AVERAGE DAILY VALUES				#	#
		MINIMUM	MAXIMUM	MEAN	MEDIAN	PTS	ZEROS
	Flow l/day	19200.	216700.	130900.	168700.	8	0
	Minimum pH	6.30	9.500	8.00	7.93	8	0
	Maximum pH	7.90	10.40	9.35	9.60	8	0
	Temperature Deg C	18.00	36.90	24.41	23.40	8	0
66	B2-Ethyhexlphthalate	0.00	0.00	0.00	0.00	0	8
69	Di-n-octyl phthalate	0.00	0.00	0.00	0.00	0	8
86	Toluene	0.00	0.00	0.00	0.00	0	3
114	Antimony	0.000	0.000	0.000	0.000	0	8
115	Arsenic	0.000	0.000	0.000	0.000	0	8
117	Beryllium	0.000	0.000	0.000	0.000	0	8
118	Cadmium	0.003	0.003	0.003	0.003	1	7
119	Chromium, Total	0.007	0.018	0.012	0.012	2	6
	Chromium, Hexavalent	0.000	0.000	0.000	0.000	0	8
120	Copper	0.021	0.056	0.038	0.038	2	6
121	Cyanide, Total	0.015	0.176	0.095	0.095	2	6
	Cyanide Amn. to Chlor.	0.015	0.176	0.095	0.095	2	6
122	Lead	0.040	4.310	2.175	2.175	2	6
124	Nickel	0.000	0.000	0.000	0.000	0	8
125	Selenium	0.000	0.000	0.000	0.000	0	8
128	Zinc	0.019	0.540	0.210	0.170	7	1
	Aluminum	0.680	25.90	6.64	4.510	7	1
	Barium	0.000	0.000	0.000	0.000	0	8
	Cobalt	0.000	0.000	0.000	0.000	0	8
	Fluorides	0.720	0.980	0.880	0.910	8	0
	Iron	0.013	0.330	0.969	0.059	8	0
	Manganese	0.019	0.180	0.111	0.135	3	5
	Phenols, Total	0.005	0.016	0.008	0.007	7	1
	Phosphorus	0.410	24.30	8.49	9.40	8	0
	Titanium	0.000	0.000	0.000	0.000	0	8
	Oil & Grease	3.000	11.00	6.85	6.70	4	4
	Total Suspended Solids	1.000	181.0	39.87	17.00	8	0

TABLE V-23

RAW WASTE: PREPARATION OF COPPER (mg/l)

		AVERAGE DAILY VALUES				#	#
		MINIMUM	MAXIMUM	MEAN	MEDIAN	PTS	ZEROS
	Flow l/day	6140.	7270.	6890.	7280.	3	0
	Minimum pH	1.800	6.500	4.833	6.20	3	0
	Maximum pH	6.50	6.60	6.55	6.55	2	0
	Temperature Deg C	19.00	28.00	21.67	19.00	3	0
6	Carbon tetrachloride	0.00	0.00	0.00	0.00	0	1
11	1,1,1-Trichloroethane	*	*	*	*	1	0
14	1,1,2-Trichloroethane	0.00	0.00	0.00	0.00	0	1
15	1,1,2,2-Tetrachloroethane	*	*	*	*	2	0
23	Chloroform	*	*	*	*	2	1
29	1,1-Dichloroethylene	0.00	0.00	0.00	0.00	0	1
44	Methylene chloride	0.00	0.00	0.00	0.00	0	1
45	Methyl chloride	0.00	0.00	0.00	0.00	0	1
48	Dichlorobromomethane	*	*	*	*	2	0
85	Tetrachloroethylene	0.00	0.00	0.00	0.00	0	3
86	Toluene	0.00	0.00	0.00	0.00	0	2
87	Trichloroethylene	*	*	*	*	1	0
114	Antimony	0.00	0.00	0.00	0.00	0	3
115	Arsenic	0.00011	0.00011	0.00011	0.00011	1	2
117	Beryllium	0.000	0.000	0.000	0.000	0	3
118	Cadmium	0.022	0.022	0.022	0.022	1	2
119	Chromium, Total	0.008	0.060	0.02566	0.009	3	0
	Chromium, Hexavalent	0.000	0.000	0.000	0.000	0	3
120	Copper	9.68	815.	278.7	12.00	3	0
121	Cyanide, Total	0.000	0.000	0.000	0.000	0	2
	Cyanide Amn. to Chlor.	0.000	0.000	0.000	0.000	0	1
122	Lead	0.770	0.770	0.770	0.770	1	2
124	Nickel	0.1199	0.1199	0.1199	0.1199	1	2
125	Selenium	0.00011	0.0001100	0.00011	0.00011	1	2
128	Zinc	0.049	2.400	0.890	0.220	3	0
	Aluminum	0.0002	0.170	0.0734	0.050	3	0
	Cobalt	0.000	0.000	0.000	0.000	0	3
	Fluorides	0.110	0.120	0.115	0.115	2	0
	Iron	0.150	51.3	27.41	30.78	3	0
	Manganese	0.010	0.2599	0.0963	0.019	3	0
	Phenols, Total	0.006	0.006	0.006	0.006	1	1
	Phosphorus	0.520	0.520	0.520	0.520	1	1
	Titanium	0.000	0.000	0.000	0.000	0	3
	Oil & Grease	196.0	196.0	196.0	196.0	1	0
	Total Suspended Solids	14.00	24.00	19.00	19.00	2	0

* $\leq$ 0.01 mg/l

TABLE V-24
SAMPLED PLANT WATER USE (l/m^2)
Steel Subcategory

Plant ID	Sampling Day	Metal. Preparation	Coating
15051	1	96.305	4.229
	2	55.020	8.767
	3	16.582	6.232
18538	1	23.060	11.480
	2	27.276	16.675
	3	23.060	8.438
36030	1	15.631	4.914
	2	13.490	4.936
	3	17.174	3.861
36077	1	-	4.472
	2	-	2.708
	3	-	5.498
40053	1	18.928	1.098
	2	18.821	1.596
	3	18.874	1.087
40063	1	9.552	18.939
	2	8.447	32.291
	3	12.248	35.137
41062	1	141.677	4.221
	2	49.633	3.384
	3	154.970	8.377
47033	1	109.024*	1.184
	2	183.749*	1.355
	3	192.136*	3.560
	Mean	40.042	8.102

*Value deleted from subcategory average.

-No water use associated with metal preparation.

TABLE V-24 (Con't)
SAMPLED PLANT WATER USE (l/m^2)
Cast Iron Subcategory*

Plant ID	Sampling Day	Metal Preparation	Coating
15712	1		0.342
	2		0.273
	3		0.238
33076	1		0.219
40053	1		1.098
	2		1.596
	3		1.087
	Mean		0.693

SAMPLED PLANT WATER USE (l/m^2)
Aluminum Subcategory

Plant ID	Sampling Day	Metal Preparation	Coating
11045	1	20.155	51.435*
	2	23.598	67.146*
	3	41.822	64.012*
33077	1	160.119*	15.656
	2	139.686*	34.921
	3	123.776*	30.869
47051	1	49.998	3.406
	2	45.491	3.771
	3	52.313	1.625
	Mean	38.896	15.041

*Value deleted from subcategory average.

TABLE V-24 (Con't)
SAMPLED PLANT FLOW DATA (l/m^2)
Copper Subcategory

Plant ID	Sampling Day	Metal Preparation	Coating
06031	1	87.357	0.168*
36030	1	59.26	5.185
	2	55.243	4.834
	3	-	4.194
		67.29	4.74

* Value deleted from subcategory average.

\- Indicates no data available.

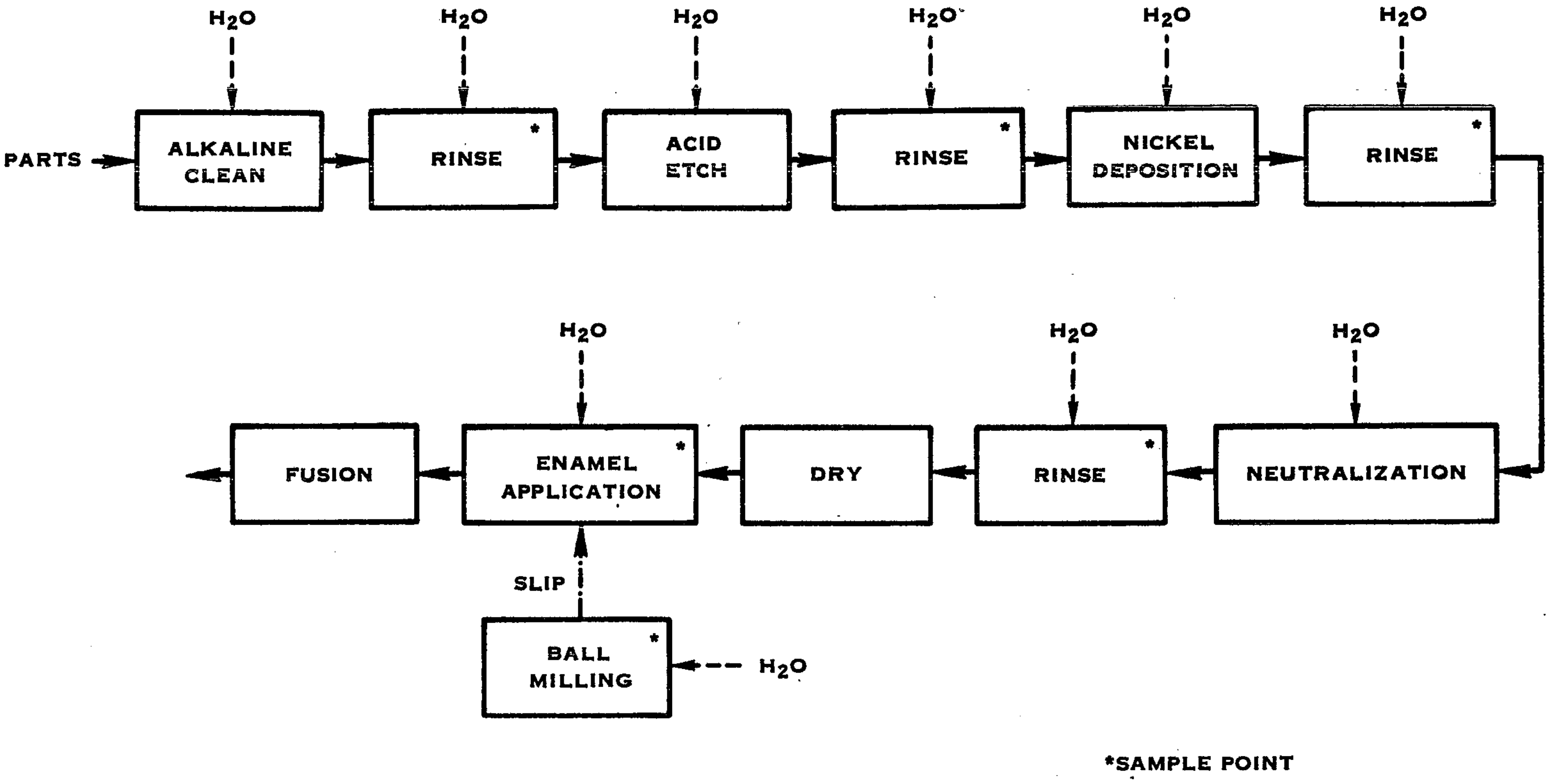
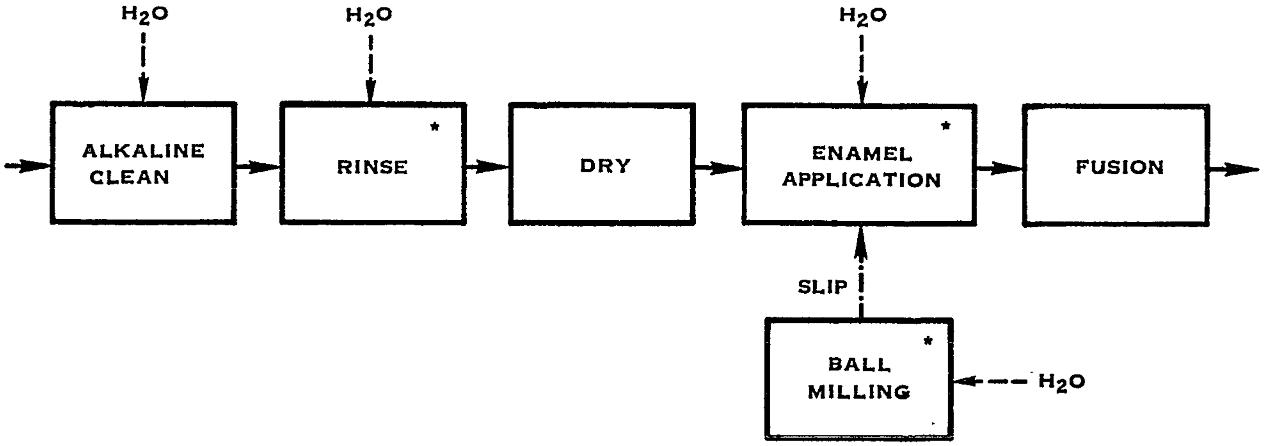
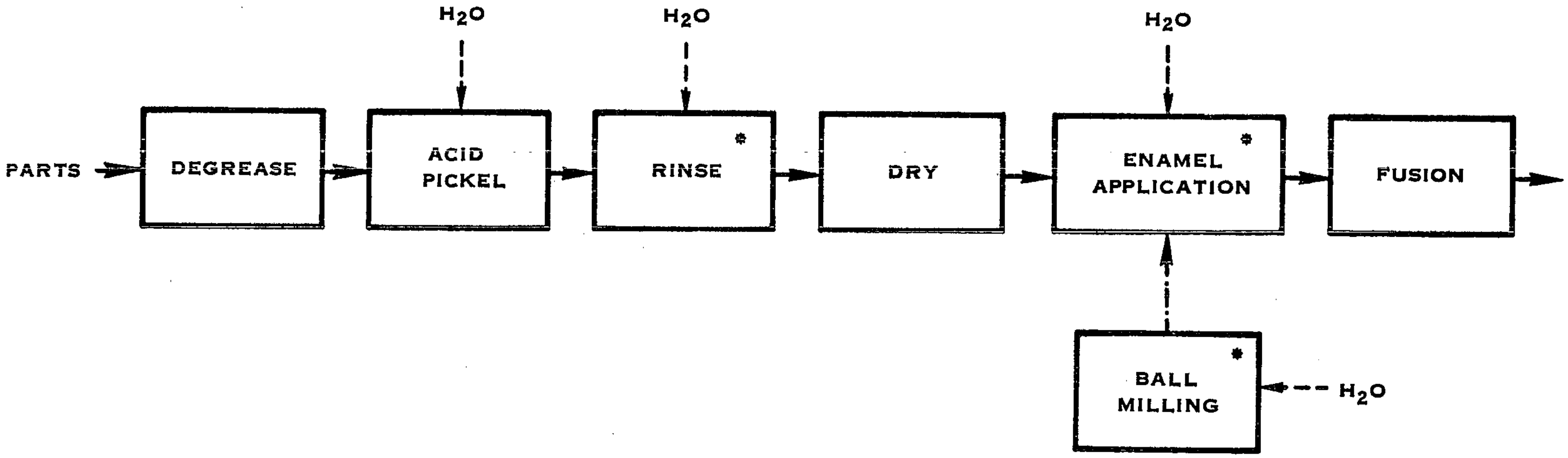


FIGURE V-1. TYPICAL PORCELAIN ENAMELING ON STEEL OPERATION



*SAMPLE POINT

FIGURE V-2. TYPICAL PORCELAIN ENAMELING ON ALUMINUM OPERATION



* SAMPLE POINT

FIGURE V-3. TYPICAL PORCELAIN ENAMELING ON COPPER OPERATION

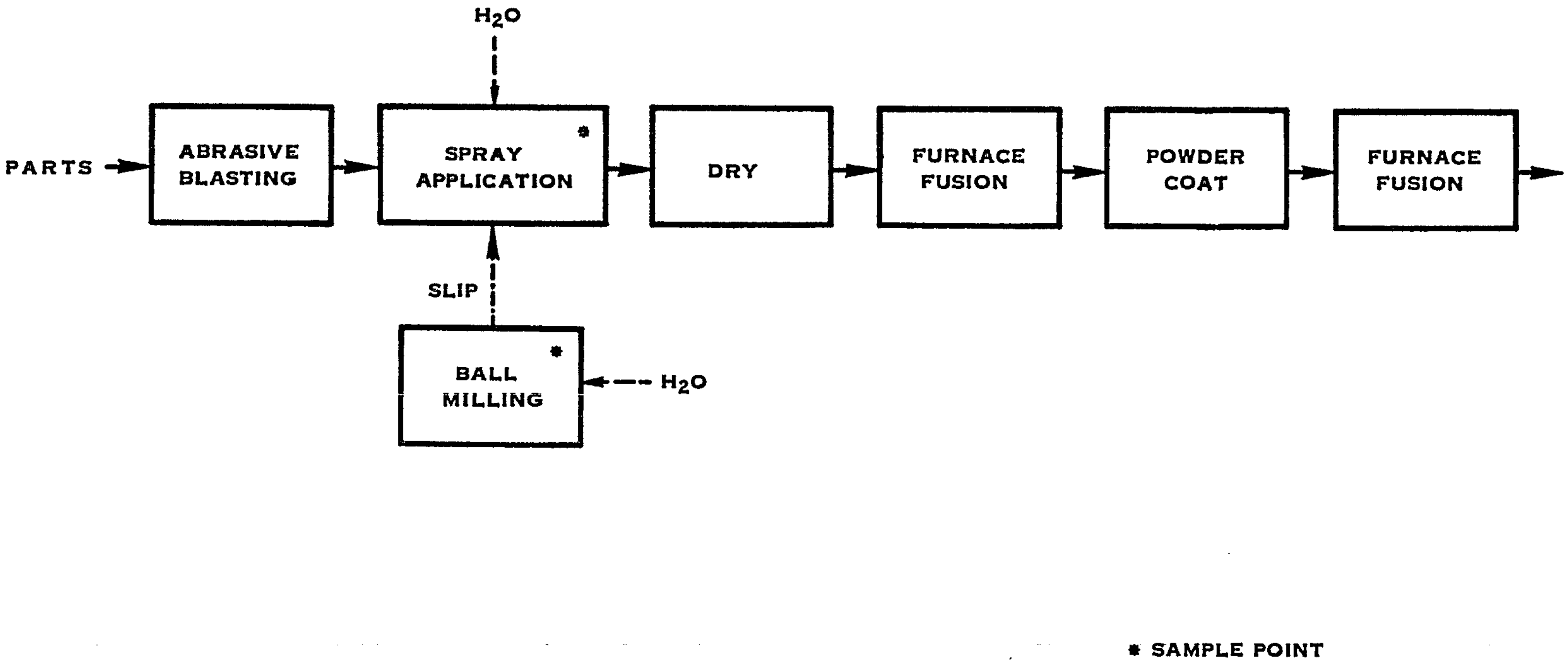


FIGURE V-4. TYPICAL PORCELAIN ENAMELING ON IRON OPERATION

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

In Section V, pollutant parameters to be examined for possible regulation were presented together with data from plant sampling visits and subsequent chemical analysis. Priority, nonconventional, and conventional pollutant parameters were selected for verification according to a specified rationale.

Each of the pollutant parameters selected for verification analysis is now discussed in detail. The selected priority pollutant parameters 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 and those dropped from further consideration in each subcategory are set forth. The rationale for that selection is also presented.

VERIFICATION PARAMETERS

Pollutant parameters selected for verification sampling and analysis in the porcelain enameling point source category are listed in Table V-7 (Page 89). The subcategory for each is designated. The following discussion is designed to provide information about: where the pollutant comes from - whether it is a naturally occurring element, a processed metal, or a manufactured compound; general physical properties of the pollutants; toxic effects of the pollutant in humans and other animals; and behavior of the pollutant in POTW at the concentrations that might be expected from industrial discharges.

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 was 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 0.00006 mg/l, 0.0006 mg/l, and 0.006 mg/l respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.418 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 detailed study of 1,1,2-trichloroethane behavior in POTW 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 consistant with the conclusions based on laboratory scale biochemical oxidation studies relating molecular structure to ease of degradation. The conclusion reached from the above information is that 1,1,2-trichloroethane will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW.

The lack of water solubility and the relatively high vapor pressure may lead to removal of this compound from POTW by volatilization.

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 terephthalic 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 plastics based on 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 plasticizer. 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 is 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. Available data show that adverse effects on freshwater aquatic life occur at phthalate ester concentrations as low as 0.003 mg/l.

The behavior of phthalate esters in POTW 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 it is expected that they will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. 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 phthalate and dimethyl phthalate will be biochemically oxidized to a lesser extent than domestic sewage by biological treatment in POTW. On the same basis, it is expected that di-n-octyl phthalate will not be biochemically oxidized to a significant extent by biological treatment in POTW. An EPA study of seven POTW revealed that for all but di-n-octyl phthalate, which was not studied, removals ranged from 62 to 87 percent.

No information was found on possible interference with POTW operation or the possible effects on sludge by the phthalate esters. The water insoluble phthalate esters - butylbenzyl 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 criterion is determined to be 15 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criteria is determined to be 50 mg/l.

Although the behavior of bis(2-ethylhexyl) phthalate in POTW 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 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 POTW is expected.

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 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.

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 toluol, methylbenzene, methacide, and phenylmethane. 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 human 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 criterion is 424 mg/l. Available data show that adverse effects 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 POTW is available. However, the biochemical oxidation of many of the priority pollutants has been investigated in laboratory scale studies at concentrations 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 theroetical 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 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 POTW. The removals ranged from 40 to 100 percent. Sludge concentrations of toluene ranged from 54×10^{-3} to 1.85 mg/l.

Trichloroethylene(87). Trichloroethylene (1,1,2-trichloroethylene or TCE) is a clear colorless liquid which boils at 87°C. 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 risks of 10^{-7},

10^{-6}, and 10^{-5} are 2.7 x 10^{-4} mg/l, 2.7 x 10^{-3} mg/l, and 2.7 x 10^{-2} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 0.807 mg/l to keep the additional lifetime cancer risk below 10^{-5}.

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.

In laboratory scale studies of organic priority pollutants, TCE was subjected to biochemical oxidation conditions. After 5, 10, and 20 days no biochemical oxidation occurred. On the basis of this study and general observations relating molecular structure to ease of degradation, the conclusion is reached that TCE would undergo little or no biochemical oxidation by biological treatment in a POTW. The volatility and relatively low water solubility of TCE is expected to result in volatilization of some of the TCE in aeration steps in a POTW.

For a recent Agency study, <u>Fate of Priority Pollutants in Publicly Owned Treatment Works</u>, the pollutant concentrations in the influent, effluent, and sludge of 20 POTW 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.

<u>Antimony(114)</u>. Antimony (chemical name - stibnium, 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 non - metal 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 schistisomiasis, have caused severe nausea, vomiting, convulsions, irregular heart action, liver damage, and skin rashes. Studies of acute industrial antimony poisoning have revealed loss of appetitie, 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 POTW. The limited solubility of most antimony compounds expected in POTW, i.e. the oxides and sulfides, suggests 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 cropland.

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. 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^{-7} mg/l, 2.2×10^{-6} mg/l, and 2.2×10^{-5} mg/l, respectively. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the water concentration should be less than 1.75×10^{-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 POTW. One EPA survey of 9 POTW reported influent concentrations ranging from 0.0005 to 0.693 mg/l; effluents from 3 POTW having biological treatment contained 0.0004 - 0.01 mg/l; 2 POTW 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 POTW, 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 ($3BeO \bullet Al_2O_3 \bullet 6SiO_2$) and bertrandite [$Be_4Si_2O_7(OH)_2$]. Only two industrial facilities produce beryllium in the U.S. because of limited demand and its 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 (1350C). Beryllium alloys are corrosion resistant, but the metal corrodes in aqueous environment. 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 chronically toxic to aquatic organisms at 0.0053 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 0.00000068 mg/l, 0.0000068 mg/l, and 0.000068 mg/l, respectively. If contaminated aquatic organisms alone are consumed excluding the consumption of water, the concentration should be less than 0.00117 mg/l to keep the increased lifeline cancer risk below 10^{-5}.

Information on the behavior of beryllium in POTW is scarce. Because beryllium hydroxide is insoluble in water, most beryllium entering POTW 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 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 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 mollusks, which accumulate cadmium in calcareous tissues and in the viscera. A concentration factor of 1000 for cadmium in fish muscle has been reported, as have 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 into the POTW sludge. In addition, it can interfere with the POTW treatment process.

In a study of 189 POTW, 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 POTW 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 mg/l, standard deviation 0.167 mg/l).

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 ($FeO \bullet Cr_2O_3$). 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 is found as an alloying component of many steels and its compounds are used in electroplating baths and as corrosion inhibitors for closed water circulation systems.

The two chromium forms most frequently found in industry wastewaters are hexavalent and trivalent chromium. Hexavalaent 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 0.200 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 (trivalent) ingested through water and contaminated aquatic organisms, the ambient water criterion is 170 mg/l. If contaminated aquatic organisms alone are consumed, excluding the consumption of water, the ambient water criterion for trivalent chromium is 3,443 mg/l. THe ambient water quality criterion for hexavalent chromium is recommended to be identical to the existing drinking water standard for total chromium which is 0.050 mg/l.

Chromium is not destroyed when treated by POTW (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 litte 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 POTW 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 uncontrolled landfills. Incineration, or similar destructive oxidation processes can produce hexavalent chromium from lower valence trivalent chromium. 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 sludge from 2,510 to 1,040 mg/kg. A similar reduction occurred in Grand Rapids, Michigan POTW 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), malachite [$CuCO_3 \bullet Cu(OH)_2$], 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 0.03 mg/l have proven 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 freshwater aquatic life is 0.0056 mg/l as a 24-hour average, and 0.012 mg/l maximum concentration at a hardness of 50 mg/l $CaCO_3$.

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. To control undesirable taste and odor quality of ambient water due to the organoleptic properties of copper, the estimated level is 1.0 mg/l for total recoverable copper.

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 was 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 from about 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 POTW, 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 a reversion of copper to less soluble forms was occurring.

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.

The ambient water quality criterion for lead is recommended to be identical to the existing drinking water standard which 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 of total recoverable lead as a 24-hour average with a water hardness of 50 mg/l as $CaCO_3$.

Lead is not destroyed in POTW, 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 POTW, 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 concentration in POTW effluents ranged from 0.003 to 1.8 mg/l (means = 0.106 mg/l, standard deviation = 0.222).

Application of lead-containing sludge to cropland should not affect the 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.

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 and 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 con- centrations 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 based on the toxic properties of nickel ingested through water and through contaminated aquatic organisms, the ambient water criterion is determined to be 0.0134 mg/l. If contaminated aquatic organisms are consumed, excluding consumption of water, the ambient water criterion is determined to be 0.100 mg/l. Available data show that adverse effects on aquatic life occur for total recoverable nickel concentrations as low as 0.0071 mg/l as a 24-hour average.

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 POTW, 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 effuent 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.

The ambient water quality criterion for selenium is recommended to be identical to the existing drinking water standard which is 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 POTW. One EPA survey of 103 POTW revealed one POTW using biological treatment and having selenium in the influent. Influent concentration was 0.0025 mg/l, effluent concentration was 0.0016 mg/l giving a removal of 37 percent. It is not known to be inhibitory to POTW processes. In another study, sludge from POTW 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.

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.

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 and odor which persists through conventional treatment. For the prevention of adverse effects due to these organoleptic properties of zinc, concentrations in ambient water should not exceed 5 mg/l. Available data show that adverse effects on aquatic life occur at concentrations as low as 0.047 mg/l as a 24-hour average.

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 concentration. 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 0.030 to

21.6 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 POTW, 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 usefuleness 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 POTW, 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 30-40 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.

Aluminum. Aluminum, a nonconventional pollutant, is an abundant silvery white metal comprising 8.1 percent of the earth's crust, but never found in a free state. The principal ore for aluminum is bauxite from which alumina (Al_2O_3) is extracted. Aluminum metal is produced by electrolysis of the alumina in the cryolite bath.

Aluminum metal is relatively corrosion resistant because it forms a protective oxide film on the surface which prevents corrosion under many conditions. Electrolytic action of other metals in contact with aluminum and strong acids and alkalis can break down the oxide layer causing rapid corrosion to occur.

Aluminum is light, malleable, ductile, possesses high thermal and electrical conductivity, and is non-magnetic. It can be formed, machined or cast. Aluminum is used in the construction, transportation, and container industries and competes with iron and steel in these markets.

Aluminum had been found to be toxic to freshwater and marine aquatic life. In freshwaters acute toxicity and solubility increases as pH levels increase above pH 7. This relationship also appears to be true as the pH levels decrease below pH 7. Chronic effects of aluminum on aquatic life have also been documented. Aluminum has been found to be toxic to certain plants. A water quality standard for aluminum was established (U.S. Federal Water Polluti9n Control Administration, 1968) for interstate agricultural and irrigation waters, which set a trace element tolerance at 1 mg/l for continuous use on all soils and 20 mg/l for short term use on fine-textured soils.

Aluminum and some of its compounds used in food preparation and as food additives are generally recognized as safe and are sanctioned by the Food and Drug Administration. No limits on aluminum content in food and beverage products have been established.

There are no reported adverse physiological effects on man from low concentrations of aluminum in drinking water, however, large concentrations of aluminum in the human body are alleged to cause changes in behavior. Salts of aluminum are used as coagulants in water treatment, and in limited quantities do not have any adverse effects on POTW operations. Some aluminum salts are soluble, however, mildly alkaline conditions cause precipitation of aluminum as hydroxide. The precipitation of aluminum hydroxide can have an adverse effect on rooted aquatics and invertebrate benthos.

<u>Barium</u>. Barium is a non-conventional pollutant. It is an alkaline earth metal which in the pure state is soft and silvery white. It reacts with moisture in the air, and reacts vigorously with water, releasing hydrogen. The principal ore is barite ($BaSO_4$) although witherite ($BaCO_3$) was a commerical ore at one time. Many barium compounds have commerical applications. However, drilling muds consume 90 percent of all barite produced. For manufacture of the other chemicals barite is converted to

barium sulfide first. The aqueous barium sulfide is then treated to produce the desired product. Barite itself and some other insoluble barium compounds are used as fillers and pigments in paints. Barium carbonate is the most important commerical barium compound except for the natural sulfate. The carbonate is used in the brick, ceramic, oil-well drilling, photographic, glass, and chemical manufacturing industries.

Barium compounds such as the acetate, chloride, hydroxide, and nitrate are water soluble; the arsenate, chromate, fluoride, oxalate, and sulfate are insoluble. Those salts soluble in water and acid, including the carbonate and sulfide are toxic to humans. Barium sulfate is so insoluble that it is non-toxic and is used in X-ray medical diagnosis of the digestive tract. For that purpose the sulfate must pass rigorous tests to assure absence of water or acid soluble barium.

Lethal adult doses of most soluble barium salts are in the range of 1 to 15 g. The barium ion stimulates muscular tissue and causes a depression in serum potassium. Symptoms of acute barium poisoning include salivation, vomiting, abdominal pain and diarrhea; slow and often irregular pulse; hypertension; heart disturbances; tinnitus, vertigo; muscle twitching progressing to convulsions or paralysis; dilated pupils, confusion; and somnolence. Death may occur from respiratory failure due to paralysis of the respiratory muscles, or from cardiac arrest or fibrillation.

Raw wastewaters from most industrial facilities are unlikely to bear concentrations of soluble barium which would pose a threat to human health. The general presence of small concentrations of sulfate ion in many wastewaters is expected to be sufficient to convert the barium to the non-toxic barium sulfate.

No data were found relating to the behavior of barium in POTW. However, the insolubility of barium sulfate and the presence of sulfates in most municipal wastewaters is expected to lead to removal of soluble barium by precipitation follwed by settling out with the other suspended solids. It is reported that the typical mineral pickup from domestic water use increases the sulfate concentration of 15 to 30 mg/l. If it is assumed that sulfate concentration exists in POTW, and the sulfate is not destroyed or precipitated by another metal ion, the dissolved barium concentration would not exceed 0.1 mg/l at neutral pH in a POTW.

Cobalt. Cobalt is a non-conventional pollutant. It is a brittle, hard, magnetic, gray metal with a reddish tinge. Cobalt ores are usually the sulfide or arsenide [smaltite-(Co,Ni)As_2;

cobaltite-CoAsS] and are sparingly distributed in the earth's crust. Cobalt is usually produced as a by-product of mining copper, nickel, arsenic, iron, manganese, or silver. Because of the variety of ores and the very low concentrations of cobalt, recovery of the metal is accomplished by several different processes. Most consumption of cobalt is for alloys. Over two-thirds of U.S. production goes to heat resistant, magnetic, and wear resistant alloys. Chemicals and color pigments make up most of the rest of consumption.

Cobalt and many of its alloys are not corrosion resistant, therefore minor corrosion of any of the tool alloys or electrical resistance alloys can contribute to its presence in raw wastewater from a variety of manufacturing facilities. Additionally, the use of cobalt soaps as dryers to accelerate curing of unsaturated oils used in coatings may be a general source of small quantities of the metal. Several cobalt pigments are used in paints to produce yellows or blues.

Cobalt is an essential nutrient for humans and other mammals, and is present at a fairly constant level of about 1.2 mg in the adult human body. Mammals tolerate low levels of ingested water-soluble cobalt salts without any toxic symptoms; safe dosage levels in man have been stated to be 2-7 mg/kg body weight per day. A goitrogenic effect in humans is observed after the systemic administration of 3-4 mg cobalt as cobaltous chloride daily for three weeks. Fatal heart disease among heavy beer drinkers was attributed to the cardiotoxic action of cobalt salts which were formerly used as additives to improve foaming. The carcinogenicity of cobalt in rats has been verified, however, there is no evidence for the involvement of dietary cobalt in carcinogenisis in mammals.

There are no data available on the behavior of cobalt in POTW. There are no data to lead to an expectation of adverse effects of cobalt on POTW operation or the utility of sludge from POTW for crop application. Cobalt which enters POTW is expected to pass through to the effluent unless sufficient sulfide ion is present, or generated in anaerobic processes in the POTW to cause precipitation of the very insoluble cobalt sulfide.

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 aluminum 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, mottling 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 POTW. Under usual operating conditions in 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 POTW 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.

<u>Iron</u>. Iron is a nonconventional 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. However, high concentrations of iron can precipitate on bottom sediments and affect rooted aquatic and invertebrate benthos.

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 POTW iron salts are added to coagulate precipitates and suspended sediments into a sludge. In an EPA study of POTW the concentration of iron in the effluent of 22 biological POTW 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.

Mangenese 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 manganese may cause building 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 limitations 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 lethergy 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 batteris buried nearby. Excess manganese in the drinking water is also believed to be the cause of a rare disease endemic in Northeastern China.'

No data were found regarding the behavior of manganese in POTW. 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 POTW, if it occurs, would not be noted until manganese concentrations exceeded 0.4 mg/l.

Phenols(Total). "Total Phenols" is a toxic 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 POTW the concentration of "total phenols" ranged from 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 POTW 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 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.

<u>Phosphorus</u>. Phosphorus, a conventional pollutant, is a general term used to designate the various anions containing pentavalent phosphorus and oxygen - orthophosphate $[(PO_4)^{-3}]$, metaphosphate $[(PO_3)^-]$, pyrophosphate $[(P_2O)_7^{-4}]$, hypophosphate $[(P_2O_6)^{-4}]$. The element phosphorus exists in several allotropic forms - red, white or yellow, and black. White phosphorus reacts with oxygen in air, igniting spontaneously. It is not found free in nature, but is widely distributed in nature. The most important commercial sources of phosphate are the apatites $[3Ca_3(PO_4)_2 \bullet CaF_2$ and $3Ca_3(PO_4)_2 \bullet CaCl_2]$. Phosphates also occur in bone and other tissue. Phosphates are essential for plant and animal life. Several millions of tons of phosphates are mined and converted for use each year in the U.S. The major form produced is phosphoric acid. The acid is then used to produce other phosphate chemicals.

The largest use for phosphates is fertilizer. Most of the U.S. production of phosphoric acid goes into that application. Phosphates are used in cleaning preparations for household and industrial applications and as corrosion inhibitors in boiler feed water and cooling towers.

Phosphates are not controlled because of toxic effects on man. Phosphates are controlled because they promote growth of algae and other plant life in aquatic environments. Such growth becomes unsightly first, and if it florishes, eventually dies, and adds to the biological oxygen demand (BOD). The result can be a dead body of water. No standards or criteria appear to have been established for U.S. surface waters.

Phosphorus is one of the concerns of any POTW, because phosphates are introduced into domestic wastewaters from human body wastes and food wastes as well as household detergents. About ten percent of the phosphorus entering POTW is insoluble and is removed by primary settling. Biological treatment removes very little of the remaining phosphate. Removal is accomplished by forming an insoluble precipitate which will settle out. Alum, lime, and ferric chloride or sulfate are commonly used for this purpose. The point of addition of chemicals for phosphate removal requires careful evaluation because pH adjustment may be required, and material and capital costs differ with different removal schemes. The phosphate content of the effluent also varies according to the scheme used. There is concern about the effect of phosphate contained in sludge used for soil amendment. Phosphate is a principal ingredient of fertilizers.

Titanium. Titanium is a non-conventional pollutant. It is a lustrous white metal occurring as the oxide in ilmenite ($FeO \bullet TiO_2$) and rutile (TiO_2). The metal is used in heat-resistant, high-strength, light-weight alloys for aircraft and missiles. It is also used in surgical appliances because of its high strength and light weight. Titanium dioxide is used extensively as a white pigment in paints, ceramics, and plastics.

Toxicity data on titanium are not abundant. Because of the lack of definitive data titanium compounds are generally considered non-toxic. Large oral doses of titanium dioxide (TiO_2) and thiotitanic acid (H_4TiSO_3) were tolerated by rabbits for several days with no toxic symptoms. However, impaired reproductive capacity was observed in rats fed 5 mg/l titanium as titanate in drinking water. There was also a reduction in the male/female ratio and in the number of animals surviving to the third generation. Titanium compounds are reported to inhibit several enzyme systems and to be carcinogenic.

The behavior of titanium in POTW has not been studied. On the basis of the insolubility of the titanium oxides in water, it is expected that most of the titanium entering the POTW will be removed by settling and will remain in the sludge. No data were found regarding possible effects on plants as a result of spreading titanium - containing sludge on agricultural cropland.

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 grease 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 makes 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 freshwater 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 chemcials 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 porcelain enameling industry. A neutral pH range (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 Exisiting 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" and "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 incrustations 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 pollutant parameters selected or not selected for consideration for specific regulation are based on data obtained by sampling and analyzing raw wastewater streams from all discrete operations generating wastewater. From one to five operations were sampled in each subcategory. For coating operations, the streams sampled included ball mill room and application; for metal preparation the streams sampled included alkaline cleaning, acid etch, nickel flash, and neutralization when applicable. Therefore, the number of data points for concentrations could be more than one per day for metal preparation or for coating.

The coating operation generates the largest quantity of pollutants in porcelain enameling. Composition of the frit used on different basis metals depends little on the metal. Color, flow characteristics and service requirements have the greater influence on frit composition. Therefore, data generated from raw wastewaters from the coating operations in all four subcategories are combined. Data on priority pollutant metals, nonconventional and conventional pollutants are reviewed. The selection for consideration for regulation is based on the combined data and is applicable to all subcategories.

Concentrations of priority pollutants appearing in streams from metal preparation processes are considered within each subcategory. Selection for consideration for regulation is based only on those data for metal preparation processes, and any final regulation must consider these selections and the selections based on coating operations.

Coating Operations - All Subcategories

Pollutant Parameters Considered for Specific Regulation. Based on verification sampling results and a careful examination of the porcelain enameling coating processes and raw materials, twenty pollutant parameters were selected for consideration for specific regulation in effluent limitations and standards for all subcategories. The twenty are: antimony, arsenic, cadmium, chromium(total), copper, lead, nickel, selenium, zinc, aluminum, barium, cobalt, fluoride, iron, manganese, phosphorus, titanium, oil and grease, total suspended solids and pH.

Antimony concentrations appeared on 17 of 40 sampling days for the coating process. The maximum concentration was 1,020 mg/l. Antimony oxides are used as coloring agents in porcelain enameling. Some of the concentrations are greater than the level that can be achieved with specific treatment methods. Therefore, antimony is considered for specific regulation in coating wastewater streams from all subcategories.

Arsenic concentrations appeared on 14 of 40 sampling days for the coating process. The maximum concentration was 3.8 mg/l. Arsenic compounds are used as coloring agents in enameling slips. All of the arsenic concentrations are greater than the level that can be achieved with specific treatment methods. Therefore, arsenic is considered for specific regulation in coating wastewater streams from all subcategories.

Cadmium concentrations appeared on 28 of 40 sampling days for the coating process. The maximum concentration was 54.0 mg/l. Cadmium compounds are used as coloring agents in enameling slip. Most of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, cadmium is considered for specific regulation in coating wastewaters from all subcategories.

Chromium(total) concentrations appeared on all 40 sampling days for the coating process. The maximum concentration was 37.4 mg/l. Chromium compounds are used as coloring agents in enamel slip. About one-third of the chromium concentrations were greater than the level achievable with specific treatment technology. Therefore, chromium(total) is considered for specific regulation in coating wastewaters from all subcategories.

Copper concentrations appeared on 38 of 40 sampling days for the coating process. The maximum concentration was 55.0 mg/l. Copper oxide is used as a coloring agent in enamel slip. About one-third of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, copper is considered for specific regulation in coating wastewater from all subcategories.

Lead concentrations appeared on 38 of 40 sampling days for the coating process. The maximum concentration was 876.3 mg/l. Lead compounds are used in enamel slips. All of the lead concentrations are greater than the level that can be achieved with specific treatment technology. Therefore, lead is considered for specific regulation in coating wastewater from all subcategories.

Nickel concentrations appeared on 32 of 40 sampling days for the coating process. The maximum concentration was 358.0 mg/l. Most of the nickel concentrations are greater than the level that can be achieved with specific treatment methods. Therefore, nickel is considered for specific regulation in coating wastewaters from all subcategories.

Selenium concentrations appeared on 29 of 40 sampling days for the coating process. The maximum concentration was 161.2 mg/l. Selenium is used in some enamel slips. Most of the selenium concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, selenium is considered for specific regulation in the coating wastewaters from all subcategories.

Zinc concentrations appeared on 39 of 40 sampling days for the coating process. The maximum concentration was 1,320 mg/l. Zinc oxide is extensively used in enamel slip. Most of the zinc concentrations were greater than the level achievable with specific treatment methods. Therefore, zinc is considered for specific regulation in coating wastewaters from all subcategories.

Aluminum concentrations appeared on all 40 sampling days for the coating process. The maximum concentration was 1,525 mg/l. Aluminum is used in some enamel slips. More than half of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, aluminum is considered for specific regulation in coating wastewaters from all subcategories.

Barium appeared on eight of nine sampling days for the coating process. The maximum concentration was 90 mg/l. Barium is present in some enamel slips. Therefore, barium is considered for specific regulation in coating wastewater from all subcategories.

Cobalt concentrations appeared on 33 of 40 sampling days for the coating process. The maximum concentration was 350.0 mg/l. Cobalt compounds are used to color enamel slips. Most of the cobalt concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, cobalt is considered for specific regulation in coating wastewaters for all subcategories.

Fluoride concentrations appeared on all 40 process sampling days for the coating process. The maximum concentration was 115.0 mg/l. Fluoride in porcelain enameling raw wastewater results from the use of fluorspar in the enamel slip. Many of the fluoride concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, fluoride is considered for specific regulation in coating wastewaters from all subcategories.

Iron concentrations appeared on 38 of 39 sampling days for the coating process. The maximum concentration was 620.0 mg/l. Many of the iron concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, iron is considered for specific regulation in coating wastewaters from all subcategories.

Manganese concentrations appeared on 34 of 40 sampling days for the coating process. The maximum concentration was 400.0 mg/l. Manganese compounds are used to color enamel slips. Many of the manganese concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, manganese is considered for specific regulation in coating wastewaters from all subcategories.

Phosphorus concentrations appeared on 25 of 36 sampling days for the coating process. The maximum concentration was 71.0 mg/l. More than half of the concentrations are greater than the level that can be achieved with specific treatment methods. Therefore phosphorus is considered for specific regulation in coating wastewaters from all subcategories.

Titanium concentrations appeared on 37 of 40 sampling days for the coating operation. The maximum concentration was 1,641.45 mg/l. Titanium oxide is used as a pigment in enamel slip. About two-thirds of the concentrations are greater than the level that can be achieved with specific treatment methods. Therefore, titanium is considered for specific regulation in the coating wastewater from all subcategories.

Oil and grease concentrations appeared on 24 of 29 sampling days for the coating process. The maximum concentration was 98 mg/l. This concentration is within the range found in domestic wastewaters and therefore should be suitable for discharge to POTW. Several of the concentrations are greater than the level that can be achieved with specific treatment methods. Therefore, Oil and Grease is considered for specific regulation in coating wastewaters from all subcategories for direct discharges only.

Total Suspended Solids (TSS) concentrations appeared on all 39 sampling days for the coating process. The maximum concentration was 319,600 mg/l. TSS from the coating process is essentially a dilute enamel slip. It therefore contains many of the priority pollutant metals which makes it unsuitable for discharge to POTW. All concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, TSS is considered for specific regulation in coating wastewaters from all subcategories for direct and indirect discharges.

pH ranged from 5.8 to 12.5 on the 30 sampling days for the coating process. Specific treatment methods can readily bring pH values within the prescribed limits of 7.5 to 10.0. Therefore, pH is considered for specific regulation in coating wastewaters from all subcategories.

<u>Pollutant Parameters Not Considered for Specific Regulation</u>. A total of six pollutant parameters that were evaluated in verification sampling and analysis were dropped from further consideration for specific regulation in coating wastewaters from all subcategories. The six are: bis (2-ethylhexyl)phthalate, di-n-octyl phthalate, toluene, beryllium, chromium (hexavalent), and phenols (total).

Bis(2-ethylhexyl)phthalate concentrations appeared on 2 of 10 sampling days for the coating process. The concentrations were below the analytical quantification limit. Therefore, bis(2-ethyl hexyl)phthalate is not considered for specific regulation in coating wastewaters from any subcategory.

Di-n-octyl phthalate concentrations did not appear on any of 10 sample days for the coating process. Therefore, di-n-octyl phthalate is not considered for specific regulation in coating wastewaters from any subcategory.

Toluene concentrations appeared on 2 of 13 sampling days for the coating process. The maximum concentration was 0.018 mg/l. Both concentrations are lower than the level treatable in this industry. Therefore, toluene is not considered for specific regulation in coating wastewaters from any subcategory.

Beryllium concentrations appeared on 15 of 40 sampling days for the coating process. The maximum concentration was 0.12 mg/l. Beryllium can not be removed by specific treatment methods from raw wastewater at that level. Therefore, beryllium is not considered for specific regulation in coating wastewaters for any subcategory.

Chromium (hexavalent) concentrations did not appear on any of 40 sample days for the coating process. Therefore, hexavalent chromium is not considered for specific regulation in coating wastewaters for any subcategory.

Phenols (Total) concentrations appeared on 27 of 38 sampling days for the coating process. The maximum concentration was 0.07 mg/l which is the same level found in influent water for some plants. Therefore, total phenols is not considered for specific regulation in coating wastewaters from any subcategory.

Metal Preparation Processes - By Subcategory

Steel Subcategory

Pollutant Parameters Considered for Specific Regulation. Based on verification sampling results and a careful examination of the steel subcategory manufacturing processes other than coating and raw materials, fourteen pollutant parameters were selected for consideration for specific regulation in effluent limitations and standards for processes other than coating in this subcategory. The fourteen are: cadmium, chromium (total), copper, lead, nickel, zinc, aluminum, cobalt, iron, manganese, phosphorus, oil and grease, total suspended solids and pH.

Cadmium concentrations appeared on 5 of 61 process sampling days for the steel subcategory. The maximum concentration was 0.084 mg/l. One of the concentrations is greater than the level than can be achieved with specific treatment methods. Therefore, cadmium is considered for specific regulation in this subcategory.

Chromium concentrations appeared on 45 of 61 process sampling days for the steel subcategory. The maximum concentration was 3.07 mg/l. Several of the concentrations are greater than the level achievable with specific treatment methods. Therefore, chromium is selected for specific regulation in this subcategory.

Copper concentrations appeared on 54 of 61 process sampling days for the steel subcategory. The maximum concentration was 0.38 mg/l. Several of the concentrations exceeded the level achievable with specific treatment methods. Therefore, copper is considered for specific regulation in this subcategory.

Lead concentrations appeared on 5 of 61 process sampling days. The maximum concentration was 0.13 mg/l.. All the concentrations exceeded the level that is achievable with specific treatment methods. Therefore, lead is considered for specific regulation in this subcategory.

Nickel concentrations appeared on 43 of 59 process sampling days for the steel subcategory. The maximum concentration was 281.0 mg/l. Nickel is used in a displacement coating process on steel strip. Most of the nickel concentrations are greater than the level achievable with specific treatment methods. Therefore, nickel is considered for specific regulation in this subcategory.

Zinc concentrations appeared on 58 of 60 process sampling days for the steel subcategory. The maximum concentration was 0.31 mg/l. Several of the zinc concentrations are greater than the level achievable with specific treatment methods. Therefore, zinc is considered for specific regulation in this subcategory.

Aluminum concentrations appeared on 39 of 61 process sampling days for the steel subcategory. The maximum concentration was 3.15 mg/l. Some of the concentrations were greater than the level achievable with specific treatment methods. Therefore, aluminum is considered for specific regulation in this subcategory.

Cobalt concentrations appeared on 32 of 61 process sampling days. The maximum concentration was 0.46 mg/l. Several of the cobalt concentrations are greater than the level achievable with specific treatment methods. Therefore, cobalt is considered for specific regulation in this subcategory.

Iron concentrations appeared on all 58 process sampling days for the steel subcategory. The maximum concentration was 10,200 mg/l. Iron is removed from steel during acid dipping and nickel flash operations. Most of the iron concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, iron is considered for specific regulation in this subcategory.

Manganese concentrations appeared on 53 of 59 process sampling days for the steel subcategory. The maximum concentration was 53.0 mg/l. Some of the concentrations are greater than the level than can be achieved with specific treatment methods. Therefore, manganese is considered for specific regulation in this subcategory.

Phosphorus concentrations appeared on 39 of 41 sampling days in the steel subcategory. The maximum was 92.4 mg/l. Phosphorus is present in many compounds used for alkaline cleaning of metals. Most of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, phosphorus is considered for specific regulation in this subcategory.

Oil and Grease concentrations appeared on all 34 process sampling days for the steel subcategory. The maximum concentration was 63 mg/l. This pollutant parameter enters porcelain enameling wastewater streams from steel cleaning operations and from equipment washdown. Some of the concentrations are greater than the level that can be achieved with specific treatment methods. All concentrations are in the range that can be handled by POTW. Therefore, the oil and grease parameter is considered for specific regulation for direct dischargers only, in this subcategory.

Total Suspended solids (TSS) concentrations appeared on 36 of 55 process sampling days for the steel subcategory. The maximum concentration was 649.2 mg/l. Nearly half of the concentrations are greater than the level that can be achieved with specific treatment methods. Therefore, total suspended solids is considered for specific regulation for direct dischargers only in this subcategory.

pH ranged from 2.0 to 11.7 on 61 process sampling days in the steel subcategory. pH can be controlled within the limits of 7.5 to 10.0 with specific treatment methods. Therefore, pH is considered for specific regulation in this subcategory.

Pollutant Parameters Not Considered for Specific Regulation. Based on verification sampling results and a careful examination of the steel subcategory manufacturing processes other than coating and raw materials six pollutant parameters were dropped from further consideration for specific regulation in the steel subcategory. These parameters were found to be present in raw wastewaters infrequently or at levels below those usually achieved by specific treatment methods. The five are: antimony, arsenic, selenium, fluoride, phenols (total), and titanium.

Arsenic concentrations did not appear on any of 61 process sampling days for the steel subcategory. Therefore, arsenic is not considered for specific regulation in this subcategory.

Selenium concentrations appeared on 4 of 61 process sampling days in the steel subcategory. The concentration was 0.21 mg/l which is lower than the level that can be achieved with specific treatment methods. Therefore, selenium is not considered for specific regulation in this subcategory.

Fluoride concentrations appeared on all 61 process sampling days. The maximum concentration was 1.8 mg/l which was less than the concentration in the inlet water at one plant. Therefore, fluoride is not considered for specific regulation in this subcategory.

Phenols (Total) concentrations appeared on 48 of 54 process sampling days for the steel subcategory. The maximum concentration was 0.69 mg/l. Only two concentrations were greater than those found in inlet water at two plants (about 0.05 mg/l). The maximum concentration was not considered to be environmentally significant. Therefore, Total Phenols is not considered for specific regulation in this subcategory.

Titanium concentrations appeared on 1 of 61 process sampling days for the steel subcategory. This concentration was 0.05 mg/l, therefore, titanium is not considered for specific regulation in this subcategory.

Cast Iron Subcategory

Coating process raw wastewater was the only stream sampled for the cast iron subcategory. Therefore, all selections for consideration for specific regulation of pollutant parameters are based on those combined coating process concentrations discussed at the beginning of this section.

Aluminum Subcategory

Pollutant Parameters Considered for Specific Regulation. Based on verification sampling results and careful examination of the aluminum subcategory alkaline cleaning process (the only process sampled other than coating), seven pollutant parameters were selected for consideration for specific regulation in effluent limitations and standards for this subcategory. The seven are: chromium (total), lead, zinc, aluminum, phosphorus, total suspended solids and pH.

Chromium (total) concentrations appeared at low levels on 2 of 8 process sampling days for the aluminum subcategory. However, dcp responses indicate that there are a few porcelain enamelers on aluminum that use a chromate coating as a basis metal preparation operation. This process operation was not included in the sampling program. Based on this dcp information total chromium is considered for specific regulation in this subcategory.

Lead concentrations appeared on 2 of 8 process sampling days for the aluminum subcategory. The greater concentration was 4.31 mg/l. Both concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, lead is considered for specific regulation in this subcategory.

Zinc concentrations appeared on 7 of 8 process sampling days for the aluminum subcategory. The maximum concentration was 0.54 mg/l. Some of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, zinc is considered for specific regulation in this subcategory.

Aluminum concentrations appeared on 7 of 8 process sampling days for the aluminum subcategory. The maximum concentration was 25.9 mg/l. Most of the aluminum concentrations and greater than the concentration level that can be achieved with specific treatment methods. Therefore, aluminum is considered for specific regulation in this subcategory.

Phosphorus concentrations appeared on all 8 process sampling days for the aluminum subcategory. The maximum concentration was 24.3 mg/l. Phosphorus compounds are used in many alkaline cleaners. Half of the phosphorus concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, phosphorus is considered for specific regulation in this subcategory.

Total Suspended Solids (TSS) concentrations appeared on all 8 process sampling days for the aluminum subcategory. The maximum concentration was 181.0 mg/l. Half of the concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, TSS is considered for specific regulation in this subcategory.

pH ranged from 6.3 to 10.4 on 8 process sampling days for the aluminum subcategory. pH can be controlled within the limits of 7.5 to 10.0 with specific treatment methods and is therefore considered for specific regulation in this subcategory.

Oil and Grease concentrations appeared on 4 of 8 process sampling days for the aluminum subcategory. The maximum concentration was 11.0 mg/l. Dcp data and engineering analysis indicate that treatable concentrations of oil and grease are present in metal preparation wastewater as a result of aluminum forming oil remaining on the basis metal. Therefore, oil and grease is considered for specific regulation in this subcategory.

Pollutant Parameters Not Considered for Specific Regulation. Based on verification sampling results and careful examination of the aluminum subcategory alkaline cleaning process (the only process sampled other than coating), eighteen pollutant parameters that were evaluated in verification sampling and analysis were dropped from further consideration for specific regulation in the aluminum subcategory. These parameters were found to be present in raw wastewaters infrequently or at levels below those usually achieved by specific treatment methods. The eighteen are: bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, antimony, arsenic, beryllium, cadmium, chromium (hexavalent), copper, nickel, selenium, barium, cobalt, fluoride, iron, manganese, phenols (total), titanium, and oil and grease.

Bis(2-ethylhexyl)phthalate concentrations appeared on 1 of 9 process sampling days for the aluminum subcategory. The concentration was 0.022 mg/l which is lower than the concentration that is treatable for this industry Therefore, bis(2-ethylhexyl)phthalate is not considered for regulation in this subcategory.

Di-n-octyl phthalate concentrations appeared on 1 of 9 process sampling days for the aluminum subcategory. The concentration was 0.011 mg/l which is lower than the concentration designated as causing or likely to cause toxic effects in hymans. Therefore, di-n-octyl phthalate is not considered for specific regulation in this subcategory.

Antimony concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, antimony is not considered for specific regulation in metal preparation wastewaters from this subcategory.

Arsenic concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, arsenic is not considered for specific regulation in this subcategory.

Beryllium concentration did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, beryllium is not considered for specific regulation in this subcategory.

Cadmium concentrations appeared on 1 of 8 process sampling days for the aluminum subcategory. The concentration was 0.003 mg/l which is lower than the level that can be achieved with specific treatment technology. Therefore, cadmium is not considered for specific regulation in this subcategory.

Chromium (hexavalent) concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, hexavalent chromium is not considered for specific regulation in this subcategory.

Copper concentrations appeared on 2 of 8 process sampling days for the aluminum subcategory. The maximum concentration was 0.056 mg/l. Both concentrations were lower than the level that can be achieved with specific treatment methods. Therefore, copper is not selected for specific regulation in this subcategory.

Nickel concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, nickel is not considered for specific regulation in metal preparation wastewaters from this subcategory.

Selenium concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, selenium is not considered for specific regulation in this subcategory.

Barium concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, barium is not considered for specific regulation in this subcategory.

Cobalt concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, cobalt is not considered for specific regulation in this subcategory.

Fluoride concentrations appeared on all 8 process sampling days for the aluminum subcategory. The maximum concentration was 0.98 mg/l. All concentrations were lower than the level that can be achieved with specific treatment methods. Therefore, fluoride is not considered for specific regulation in this subcategory.

Iron concentrations appeared on all 8 process sampling days for the aluminum subcategory. The maximum concentration was 0.33 mg/l. This concentration was only slightly greater than the level that can be achieved with specific treatment methods. Therefore, iron is not considered for specific regulation in metal preparation wastewaters from this subcategory.

Manganese concentrations appeared on 3 of 8 process sampling days for the aluminum subcategory. The maximum concentration was 0.18 mg/l. All concentrations were lower than the level that can be achieved with specific treatment methods. Therefore, manganese is not considered for specific regulation in this subcategory.

Phenols (total) concentrations appeared on 7 of 8 process sampling days for the aluminum subcategory. The maximum concentration was 0.016 mg/l. This concentration is lower than the level that can be achieved for many specific phenols using specific treatment methods. Therefore, total phenols is not considered for specific regulation in this subcategory.

Titanium concentrations did not appear on any of 8 process sampling days for the aluminum subcategory. Therefore, titanium is not considered for specific regulation in the aluminum subcategory.

Copper Subcategory

Pollutant Parameters Considered for Specific Regulation - Based on verification sampling results and careful examination of the copper subcategory acid etching process (the only process sampled other than coating), six pollutant parameters were selected for consideration for specific regulation in effluent limitations and standards for this subcategory. The six are: copper, zinc, iron, oil and grease, total suspended solids, and pH.

Copper concentrations appeared on 3 of 3 sampling days for the acid etching process. The maximum concentration was 814.52 mg/l. All of the copper concentrations are greater than the level that can be achieved with specific treatment technology. Therefore, copper is considered for specific regulation in the copper subcategory.

Zinc concentrations appeared on 3 of 3 process sampling days for the copper subcategory. The maximum concentrations was 2.40 mg/l. One of the concentrations was greater than the level that can be achieved with specific treatment methods. Therefore, zinc is considered for specific regulation in this subcategory.

Iron concentrations appeared on all 3 process sampling days for the copper subcategory. The maximum concentration was 30.78 mg/l. Two of the iron concentrations were greater than the level that can be achieved with specific treatment methods. Therefore, iron is considered for specific regulation in this subcategory.

Oil and grease concentrations appeared on 1 of 3 process sampling days for the copper subcategory. This concentration was 196.0 mg/l. This pollutant parameter enters porcelain enameling wastewater streams from copper etching operations. This concentration is greater than the level that can be achieved with specific treatment methods. All concentrations are in the range that can be handled by POTW. Therefore, the oil and grease parameter is considered for specific regulation for direct dischargers only, in this subcategory.

Total suspended solids (TSS) concentrations appeared on 2 of 2 process sampling days. The maximum concentration was 24.0 mg/l. This concentration is greater than the level that can be achieved with specific treatment methods. Therefore TSS is considered for specific regulation in this subcategory.

pH ranged from 1.8 to 6.5 on 3 process sampling days for the copper subcategory. pH can be controlled within the limits of 7.5 to 10.0 with specific treatment methods and is therefore considered for specific regulation in this subcategory.

Pollutant Parameters Not Considered for Specific Regulation. Based on verification sampling results and careful examination of the copper subcategory etching process (the only process sampled other than coating) eighteen pollutant parameters that were evaluated in verification sampling and analysis were dropped from further consideration for specific regulation in the copper subcategory. These parameters were found to be present in raw wastewaters infrequently or at nonquanitifiable levels (i. e. below 0.01 mg/l) levels below those usually achieved by specific treatment methods. The eighteen are: 1,1,2-trichloroethane, toluene, trichloroethylene, antimony, arsenic, cadmium, total chromium, lead, nickel, selenium, aluminum, barium, cobalt, fluoride, manganese, total phenols, phosphorus, and titanium.

1,1,2-Trichloroethane, toluene, trichloroethylene, antimony, arsenic, selenium, cobalt, and titanium were not found above the analytical quantification limit on any of the 3 sampling days for this subcategory. Therefore, these parameters were dropped from any further consideration as pollutant parameters within this subcategory.

Cadmium concentrations appeared on 1 of 2 process sampling days for the aluminum subcategory. The concentration was 0.02 mg/l which is lower than the level that can be achieved with specific treatment technology. Therefore, cadmium is not considered for specific regulation in this subcategory.

Chromium (total) concentrations appeared on 3 of 3 process sampling days for the aluminum subcategory. The concentrations were lower than the level that can be achieved with specific treatment methods. Therefore, total chromium is not considered for specific regulation in this subcategory.

Nickel concentrations appeared on only 1 of 3 sampling days for this subcategory. This concentration was 0.12 mg/l. This concentration was lower than the level that can be achieved with specific treatment methods. Therefore, nickel is not considered for specific regulation in metal preparation wastewaters from this subcategory.

Barium concentrations did not appear on any of 3 process sampling days for the copper subcategory. Therefore, barium is not considered for specific regulation in this subcategory.

Fluoride concentrations appeared on 2 of 2 process sampling days for the copper subcategory. The maximum concentration was 0.11 mg/l. All concentrations were lower than the level that can be achieved with specific treatment methods. Therefore, fluoride is not considered for specific regulation in this subcategory.

Manganese concentrations appeared on 3 of 3 process sampling days for the copper subcategory. The maximum concentration was 0.26 mg/l. All concentrations were lower than the level that can be achieved with specific treatment methods. Therefore, manganese is not considered for specific regulation in this subcategory.

Phenols (total) concentrations appeared on 1 of 2 process sampling days for the copper subcategory. The maximum concentration was 0.006 mg/l. This concentration is lower than the level that can be achieved for many specific phenols using specific treatment methods. Therefore, total phenols is not considered for regulation within this subcategory.

Lead concentrations appeared on only 1 of 3 process sampling days for this subcategory. This concentration was 0.77 mg/l. Concentrations which appeared on the other two sampling days were less than the minimum detectable limit. Therefore, lead was dropped from further consideration as a pollutant parameter within metal preparation wastewaters from this subcategory.

Aluminum concentrations appeared on 2 of 3 process sampling days. The maximum concentration was 0.17 mg/l. This concentration is lower than the level that can be achieved by many specific treatment methods. Therefore, aluminum is not considered for regulation within this subcategory.

Phosphorus concentrations appeared on 1 of 2 process sampling days for the copper subcategory. This concentration was 0.52 mg/l. This concentration is lower than the level that can be achieved by many specific treatment methods. Therefore, phosphorus is not considered for regulation within the copper subcategory.

Summary

Table VI-1 (Page 165) presents the results of selection of priority pollutant parameters for consideration for specific regulation for the steel, cast iron, aluminum, and copper subcategories, respectively. The "Not Detected" symbol includes pollutants not detected in raw wastewater streams during screening and verification analysis. "Not Controlled" includes unique parameters found in only one plant. "Not Treatable" means that the concentrations were lower than the level achievable with the specific treatment methods considered in Section VII. Table VI-2 (Page 169) summarizes the selection of non-conventional and conventional pollutant parameters for consideration for specific regulation by subcategory.

TABLE VI-1
PRIORITY POLLUTANT DISPOSITION

PORCELAIN ENAMELING

	Subcategory			
Pollutant	Steel	Cast Iron	Aluminum	Copper
093 4,4-DDE (p,p-DDX)	ND	ND	ND	ND
094 4,4-DDD (p,p-TDE)	ND	ND	ND	ND
095 Alpha-endosulfan	ND	ND	ND	ND
096 Beta-endosulfan	ND	ND	ND	ND
097 Endosulfan sulfate	ND	ND	ND	ND
098 Endrin	ND	ND	ND	ND
099 Endrin aldehyde	ND	ND	ND	ND
100 Heptachlor	ND	ND	ND	ND
101 Heptachlor epoxide (BHC-hexachlorocyclohexane)	ND	ND	ND	ND
102 Alpha-BHC	ND	ND	ND	ND
103 Beta-BHC	ND	ND	ND	ND
104 Gamma-BHC (lindane)	ND	ND	ND	ND
105 Delta-BHC (PCB-polychlorinated biphenyls)	ND	ND	ND	ND
106 PCB-1242(Arochlor 1242)	ND	ND	ND	ND
107 PCB-1254(Arochlor 1254)	ND	ND	ND	ND
108 PCB-1221(Arochlor 1221)	ND	ND	ND	ND
109 PCB-1232(Arochlor 1232)	ND	ND	ND	ND
110 PCB-1248(Arochlor 1248)	ND	ND	ND	ND
111 PCB-1260(Arochlor 1260)	ND	ND	ND	ND
112 PCB-1016(Arochlor 1016)	ND	ND	ND	ND
113 Toxaphene	ND	ND	ND	ND
114 Antimony	REG	REG	REG	REG.
115 Arsenic	REG	REG	REG	REG
116 Asbestos	ND	ND	ND	ND
117 Beryllium	NT	ND	NT	ND
118 Cadmium	REG	REG	REG	REG
119 Chromiumm	REG	REG	REG	REG
120 Copper	REG	REG	REG	REG
121 Cyanide, Total	ND	ND	EI	ND
122 Lead	REG	REG	REG	REG
123 Mercury	ND	ND	ND	ND
124 Nickel	REG	REG	REG	REG
125 Selenium	REG	REG	REG	REG
126 Silver	REG	ND	ND	ND
127 Thallium	ND	ND	ND	ND
128 Zinc	REG	REG	REG	REG
129 dibenzo-p-dioxin (TCDD)	ND	ND	ND	ND

TABLE VI-1
PRIORITY POLLUTANT DISPOSITION

PORCELAIN ENAMELING

Pollutant		Subcategory			
		Steel	Cast Iron	Aluminum	Copper
062	N-nitrosodiphenylamine	ND	ND	ND	ND
063	N-nitrosodi-n-propylamine	ND	ND	ND	ND
064	Pentachlorophenol	ND	ND	ND	ND
065	Phenol	ND	ND	ND	ND
066	Bis(2-ethylhexyl) phthalate)	ND	NQ	EI	ND
067	Butyl benzyl phthalate	ND	ND	ND	ND
068	Di-N-Butyl Phthalate	ND	ND	ND	ND
069	Di-n-octyl phthalate	ND	ND	EI	ND
070	Diethyl Phthalate	ND	ND	ND	ND
071	Dimethyl phthalate	ND	ND	ND	ND
072	1,2-benzanthracene (benzo(a)anthracene)	ND	ND	ND	ND
073	Benzo(a)pyrene (3,4-benzopyrene)	ND	ND	ND	ND
074	3,4-Benzofluoranthene (benzo(b)fluoranthene)	ND	ND	ND	ND
075	11,12-benzofluoranthene (benzo(b)fluoranthene)	ND	ND	ND	ND
076	Chrysene	ND	ND	ND	ND
077	Acenaphthylene	ND	ND	ND	ND
078	Anthracene	ND	ND	ND	ND
079	1,12-benzoperylene (benzo(ghi)perylene)	ND	ND	ND	ND
080	Fluorene	ND	ND	ND	NQ
081	Phenanthrene	ND	ND	ND	ND
082	1,2,5,6-dibenzanthracene (dibenzo(,h)anthracene)	ND	ND	ND	ND
083	Indeno(1,2,3-cd) pyrene (2,3-o-pheynylene pyrene)	ND	ND	ND	ND
084	Pyrene	ND	ND	ND	ND
085	Tetrachloroethylene	ND	ND	ND	ND
086	Toluene	ND	ND	ND	NQ
087	Trichloroethylene	NQ	ND	ND	ND
088	Vinyl chloride (chloroethylene)	ND	ND	ND	ND
089	Aldrin	ND	ND	ND	ND
090	Dieldrin	ND	ND	ND	ND
091	Chlordane (technical mixture and metabolites)	ND	ND	ND	ND
092	4,4-DDT	ND	ND	ND	ND

TABLE VI-1
PRIORITY POLLUTANT DISPOSITION

PORCELAIN ENAMELING

Pollutant		Steel	Cast Iron	Aluminum	Copper
		Subcategory			
030	1,2-trans-dichloroethylene	ND	ND	ND	ND
031	2,4-dichlorophenol	ND	ND	ND	ND
032	1,2-dichloropropane	ND	ND	ND	ND
033	1,2-dichloropropylene (1,3-dichloropropene)	ND	ND	ND	ND
034	2,4-dimethylphenol	ND	ND	ND	ND
035	2,4-dinitrotoluene	ND	ND	ND	ND
036	2,6-dinitrotoluene	ND	ND	ND	ND
037	1,2-diphenylhydrazine	ND	ND	ND	ND
038	Ethylbenzene	ND	ND	ND	ND
039	Fluoranthene	ND	ND	ND	ND
040	4-chlorophenyl phenyl ether	ND	ND	ND	ND
041	4-bromophenyl phenyl ether	ND	ND	ND	ND
042	Bis(2-chloroisopropyl) ether	ND	ND	ND	ND
043	Bis(2-chloroethoxy) methane	ND	ND	ND	ND
044	Methylene chloride (dichloromethane)	ND	ND	ND	ND
045	Methyl chloride (dichloromethane)	ND	ND	ND	ND
046	Methyl bromide (bromomethane)	ND	ND	ND	ND
047	Bromoform (tribromomethane)	ND	ND	ND	ND
048	Dichlorobromomethane	ND	ND	ND	ND
049	Trichlorofluoromethane	ND	ND	ND	ND
050	Dichlorodifluoromethane	ND	ND	ND	ND
051	Chlorodibromomethane	ND	ND	ND	ND
052	Hexachlorobutadiene	ND	ND	ND	ND
053	Hexachloromyclopentadiene	ND	ND	ND	ND
054	Isophorone	ND	ND	ND	ND
055	Naphthalene	ND	ND	ND	ND
056	Nitrobenzene	ND	ND	ND	ND
057	2-nitrophenol	ND	ND	ND	ND
058	4-nitrophenol	ND	ND	ND	ND
059	2,4-dinitrophenol	ND	ND	ND	ND
060	4,6-dinitro-o-cresol	ND	ND	ND	ND
061	N-nitrosodimethylamine	ND	ND	ND	ND

TABLE VI-1
PRIORITY POLLUTANT DISPOSITION

PORCELAIN ENAMELING

	Subcategory			
Pollutant	Steel	Cast Iron	Aluminum	Copper
001 Acenaphthene	ND	ND	ND	ND
002 Acrolein	ND	ND	ND	ND
003 Acrylonitrile	ND	ND	ND	ND
004 Benzene	ND	ND	ND	ND
005 Benzidine	ND	ND	ND	ND
006 Carbon tetrachloride (tetrachloromethane)	ND	ND	ND	ND
007 Chlorobenzene	ND	ND	ND	ND
008 1,2,4-trichlorobenzene	ND	ND	ND	ND
009 Hexachlorobenzene	ND	ND	ND	ND
010 1,2-dichloroethane	ND	ND	ND	ND
011 1,1,1-trichlorethane	ND	ND	ND	ND
012 Hexachloroethane	ND	ND	ND	ND
013 1,1-dichloroethane	ND	ND	ND	ND
014 1,1,2-trichloroethane	ND	ND	ND	NQ
015 1,1,2,2-tetrachloroethane	ND	ND	ND	ND
016 Chloroethane	ND	ND	ND	ND
017 Bis (chloromethyl) ether	ND	ND	ND	ND
018 Bis (2-chloroethyl) ether	ND	ND	ND	ND
019 2-chloroethyl vinyl ether (mixed)	ND	ND	ND	ND
020 2-chloronaphthalene	ND	ND	ND	ND
021 2,4,6-trichlorophenol	ND	ND	ND	ND
022 Parachlorometa cresol	ND	ND	ND	ND
023 Chloroform (trichloromethane)	ND	ND	ND	ND
024 2-chlorophenol	ND	ND	ND	ND
025 1,2-dichlorobenzene	ND	ND	ND	ND
026 1,3-dichlorobenzene	ND	ND	ND	ND
027 1,4-dichlorobenzene	ND	ND	ND	ND
028 3,3-dichlorobenzidine	ND	ND	ND	ND
029 1,1-dichloroethylene	ND	ND	ND	ND

LEGEND:

ND = NOT DETECTED
NQ = NOT QUANTIFIABLE
EI = ENVIRONMENTALLY INSIGNIFICANT
NT = NOT TREATABLE
REG = REGULATION CONSIDERED

TABLE VI-2

NON-CONVENTIONAL AND CONVENTIONAL POLLUTANT PARAMETERS SELECTED FOR CONSIDERATION FOR SPECIFIC REGULATION IN THE PORCELAIN ENAMELING CATEGORY

Pollutant Parameter	Subcategory Steel	Cast Iron	Aluminum	Copper
Aluminum	X	X	X	X
Barium	X	X	X	X
Cobalt	X	X	X	X
Fluoride	X	X	X	X
Iron	X	X	X	X
Manganese	X	X	X	X
Phosphorus	X	X	X	X
Titanium	X	X	X	X
Oil and Grease	X	X	X	X
TSS	X	X	X	X
pH	X	X	X	X

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

This section describes the treatment techniques currently used or available to remove or recover wastewater pollutants normally generated by the porcelain enameling industrial point source category. Included are discussions of individual end-of-pipe treatment technologies and in-plant technologies. These treatment technologies are widely used in many industrial categories and data and information to support their effectiveness has been drawn from a similarly wide range of sources and data bases.

END-OF-PIPE TREATMENT TECHNOLOGIES

Individual recovery and treatment technologies are described which are used or are suitable for use in treating wastewater discharges from porcelain enameling facilities. Each description includes a functional description and discussions of application and performance, advantages and limitations, operational factors (reliability, maintainability, solid waste aspects), and demonstration status. The treatment processes described include both technologies presently demonstrated within the porcelain enameling category, and technologies demonstrated in treatment of similar wastes in other industries.

Porcelain enameling wastewater streams characteristically contain significant levels of toxic inorganics. Chromium, lead, nickel, and zinc are found in porcelain enameling wastewater streams at substantial concentrations. These toxic inorganic pollutants constitute the most significant wastewater pollutants in this category.

In general, these pollutants are removed by chemical precipitation and sedimentation or filtration. Most of them may be effectively removed by precipitation of metal hydroxides or carbonates utilizing the reaction with lime, sodium hydroxide, or sodium carbonate. For some, improved removals are provided by the use of sodium sulfide or ferrous sulfide to precipitate the pollutants as sulfide compounds with very low solubilities.

Discussion of end-of-pipe treatment technologies is divided into three parts: the major technologies; the effectiveness of major technologies; and minor end-of-pipe technologies.

MAJOR TECHNOLOGIES

In Sections IX, X, XI and XII, 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: chemical reduction of hexavalent chromium, chemical precipitation of dissolved metals, cyanide precipitation, granular bed filtration, pressure filtration, settling of suspended solids, and skimming of oil. 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. Chemical Reduction Of Chromium

Description of the Process. Reduction is a chemical reaction in which electrons are transferred to the chemical being reduced from the chemical initiating the transfer (the reducing agent). Sulfur dioxide, sodium bisulfite, sodium metabisulfite, and ferrous sulfate form strong reducing agents in aqueous solution and are often used in industrial waste treatment facilities for the reduction of hexavalent chromium to the trivalent form. The reduction allows removal of chromium from solution in conjunction with other metallic salts by alkaline precipitation. Hexavalent chromium is not precipitated as the hydroxide.

Gaseous sulfur dioxide is a widely used reducing agent and provides a good example of the chemical reduction process. Reduction using other reagents is chemically similar. The reactions involved may be illustrated as follows:

$$3\ SO_2 + 3\ H_2O \text{--------->} 3\ H_2SO_3$$

$$3\ H_2SO_3 + 2H_2CrO_4 \text{--->} Cr_2(SO_4)_3 + 5\ H_2O$$

The above reaction is favored by low pH. A pH of from 2 to 3 is normal for situations requiring complete reduction. At pH levels above 5, the reduction rate is slow. Oxidizing agents such as dissolved oxygen and ferric iron interfere with the reduction process by consuming the reducing agent.

A typical treatment consists of 45 minutes retention in a reaction tank. The reaction tank has an electronic recorder-controller device to control process conditions with respect to pH and oxidation reduction potential (ORP). Gaseous sulfur dioxide is metered to the reaction tank to maintain the ORP within the range of 250 to 300 millivolts. Sulfuric acid is added to maintain a pH level of from 1.8 to 2.0. The reaction tank is equipped with a propeller agitator designed to provide approximately one turnover per minute. Figure VII-13 (page 279) shows a continuous chromium reduction system.

Application and Performance. Chromium reduction is used in porcelain enameling for treating chromating rinses for high-magnesium aluminum basis materials. Electroplating rinse waters and cooling tower blowdown are two major sources of chromium in waste streams. A study of an operational waste treatment facility chemically reducing hexavalent chromium has shown that a 99.7 percent reduction efficiency is easily achieved. Final concentrations of 0.05 mg/l are readily attained, and concentrations of 0.01 mg/l are considered to be attainable by properly maintained and operated equipment.

Advantages and Limitations. The major advantage of chemical reduction to reduce hexavalent chromium is that it is a fully proven technology based on many years of experience. Operation at ambient conditions results in low energy consumption, and the process, especially when using sulfur dioxide, is well suited to automatic control. Furthermore, the equipment is readily obtainable from many suppliers, and operation is straightforward.

One limitation of chemical reduction of hexavalent chromium is that for high concentrations of chromium, the cost of treatment chemicals may be prohibitive. When this situation occurs, other treatment techniques are likely to be more economical. Chemical interference by oxidizing agents is possible in the treatment of mixed wastes, and the treatment itself may introduce pollutants if not properly controlled. Storage and handling of sulfur dioxide is somewhat hazardous.

Operational Factors. Reliability: Maintenance consists of periodic removal of sludge, the frequency of which is a function of the input concentrations of detrimental constituents.

Solid Waste Aspects: Pretreatment to eliminate substances which will interfere with the process may often be necessary. This process produces trivalent chromium which can be controlled by further treatment. There may, however, be small amounts of sludge collected due to minor shifts in the solubility of the contaminants. This sludge can be processed by the main sludge treatment equipment.

Demonstration Status. The reduction of chromium waste by sulfur dioxide or sodium bisulfite is a classic process and is used by numerous plants which have hexavalent chromium compounds in wastewaters from operations such as electroplating and noncontact cooling.

2. 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 porcelain enameling 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. Irrespective 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 (page 267), and by plotting effluent zinc concentrations against pH as shown in Figure VII-3 (page 269). Figure VII-3 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-3 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-1. Flow through this system is approximately 49,263 l/h (13,000 gal/hr).

TABLE VII-1
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). Data are displayed in Table VII-2.

TABLE VII-2

Effectiveness of Sodium Hydroxide for Metals Removal

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range	2.1-2.9	9.0-9.3	2.0-2.4	8.7-9.1	2.0-2.4	8.6-9.1
(mg/l)						
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-3 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-3
Effectiveness of Lime and Sodium Hydroxide for Metals Removal

	Day 1		Day 2		Day 3	
	In	Out	In	Out	In	Out
pH Range	9.2-9.6	8.3-9.8	9.2	7.6-8.1	9.6	7.8-8.2
(mg/l)						
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	0.0044	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-4 (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-5.

TABLE VII-4

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-5

SAMPLING DATA FROM SULFIDE PRECIPITATION-SEDIMENTATION SYSTEMS

Treatment	Lime, FeS, Poly-electrolyte, Settle, Filter		Lime, FeS, Poly-electrolyte, Settle, Filter		NaOH, Ferric Chloride, Na_2S Clarify (1 stage)	
	In	Out	In	Out	In	Out
pH	5.0-6.8	8-9	7.7	7.38		
(mg/l)						
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-2, 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.

Of particular interest is the ability of sulfide to precipitate hexavalent chromium (Cr+6) without prior reduction to the trivalent state as is required in the hydroxide process. When ferrous sulfide is used as the precipitant, iron and sulfide act as reducing agents for the hexavalent chromium according to the reaction:

$$CrO_3 + FeS + 3H_2O \dashrightarrow Fe(OH)_3 + Cr(OH)_3 + S$$

The sludge produced in this reaction consists mainly of ferric hydroxides, chromic hydroxides and various metallic sulfides. Some excess hydroxyl ions are generated in this process, possibly requiring a downward re-adjustment of pH.

Based on the available data, Table VII-6 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-6

SULFIDE PRECIPITATION-SEDIMENTATION PERFORMANCE

Parameter	Treated Effluent (mg/l)
Cd	0.01
Cr	0.05
Cu	0.05
Pb	0.01
Hg	0.03
Ni	0.05
Ag	0.05
Zn	0.01

Table VII-6 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-2 (page 268) ("Heavy Metals Removal," by Kenneth Lanovette, Chemical Engineering/Deskbook Issue, Oct. 17, 1977) explain this phenomenon.

"Co-precipitation With Iron" - The presence of substantial quantites of iron in metal bearing wastewaters before treatment has been shown to improve the removal of toxic metals. In some cases this iron is an integral part of the industrial wastewater; in other cases iron is deliberately added as a pre 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-7.

Table VII-7

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. Chemical precipitation of metals in the carbonate form alone has been found to be feasible and is commercially used to permit metals recovery and water reuse. Full scale commercial sulfide precipitation units are in operation at numerous installations. As noted earlier, sedimentation to remove precipitates is discussed separately.

Use in Porcelain Enameling Plants. Chemical precipitation is used at 28 porcelain enameling plants. The quality of treatment provided, however, is variable. A review of collected data and on-site observations reveals that control of system parameters is often poor. Where precipitates are removed by clarification, retention times are likely to be short and cleaning and maintenance questionable. Similarly, pH control is frequently inadequate. As a result of these factors, effluent performance at porcelain enameling plants nominally practicing the same wastewater treatment is observed to vary widely.

3. Cyanide Precipitation

Cyanide precipitation, although a method for treating cyanide in wastewaters, does not destroy cyanide. The cyanide is retained in the sludge that is formed. Reports indicate that during exposure to sunlight the cyanide complexes can break down and form free cyanide. For this reason the sludge from this treatment method must be disposed of carefully.

Cyanide may be precipitated and settled out of wastewaters by the addition of zinc sulfate or ferrous sulfate. In the presence of iron, cyanide will form extremely stable cyanide complexes. The addition of zinc sulfate or ferrous sulfate forms zinc ferrocyanide or ferro and ferricyanide complexes.

Adequate removal of the precipitated cyanide requires that the pH must be kept at 9.0 and an appropriate retention time be maintained. A study has shown that the formation of the complex is very dependent on pH. At pH's of 8 and 10 the residual cyanide concentrations measured are twice those of the same reaction carried out at a pH of 9. Removal efficiencies also depend heavily on the retention time allowed. The formation of the complexes takes place rather slowly. Depending upon the excess amount of zinc sulfate or ferrous sulfate added, at least a 30 minute retention time should be allowed for the formation of the cyanide complex before continuing on to the clarification stage.

One experiment with an initial concentration of 10 mg/l of cyanide showed that (98 percent) of the cyanide was complexed ten minutes after the addition of ferrous sulfate at twice the theoretical amount necessary. Interference from other metal ions, such as cadmium, might result in the need for longer retention times.

Table VII-8 presents data from three coil coating plants. A fourth plant was visited for the purpose of observing plant testing of the cyanide precipitation system. Specific data from this facility are not included because: (1) the pH was usually well below the optimum level of 9.0; (2) the historical treatment data were not obtained using the standard cyanide analysis procedure; and (3) matched input-output data were not made available by the plant. Scanning the available data indicates that the raw waste CN level was in the range of 25.0; the pH 7.5; and treated CN level was from 0.1 to 0.2.

TABLE VII-8

CONCENTRATION OF TOTAL CYANIDE
(mg/l)

Plant	Method	In	Out
1057	$FeSO_4$	2.57	0.024
		2.42	0.015
		3.28	0.032
33056	$FeSO_4$	0.14	0.09
		0.16	0.09
12052	$ZnSO_4$	0.46	0.14
		0.12	0.06
Mean			0.07

The concentrations are those of the stream entering and leaving the treatment system. Plant 1057 allowed a 27 minute retention time for the formation of the complex. The retention time for the other plants is not known. The data suggest that over a wide range of cyanide concentration in the raw waste, the concentration of cyanide can be reduced in the effluent stream to under 0.15 mg/l.

Application and Performance. Cyanide precipitation can be used when cyanide destruction is not feasible because of the presence of cyanide complexes which are difficult to destroy. Effluent concentrations of cyanide well below 0.15 mg/l are possible.

Advantages and Limitations. Cyanide precipitation is an inexpensive method of treating cyanide. Problems may occur when metal ions interfere with the formation of the complexes.

Demonstration Status: Cyanide precipitation is not used in any porcelain enameling plants.

4. Granular Bed Filtration

Filtration occurs in nature as the surface ground waters are cleansed by sand. 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-19 (page 280) 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.

<u>Application</u> <u>and</u> <u>Performance</u>. 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 below 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-9 below.

Table VII-9

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 municipal treatment plants. 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. As noted previously, however, little data is available characterizing the effectiveness of filters presently in use within the 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-15 (page 281) 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 porcelain enameling 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.

<u>Advantages and Limitations</u>. 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.

<u>Operational Factors</u>. 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 porcelain enameling wastewater necessitate 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-16 (page 282) shows two typical settling devices.

Settling is often preceded by chemical precipitation which converts dissolved pollutants to 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, 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 porcelain enameling 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, metal finishing, metal working, and any other industry with high concentrations of metal ions in their wastewaters. In addition to toxic metals, suitably precipitated materials effectively removed by settling include aluminum, iron, manganese, cobalt, antimony, beryllium, molybdenum, fluoride, phosphate, and many others.

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-10 indicate suspended solids removal efficiencies in settling systems.

TABLE VII-10
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 Settling Ponds	1100	9	1900	12	1620	5
11058	Clarifier	451	17	-	-	-	-
12075	Settling Pond	284	6	242	10	502	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-10 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 many porcelain enameling plants as shown below.

Settling Device	No. Plants
Settling Tanks	51
Clarifier	24
Tube or Plate Settler	4
Lagoon	11

Settling is used both as part of end-of-pipe treatment and within the plant to allow recovery of process solutions and raw materials.

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.

<u>Application and Performance</u>. 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 in Table VII-11 illustrate the capabilities of the technology with both extremely high and moderate oil influent levels.

Table VII-11

SKIMMING PERFORMANCE

Plant	Skimmer Type	Oil & Grease mg/l In	Oil & Grease mg/l 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
1	Acenaphthene	4.33
39	Fluoranthene	5.33
72	Benzo(a)anthracene	5.61
73	Benzo(a)pyrene	6.04
74	3,4-benzofluoranthene	6.57
75	Benzo(k)fluoranthene	6.84
76	Chrysene	5.61
77	Acenaphthylene	4.07
78	Anthracene	4.45
79	Benzo(ghi)perylene	7.23
80	Fluorene	4.18
81	Phenanthrene	4.46
82	Dibenzo(a,h)anthracene	5.97
83	Indeno(1,2,3,cd)pyrene	7.66
84	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 visited 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 Table VII-12 (all values in mg/l).

TABLE VII-12

TRACE ORGANIC REMOVAL BY SKIMMING
API PLUS BELT SKIMMERS
(From Plant 06058)

	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, and chemical oxidation is another possibility. 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 at least two porcelain enameling plants.

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 chemical reduction of chromium, cyanide precipitation, and oil skimming are 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 porcelain enameling 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 the first two data items below were removed; the third data item was removed after the homogeneity examination. 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-4 to VII-12 (Pages 270-278). 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 σ^2. The mean, variance and 99th percentile of X are then:

$$\text{mean of } X = E(X) = \exp(\mu + \sigma^2/2)$$

$$\text{variance of } X = V(X) = \exp(2\mu + \sigma^2)[\exp(\sigma^2)-1]$$

$$\text{99th percentile} = X_{.99} = \exp(\mu + 2.33\sigma)$$

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 μ and variance σ^2. Using the basic 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 x_{ij} = the jth observation on a particular pollutant at plant i

where $i = 1,\ldots, I$
$j = 1,\ldots, J_i$
I = total number of plants
J_i = number of observations at plant i.

Then $y_{ij} = \ln x_{ij}$

where ln means the natural logarithm.

Then $\bar{y}$ = log mean over all plants

$$= \sum_{i=1}^{I} \sum_{j=1}^{J_i} y_{ij}/n,$$

where n = total number of observations

$$= \sum_{i=1}^{I} J_i$$

and $V(y)$ = pooled log variance

$$= \frac{\sum_{i=1}^{I} (J_i - 1) S_i^2}{\sum_{i=1}^{I} (J_i - 1)}$$

where S_i^2 = log variance at plant i

$$= \sum_{j=1}^{J_i} (y_{ij} - \bar{y}_i)^2 / (J_i - 1)$$

$\bar{y}_i$ = 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

$$\text{mean} = \hat{E}(X) = \exp(\bar{y})\Psi\ n\ (0.5\ V(y))$$

$$\text{99th percentile} = \hat{X}_{.99} = \exp[\bar{y} + 2.33 \sqrt{V(y)}\ ]$$

where ψ (.) 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-13 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-13 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 μ and σ^2, respectivey. Let X_{10} denote the mean of 10 consecutive measurements. The following relationships then hold assuming the daily measurements are independent:

$$\text{mean of } \overline{X}_{10} = E(\overline{X}_{10}) = E(X)$$

$$\text{variance of } \overline{X}_{10} = V(\overline{X}_{10}) = V(X) \div 10.$$

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 σ_{10}. The mean and variance of X_{10} are then

$$\bar{E}(X_{10}) = \exp(\mu_{10} + 0.5\,\sigma^2_{10})$$

$$V(\bar{X}_{10}) = \exp(2\,\mu_{10} + \sigma^2_{10})[\exp(\sigma^2_{10})-1]$$

Now, μ_{10} and σ^2_{10} can be derived in terms of μ and σ^2 as

$$\mu_{10} = \mu + \sigma^2/2 - 0.5 \ln [1+(\exp(\sigma^2)-1)/N]$$

$$\sigma^2_{10} = \ln[1+(\exp(\sigma^2)-1)/N]$$

Therefore, μ_{10} and σ^2_{10} can be estimated using the above relationships and the estimates of μ 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

$$\hat{\bar{X}}_{10}\,(.99) = \exp(\hat{\mu}_{10} + 2.33\,\hat{\sigma}_{10}).$$

where $\hat{\mu}_{10}$ and $\hat{\sigma}_{10}$ 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:

$$\text{mean of } \overline{X}_{30} = E(\overline{X}_{30}) = E(X)$$

$$\text{variance of } \overline{X}_{30} = V(\overline{X}_{30}) = V(X) \div 30.$$

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

$$\hat{\overline{X}}_{30}(.99) = \hat{E}(X) + 2.33 \sqrt{\hat{V}(X) \div 30}$$

where

$$\hat{E}(X) = \exp(\overline{y})\, \psi_n(0.5V(y))$$

$$\text{and } \hat{V}(X) = \exp(2\overline{y}) [\, \psi_n(2V(y)) - \psi_n\left(\left(\frac{n-2}{n-1}\right)V(y)\right)].$$

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, <u>The Lognormal Distribution</u>, Cambridge University Press, 1963, page 45.

Table VII-13

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

In response to the proposed coil coating and porcelain enameling regulations, the Agency received comments 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-14 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-14
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-14 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-15 and VII-16 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 data 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-15

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-16
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-16 is comparable with the combined data set matrix.

Beryllium (Be) - The treatability of beryllium is transferred from the nonferrous metals manufacturing industry. The 0.3 performance is achieved at a beryllium plant with the comparable untreated wastewater matrix shown in Table VII-16.

Mercury (Hg) - The 0.06 mg/l treatability of mercury is based on data from four battery plants. The untreated wastewater matrix at these plants was considered in the combined metals data set.

Selenium (Se) - The 0.30 mg/l treatability of selenium is based on recent permit data from one of the nonferrous metals manufacturing plants also used for antimony performance. The untreated wastewater matrix for this plant is shown in Table VII-16.

Silver - The treatability of silver is based on a 0.1 mg/l treatability estimate from the inorganic chemicals industry. Additional data supporting a treatability as stringent or more stringent than 0.1 mg/l is also available from seven nonferrous metals manufacturing plants. The untreated wastewater matrix for these plants is comparable and summarized in Table VII-16.

Thallium (Tl) - The 0.50 mg/l treatability for thallium is transferred from the inorganic chemicals industry. Although no untreated wastewater data are available to verify comparability with the combined metals data set plants, no other sources of data for thallium treatability could be identified.

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-16 is comparable to the combined metals data set.

LS&F Performance

Tables VII-17 and VII-18 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-19 (Page 215) 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-17

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 ±0.0.29	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-18

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	0.401 ±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-19

PRECIPITATION-SETTLING-FILTRATION (LS&F) PERFORMANCE
Plant C

For Treated Wastewater 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 co-precipitation 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 melting and refining.

Analysis of Treatment System Effectiveness

Data are presented in Table VII-13 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 - 4.100; ten day average - 1.821; and 30 day average - 1.618.) For values not calculated from the common data base as previously discussed, the mean value for pollutants shown in Table VII-14 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-20.

LS&F technology data are presented in Tables VII-17 and VII-18. 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 occurred 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-17 and VII-18 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-20.

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-17 (page 213) and is incorporated into Table VII-20 for LS&F. The zinc data was analyzed for compliance with the 1-day and 30-day values in Table VII-20; 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-20 value of 0.31 mg/l. Additionally the Plant C raw wastewater pollutant concentrations (Table VII-19) are well within the range of raw wastewater concentrations of the combined metals data base (Table VII-15), 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-20. Mean one day, ten day and 30 day values for L&S for nine pollutants were taken from Table VII-12; the remaining L&S values were developed using the mean values in Table VII-14 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.

L&S cyanide mean levels shown in Table VII-8 are ratioed to one day, ten day and 30 day values using mean variability factors. LS&F mean cyanide is calculated by applying the ratios of removals L&S and LS&F as discussed previously for LS&F metals limitations. The cyanide performance was arrived at by using the average metal variability factors. The treatment method used here is cyanide precipitation. Because cyanide precipitation is limited by the same physical processes as the metal precipitation, it is expected that the variabilities will be similar. Therefore, the average of the metal variability factors has been used as a basis for calculating the cyanide one day, ten day and thirty day average treatment effectiveness values.

The filter performance for removing TSS as shown in Table VII-9 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-20

Summary of Treatment Effectiveness
(mg/l)

Pollutant Parameter		L&S Technology System				LS&F Technology System		
	Mean	One Day Max.	Ten Day Avg.	Thirty Day Avg.	Mean	One Day Max.	Ten Day Avg.	Thirty Day Avg.
114 Sb	0.70	2.87	1.28	1.14	0.47	1.93	0.86	0.76
115 As	0.51	2.09	0.86	0.83	0.34	1.39	0.57	0.55
117 Be	0.30	1.23	0.51	0.49	0.20	0.82	0.34	0.32
118 Cd	0.079	0.32	0.15	0.13	0.049	0.20	0.08	0.08
119 Cr	0.080	0.42	0.17	0.12	0.07	0.37	0.15	0.10
120 Cu	0.58	1.90	1.00	0.73	0.39	1.28	0.61	0.49
121 CN	0.07	0.29	0.12	0.11	0.047	0.20	0.08	0.08
122 Pb	0.12	0.15	0.13	0.12	0.08	0.10	0.09	0.08
123 Hg	0.06	0.25	0.10	0.10	0.036	0.15	0.06	0.06
124 Ni	0.57	1.41	1.00	0.75	0.22	0.55	0.37	0.29
125 Se	0.30	1.23	0.55	0.49	0.20	0.82	0.37	0.33
126 Ag	0.10	0.41	0.17	0.16	0.07	0.29	0.12	0.10
127 Tl	0.50	2.05	0.84	0.81	0.34	1.40	0.57	0.55
128 Zn	0.30	1.33	0.56	0.41	0.23	1.02	0.42	0.31
Al	1.11	4.55	1.86	1.80	0.74	3.03	1.24	1.20
Co	0.05	0.21	0.09	0.08	0.034	0.14	0.07	0.06
F	14.5	59.5	26.4	23.5	9.67	39.7	17.6	15.7
Fe	0.41	1.23	0.63	0.51	0.28	1.23	0.63	0.51
Mn	0.21	0.43	0.34	0.27	0.14	0.30	0.23	0.19
P	4.08	16.7	6.83	6.60	2.72	11.2	4.6	4.4
O&G		20.0	12.0	10.0		10.0	10.0	10.0
TSS	12.0	41.0	20.0	15.5	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/gm 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-17 (page 283). 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 shown in Table VII-21.

Table VII-21

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-22 (page 265) summarizes the treatability effectiveness for most of the organic priority pollutants by activated carbon as compiled by EPA. Table VII-23 (page 266) 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 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-18 (page 284).

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 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 wastewater, although none are currently not in use at any porcelain enameling facility.

11. Cyanide Oxidation By Chlorine

Cyanide oxidation using chlorine is widely used in industrial waste treatment to oxidize cyanide. Chlorine can be utilized in either the elemental or hypochlorite forms. This classic procedure can be illustrated by the following two step chemical reaction:

1. $Cl_2 + NaCN + 2NaOH \rightarrow NaCNO + 2NaCl + H_2O$

2. $3Cl_2 + 6NaOH + 2NaCNO \rightarrow 2NaHCO_3 + N_2 + 6NaCl + 2H_2O$

The reaction presented as equation (2) for the oxidation of cyanate is the final step in the oxidation of cyanide. A complete system for the alkaline chlorination of cyanide is shown in Figure VII-19 (page 285).

The alkaline chlorination process oxidizes cyanides to carbon dioxide and nitrogen. The equipment often consists of an equalization tank followed by two reaction tanks, although the reaction can be carried out in a single tank. Each tank has an electronic recorder-controller to maintain required conditions with respect to pH and oxidation reduction potential (ORP). In the first reaction tank, conditions are adjusted to oxidize cyanides to cyanates. To effect the reaction, chlorine is metered to the reaction tank as required to maintain the ORP in the range of 350 to 400 millivolts, and 50 percent aqueous caustic soda is added to maintain a pH range of 9.5 to 10. In the second reaction tank, conditions are maintained to oxidize cyanate to carbon dioxide and nitrogen. The desirable ORP and pH for this reaction are 600 millivolts and a pH of 8.0. Each of the reaction tanks is equipped with a propeller agitator designed to provide approximately one turnover per minute. Treatment by the batch process is accomplished by using two tanks, one for collection of water over a specified time period, and one tank for the treatment of an accumulated batch. If dumps of concentrated wastes are frequent, another tank may be required to equalize the flow to the treatment tank. When the holding tank is full, the liquid is transferred to the reaction tank for treatment. After treatment, the supernatant is discharged and the sludges are collected for removal and ultimate disposal.

Application and Performance. The oxidation of cyanide waste by chlorine is a classic process and is found in most industrial plants using cyanide. This process is capable of achieving effluent levels that are nondetectable. The process is potentially applicable to coil coating facilities where cyanide is a component in conversion coating formulations.

Advantages and Limitations. Some advantages of chlorine oxidation for handling process effluents are operation at ambient temperature, suitability for automatic control, and low cost. Disadvantages include the need for careful pH control, possible chemical interference in the treatment of mixed wastes, and the potential hazard of storing and handling chlorine gas.

Operational Factors. Reliability: Chlorine oxidation is highly reliable with proper monitoring and control, and proper pretreatment to control interfering substances.

Maintainability: Maintenance consists of periodic removal of sludge and recalibration of instruments.

Solid Waste Aspects: There is no solid waste problem associated with chlorine oxidation.

Demonstration Status. The oxidation of cyanide wastes by chlorine is a widely used process in plants using cyanide in cleaning and metal processing baths.

12. Cyanide Oxidation By Ozone

Ozone is a highly reactive oxidizing agent which is approximately ten times more soluble than oxygen on a weight basis in water. Ozone may be produced by several methods, but the silent electrical discharge method is predominant in the field. The silent electrical discharge process produces ozone by passing oxygen or air between electrodes separated by an insulating material. A complete ozonation system is represented in Figure VII-20 (page 286).

Application and Performance. Ozonation has been applied commercially to oxidize cyanides, phenolic chemicals, and organo-metal complexes. Its applicability to photographic wastewaters has been studied in the laboratory with good results. Ozone is used in industrial waste treatment primarily to oxidize cyanide to cyanate and to oxidize phenols and dyes to a variety of colorless nontoxic products.

Oxidation of cyanide to cyanate is illustrated below:

$$CN^- + O_3 \longrightarrow CNO^- + O_2$$

Continued exposure to ozone will convert the cyanate formed to carbon dioxide and ammonia; however, this is not economically practical.

Ozone oxidation of cyanide to cyanate requires 1.8 to 2.0 pounds ozone per pound of CN-; complete oxidation requires 4.6 to 5.0 pounds ozone per pound of CN-. Zinc, copper, and nickel cyanides are easily destroyed to a nondetectable level, but cobalt and iron cyanides are more resistant to ozone treatment.

Advantages and Limitations. Some advantages of ozone oxidation for handling process effluents are its suitability to automatic control and on-site generation and the fact that reaction products are not chlorinated organics and no dissolved solids are added in the treatment step. Ozone in the presence of activated carbon, ultraviolet, and other promoters shows promise of reducing reaction time and improving ozone utilization, but the process at present is limited by high capital expense, possible chemical interference in the treatment of mixed wastes, and an energy requirement of 25 kwh/kg of ozone generated. Cyanide is not economically oxidized beyond the cyanate form.

Operational Factors. Reliability: Ozone oxidation is highly reliable with proper monitoring and control, and proper pretreatment to control interfering substances.

Maintainability: Maintenance consists of periodic removal of sludge, and periodic renewal of filters and desiccators required for the input of clean dry air; filter life is a function of input concentrations of detrimental constituents.

Solid Waste Aspects: Pretreatment to eliminate substances which will interfere with the process may be necessary. Dewatering of sludge generated in the ozone oxidation process or in an "in line" process may be desirable prior to disposal.

13. Cyanide Oxidation By Ozone With UV Radiation

One of the modifications of the ozonation process is the simultaneous application of ultraviolet light and ozone for the treatment of wastewater, including treatment of halogenated organics. The combined action of these two forms produces reactions by photolysis, photosensitization, hydroxylation, oxygenation and oxidation. The process is unique because several reactions and reaction species are active simultaneously.

Ozonation is facilitated by ultraviolet absorption because both the ozone and the reactant molecules are raised to a higher energy state so that they react more rapidly. In addition, free radicals for use in the reaction are readily hydrolyzed by the water present. The energy and reaction intermediates created by the introduction of both ultraviolet and ozone greatly reduce the amount of ozone required compared with a system using ozone alone. Figure VII-21 (page 287) shows a three-stage UV-ozone system. A system to treat mixed cyanides requires pretreatment that involves chemical coagulation, sedimentation, clarification, equalization, and pH adjustment.

Application and Performance. The ozone-UV radiation process was developed primarily for cyanide treatment in the electroplating and color photo-processing areas. It has been successfully applied to mixed cyanides and organics from organic chemicals manufacturing processes. The process is particularly useful for treatment of complexed cyanides such as ferricyanide, copper cyanide and nickel cyanide, which are resistant to ozone alone.

Ozone combined with UV radiation is a relatively new technology. Four units are currently in operation and all four treat cyanide bearing waste.

Ozone-UV treatment could be used in coil coating plants to destroy cyanide present in waste streams from some conversion coating operations.

1.4. Cyanide Oxidation By Hydrogen Peroxide

Hydrogen peroxide oxidation removes both cyanide and metals in cyanide containing wastewaters. In this process, cyanide bearing waters are heated to 49 - 54°C (120 - 130°F) and the pH is adjusted to 10.5 - 11.8 Formalin (37 percent formaldehyde) is added while the tank is vigorously agitated. After 2-5 minutes, a proprietary peroxygen compound (41 percent hydrogen peroxide with a catalyst and additives) is added. After an hour of mixing, the reaction is complete. The cyanide is converted to cyanate and the metals are precipitated as oxides or hydroxides. The metals are then removed from solution by either settling or filtration.

The main equipment required for this process is two holding tanks equipped with heaters and air spargers or mechanical stirrers. These tanks may be used in a batch or continuous fashion, with one tank being used for treatment while the other is being filled. A settling tank or a filter is needed to concentrate the precipitate.

Application and Performance. The hydrogen peroxide oxidation process is applicable to cyanidebearing wastewaters, especially those containing metal-cyanide complexes. In terms of waste reduction performance, this process can reduce total cyanide to less than 0.1 mg/l and the zinc or cadmium to less than 1.0 mg/l.

Advantages and Limitations. Chemical costs are similar to those for alkaline chlorination using chlorine and lower than those for treatment with hypochlorite. All free cyanide reacts and is completely oxidized to the less toxic cyanate state. In addition, the metals precipitate and settle quickly, and they may be recoverable in many instances. However, the process requires energy expenditures to heat the wastewater prior to treatment.

Demonstration Status. This treatment process was introduced in 1971 and is used in several facilities. No porcelain enameling plants use oxidation by hydrogen peroxide.

15. 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-22 (page 288) 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 porcelain enameling plants.

16. 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-23 (page 289) 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 and is readily available for the treatment of a wide variety of industrial waste streams.

17. 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-24 (page 290) 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: 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 industry to reduce water content to a level where the sludge may be efficiently handled. Further dewatering is usually practiced to minimize costs of hauling the sludge to approved landfill areas. Sludge thickening is used in seven coil coating plants.

18. Insoluble Starch Xanthate

Insoluble starch xanthate is essentially an ion exchange medium used to remove dissolved heavy metals from wastewater. The water may then either be reused (recovery application) or discharged (end-of-pipe application). In a commercial electroplating operation, starch xanthate is coated on a filter medium. Rinse water containing dragged out heavy metals is circulated through the filters and then reused for rinsing. The starch-heavy metal complex is disposed of and replaced periodically. Laboratory tests indicate that recovery of metals from the complex is feasible, with regeneration of the starch xanthate. Besides electroplating, starch xanthate is potentially applicable to coil coating, porcelain enameling, copper fabrication, and any other industrial plants where dilute metal wastewater streams are generated. Its present use is limited to one electroplating plant.

19. Ion Exchange

Ion exchange is a process in which ions, held by electrostatic forces to charged functional groups on the surface of the ion exchange resin, are exchanged for ions of similar charge from the solution in which the resin is immersed. This is classified as a sorption process because the exchange occurs on the surface of the resin, and the exchanging ion must undergo a phase transfer from solution phase to solid phase. Thus, ionic contaminants in a waste stream can be exchanged for the harmless ions of the resin.

Although the precise technique may vary slightly according to the application involved, a generalized process description follows. The wastewater stream being treated passes through a filter to remove any solids, then flows through a cation exchanger which contains the ion exchange resin. Here, metallic impurities such as copper, iron, and trivalent chromium are retained. The stream then passes through the anion exchanger and its associated resin. Hexavalent chromium, for example, is retained in this stage. If one pass does not reduce the contaminant levels sufficiently, the stream may then enter another series of exchangers. Many ion exchange systems are equipped with more than one set of exchangers for this reason.

The other major portion of the ion exchange process concerns the regeneration of the resin, which now holds those impurities retained from the waste stream. An ion exchange unit with in-place regeneration is shown in Figure VII-25 (page 291). Metal ions such as nickel are removed by an acid, cation exchange resin, which is regenerated with hydrochloric or sulfuric acid, replacing the metal ion with one or more hydrogen ions. Anions such as dichromate are removed by a basic, anion exchange resin, which is regenerated with sodium hydroxide, replacing the anion with one or more hydroxyl ions. The three principal methods employed by industry for regenerating the spent resin are:

A) Replacement Service: A regeneration service replaces the spent resin with regenerated resin, and regenerates the spent resin at its own facility. The service then has the problem of treating and disposing of the spent regenerant.

B) In-Place Regeneration: Some establishments may find it less expensive to do their own regeneration. The spent resin column is shut down for perhaps an hour, and the spent resin is regenerated. This results in one or more waste streams which must be treated in an appropriate manner. Regeneration is performed as the resins require it, usually every few months.

C) Cyclic Regeneration: In this process, the regeneration of the spent resins takes place within the ion exchange unit itself in alternating cycles with the ion removal process. A regeneration frequency of twice an hour is typical. This very short cycle time permits operation with a very small quantity of resin and with fairly concentrated solutions, resulting in a very compact system. Again, this process varies according to application, but the regeneration cycle generally begins with caustic being pumped through the anion exchanger, carrying out hexavalent chromium, for example, as sodium dichromate. The sodium dichromate stream then passes through a cation exchanger, converting the sodium dichromate to chromic acid. After concentration by evaporation or other means, the chromic acid can be returned to the process line. Meanwhile, the cation exchanger is regenerated with sulfuric acid, resulting in a waste acid stream containing the metallic impurities removed earlier. Flushing the exchangers with water completes the cycle. Thus, the wastewater is purified and, in this example, chromic acid is recovered. The ion exchangers, with newly regenerated resin, then enter the ion removal cycle again.

Application and Performance. The list of pollutants for which the ion exchange system has proven effective includes aluminum, arsenic, cadmium, chromium (hexavalent and trivalent), copper, cyanide, gold, iron, lead, manganese, nickel, selenium, silver, tin, zinc, and more. Thus, it can be applied to a wide variety of industrial concerns. Because of the heavy concentrations of metals in their wastewater, the metal finishing industries utilize ion exchange in several ways. As an end-of-pipe treatment, ion exchange is certainly feasible, but its greatest value is in recovery applications. It is commonly used as an integrated treatment to recover rinse water and process chemicals. Some electroplating facilities use ion exchange to concentrate and purify plating baths. Also, many industrial concerns use ion exchange to reduce salt concentrations in incoming water sources.

Ion exchange is highly efficient at recovering metal bearing solutions. Recovery of chromium, nickel, phosphate solution, and sulfuric acid from anodizing is commercial. A chromic acid recovery efficiency of 99.5 percent has been demonstrated. Typical data for purification of rinse water have been reported and are displayed in Table VII-24.

Table VII-24

Ion Exchange Performance

Parameter	Plant A		Plant B	
All Values mg/l	Prior To Purification	After Purification	Prior To Purification	After Purification
Al	5.6	0.20	-	-
Cd	5.7	0.00	-	-
Cr+3	3.1	0.01	-	-
Cr+6	7.1	0.01	-	-
Cu	4.5	0.09	43.0	0.10
CN	9.8	0.04	3.40	0.09
Au	-	-	2.30	0.10
Fe	7.4	0.01	-	-
Pb	-	-	1.70	0.01
Mn	4.4	0.00	-	-
Ni	6.2	0.00	1.60	0.01
Ag	1.5	0.00	9.10	0.01
SO4	-	-	210.00	2.00
Sn	1.7	0.00	1.10	0.10
Zn	14.8	0.40	-	-

Advantages and Limitations. Ion exchange is a versatile technology applicable to a great many situations. This flexibility, along with its compact nature and performance, makes ion exchange a very effective method of waste water treatment. However, the resins in these systems can prove to be a limiting factor. The thermal limits of the anion resins, generally in the vicinity of 60°C, could prevent its use in certain situations. Similarly, nitric acid, chromic acid, and hydrogen peroxide can all damage the resins, as will iron, manganese, and copper when present with sufficient concentrations of dissolved oxygen. Removal of a particular trace contaminant may be uneconomical because of the presence of other ionic species that are preferentially removed. The regeneration of the resins presents its own problems. The cost of the regenerative chemicals can be high. In addition, the waste streams originating from the regeneration process are extremely high in pollutant concentrations, although low in volume. These must be further processed for proper disposal.

Operational Factors. Reliability: With the exception of occasional clogging or fouling of the resins, ion exchange has proved to be a highly dependable technology.

Maintainability: Only the normal maintenance of pumps, valves, piping and other hardware used in the regeneration process is required.

Solid Waste Aspects: Few, if any, solids accumulate within the ion exchangers, and those which do appear are removed by the regeneration process. Proper prior treatment and planning can eliminate solid buildup problems altogether. The brine resulting from regeneration of the ion exchange resin most usually must be treated to remove metals before discharge. This can generate solid waste.

Demonstration Status. All of the applications mentioned in this document are available for commercial use, and industry sources estimate the number of units currently in the field at well over 120. The research and development in ion exchange is focusing on improving the quality and efficiency of the resins, rather than new applications. Work is also being done on a continuous regeneration process whereby the resins are contained on a fluid-transfusible belt. The belt passes through a compartmented tank with ion exchange, washing, and regeneration sections. The resins are therefore continually used and regenerated. No such system, however, has been reported beyond the pilot stage.

20. Membrane Filtration

Membrane filtration is a treatment system for removing precipitated metals from a wastewater stream. It must therefore be preceded by those treatment techniques which will properly prepare the wastewater for solids removal. Typically, a membrane filtration unit is preceded by pH adjustment or sulfide addition for precipitation of the metals. These steps are followed by the addition of a proprietary chemical reagent which causes the precipitate to be non-gelatinous, easily dewatered, and highly stable. The resulting mixture of pretreated wastewater and reagent is continuously recirculated through a filter module and back into a recirculation tank. The filter module contains tubular membranes. While the reagent-metal hydroxide precipitate mixture flows through the inside of the tubes, the water and any dissolved salts permeate the membrane. When the recirculating slurry reaches a concentration of 10 to 15 percent solids, it is pumped out of the system as sludge.

Application and Performance. Membrane filtration appears to be applicable to any wastewater or process water containing metal ions which can be precipitated using hydroxide, sulfide or carbonate precipitation. It could function as the primary treatment system, but also might find application as a polishing treatment (after precipitation and settling) to ensure continued compliance with metals limitations. Membrane filtration systems are being used in a number of industrial applications, particularly in the metal finishing area. They have also been used for heavy metals removal in the metal fabrication industry and the paper industry.

The permeate is claimed by one manufacturer to contain less than the effluent concentrations shown in the following table, regardless of the influent concentrations. These claims have been largely substantiated by the analysis of water samples at various plants in various industries.

In the performance predictions for this technology, pollutant concentrations are reduced to the levels shown below unless lower levels are present in the influent stream.

Table VII-25

MEMBRANE FILTRATION SYSTEM EFFLUENT

Specific	Manufacturers	Plant 19066		Plant 31022		Predicted
Metal	Guarantee	In	Out	In	Out	Performance
Al	0.5	---	---	---	---	
Cr, (+6)	0.02	0.46	0.01	5.25	<0.005	
Cr (T)	0.03	4.13	0.018	98.4	0.057	0.05
Cu	0.1	18.8	0.043	8.00	0.222	0.20
Fe	0.1	288	0.3	21.1	0.263	0.30
Pb	0.05	0.652	0.01	0.288	0.01	0.05
CN	0.02	<0.005	<0.005	<0.005	<0.005	0.02
Ni	0.1	9.56	0.017	194	0.352	0.40
Zn	0.1	2.09	0.046	5.00	0.051	0.10
TSS	---	632	0.1	13.0	8.0	1.0

Advantages and Limitations. A major advantage of the membrane filtration system is that installations can use most of the conventional end-of-pipe systems that may already be in place. Removal efficiencies are claimed to be excellent, even with sudden variation of pollutant input rates; however, the effectiveness of the membrane filtration system can be limited by clogging of the filters. Because pH changes in the waste stream greatly intensify clogging problems, the pH must be carefully monitored and controlled. Clogging can force the shutdown of the system and may interfere with production. In addition, relatively high capital cost of this system may limit its use.

Operational Factors. Reliability: Membrane filtration has been shown to be a very reliable system, provided that the pH is strictly controlled. Improper pH can result in the clogging of the membrane. Also, surges in the flow rate of the waste stream must be controlled in order to prevent solids from passing through the filter and into the effluent.

Maintainability: The membrane filters must be regularly monitored, and cleaned or replaced as necessary. Depending on the composition of the waste stream and its flow rate, frequent cleaning of the filters may be required. Flushing with hydrochloric acid for 6-24 hours will usually suffice. In addition, the routine maintenance of pumps, valves, and other plumbing is required.

Solid Waste Aspects: When the recirculating reagent-precipitate slurry reaches 10 to 15 percent solids, it is pumped out of the system. It can then be disposed of directly or it can undergo a dewatering process. Because this sludge contains toxic metals, it requires proper disposal.

Demonstration Status. There are more than 25 membrane filtration systems presently in use on metal finishing and similar wastewaters. Bench scale and pilot studies are being run in an attempt to expand the list of pollutants for which this system is known to be effective. Although there are no data on the use of membrane filtration in porcelain enameling plants, the concept has been successfully demonstrated using coil coating plant wastewater. A unit has been installed at one coil coating plant based on these tests.

21. Peat Adsorption

Peat moss is a complex natural organic material containing lignin and cellulose as major constituents. These constituents, particularly lignin, bear polar functional groups, such as alcohols, aldehydes, ketones, acids, phenolic hydroxides, and ethers, that can be involved in chemical bonding. Because of the polar nature of the material, its adsorption of dissolved solids such as transition metals and polar organic molecules is quite high. These properties have led to the use of peat as an agent for the purification of industrial wastewater.

Peat adsorption is a "polishing" process which can achieve very low effluent concentrations for several pollutants. If the concentrations of pollutants are above 10 mg/l, then peat adsorption must be preceded by pH adjustment for metals precipitation and subsequent clarification. Pretreatment is also required for chromium wastes using ferric chloride and sodium sulfide. The wastewater is then pumped into a large metal chamber called a kier which contains a layer of peat through which the waste stream passes. The water flows to a second kier for further adsorption. The wastewater is then ready for discharge. This system may be automated or manually operated.

Application and Performance. Peat adsorption can be used in coil coating for removal of residual dissolved metals from clarifier effluent. Peat moss may be used to treat wastewaters containing heavy metals such as mercury, cadmium, zinc, copper, iron, nickel, chromium, and lead, as well as organic matter such as oil, detergents, and dyes. Peat adsorption is currently used commercially at a textile plant, a newsprint facility, and a metal reclamation operation.

The following table contains performance figures obtained from pilot plant studies. Peat adsorption was preceded by pH adjustment for precipitation and by clarification.

Table VII-26

PEAT ADSORPTION PERFORMANCE

Pollutant (mg/l)	In	Out
Cr+6	35,000	0.04
Cu	250	0.24
CN	36.0	0.7
Pb	20.0	0.025
Hg	1.0	0.02
Ni	2.5	0.07
Ag	1.0	0.05
Sb	2.5	0.9
Zn	1.5	0.25

In addition, pilot plant studies have shown that chelated metal wastes, as well as the chelating agents themselves, are removed by contact with peat moss.

Advantages and Limitations. The major advantages of the system include its ability to yield low pollutant concentrations, its broad scope in terms of the pollutants eliminated, and its capacity to accept wide variations of waste water composition.

Limitations include the cost of purchasing, storing, and disposing of the peat moss; the necessity for regular replacement of the peat may lead to high operation and maintenance costs. Also, the pH adjustment must be altered according to the composition of the waste stream.

Operational Factors. Reliability: The question of long term reliability is not yet fully answered. Although the manufacturer reports it to be a highly reliable system, operating experience is needed to verify the claim.

Maintainability: The peat moss used in this process soon exhausts its capacity to adsorb pollutants. At that time, the kiers must be opened, the peat removed, and fresh peat placed inside. Although this procedure is easily and quickly accomplished, it must be done at regular intervals, or the system's efficiency drops drastically.

Solid Waste Aspects: After removal from the kier, the spent peat must be eliminated. If incineration is used, precautions should be taken to insure that those pollutants removed from the water are not released again in the combustion process. Presence of sulfides in the spent peat, for example, will give rise to sulfur dioxide in the fumes from burning. The presence of significant quantities of toxic heavy metals in coil coating manufacturing wastewater will in general preclude incineration of peat used in treating these wastes.

Demonstration Status. Only three facilities currently use commercial adsorption systems in the United States - a textile manufacturer, a newsprint facility, and a metal reclamation firm. No data have been reported showing the use of peat adsorption in porcelain enameling plants.

22. Reverse Osmosis

The process of osmosis involves the passage of a liquid through a semipermeable membrane from a dilute to a more concentrated solution. Reverse osmosis (RO) is an operation in which pressure is applied to the more concentrated solution, forcing the permeate to diffuse through the membrane and into the more dilute solution. This filtering action produces a concentrate and a permeate on opposite sides of the membrane. The concentrate can then be further treated or returned to the original operation for continued use, while the permeate water can be recycled for use as clean water. Figure VII-26 (page 292) depicts a reverse osmosis system.

As illustrated in Figure VII-27 (page 293), there are three basic configurations used in commercially available RO modules: tubular, spiral-wound, and hollow fiber. All of these operate on the principle described above, the major difference being their mechanical and structural design characteristics.

The tubular membrane module uses a porous tube with a cellulose acetate membrane-lining. A common tubular module consists of a length of 2.5 cm (1 inch) diameter tube wound on a supporting spool and encased in a plastic shroud. Feed water is driven into the tube under pressures varying from 40 - 55 atm (600-800 psi). The permeate passes through the walls of the tube and is collected in a manifold while the concentrate is drained off at the end of the tube. A less widely used tubular RO module uses a straight tube contained in a housing, under the same operating conditions.

Spiral-wound membranes consist of a porous backing sandwiched between two cellulose acetate membrane sheets and bonded along three edges. The fourth edge of the composite sheet is attached to a large permeate collector tube. A spacer screen is then placed on top of the membrane sandwich and the entire stack is rolled around the centrally located tubular permeate collector. The rolled up package is inserted into a pipe able to withstand the high operating pressures employed in this process, up to 55 atm (800 psi) with the spiral-wound module. When the system is operating, the pressurized product water permeates the membrane and flows through the backing material to the central collector tube. The concentrate is drained off at the end of the container pipe and can be reprocessed or sent to further treatment facilities.

The hollow fiber membrane configuration is made up of a bundle of polyamide fibers of approximately 0.0075 cm (0.003 in.) OD and 0.0043 cm (0.0017 in.) ID. A commonly used hollow fiber module contains several hundred thousand of the fibers placed in a long tube, wrapped around a flow screen, and rolled into a spiral. The fibers are bent in a U-shape and their ends are supported by an epoxy bond. The hollow fiber unit is operated under 27 atm (400 psi), the feed water being dispersed from the center of the module through a porous distributor tube. Permeate flows through the membrane to the hollow interiors of the fibers and is collected at the ends of the fibers.

The hollow fiber and spiral-wound modules have a distinct advantage over the tubular system in that they are able to load a very large membrane surface area into a relatively small volume. However, these two membrane types are much more susceptible to fouling than the tubular system, which has a larger flow channel.

This characteristic also makes the tubular membrane much easier to clean and regenerate than either the spiral-wound or hollow fiber modules. One manufacturer claims that their helical tubular module can be physically wiped clean by passing a soft porous polyurethane plug under pressure through the module.

Application and Performance. In a number of metal processing plants, the overflow from the first rinse in a countercurrent setup is directed to a reverse osmosis unit, where it is separated into two streams. The concentrated stream contains dragged out chemicals and is returned to the bath to replace the loss of solution due to evaporation and dragout. The dilute stream (the permeate) is routed to the last rinse tank to provide water for the rinsing operation. The rinse flows from the last tank to the first tank and the cycle is complete.

The closed-loop system described above may be supplemented by the addition of a vacuum evaporator after the RO unit in order to further reduce the volume of reverse osmosis concentrate. The evaporated vapor can be condensed and returned to the last rinse tank or sent on for further treatment.

The largest application has been for the recovery of nickel solutions. It has been shown that RO can generally be applied to most acid metal baths with a high degree of performance, providing that the membrane unit is not overtaxed. The limitations most critical here are the allowable pH range and maximum operating pressure for each particular configuration. Adequate prefiltration is also essential. Only three membrane types are readily available in commercial RO units, and their overwhelming use has been for the recovery of various acid metal baths. For the purpose of calculating performance predictions of this technology, a rejection ratio of 98 percent is assumed for dissolved salts, with 95 percent permeate recovery.

Advantages and Limitations. The major advantage of reverse osmosis for handling process effluents is its ability to concentrate dilute solutions for recovery of salts and chemicals with low power requirements. No latent heat of vaporization or fusion is required for effecting separations; the main energy requirement is for a high pressure pump. It requires relatively little floor space for compact, high capacity units, and it exhibits good recovery and rejection rates for a number of typical process solutions. A limitation of the reverse osmosis process for treatment of process effluents is its limited temperature range for satisfactory operation. For cellulose acetate systems, the preferred limits are 18° to 30°C (65° to 85°F); higher temperatures will increase the rate of membrane hydrolysis and reduce system life, while lower temperatures will result in decreased fluxes with no damage to the membrane. Another limitation is inability to handle certain solutions. Strong oxidizing agents, strongly acidic or basic solutions, solvents, and other organic compounds can cause dissolution of the membrane. Poor rejection of some compounds such as borates and low molecular weight organics is another problem. Fouling of membranes by slightly soluble components in solution or colloids has caused failures, and fouling of membranes by feed waters with high levels of suspended solids can be a problem. A final limitation is inability to treat or achieve high concentration with some solutions. Some concentrated solutions may have initial osmotic pressures which are so high that they either exceed available operating pressures or are uneconomical to treat.

Operational Factors. Reliability: Very good reliability is achieved so long as the proper precautions are taken to minimize the chances of fouling or degrading the membrane. Sufficient testing of the waste stream prior to application of an RO system will provide the information needed to insure a successful application.

Maintainability: Membrane life is estimated to range from six months to three years, depending on the use of the system. Down time for flushing or cleaning is on the order of 2 hours as often as once each week; a substantial portion of maintenance time must be spent on cleaning any prefilters installed ahead of the reverse osmosis unit.

Solid Waste Aspects: In a closed loop system utilizing RO there is a constant recycle of concentrate and a minimal amount of solid waste. Prefiltration eliminates many solids before they reach the module and helps keep the buildup to a minimum. These solids require proper disposal.

Demonstration Status. There are presently at least one hundred reverse osmosis waste water applications in a variety of industries. In addition to these, there are thirty to forty units being used to provide pure process water for several industries. Despite the many types and configurations of membranes, only the spiral-wound cellulose acetate membrane has had widespread success in commercial applications.

23. 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-28 (page 294) 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 climatic 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 provision for runoff control and leachate monitoring.

Demonstration Status. Sludge beds have been in common use in both municipal and industrial facilities for many years. However, protection of ground water from contamination is not always adequate.

24. 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-29 (page 295) represents the ultrafiltration process.

Application and Performance. Ultrafiltration has potential application to porcelain enameling plants for separation of oils and residual solids from a variety of waste streams. In treating porcelain enameling wastewater its greatest applicability would be as a polishing treatment to remove residual precipitated metals after chemical precipitation and clarification. Successful commercial use, however, has been primarily for separation of emulsified oils from wastewater. 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-27

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 and suspended solids 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 treatment of process effluents is its narrow temperature range (18° to 30°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: Ultrafiltration is used primarily to recover solids and liquids. It therefore eliminates solid waste problems when the solids (e.g., paint solids) can be recycled to the process. Otherwise, the stream containing solids must be treated by end-of-pipe equipment. In the most probable applications within the porcelain enameling category, the ultrafilter would remove hydroxides or sulfides of metals which have recovery value.

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.

25. 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-30 (page 296).

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 for the porcelain enameling industrial segment is to reduce or eliminate the waste load requiring end-of-pipe treatment and thereby improve the quality of the effluent discharge. In-plant technology involves water reuse, process materials conservation, reclamation of waste enamel, process modifications, material substitutions, improved rinse techniques and good housekeeping practices. The sections which follow detail each of these in-plant technologies describing the applicability and overall effect of each in the porcelain enameling category.

Water Reuse

There are several plants in the porcelain enameling data base that demonstrated the potential for water reuse in this category. For example, water which is employed for non-contact cooling or air conditioning can be reused for rinses in the base metal preparation line and as washdown water in the ball milling area. Plant 11045 utilized water from their air conditioning system as washdown for improperly coated parts and spray coating equipment. Plant 40053 utilized a recirculation of rinse water from the acid pickling rinses to the alkaline cleaner rinses. The facility also used cooling water from air compressors as make-up water for the acid pickle rinses. Plant personnel reported an overall water savings of 22 percent per year using these water reuse schemes. Reuse of acid rinse water in alkaline rinses has been demonstrated at many electroplating plants.

Another method for reusing rinse water is a closed loop deionized rinse water system. Some plants, in order to remove any traces of process solution from the surfaces of the workpieces prior to enameling, rinse their workpieces in a deionized water final rinse. This water can be recirculated through an ion exchange unit to remove the impurities picked up in rinsing. The purified water is then returned to the rinse tank for further process work. This type of rinse is most commonly seen in the porcelain enameling on aluminum subcategory where the basis material is relatively clean.

Process Materials Conservation Filtration of Nickel Baths - During the nickel deposition process, a chemical reaction takes place in which ions come out of the solution and displace iron ions going into solution. It is good practice from a process standpoint to filter the nickel bath to prevent the iron from building up to a contaminating level. Several types of filters are available for this purpose. Filter types can include: filter leaf, filter bag, flat bed filter, and string wound "cartridge" type filters. Many of these filters can incorporate diatomaceous earth as a filtering aid by spraying it on the filter substrate. Utilization of a filter extends the life of the process solution. This is advantageous from a waste treatment point of view since the bath will have to be dumped less often, in some cases bath life can be increased as much as six months to one year. This means a smaller pollutant load on the waste treatment system that is directly attributable to the nickel deposition process. A similar filtration scheme can be utilized on neutralizer baths.

Dry Spray Booths - Plants which utilize spray coating as their means of enamel application must contain the overspray. Most companies employ wet spray booths which use a curtain of water to trap oversprayed enamel particles. Also available are dry spray booths which use filter screens to remove the enamel particles from the air that is forced through the booth. These dry booths eliminate the entry of oversprayed enamel into a wastewater stream. Plant 40053 which porcelain enamels both steel and cast iron used dry spray booths for applying enamel to both basis materials. Enamel overspray was allowed to dry on the floor and was simply swept up at the end of the day. Plants 06031 and 13330 also use dry spray booths for the ground and cover coat application on copper parts. After the overspray drys, it is collected and reused.

Reclamation of Waste Enamel

Enamel slip which is oversprayed does not undergo chemical or physical changes. This material can therefore be reused under certain conditions. The frit which is recovered cannot include a mixture of colors since it would be impossible to separate the colors. Therefore, only a plant which consistently uses a particular color can efficiently recover its frit. Plants 15712, 44031, and 33076, recover enamel from their spray booths and associated settling sumps. The recovered enamel is then used in the ground coat enamel mixtures (approximately 50 percent of the mixture). Many other plants recover waste enamel for eventual reclamation by suppliers. Plant 06031, which porcelain enamels on copper, also recovers waste enamel. Waste dry powder enamel is mixed in a ratio of 7:10 with new frit in the formulation of new ground coat enamel. Plant 13330 currently has a working enamel reclamation system for both ground and cover coat enamels. The facility incorporates several dry spray booths to segregate the application of ground and different colors of cover coat enamel. Oversprayed enamel is allowed to dry on the walls and floor area of the spray booths then scraped and swept up for reuse. This reclamation system has allowed this facility to significantly reduce water use in the ball milling and enamel application areas. Experimental work is being done with reusing multi-color waste enamel for ground coats in the porcelain enameling on steel subcategory. However, colors of enamel vary tremendously within this subcategory making it difficult to produce a consistent ground coat color from waste enamel.

Process Modifications

Process modifications can reduce the amount of water required for rinsing or even eliminate waste load sources. Significant water savings can also be realized by proper scheduling of slip preparation runs. If facilities do not have enough ball mills to have one for each color, employing a pattern of milling light to dark colored enamels can preclude washing the mills between each color change. This will significantly increase the time between required ball mill cleanings. As another example, one plant has reported finding a new basis material preparation process called NPNN (No-Pickle, No-Nickel). This basis material preparation process consists of seven steps: 1. solvent clean 2. detergent clean 3. cold rinse 4. acid clean (50 percent phosphoric acid) 5. acid clean (30 percent cleaner, 70 percent phosphoric acid) 6. cold rinse 7. neutralizer (soda ash & borox). After this treatment, enamel is applied in a normal fashion. Plant ID 13330 realized significant water use reductions through spray application of basis material preparation chemicals instead of the typical bath system. Basis material preparation operations still include alkaline cleaning, acid etch, nickel flash and neutralization. This facility also adds a hydrogen peroxide solution to the sulfuric acid etch solution to control the ferric ion concentration. Plant personnel report that the addition of hydrogen peroxide both significantly extends the life of the etch solution and results in a thirty-three percent increase in etching capacity per amount of chemical used.

Another process line modification is the replacement of a wet process with a dry one. For example, dry surface blasting can sometimes be employed in place of chemical cleaning with its attendant water use. This can only be employed with certain types of steel since the highly abrasive blasting may damage light gauge steel. Another water saving process modification involves the method of enamel application. Electrostatic spray coating achieves the same results as normal spray coating, but at a much higher coverage efficiency. Consequently, electrostatic spray coating has much less overspray to be caught in a water curtain, so it generates only part of the waste load of normal spray coating. Work is also being done using electrostatic dry powder application; a system which generates no waste water for coating or ball milling.

Electrostatic dry powder application operates on the same principle as electrostatic wet spraying operations with the enamel particles and workpiece having opposite electrical charges. Currently electrostatic dry powder porcelain applications require only one coat of enamel which is fired at a much lower temperature than conventional porcelain enamels. Traditional preparation operations followed by electrostatic dry powder application are currently being used at two porcelain enameling facilities (ID#'s 12038,21060). Pilot operations are functional at three other porcelain enameling facilities (ID's 33617, 47034, 33054). A basis material preparation option associated with dry powder coating is electrophoretic application of a thin coating of zinc to prevent oxidation and produce a tightened bond with the porcelain enamel. This system is currently used by several porcelain enamelers in Europe. A supplier of enamels has developed another basis metal preparation option which incorporates an acid cleaning step followed by the electrostatic application of a preparation compound followed by electrostatic dry powder porcelain application. Suppliers of the various dry powder systems claim they not only save significant amounts of water, but also use of these systems can result in up to a 50 percent savings in energy use.

A number of plants within the data base have omitted the nickel deposition step. Deletion of this step, however, can require changes in slip formulations and firing temperatures.

Changes in production schedule can also lighten the load on a waste treatment system either directly or indirectly. Scheduling a succession of the same color coatings can increase the time between required ball mill washings. In addition, raw basis material or parts to be porcelain enameled which are kept in storage for any length of time can develop corrosion. This corrosion and the presence of dried fabricating lubricants often necessitates the use of an extra system. Another consideration is the timing of batch dumps. If an alkaline bath can be dumped safely with an acid bath, it reduces the consumption of treatment chemicals relative to separate dumps. Holding tanks can be installed to facilitate this concurrent dumping of acid and alkaline baths to the waste treatment system.

Material Substitutions

The substitution of non-toxic or easily treatable materials for toxic materials is another method of easing the load on and increasing the effectiveness of an end-of-pipe treatment system. The replacement of sulfuric acid with hydrochloric acid in the pickling process is a possible material substitution. It has been shown, however, that hydrochloric acid etchant can take 2 to 3 times longer than sulfuric acid. Although sulfuric acid is cheaper to purchase, hydrochloric acid is easier to regenerate. It has been shown however, that acid regeneration done on a small scale is not economically feasible. Care should also be used in the selection of alkaline cleaners. Cleaners should be specifically tailored to the basis material being cleaned and the nature of the soils and oils to be removed. Avoiding cleaners with high concentrations of complexing agents or caustics can preclude subsequent solids precipitation problems in waste treatment. A few facilities report using alkaline cleaners specifically tailored to remove a drawing compound which was purchased from the same supplier as the alkaline cleaner.

The potential for reuse of treated wastewater in coating operations were examined. Only product formulation and ball mill wash out require for high quality water. Both of these water uses have direct contact with the product and impurities could possible affect product quality. Ball mill cooling uses only the thermal capacity of water to absorb heat and is not affected by other treated wastewater characteristics. Water used for overspray control need only be met and the various washdown and flume or sewer flushing functions require only hydraulic flow. Hence the quality of treated wastewater from other porcelain enameling operations appears to be totally adequate for all coating operations except possibly product formulation and ball mall washout.

Rinse Techniques

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

Rinsing is essentially a dilution step which reduces the concentration of contaminants on the workpiece. The design of rinse systems for minimum water use depends on the maximum level of contamination allowed to remain on the workpiece (without reducing acceptable product quality or causing poisoning of a subsequent bath) as well as on the efficiency or effectiveness of each rinse stage.

A rinse system is considered efficient if the dissolved solids concentration is reduced just to the point where no noticeable effects occur either as a quality problem or as excessive drag-in to the next process step. Operation of a rinse tank or tanks which achieve a 10,000 to 1 reduction in concentrations where only a 1,000 to 1 reduction is required represents inefficient use of water. Operating rinse tanks at or near their maximum acceptable level of contamination provides the most efficient and economical form of rinsing. Inefficient operation manifests itself in higher operating costs not only from the purchase cost of water, but also from the treatment of it.

Since the purpose of rinsing is to remove process solution from the surface of the workpiece, the best way to reduce the amount of rinsing required is to reduce the dragout. A reduction in dragout results in a reduction of waste that has to be treated. Dragout is a function of several factors including workpiece geometry, viscosity and surface tension of the process solution, withdrawal and drainage time and racking. These factors affecting dragout are described below.

1. Geometry of the Part - This partly determines the amount of dragout contributed by a part and is one of the principal determinants for the type of rinsing arrangement selected. A flat sheet with holes is well suited for an impact spray rinse rather than an immersion rinse, but for parts with cups or recesses a spray rinse is totally ineffective.

2. Kinematic Viscosity of the Process Solution - Kinematic viscosity is an important factor in determining process bath dragout. The effect of increasing kinematic viscosity is that it increases the dragout volume in the withdrawal phase and decreases the rate of draining during the drainage phase. It is advantageous to decrease the dragout and increase the drainage rate. Consequently, the process solution kinematic viscosity should be as low as possible. Increasing the temperature of the solution decreases its viscosity, thereby reducing the volume of process solution going to the rinse tank. Care must be exercised in increasing bath temperature since the rate of bath decomposition may increase significantly with temperature increases.

3. Surface Tension of the Process Solution - Surface tension is a major factor that controls the removal of dragout during the drainage phase. To remove a liquid film from a solid surface, the gravitation force must overcome the adhesive force between the liquid and the surface. The amount of work required to remove the film is a function of the surface tension of the liquid and the contact angle. Lowering the surface tension reduces the amount of work required to remove the liquid and reduces the edge effect (the bead of liquid adhering to the edges of the part). A secondary benefit of lowering the surface tension is to increase the metal uniformity. Surafce tension may be reduced by increasing the temperature of the process solution or more effectively, by use of a wetting agent.

4. Time of Withdrawal and Drainage - The withdrawal velocity of a part from a solution had an effect

similar to that of kinematic viscosity. Increasing the velocity or decreasing the time of withdrawal increases the volume of solution that is retained by the part. Since time is directly related to production rate, it is more advantageous to reduce the dragout volume initially adhering to the part rather than attempt to drain a large volume from the part.

5. Racking - Proper racking of parts is the most effective way to reduce dragout. Parts should be arranged so that no cup-like recesses are formed, the longest dimension should be horizontal, the major surface vertical, and each part should drain freely without dripping onto another part. The racks themselves should be periodically inspected to insure the integrity of the rack coating. Loose coatings can contribute significantly to dragout. Physical or geometrical design of racks is of primary concern for the control of dragout both from the racks and the parts themselves. Dragout from the rack can be minimized by designing it to drain freely such that no pockets of process solution can be retained.

The different types of rinsing commonly used within the metal finishing industry are described below.

1. Single Running Rinse - This arrangement requires a large volume of water to effect a large degree of contaminant removal. Although in widespread use, single running rinse tanks should be modified or replaced by a more effective rinsing arrangement to reduce water use.

2. Countercurrent Rinse - The countercurrent rinse provides for the most efficient water usage and thus, where possible, the countercurrent rinse should be used. There is only one fresh water feed for the entire set of tanks, and it is introduced in the last tank of the arrangement. The overflow from each tank becomes the feed for the tank preceding it. Thus, the concentration of dissolved salts decreases rapidly from the first to the last tank.

   In a situation requiring a 1,000 to 1 concentration reduction, the addition of a second rinse tank (with a countercurrent flow arrangement) will reduce the theoretical water demand by 97 percent.

3. Series Rinse - The major advantage of the series rinse over the countercurrent system is that the tanks of the series can be individually heated or level controlled since each has a separate feed. Each tank reaches its own equilibrium condition; the first rinse having the lowest concentration. This system uses water more efficiently than the single running rinse, and the concentration of dissolved salts decreases in each successive tank.

4. Spray Rinse - Spray rinsing is considered the most efficient of the various rinse techniques in continuous dilution rinsing. The main concern encountered in use of this mode is the efficiency of the spray (i.e., the volume of water contacting the part and removing contamination compared to the volume of water discharged). Spray rinsing is well suited for flat sheets. The impact of the spray also provides an effective mechanism for removing dragout from recesses with a large width to depth ratio.

5. Dead, Still, or Reclaim Rinses - This form of rinsing is particularly applicable for initial rinsing after metal plating because the dead rinse allows for easier recovery of the metal and lower water usage. The rinsing should then be continued in a countercurrent or spray arrangement.

The use of different rinse types will result in wide variations in water use. Table VII-28 shows the theoretical flow requirements for several different rinse types to maintain a 1,000 to 1 reduction in concentration.

TABLE VII-28

THEORETICAL RINSE WATER FLOWS REQUIRED TO MAINTAIN A 1,000 TO 1 CONCENTRATION REDUCTION

Type of Rinse	Single	Series		Countercurrent	
Number of Rinses	1	2	3	2	3
Required Flow (gpm)	10	0.61	0.27	0.31	0.1

Another method of conserving water through efficient rinsing is by controlling the flow of the feed water entering the rinse tanks. Some flow control methods are listed below.

1. Conductivity Controllers - Conductivity controllers provide for efficient use and good control of the rinse process. This controller utilizes a conductivity cell to measure the conductance of the solution which, for an electrolyte, is dependent upon the ionic concentration. The conductivity cell, immersed in the rinse tank or overflow line, is connected to a controller which will open or close a solenoid on the makeup line.

   As the rinse becomes more contaminated, its conductance increases until the set point of the controller is reached, causing the solenoid to open and allowing makeup to enter. Makeup flow will continue until the conductance drops below the set point. The advantage of this method of control is that water is flowing only when required. A major manufacturer of conductivity controllers supplied to plants in the Metal Finishing Category claims that water usage can be reduced by as much as 50-85 percent when the controllers are used.

2. Liquid Level Controllers - These controllers find their greatest use on closed loop rinsing systems. A typical arrangement uses a liquid level sensor in both the rinse tank and the process tank, and a solenoid on the rinse tank makeup water line. When the process solution evaporates to below the level of the level controller, the pump is activated, and solution is transferred from the rinse tank to the process tank. The pump will remain active until the process tank level controller is satisfied. As the liquid level of the rinse tank drops due to the pumpout, the rinse tank controller will open the solenoid allowing makeup water to enter.

3. Manually Operated Valves - Manually operated valves are susceptible to misuse and should, therefore, be installed in conjunction only with other devices. Orifices should be installed in addition to the valve to limit the flow rate of rinse water. For rinse stations that require manual movement of work and require manual control of the rinse (possibly due to low use), dead man valves should be installed in addition to the orifice to limit the flow rate of rinse water. They should be located so as to discourage jamming them open.

4. Orifices or Flow Restrictors - These devices are usually installed for rinse tanks that have a constant production rate. the newer restrictors can maintain a

constant flow even if the water supply pressure fluctuates. Orifices are not as efficient as conductivity or liquid level controllers, but are far superior to manual valves.

Good Housekeeping

Good housekeeping and proper maintenance of coating equipment are required to reduce wastewater loads to the treatment systems. The ball milling and enamel application areas need constant attention to maintain cleanliness and to avoid the waste of clean-up water. Hoses should be shut off when not in use (it was noticed that at several visited plants they were left running constantly). It is also recommended that pressure nozzles be installed on the hoses to increase cleaning effectiveness and reduce water use.

Periodic inspection of the basis material preparation tank liner and the tanks themselves reduces the chance of a catastrophic failure which could overload the waste discharge. Periodic inspection should also be performed on all auxiliary porcelain enameling equipment. This includes lead inspections of pumps, filters, process piping, and immersion steam heating coils. Neutralizer and nickel filter cleaning should be done in curbed areas or in a manner such that solution retained by the filter is dumped to the appropriate waste stream.

Good housekeeping is also applicable to chemical storage areas. Storage areas should be isolated from high hazard fire areas and arranged so that if a fire or explosion occurs in such areas, loss of the stored chemicals due to deluged quantities of water would not overwhelm the treatment facilities or cause excessive ground water pollution. Good housekeeping practices also include the use of drain boards between processing tanks. Bridging the gap between adjacent tanks via drain boards allows for recovery of dragout that drips off the parts while they are being transferred from one tank to another. The board should be mounted in a fashion that drains the dragout back into the tank from which it originated.

TABLE VII-22
TREATABILITY RATING OF PRIORITY POLLUTANTS UTILIZING CARBON ADSORPTION

Priority Pollutant	*Removal Rating
1. acenaphthene	H
2. acrolein	L
3. acrylonitrile	L
4. benzene	M
5. benzidine	H
6. carbon tetrachloride (tetrachloromethane)	M
7. chlorobenzene	H
8. 1,2,3-trichlorobenzene	H
9. hexachlorobenzene	H
10. 1,2-dichloroethane	M
11. 1,1,1-trichloroethane	M
12. hexachloroethane	H
13. 1,1-dichloroethane	M
14. 1,1,2-trichloroethane	M
15. 1,1,2,2-tetrachlorethane	H
16. chloroethane	L
17. bis(chloromethyl) ether	-
18. bis(2-chloroethyl) ether	M
19. 2-chloroethylvinyl ether (mixed)	L
20. 2-chloronaphthalene	H
21. 2,4,6-trichlorophenol	H
22. parachlorometa cresol	H
23. chloroform (trichloromethane)	L
24. 2-chlorophenol	H
25. 1,2-dichlorobenzene	H
26. 1,3-dichlorobenzene	H
27. 1,4-dichlorobenzene	H
28. 3,3'-dichlorobenzidine	H
29. 1,1-dichloroethylene	L
30. 1,2-trans-dichloroethylene	L
31. 2,4-dichlorophenol	H
32. 1,2-dichloropropane	M
33. 1,2-dichloropropylene (1,3-dichloropropene)	M
34. 2,4-dimethylphenol	H
35. 2,4-dinitrotoluene	H
36. 2,6-dinitrotoluene	H
37. 1,2-diphenylhydrazine	H
38. ethylbenzene	M
39. fluoranthene	H
40. 4-chlorophenyl phenyl ether	H
41. 4-bromophenyl phenyl ether	H
42. bis(2-chloroisopropyl)ether	M
43. bis(2-chloroethoxy)methane	M
44. methylene chloride (dichloromethane)	L
45. methyl chloride (chloromethane)	L
46. methyl bromide (bromomethane)	L
47. bromoform (tribromomethane)	H
48. dichlorobromomethane	M
49. trichlorofluoromethane	M
50. dichlorodifluoromethane	L
51. chlorodibromomethane	M
52. hexachlorobutadiene	H
53. hexachlorocyclopentadiene	H
54. isophorone	H
55. naphthalene	H
56. nitrobenzene	H
57. 2-nitrophenol	H
58. 4-nitrophenol	H
59. 2,4-dinitrophenol	H
60. 4,6-dinitro-o-cresol	H
61. N-nitrosodimethylamine	M
62. N-nitrosodiphenylamine	H
63. N-nitrosodi-n-propylamine	M
64. pentachlorophenol	H
65. phenol	M
66. bis(2-ethylhexyl)phthalate	H
67. butyl benzyl phthalate	H
68. di-n-butyl phthalate	H
69. di-n-octyl phthalate	H
70. diethyl phthalate	H
71. dimethyl phthalate	H
72. 1,2-benzanthracene (benzo(a)anthracene)	H
73. benzo(a)pyrene (3,4-benzopyrene)	H
74. 3,4-benzofluoranthene (benzo(b)fluoranthene)	H
75. 11,12-benzofluoranthene (benzo(k)fluoranthene)	H
76. chrysene	H
77. acenaphthylene	H
78. anthracene	H
79. 1,12-benzoperylene (benzo (ghi)-perylene)	H
80. fluorene	H
81. phenanthrene	H
82. 1,2,3,6-dibenzanthracene (dibenzo(a,h) anthracene)	H
83. indeno (1,2,3-cd) pyrene (2,3-o-phenylene pyrene)	H
84. pyrene	-
85. tetrachloroethylene	M
86. toluene	M
87. trichloroethylene	L
88. vinyl chloride (chloroethylene)	L
106. PCB-1242 (Aroclor 1242)	H
107. PCB-1254 (Aroclor 1254)	H
108. PCB-1221 (Aroclor 1221)	H
109. PCB-1332 (Aroclor 1232)	H
110. PCB-1248 (Aroclor 1248)	H
111. PCB-1260 (Aroclor 1260)	H
112. PCB-1016 (Aroclor 1016)	H

*Note Explanation of Removal Ratings

Category H (high removal)

adsorbs at levels ≥ 100 mg/g carbon at $C_f = 10$ mg/l

adsorbs at levels ≥ 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 ≤ 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 - 23

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, resorcenol and polyphenyls
Chorinated Phenolics	trichlorophenol, pentachlorophenol
*High Molecular Weight Aliphatic and Branch Chain hydrocarbons	gasoline, kerosine
Chlorinated Aliphatic hydrocarbons	carbon tetrachloride, perchloroethylene
*High Molecular Weight Aliphatic Acids and Aromatic Acids	tar acids, benzoic acid
*High Molecular Weight Aliphatic Amines and Aromatic Amines	aniline, toluene diamine
*High Molecular Weight Ketones, Esters, Ethers and Alcohols	hydroquinone, polyethylene glycol
Surfactants	alkyl benzene sulfonates
Soluble Organic Dyes	methylene blue, indigo carmine

---

* High Molecular Weight includes compounds in the broad range of from 4 to 20 carbon atoms

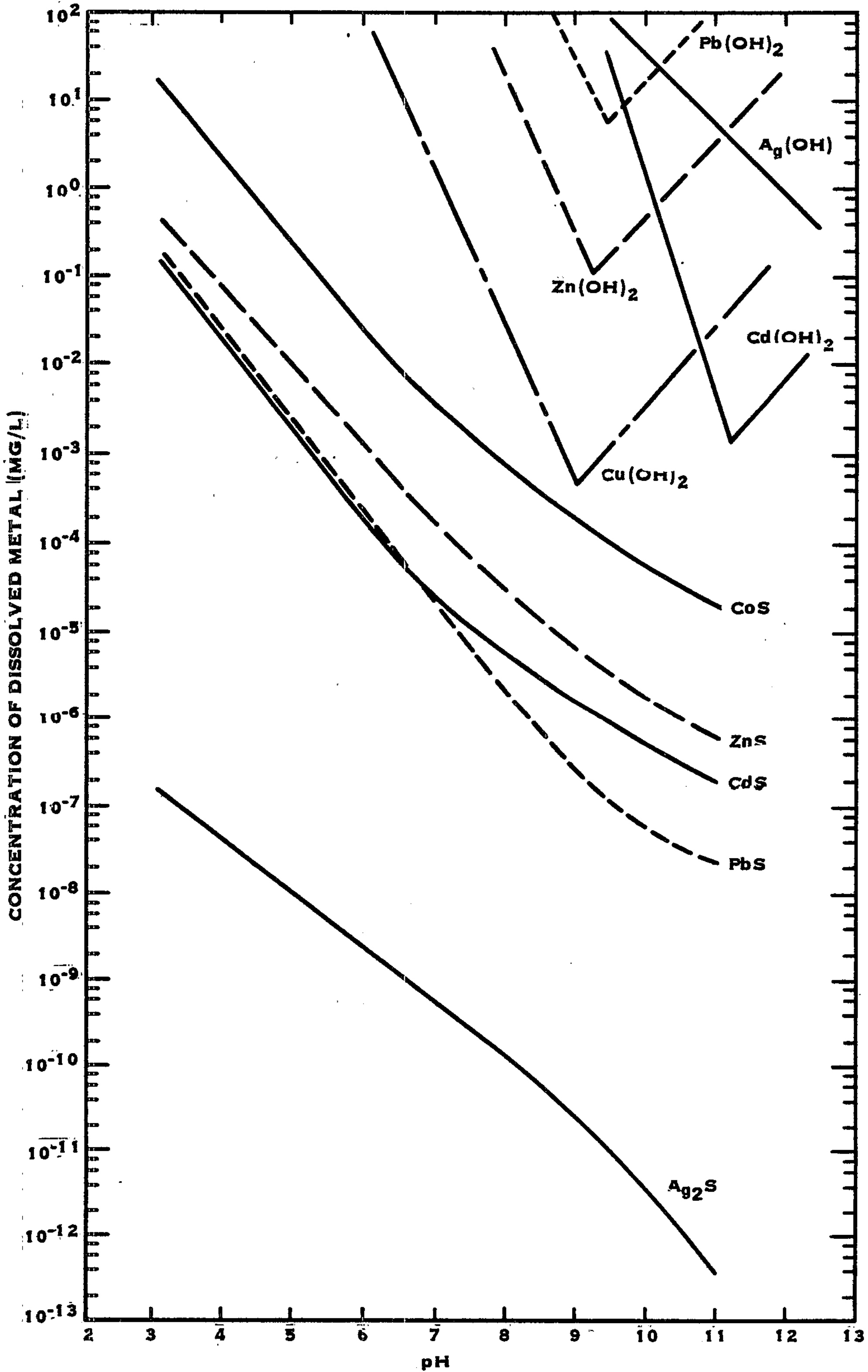


FIGURE VII-1. COMPARATIVE SOLUBILITIES OF METAL HYDROXIDES AND SULFIDE AS A FUNCTION OF pH

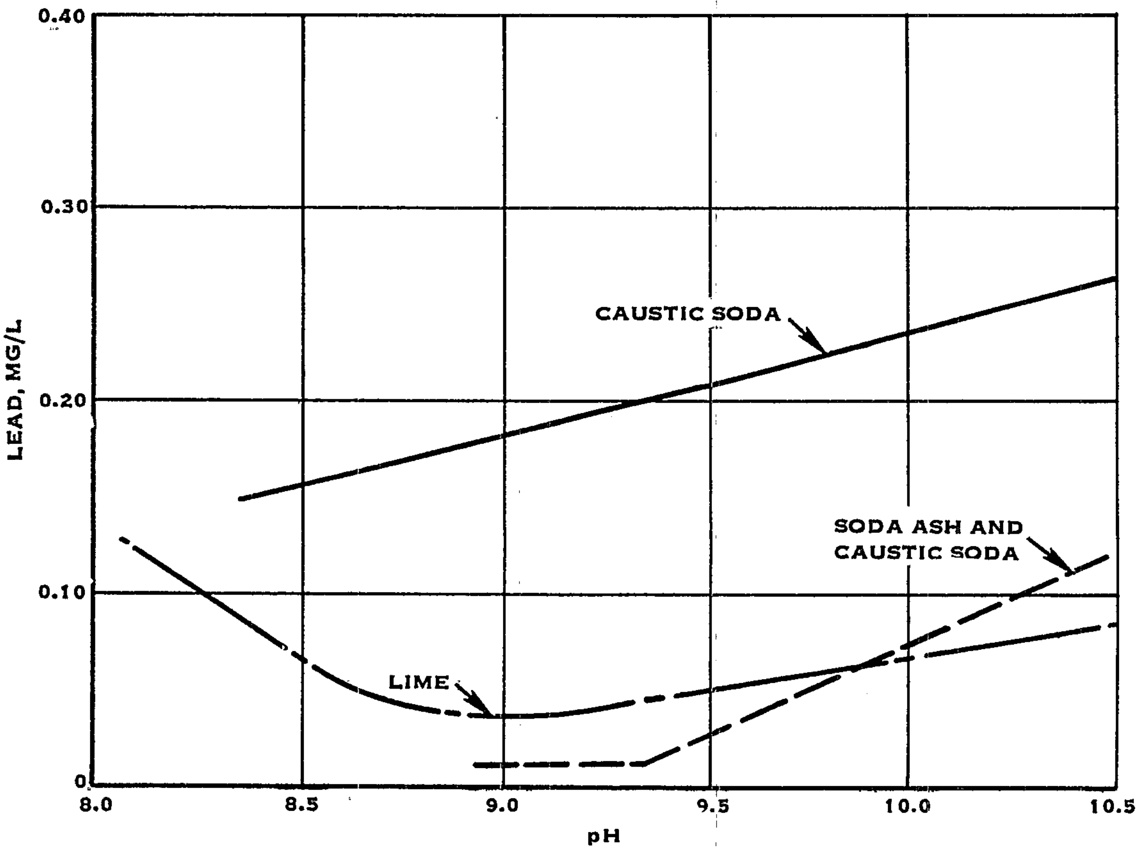


FIGURE VII-2. LEAD SOLUBILITY IN THREE ALKALIES

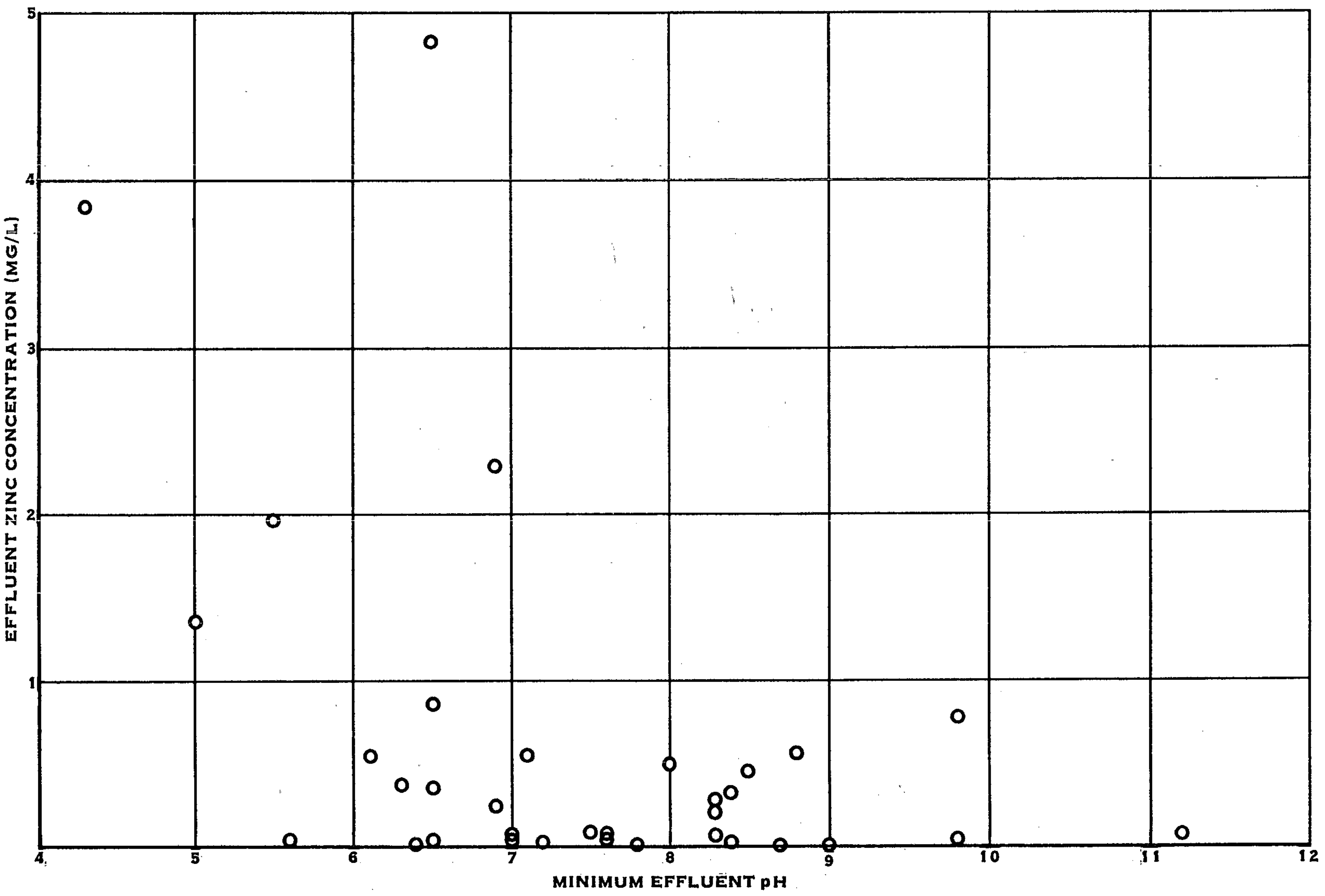


FIGURE VII-3. EFFLUENT ZINC CONCENTRATION VS. MINIMUM EFFLUENT pH

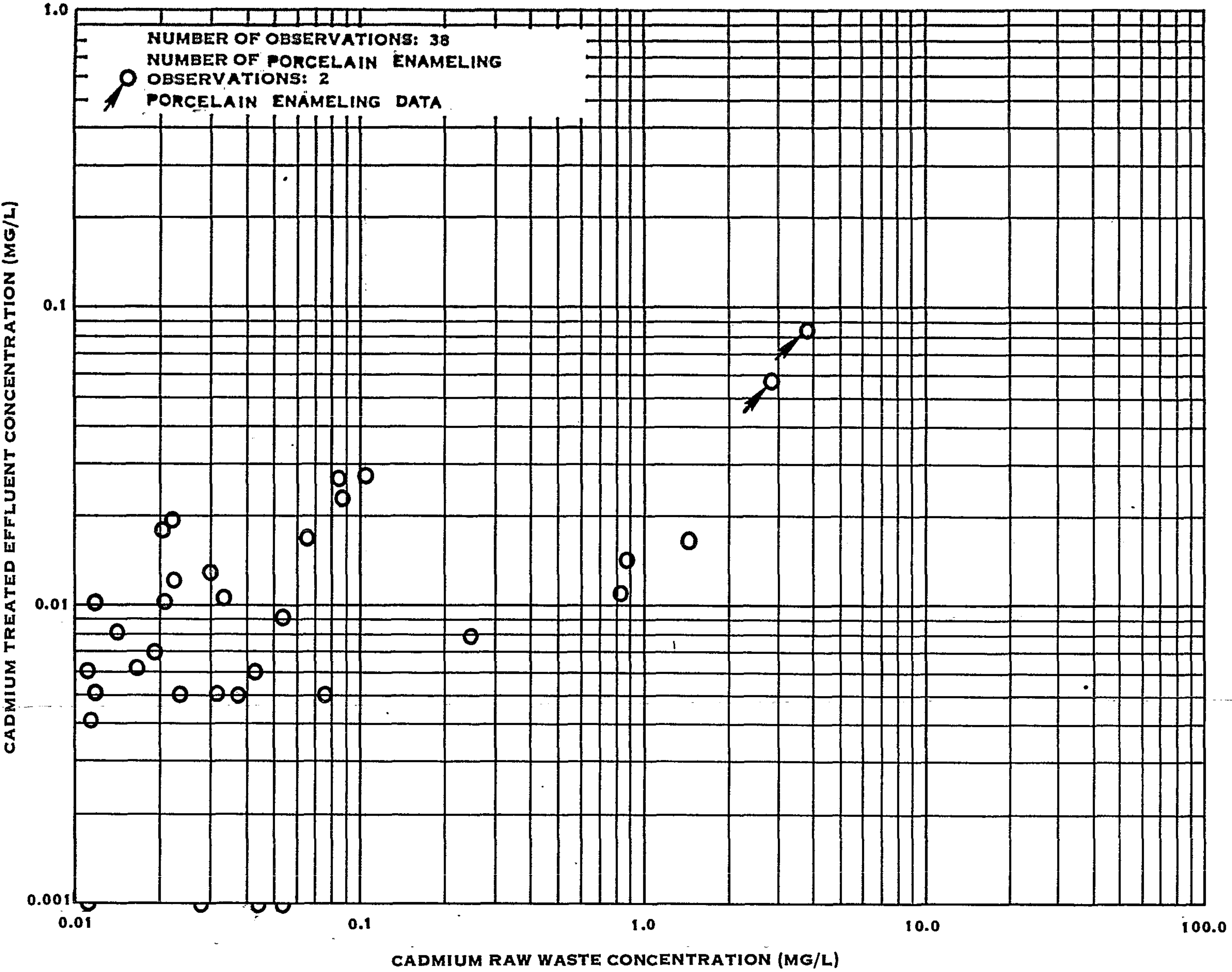


FIGURE VII-4. **HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - CADMIUM**

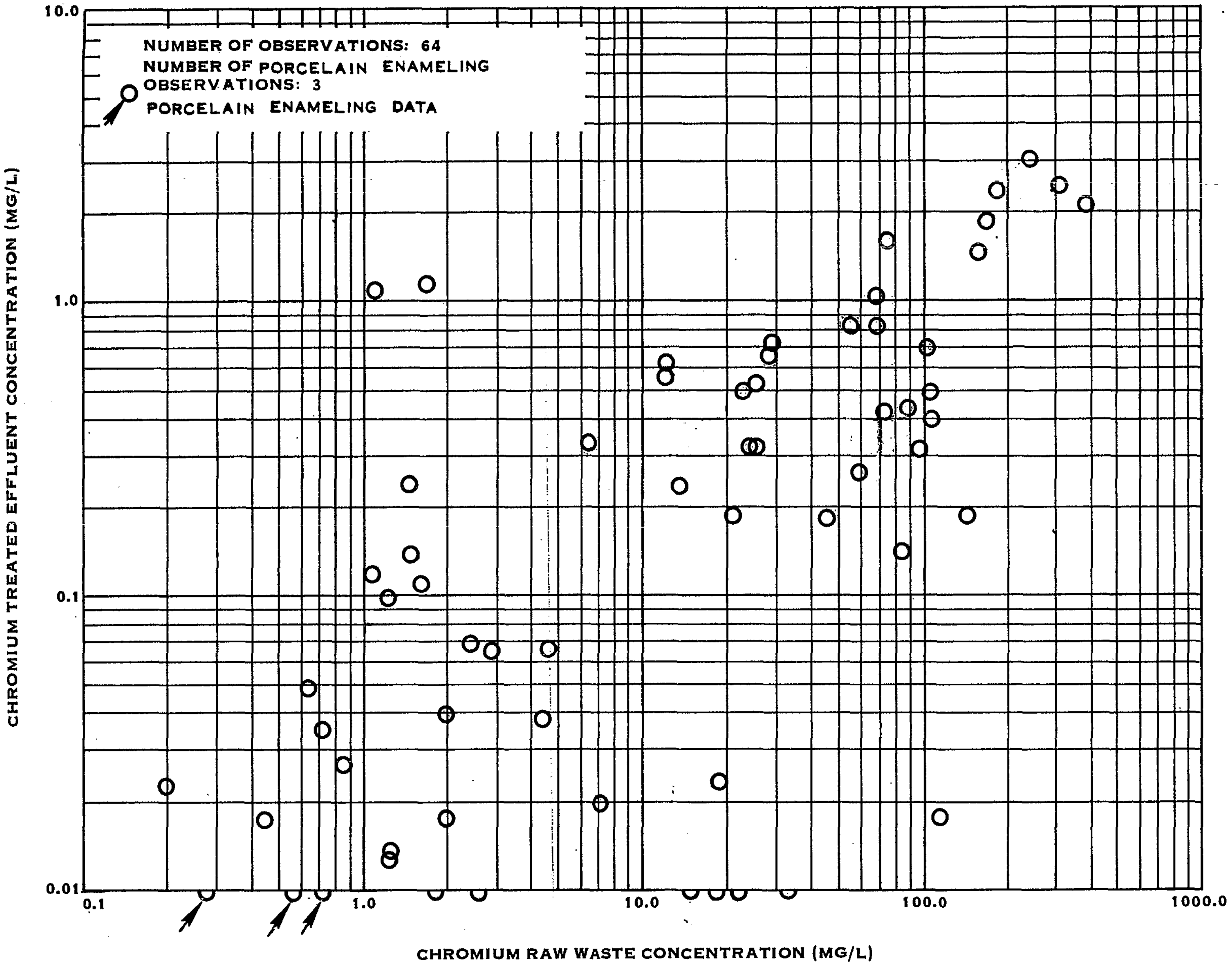


FIGURE VII-5. **HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - CHROMIUM**

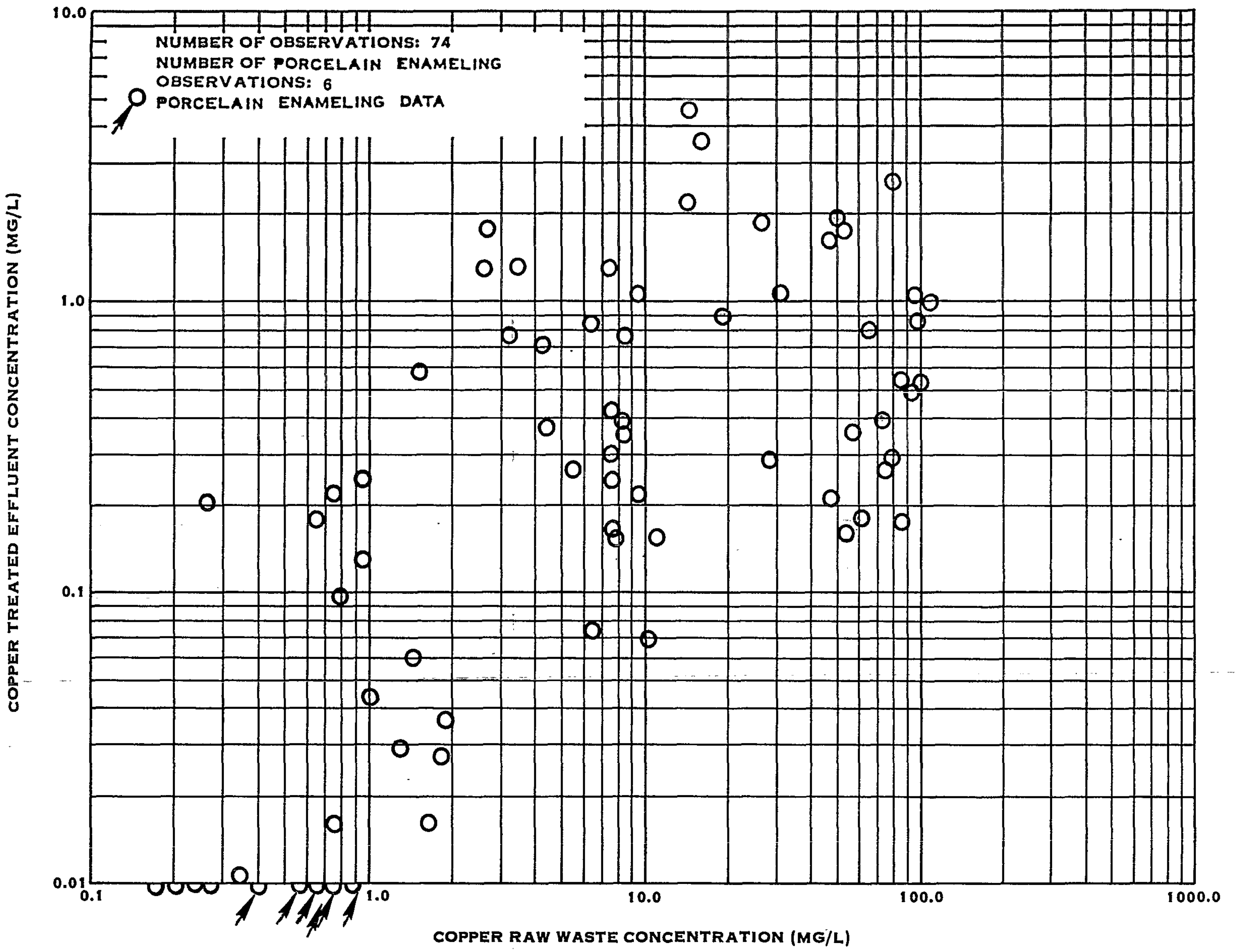


FIGURE VII-6. **HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - COPPER**

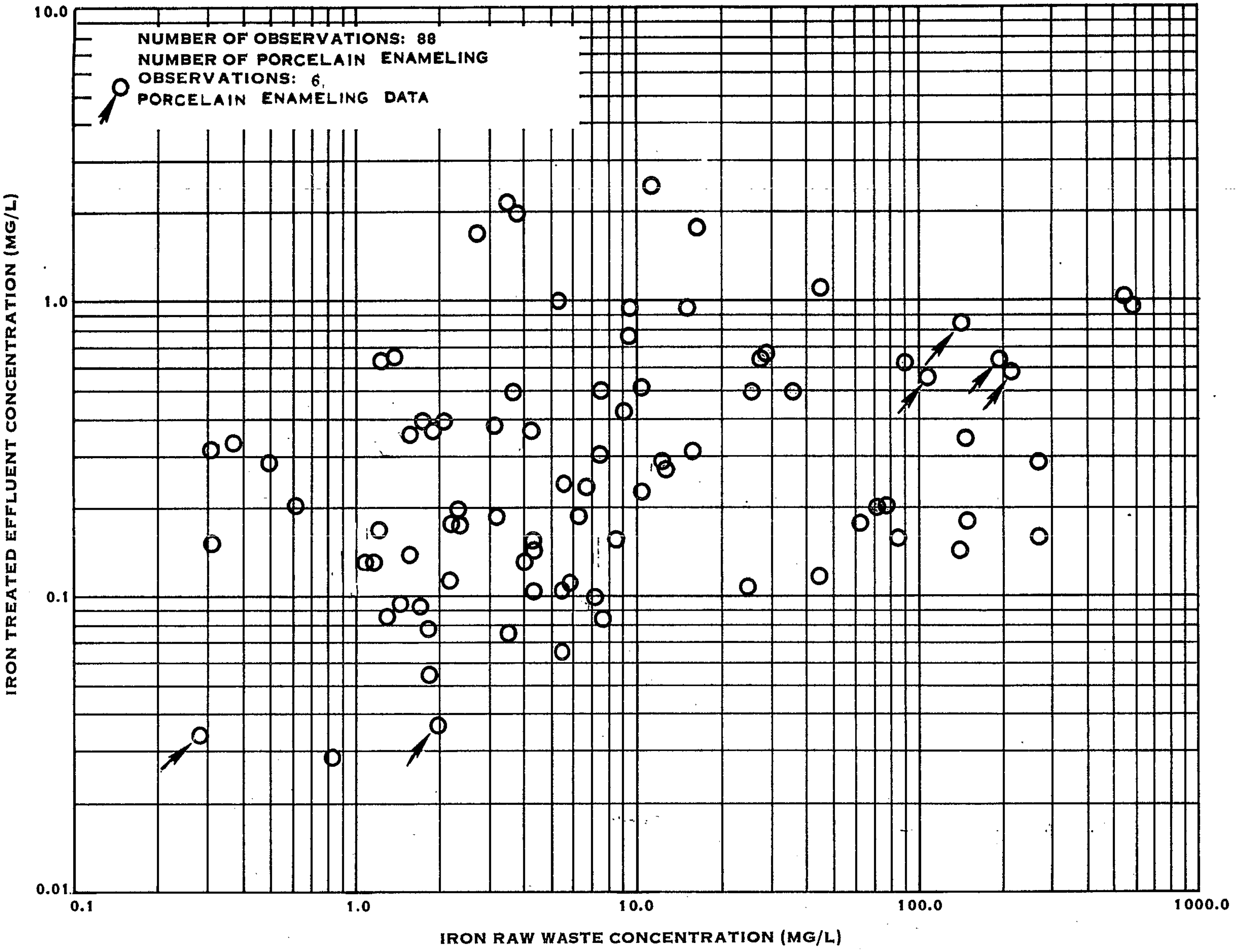


FIGURE VII-7. HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - IRON

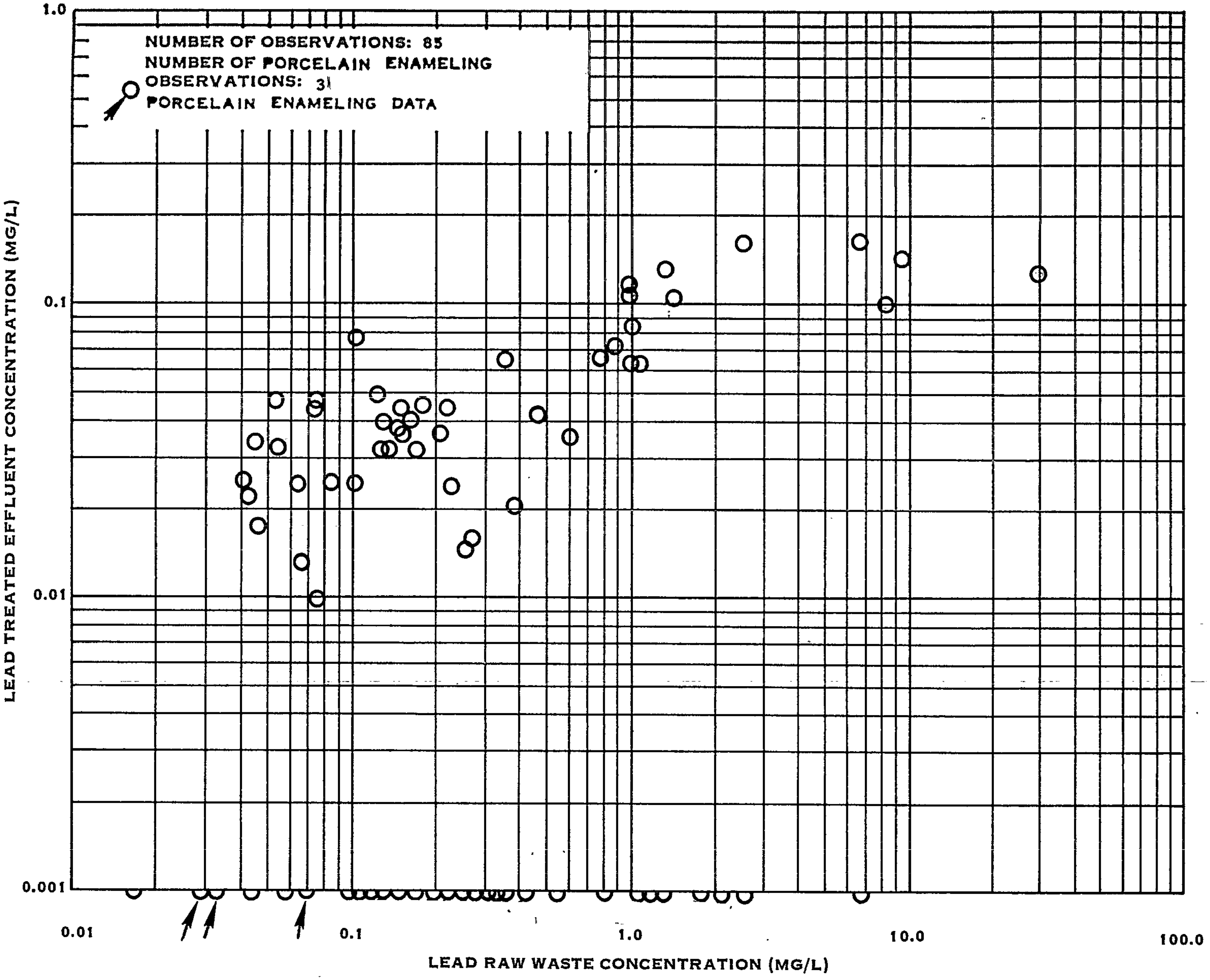


FIGURE VII-8. **HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - LEAD**

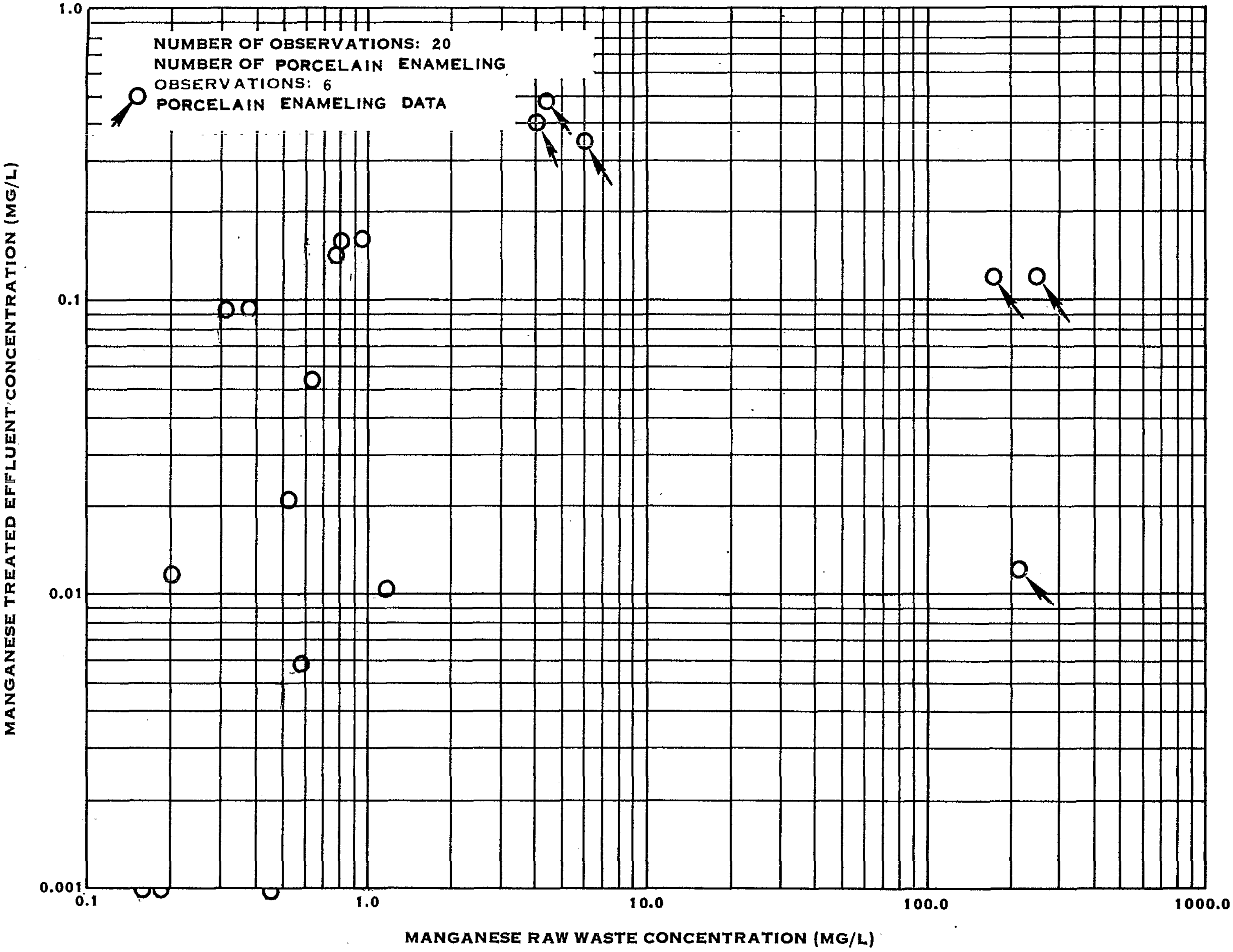


FIGURE VII-9. HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - MANGANESE

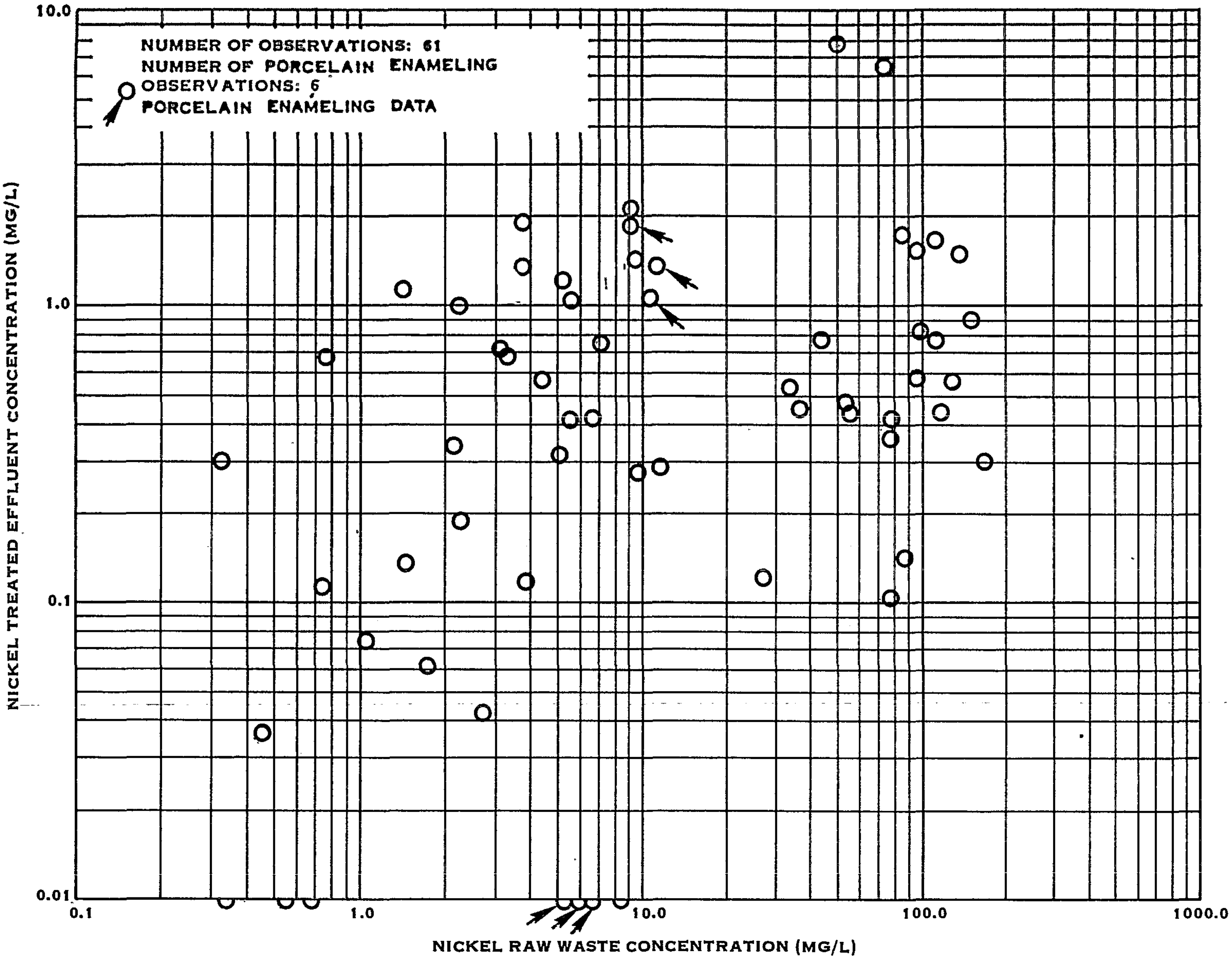


FIGURE VII-10. **HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - NICKEL**

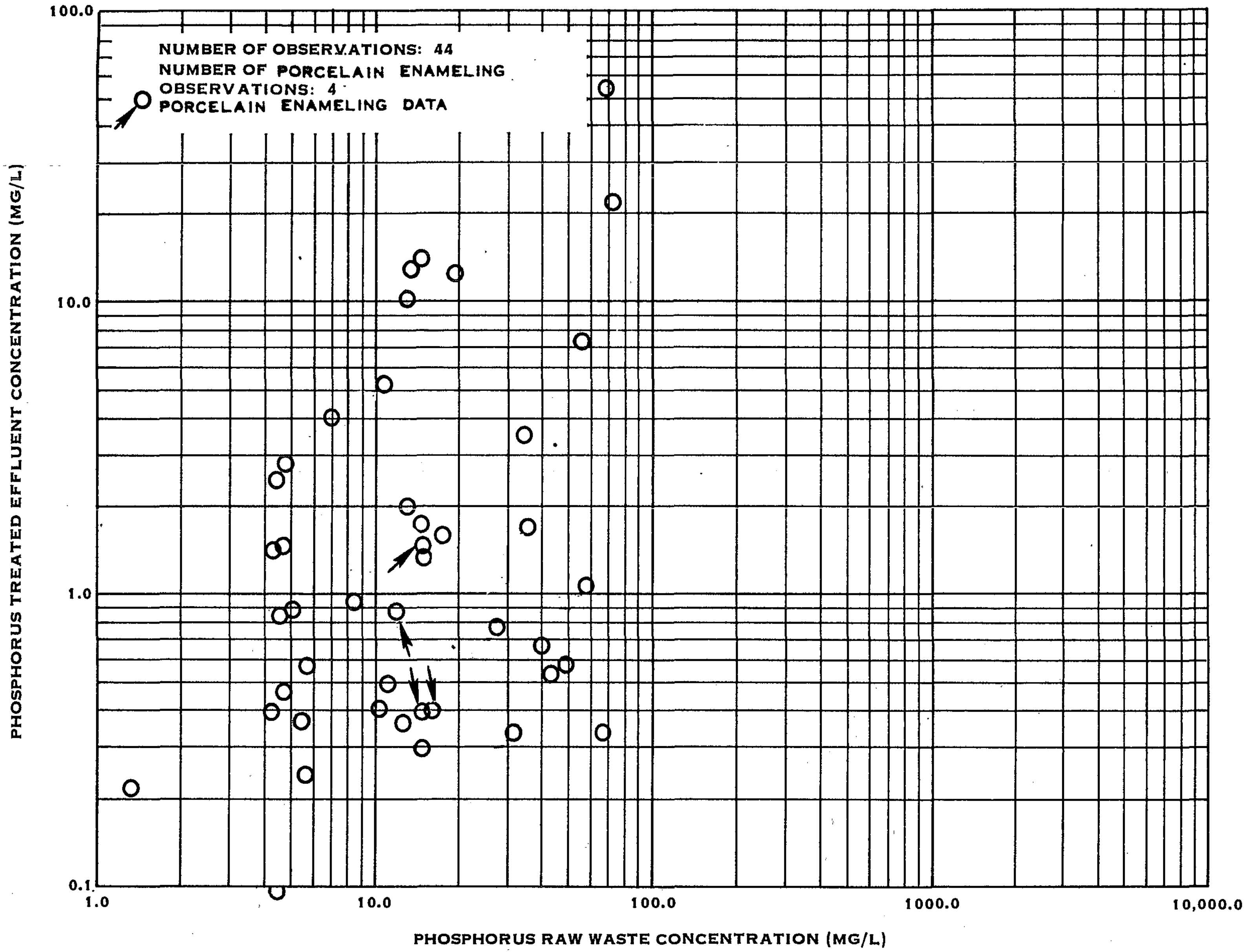


FIGURE VII-11. HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - PHOSPHORUS

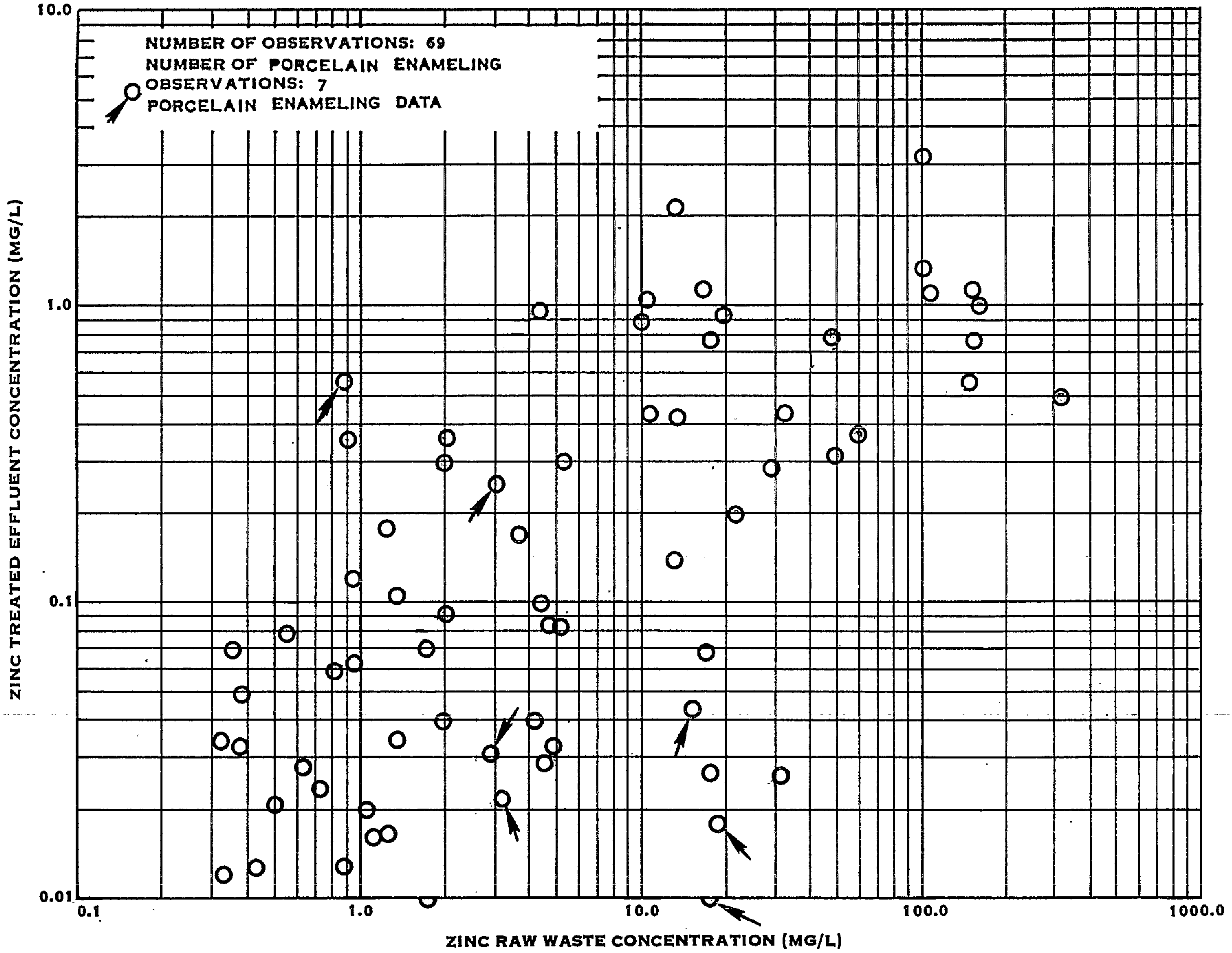


FIGURE VII-12. HYDROXIDE PRECIPITATION & SEDIMENTATION EFFECTIVENESS - ZINC

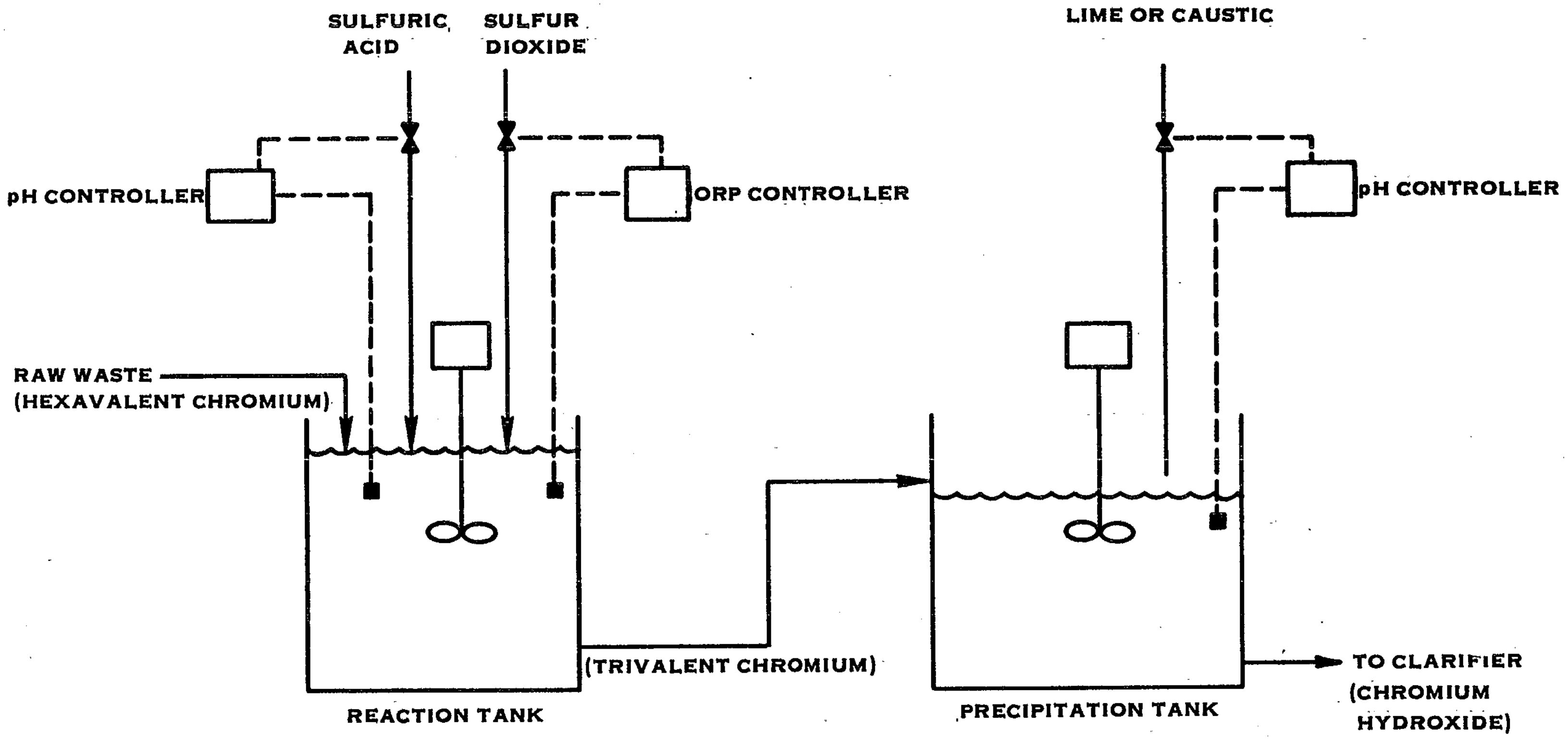


FIGURE VII-13. HEXAVALENT CHROMIUM REDUCTION WITH SULFUR DIOXIDE

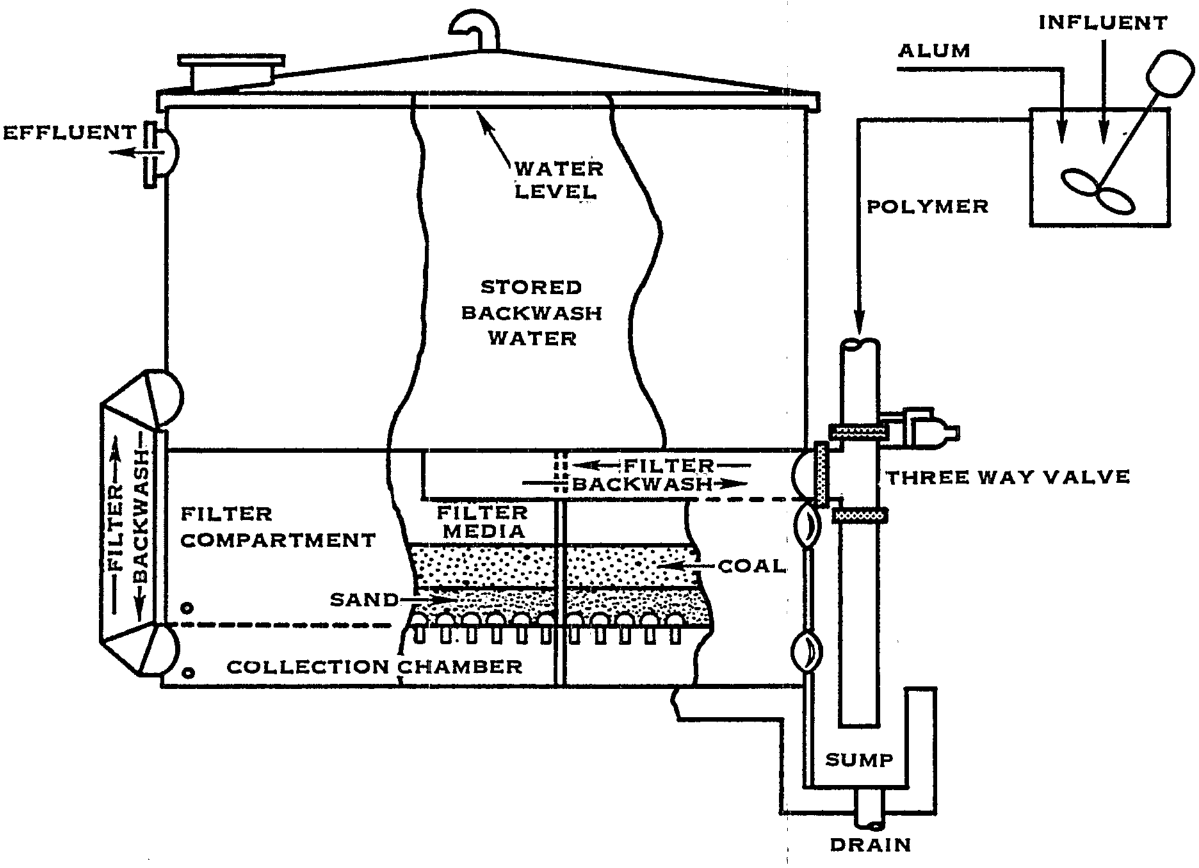


FIGURE VII-14. GRANULAR BED FILTRATION

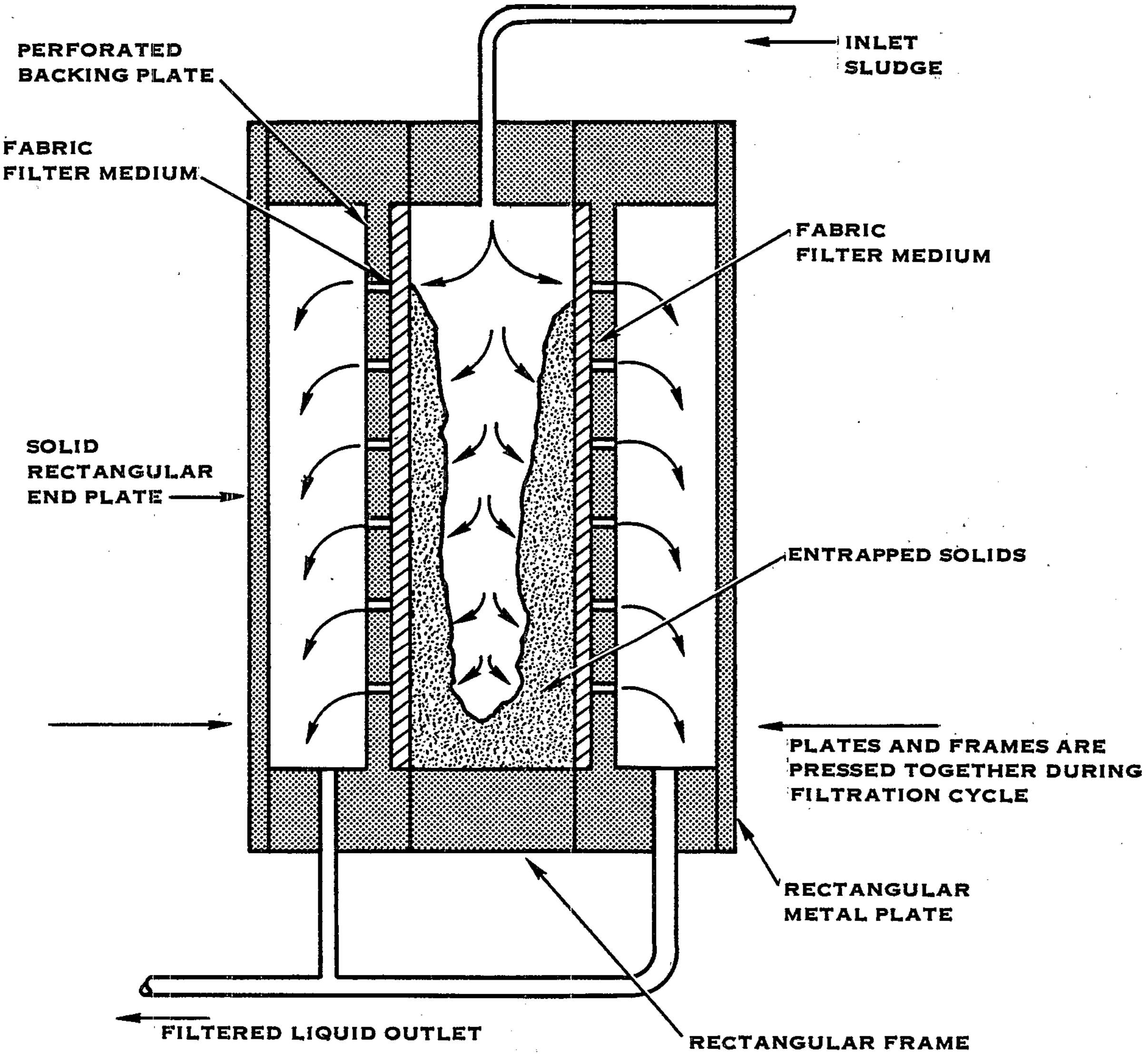
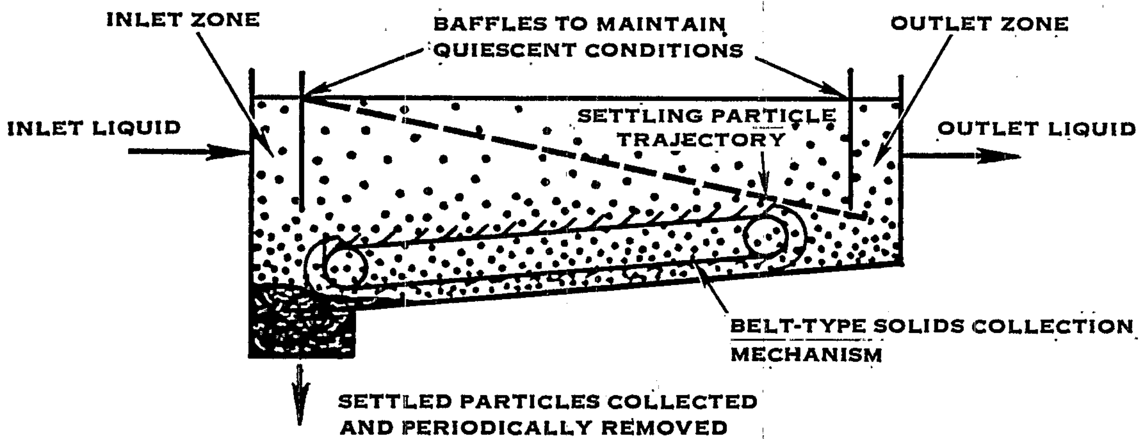


FIGURE VII-15. PRESSURE FILTRATION

SEDIMENTATION BASIN



CIRCULAR CLARIFIER

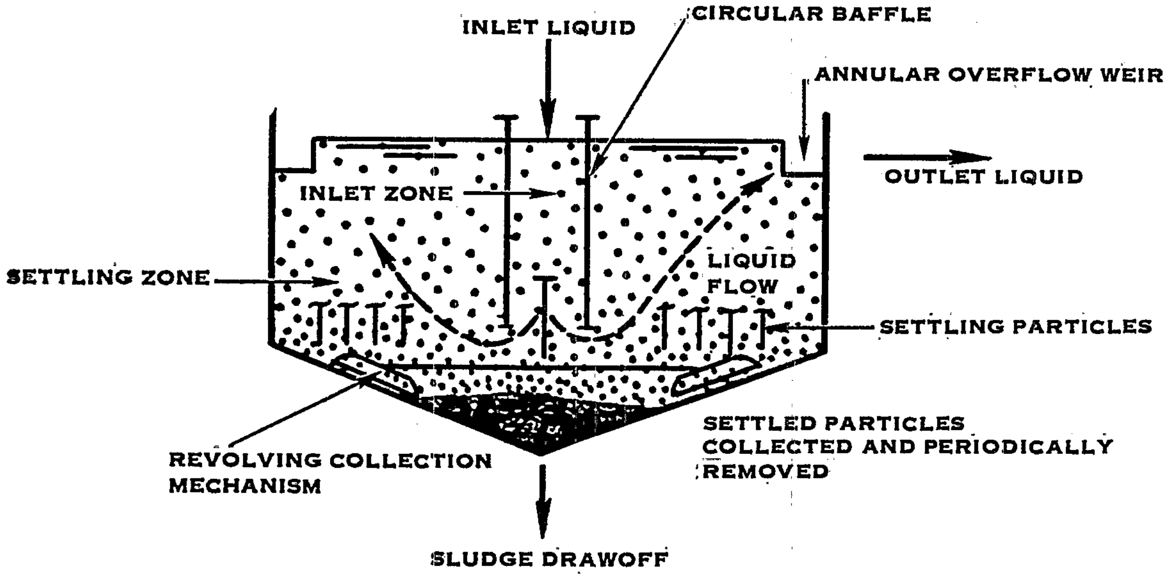


FIGURE VII-16. REPRESENTATIVE TYPES OF SEDIMENTATION

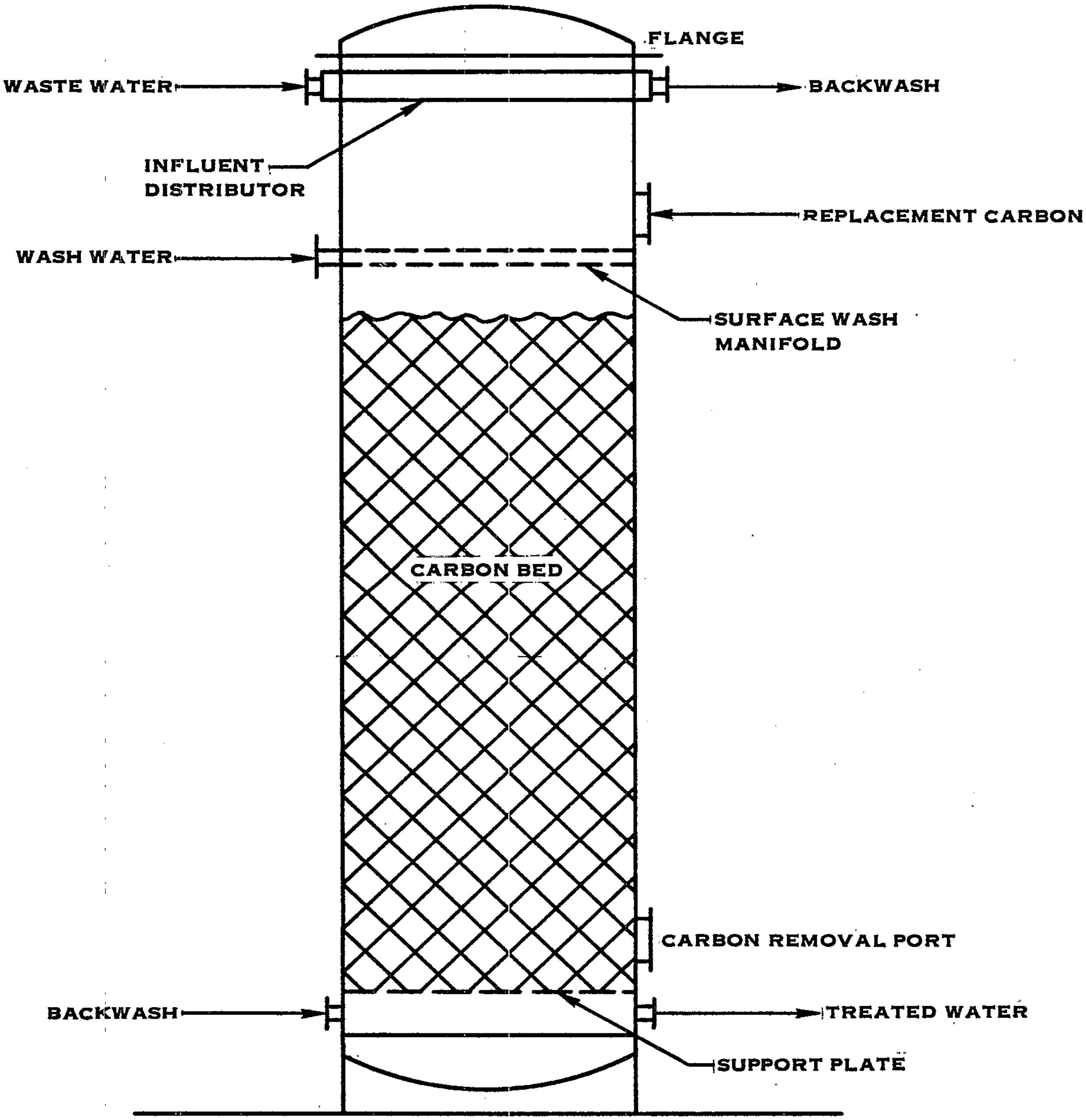


FIGURE VII-17. ACTIVATED CARBON ADSORPTION COLUMN

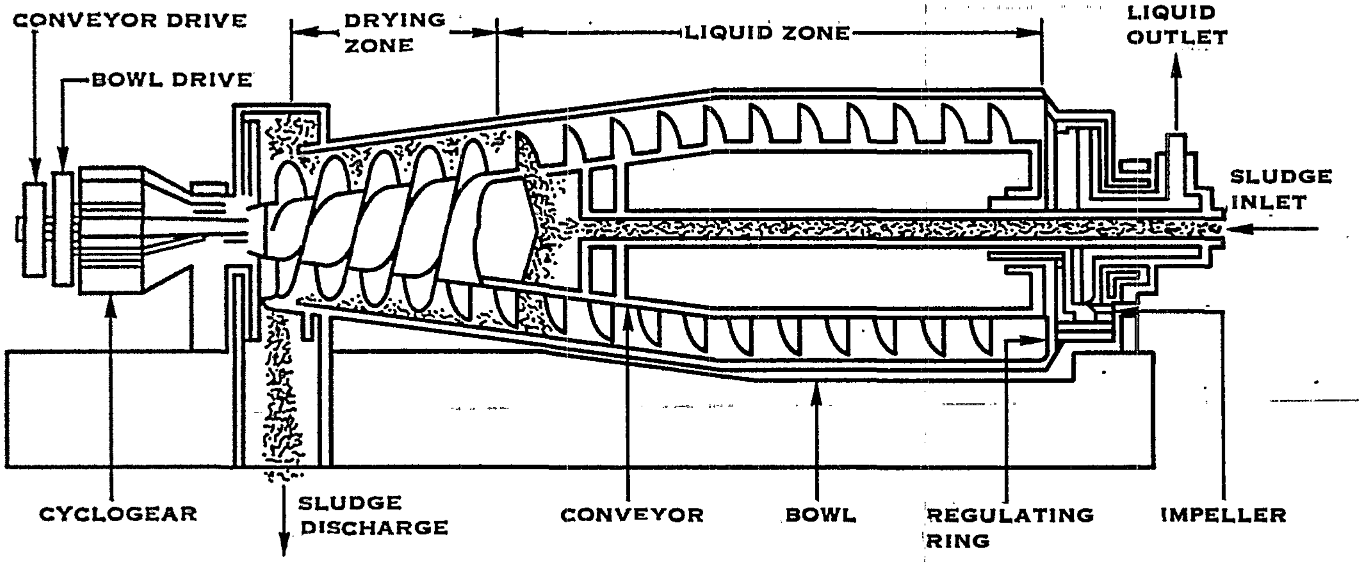


FIGURE VII-18. CENTRIFUGATION

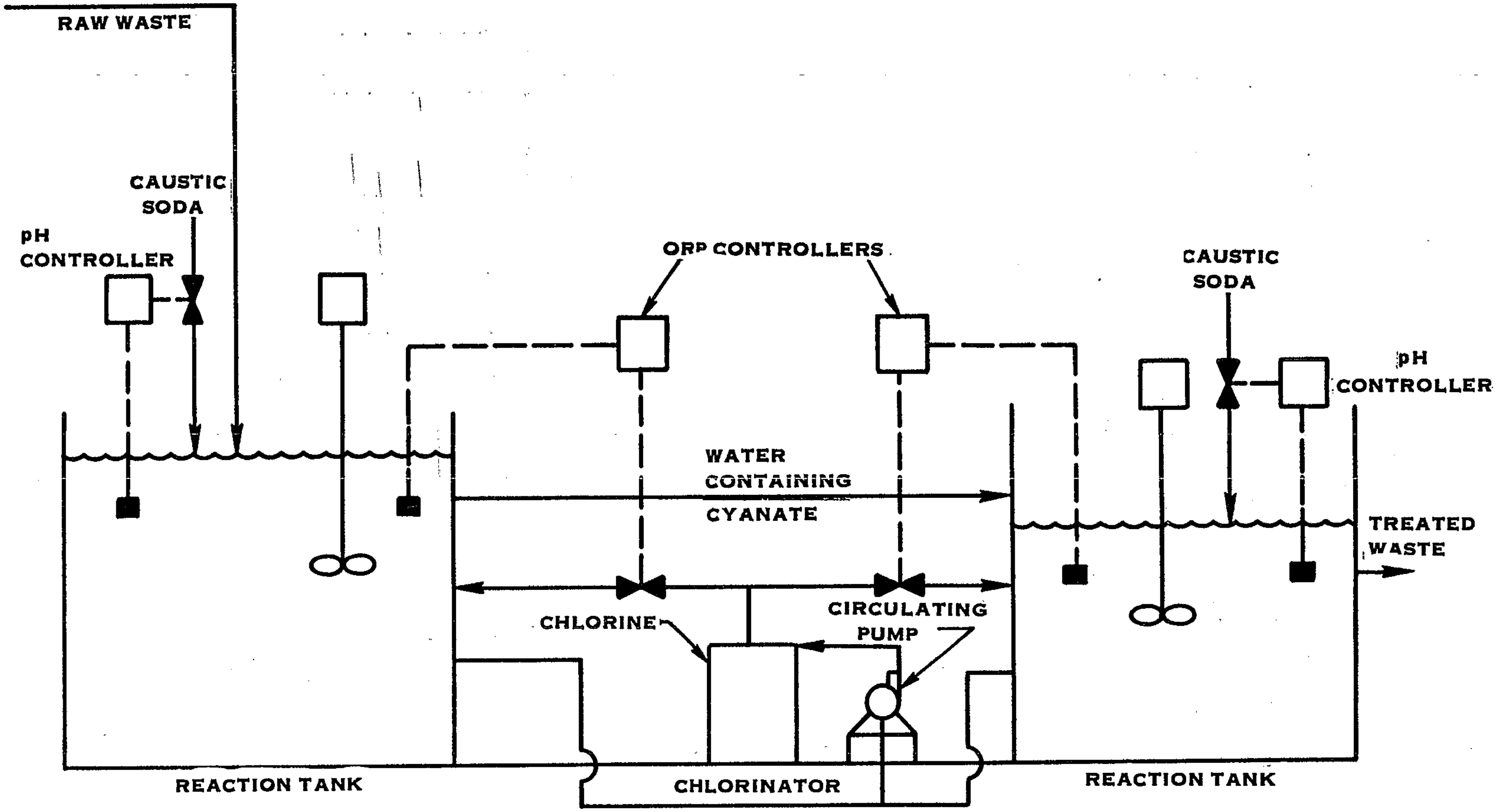


FIGURE VII-19. TREATMENT OF CYANIDE WASTE BY ALKALINE CHLORINATION

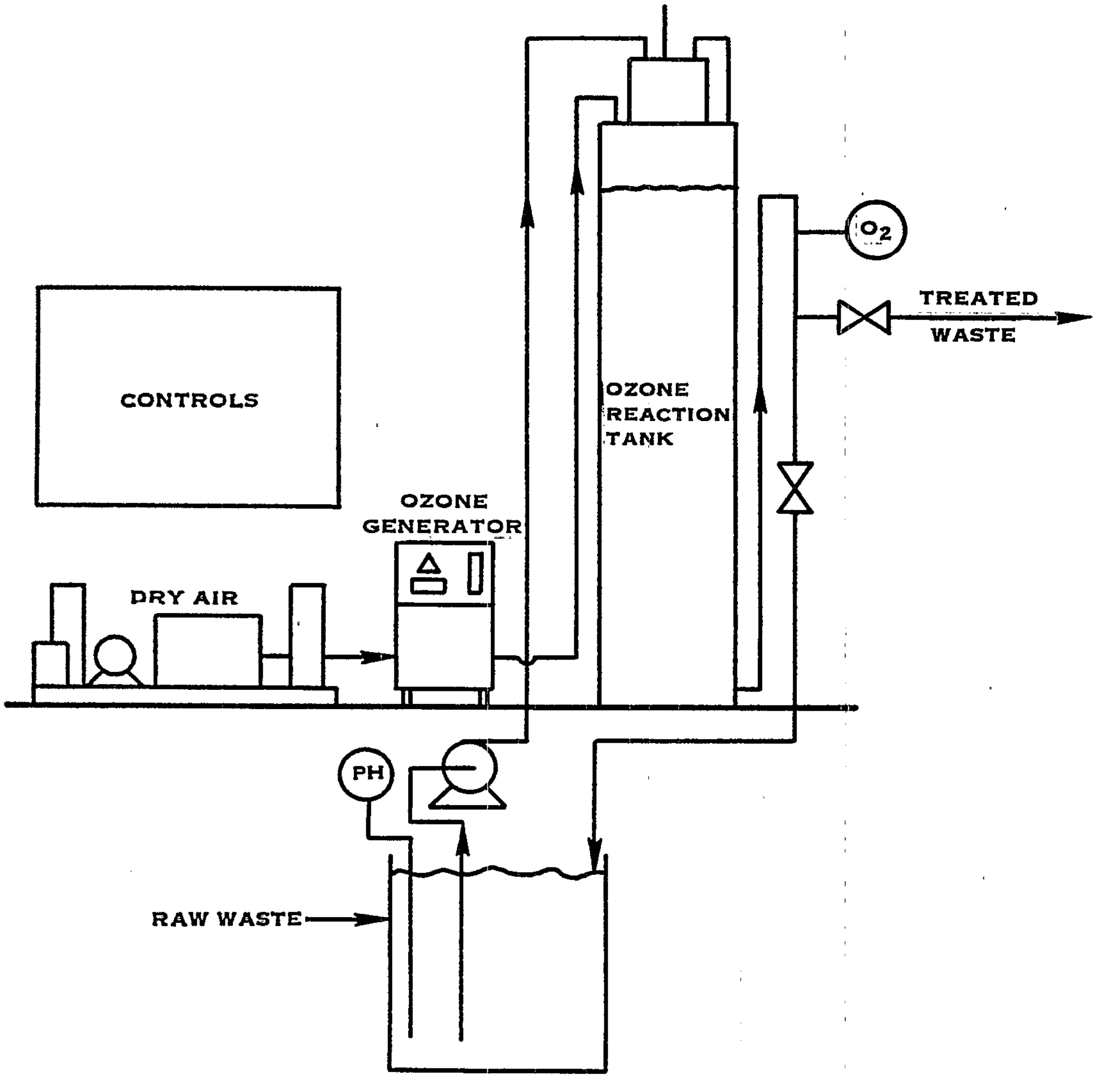


FIGURE VII-20. TYPICAL OZONE PLANT FOR WASTE TREATMENT

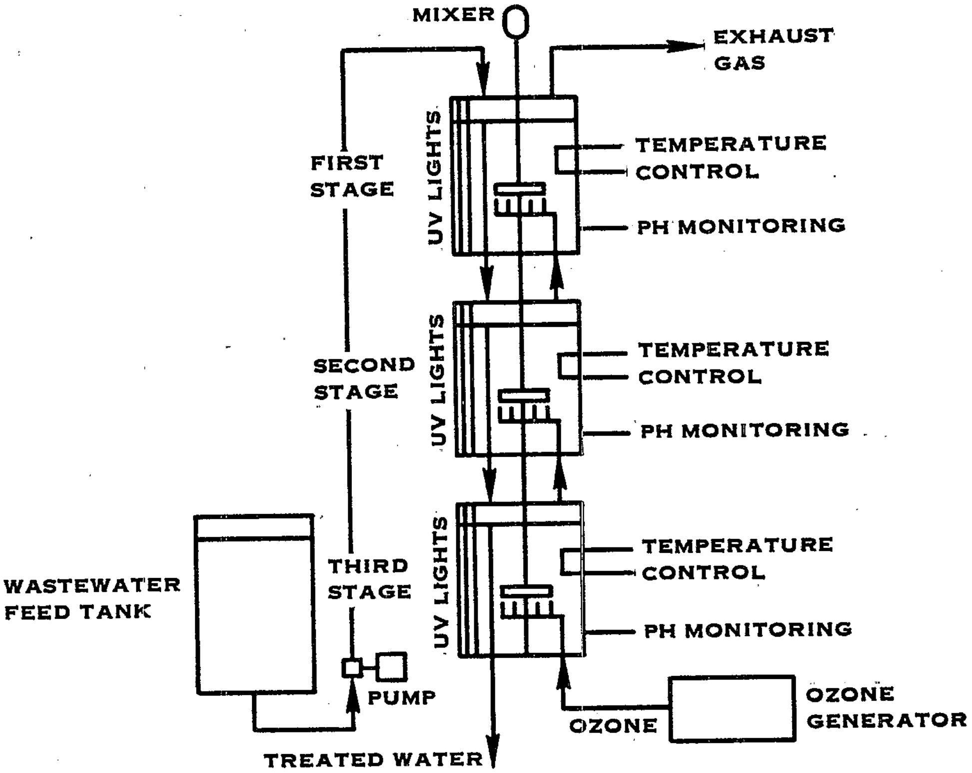
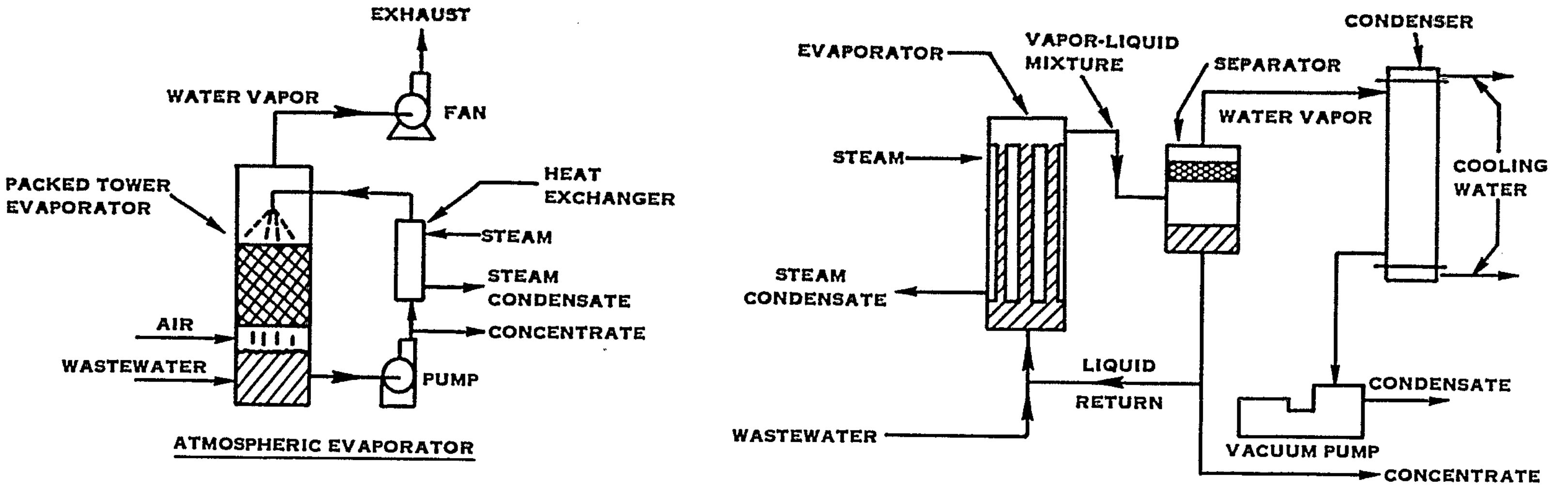
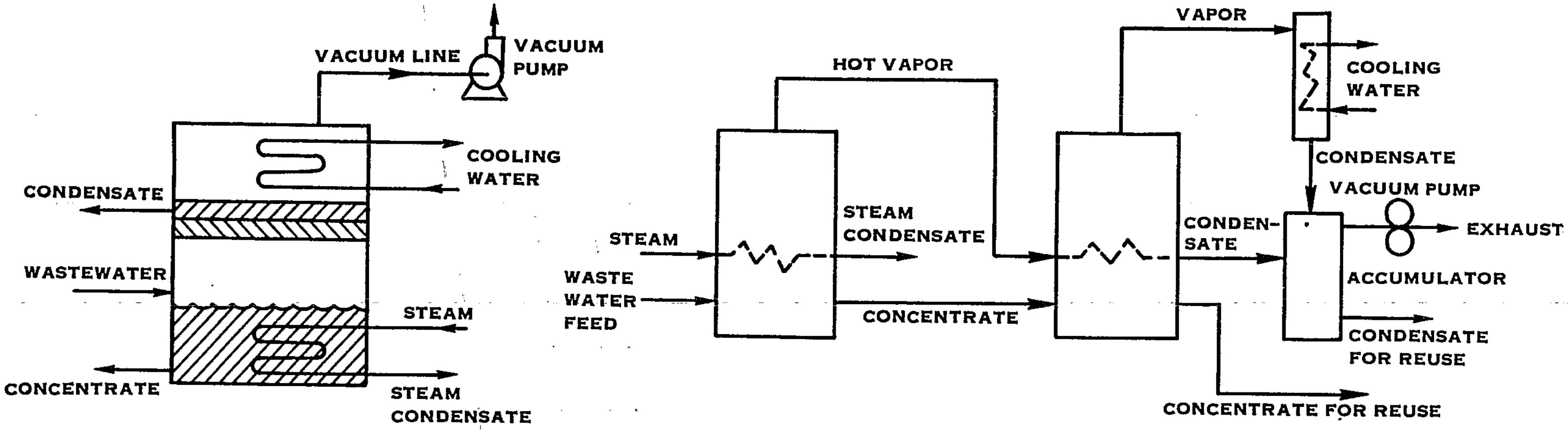


FIGURE VII-21. UV/OZONATION



ATMOSPHERIC EVAPORATOR

CLIMBING FILM EVAPORATOR



SUBMERGED TUBE EVAPORATOR

DOUBLE-EFFECT EVAPORATOR

FIGURE VII-22. TYPES OF EVAPORATION EQUIPMENT

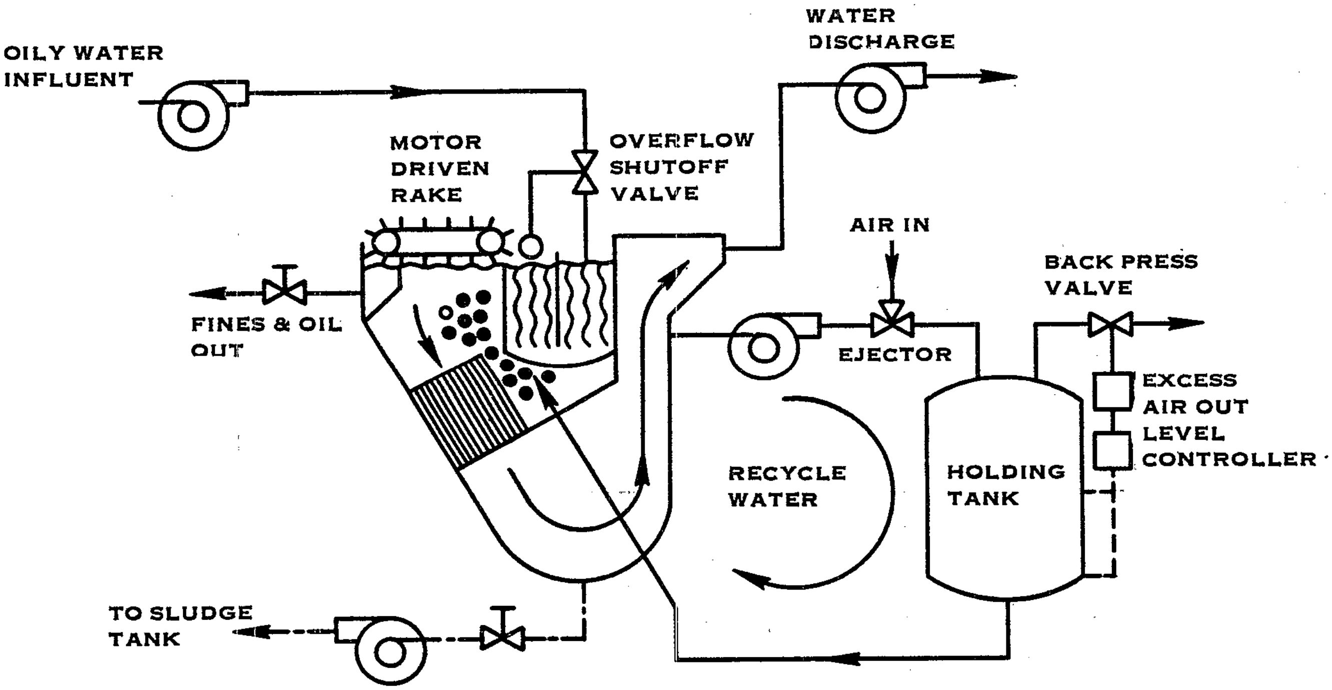
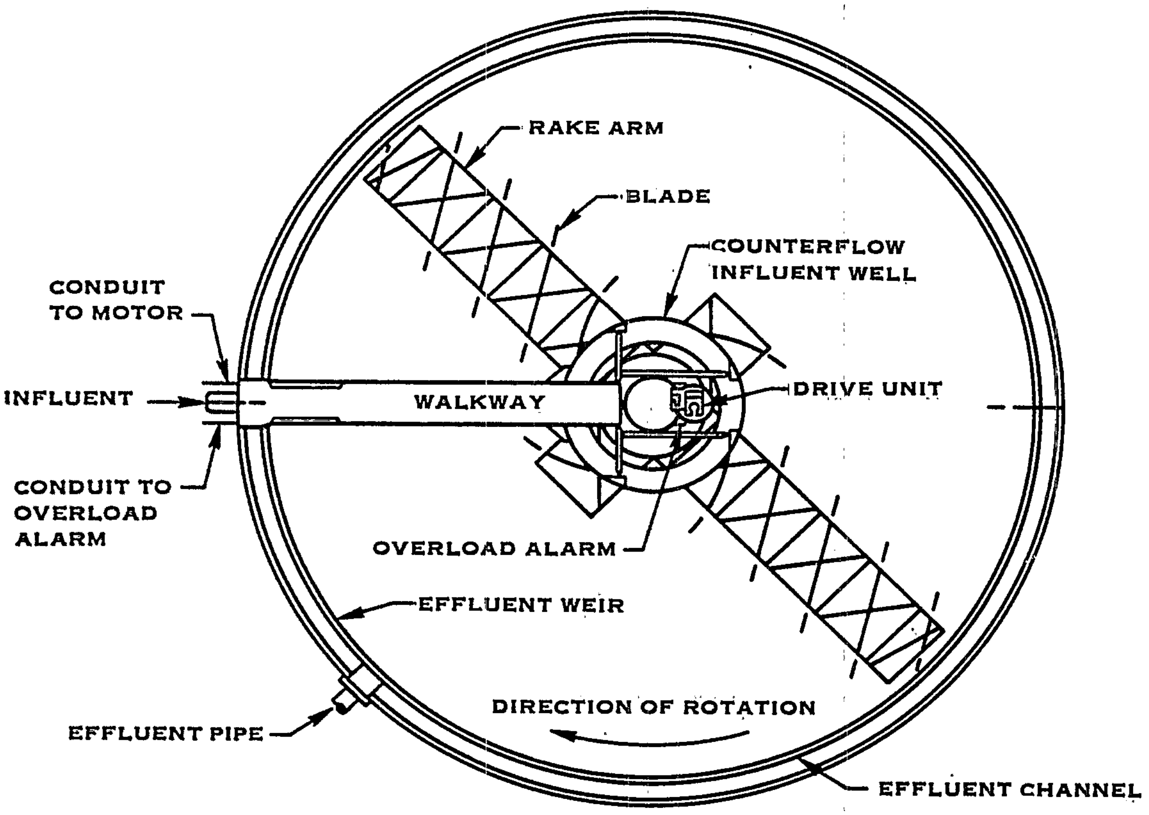


FIGURE VII-23. DISSOLVED AIR FLOTATION



PLAN

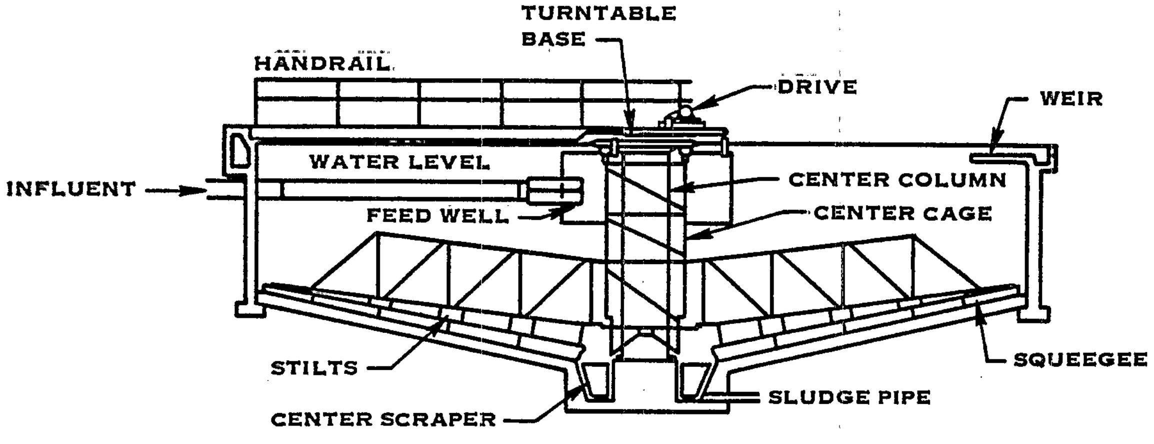


FIGURE VII-24. GRAVITY THICKENING

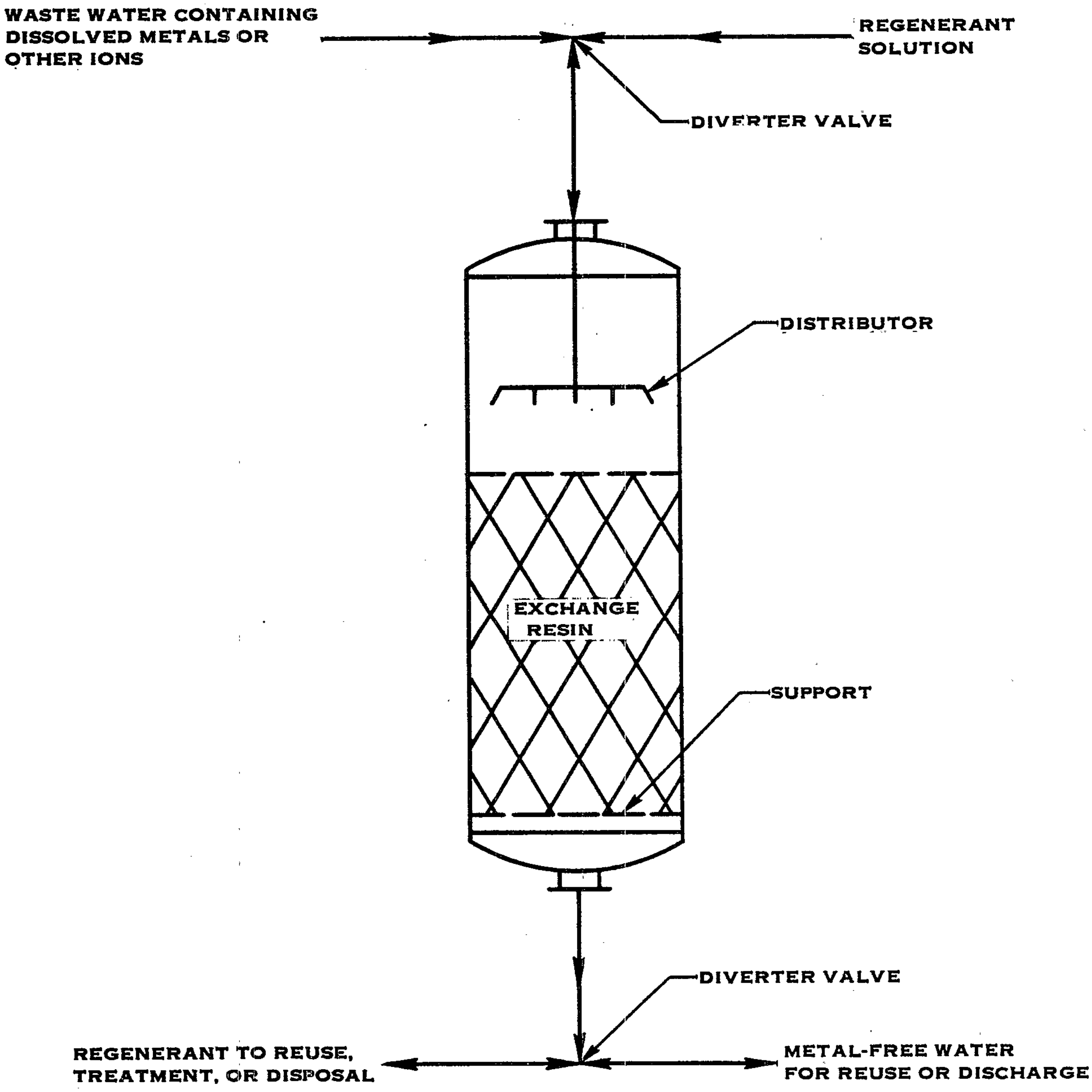


FIGURE VII-25. ION EXCHANGE WITH REGENERATION

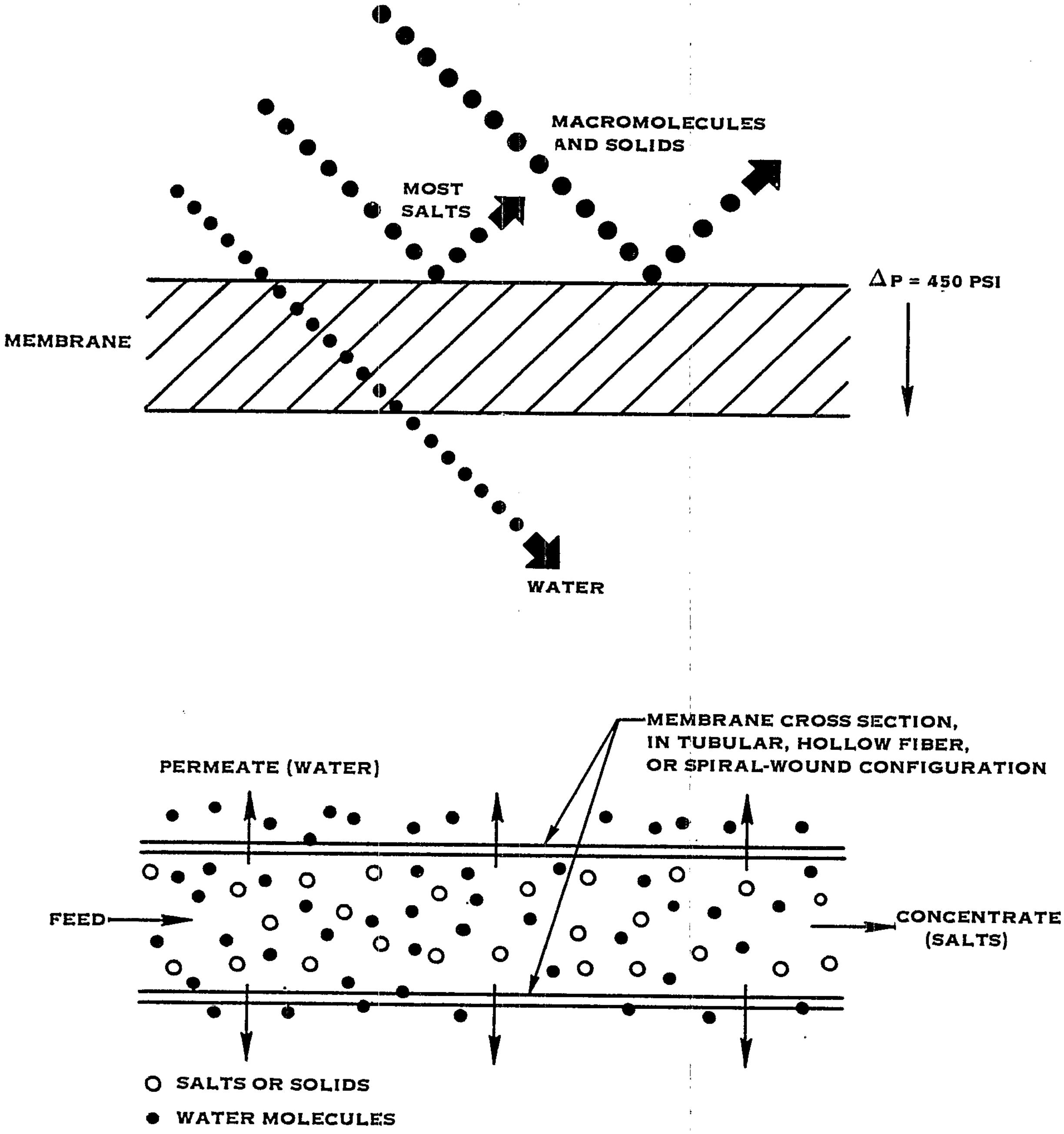
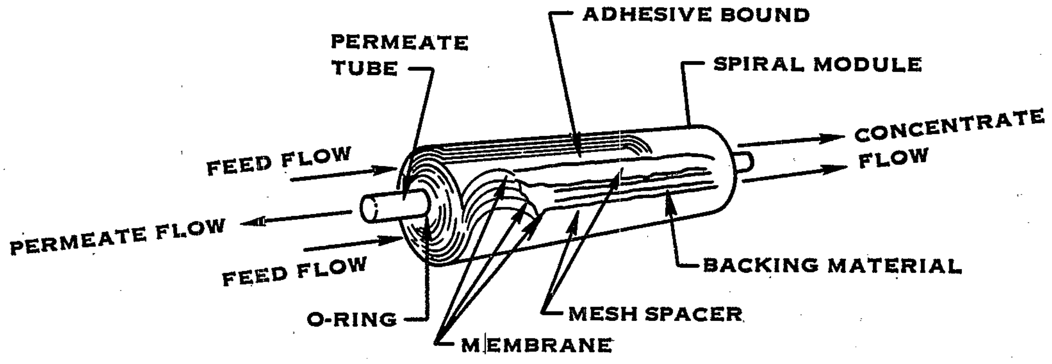
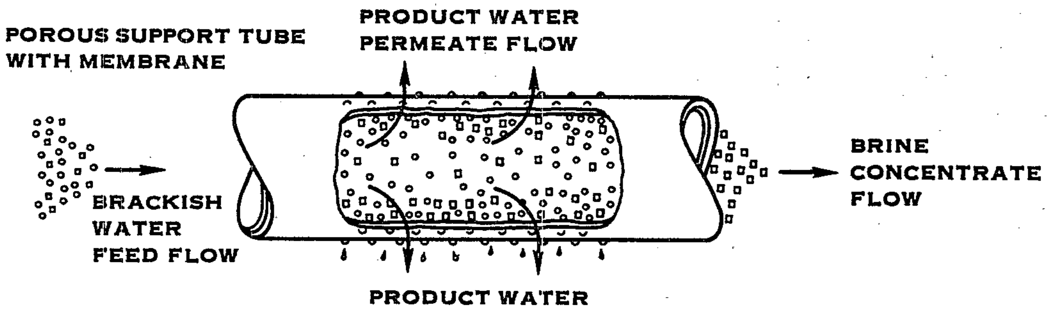


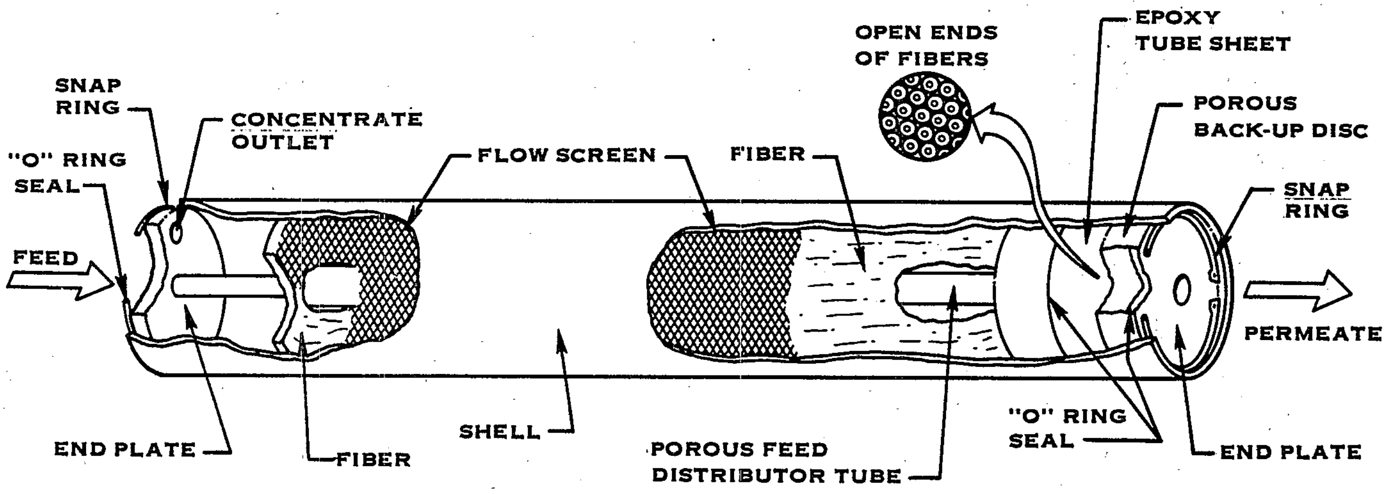
FIGURE VII-26. SIMPLIFIED REVERSE OSMOSIS SCHEMATIC



SPIRAL MEMBRANE MODULE

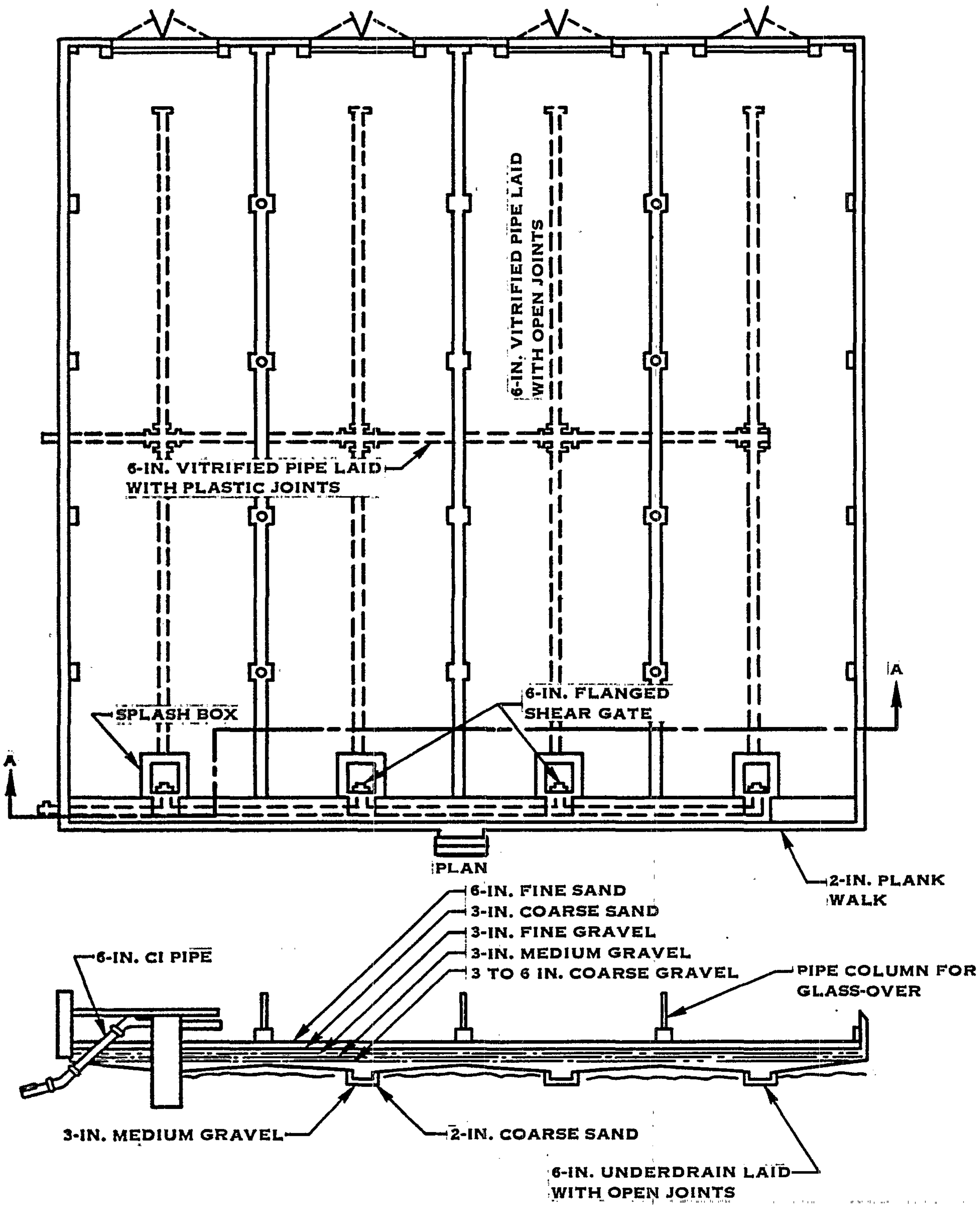


TUBULAR REVERSE OSMOSIS MODULE



HOLLOW FIBER MODULE

FIGURE VII-27. REVERSE OSMOSIS MEMBRANE CONFIGURATIONS



PLAN

SECTION A-A

FIGURE VII-28. SLUDGE DRYING BED

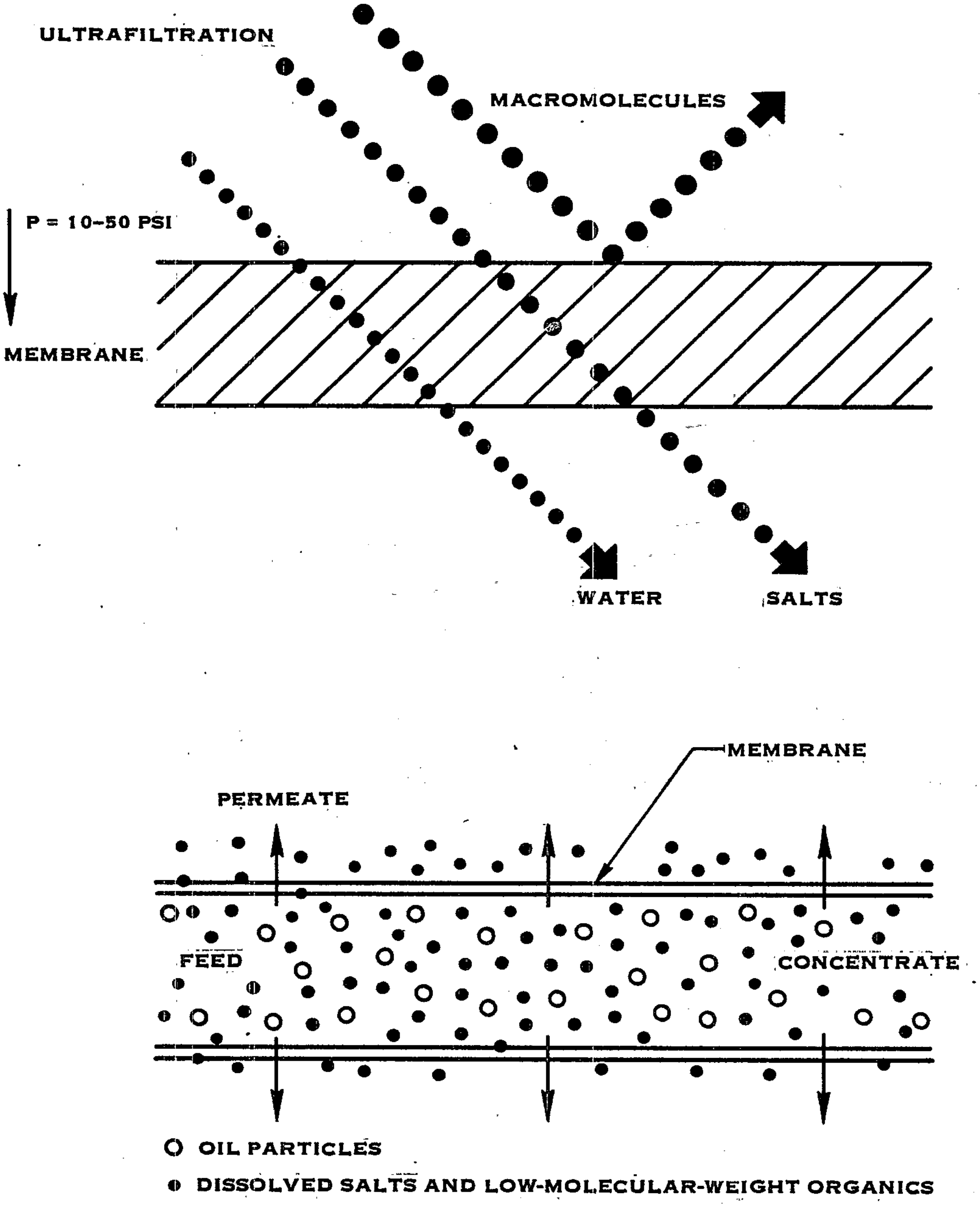


FIGURE VII-29. SIMPLIFIED ULTRAFILTRATION FLOW SCHEMATIC

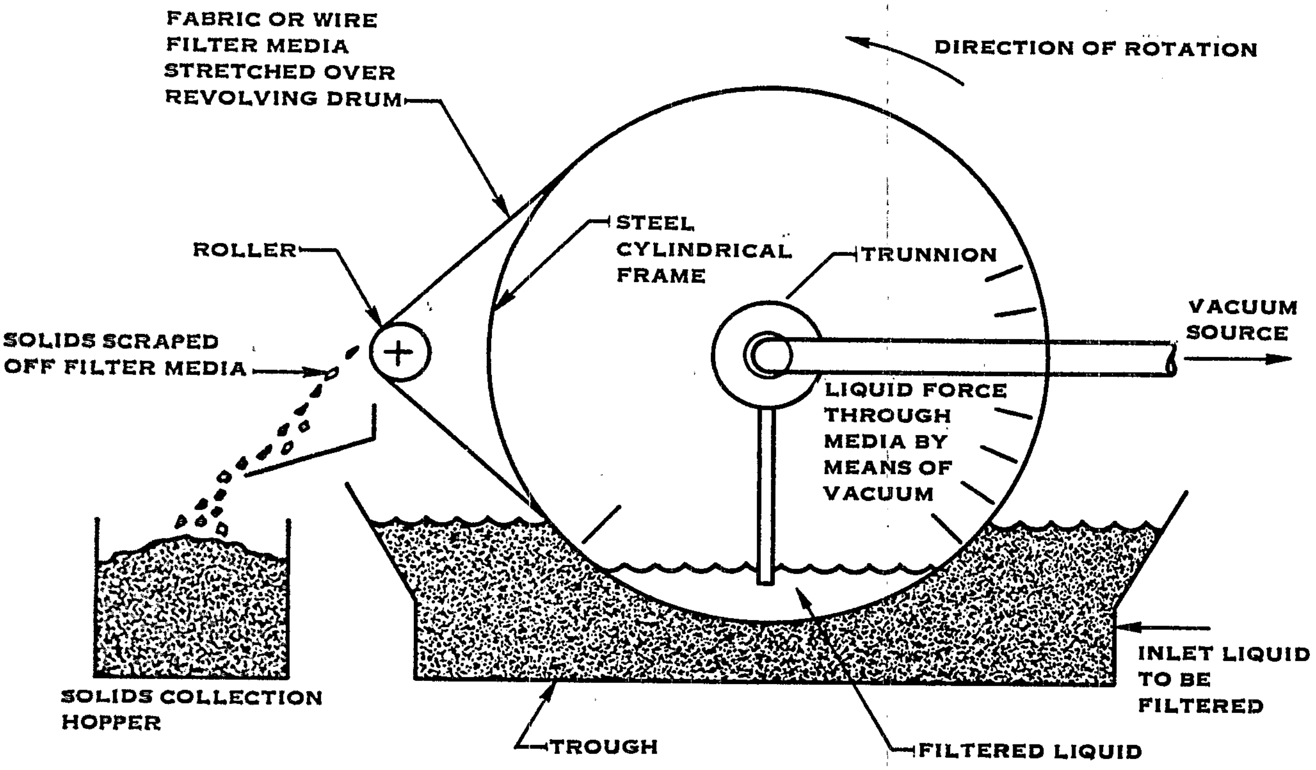


FIGURE VII-30. VACUUM FILTRATION

SECTION VIII

COST OF WASTE WATER CONTROL AND TREATMENT

This section presents estimates of the cost of implementation of the major wastewater treatment and control technologies described in Section VII. These cost estimates, together with the pollutant reduction performance for each treatment and control option presented in Sections IX, X, XI, XII and XIII provide a basis for evaluation of the options presented and identification of the best practicable control technology currently available (BPT), best available technology economically achievable (BAT), best demonstrated technology (BDT), the appropriate technology for pretreatment. Cost estimates are included in this Section for technology that the Agency may later designate as best conventional pollutant control technology (BCT). The cost estimates also provide the basis for the determination of the probable economic impact of regulation at different pollutant discharge levels on the porcelain enameling industrial segment. In addition, this section addresses non-water quality environmental impacts of wastewater treatment and control alternatives including air pollution, noise pollution, solid wastes, and energy requirements.

To arrive at the cost estimates presented in this section, specific wastewater treatment technologies and in-process control techniques were selected from among those discussed in Section VII and combined in wastewater treatment and control systems appropriate for each subcategory. Investment and annual costs for each system were estimated based on wastewater flows and raw wastewater characteristics for each subcategory as presented in Section V.

COST ESTIMATION METHODOLOGY

Cost estimation is accomplished using a computer program which accepts inputs specifying the treatment system to be estimated, chemical characteristics of the raw wastewater streams treated, flow rates and operating schedules. The program accesses models for specific treatment components which relate component investment and operating costs, materials and energy requirements, and effluent stream characteristics to influent flow rates and stream characteristics. Component models are exercised sequentially as the components are encountered in the system to determine chemical characteristics and flow rates at each point. Component investment and annual costs are also determined and used in the computation of total system costs.

Mass balance calculations are used to determine the characteristics of combined streams resulting from mixing two or more streams and to determine the volume of sludges or liquid wastes resulting from treatment operations such as chemical precipitation and settling and filtration.

Cost estimates are broken down into several distinct elements in addition to total investment and annual costs: operation and maintenance costs, energy costs, depreciation, and annual costs of capital. The cost estimation program incorporates provisions for adjustment of all costs to a common dollar base on the basis of economic indices appropriate to capital equipment and operating supplies. Labor and electrical power costs are input variables appropriate to the dollar base year for cost estimates. These cost breakdown and adjustment factors as well as other aspects of the cost estimation process are discussed in greater detail in the following paragraphs.

Cost Estimation Input Data

The wastewater treatment system descriptions input to the computer cost estimation program include both a specification of the wastewater treatment components included and a definition of their interconnections. For some components, retention times or other operating parameters are specified in the input, while for others, such as reagent mix tanks and clarifiers, these parameters are specified within the program based on prevailing design practice in industrial wastewater treatment. The wastewater treatment system descriptions may include multiple raw wastewater stream inputs and multiple treatment trains. For example, chromium-bearing wastewater streams are segregated and treated by chemical reduction prior to mixing with other metal preparation and coating wastewaters for subsequent chemical precipitation treatment.

The specific treatment systems selected for cost estimation for each subcategory were based on an examination of raw wastewater characteristics, consideration of manufacturing processes, and an evaluation of available treatment technologies discussed in Section VII. The rationale for selection of these systems is presented in Sections IX through XII.

The input data set also includes chemical characteristics for each raw wastewater stream specified as input to the treatment systems for which costs are to be estimated. These characteristics are derived from the raw wastewater sampling data presented in Section V. The pollutant parameters which are presently accepted as input by the cost estimation program are shown in Table VIII-1. The values of these parameters are used in determining materials consumption, sludge volumes, treatment component sizes, and effluent characteristics. The list of input parameters is expanded periodically as additional pollutants are found to be significant in wastewater streams from industries under study and as additional treatment technology cost and performance data become available. For the porcelain enameling industrial segment, individual subcategories commonly encompass a number of different wastewater streams which are present to varying degrees at different facilities. The raw wastewater characteristics shown as input to wastewater treatment represent a mix of these streams including all significant pollutants generated in the subcategory and will not in general correspond precisely to process wastewater at any existing facility. The process by which these raw wastewaters were defined is explained in Section V.

TABLE VIII-1

COST PROGRAM POLLUTANT PARAMETERS

Parameter, Units

Flow, MGD
pH, pH units
Turbidity, Jackson Units
Temperature, degree C
Dissolved Oxygen, mg/l
Residual Chlorine, mg/l
Acidity, mg/l $CaCO_3$
Alkalinity, mg/l $CaCO_3$
Ammonia, mg/l
Biochemical Oxygen Demand mg/l
Color, Chloroplatinate units
Sulfide, mg/l
Cyanides, mg/l
Kjeldahl Nitrogen, mg/l
Phenols, mg/l
Conductance, micromhos/cm
Total Solids, mg/l
Total Suspended Solids, mg/l
Settleable Solids, mg/l
Aluminum, mg/l
Barium, mg/l
Cadmium, mg/l
Calcium, mg/l
Chromium, Total, mg/l
Copper, mg/l
Fluoride, mg/l
Iron, Total, mg/l

Parameter, Units

Oil, Grease, mg/l
Hardness, mg/l $CaCO_3$
Chemical Oxygen Demand, mg/l
Algicides, mg/l
Total Phosphates, mg/l
Polychlorobiphenyls, mg/l
Potassium, mg/l
Silica, mg/l
Sodium, mg/l
Sulfate, mg/l
Sulfite, mg/l
Titanium, mg/l
Zinc, mg/l
Arsenic, mg/l
Boron, mg/l
Iron, Dissolved, mg/l
Mercury, mg/l
Nickel, mg/l
Nitrate, mg/l
Selenium, mg/l
Silver, mg/l
Strontium, mg/l
Surfactants, mg/l
Beryllium, mg/l
Plasticizers, mg/l
Antimony, mg/l
Bromide, mg/l

Lead, mg/l
Magnesium, mg/l
Molybdenum, mg/l
Total Volatile Solids, mg/l
Cobalt, mg/l
Thallium, mg/l
Tin, mg/l
Chromium, Hexavalent, mg/l

The final input data set comprises raw wastewater flow rates for each input stream for a "normal" plant in each subcategory. The normal plant is defined as a plant having the mean production level, mean production normalized water use, and mean production normalized pollutant concentrations for the subcategory. The normal plant is used to indicate the flows encountered at existing facilities, for each porcelain enameling subcategory and to indicate the treatment costs which would be incurred in the implementation of each control and treatment option considered. In addition, data corresponding to the flow rates and equipment in place reported by each plant in the category were used to provide cost estimates for use in economic impact analysis.

System Cost Computation

In the estimate of wastewater treatment and control costs raw wastewater characteristics and flow rates for the first case are used as input to the model for the first treatment technology specified in the system definition. This model is used to determine the size and cost of the component, materials and energy consumed in its operation, and the volume and characteristics of the stream(s) discharged from it. These stream characteristics are then used as input to the next component(s) encountered in the system definition. This procedure is continued until the complete system costs and the volume and characteristics of the final effluent stream(s) and sludge wastes have been determined. In addition to treatment components, the system may include mixers in which two streams are combined, and splitters in which part of a stream is directed to another destination. These elements are handled by mass balance calculations and allow cost estimation for specific treatment of segregated process wastewaters prior to combination with other process wastewaters for further treatment, and representation of partial recycle of wastewater.

As an example of this computation process, the sequence of calculations involved in the development of cost estimates for the simple treatment system shown in Figure VIII-1 (Page 332) is described. Initially, input specifications for the treatment system are read to set up the sequence of computations. The subroutine addressing chemical precipitation and clarification is then accessed. The sizes of the mixing tank and clarification basin are calculated based on the raw wastewater flow rate to provide 45 minute retention in the mix tank and a 15.0 gal/hr/ft^2

surface loading in the clarifier. Based on these sizes, investment and annual costs for labor, supplies for the mixing tank and clarifier including mixers, clarifier rakes and other directly related equipment are determined. Fixed investment costs are then added to account for sludge pumps, controls, piping, and reagent feed systems.

Based on the input raw wastewater concentrations and flow rates, the reagent additions (lime, alum, and polyelectrolyte) are calculated to provide fixed concentrations of alum and polyelectrolyte and 10 percent excess lime over that required for stoichiometric reaction with the acidity and metals present in the wastewater stream. Costs are calculated for these materials, and the suspended solids and flow leaving the mixing tank and entering the clarifier are increased to reflect the lime solids added and precipitates formed. These modified stream characteristics are then used with performance algorithms for the clarifier (as discussed in Section VII) to determine concentrations of each pollutant in the clarifier effluent stream. By mass balance, the amount of each pollutant in the clarifier sludge may be determined. The volume of the sludge stream is determined by the concentration of TSS which is fixed at 4.5 percent based on general operating experience, and concentrations of other pollutants in the sludge stream are determined from their masses and the volume of the stream.

The subroutine describing vacuum filtration is then called, and the mass of suspended solids in the clarifier sludge stream is used to determine the size and investment cost of the vacuum filtration unit. To determine manhours required for operation, operating hours for the filter are calculated from the flow rate and TSS concentration. Maintenance labor requirements are added as a fixed additional cost.

The sludge flow rate and TSS content are then used to determine costs of materials and supplies for vacuum filter operation including iron and alum added as filter aids, and the electrical power costs for operation. Finally, the vacuum filter performance algorithms are used to determine the volume and characteristics of the vacuum filter sludge and filtrate, and the costs of contract disposal of the sludge are calculated. The recycle of vacuum filter filtrate to the chemical precipitation and settling system is not reflected in the calculations due to the difficulty of iterative solution of such loops and the general observation that the contributions of such streams to the total flow and pollutant levels are, in practice, negligibly small. Allowance for such minor contributions is made in the 20 percent excess capacity provided in most components, and 40 percent excess capacity of the flocculator, settling tank, and sludge pumps of the clarifier.

The costs determined for all components of the system are summed and subsidiary costs (piping, buildings, instrumentation, contingency) are added to provide output specifying total investment and annual costs for the system and annual costs for capital, depreciation, operation and maintenance, and energy. Costs for specific system components and the characteristics of all streams in the system may also be specified as output from the program.

After proposal numerous public comments were received about the Agency's cost estimates. Review of data and consideration of information provided in comments resulted in a number of changes that increased substantially the Agency's cost estimates.

These changes are summarized here, as well as being incorporated in the following discussion.

1. The hydraulic surface loading of clarifier was reduced from 33.3 to 15.0 gal/hr/ft^2.

2. The TSS concentration in clarifier sludge stream was corrected to read 4.5 percent.

3. The excess capacity factor for flocculator, settling tank, and sludge pumps of clarifier was increased from 1.2 to 1.4.

4. Intercomponent piping, instrumentation, and contingency costs were added to list of subsidiary costs.

5. The wastewater sampling frequency chart was corrected to show weekly rather than monthly sampling at the third size level (189, 251-378, 500 lb/day).

6. Intrumentation costs are now assigned fixed value of $25,000 for continuous treatment, zero cost for batch treatment.

7. Engineering costs were increased and now range from 10.6 percent of total investment for a $650,000 plant to 22 percent for a $55,000 plant.

8. Legal, fiscal, and administrative costs were increased and now range from 1.6 percent of total plant investment cost for a $650,000 plant, to 3.7 percent for a $55,000 plant.

9. Interest for construction costs was increased from 10 percent to 16 percent.

Treatment Component Models

The cost estimation program presently incorporates subroutines providing cost and performance calculations for the treatment technologies identified in Table VIII-2. These subroutines have been developed over a period of years from the best available information including on-site observations of treatment system performance, costs, construction practices at a large number of industrial facilities, published data, and information obtained from suppliers of wastewater treatment equipment. The subroutines are modified and new subroutines added as additional data allow improvements in treatment technologies presently available, and as additional treatment technologies are required for the industrial wastewater streams under study. Specific discussion of each of the treatment component models used in costing wastewater treatment and control systems for the porcelain enameling industrial segment is presented later in this section where cost estimation is addressed, and in Section VII where performance aspects were developed.

TABLE VIII-2

TREATMENT TECHNOLOGY SUBROUTINES

Treatment Process Subroutines

Spray/Fog Rinse
Countercurrent Rinse
Vacuum Filtration
Gravity Thickening
Sludge Drying Beds
Holding Tanks
Centrifugation
Equalization
Contractor Removal
Reverse Osmosis
Landfill
Chemical Reduction of Chrom.
Chemical Oxidaton of Cyanide
Neutralization
Clarification (Settling Tank/Tube Settler)
API Oil Skimming
Emulsion Breaking (Chem/Thermal)
Membrane Filtration
Filtration (Diatomaceous Earth)
Ion Exchange - w/Plant Regeneration
Ion Exchange - Service Regeneration
Flash Evaporation
Climbing Film Evaporation

Sanitary Sewer Discharge Fee
Ultrafiltration
Submerged Tube Evaporation
Flotation/Separation
Wiped Film Evaporation
Trickling Filter
Activated Carbon Adsorption
Nickel Filter
Sulfide Precipitation
Sand Filter
Chromium Regeneration
Pressure Filter
Multimedia Granular Filter
Sump
Cooling Tower
Ozonation
Activated Sludge
Coalescing Oil Separator
Non Contact Cooling Basin

Raw Wastewater Pumping
Preliminary Treatment
Preliminary Sedimentation

Atmospheric Evaporation
Cyclic Ion Exchange
Post Aeration
Sludge Pumping
Copper Cementation
Aerator - Final Settler
Chlorination
Flotation Thickening
Multiple Hearth Incineration
Aerobic Digestion

In general terms, cost estimation is provided by mathematical relationships in each subroutine approximating observed correlations between component costs and the most significant operational parameters such as water flow rate, retention times, and pollutant concentrations. In general, flow rate is the primary determinant of investment costs and of most annual costs with the exception of materials costs. In some cases, however, as discussed for the vacuum filter, pollutant concentrations may also significantly influence costs.

Cost Factors and Adjustments

As previously indicated, costs are adjusted to a common dollar base and are generally influenced by a number of factors including: Cost of Labor, Cost of Energy, Capital Recovery Costs and Debt-Equity Ratio. These cost adjustments and factors are discussed below.

Dollar Base - A dollar base of January 1978 was used for all costs.

Investment Cost Adjustment - Investment costs were adjusted to the aforementioned dollar base by use of the Sewage Treatment Plant Construction Cost Index. This cost is published quarterly (formerly monthly) by the EPA Division of Facilities Construction and Operation. The national average of the Construction Cost Index for January 1978 was 288.0.

Supply Cost Adjustment - Costs of supplies such as chemicals were related to the dollar base by the Producer Price Index (formerly known as the Wholesale Price Index). This figure was obtained from the U.S. Department of Labor, Bureau of Labor Statistics, "Monthly Labor Review". For January 1978 the "Industrial Commodities" Wholesale Price Index was 201.6. Process supply and replacement costs were included in the estimate of the total process operating and maintenance cost.

Cost of Labor - To relate the operating and maintenance labor costs, the hourly wage rate for non-supervisory workers in water, stream, and sanitary systems was used from the U.S. Department of Labor, Bureau of Labor Statistics Monthly publication, "Employment and Earnings". For January 1978, this wage rate was $6.00 per hour. This wage rate was then applied to estimates of operation and maintenance man-hours within each process to obtain process direct labor charges. To account for indirect labor charges, 15 percent of the direct labor costs was added to the direct labor charge to yield estimated total labor costs. Such items as Social Security, employer contributions to pension or retirement funds, and employer-paid premiums to various forms of insurance programs were considered indirect labor costs.

Cost of Energy - Energy requirements were calculated directly within each process. Estimated costs were then determined by applying an electrical rate of 3.4 cents per kilowatt hour.

The electrical charge for January 1978 was corroborated through consultation with the Energy Consulting Services Department of the Connecticut Light and Power Company. This electrical charge was determined by assuming that any electrical needs of a waste treatment facility or in-process technology would be satisfied by an existing electrical distribution system; i.e., no new meter would be required. This eliminated the formation of any new demand load base for the electrical charge.

Capital Recovery Costs - Capital recovery costs were divided into straight line ten-year depreciation and cost of capital at a ten percent annual interest rate for a period of ten years. The ten year depreciation period was consistent with the faster write-off (financial life) allowed for these facilities even though the equipment life is in the range of 20 to 25 years.

The annual cost of capital was calculated by using the capital recovery factor approach.

The capital recovery factor is normally used in industry to help allocate the initial investment and the interest to the total operating cost of the facility. It is equal to:

$$CRF = i + \frac{i}{(1+i)\ n-1}$$

where i is the annual interest rate and n is the number of years over which the capital is to be recovered. The annual capital recovery was obtained by multiplying the initial investment by the capital recovery factor. The annual depreciation of the capital investment was calculated by dividing the initial investment by the depreciation period N, which was assumed to be ten years. The annual cost of capital was then equal to the annual capital recovery minus the depreciation.

Debt-Equity Ratio - Limitations on new borrowings assume that debt may not exceed a set percentage of the shareholders equity. This defines the breakdown of the capital investment between debt and equity charges. However, due to the lack of information about the financial status of various plants, it was not feasible to estimate typical shareholders equity to obtain debt financing limitations. For these reasons, capital cost was not broken into debt and equity charges. Rather, the annual cost of capital was calculated via the procedure outlined in the Capital Recovery Costs section above.

Subsidiary Costs

The wastewater treatment and control system costs presented in Figures VIII-2 through VIII-20 (pages 333-351) for end-of-pipe and in-process wastewater control and treatment systems include subsidiary costs associated with system construction and operation. These subsidiary costs include:

- administration and laboratory facilities
- garage and shop facilities
- line segregation
- yardwork
- piping (including intercomponent and return piping)
- instrumentation
- land
- engineering
- legal, fiscal, and administrative
- interest during construction
- contingency

Administrative and laboratory facility treatment investment is the cost of constructing space for administration and laboratory functions for the wastewater treatment system. For these cost computations, it was assumed that new building space would be required to house the waste treatment system control components (metering and instrumentation as applicable), laboratory facilities (if desired) and any other supportive functions requiring building space. A fixed investment cost for the construction of a nine hundred square foot (900 ft^2) one story building was included in the capital cost estimation.

For laboratory operations, an analytical fee of $90 (January 1978 dollars) was allowed for each wastewater sample, regardless of whether the laboratory work was done on or off site. This analytical fee is typical of the charges experienced by the EPA contractor during the past several years of sampling programs. The frequency of wastewater sampling is a function of wastewater discharge flow and is presented in Table VIII-3. This frequency was suggested by the Water Compliance Division of the USEPA.

For industrial wastewater treatment facilities being costed, no garage and shop investment cost was included. This cost item was assumed to be part of the normal plant costs and was not allocated to the wastewater treatment system.

Line segregation investment costs account for plant modifications to segregate wastewater streams. The investment costs for line segregation included placing a trench in the existing plant floor and installing the lines in this trench. The same trench was used for all pipes. The pipes were assumed to run from the center of the floor to a corner. A rate of 2.04 liters per hour of wastewater discharge per square meter of area (0.05 gal/hr-ft^2) was used to estimate floor and trench dimensions from wastewater flow rates for use in this cost estimation process. It was assumed that a transfer pump would be required for each segregated process line in order to transfer the wastewater to the treatment system.

TABLE VIII-3

WASTEWATER SAMPLING FREQUENCY

Waste Water Discharge (liters per day)	Sampling Frequency
0 - 37,850	once per month
37,851 - 189,250	twice per month
189,251 - 378,500	once per week
378,501 - 946,250	twice per week
946,250+	thrice per week

The yardwork investment cost item includes the cost of general site clearing, lighting, manholes, tunnels, conduits, and general site items outside the structural confines of particular individual plant components. This cost is typically 9 to 18 percent of the installed components investment costs. For these cost estimates, an average of 14 percent was utilized. Annual yardwork operation and maintenance costs are considered a part of normal plant maintenance and were not included in these cost estimates.

The piping investment cost item includes the cost of intercomponent piping, valves, and piping required to transfer the wastewater to the wastewater treatment system. This cost is estimated to be equal to 20 percent of installed component investment costs.

The instrumentation investment cost item includes the cost of metering equipment, electrical wiring, cable, treatment component operational controls, and motor control centers as required for each of the waste treatment systems described in Sections IX through XII of the document. A fixed cost of $25,000 was allowed for instrumentation investment for plants where the least cost treatment was the continuous mode. No cost was allocated for instrumentation investment where batch treatment was determined to be the least cost mode.

No new land purchases were required. It was assumed that the land required for the end-of-pipe treatment system was already available at the plant.

Engineering costs include both basic and special services. Basic services include preliminary design reports, detailed design, and certain office and field engineering services during construction of projects. Special services include improvement studies, resident engineering, soils investigations, land surveys, operation and maintenance manuals, and other miscellaneous services. Engineering cost is a function of investment in treatment process installed and yardwork. Engineering cost ranges from 10.6 percent of total plant investment cost for a $650,000 plant, to 22 percent for a $55,000 plant.

Legal, fiscal and administrative costs relate to planning and construction of waste water treatment facilities and include such items as preparation of legal documents, preparation of construction contracts, acquisition of land, etc. These costs are a function of process installed, yardwork, engineering, and land investment costs, and range from 1.6 percent of total plant investment cost for a $650,000 plant to 3.7 percent for a $55,000 plant.

Interest cost during construction is the interest cost accrued on funds from the time payment is made to the contractor, to the end of the construction period. The total of all other project investment costs (process installed; yardwork; land; engineering; and legal, fiscal, and administrative) and the applied interest affect this cost. An interest rate of 16 percent was used to determine the interest cost for these estimates.

A contingency allowance was included equal to ten percent of the sum of the cost of individual treatment technologies; piping, line segregation, and yardwork.

COST ESTIMATES FOR INDIVIDUAL TREATMENT TECHNOLOGIES

Table VIII-4 lists those technologies which are incorporated in the wastewater treatment and control options offered for the porcelain enameling industrial segment and for which cost estimates have been developed. These treatment technologies have been selected from among the larger set of available alternatives discussed in Section VII on the basis of an evaluation of raw wastewater characteristics, typical plant characteristics (e.g. location, production schedules, product mix, and land availability), and present treatment practices within the subcategories addressed. Specific rationale for selection is addressed in Sections IX, X, XI and XII. Cost estimates for each technology addressed in this section include investment costs and annual costs for depreciation, capital, operation and maintenance, and energy.

Investment - Investment is the capital expenditure required to bring the technology into operation. If the installation is a package contract, the investment is the purchase price of the installed equipment. Otherwise, it includes the equipment cost, cost of freight, insurance and taxes, and installation costs.

Total Annual Cost - Total annual cost is the sum of annual costs for depreciation, capital, operation and maintenance (less energy), and energy (as a separate function).

> Depreciation - Depreciation is an allowance, based on tax regulations, for the recovery of fixed capital from an investment to be considered as a non-cash annual expense. It may be regarded as the decline in value of a capital asset due to wearout and obsolescence.
>
> Capital - The annual cost of capital is the cost, to the plant, of obtaining capital expressed as an interest rate. It is equal to the capital recovery cost (as previously discussed on cost factors) less depreciation.

Operation and Maintenance - Operation and maintenance cost is the annual cost of running the wastewater treatment equipment. It includes labor and materials such as wastewater treatment chemicals. As presented in the tables, operation and maintenance cost does not include energy (power or fuel) costs because these costs are shown separately.

Energy - The annual cost of energy is shown separately, although it is commonly included as part of operation and maintenance cost. Energy cost has been shown separately because of its importance to the nation's economy and natural resources.

TABLE VIII-4

INDEX TO TECHNOLOGY COST FIGURES

Figures	Wastewater Treatment Technology	Page
VIII-2 through	Holding Tanks	333
VIII-8		339
VIII-9 through	Chromium Reduction	340
VIII-11		342
VIII-12 through	Chemical Precipitation and Settling;	343
VIII-14		345
VIII-15	Multimedia Filtration	346
VIII-16 through	"In-line" Filtration	347
VIII-17		348
VIII-18 through	Vacuum Filtration	349
VIII-20		351

Holding Tanks

Tanks serving a variety of purposes in wastewater treatment and control systems are fundamentally similar in design and construction and in cost. They may include equalization tanks, solution holding tanks, slurry or sludge holding tanks, mixing tanks, and settling tanks from which sludge is intermittently removed manually or by sludge pumps. Tanks for all of these purposes are addressed in a single cost estimation subroutine with additional costs for auxilliary equipment such as sludge pumps added as appropriate.

Capital Costs. Costs are estimated for lined concrete or steel tanks. Tank construction may be specified as input data, or determined on a least cost basis. Retention time is specified as input data and, together with stream flow rate, determines tank size. Capital costs for steel tanks sized for 20 percent excess capacity are shown as functions of stream flow rate in Figures VIII-2 through VIII-4 (Pages 333-335). These costs include mixers, pumps and installation.

Operation and Maintenance Costs. For all holding tanks operation and maintenance costs are minimal in comparison to other system O&M costs Figure VIII-5, page 336. Energy costs for pump and mixer operation are presented in Figures VIII-6 through VIII-8 (Pages 337-339).

Where tanks are used for settling as in lime precipitation and clarification batch treatment, additional operation and maintenance costs are calculated as discussed specifically for each technology.

Chromium Reduction

This technology provides chemical reduction of hexavalent chromium under acid conditions to allow subsequent removal of the trivalent form by precipitation as the hydroxide. Treatment may be provided in either continuous or batch mode, and cost estimates are developed for both. Operating mode for system cost estimates is selected on a least cost basis.

Capital Cost. Cost estimates include all required equipment for performing this treatment technology including reagent dosage, reaction tanks, mixers and controls. Different reagents are provided for batch and continuous treatment resulting in different system design considerations as discussed below.

For both continuous and batch treatment, sulfuric acid is added for pH control. If more than two 55-gallon drums per day are required, a 5 day supply is stored in an above-ground, fiberglass reinforced plastic tank.

For continuous chromium reduction the single chromium reduction tank is sized in an above-ground cylindrical rubber lined steel tank with a a one hour retention time, and an excess capacity factor of 1.2. Sulfur dioxide is added to convert the influent hexavalent chromium to the trivalent form. The control system for continuous chromium reduction consists of:

1	immersion pH probe and transmitter
2	immersion ORP probe and transmitter
1	pH and ORP monitor
2	slow process controllers
1	pen recorder
1	sulfonator and associated pressure regulator

3	pump stands
2	sulfuric acid pumps
1	transfer pump
2	mixers
1	maintenance kits for pH probe and miscellaneous electrical equipment and piping

For batch chromium reduction, the dual chromium reduction tanks are sized as above-ground cylindrical rubber-lined steel tanks, with a 4 hour, 1 day, or 5 day retention time selected to minimize total annual cost, and an excess capacity factor of 1.2. Sodium bisulfite is added to reduce the hexavalent chromium.

A completely manual system is provided for batch operation. Subsidiary equipment includes:

1	wall mounted mixer
1	sulfuric acid pump
1	sulfuric acid mixer with disconnects
2	immersion pH probes
1	pH meter, and miscellaneous piping
3	ORP probes
1	pH probe maintenance kit

Capital costs for batch and continuous treatment systems are presented in Figure VIII-9 (Page 340).

Operation and Maintenance. Costs for operating and maintaining chromium reduction systems include labor, chemical addition, liner replacement and energy requirements and are presented in Figure VIII-10 (Page 341). These factors are determined as follows:

- LABOR

The labor requirements are plotted in Figure VIII-11 (Page 342).

- CHEMICAL ADDITION

For the continuous system, sulfur dioxide is added according to the following:

$$(\text{lbs } SO_2/\text{day}) = (8.34) \text{ flow to unit in MGD) } (1.85 \times \text{mg/l } Cr^{+6} + 4 \times \text{mg/l dissolved } O_2) \text{ (1.1 excess capacity factor)}$$

In the batch mode, sodium meta bisulfite is added in place of sulfur dioxide according to the following:

($lbs\ Na_2S_2O_5/day$ = (8.34) (flow to unit in MGD) (2.74 x mg/l Cr^{+6} + 5.94 mg/l dissolved O_2) (1.1 excess capacity factor)

- ENERGY

For both systems, horsepower of the tank mixers and the transfer pump are a function of the tank volume and stream flow, respectively. The acid feed pump requires 0.2 horsepower. The mixers are assumed to operate continuously over the operation time of the treatment system.

Given the above requirements, operation and maintenance costs presented in Figure VIII-12 (Page 343) are calculated based on the following:

- \$6.00 per manhour + 15 percent indirect labor charge
- \$354/ton of sulfur dioxide
- \$280/ton of sodium meta bisulfite
- \$0.034/kilowatt hour of required electricity
- \$112/ton of sulfuric acid

Chemical Precipitation and Settling

This technology removes dissolved pollutants by the formation of precipitates by reaction with added lime and subsequent removal of the precipitated solids by gravity settling in a clarifier. Several distinct operating modes and construction techniques are costed to provide least cost treatment over a broad range of flow rates. Because of their interrelationships and integration in common equipment in some installations, both the chemical addition and solids removal equipment are addressed in a single subroutine. The chemical precipitation and sedimentation subroutine also incorporates an oil skimming device on the clarifier for removal of floating oils.

Investment Costs. Investment costs are determined for this technology for both batch and continuous treatment systems using steel tank or concrete tank construction. The system selected is based upon least cost on an annual basis as discussed previously in this Section. Continuous treatment systems include a mix tank for reagent feed addition (flocculation basin) and a clarification basin with associated sludge rakes and pumps. Batch treatment systems include only reaction settling tanks and sludge pumps.

The flocculator included in the continuous chemcial precipitation and sedimentation system can be either a steel tank or concrete tank unit. The concrete flocculator is an in-ground unit based on a 45 minute retention time, a length to width ratio of 5, a depth of 8 feet, a wall thickness of 1 foot, and a 40 percent excess capacity factor. The steel unit size is based on a 45 minute retention time, and a 40 percent excess capacity factor. Capital costs for both the concrete and steel units include excavation (as required) and a mixer.

The concrete settling tank included in the continuous chemical precipitation and clarification system is an in-ground unit sized for a hydraulic loading of 15.0 gph/ft^2, a wall thickness of 1 foot, and an excess capacity factor of 40 percent. The steel settling tank included in the continuous chemical precipitation and clarification system is a circular above-ground unit sized for a hydraulic loading of 15.0 gph/ft^2, and an excess capacity factor of 40 percent. The depth of the circular steel tank is assumed to increase linearly with the diameter between six and fifteen feet for tanks with diameters between eight and twenty-four feet respectively. For tanks greater than twenty-four feet in diameter, the depth is assumed to be a constant fifteen feet. An allowance for field fabrication for the larger volume steel settling tanks is included in the capital cost estimation.

For batch treatment systems, dual above ground cylindrical steel tanks sized for an eight hour retention period and a 40 percent excess capacity factor are employed. The batch treatment system does not include a flocculation unit.

The cost of sludge rakes, motors, skimmer, and weirs was based on the size of the unit and was included in the clarifier capital cost. The selection of steel or concrete tank clarifier for the continuous mode is determined by a comparison of the capital costs of the two units.

A fixed cost of $3,202 is included in the clarifier capital cost estimates for sludge pumps regardless of whether above-ground steel tanks (in the batch or continuous operation modes) or the in-ground concrete settling tank are used. This cost covers the expense of two centrifugal sludge pumps. Costs of polymer feed systems for the batch and continuous operation modes are based on tank volume and flow. The system includes a dilution tank, transfer pump, and a small mixer.

Lime addition for chemical precipitation in the batch mode is assumed to be performed manually. A variable cost allowance for lime addition equipment is included in the continuous operation mode. This cost allowance covers the expense associated with a lime storage hopper, feeding equipment, slurry formation and mixing and slurry feed pumps. The cost allowance increases as clarifier tank size increases.

Figure VIII-13 (Page 344) shows a comparison of capital (investment) cost curves for batch and continuous chemical precipitation and clarification systems. The continuous treatment system investment cost is based on a steel flocculation unit followed by a steel clarification basin. This combination of treatment components was found to be less expensive than the concrete flocculation basin, concrete clarification basin combination, or any combination of steel and concrete flocculation and clarification units. The batch treatment investment curve is based upon two above-ground cylindrical steel tank clarifier units. Both the continuous and batch system investment curves include allowances for the sludge pump, polymer feed systems, and lime addition equipment (continuous system only).

All costs presented above include motors, starters, alternators, and piping specifically associated with each treatment component.

Operation and Maintenance Costs

The operation and maintenance costs for the clarifier routine are presented in Figure VIII-14 (Page 345) included:

1) Cost of chemicals added (lime, alum, and polymer
2) Labor (operation and maintenance)
3) Energy

Each of these contributing factors are discussed below.

- CHEMICAL COST

  Lime is added for metals and solids removal. The amount of chemical required is based on equivalent amounts of various pollutant parameters present in the stream entering the treatment unit. The methods used in determining the lime requirements are shown in Table VIII-5.

- LABOR

  Figure VIII-15 (Page 346) presents the man-hour requirements for the continuous clarifier system. For the batch system, maintenance labor is assumed negligible and operation labor is calculated from:

  (man-hours for operation) = 390 + (.975) (lbs. lime added per day)

- ENERGY

The energy costs are calculated from the treatment and sludge pump horsepower requirements.

Continuous Mode

The treatment horsepower requirement is assumed constant over the hours of operation of the treatment system at a level of 0.0000265 horsepower per 1 gph of flow influent to the clarifier. The sludge pumps are assumed operational for 5 minutes of each operational hour at a level of 0.00212 horsepower per 1 gph of sludge stream flow.

Batch Mode

The treatment horsepower requirement is assumed to occur for 7.5 minutes per operational hour at the following level:

influent flow <1042 gph; 0.0048 hp/gph

influent flow >1042 gph; 0.0096 hp/gph

The power required for the sludge pumps in the batch system is the same as that required for the sludge pumps in the continuous mode.

Figure 16, page 347, presents a comparison of energy costs for batch and continues modes.

TABLE VIII-5

CLARIFIER CHEMICAL REQUIREMENTS

LIME REQUIREMENT[1]

POLLUTANT	A(Lime)
Chromium, Total	0.000470
Copper	0.000256
Acidity	0.000162
Iron, Dissolved	0.000438
Zinc	0.000250
Cadmium	0.000146
Cobalt	0.000276
Manganese	0.000296
Aluminum	0.000907

1) (Lime Demand Per Pollutant, lbs/day) = A(Lime) x Flow Rate (GPH) x Pollutant Concentration (mg/l)

Given the above requirements, operation and maintenance costs are calculated based on the following:

- $6.00 per man-hour + 15 percent indirect labor charge
- $41.26/ton of lime
- $0.034/kilowatt-hour of required electricity

Granular Bed Multimedia Filtration

This technology provides removal of suspended solids by filtration through a bed of particles of several distinct size ranges. As a polishing treatment after chemical precipitation and clarification processes, multimedia filtration provides improved removal of precipitates and thereby improved removal of the original dissolved pollutants.

Capital Costs. The size of the granular bed multimedia filtration unit is based on 20 percent excess flow capacity and a hydraulic loading of 0.5 ft^2/gpm. Capital cost is presented in Figure VIII-17 (Page 348) as a function of flow to the installation.

Operation and Maintenance. The costs for operation and maintenance include contributions of materials, electricity and labor. These curves result from correlations made with data obtained by a major manufacturer. Energy costs are estimated to be 3 percent of total O&M.

In-Line Filtration

In-line filtration for removal of suspended solids is accomplished by using one of several types of filtration apparatuses. The various types of filters available include filter leaf, filter bag, flat bed filters and string-wound "cartridge" type filters. Many of these filters can incorporate diatomaceous earth as a filtering aid by spraying it on the filter substrate.

Capital Cost. Unit cost estimates for in-line filtration apparatuses are based on one filter station comprised of one filter unit, one pump and associated valving. Capital costs for the in-line filtration unit are displayed in Figure VIII-18 (Page 349).

Operation and Maintenance Cost. The operation and maintenance costs for in-line filtration shown in Figure VIII-19, page 350, include labor, materials and energy. Each of these costs is discussed below.

- LABOR

  A labor rate of $6.00 per hour plus 15 percent indirect labor charge is used in determining labor costs. Operation and maintenance hours are based on 20 hours per year maintenance, 10 minutes per backwash cycle and 30 seconds per cartridge per replacement.

- MATERIALS

  Material costs for operation and maintenance of the in-line filtration unit are shown in Figure VIII-20 (Page 351) and are based on use of 5 micron filter and 65 day replacement cycle.

- ENERGY

  Electrical energy requirements for the in-line filtration unit are shown in Figure VIII-21 (Page 352). Electrical cost is calculated based on a charge of $0.034 per kilowatt hour.

  Power requirements, filter flux rate and manpower requirements are based on manufacturers data.

Vacuum Filtration

Vacuum filtration is widely used to reduce the water content of high solids streams. In the porcelain enameling industrial segment, this technology is applied to dewatering sludge from clarifiers, membrane filters and other wastewater treatment units.

Capital Costs. The vacuum filter is sized based on a typical loading of 14.6 kg of influent solids per hr per m^2 of filter area (3 lbs/ft^2-hr). The curves of cost versus flow rate at TSS concentrations of 3 percent and 5 percent are shown in Figure VIII-22 (Page 353). The capital costs obtained from this curve include installation costs.

Operation and Maintenance Cost

Operation and maintenance costs for vacuum filtration are shown in Figure VIII-23, page 354.

- LABOR

The vacuum filtration subroutine calculates operating hours per year based on flow rate and the total suspended solids concentration in the influent stream.

Maintenance labor for vacuum filtration is fixed at 24 manhours per year.

. MATERIALS

The cost of materials and supplies needed for operation and maintenance includes belts, oil, grease, seals, and chemicals required to raise the total suspended solids to the vacuum filter. The amount of chemicals required (iron and alum) is based on raising the TSS concentration to the filter by 1 mg/l.

- ENERGY

Electrical costs needed to supply power for pumps and controls is presented in Figure VIII-24 (Page 355). As the required horsepower of the pumps is dependent on the influent TSS level, the costs are presented as a function of flow rate and TSS level.

Contract Removal

Sludge, waste oils, and in some cases concentrated waste solutions frequently result from wastewater treatment processes. These may be disposed of on-site by incineration, landfill or reclamation, but are most often removed on a contract basis for off-site disposal. System cost estimates presented in this report are based on contract removal of sludges and waste oils. In addition, where only small volumes of concentrated wastewater are produced, contract-removal of off-site treatment may represent the most cost-effective approach to water pollution abatement. Estimates of solution contract haul costs are also provided by this subroutine and may be selected in place of on-site treatment on a least-cost basis.

Capital Costs. Capital investment for contract removal is zero.

Operating Costs. Annual costs are estimated for contract removal of total waste streams, or sludge and oil streams as specified in input data. Sludge and oil removal costs are further divided into wet and dry haulage depending upon whether or not upstream sludge dewatering is provided. The use of wet haulage or of sludge dewatering and dry haulage is based on least cost as determined by annualized system costs over a ten year period. Wet haulage costs are always used in batch treatment systems and when the volume of the sludge stream is less than 100 gallons per day.

Both wet sludge haulage and total waste haulage differ in cost depending on the chemical composition of the waste removed. Wastes are classified as cyanide bearing, hexavalent chromium bearing, or oily, and are assigned different haulage costs as shown below.

Waste Composition	Haulage Cost
0.05 mg/l CN^-	\$0.45/gallon
≥0.1 mg/l Cr^{+6}	\$0.20/gallon
Oil & grease-TSS	\$0.12/gallon
All others	\$0.16/gallon

Dry sludge (40 percent dry solids in the sludge) haul costs are estimated at \$0.12 gallon.

In-process Treatment and Control Components

Several major in-process control techniques have been identified for use in reducing wastewater pollutant discharges from porcelain enameling facilities.

Recycle Pump

In order to recycle the treated wastewater back to the coating process operations, construction of a small pump station will be required. Due to engineering considerations, it was assumed that the pump station would be constructed next to the holding tank in the end-of-pipe treatment system.

Capital Cost. Cost estimates for the pump station are based on a one-pump station comprised of an in-ground concrete dry well, one pump, piping, valving and control instrumenation. Construction cost estimates also included such variables as excavation, concrete and reinforcing steel.

Operation and Maintenance Cost. The operation and maintenance costs for the pump station include labor, materials and energy. Each of these costs is discussed below.

- LABOR

  Labor requirements for operation and maintenance of the pump station are based upon one hour of maintenance per week of operation. A rate of $6.00 per hour plus a 15 percent indirect labor charge (to cover the cost of employee fringe benefits) is used in determining labor costs.

- MATERIALS

  Annual material costs for operation and maintenance of the pump station are assummed to be equal to 3 percent of the initial capital cost.

- ENERGY

  Electrical energy requirements for the pump station are based upon pump motor horsepower requirements. Electrical cost is calculated based upon a charge of $0.033 per kilowatt-hour.

Countercurrent Rinsing

Countercurrent rinsing is included in the model technology train to reduce the volume of the surface preparation wastewater streams to levels necessary to allow LS&F end-of-pipe technology to be applied. Countercurrent rinsing requires additional rinse tanks or spray equipment and plumbing as compared to single-stage rinses, and extension of materials handling equipment or provision of additional manpower for rinse operation.

Capital Cost. Cost estimates for countercurrent rinsing are based upon installation of a three stage system on each of the individual waste streams associated with surface preparation.. The installation cost is small for a new source. Cost estimates included such variables as tank costs, recycle pump and motor costs, piping, valving, and control instrumentation costs.

The investment cost curve used is the equalization tank curve (Figure VIII-25, page 356). These costs include mixers, pumps, and installation. The motor costs needed for countercurrent rinse are estimated equal to the mixer costs.

Operation and Maintenance Cost. The operation and maintenance costs associated with countercurrent rinsing include labor, materials and energy. Each of these costs is discussed below.

- LABOR

  Labor requirements for operation and maintenance of the pump station are based upon one hour of maintenance per week of operation for each process line associated with surface preparation. A rate of $6.00 per hour plus a 15 percent indirect labor charge (to cover the cost of employee fringe benefits) is used in determining labor costs.

- MATERIALS

  Annual material costs for operation and maintenance of each countercurrent rinsing system are assumed to be 3 percent of the initial system capital cost.

- ENERGY

  The energy requirement curve used is the equalization tank curve (Figure VIII-26 page 357). Electrical energy requirements for each countercurrent rinsing system are based upon recirculation pump motor horsepower requirements. Electrical cost is calculated based upon a charge of $0.034 per kilowatt-hour.

TREATMENT SYSTEM COST ESTIMATES

This section presents estimates of the total cost of wastewater treatment and control systems for porcelain enameling process wastewater incorporating the treatment and control components discussed above. Cost estimates for the normal plant (defined earlier in this section) flow rate in the subcategory addressed are presented for BPT, BAT and BDT systems in order to provide an indication of the costs to be incurred in implementing each level of treatment. Raw wastewater characteristics were determined based on sampling data as discussed in Section V.

The system costs presented include component costs as discussed above and subsidiary costs including engineering, line segregation, piping, yardwork, administration, contingency and interest expenses during construction. In developing cost estimates, it is assumed that none of the specified treatment and control measures are in place so that the presented costs represent total costs for the systems.

System Cost Estimates (BPT)

This section presents the system cost estimates for the BPT end-of-pipe treatment systems for a normal plant in each subcategory.

The representative end-of-pipe treatment systems for the steel, aluminum, and cast iron subcategories are depicted in Section IX of the document. The chemical reduction of chromium is shown as an optional treatment process. The use of this treatment component is determined by the production processes being employed at the plant. All subcategories have chemical (lime) precipitation and settling (clarifier) followed by vacuum filtration.

The costing assumptions for each component of the BPT system were discussed above under Technology Costs and Assumptions. In addition to these components, contractor sludge removal was included in all cost estimates.

Table VIII-6 (page 327) presents costs for the three subcategories, steel, cast iron, and aluminum. The basic cost elements used in preparing these tables are: investment, annual capital costs, annual depreciation, annual operations and maintenance cost (less energy cost), energy cost, and total annual cost. These elements were discussed in detail earlier in this section.

For the cost computations, a least cost treatment system selection was performed. This procedure calculated the costs for a batch tretment system, a continuous treatment system, and haulaway of the complete wastewater flow over a 10 year comparison period, and the least expensive system was selected for presentation in the system cost tables. The various investment costs assume that the treatment system must be especially constructed and include all subsidiary costs discussed under the Cost Breakdown Factors segment of this section. Operation and maintenance costs assume continuous operation, 24 hours a day, 5 days per week, for 52 weeks per year.

System Cost Estimates (BAT)

The BAT system calls for reduction of the plant discharge flow rate by reuse of water equivalent to all coating water requirements except ball mill wash out. Total flow through the treatment system remains the same as for the BPT system.

The representative treatment system for the steel, cast iron, and aluminum subcategories are shown in Section X. The chemical reduction of chromium is shown as an optional treatment process. For a portion of the treated wastewater can be recycled back to the ball milling process. This will result in a reduction of the total plant discharge flow.

Table VIII-7 presents the BAT treatment system costs for construction of the entire system. These costs would be representative of expenditures to be expected for a plant with no treatment in place to attain the BAT level of treatment.

System Cost Estimates - (New Sources)

The treatment system for NSPS is based on the BAT system with the addition of three stage countercurrent rinsing for each metal preparation rinsing operation, and a filter added to the end-of-pipe system after the holding tank.

Table VIII-8 presents treatment system costs for construction of the NSPS system for each subcategory, including copper.

Use of Cost Estimation Results

Cost estimates presented in the tables in this section are representative of costs typically incurred in implementing treatment and control equivalent to the specified levels. They will not, in general, correspond precisely to cost experience at any individual plant. Specific plant conditions such as age, location, plant layout, or present production and treatment practices may yield costs which are either higher or lower than the presented costs. Because the BPT costs shown are total system costs and do not assume any treatment in place, it is probable that most plants will require smaller expenditures to reach the specified levels of control from their present status.

The actual costs of installing and operating a BPT system at a particular plant may be substantially lower than the tabulated values. Reductions in investment and operating costs are possible in several areas. Design and installation costs may be reduced by using plant workers. Equipment costs may be reduced by using or modifying existing equipment instead of purchasing all new equipment. Application of an excess capacity factor, which increases the size of most equipment foundation costs could be reduced if an existing concrete pad or floor can be utilized. Equipment size requirements may be reduced by the ease of treatment (for example, shorter retention time) of particular wastewater streams. Substantial reduction in both investment and operating cost may be achieved if a plant reduces its water use rate below that assumed in costing.

ENERGY AND NON-WATER QUALITY ASPECTS

Energy and non-water quality aspects of the wastewater treatment technologies described in Section VII are summarized in Tables VIII-9 and VIII-10 (Pages 330-331). Energy requirements are listed, the impact on environmental air and noise pollution is noted, and solid waste generation characteristics are summarized. The treatment processes are divided into two groups, wastewater treatment processes on Table VIII-9, and sludge and solids handling processes on Table VIII-10.

Energy Aspects

Energy aspects of the wastewater treatment processes are important because of the impact of energy use on our natural resources and on the economy. Electrical power and fuel requirements (coal, oil, or gas) are listed in units of kilowatt hours per ton of dry solids for sludge and solids handling. Specific energy uses are noted in the "Remarks" column.

Non-Water Quality Aspects

The Agency has considered the non-water quality impacts of each treatment process on air, noise, and radiation pollution of the environment to preclude the development of a more adverse environmental impact.

In general, none of the liquid handling processes causes air pollution. With sulfide precipitation, however, the potential exists for evolution of hydrogen sulfide, a toxic gas. Proper control of pH in treatment eliminates this problem. Alkaline chlorination for cyanide destruction and chromium reduction using sulfur dioxide also have potential atmospheric emissions. With proper design and operation, however, air pollution impacts are eliminated. None of the wastewater treatment processes causes objectionable noise and none of the treatment processes has any potential for radioactive radiation hazards.

The solid waste impact of each wastewater treatment process is indicated in two columns on Table VIII-10. The first column shows whether effluent solids are to be expected and, if so, the solids content in qualitative terms. The second column lists typical values of percent solids of sludge or residue.

The processes for treating the wastewaters from this category produce considerable volumes of sludges. In order to ensure long-term protection of the environment from harmful sludge constituents, special consideration of disposal sites should be made by the Resource Conservation and Recovery Act (RCRA) and municipal authorities where applicable.

TABLE VIII-6

BPT COSTS
NORMAL PLANT

	Steel	Cast Iron	Aluminum
Flow Rate (liters/hour)	16,465	149	3,563
Least Cost Operation Mode	Batch	Batch	Batch
Investment	$412,807	$70,007	$225,321
Annual Costs			
Capital Costs	25,902	4,393	14,138
Depreciation	41,281	7,001	22,532
Operation and Maintenance Costs (excluding energy and power costs)	102,923	9,666	29,990
Energy and Power Costs	2,280	10	1,010
Total Annual Costs	$172,386	$21,070	$67,670

TABLE VIII-7

BAT COSTS
NORMAL PLANT

	Steel	Cast Iron	Aluminum
Flow Rate (liters/hour)	13,625	139	2753
Least Cost Operation Mode	Batch	Batch	Batch
Investment	$431,717	$70,007	$239,958
Annual Costs			
Capital Costs	27,088	4,393	15,057
Depreciation	43,172	7,001	23,996
Operation and Maintenance Costs (excluding energy and power costs)	103,061	9,666	32,682
Energy and Power Costs	2,340	10	1,154
Total Annual Costs	$175,661	$21,070	$72,889

TABLE VIII-8

NSPS COSTS
NORMAL PLANT

	Steel	Cast Iron	Aluminum	Copper
Flow Rate (liters/hour)	4,276	149	1,089	154
Least Cost Operation Mode	Batch	Batch	Batch	Batch
Investment	$259,830	195,012	81,978	83,978
Annual Costs				
Capital Costs	16,303	12,236	5,144	5,269
Depreciation	25,983	19,501	8,198	8,398
Operation and Maintenance Costs (excluding energy and power costs)	30,950	24,156	9,978	9,978
Energy and Power Costs	807	975	10	10
Total Annual Costs	74,043	56,868	23,330	23,655

TABLE VIII-9

NONWATER QUALITY ASPECTS OF WASTE WATER TREATMENT

PROCESS	ENERGY REQUIREMENTS			NONWATER QUALITY IMPACT			
	Power kwh/1000 liters	Fuel	Energy Use	Air Pollution Impact	Noise Pollution Impact	Solid Waste	Solid Waste Concentration % Dry Solids
Chemical Reduction	1.0	——	Mixing	None	None	None	———
Skimming	0.01-.3	——	Skimmer Drive	None	None	Concentrated	5-50 (oil)
Clarification	0.1-3.2	——	Sludge Collector Drive	None	None	Concentrated	1-10
Flotation	1.0	——	Recirculation Pump, Compressor, Skim	None	None	Concentrated	3-5
Chemical	0.3	——	Mixing	None	None	None	———
Oxidation by Chlorine	0.5-5.0	——	Mixing	None	None	None	———
Oxidation By Ozone			Ozone Generation				
Chemical Precipitation	1.02	——	Flocculation Paddles	None	None	Concentrated	3-10
Sedimentation	0.1-3.2	——	Sludge Collector Drive	None	None	Concentrated	1-3
Deep Bed	0.10	——	Head, Backwash Pumps	None	None	Concentrated	Variable
Ion Exchange	0.5	——	Pumps	None	Not Objectionable	None	NA
Adsorption	0.1	——	Pumps, Evaporate During Regeneration	None	None Carbon	None/Waste	40
Evaporation	——	*2.5	Evaporate Water	None	None	Concentrated/ Dewatered	50-100
Reverse Osmosis	3.0	——	High Pressure Pump	None	Not Objectionable	Dilute Concentrate	1-40
Ultrafiltration	1.25-3.0	——	High Pressure Pump	None	Not Objectionable	Dilute Concentrate	1-40
Membrane Filtration	1.25-3.0		High Pressure Pump	None	Not Objectionable	Dilute Concentrate	1-40
Electrochemical	0.2-0.8	——	Reactifier, Pump	None	None	Concentrate	1-3
Chromium Reduction Electrochemical Chromium Regeneration	2.0	——	Regeneration, Pump	None	None	None	———

* 10^6 BTU/1000 liters

TABLE VIII-10

NONWATER QUALITY ASPECTS OF SLUDGE AND SOLIDS HANDLING

PROCESS	ENERGY REQUIREMENTS		NONWATER QUALITY IMPACT				
	Power kwh / ton dry solids	Fuel kwh / ton dry solids	Energy Use	Air Pollution Impact	Noise Pollution Impact	Solid Waste	Solid Waste Concentration % Dry Solids
Sludge Thickening	29-920	---	Skimmer, Sludge Rake Drive	None	None	Concentrated	4-27
Pressure Filtration	21	---	High Pressure Pumps	None	None	Dewatered	25-50
Sand Bed Drying	---	35	Removal Equipment	None	None	Dewatered	15-40
Vacuum Filter	16.7-66.8	---	Vacuum Pump, Rotation	None	Not Objectionable	Dewatered	20-40
Centrifugation	0.2-98.5	---	Rotation	None	Not Objectionable	Dewatered	15-50
Landfill	---	20-980	Haul, Landfill 1-10 Mile Trip	None	None	Dewatered	N/A
Lagooning	---	36	Removal Equipment	None	None	Dewatered	3-5

SIMPLIFIED LOGIC DIAGRAM
SYSTEM COST ESTIMATION PROGRAM

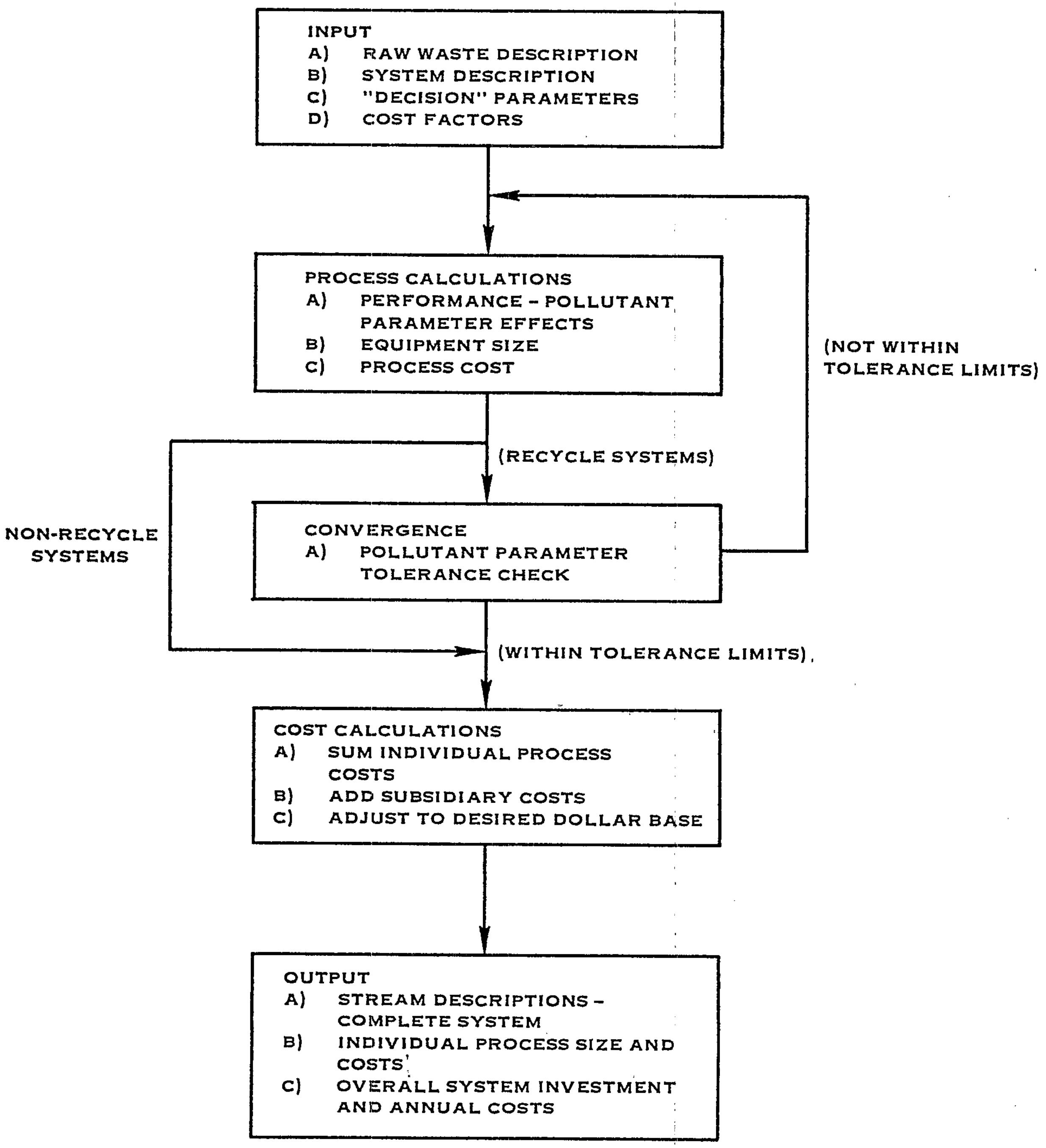


FIGURE VIII-1. COST ESTIMATION PROGRAM

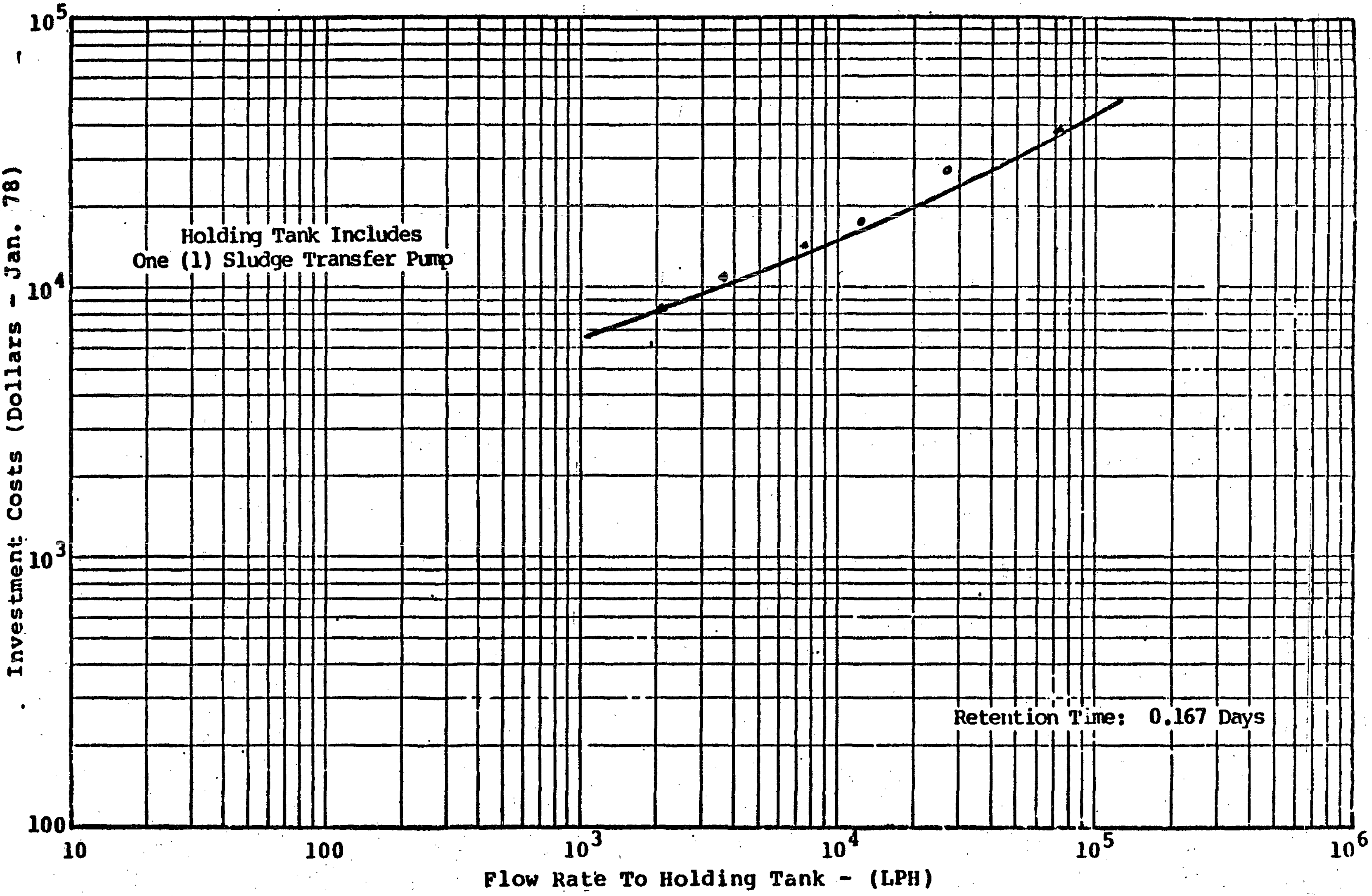


FIGURE VIII-2

HOLDING TANK INVESTMENT COSTS

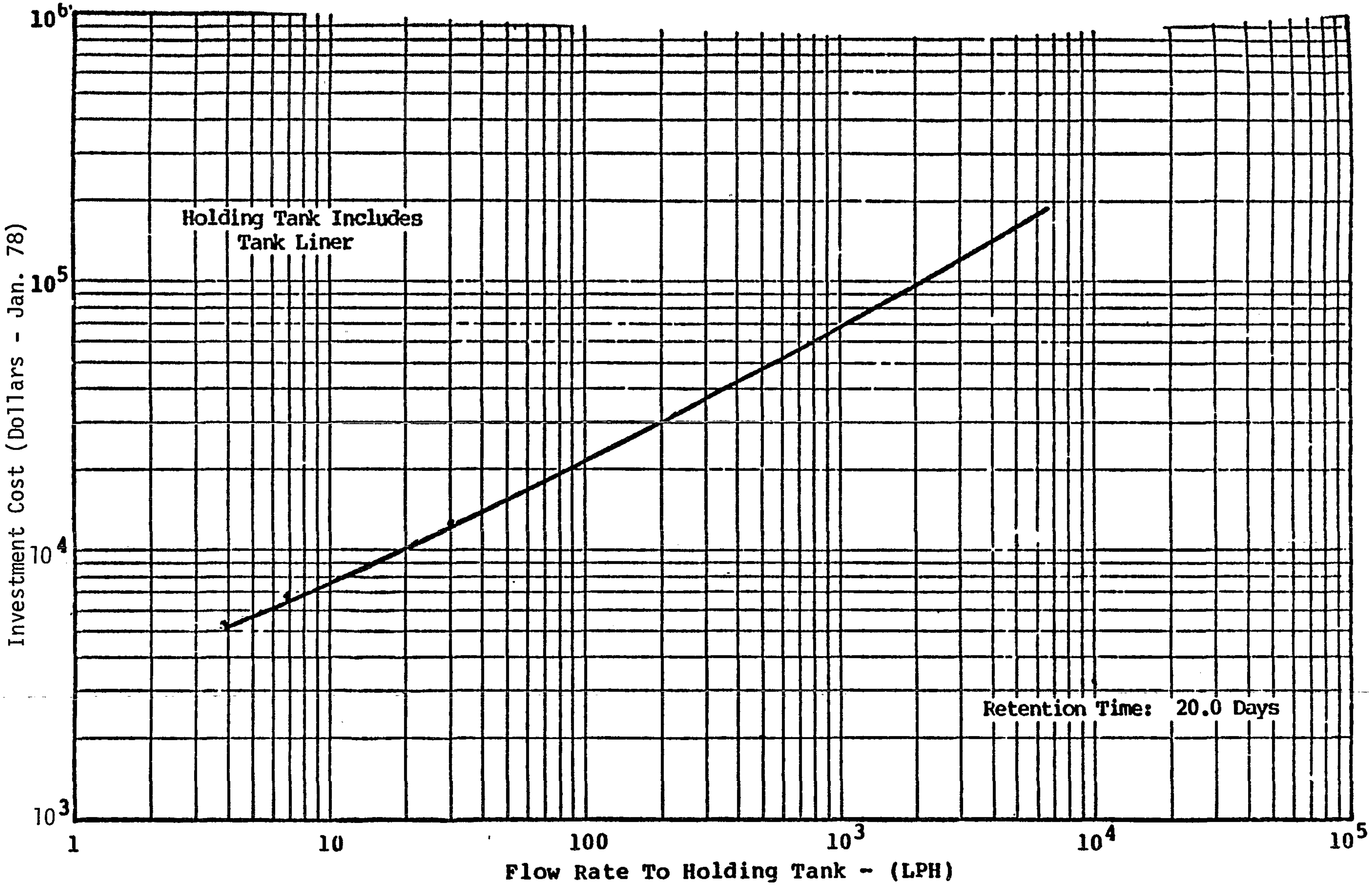
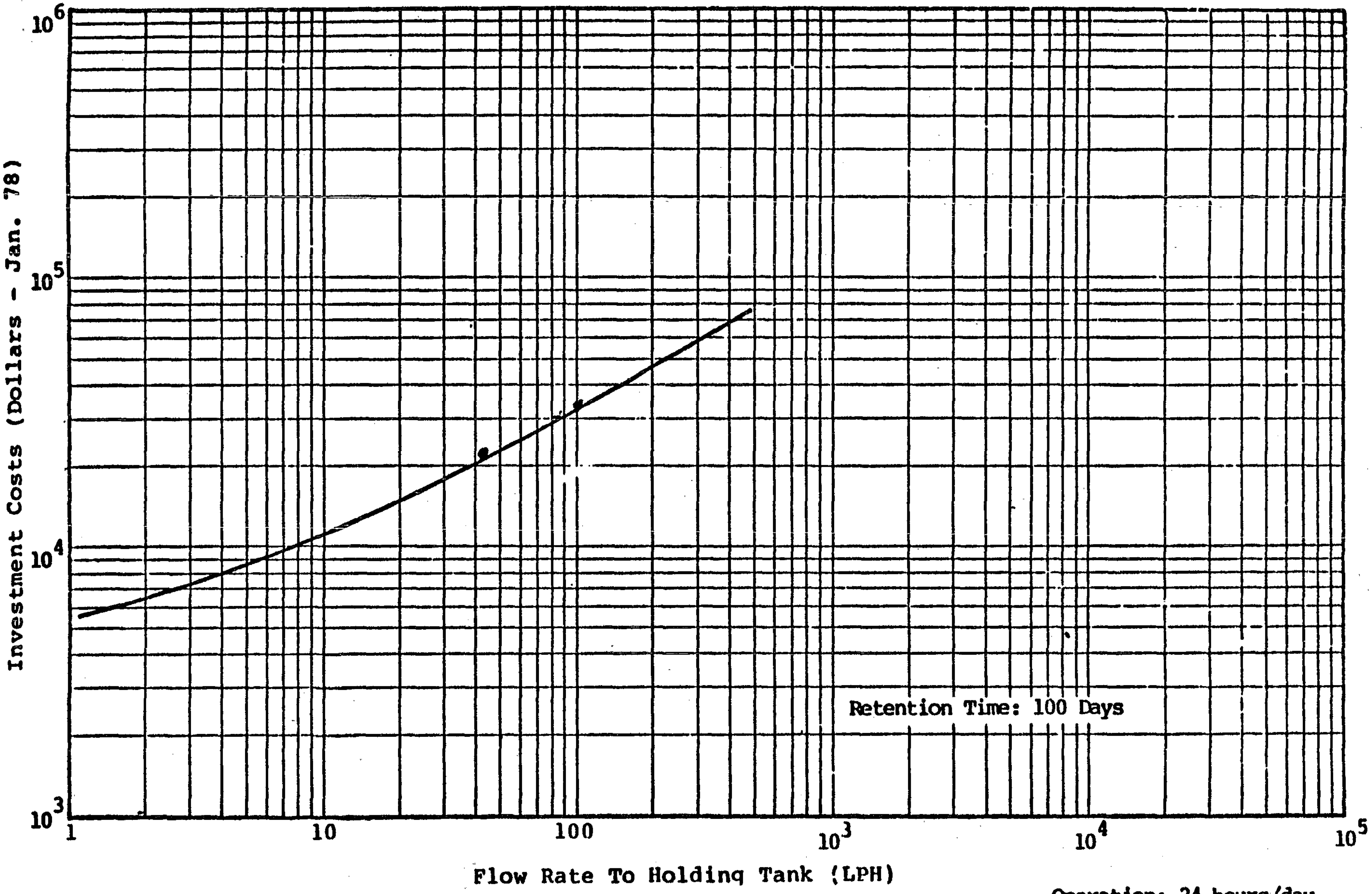


FIGURE VIII-3

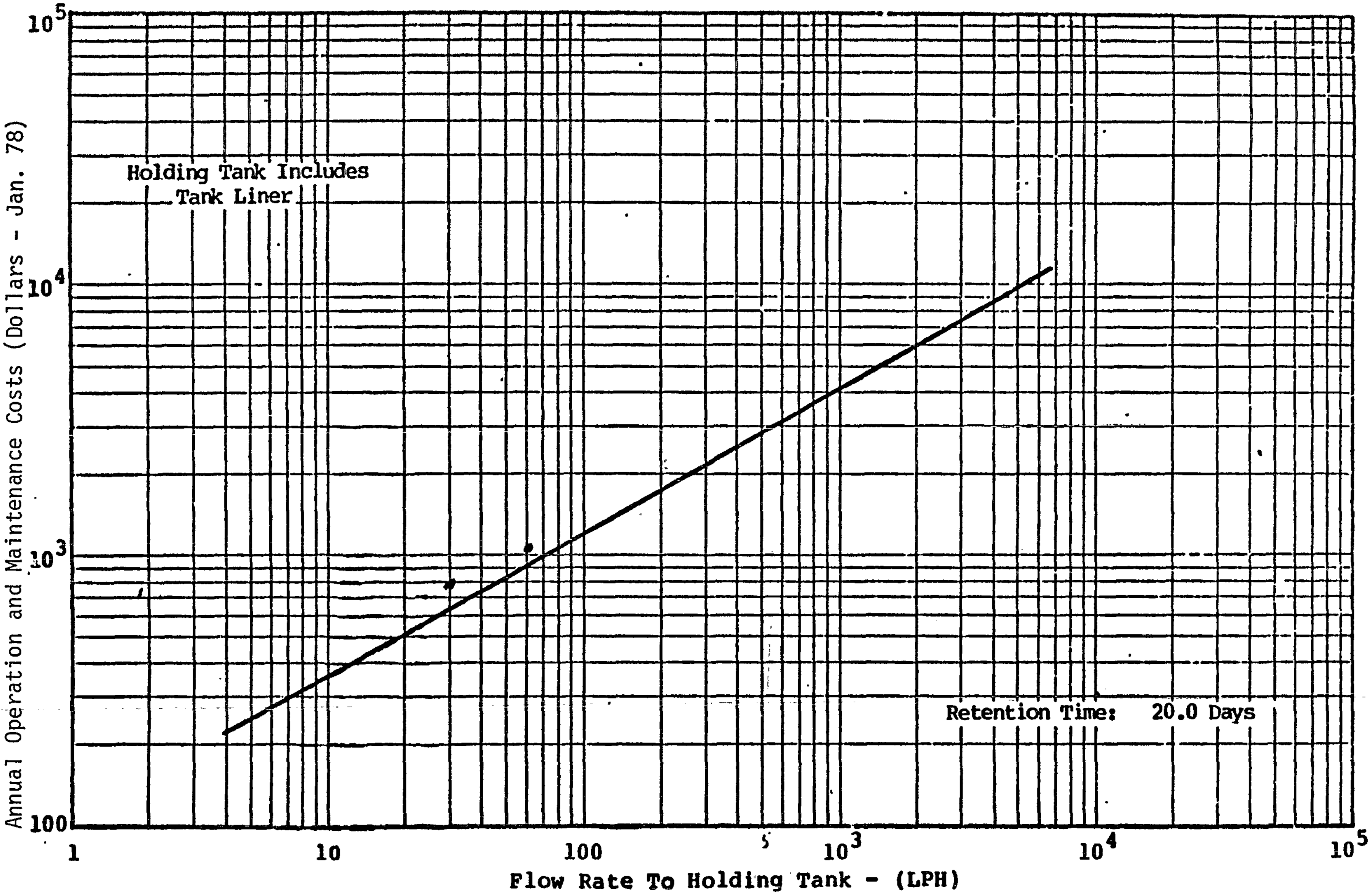
HOLDING TANK INVESTMENT COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII-4

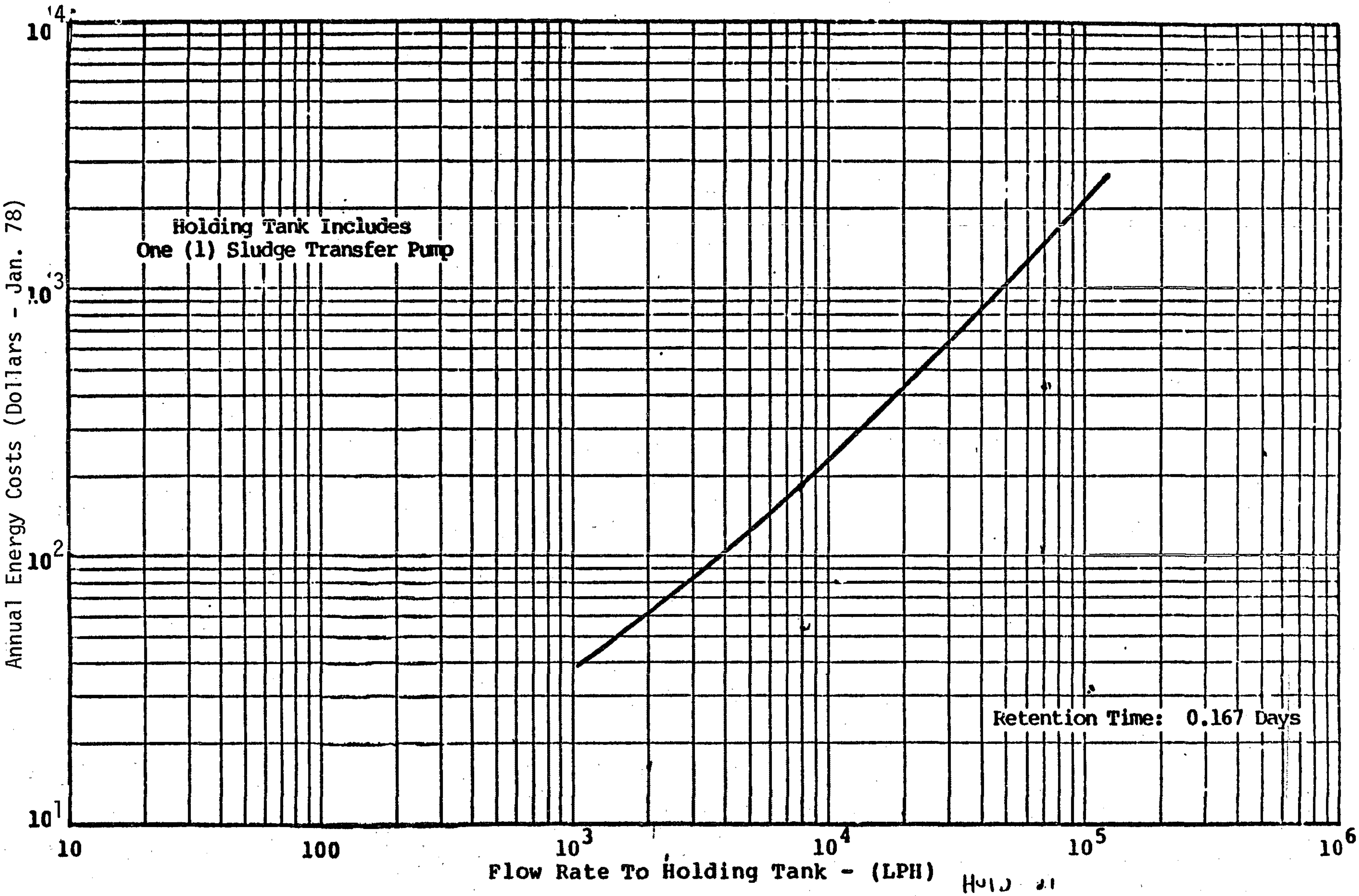
HOLDING TANK INVESTMENT COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII-5

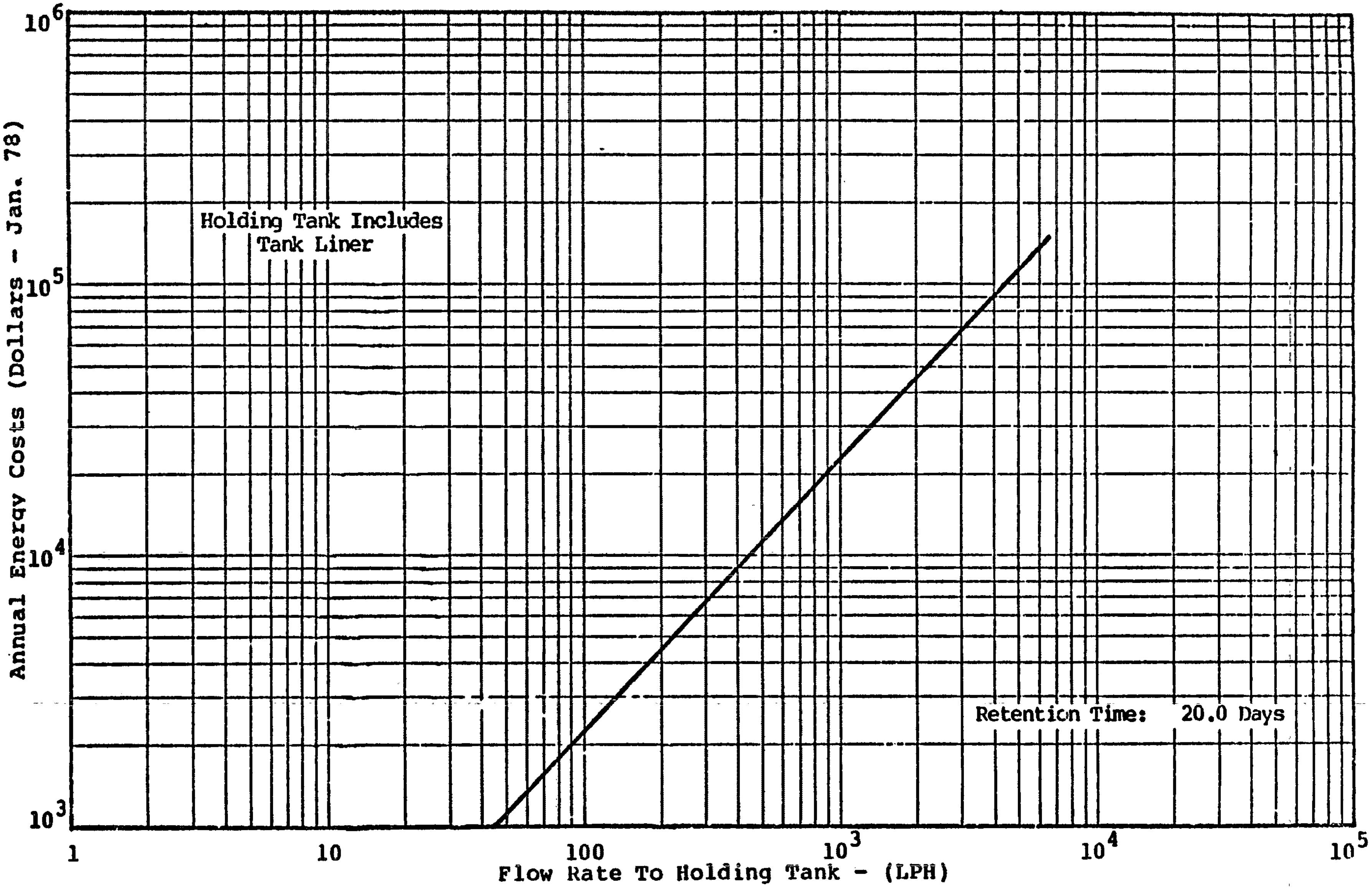
HOLDING TANK OPERATION AND MAINTENANCE COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII-6

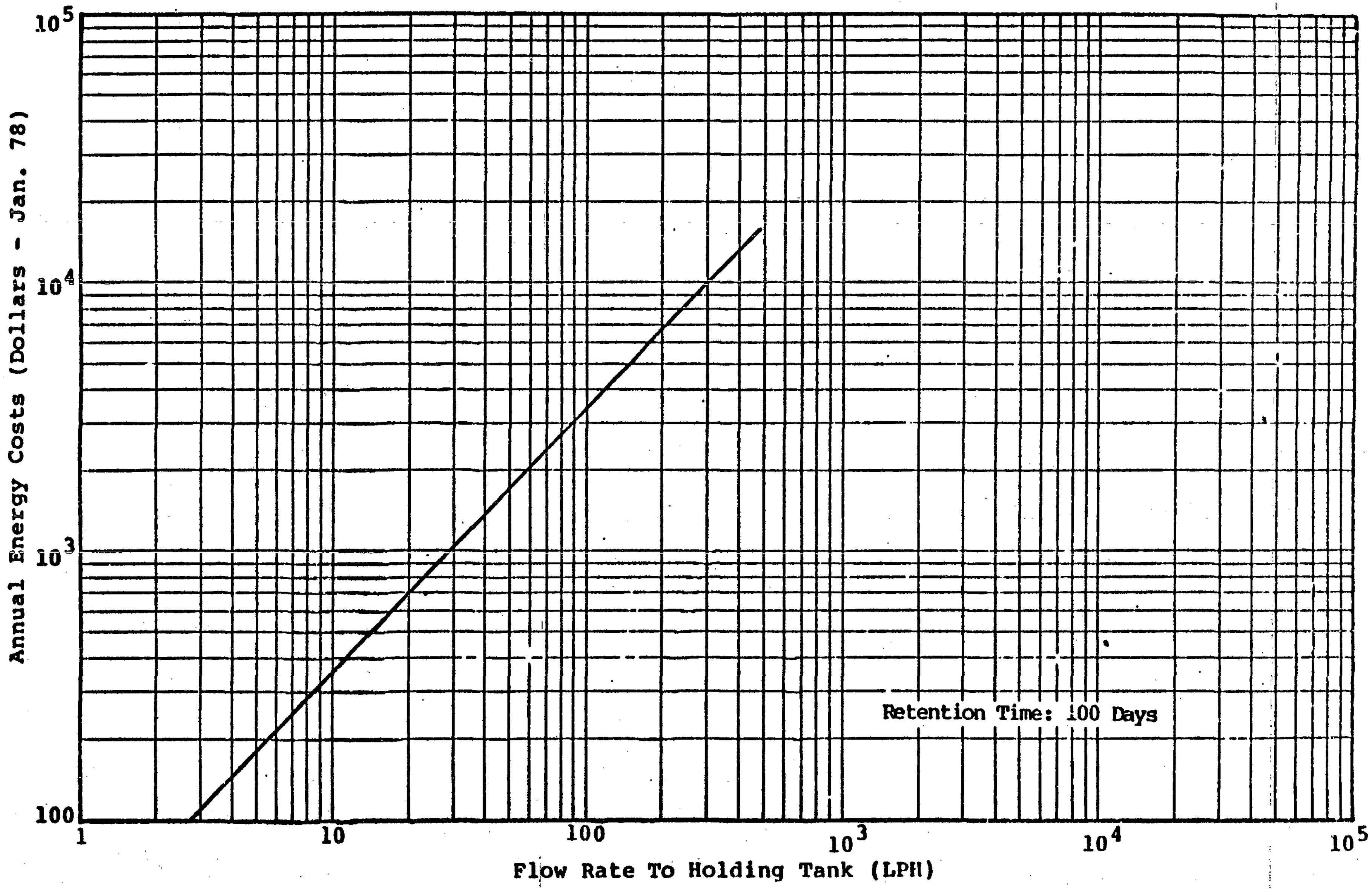
HOLDING TANK ENERGY COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII- 7

HOLDING TANK ENERGY COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII-8

HOLDING TANK ENERGY COSTS

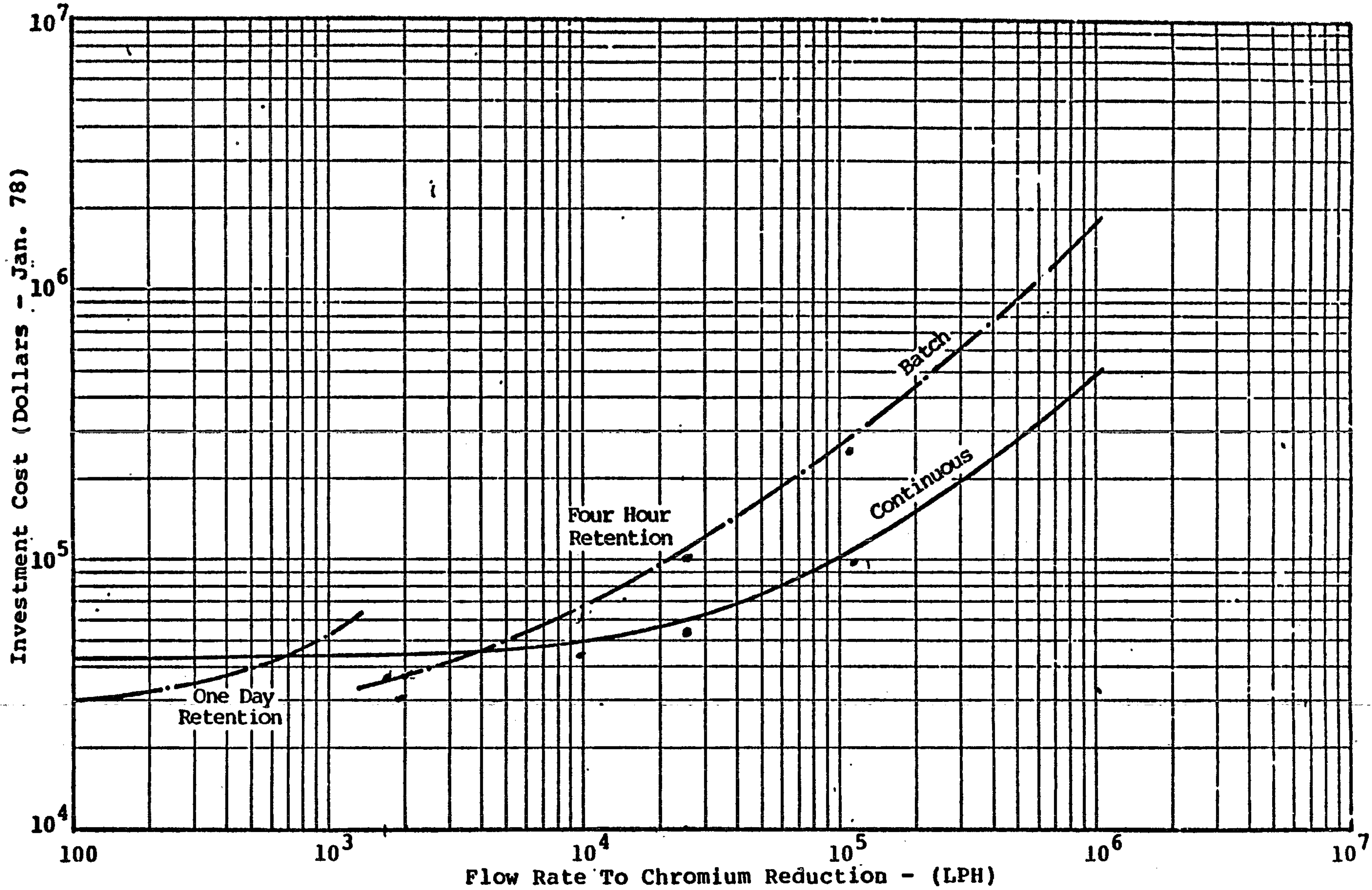
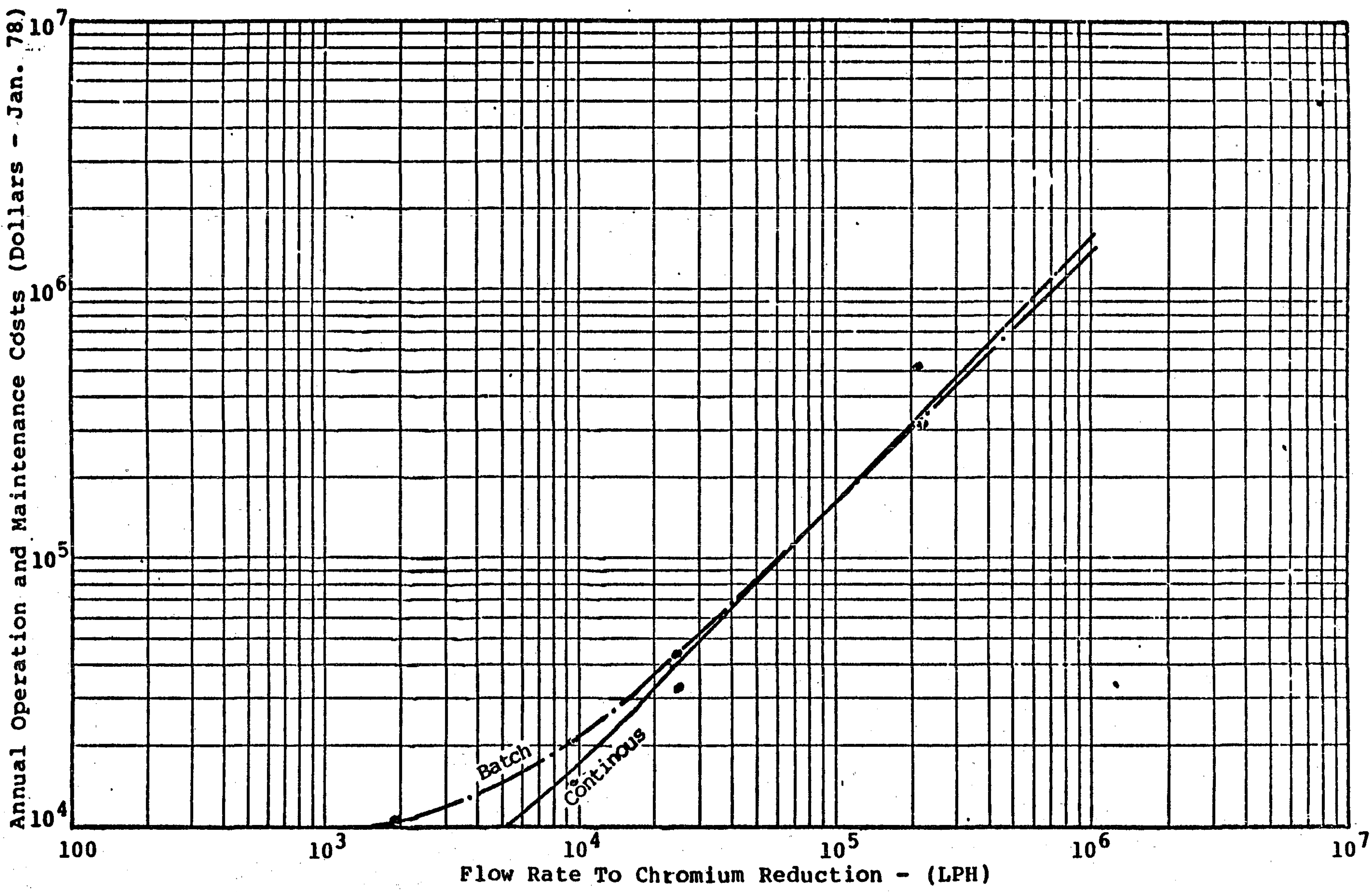


FIGURE VIII-9

CHROMIUM REDUCTION INVESTMENT COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII-10

CHROMIUM REDUCTION OPERATION AND MAINTENANCE COSTS

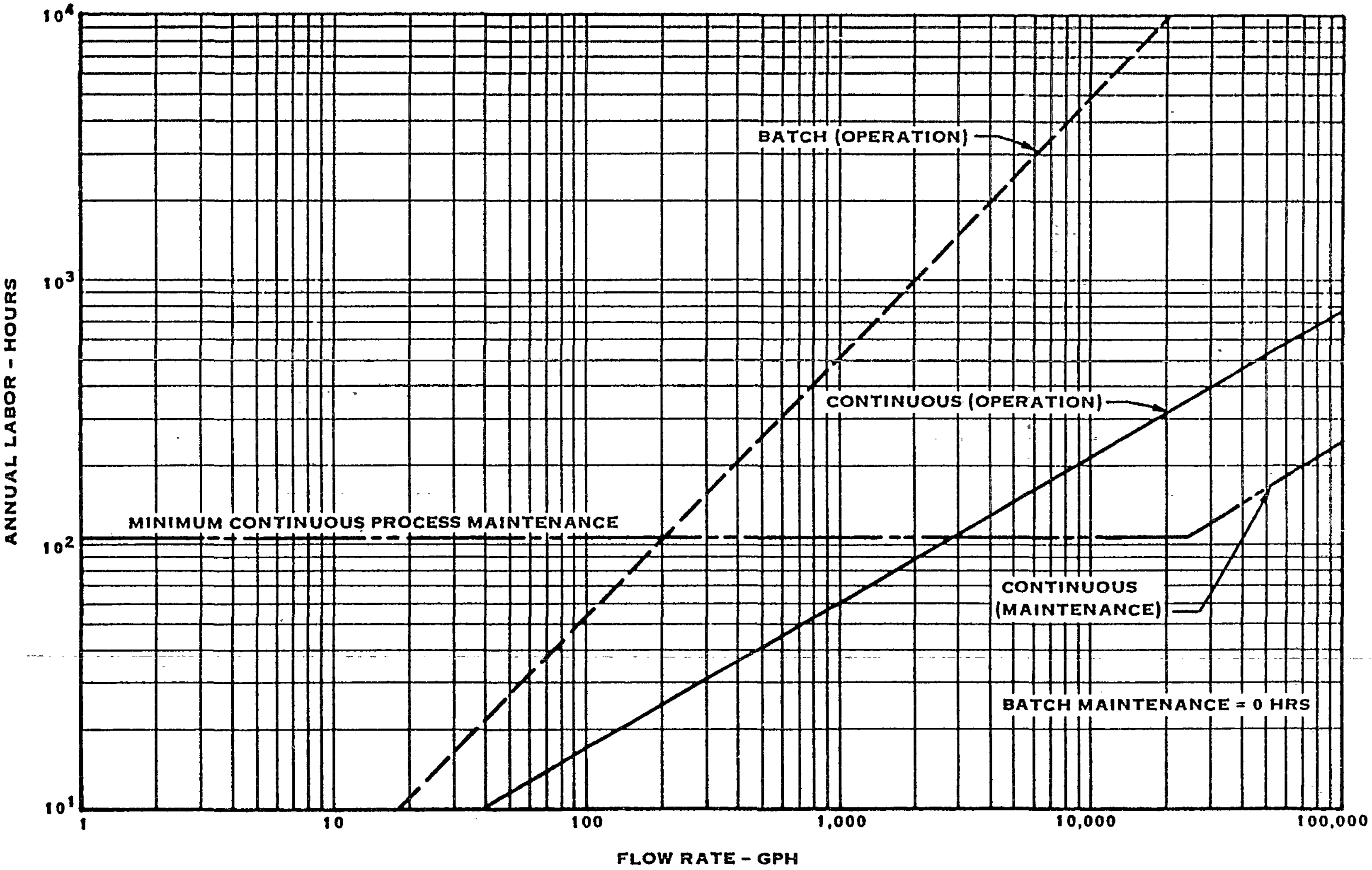
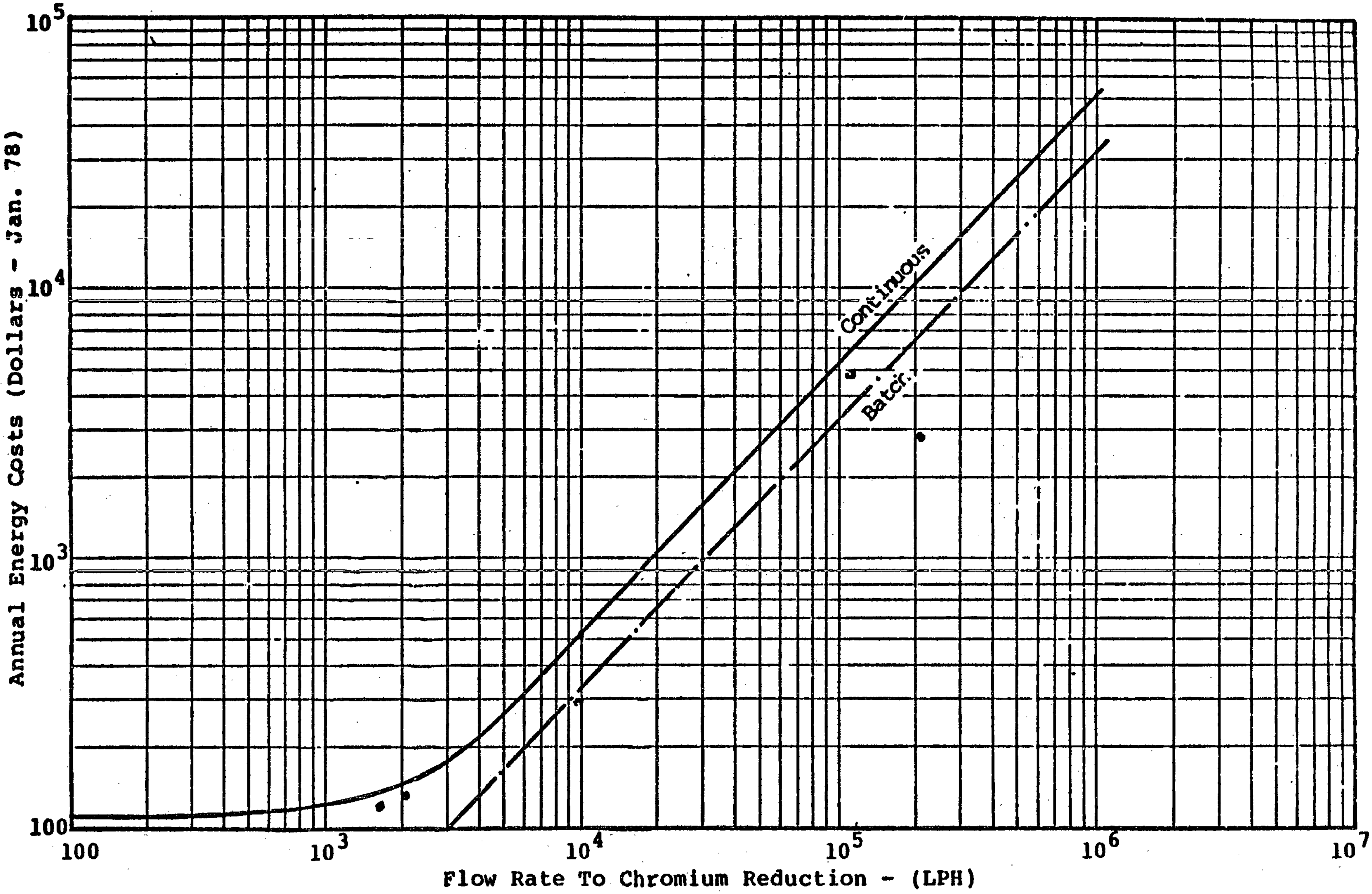


FIGURE VIII-11. **CHEMICAL REDUCTION OF CHROMIUM ANNUAL LABOR REQUIREMENTS**



Operation: 24 hours/day
260 days/year

FIGURE VIII-12

CHROMIUM REDUCTION ENERGY COSTS

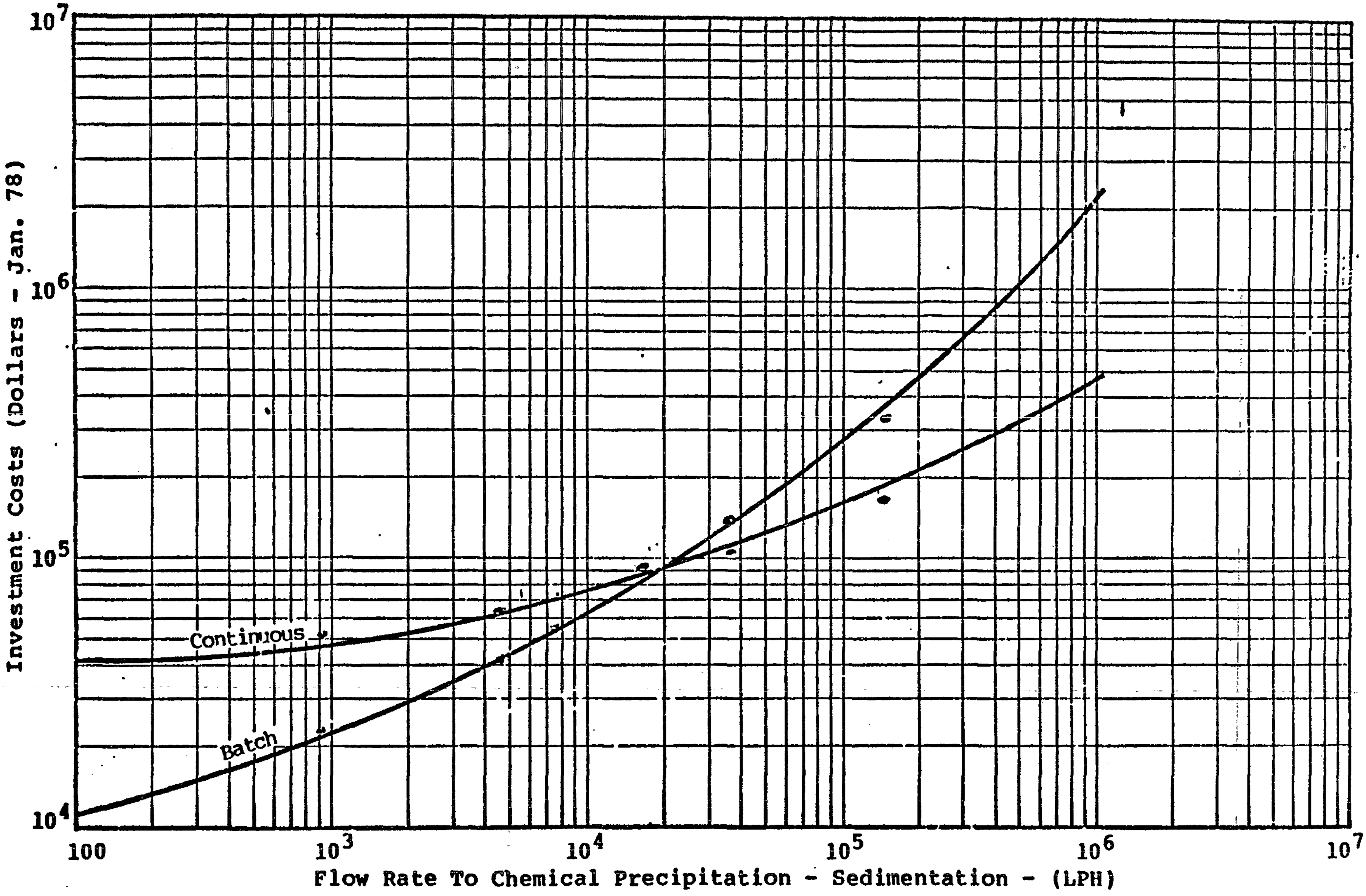
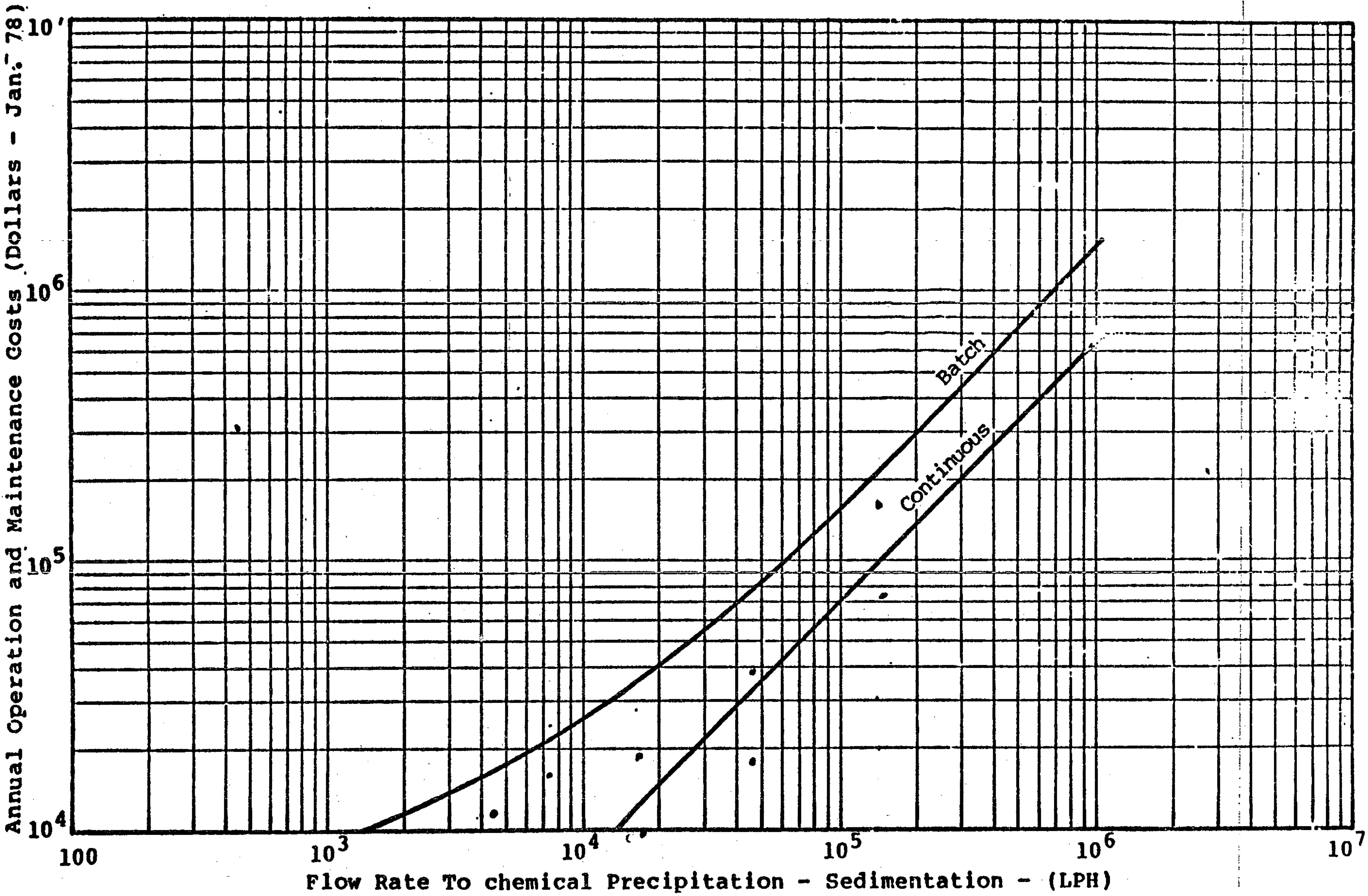


FIGURE VIII-13

CHEMICAL PRECIPITATION - SEDIMENTATION INVESTMENT COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII- 14

CHEMICAL PRECIPITATION - SEDIMENTATION OPERATION AND MAINTENANCE COSTS

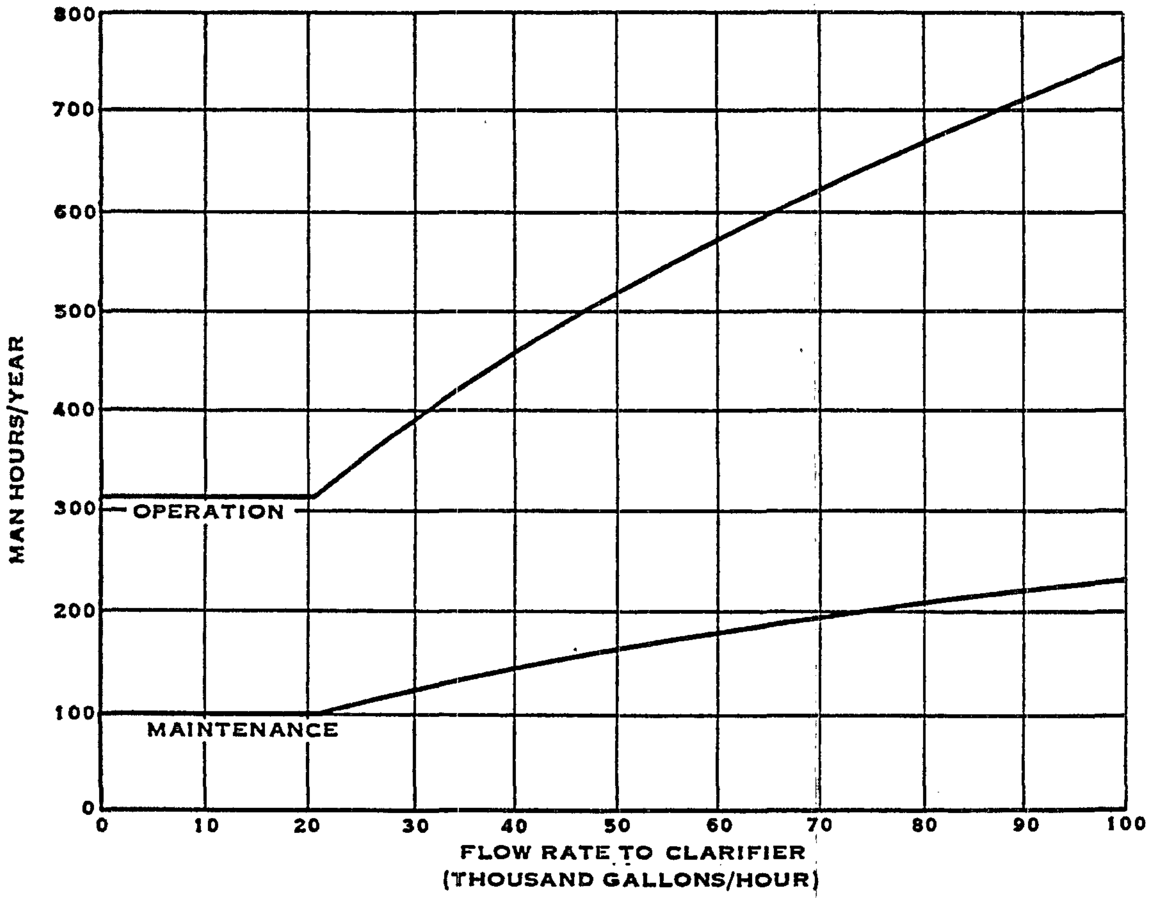
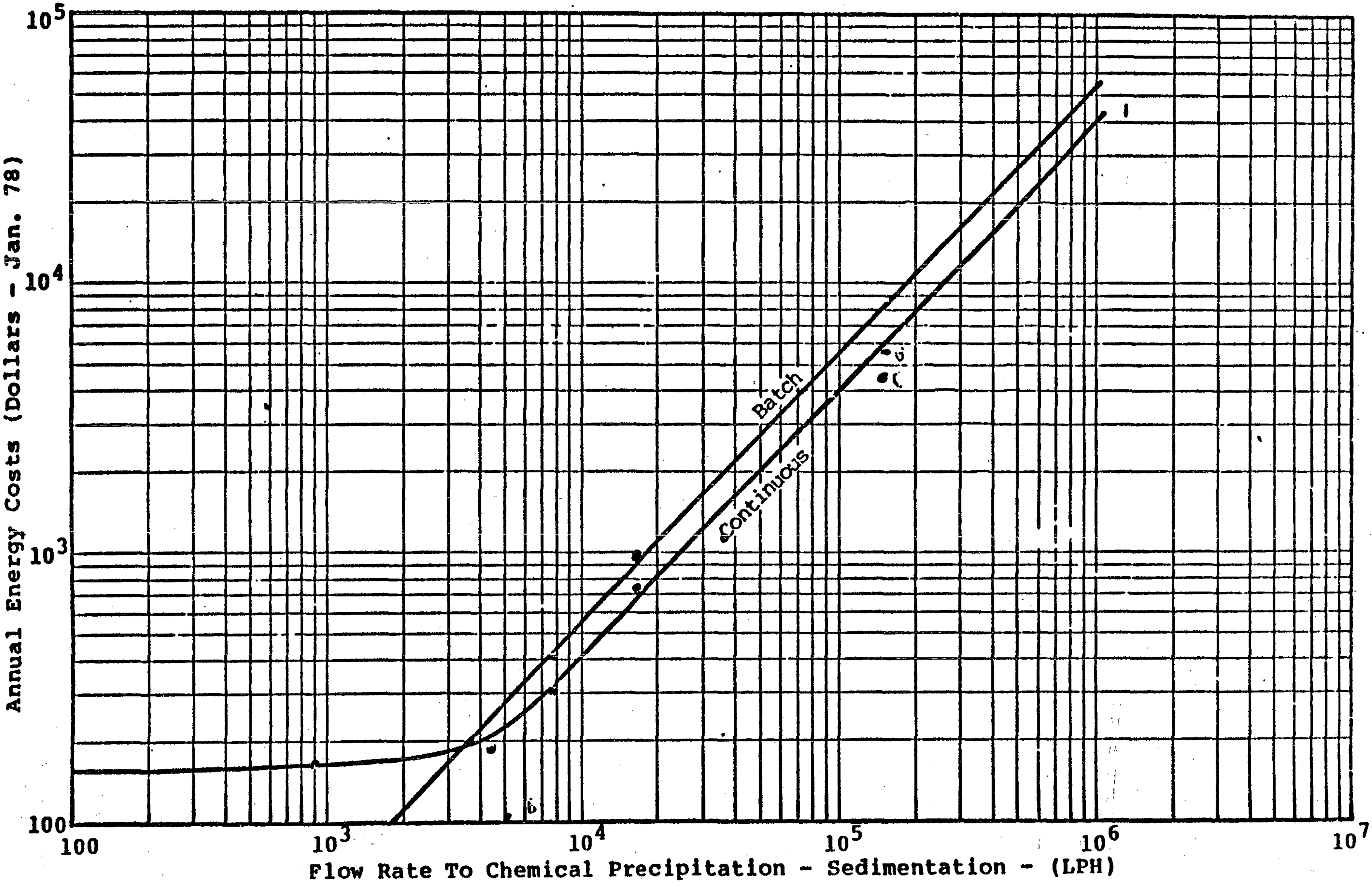


FIGURE VIII-15. CLARIFICATION MAN HOUR REQUIREMENTS FOR CONTINUOUS OPERATION



Operation: 24 hours/day
260 days/year

FIGURE VIII-16

CHEMICAL PRECIPITATION - SEDIMENTATION ENERGY COSTS

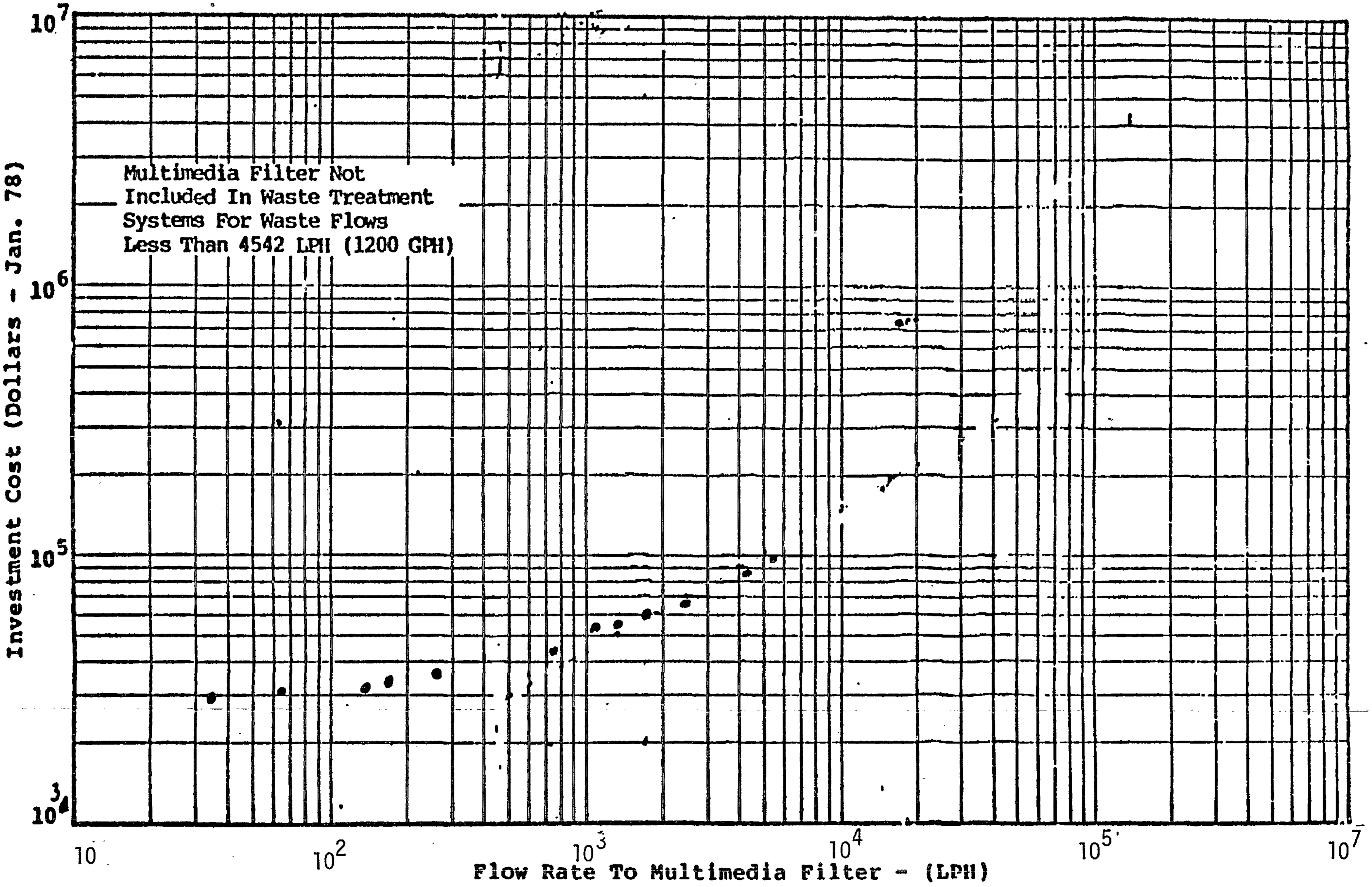


FIGURE VIII-17

MULTIMEDIA FILTER INVESTMENT COSTS

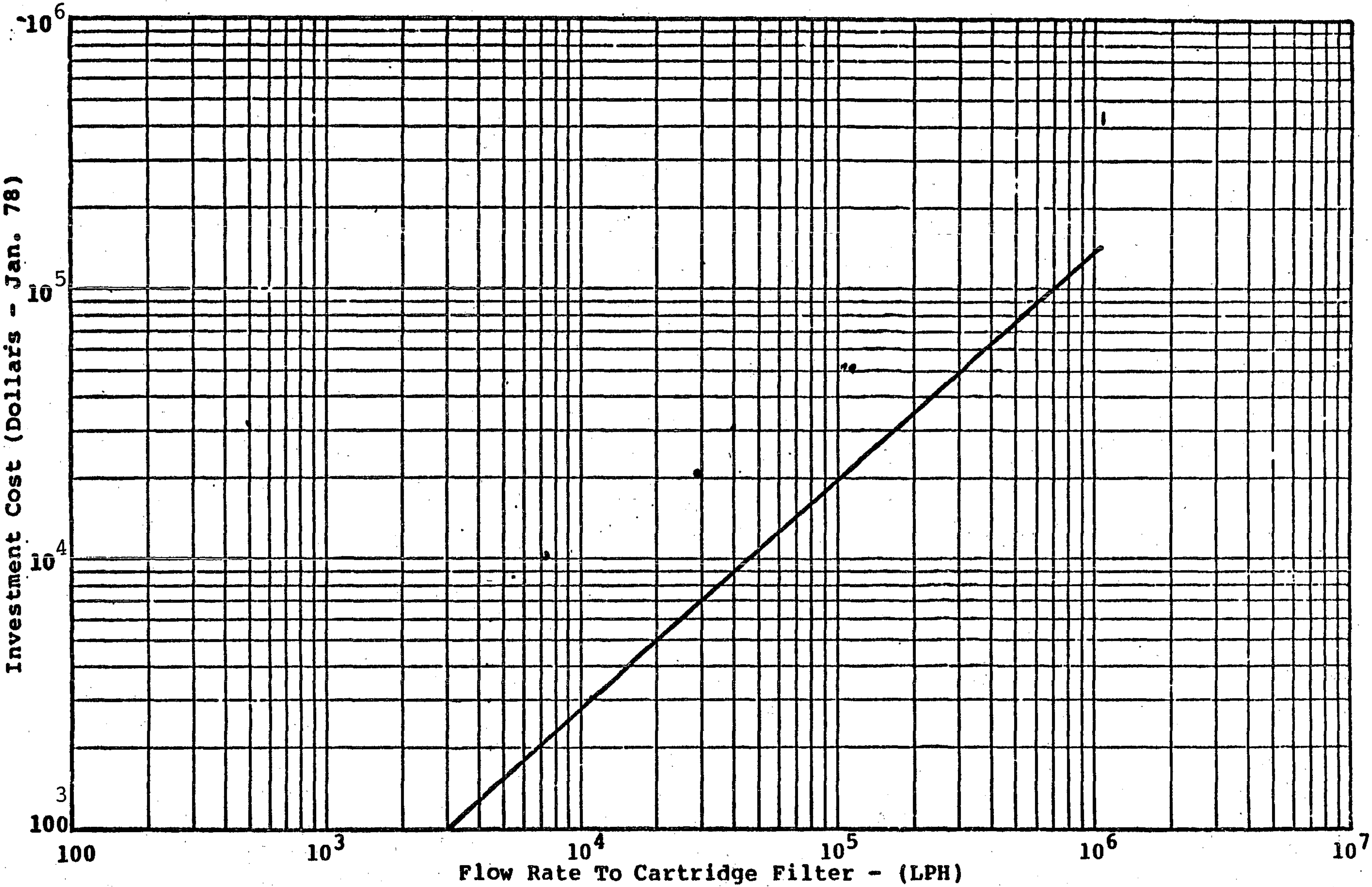
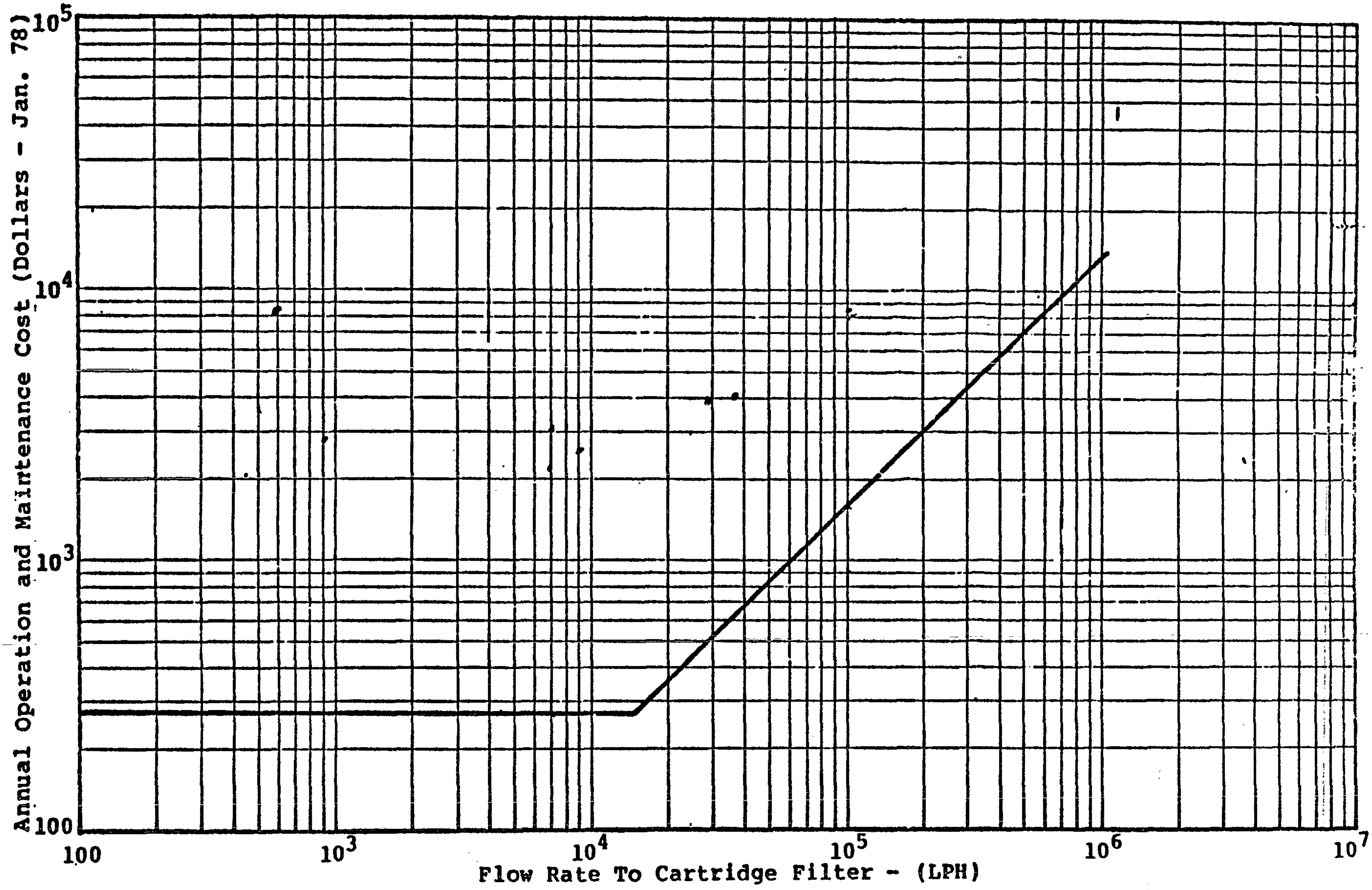


FIGURE VIII-18

CARTRIDGE FILTER INVESTMENT COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII-19

CARTRIDGE FILTER OPERATION AND MAINTENANCE COSTS

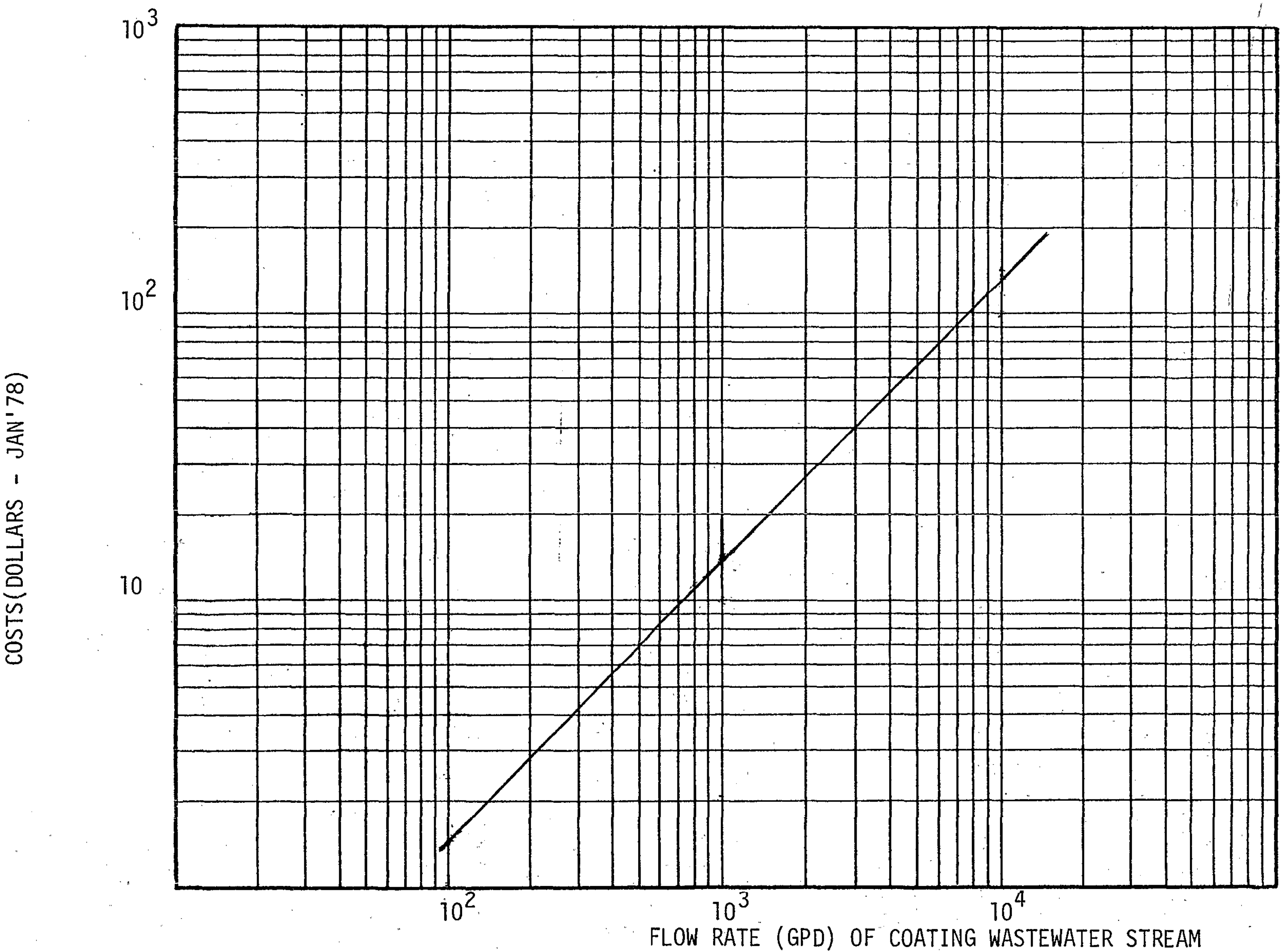


FIGURE VIII-20. CARTRIDGE FILTER OPERATION AND MAINTENANCE COSTS

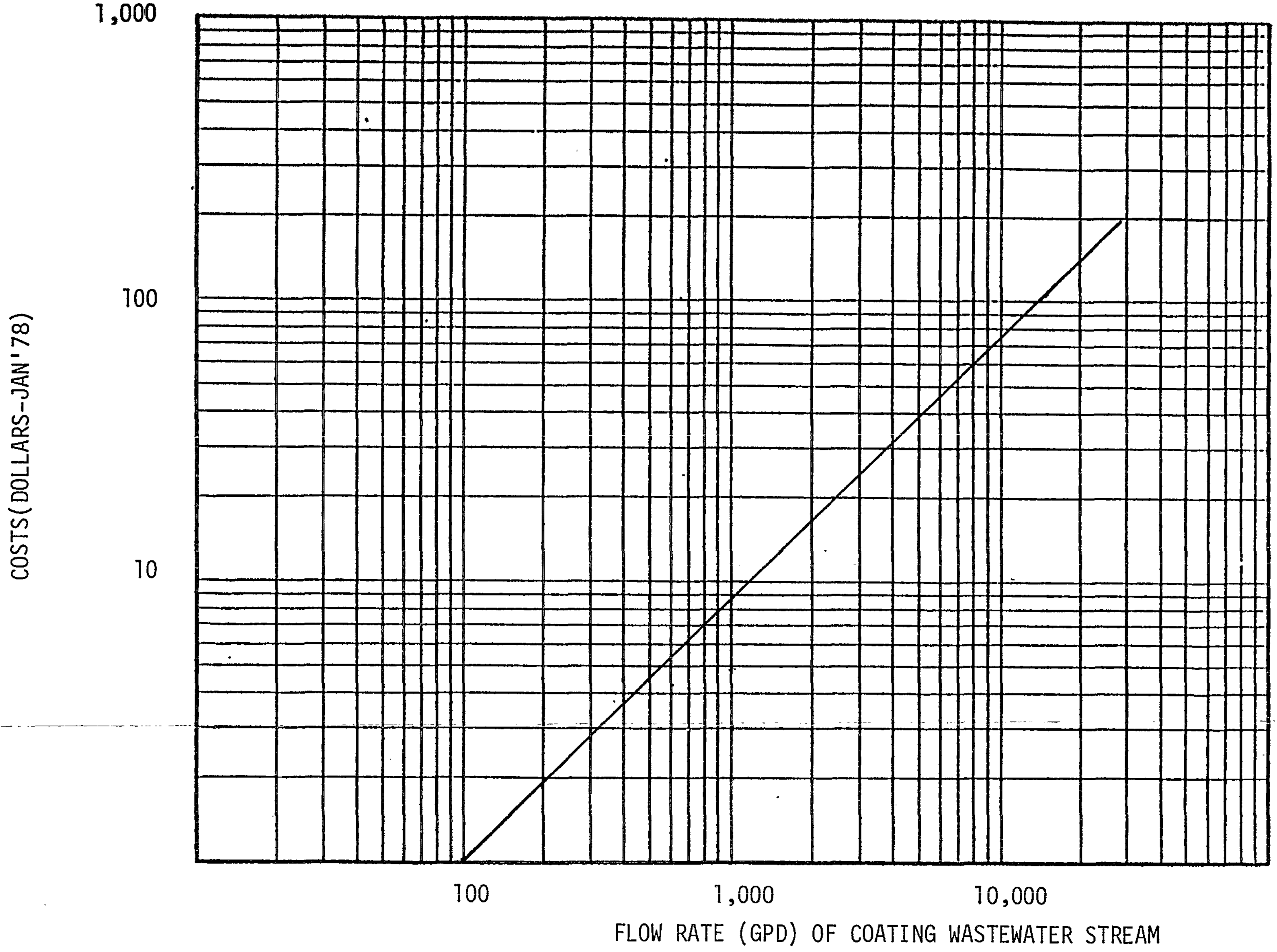


FIGURE VIII-21. CARTRIDGE FILTER OPERATION AND MAINTENANCE ENERGY REQUIREMENTS

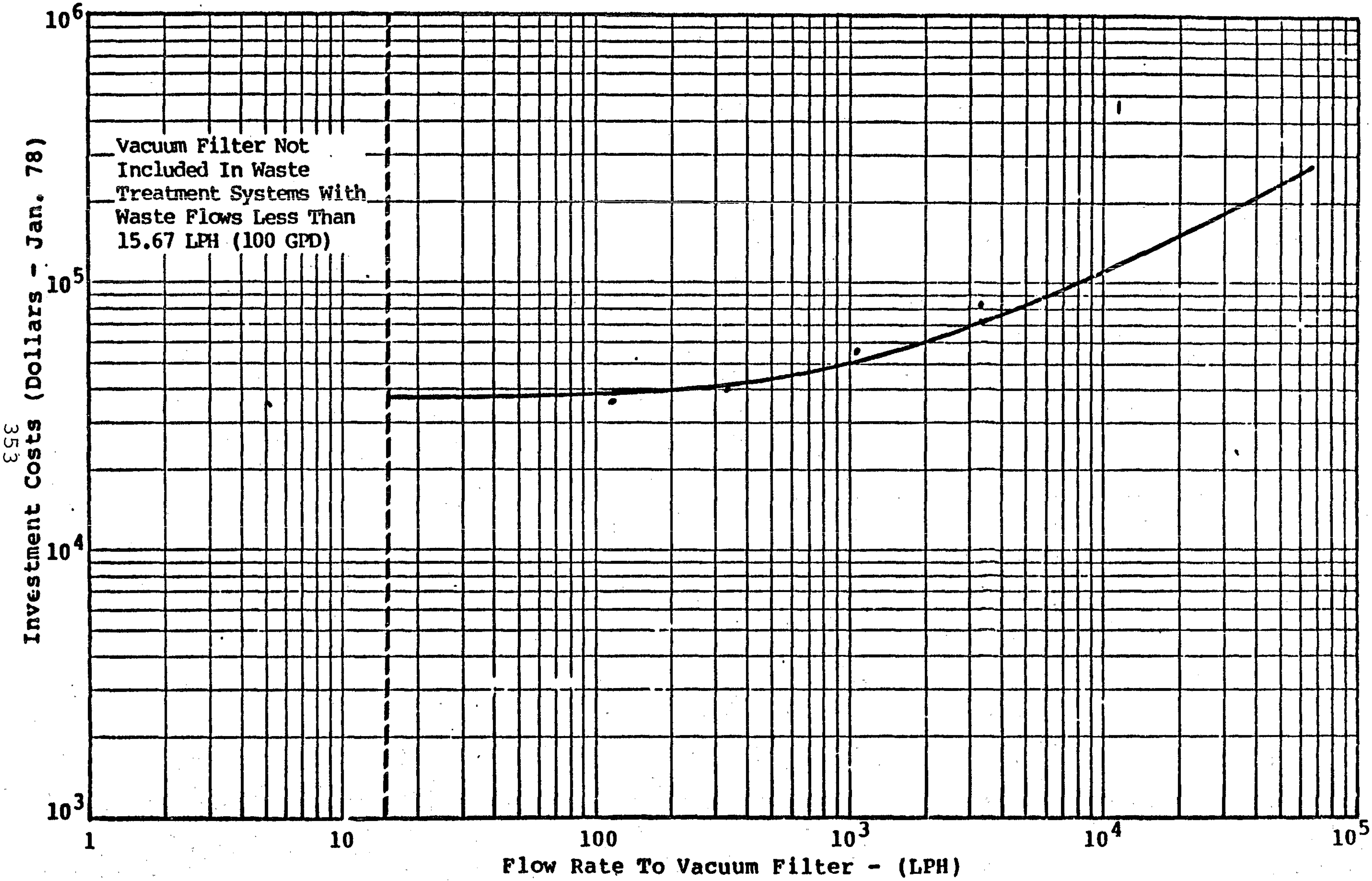
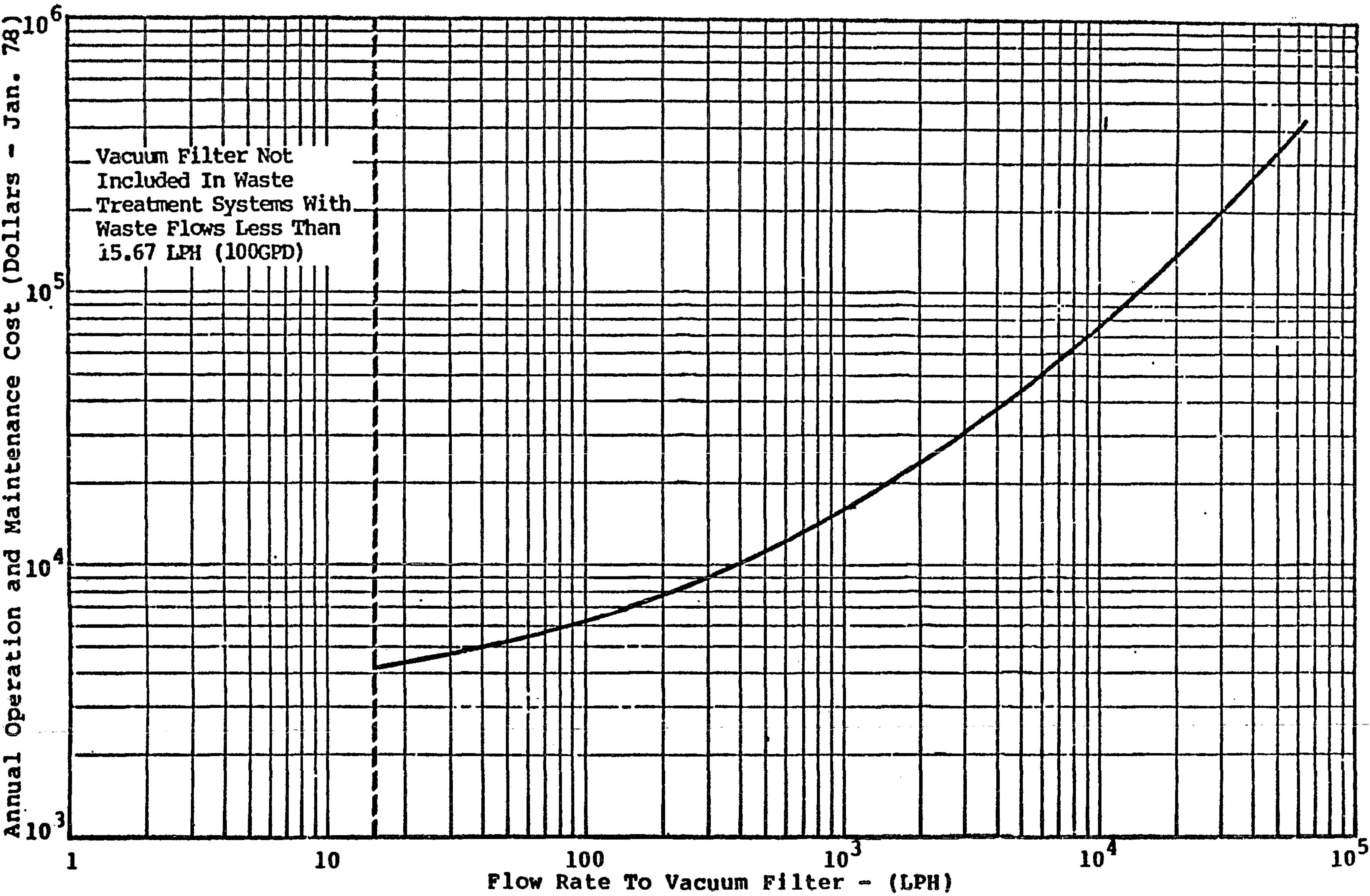


FIGURE VIII-22

VACUUM FILTER INVESTMENT COSTS



Operation: 24 hours/day
260 days/year

FIGURE VIII-23

VACUUM FILTER OPERATION AND MAINTENANCE COSTS

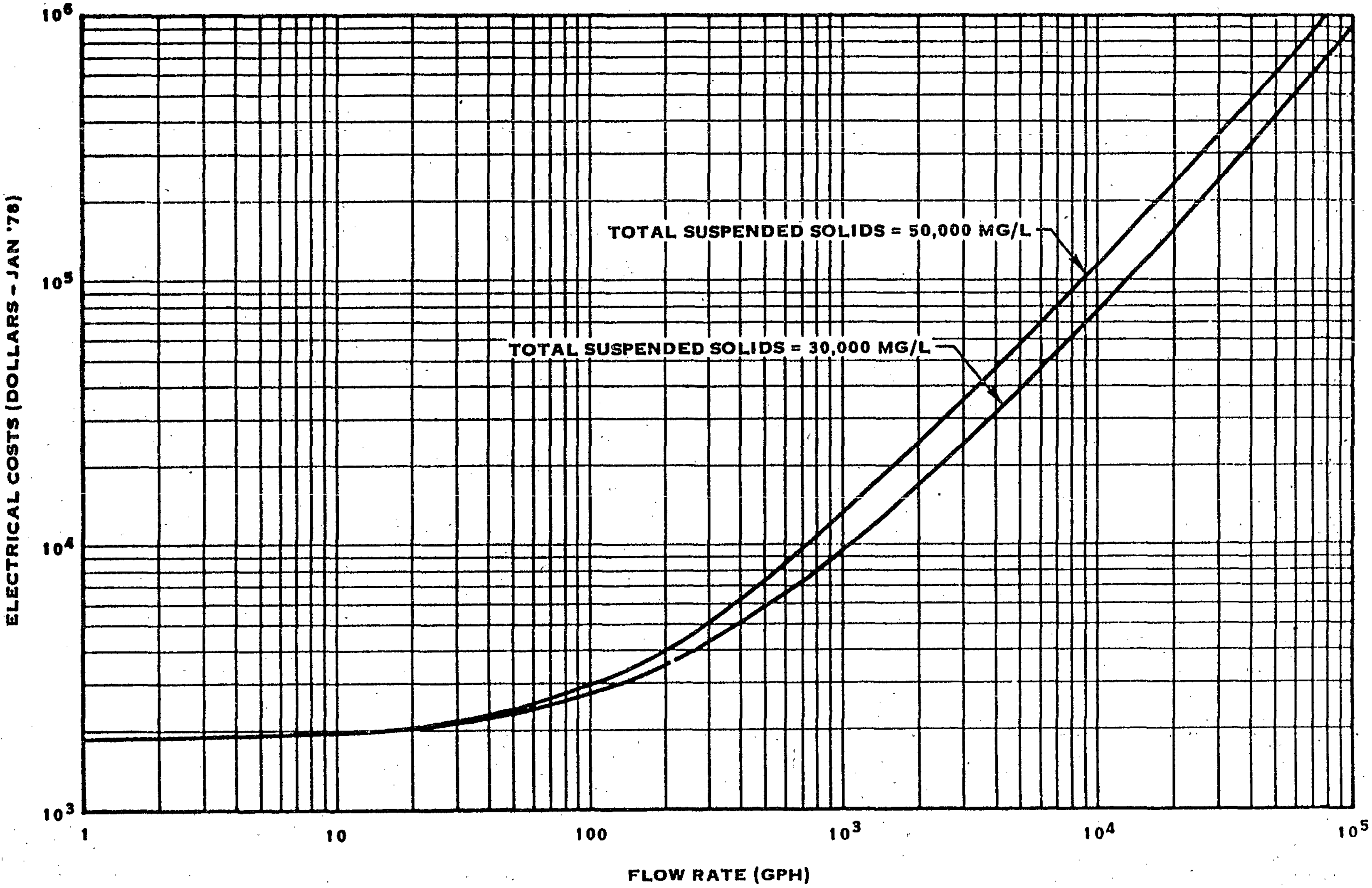


FIGURE VIII-24. VACUUM FILTRATION ELECTRICAL COST

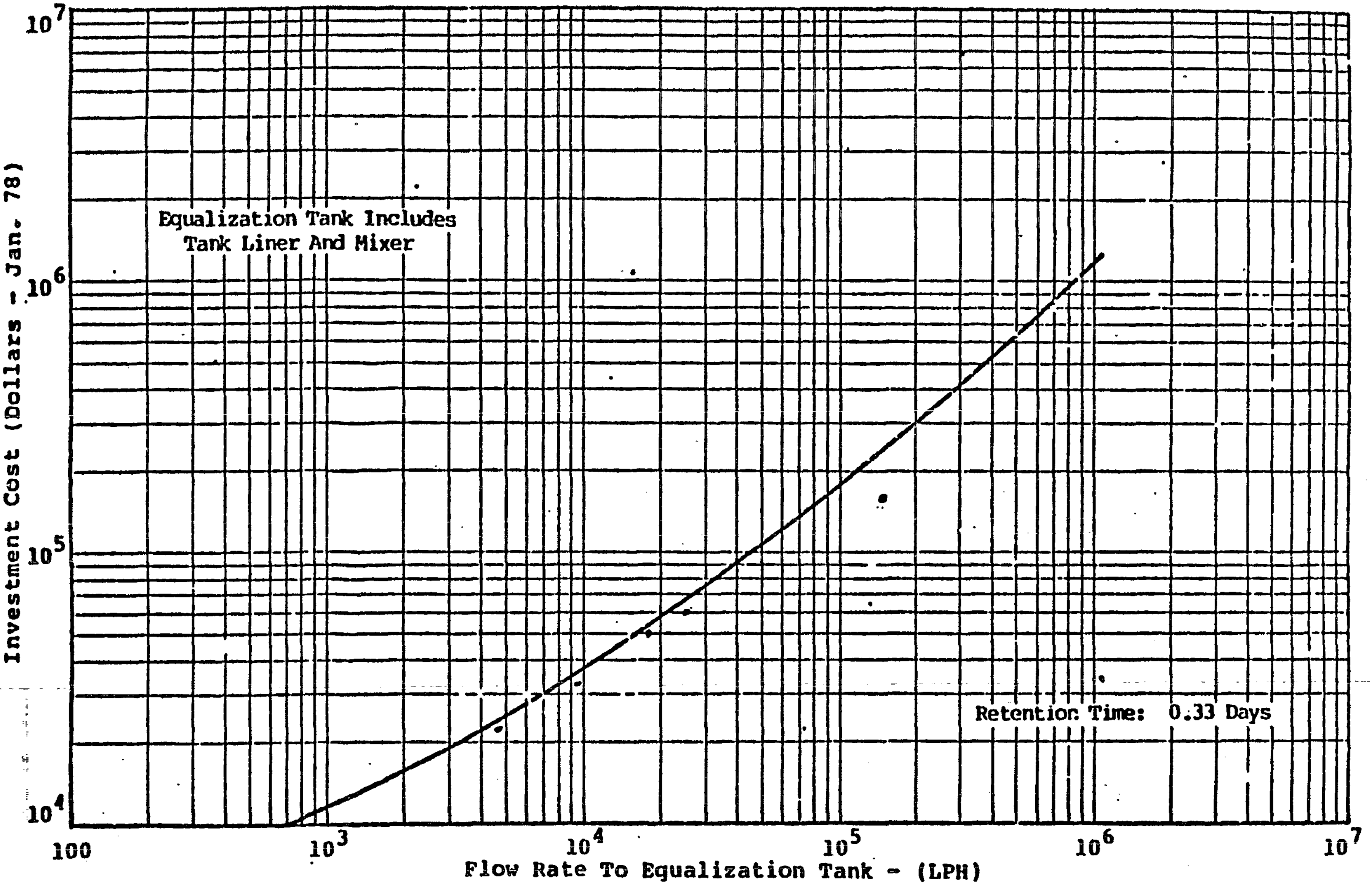


FIGURE VIII-25

EQUALIZATION TANK INVESTMENT COSTS

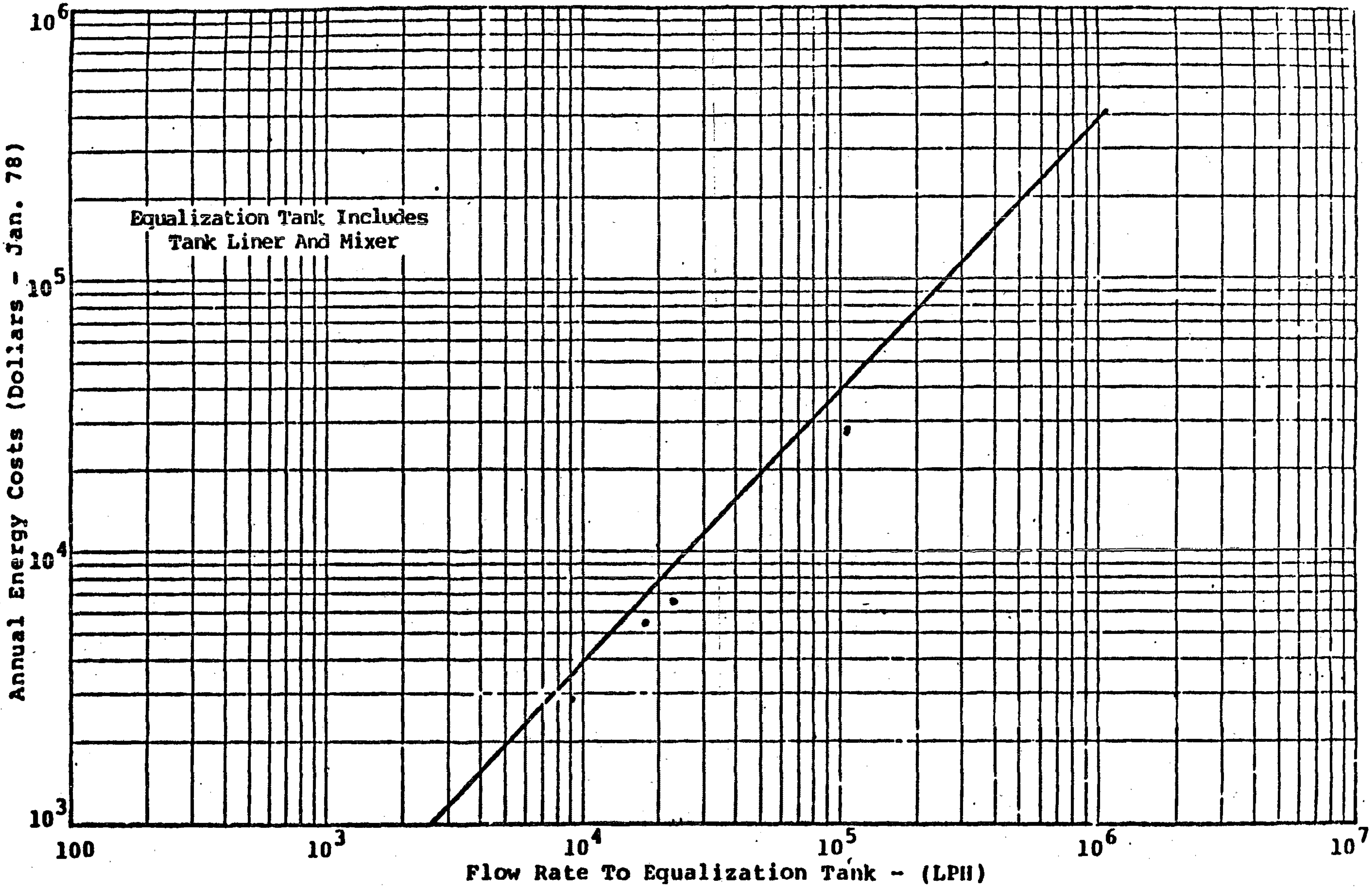


FIGURE VIII- 26

EQUALIZATION TANK ENERGY COSTS

SECTION IX

BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

The factors considered in defining BPT include the total cost of application of technology in relation to the effluent reduction benefits from such application, the age of equipment and facilities involved, the process employed, non-water quality environmental impacts (including energy requirements) and other factors the Administrator considers appropriate. In general, the BPT technology level represents the average of the best existing performances of plants of various ages, sizes, processes or other common characteristics. Where existing performance is uniformly inadequate, BPT may be transferred from a different subcategory or category. Limitations based on transfer technology must be supported by a conclusion that the technology is, indeed, transferable and a reasonable prediction that it will be capable of achieving the prescribed effluent limits. See Tanners' Council of America v. Train, supra. BPT focuses on end-of-pipe treatment rather than process changes or internal controls, except where such are common industry practice.

TECHNICAL APPROACH TO BPT

This category was studied and previous work examined to identify the processes used and the wastewaters generated during porcelain enameling operations. After subcategorization and additional information collection using dcp forms and results from specific plant sampling and analysis, the total information about the industrial segment was examined to determine what constituted an appropriate BPT. Some of the salient considerations were:

Basis metal preparation generates acidic and alkaline wastewaters containing oils, dissolved metals, and suspended solids in the steel, aluminum, and copper subcategories.

Coating, which includes ball milling and enamel application, generates wastewaters in all four subcategories containing a high level of toxic metals from frit and color oxides, plus solids from clays in the enamel slip.

Of the 116 porcelain enameling plants, 28 have chemical precipitation equipment, 11 have sedimentation lagoons, 28 have clarifiers or tube or plate settlers, and 19 have sludge dewatering to assist in sludge disposal. Seventy-two percent of the plants have no treatment in place.

Some of the factors outlined above which must be considered in establishing effluent limitations based on BPT have already been considered by this document. The age of equipment and facilities involved and the processes employed were taken into account in subcategorization and are discussed fully in Section IV. Non-water quality impacts and energy requirements are considered in Section VIII.

Porcelain enameling consists of two sets of processes - metal preparation and coating - that generate different wastewater streams in each subcategory. In both wastewater streams for each subcategory, as discussed in Section III and IV, the volume of wastewater is related to the area of material processed.

The bases for establishing mass-based BPT limitations are (1) the ability of a model treatment system to reduce the concentration of pollutants in effluent and (2) an expected amount of water use (or flow).

EPA based BPT limitations on average flows from plants EPA sampled. In the porcelain enameling category, in contrast to some other categories, a general lack of attention to water consumption was noted at visited plants. Because water use was not a significant criterion in selecting plants for sampling, the mass limitations were based on carefully evaluated visited plant water use data. Several plant sampling days of flow data judged to be excessively high because of observed water use practices were excluded from the data base before calculating average production normalized water use. Several of the comments received after proposal urged that the dcp data base with its greater number of data points be used to calculate mass based limitations.

A review of the visited plant and dcp data was made. Seven plants in the steel and aluminum subcategories which EPA sampled also were listed in Tables V-8 or V-9 which give production normalized flows derived from dcps. Many dcps had insufficient data to allow the production of normalized flows to be calculated. The dcp data together with the average of the three sampling days (Table V-24) for each of 7 plants for both metal preparation and coating gives 14 pairs of data points to compare. Of the 14 pairs compared, 3 were nearly equal. For 5 pairs the visited plant numbers were greater by factors up to 4. For 5 pairs the dcp numbers were greater by factors up to 10; and for one pair the dcp number was 120 times the visited plant number. This wide range of differences between visited plant data and dcp data emphasizes the need to critically evaluate water use practices at each plant before using the flow data. The evaluation can only be made on the basis of observed water use practices. Dcps do not contain enough information for the Agency to carry out such an evaluation.

Therefore, for each porcelain enameling subcategory the mean visited plant water usage, adjusted by eliminating certain data points, is the basis for mass limitations. The specific reason for eliminating the points in each subcategory is given with the discussion for that subcategory. Out of 58 plants for which production normalized water use could be calculated in the Steel and Aluminum Subcategories (Tables V-8 and V-9), 24 meet the water use numbers used for those subcategories.

As a general approach to developing a model BPT treatment system for this industrial segment, treatment of wastewaters from the two processes in each subcategory in a single (combined) treatment system is provided. Although a substantial part of the metals in the coating wastewater stream may be present as undissolved metal oxides or other compounds, the metals in those compounds can be released by the dissolving action of acidic wastewater from the metal preparation operations. Certain toxic metals, such as beryllium and selenium, which are present as undissolved compounds in slip, cannot be removed as effectively if they are dissolved and then precipitated. For this reason the BPT treatment strategy requires introduction of coating wastewaters into the lime rapid mix unit, to avoid mixing these wastewaters with the acidic metal preparation wastewaters. In some cases, plants that use a chromating process prior to porcelain enameling on aluminum must reduce hexavalent chromium to the trivalent state so that it can be precipitated and removed along with other metals. In all subcategories the dissolved metals must be precipitated and suspended solids, including the metal precipitate, removed.

At proposal the BPT model treatment system was: introduce metal preparation wastewaters into an equalization tank; presettle coating wastewater; combine the two streams and apply oil skimming if required, followed by lime and settle technology for the combined streams. Oil skimming may be required to meet the oil and grease limitations. The ability of oil skimming to remove oil and grease to the levels required at BPT is established in Section VII of this Development Document (see Table VII-11). The model BPT technology for the final regulation eliminates the presettling of the coating wastewater stream and by eliminating the equalization tanks. The settling sump found in many plants is not considered to be part of the treatment systems. (The sump did not contribute to nor enhance the treatment attributed to that train.) However, the cost of a sump is included in the estimated cost of the BPT treatment system.

All other parts of the model technology remain the same as at proposal.

The water use numbers were changed as noted in Section V (Table V-24) for the steel and aluminum subcategories in response to public comments. Changes are discussed below.

The pollutants selected for regulation are fewer than were selected at proposal. Regulation of fewer pollutants reduces the monitoring cost of the regulation to industry. The effectiveness of the effluent removal is not reduced because the unregulated pollutants are removed to the desired level by the treatment system if the system is operated in such a way as to remove regulated pollutants to the required level. (i.e., If the regulated metal pollutants are present in the raw wastewater and are removed to the regulated levels by lime and settle technology, the unregulated metal pollutants will be removed to the desired levels.)

Therefore, the model BPT treatment system includes reducing hexavalent chromium in the metal preparation stream where necessary, oil skimming, combining the wastewater streams, and applying lime and settle technology to remove metals and solids (see Figure IX-1 at Page 380). The overall treatment strategy is applicable throughout the category. The BPT approach for this subcategory is therefore chemical precipitation and settling of coating wastewater (see Figure IX-2 at Page 381).

An examination of the wastewater treatment systems used by visited porcelain enameling plants shows that all of the elements of the proposed end-of-pipe BPT system are in place at two sampled plants in the steel and aluminum subcategories (40063, 33077). Lime and settle treatment is part of the overall system at three other visited plants, but the effectiveness of the lime and settle portion alone could not be evaluated because of additional treatment technology (filters) at two plants, and the use of countercurrent rinsing at plant ID 33617. The copper and cast iron subcategories have universally inadequate treatment, and therefore the BPT technology must be transferred to these subcategories. The plants sampled were initially selected as the best plants with BPT systems; however, not all of the sampled plants proved to be the best, as only two sampled plants in the steel subcategory and one sampled plant in the aluminum subcategory demonstrated proper operation of BPT systems. Therefore, the performance data presented in Table VII-16 are derived from porcelain enameling and other industrial categories that treat wastewaters bearing toxic metal pollutants. At proposal, electroplating facilities were included in the data base. After proposal, the data were subjected to a new statistical analysis as described in Section VII, and the electroplating data points were excluded from the data base upon which limitation were based for porcelain enameling. One sampled BPT plant (40063) shows performance equal to or better than that indicated by the Table VII-16 data and therefore justifies the transfer of performance data.

SELECTION OF POLLUTANT PARAMETERS

Pollutant parameters to be regulated by BPT in the porcelain enameling industrial segment were selected because of their presence at treatable concentrations in wastewaters from each of the four subcategories. When pH and TSS are controlled within specified limits, metals can be removed adequately. Table VII-20 summarizes the treatment effectiveness of lime and settle technology (L&S) for all pollutant parameters regulated in the porcelain enameling category.

At proposal, we proposed to regulate 18 toxic, conventional and non-conventional pollutants found in the porcelain enameling raw wastewater. Comments on the proposal objected to the number of pollutants regulated, and EPA reconsidered the list in response to the comments. The pollutants selected for the final regulation are the ones which, if present in raw wastewaters, will assure proper operation of the lime and settle system and the oil skimming technology.

The importance of pH control is stressed in Section VII and its importance for metals removal cannot be over-emphasized. Even small variations from the optimum pH level can result in less than optimum functioning of the system. A study of plant effluent data presented for each subcategory shows the importance of pH. The optimum level may shift slightly from the normal 8.8 to 9.3 level depending upon wastewater composition. Therefore, the regulated pH is specified to be within a range of 7.5-10.0 (instead of the more common 6.0-9.0) to accommodate optimum efficiency without the necessity for a final pH adjustment.

STEEL SUBCATEGORY

The BPT model technology train for steel subcategory wastewater treatment consists of combining wastewaters from both wastewater streams, oil skimming if required, chemical precipitation and sedimentation. Lime and settle technology will achieve the BPT limits for the pollutants listed in Table IX-1. In some cases an aeration step may be required to oxidize ferrous iron to ferric iron so that lime precipitation will be effective for iron.

The mean water usage from eight sampled plants (Table V-24) was used to calculate allowable mass discharges for the 100 steel subcategory plants because these data were verified by on-site measurement. The sampled plants were initially believed to have good wastewater treatment technology and representative water use; however, some of the sampled plants proved to have unusually high water use. At proposal flow data from Plant ID 47033 were excluded from the calculation of the average normalized flow for the metal preparation stream. This plant had significantly higher water use in the metal preparation area than the other sampled plants. Examination of the information obtained during this visit revealed that rinse tanks on the pickle line were corroded and leaking severely. The plant had nearly three times the production normalized water use of other sampled plants and is clearly not among the best plants. After proposal, as the result of several comments, flows from plant ID #33617 (which uses countercurrent rinsing and rinse water recycle) were also deleted from the BPT flow data base. Excluding Plant ID 47033 and 33617, in determining production related flow for metal preparation, and recalculating water usage for Plant ID 40053 in response to comments, the average discharge flows per unit of production at sampled plants are (see Section V and Table V-24):

Metal Preparation: 40.042 l/m^2 (6 plants)
Coating: 8.102 l/m^2 (8 plants)

These values are used as the flow basis for calculating mass based limitations for BPT for reasons discussed at the beginning of this section. Production related discharge flows were also calculated from flow and production data reported in the dcp's (Table V-8). Average discharge flows per unit of production reported on dcps for porcelain enameling on steel are:

Metal Preparation: 57.04 l/m^2
Coating: 25.98 l/m^2

These flows are significantly higher than the average production normalized flow measured at sampled plants.

However, the flows reported in the dcp's are comparable to the measured flows at sampled plants when those plants which appear to be excessive water users are eliminated from the dcp average calculations. For the metal preparation stream, the elimination of the five plants (IDs 11105, 15194, 20059, 33098 and 47033) with production normalized flows greater than the mean measured flow (161.636 l/m^2) at sampled Plant ID 47033 (identified as a user of excessive water because of leaking tanks), reduces the average discharge flow for dcp plants. Likewise, the elimination of ten plants (IDs 11105, 15194, 15949, 20059, 20091, 33054, 33098, 36030, 47033 and 47034) reporting flow rates from coating greater than the highest water use (35.137 l/m^2) for any sampled plant day reduces the dcp average for the coating stream. This plant water use was judged to be excessive because of high water use in cleaning parts for recoating. Average of discharge flows per unit of production reported for the remaining plants are:

Metal Preparation:	28.46 l/m^2 (43 plants)
Coating:	10.16 l/m^2 (38 plants)

These adjusted average flows, though not used in determining mass discharge limitations, are close to the adjusted average water usages at sampled plants. This suggests that if a usable criterion could be found for eliminating dcp plants with excessive water usage, a dcp average would be close to the adjusted visited plant average which is used. The metal preparation water usage based on visited plants is 41 percent greater than that which would be derived from dcp data.

Plants whose present production normalized flows are significantly above the average flows used in calculating the BPT limitations for metal preparation and coating will need to reduce these flows to meet the BPT limitations. Based on the dcp data in Table V-8, approximately 28 of 48 plants will need to reduce water usage. This can usually be done at no significant cost by correcting obvious excessive water using practices (such as leaking rinse tanks) or by shutting off flows to rinses when they are not in use and installing flow control valves on rinse tanks. Specific water conservation practices applicable are detailed in Section VII.

The typical characteristics of wastewaters from the metal preparation operations in the steel subcategory and coating operations in all subcategories as shown in Tables V-21 and V-10 respectively. Tables VI-1 and VI-2 list the pollutants that were considered when setting effluent limitations for this subcategory. The Agency proposed BPT limitations for eighteen pollutants and pollutant parameters. In response to comments, the list of pollutants was reevaluated. The pollutants selected for regulation at BPT are chromium, lead, nickel, zinc, aluminum, iron, oil and grease, total suspended solids and pH. The pollutants selected for regulation are fewer than were selected at proposal. Regulation of fewer pollutants reduces the monitoring cost of the regulations to industry. The effectiveness of the effluent removal is not reduced because the unregulated pollutants are removed to the desired level by the treatment system if the system is operated in such a way as to remove regulated pollutants to the required level. Using lime and settle technology, the concentration of regulated pollutants

would be reduced to the levels shown on Table VII-16. When those concentrations are applied to the wastewater flow described above, the mass of pollutant allowed to be discharged per unit area prepared and coated can be calculated. Table IX-1 on page 375 presents the limitations derived from this calculation.
BPT limitations are based on the assumption that metal preparation and coating wastewaters will be combined and treated in a single treatment system. The permitted discharge of pollutants from this treatment system is equal to the sum of the allowable pollutant discharge from metal preparation operations and coating operations.

To determine the reasonableness of these limitations, data from the sampled plants were examined to determine how many plants met this limitation. Table IX-2 (Page 376) presents a comparison of the sampled plant mass discharges and the discharge limitations for the one sampled plant (ID 40063) which used lime and settle (BPT) technology. It met all limitations on all three sampling days.

A review of dcp data showed that of the 28 plants identified in Section III as having treatment in-place, 27 were in the steel subcategory. Seven of these had lime, settle, and filter technology. The remaining twenty all had settling devices with overflow and underflow (i.e., clarifiers, tube settlers, or settling tanks, but not sedimentation lagoons). Of the twenty: three reported no effluent data, two did not lime and settle the combined wastewaters from metal preparation and coating, and one used anhydrous ammonia, a metal ion complexing agent, to precipitate the metals. The remaining fourteen plants, including one plant with countercurrent rinsing, were judged from dcp descriptions to have satisfactory BPT end-of-pipe treatment in place, but six plants reported analyses after dilution with other wastewater ot after lagooning.

Because production normalized flows matched to individual effluent analysis results were not available, a comparison of effluent concentrations to the one-day maximum L&S numbers was made. Effluent data from eight wastewater treatment facilities using lime and settle technology on combined metal preparation and coating wastewaters is presented in Table IX-3 (page 367) for the regulated pollutants included in the dcp data. No plant reported effluent values for all nine regulated pollutants. By plant ID number, the pollutants meeting or exceeding the lime and settle one-day maximum concentrations (Table VII-20) are tabulated.

TABLE IX-3

Comparison of Effluent Concentrations and One-Day Maximum L&S Numbers

Plant ID	Concentrations Regulated Pollutants	
	Meeting L&S 1 Day Max	Exceeding L&S 1 Day Max
15194	Cr,Ni,Fe,SS	-----
33097	Ni,TSS,pH	-----
36052	Cr,Zn,O&G,TSS	Ni 3.0, Fe 7
40032	Cr,Ni,Zn,Fe,TSS	Fe 9.3,SS 44.0
40035	Cr,Pb,Ni,Zn,pH	-----
40041	Cr,Pb,Zn,O&G	Ni 1.7, TSS 36
40043	Cr,Pb,Ni,Zn,Fe	pH 7.0
40063	Ni,Fe,SS,pH	-----

It is seen that four plants meet the one day maximum concentrations for all of the regulated pollutants they reported. Two plants reported suspended solids or total suspended solids greater than the one-day maximum for lime and settle, but collectively they met the limits for seven of nine regulated metals. One plant reported pH slightly lower than the regulated value, but all other regulated pollutants for the plant were within the one-day maximum for lime and settle concentrations. One plant reported results only in terms of meeting its permit limits and specific values were not available for nickel or iron.

These listed plants force the conclusion that L&S technology in porcelain enameling can be and is being operated to meet the treatment effectiveness concentrations tabulated in Section VII.

The data presented above and in Section VII indicate that the lime and settle treatment system is capable of producing effluent within the limitations proposed when the system is operated properly. Therefore, the limitations on the selected pollutant parameters in Table IX-1 for the steel subcategory are reasonable and achievable.

Pollutant reduction benefits are presented for BPT and each BAT option in Section X. In cases where the technology is to be applied to combined metal preparation and coating streams, pollutant reduction benefits were calculated by considering the streams as one stream. Thus, for the steel subcategory, the lime and settle system is considered to be acting on a raw wastewater stream composed of the metal preparation and coating raw wastewater streams for the steel subcategory.

The production-normalized flow and pollutant concentrations for the combined stream for each subcategory were obtained as follows:

- To obtain production normalized flow for the combined stream the yearly flows for each process stream were calculated from production normalized water use (Table V-24) and annual subcategory production (by operation) from Section III. The sum of these process water usages for metal preparation and coating was divided by the sum of yearly production for metal preparation and for coating.
- Combined raw wastewater concentrations for each pollutant parameter were obtained from the following calculation:

where: $$\frac{C_1 F_1 + C_2 F_2}{F_3 + F_4} = C_3$$

C_1 = pollutant concentration for the metal preparation raw wastewater stream (mg/l)

C_2 = pollutant concentration for the coating raw wastewater stream (mg/l)

C_3 = pollutant concentration for the combined stream (mg/l)

F_1 = normal plant raw wastewater flow for metal preparation (l/yr)

F_2 = normal plant raw wastewater flow for coating (l/yr)

F_3 = normal plant treated flow for metal preparation (l/yr)

F_4 = normal plant treated flow for coating (l/yr)

In the establishment of BPT, the cost of application of technology must be considered in relation to the effluent reduction benefits from such application. The quantity of pollutants removed by BPT and the total cost of application of BPT are displayed in Tables X-15 and X-20 (Pages 403-408). The capital cost of BPT (in January 1978 dollars) as in increment above the cost of in-place treatment equipment is estimated to be $5.18 million for the steel subcategory. Annual cost of BPT for the steel subcategory is estimated to be $2.692 million. The quantity of pollutants removed by the BPT system for this subcategory is estimated to be 9,340 kkg/yr (10,290 tons/yr) including 117.3 kkg/yr (129.2 tons/yr) of toxic pollutants. The effluent reduction benefit is worth the dollar cost of required BPT.

CAST IRON SUBCATEGORY

The BPT model technology train for the cast iron subcategory wastewater treatment consists of chemical precipitation and settling. None of the cast iron subcategory plants reported treatment in-place on their dcps. The metal preparation operations in the cast iron subcategory are generally dry and dry application technology appears to be applicable to all cast iron production. Porcelain enamelers on cast iron often reuse the settled slip in a 1:1 ratio with new slip in the formulation of enamel ground coat.

All three visited plants were included in the subcategory average flow used to calculate BPT mass discharge limitations for the 13 cast iron subcategory plants. The average production related wastewater flow is (Table V-24):

Coating: 0.693 l/m^2 (3 plants)

Production normalized water use for dcp plants was not developed for cast iron subcategory plants. The typical characteristics of wastewaters from the ball milling and enamel application operations in the cast iron subcategory are presented in Table V-10. Tables VI-2 and VI-3 list the pollutants that were considered in setting effluent limitations for this subcategory. Chromium, lead, nickel, zinc, aluminum, iron, oil and grease, total suspended solids, and pH are selected for regulation at BPT. Using lime and settle technology, the concentration of regulated pollutants would be reduced to the levels shown on Table VII-16.

When those concentrations are applied to the sampled plant mean wastewater flow described above, the mass of pollutant allowed to be discharged per unit area coated can be calculated. Table IX-4 on page 377 presents the limitations derived from this calculation.

To determine the reasonableness of these limitations, the cast iron subcategory data base was examined to determine if any plants meet the requirements for BPT. The cast iron subcategory was found to have universally inadequate treatment based on the absence of BPT or equivalent treatment system in place at any cast iron plant in the dcp data base. Therefore, BPT must be transferred to the cast iron subcategory from the other subcategories such as the steel subcategory in the porcelain enameling industry and from treatment found in other industries which generate similar wastewaters. The coating wastewaters in the cast iron subcategory are the same as the coating wastewater in the other subcategories.

The data indicate that the technology being transferred is capable of producing effluent that meets the expected BPT performance levels. The treatment system is capable of producing effluent within the limitations proposed for the cast iron subcategory when the system is operated properly and when wastewater generation is carefully controlled. Therefore, the limitations in Table IX-4 for the cast iron subcategory are reasonable and achievable.

In the establishment of BPT, the cost of application of technology must be considered in relation to the effluent reduction benefits from such application. The quantity of pollutants removed by BPT and the total cost of application of BPT are displayed in Tables X-16 and X-20 (Pages 407 & 411). The capital cost of BPT (in January 1978 dollars) as an increment above the cost of in-place treatment equipment is estimated to be $0.135 million for the cast iron subcategory. Total annual cost of BPT for the cast iron subcategory is estimated to be $0.057 million. The quantity of pollutants removed by the BPT system for this subcategory is estimated to be 65,000 kg/yr (71.6 tons/yr) including 752 kg/yr (0.83 tons/yr) of toxic pollutants. The effluent reduction benefit is worth the dollar cost of required BPT.

ALUMINUM SUBCATEGORY

The BPT model treatment technology train for aluminum subcategory wastewater consists of chromium reduction where chromating wastewater is generated, combining wastewaters from the metal preparation and coating wastewater streams, oil skimming where required and chemical precipitation and sedimentation. Lime addition and settling are the model technology suggested for solids removal.

Flow data from three sampled plants were used to calculate allowable mass discharges for the 16 plants in the aluminum subcategory. At proposal flow data from Plant ID 33077 were excluded from the subcategory average flow calculation for the metal preparation stream. Observation of the metal preparation operation at this plant revealed excessive water use, including the discharge of rinse water during off-hours of production. The plant used more than four times the average quantity of metal preparation water used by other visited plants. Similarly, water use data from Plant ID 11045 were excluded from the subcategory average flow calculation for the coating stream. During the sampling period, this plant used excessive quantities of water in washing off improperly enameled parts. The additional water used for this purpose increased the total coating discharge to nearly 5 1/2 times the average water use at other visited plants. At proposal, water usage for one sampling day at Plant ID 33077 was excluded. As a result of comments reexamination of the trip report revealed that all three days of coating water usage data should be used. A typographical error and a calculation error in metal preparation water usage were also corrected. The latter correction resulted in an increase in mean water usage. The typographical error had not been incorporated into the calculation of the mean and resulted in no additional change to the mean.

Excluding Plant ID 33077 from the metal preparation flow calculations and Plant ID 11045 from the coating flow calculations, the adjusted average discharge flow rates per unit of production at the three sampled plants are:

Metal Preparation: 38.896 l/m^2 (6 sampling days at 2 plants)
Coating: 15.041 l/m^2 (6 sampling days at 2 plants)

These production normalized flows are used for BPT mass limitation calculations. Production related discharge flow rates were also calculated from flow rate and production data reported in dcp's. Average discharge flows per unit of production reported by 10 plants are:

Metal Preparation: 68.63 l/m^2
Coating: 21.95 l/m^2

The flows reported in the dcp's (Table V-9) are comparable to the measured flow rates at sampled plants when those plants which appear to use excessive quantities of water are eliminated from the dcp average calculations. For the metal preparation stream, the elimination of two plants reporting flows equal to or greater than the flow at Plant ID 33077 (identified as a user of excessive water because of water flow during off hours of production) reduces the average discharge flow rate for dcp plants. Likewise, the elimination of the one plant reporting a flow from coating greater than or equal to the flow at Plant ID 11045 (identified as a user of excessive water for reworking parts) also reduces the average. These adjusted dcp flows are consistent with the average measured flows for visited plants. Adjusted average discharge flows per unit of production at dcp plants are:

Metal Preparation: 45.00 l/m^2 (8 plants)
Coating: 17.33 l/m^2 (9 plants)

The typical characteristics of wastewaters from the metal preparation operations in the aluminum subcategory and coating operations in all subcategories are presented in Tables V-22 and V-10 respectively. Tables VI-1 and VI-2 list the pollutants that were considered in setting effluent limitations for this subcategory. Chromium, lead, nickel, zinc, aluminum, iron, oil and grease, total suspended solids, and pH are selected for regulation at BPT. Using lime and settle technology, the concentration of regulated pollutants would be reduced to the levels described in Table VII-16.

When those concentrations are applied to the sampled plant mean wastewater flow described above, the mass of pollutant allowed to be discharged per unit area prepared and coated can be calculated. Table IX-5 at page 378 presents the limitations derived from this calculation.

At BPT it is presumed that metal preparation and coating wastewaters will be combined and treated in a single treatment system. The permitted discharge of pollutants from this treatment system is equal to the sum of the allowable pollutant discharge from metal preparation operations and coating operations.

To determine the reasonableness of these limitations, data from the one sampled plant having BPT technology (33077) were examined to determine whether the plant meets these limitations. Table IX-6 (Page 379) presents a comparison of the sampled plant mass discharges and the discharge limitations for the aluminum subcategory. Plant 33077 meets seven of the twelve limitations for regulated pollutants shown on the table for three sampling days where non-zero values were reported. The plant failed to meet some of the limitations because water use for both the metal preparation and coating wastewater streams exceeds the sampled plant averages by a significant amount. As explained earlier in this section, Plant 33077 was observed to use more than four times the average water used by the other sampled plants in its metal preparation operations. In this subcategory treatment is considered to be universally inadequate, because the only plant with BPT technology installed and operated properly (ID 33077) has uncharacteristically high water usage. The water usage exceeds the adjusted average BPT usage by about the same factor (more than four) as the largest factor by which an actual mass discharge exceeded the limitation for any of the twelve values reported.

Dcp's submitted by plants in the aluminum subcategory were carefully scrutinized to determine which plants employ a wastewater treatment system. With the exception of one of the sampled plants, none of the aluminum subcategory plants submitting dcp's has an operating BPT treatment system.

The data indicate that the treatment system is capable of producing effluent within the limitations proposed when the system is operated properly and when wastewater generation is carefully controlled. Therefore, the limitations set forth in Table IX-5 for the aluminum subcategory are reasonable and achievable.

In the establishment of BPT, the cost of application of technology must be considered in relation to the effluent reduction benefits from such application. The quantity of pollutants removed by BPT and the total cost of application of BPT are displayed in Tables X-17 and X-20. The capital cost of BPT (in January 1978 dollars) as an increment above the cost of in-place treatment equipment is estimated to be $0.091 million for the aluminum subcategory. Total annual cost of BPT for the aluminum subcategory is estimated to be $0.044 million. The quantity of pollutants removed by the BPT system for this subcategory is estimated to be 368.9 kkg/yr (406.5 tons/yr) including 4.260 kkg/yr (4.695 tons/yr) of toxic pollutants. The effluent reduction benefit is worth the dollar cost of required BPT.

COPPER SUBCATEGORY

Both copper subcategory plants submitting dcp's were sampled. Of the two sampled plants, Plant ID 06031 had an essentially dry coating process and was therefore excluded from the subcategory average for the coating wastewater stream. The average production normalized flow for the copper subcategory for metal preparation is 67.29 l/m^2. The coating flow for the one plant in the subcategory generating coating wastewater is 4.74 l/m^2.

The typical characteristics of wastewaters from the metal preparation operations in the copper subcategory and coating operations in all subcategories are presented in Tables V-23 and V-10 respectively. Tables VI-1 and VI-2 list the pollutants that were considered in setting effluent limitatons for this subcategory. BPT effluent limitations are not established because no active direct dischargers were found in the copper subcategory.

TABLE IX - 1
STEEL SUBCATEGORY
BPT EFFLUENT LIMITATIONS

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
	Metric Units - mg/m^2 of area processed or coated			
ANTIMONY	8.409	1.701	3.604	0.729
ARSENIC	83.688	16.933	34.436	6.968
CADMIUM	12.813	2.593	6.006	1.215
*CHROMIUM	16.818	3.403	6.807	1.377
COPPER	76.080	15.394	40.042	8.102
*LEAD	6.006	1.215	5.205	1.053
*NICKEL	56.459	11.424	40.042	8.102
SELENIUM	1.602	0.324	0.801	0.162
*ZINC	53.256	10.776	22.424	4.537
*ALUMINUM	182.191	36.864	74.478	15.070
COBALT	11.612	2.350	4.805	0.972
FLUORIDE	2330.444	471.536	953.000	192.828
*IRON	49.252	9.965	25.226	5.104
MANGANESE	17.218	3.484	13.614	2.755
*OIL & GREASE	800.840	162.040	480.504	97.224
*TSS	1641.722	332.182	800.840	162.040
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			
	English Units - lb/1,000,000 ft^2 of area processed or coated			
ANTIMONY	1.722	0.348	0.738	0.149
ARSENIC	17.141	3.468	7.053	1.427
CADMIUM	2.624	0.531	1.230	0.249
*CHROMIUM	3.445	0.697	1.394	0.282
COPPER	15.582	3.153	8.201	1.659
*LEAD	1.230	0.249	1.066	0.216
*NICKEL	11.564	2.340	8.201	1.659
SELENIUM	0.328	0.066	0.164	0.033
*ZINC	10.908	2.207	4.593	0.929
*ALUMINUM	37.316	7.550	15.254	3.087
COBALT	2.378	0.481	0.984	0.199
FLUORIDE	477.313	96.578	195.190	39.494
*IRON	10.088	2.041	5.167	1.045
MANGANESE	3.527	0.714	2.788	0.564
*OIL & GREASE	164.025	33.188	98.415	19.913
*TSS	336.251	68.036	164.025	33.188
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE IX-2

COMPARISON OF BPT MASS DISCHARGE LIMITATIONS AND ACTUAL DISCHARGES OF STEEL SUBCATEGORY SAMPLED PLANTS WITH BPT

PLANT 40063

	DAY 1 (kg/day)		DAY 2 (kg/day)		DAY 3 (kg/day)	
POLLUTANT PARAMETER	ACTUAL TOTAL DISCHARGE	TOTAL LIMITATION	ACTUAL TOTAL DISCHARGE	TOTAL LIMITATION	ACTUAL TOTAL DISCHARGE	TOTAL LIMITATION
114 Antimony	0	0.096	0	0.102	0	0.092
115 Arsenic	0	0.955	0	1.012	0	0.913
118 Cadmium	0.002	0.146	0.002	0.154	0.002	0.140
119 Chromium, Total	0	0.192	----	0.203	----	0.183
120 Copper	0.001	0.868	0.001	0.919	0.001	0.830
122 Lead	0	0.069	----	0.072	----	0.065
124 Nickel	0	0.644	0	0.683	0	0.615
125 Selenium	0	0.018	0	0.019	0	0.018
128 Zinc	0.007	0.608	0.017	0.644	0.004	0.581
Aluminum	0.091	2.079	0.137	2.202	0.144	1.987
Cobalt	0	0.133	0	0.140	0	0.127
Fluoride	6.78	26.591	8.59	28.169	8.86	25.725
Iron	0.128	0.562	0.222	0.595	0.239	0.537
Manganese	0.031	0.196	0.005	0.208	0.049	0.188
Oil and Grease	2.08	9.138	0.781	9.681	0.989	8.735
Total Suspended Solids	2.35	18.732	5.08	19.844	5.36	17.905

- Indicates no data available.
0 Indicates less than minimum detectable limit
or not detected at all.

TABLE IX - 4
CAST IRON SUBCATEGORY
BPT EFFLUENT LIMITATIONS

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2 (lb/1,000,000 ft^2) of area coated			
ANTIMONY	0.146	(0.030)	0.062	(0.013)
ARSENIC	1.448	(0.297)	0.596	(0.122)
CADMIUM	0.222	(0.045)	0.104	(0.021)
*CHROMIUM	0.291	(0.060)	0.118	(0.024)
COPPER	1.317	(0.270)	0.693	(0.142)
*LEAD	0.104	(0.021)	0.090	(0.018)
*NICKEL	0.977	(0.200)	0.693	(0.142)
*ZINC	0.922	(0.189)	0.388	(0.079)
*ALUMINUM	3.153	(0.646)	1.289	(0.264)
COBALT	0.201	(0.041)	0.083	(0.017)
FLUORIDE	40.333	(8.261)	16.493	(3.378)
*IRON	0.852	(0.175)	0.437	(0.090)
MANGANESE	0.298	(0.061)	0.236	(0.048)
*OIL & GREASE	13.860	(2.839)	8.316	(1.703)
*TSS	28.413	(5.819)	13.860	(2.839)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE IX - 5
ALUMINUM SUBCATEGORY
BPT EFFLUENT LIMITATIONS

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
	Metric Units - mg/m^2 of area processed or coated.			
ANTIMONY	8.168	3.159	3.501	1.354
ARSENIC	81.293	31.436	33.451	12.935
CADMIUM	12.447	4.813	5.834	2.256
*CHROMIUM	16.336	6.317	6.612	2.557
COPPER	73.902	28.578	38.896	15.041
CYANIDE	11.280	4.362	4.668	1.805
*LEAD	5.834	2.256	5.056	1.955
*NICKEL	54.843	21.208	38.896	15.041
*ZINC	51.732	20.005	21.782	8.423
*ALUMINUM	176.977	68.437	72.347	27.976
COBALT	11.280	4.362	4.668	1.805
FLUORIDE	2263.747	875.386	925.725	357.976
*IRON	47.842	18.500	24.504	9.476
MANGANESE	16.725	6.468	13.225	5.114
*OIL & GREASE	777.920	300.820	466.752	180.492
*TSS	1594.736	616.681	777.920	300.820
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			
	English Units - lb/1,000,000 ft^2 of area processed or coated			
ANTIMONY	1.673	0.647	0.717	0.277
ARSENIC	16.650	6.439	6.851	2.649
CADMIUM	2.549	0.986	1.195	0.462
*CHROMIUM	3.346	1.294	1.354	0.524
COPPER	15.136	5.853	7.967	3.081
CYANIDE	2.310	0.893	0.956	0.370
*LEAD	1.195	0.462	1.036	0.400
*NICKEL	11.233	4.344	7.967	3.081
*ZINC	10.596	4.097	4.461	1.725
*ALUMINUM	36.248	14.017	14.818	5.730
COBALT	2.310	0.893	0.956	0.370
FLUORIDE	463.652	179.293	189.603	73.319
*IRON	9.799	3.789	5.019	1.941
MANGANESE	3.426	1.325	2.709	1.047
*OIL & GREASE	159.331	61.613	95.598	36.968
*TSS	326.628	126.306	159.331	61.613
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE IX-6
COMPARISON OF BPT MASS DISCHARGE LIMITATIONS AND ACTUAL DISCHARGES OF ALUMINUM SUBCATEGORY SAMPLED PLANT WITH BPT

PLANT 33077

POLLUTANT PARAMETER		DAY 1 (kg/day)		DAY 2 (kg/day)		DAY 3 (kg/day)	
		ACTUAL TOTAL DISCHARGE	TOTAL LIMITATION	ACTUAL TOTAL DISCHARGE	TOTAL LIMITATION	ACTUAL TOTAL DISCHARGE	TOTAL LIMITATION
114	Antimony	0	0.004	0	0.012	0	0.016
115	Arsenic	0	0.044	0	0.115	0	0.158
118	Cadmium	0.01	0.007	0.061	0.018	0.018	0.024
119	Chromium, Total	0	0.008	0.0004	0.023	0	0.032
120	Copper	0	0.040	0	0.105	0	0.144
122	Lead	0	0.003	0.034	0.008	0.026	0.011
124	Nickel	0	0.030	0	0.078	0	0.107
128	Zinc	0.0969	0.028	0.0048	0.073	0.124	0.101
	Aluminum	0	0.096	0.0136	0.251	0.006	0.345
	Cobalt	0	0.006	0	0.134	0	0.022
	Fluoride	0.359	1.224	0.102	3.205	0.391	4.411
	Iron	0.007	0.026	0	0.068	0.007	0.033
	Manganese	0	0.009	0	0.024	0	0.033
	Oil and Grease	0	0.421	0	1.101	0	1.516
	Total Suspended Solids	0	0.862	0.341	2.258	7.169	3.107

0 Indicates less than minimum detectable limit or not detected at all.

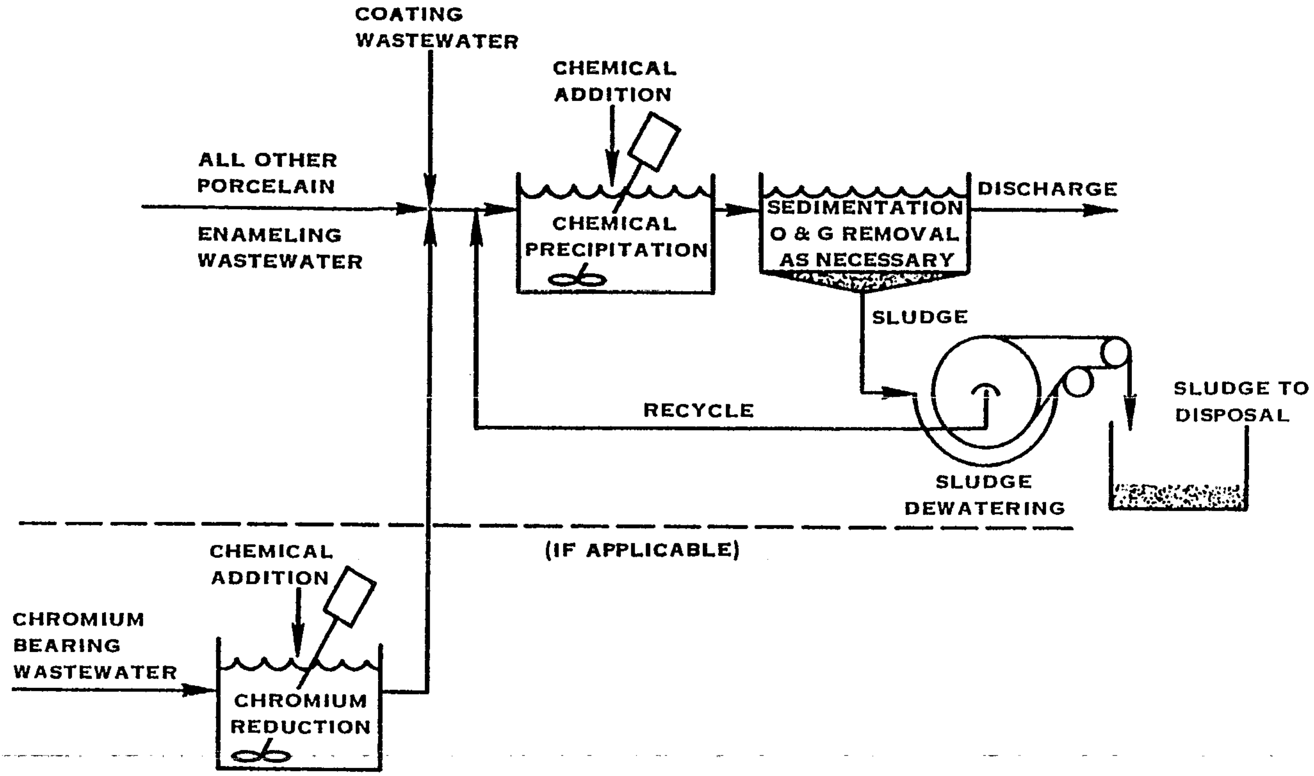


FIGURE IX-1. BPT TREATMENT SYSTEM FOR STEEL AND ALUMINUM SUBCATEGORIES

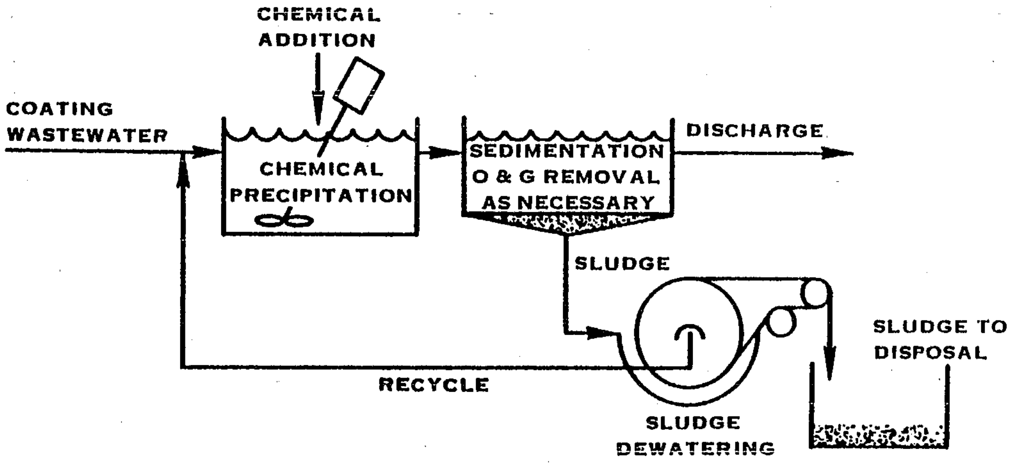


FIGURE IX-2. BPT TREATMENT SYSTEM FOR THE CAST IRON SUBCATEGORY

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

The factors considered in assessing best available technology economically achievable (BAT) include the age of equipment and facilities involved, the process employed, process changes, non-water quality environmental impacts (including energy requirements) and the costs of application of such technology (Section 304(b)(2)(B)). In general, the BAT technology level represents, at a minimum, the best existing economically achievable performance of plants of various ages, sizes, processes or other shared characteristics. As with BPT, in those categories where existing performance is universally inadequate BAT may be transferred from a different subcategory or category BAT may include process changes or internal controls, even when not common industry practice.

Several changes were made in the model BAT technology and in the calculation of BAT limitations after proposal. These changes are discussed below.

TECHNICAL APPROACH TO BAT

In developing this regulation, the Agency evaluated several BAT technology options, which would reduce the discharge of toxic pollutants beyond the reduction achieved by BPT.

The proposed BAT model technology was:

- Coating wastewaters
  - settling sump

- Settled coating wastewater plus metal preparation wastewaters
  - chromium reduction (where necessary in aluminum subcategory)
  - equalization tank
  - oil skimming
  - chemical precipitation
  - settling (clarifier)
  - polishing filtration

The Agency received many comments on the proposed BAT model technology. A number of comments objected to polishing filtration in the model BAT technology because of its cost.

Other comments asserted that the discharge allowance for ball mill washout was inadequate.

After reviewing the comments received from proposal, the Agency considered possible modification to the proposed BAT and developed the following options. These options are now designated by letter to minimize confusion

Option A (see Figure X-1, page 415) consists of the following treatment technology:

- chromium reduction (where necessary)
- combined treatment of coating and metal preparation wastewater
- Chemical precipitation (lime)
- settling (clarifier)
- reuse of water in most coating operations
- sludge densification

Option B (see Figure X-2, page 416) consists of:

- chromium reduction (where necessary)
- combined treatment of coating and metal prepration wastewaters
- chemical precipitation (lime)
- settling (clarifier)
- polishing filtration
- sludge densification

Option C (see Figure X-3, page 417) consists of:

- chromium reduction (where necessary)
- combined treatment of coating and metal preparation wastewaters
- chemical precipitation (lime)
- settling (clarifier)

- reuse of water in most coating operations
- polishing filtration.
- sludge densification

Option D (see Figure X-4, page 418) consists of separate treatment:

- For coating wastewaters
  - chemical precipitation (lime)
  - settling (clarifier)
  - recycle of all coating water needs except ball mill washout
  - paper element pressure filter for discharged water
  - sludge densification

- For metal preparation wastewaters

  - chromium reduction (where necessary)
  - chemical precipitation (lime)
  - settling (clarifier)
  - polishing filtration
  - sludge densification

Option E (see Figure X-5, page 419) consists of separate treatment:

- For coating wastewaters
  - chemical precipitation (lime)
  - settling (clarifier)
  - recycle of all coating water needs except ball mill washout
  - paper element pressure filter for discharged water

- For metal preparation wastewaters

  - chromium reduction (where necessary)
  - chemical precipitation (lime)
  - settling (clarifier)
  - polishing filtration
  - three-stage counter current rinsing after alkaline cleaning, acid etch, (and nickel flash in steel subcategory).

The Agency reconsidered the need for settling sumps and equalization tanks after proposal. All options were modified by eliminating specific technologies from consideration: settling sumps and equalization tanks. The reasons for excluding settling sumps and equalization tanks from BAT technology are ones given in Section IX where their deletion from proposed BPT technology was discussed.

SELECTION OF BAT MODEL TECHNOLOGY

Option A was selected as the model technology for BAT after all five final BAT options were considered. Although Options D and E would remove more toxic metal pollutants than the other three options, they are more complex to operate because each requires two separate lime, settle and filter systems. The incremental removals achieved are considered not to be sufficient to justify the greater complexity.

Options B and C both require polishing filters. The polishing filter (multimedia or cartridge type) following settling was eliminated from the proposed BAT model technology after proposal for two reasons: (1) filtration would cost approximately $1.9 million (capital) and $0.45 million annually; and (2) about half of the porcelain enameling facilities are part of larger manufacturing operations where combined wastewater treatment may be most appropriate, and the other categories may not require filtration in their model treatment technology.

The selected model BAT treatment technology includes the reuse of treated wastewaters for purposes such as cooling ball mills, washing unfired enamel off parts for rework, washing down floors in ball mill rooms, water curtain spray booths, and certain flow enhancement purposes to keep lines clear. None of these uses requires a high quality water. Therefore, the water reuse technology is considered to be appropriate. One dcp wastewater treatment diagram (ID 15194) included a holding tank and return of treated wastewater to process. The specific processes were not specified and a note indicated that the reuse technology was being installed - not in use at the time the dcp was completed.

Because the end-of-pipe treatment technology for BAT is identical to that for BPT, the same discussion of achievability of concentration limits by porcelain enameling plants with lime and settle systems applies here as in BPT. The reduction in pollutant discharge between BPT and BAT is achieved entirely by reduced water usage. Flow estimates used to calculate mass-based limitations for each subcategory are discussed below.

Because comments complained that the wastewater allowance for ball mill wastewater was too small, we reevaluated the existing data for this operation. This reconsideration is detailed in Section V and is the basis for the ball mill washout allowance of 0.0636 l/m^2 costed. This value is the same for all subcategories.

The BAT technology is applied as described to steel, cast iron, and aluminum subcategories. The copper subcategory is not regulated at BAT because there are no active direct dischargers.

INDUSTRY COST AND EFFLUENT REDUCTION BENEFITS OF TREATMENT OPTIONS

An estimate of capital and annual costs for BAT Options A, B, C, D, and E was prepared for each subcategory (Table X-20). The capital cost of treatment technology in place was also estimated for each subcategory using the methodology in Section VIII.

The capital and operating costs of treatment were estimated for each existing plant and summed to develop estimates for each subcategory using production and treatment equipment information provided on dcp's. The cost for a "normal plant" was determined by dividing each total subcategory cost by the number of regulated plants having operations in that subcategory. "Capital in-place" in Table X-20 is the difference in capital costs calculated first presuming no treatment in-place and second costing only additional equipment needed to meet the specific option.

Pollutant reduction benefits were calculated for each subcategory based on all porcelain enameling plants (direct and indirect dischargers) and were derived by ; (a) characterizing raw wastewater and effluent from each proposed treatment system in terms of concentrations produced and production normalized discharges (Tables X-1 through X-4) (Pages 392-395) for each significant pollutant found; (b) calculating the quantities removed and discharged in one year by a normal plant (Tables X-5 through X-8 (Pages 396-399); and (c) calculating the quantities removed and discharged in one year by subcategory and for the category (Tables X-9 through X-13) (Pages 400-404). Table X-14 (Page 405) summarizes treatment performances by subcategory for all porcelain enameling plants BPT technology and each BAT option showing the mass of pollutants removed and discharged by each option. The capital and annual costs for BPT and BAT are presented by subcategory in the cost Table X-20, (Page 411). Four sets of costs are given in Table X-20: (a) "normal plant" - average of estimated treatment costs for all non-excluded plants in subcategory or category (direct and indirect) derived from (d), below, and the total number of non-excluded plants used for (b) and (c), below; (b) "direct dischargers" - sum of estimated treatment costs for direct dischargers; (c) "indirect dischargers" - sum of estimated treatment costs for non-excluded indirect dischargers and (d) the sum of (b) and (c). In Tables X-9 through X-14 and X-20 all plants in the category are included as if they were direct dischargers. These tables can also be compared with those presented in the proposal development document. Both sets are based on all plants (direct and indirect) in the industry. In each case only regulated plants are included (i.e. at proposal, all plants; at promulgation, non-excluded plants). All pollutant parameter calculations were based on mean raw wastewater concentrations for visited plants, production normalized water use by subcategory from visited plants Table (V-24) and dcp production data presented in Section III. The quantities of pollutants were summed into workable groupings; total toxic metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, and zinc), conventional (oil and grease, TSS) and total pollutants (total toxic metals, conventional, aluminum, barium, cobalt, fluoride, iron, manganese and phosphorus).

A further set of tables, X-15 through X-19 gives total treatment performance for each subcategory and the total category for direct dischargers only. These tables may be used with the appropriate line on table X-20 to compare actual BAT performance with BAT costs.

REGULATED POLLUTANT PARAMETERS

The raw wastewater concentrations from individual operations and from the subcategory total were examined to select toxic and other pollutant parameters found at treatable levels. In each subcategory at proposal, several toxic metals were selected for regulation. Comments on the proposal criticized the number of pollutants to be specifically regulated because of the high cost of monitoring. In response to these comments, the number of metals specifically regulated has been reduced to six in the final regulation. Control of the specifically regulated pollutants will ensure removal of non-regulated toxic pollutants when the BAT mass limitations are met. The achievable effluent concentrations of the regulated pollutants using the BAT model technology are listed in Table VII-20.

The metals selected for specific regulation are discussed under each subcategory. The effluent limitations achievable by application of the BAT model technology are also presented by subcategory.

STEEL SUBCATEGORY

The effluent limitations based on BAT for the steel subcategory are based on: the achievable concentration of regulated pollutants (mg/l) using L&S in Table VII-20; the subcategory mean water usage for the metal preparation stream (l/m^2 area prepared) identical to corresponding BPT subcategory usage; and coating stream water use (usage l/m^2 coating area) equal to the category mean water use for ball mill washout the same in each subcategory and derived in Section V. The water use values used as the flow basis for BAT mass discharge limitation for the steel subcategory are:

Metal preparation:	40.042 l/m^2
Coating:	0.636 l/m^2

These flows are used to calculate limitations based on BAT for the metal preparation and the coating wastewater streams for the steel subcategory.

Pollutant parameters selected for specific regulation for the steel subcategory at BAT are: chromium, lead, nickel, zinc, aluminum and iron. In Section VI nine toxic pollutants were selected for consideration for regulation in this section. In response to comments on the cost of monitoring the fourteen pollutants as proposed, a review was made of this listing and also nonconventional pollutants found in large quantities. The Agency has concluded that regulation of the six pollutants listed will provide adequate control of all of the toxic pollutants.

When the flows presented above are applied to the achievable effluent concentrations for L&S technology listed in Table VII-20, the mass of pollutant allowed to be discharged area of metal prepared or per unit coated can be calculated. Table X-21 on page 412 shows the limitations derived from this calculation.

CAST IRON SUBCATEGORY

The BAT effluent limitations for the cast iron subcategory are based on the concentrations of regulated pollutants (mg/l) achievable by L&S technology Table VII-20 and on the mean water usage for coating equal to the category mean water usage for ball mill washout (l/m^2 area coated). Metal preparation in the cast iron subcategory is dry, and therefore metal preparation is set at zero discharge. The water use for coating on which mass discharge limitations are based is 0.636 l/m^2. If more than one wet coats are applied to the same area, the mass limitation applies to each coat.

Pollutant parameters selected for regulation for the cast iron subcategory are: chromium, lead, nickel, zinc, aluminum, and iron. In Section VI nine toxic pollutants were selected, as proposed, for consideration for regulation in this section. Comments were received on the cost of monitoring the large number of pollutants. After reviewing this listing and also nonconventional pollutants found in large quantities the Agency has concluded that regulation of the six pollutants listed will provide adequate control for all of the toxic pollutants.

When the flow of 0.636 l/m^2 is applied to the achievable effluent concentrations for L&S technology listed in Table VII-20 the mass of pollutant allowed to be discharged per unit area coated can be calculated. Table X-22 on page 413 shows the limitations derived from this calculation.

ALUMINUM SUBCATEGORY

The effluent limitations based on BAT for the aluminum subcategory are based on: the achievable concentrations of regulated pollutants (mg/l) using L&S technology Table VII-20; the subcategory mean water usage for the metal preparation stream (l/m^2 of the metal prepared, identical to BPT water usage for metal preparation), the water use for coating equal to the category mean water use for ball mill washout (l/m^2 coating area). The mean water use for the metal preparation stream set forth in Section IX is 38.896 l/m^2. The average water use for coating used as the basis for BAT effluent limitation is 0.636 l/m^3.

Parameters selected for regulation for the aluminum subcategory at BAT are: chromium, lead, nickel, zinc, aluminum, and iron. In Section VI nine toxic pollutants were selected, as proposed, for consideration for regulation in this section. Comments were received on the cost of monitoring the large number of pollutants. After reviewing this listing and also nonconventional pollutants found in large quantities the Agency has concluded that regulation of the six pollutants listed will provide adequate control of all of the toxic pollutants.

When the flows for the metal preparation stream and for the coating stream are applied to the effluent concentrations achievable by application of L&S technology listed in Table VII-20, the mass of pollutant allowed to be discharged per unit area prepared or unit are coated can be calculated. Table X-23 on page 414 shows the limitations derived from this calculation.

DEMONSTRATION STATUS

Reuse of treated wastewater for most coatings operations water uses - all except ball mill washout - is the technology basis for the improved BAT performance above BPT. This technology was proposed and we received no adverse comments on it. Before proposal we examined the uses of water in coating operations and found that high quality water was not required for any of these uses except possibly for ball mill washout. Even though water reuse in the coatings operation is now minimal, we believe the applicability of this technology is fully supported by our technical analysis and the lack of any adverse comment.

TABLE X-1
SUMMARY OF TREATMENT EFFECTIVENESS
STEEL SUBCATEGORY

PARAMETER	RAW WASTE						BPT (PSES 0)		BAT A (PSES A)		BAT B (PSES B)	
	METAL PREPARATION		COATING		COMBINED		COMBINED		COMBINED		COMBINED	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW l/m^2	40.042		8.102		23.039*		23.039*		19.065*		23.039*	
114 ANTIMONY	0.000	0.000	68.154	552.184	12.758	293.932	0.050	1.152	0.050	0.953	0.034	0.783
115 ARSENIC	0.000	0.000	1.220	9.884	0.228	5.253	0.228	5.253	0.276	5.253	0.228	5.253
117 BERYLLIUM	0.000	0.000	0.043	0.348	0.008	0.184	0.008	0.184	0.010	0.184	0.008	0.184
118 CADMIUM	0.009	0.360	8.259	66.914	1.553	35.780	0.079	1.820	0.079	1.506	0.049	1.129
119 CHROMIUM	0.109	4.365	1.370	11.100	0.345	7.948	0.080	1.843	0.080	1.525	0.070	1.613
120 COPPER	0.057	2.282	3.492	28.292	0.700	16.127	0.580	13.363	0.580	11.058	0.390	8.985
122 LEAD	0.024	0.961	42.814	346.879	8.034	185.095	0.120	2.765	0.120	2.288	0.080	1.843
124 NICKEL	14.510	581.009	28.334	229.562	17.098	393.921	0.570	13.132	0.570	10.867	0.220	5.069
125 SELENIUM	0.096	3.844	10.047	81.401	1.959	45.133	0.010	0.230	0.010	0.191	0.007	0.161
128 ZINC	0.100	4.004	98.034	794.271	18.432	424.655	0.300	6.912	0.300	5.720	0.230	5.299
ALUMINUM	0.345	13.814	162.808	1319.070	30.757	708.611	1.110	25.573	1.110	21.162	0.740	17.049
COBALT	0.052	2.082	29.622	239.997	5.587	128.719	0.070	1.613	0.070	1.335	0.050	1.152
FLUORIDE	0.696	27.869	24.133	195.526	5.083	117.107	5.083	117.107	6.143	117.107	5.083	117.107
IRON	535.000	21422.470	36.922	299.142	441.764	10177.801	0.410	9.446	0.410	7.817	0.280	6.451
MANGANESE	1.938	77.601	44.094	357.250	9.829	226.450	0.210	4.838	0.210	4.004	0.140	3.225
PHOSPHORUS	5.430	217.428	4.249	34.425	5.209	120.010	4.080	93.999	4.080	77.785	2.720	62.666
OIL & GREASE	12.350	494.519	16.107	130.499	13.053	300.728	10.000	230.390	10.000	190.650	10.000	230.390
TSS	84.000	3363.528	21918.167	177580.989	4171.182	96099.862	12.000	276.468	12.000	228.780	2.600	59.901

PARAMETER	BAT C (PSES C)		BAT D (PSES D)				BAT E (PSES E)			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW l/m^2	19.065*		40.042		0.636		3.575		0.636	
114 ANTIMONY	0.034	0.648	0.000	0.000	0.034	0.022	0.000	0.000	0.034	0.022
115 ARSENIC	0.276	5.253	0.000	0.000	0.340	0.216	0.000	0.000	0.340	0.216
117 BERYLLIUM	0.010	0.184	0.000	0.000	0.200	0.127	0.000	0.000	0.200	0.127
118 CADMIUM	0.049	0.934	0.009	0.360	0.049	0.031	0.049	0.175	0.049	0.031
119 CHROMIUM	0.070	1.335	0.070	2.803	0.070	0.045	0.070	0.250	0.070	0.045
120 COPPER	0.390	7.435	0.057	2.282	0.390	0.248	0.390	1.394	0.390	0.248
122 LEAD	0.080	1.525	0.024	0.961	0.080	0.051	0.080	0.286	0.080	0.051
124 NICKEL	0.220	4.194	0.220	8.809	0.220	0.140	0.220	0.786	0.220	0.140
125 SELENIUM	0.007	0.133	0.007	0.280	0.007	0.004	0.007	0.025	0.007	0.004
128 ZINC	0.230	4.385	0.100	4.004	0.230	0.146	0.230	0.822	0.230	0.146
ALUMINUM	0.740	14.108	0.345	13.814	0.740	0.471	0.740	2.646	0.740	0.471
COBALT	0.050	0.953	0.050	2.002	0.050	0.032	0.050	0.179	0.050	0.032
FLUORIDE	6.143	117.107	0.696	27.869	9.460	6.017	7.796	27.869	9.460	6.017
IRON	0.280	5.338	0.280	11.212	0.280	0.178	0.280	1.001	0.280	0.178
MANGANESE	0.140	2.669	0.140	5.606	0.140	0.089	0.140	0.500	0.140	0.089
PHOSPHORUS	2.720	51.857	2.720	108.914	2.720	1.730	2.720	9.724	2.720	1.730
OIL & GREASE	10.000	190.650	10.000	400.420	10.000	6.360	10.000	35.750	10.000	6.360
TSS	2.600	49.569	2.600	104.109	2.600	1.654	2.600	9.295	2.600	1.654

*The ratio of coating production to metal preparation production is 1.14.

TABLE X-2
SUMMARY OF TREATMENT EFFECTIVENESS
CAST IRON SUBCATEGORY

PARAMETER	RAW WASTE COATING		BPT (PSES 0) COATING		BAT A (PSES A) COATING		BAT B (PSES B) COATING		BAT C (PSES C) COATING		BAT D (PSES D) COATING		BAT E (PSES E) COATING	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW l/m^2	0.693		0.693		0.636		0.693		0.636		0.636		0.636	
114 ANTIMONY	68.154	47.231	0.050	0.035	0.050	0.032	0.034	0.024	0.034	0.022	0.034	0.022	0.034	0.022
115 ARSENIC	1.220	0.845	0.510	0.353	0.510	0.324	0.340	0.236	0.340	0.216	0.340	0.216	0.340	0.216
117 BERYLLIUM	0.043	0.030	0.043	0.030	0.046	0.029	0.043	0.030	0.046	0.029	0.047	0.030	0.047	0.030
118 CADMIUM	8.259	5.723	0.079	0.055	0.079	0.050	0.049	0.034	0.049	0.031	0.049	0.031	0.049	0.031
119 CHROMIUM	1.370	0.949	0.080	0.055	0.080	0.051	0.070	0.049	0.070	0.045	0.070	0.045	0.070	0.045
120 COPPER	3.492	2.420	0.580	0.402	0.580	0.369	0.390	0.270	0.390	0.248	0.390	0.248	0.390	0.248
122 LEAD	42.814	29.670	0.120	0.083	0.120	0.076	0.080	0.055	0.080	0.051	0.080	0.051	0.080	0.051
124 NICKEL	28.334	19.635	0.570	0.395	0.570	0.363	0.220	0.152	0.220	0.140	0.220	0.140	0.220	0.140
125 SELENIUM	10.047	6.963	0.010	0.007	0.010	0.006	0.007	0.005	0.007	0.004	0.007	0.004	0.006	0.004
128 ZINC	98.034	67.938	0.300	0.208	0.300	0.191	0.230	0.159	0.230	0.146	0.230	0.146	0.230	0.146
ALUMINUM	162.808	112.826	1.110	0.769	1.110	0.706	0.740	0.513	0.740	0.471	0.740	0.471	0.740	0.471
COBALT	29.622	20.528	0.070	0.049	0.070	0.045	0.050	0.035	0.050	0.032	0.050	0.032	0.050	0.032
FLUORIDE	24.133	16.724	14.200	9.841	14.200	9.031	9.460	6.556	9.460	6.017	9.460	6.017	9.460	6.017
IRON	36.922	25.587	0.410	0.284	0.410	0.261	0.280	0.194	0.280	0.178	0.280	0.178	0.280	0.178
MANGANESE	44.094	30.557	0.210	0.146	0.210	0.134	0.140	0.097	0.140	0.089	0.140	0.089	0.140	0.089
PHOSPHORUS	4.249	2.945	4.080	2.827	4.080	2.595	2.720	1.885	2.720	1.730	2.720	1.730	2.720	1.730
OIL & GREASE	16.107	11.162	10.000	6.930	10.000	6.360	10.000	6.930	10.000	6.360	10.000	6.360	10.000	6.360
TSS	21918.167	15189.290	12.000	8.316	12.000	7.632	2.600	1.802	2.600	1.654	2.600	1.654	2.600	1.654

TABLE X-3
SUMMARY OF TREATMENT EFFECTIVENESS
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE						BPT (PSES 0)		BAT A (PSES A)		BAT B (PSES B)	
	METAL PREPARATION		COATING		COMBINED		COMBINED		COMBINED		COMBINED	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW 1/m^2	38.896		15.041		28.254*		28.254*		21.827*		28.254*	
114 ANTIMONY	0.000	0.000	68.154	1025.104	16.186	457.319	0.050	1.413	0.050	1.091	0.034	0.961
115 ARSENIC	0.000	0.000	1.220	18.350	0.290	8.194	0.290	8.194	0.375	8.185	0.290	8.194
117 BERYLLIUM	0.000	0.000	0.043	0.647	0.010	0.283	0.010	0.283	0.013	0.283	0.010	0.283
118 CADMIUM	0.003	0.117	8.259	124.224	1.964	55.491	0.079	2.232	0.079	1.724	0.049	1.384
119 CHROMIUM	0.013	0.506	1.370	20.606	0.335	9.465	0.080	2.260	0.080	1.746	0.070	1.978
120 COPPER	0.039	1.517	3.492	52.523	0.859	24.270	0.580	16.387	0.580	12.660	0.390	11.019
122 LEAD	2.175	84.599	42.814	643.965	11.827	334.160	0.120	3.390	0.120	2.619	0.080	2.260
124 NICKEL	0.000	0.000	28.334	426.172	6.729	190.121	0.570	16.105	0.570	12.441	0.220	6.216
125 SELENIUM	0.000	0.000	10.047	151.117	2.386	67.414	0.010	0.283	0.010	0.218	0.007	0.198
128 ZINC	0.210	8.168	98.034	1474.529	23.443	662.359	0.300	8.476	0.300	6.548	0.230	6.498
ALUMINUM	6.640	258.269	162.808	2448.795	43.729	1235.519	1.110	31.362	1.110	24.228	0.740	20.908
COBALT	0.000	0.000	29.622	445.545	7.035	198.767	0.070	1.978	0.070	1.528	0.050	1.413
FLUORIDE	0.880	34.228	24.133	362.984	6.402	180.882	6.402	180.882	8.287	180.880	6.402	180.882
IRON	0.097	3.773	36.922	555.344	8.843	249.850	0.410	11.584	0.410	8.949	0.280	7.911
MANGANESE	0.111	4.317	44.094	663.218	10.557	298.277	0.210	5.933	0.210	4.584	0.140	3.956
PHOSPHORUS	8.487	330.110	4.249	63.909	7.481	211.368	4.080	115.276	4.080	89.054	2.720	76.851
OIL & GREASE	6.850	266.438	16.107	242.265	9.048	255.642	9.048	255.642	10.000	218.270	9.048	255.642
TSS	39.880	1551.172	21918.167	329671.150	5235.838	147933.367	12.000	339.048	12.000	261.924	2.600	73.460

PARAMETER	BAT C (PSES C)		BAT D (PSES D)				BAT E (PSES E)			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW 1/m^2	21.827*		38.896		0.636		3.473		0.636	
114 ANTIMONY	0.034	0.742	0.000	0.000	0.034	0.022	0.000	0.000	0.034	0.022
115 ARSENIC	0.340	7.421	0.000	0.000	0.340	0.216	0.000	0.000	0.340	0.216
117 BERYLLIUM	0.013	0.283	0.000	0.000	0.200	0.127	0.000	0.000	0.200	0.127
118 CADMIUM	0.049	1.070	0.003	0.117	0.049	0.031	0.034	0.117	0.049	0.031
119 CHROMIUM	0.070	1.528	0.013	0.506	0.070	0.045	0.070	0.243	0.070	0.045
120 COPPER	0.390	8.513	0.039	1.517	0.390	0.248	0.390	1.354	0.390	0.248
122 LEAD	0.080	1.746	0.080	3.112	0.080	0.051	0.080	0.278	0.080	0.051
124 NICKEL	0.220	4.802	0.000	0.000	0.220	0.140	0.000	0.000	0.220	0.140
125 SELENIUM	0.007	0.153	0.000	0.000	0.007	0.004	0.000	0.000	0.007	0.004
128 ZINC	0.230	5.020	0.210	8.168	0.230	0.146	0.230	0.799	0.230	0.146
ALUMINUM	0.740	16.152	0.740	28.783	0.740	0.471	0.740	2.570	0.740	0.471
COBALT	0.050	1.091	0.000	0.000	0.050	0.032	0.000	0.000	0.050	0.032
FLUORIDE	8.287	180.880	0.880	34.228	9.460	6.017	9.460	32.855	9.460	6.017
IRON	0.280	6.112	0.097	3.773	0.280	0.178	0.280	0.972	0.280	0.178
MANGANESE	0.140	3.056	0.111	4.317	0.140	0.089	0.140	0.486	0.140	0.089
PHOSPHORUS	2.720	59.369	2.720	105.797	2.720	1.730	2.720	9.447	2.720	1.730
OIL & GREASE	10.000	218.270	6.850	266.438	10.000	6.360	10.000	34.730	10.000	6.360
TSS	2.600	56.750	2.600	101.130	2.600	1.654	2.600	9.030	2.600	1.654

*The ratio of coating production to metal preparation production is 0.81.

TABLE X-4
SUMMARY OF TREATMENT EFFECTIVENESS
COPPER SUBCATEGORY

PARAMETER	RAW WASTE						BPT (PSES 0)		BAT A (PSES A)		BAT B (PSES B)	
	METAL PREPARATION		COATING		COMBINED		COMBINED		COMBINED		COMBINED	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW l/m^2	67.290		4.740		35.420*		35.420*		33.330*		35.420*	
114 ANTIMONY	0.000	0.000	68.154	323.050	4.646	164.561	0.050	1.771	0.050	1.667	0.034	1.204
115 ARSENIC	0.000	0.000	1.220	5.783	0.083	2.940	0.083	2.940	0.088	2.933	0.083	2.940
117 BERYLLIUM	0.000	0.000	0.043	0.204	0.003	0.106	0.003	0.106	0.003	0.100	0.003	0.106
118 CADMIUM	0.022	1.480	8.259	39.148	0.583	20.650	0.079	2.798	0.079	2.633	0.049	1.736
119 CHROMIUM	0.026	1.750	1.370	6.494	0.118	4.180	0.080	2.834	0.080	2.666	0.070	2.479
120 COPPER	278.700	18753.723	3.492	16.552	259.941	9207.110	0.580	20.544	0.580	19.331	0.390	13.814
122 LEAD	0.770	51.813	42.814	202.938	3.636	128.787	0.120	4.250	0.120	4.000	0.080	2.834
124 NICKEL	0.120	8.075	28.334	134.303	2.043	72.363	0.570	20.189	0.570	18.998	0.220	7.792
125 SELENIUM	0.000	0.000	10.047	47.623	0.685	24.263	0.010	0.354	0.010	0.333	0.007	0.248
128 ZINC	0.890	59.888	98.034	464.681	7.512	266.075	0.300	10.626	0.300	9.999	0.230	8.147
ALUMINUM	0.073	4.912	162.808	771.710	11.166	395.500	1.110	39.316	1.110	36.996	0.740	26.211
COBALT	0.000	0.000	29.622	140.408	2.019	71.513	0.070	2.479	0.070	2.333	0.050	1.771
FLUORIDE	0.115	7.738	24.133	114.390	1.752	62.056	1.752	62.056	1.862	62.056	1.752	62.056
IRON	27.410	1844.419	36.922	175.010	28.058	993.814	0.410	14.522	0.410	13.665	0.280	9.918
MANGANESE	0.096	6.460	44.094	209.006	3.095	109.625	0.210	7.438	0.210	6.999	0.140	4.959
PHOSPHORUS	0.520	34.991	4.249	20.140	0.774	27.415	0.774	27.415	0.823	27.415	0.774	27.415
OIL & GREASE	196.000	13188.840	16.107	76.347	183.738	6508.000	10.000	354.200	10.000	333.300	10.000	354.200
TSS	19.000	1278.510	21918.167	103892.112	1511.743	53545.937	12.000	425.040	12.000	399.960	2.600	92.092

PARAMETER	BAT C (PSES C)		BAT D (PSES D)				BAT E (PSES E)			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2	mg/l	mg/m^2
FLOW l/m^2	33.330*		67.290		0.636		6.010		0.636	
114 ANTIMONY	0.034	1.133	0.000	0.000	0.034	0.022	0.000	0.000	0.034	0.022
115 ARSENIC	0.088	2.933	0.000	0.000	0.340	0.216	0.000	0.000	0.340	0.216
117 BERYLLIUM	0.003	0.100	0.000	0.000	0.200	0.127	0.000	0.000	0.200	0.127
118 CADMIUM	0.049	1.633	0.022	1.480	0.049	0.031	0.049	0.294	0.049	0.031
119 CHROMIUM	0.070	2.333	0.026	1.750	0.070	0.045	0.070	0.421	0.070	0.045
120 COPPER	0.390	12.999	0.390	26.243	0.390	0.248	0.390	2.344	0.390	0.248
122 LEAD	0.080	2.666	0.080	5.383	0.080	0.051	0.080	0.481	0.080	0.051
124 NICKEL	0.220	7.333	0.120	8.075	0.220	0.140	0.220	1.322	0.220	0.140
125 SELENIUM	0.007	0.233	0.000	0.000	0.007	0.004	0.000	0.000	0.007	0.004
128 ZINC	0.230	7.666	0.230	15.477	0.230	0.146	0.230	1.382	0.230	0.146
ALUMINUM	0.740	24.664	0.073	4.912	0.740	0.471	0.740	4.447	0.740	0.471
COBALT	0.050	1.667	0.000	0.000	0.050	0.032	0.000	0.000	0.050	0.032
FLUORIDE	1.862	62.056	0.115	7.738	9.460	6.017	1.288	7.738	9.460	6.017
IRON	0.280	9.332	0.280	18.841	0.280	0.178	0.280	1.683	0.280	0.178
MANGANESE	0.140	4.666	0.096	6.460	0.140	0.089	0.140	0.841	0.140	0.089
PHOSPHORUS	0.823	27.415	0.520	34.991	2.720	1.730	2.720	16.347	2.720	1.730
OIL & GREASE	10.000	333.300	10.000	672.900	10.000	6.360	10.000	60.100	10.000	6.360
TSS	2.600	86.658	2.600	174.954	2.600	1.654	2.600	15.626	2.600	1.654

*The ratio of coating production to metal preparation production is 1.04.

TABLE X-5
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
STEEL SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE			BPT (PSES 0)		BAT A (PSES A)		BAT B (PSES B)		BAT C (PSES C)	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW 1/yr (10^6)	49.25	11.34	60.59		60.59		50.14		60.59		50.14
114 ANTIMONY	0.00	772.87	772.87	769.84	3.03	770.36	2.51	770.81	2.06	771.17	1.70
115 ARSENIC	0.00	13.83	13.83	0.00	13.83	0.00	13.83	0.00	13.83	0.00	13.83
117 BERYLLIUM	0.00	0.49	0.49	0.00	0.49	0.00	0.49	0.00	0.49	0.00	0.49
118 CADMIUM	0.44	93.66	94.10	89.31	4.79	90.14	3.96	91.13	2.97	91.64	2.46
119 CHROMIUM	5.37	15.54	20.91	16.06	4.85	16.90	4.01	16.67	4.24	17.40	3.51
120 COPPER	2.81	39.60	42.41	7.27	35.14	13.33	29.08	18.78	23.63	22.86	19.55
122 LEAD	1.18	485.51	486.69	479.42	7.27	480.67	6.02	481.84	4.85	482.68	4.01
124 NICKEL	714.62	321.31	1035.93	1001.39	34.54	1007.35	28.58	1022.60	13.33	1024.90	11.03
125 SELENIUM	4.73	113.93	118.66	118.05	0.61	118.16	0.50	118.24	0.42	118.31	0.35
128 ZINC	4.93	1111.71	1116.64	1098.46	18.18	1101.60	15.04	1102.70	13.94	1105.11	11.53
ALUMINUM	16.99	1846.24	1863.23	1795.98	67.25	1807.57	55.66	1818.39	44.84	1826.13	37.10
COBALT	2.56	335.91	338.47	334.23	4.24	334.96	3.51	335.44	3.03	335.96	2.51
FLUORIDE	34.28	273.67	307.95	0.00	307.95	0.00	307.95	0.00	307.95	0.00	307.95
IRON	26348.75	418.70	26767.45	26742.61	24.84	26746.89	20.56	26750.48	16.97	26753.41	14.04
MANGANESE	95.45	500.03	595.48	582.76	12.72	584.95	10.53	587.00	8.48	588.46	7.02
PHOSPHORUS	267.43	48.18	315.61	68.40	247.21	111.04	204.57	150.81	164.80	179.23	136.38
OIL & GREASE	608.24	182.65	790.89	184.99	605.90	289.49	501.40	184.99	605.90	289.49	501.40
TSS	4137.00	248552.01	252689.01	251961.93	727.08	252087.33	601.68	252531.48	157.53	252558.65	130.36
TOXIC METALS	734.08	2968.45	3702.53	3579.80	122.73	3598.51	104.02	3622.77	79.76	3634.07	68.46
CONVENTIONALS	4745.24	248734.66	253479.90	252146.92	1332.98	252376.82	1103.08	252716.47	763.43	252848.14	631.76
TOTAL POLLU.	32244.78	255125.84	287370.62	285250.70	2119.92	285560.74	1809.88	285981.36	1389.26	286165.40	1205.22
SLUDGE GEN				1673293.65		1676269.12		1679990.40		1681811.25	

PARAMETER	BAT D (PSES D)				BAT E (PSES E)				NSPS (PSNS)	
	METAL PREPARATION		COATING		METAL PREPARATION		COATING		COMBINED	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)		49.25		0.89		4.40		0.89		5.29
114 ANTIMONY	0.00	0.00	772.84	0.03	0.00	0.00	772.84	0.03	772.69	0.18
115 ARSENIC	0.00	0.00	13.53	0.30	0.00	0.00	13.53	0.30	12.03	1.80
117 BERYLLIUM	0.00	0.00	0.31	0.18	0.00	0.00	0.31	0.18	0.00	0.49
118 CADMIUM	0.00	0.44	93.62	0.04	0.22	0.22	93.62	0.04	93.84	0.26
119 CHROMIUM	1.92	3.45	15.48	0.06	5.06	0.31	15.48	0.06	20.54	0.37
120 COPPER	0.00	2.81	39.25	0.35	1.09	1.72	39.25	0.35	40.35	2.06
122 LEAD	0.00	1.18	485.44	0.07	0.83	0.35	485.44	0.07	486.27	0.42
124 NICKEL	703.78	10.84	321.11	0.20	713.65	0.97	321.11	0.20	1034.77	1.16
125 SELENIUM	4.39	0.34	113.92	0.01	4.70	0.03	113.92	0.01	118.62	0.04
128 ZINC	0.00	4.93	1111.51	0.20	3.92	1.01	1111.51	0.20	1115.42	1.22
ALUMINUM	0.00	16.99	1845.58	0.66	13.73	3.26	1845.58	0.66	1859.32	3.91
COBALT	0.10	2.46	335.87	0.04	2.34	0.22	335.87	0.04	338.21	0.26
FLUORIDE	0.00	34.28	265.25	8.42	0.00	34.28	265.25	8.42	257.93	50.02
IRON	26334.96	13.79	418.45	0.25	26347.52	1.23	418.45	0.25	26765.97	1.48
MANGANESE	88.55	6.90	499.91	0.12	94.83	0.62	499.91	0.12	594.74	0.74
PHOSPHORUS	133.47	133.96	45.76	2.42	255.46	11.97	45.76	2.42	301.23	14.38
OIL & GREASE	115.74	492.50	173.75	8.90	564.24	44.00	173.75	8.90	738.02	52.87
TSS	4008.95	128.05	248549.70	2.31	4125.56	11.44	248549.70	2.31	252675.26	13.75
TOXIC METALS	710.09	23.99	2967.01	1.44	729.47	4.61	2967.01	1.44	3644.53	8.00
CONVENTIONALS	4124.69	620.55	248723.45	11.21	4689.80	55.44	248723.45	11.21	253413.28	66.62
TOTAL POLLU.	31391.86	852.92	255101.28	24.56	32133.15	111.63	255101.28	24.56	287175.21	145.41
SLUDGE GEN	328558.25		1358332.73		335562.03		1358332.73		1693027.41	

TABLE X-6
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
CAST IRON SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE COATING	BPT (PSES O) COATING		BAT (PSES A) COATING		BAT B (PSES B) COATING		BAT C (PSES C) COATING	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW l/yr (10^6)	0.55		0.55		0.51		0.55		0.51
114 ANTIMONY	37.48	37.45	0.03	37.45	0.03	37.46	0.02	37.46	0.02
115 ARSENIC	0.67	0.39	0.28	0.41	0.26	0.48	0.19	0.50	0.17
117 BERYLLIUM	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02
118 CADMIUM	4.54	4.50	0.04	4.50	0.04	4.51	0.03	4.52	0.02
119 CHROMIUM	0.75	0.71	0.04	0.71	0.04	0.71	0.04	0.71	0.04
120 COPPER	1.92	1.60	0.32	1.62	0.30	1.71	0.21	1.72	0.20
122 LEAD	23.55	23.48	0.07	23.49	0.06	23.51	0.04	23.51	0.04
124 NICKEL	15.58	15.27	0.31	15.29	0.29	15.46	0.12	15.47	0.11
125 SELENIUM	5.53	5.52	0.01	5.52	0.01	5.53	0.00	5.53	0.00
128 ZINC	53.92	53.75	0.17	53.77	0.15	53.79	0.13	53.80	0.12
ALUMINUM	89.54	88.93	0.61	88.97	0.57	89.13	0.41	89.16	0.38
COBALT	16.29	16.25	0.04	16.25	0.04	16.26	0.03	16.26	0.03
FLUORIDE	13.27	5.46	7.81	6.03	7.24	8.07	5.20	8.45	4.82
IRON	20.31	20.08	0.23	20.10	0.21	20.16	0.15	20.17	0.14
MANGANESE	24.25	24.13	0.12	24.14	0.11	24.17	0.08	24.18	0.07
PHOSPHORUS	2.34	0.10	2.24	0.26	2.08	0.84	1.50	0.95	1.39
OIL & GREASE	8.86	3.36	5.50	3.76	5.10	3.36	5.50	3.76	5.10
TSS	12054.99	12048.39	6.60	12048.87	6.12	12053.56	1.43	12053.66	1.33
TOXIC METALS	143.96	142.67	1.29	142.76	1.20	143.16	0.80	143.22	0.74
CONVENTIONALS	12063.85	12051.75	12.10	12052.63	11.22	12056.92	6.93	12057.42	6.43
TOTAL POLLU.	12373.81	12349.37	24.44	12351.14	22.67	12358.71	15.10	12359.81	14.00
SLUDGE GEN		65612.59		65632.80		65714.79		65727.90	

PARAMETER	BAT D (PSES D) COATING		BAT E (PSES E) COATING		NSPS (PSNS) COATING	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW l/yr (10^6)		0.51		0.51		0.51
114 ANTIMONY	37.46	0.02	37.46	0.02	37.46	0.02
115 ARSENIC	0.50	0.17	0.50	0.17	0.50	0.17
117 BERYLLIUM	0.00	0.02	0.00	0.02	0.00	0.02
118 CADMIUM	4.52	0.02	4.52	0.02	4.52	0.02
119 CHROMIUM	0.71	0.04	0.71	0.04	0.71	0.04
120 COPPER	1.72	0.20	1.72	0.20	1.72	0.20
122 LEAD	23.51	0.04	23.51	0.04	23.51	0.04
124 NICKEL	15.47	0.11	15.47	0.11	15.47	0.11
125 SELENIUM	5.53	0.00	5.53	0.00	5.53	0.00
128 ZINC	53.80	0.12	53.80	0.12	53.80	0.12
ALUMINUM	89.16	0.38	89.16	0.38	89.16	0.38
COBALT	16.26	0.03	16.26	0.03	16.26	0.03
FLUORIDE	8.45	4.82	8.45	4.82	8.45	4.82
IRON	20.17	0.14	20.17	0.14	20.17	0.14
MANGANESE	24.18	0.07	24.18	0.07	24.18	0.07
PHOSPHORUS	0.95	1.39	0.95	1.39	0.95	1.39
OIL & GREASE	3.76	5.10	3.76	5.10	3.76	5.10
TSS	12053.66	1.33	12053.66	1.33	12053.66	1.33
TOXIC METALS	143.22	0.74	143.22	0.74	143.22	0.74
CONVENTIONALS	12057.42	6.43	12057.42	6.43	12057.42	6.43
TOTAL POLLU.	12359.81	14.00	12359.81	14.00	12359.81	14.00
SLUDGE GEN	65727.90		65727.90		65727.90	

TABLE X-7
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
ALUMINUM SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE			BPT (PSES 0)		BAT A (PSES A)		BAT B (PSES B)		BAT C (PSES C)	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)	10.00	3.11	13.11		13.11		10.13		13.11		10.13
114 ANTIMONY	0.00	211.96	211.96	211.30	0.66	211.45	0.51	211.51	0.45	211.62	0.34
115 ARSENIC	0.00	3.79	3.79	0.00	3.79	0.00	3.79	0.00	3.79	0.35	3.44
117 BERYLLIUM	0.00	0.13	0.13	0.00	0.13	0.00	0.13	0.00	0.13	0.00	0.13
118 CADMIUM	0.03	25.69	25.72	24.68	1.04	24.92	0.80	25.08	0.64	25.22	0.50
119 CHROMIUM	0.13	4.26	4.39	3.34	1.05	3.58	0.81	3.47	0.92	3.68	0.71
120 COPPER	0.39	10.86	11.25	3.65	7.60	5.37	5.88	6.14	5.11	7.30	3.95
122 LEAD	21.75	133.15	154.90	153.33	1.57	153.68	1.22	153.85	1.05	154.09	0.81
124 NICKEL	0.00	88.12	88.12	80.65	7.47	82.35	5.77	85.24	2.88	85.89	2.23
125 SELENIUM	0.00	31.25	31.25	31.12	0.13	31.15	0.10	31.16	0.09	31.18	0.07
128 ZINC	2.10	304.89	306.99	303.06	3.93	303.95	3.04	303.97	3.02	304.66	2.33
ALUMINUM	66.40	506.33	572.73	558.18	14.55	561.49	11.24	563.03	9.70	565.23	7.50
COBALT	0.00	92.12	92.12	91.20	0.92	91.41	0.71	91.46	0.66	91.61	0.51
FLUORIDE	8.80	75.05	83.85	0.00	83.85	0.00	83.85	0.00	83.85	0.00	83.85
IRON	0.97	114.83	115.80	110.42	5.38	111.65	4.15	112.13	3.67	112.96	2.84
MANGANESE	1.11	137.13	138.24	135.49	2.75	136.11	2.13	136.40	1.84	136.82	1.42
PHOSPHORUS	84.87	13.21	98.08	44.59	53.49	56.75	41.33	62.42	35.66	70.53	27.55
OIL & GREASE	68.50	50.09	118.59	0.00	118.59	17.29	101.30	0.00	118.59	17.29	101.30
TSS	398.80	68165.50	68564.30	68406.98	157.32	68442.74	121.56	68530.21	34.09	68537.96	26.34
TOXIC METALS	24.40	814.10	838.50	811.13	27.37	816.45	22.05	820.42	18.08	823.99	14.51
CONVENTIONALS	467.30	68215.59	68682.89	68406.98	275.91	68460.03	222.86	68530.21	152.68	68555.25	127.64
TOTAL POLLU.	653.85	69968.36	70622.21	70157.99	464.22	70233.89	388.32	70316.07	306.14	70356.39	265.82
SLUDGE GEN				374388.94		375174.95		375837.76		376297.26	

PARAMETER	BAT D (PSES D)				BAT E (PSES E)				NSPS (PSNS)	
	METAL PREPARATION		COATING		METAL PREPARATION		COATING		COMBINED	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)		10.00		0.13		0.89		0.13		1.03
114 ANTIMONY	0.00	0.00	211.96	0.00	0.00	0.00	211.96	0.00	211.93	0.03
115 ARSENIC	0.00	0.00	3.75	0.04	0.00	0.00	3.75	0.04	3.44	0.35
117 BERYLLIUM	0.00	0.00	0.10	0.03	0.00	0.00	0.10	0.03	0.00	0.13
118 CADMIUM	0.00	0.03	25.68	0.01	0.00	0.03	25.68	0.01	25.67	0.05
119 CHROMIUM	0.00	0.13	4.25	0.01	0.07	0.06	4.25	0.01	4.32	0.07
120 COPPER	0.00	0.39	10.81	0.05	0.04	0.35	10.81	0.05	10.85	0.40
122 LEAD	20.95	0.80	133.14	0.01	21.68	0.07	133.14	0.01	154.82	0.08
124 NICKEL	0.00	0.00	88.09	0.03	0.00	0.00	88.09	0.03	87.89	0.23
125 SELENIUM	0.00	0.00	31.25	0.00	0.00	0.00	31.25	0.00	31.24	0.01
128 ZINC	0.00	2.10	304.86	0.03	1.90	0.20	304.86	0.03	306.75	0.24
ALUMINUM	59.00	7.40	506.23	0.10	65.74	0.66	506.23	0.10	571.97	0.76
COBALT	0.00	0.00	92.11	0.01	0.00	0.00	92.11	0.01	92.07	0.05
FLUORIDE	0.00	8.80	73.82	1.23	0.38	8.42	73.82	1.23	74.15	9.70
IRON	0.00	0.97	114.79	0.04	0.72	0.25	114.79	0.04	115.51	0.29
MANGANESE	0.00	1.11	137.11	0.02	0.99	0.12	137.11	0.02	138.10	0.14
PHOSPHORUS	57.67	27.20	12.86	0.35	82.45	2.42	12.86	0.35	95.29	2.79
OIL & GREASE	0.00	68.50	48.79	1.30	59.60	8.90	48.79	1.30	108.34	10.25
TSS	372.80	26.00	68165.16	0.34	396.49	2.31	68165.16	0.34	68561.63	2.67
TOXIC METALS	20.95	3.45	813.89	0.21	23.69	0.71	813.89	0.21	836.91	1.59
CONVENTIONALS	372.80	94.50	68213.95	1.64	456.09	11.21	68213.95	1.64	68669.98	12.92
TOTAL POLLU.	510.42	143.43	69964.76	3.60	630.06	23.79	69964.76	3.60	70593.98	28.24
SLUDGE GEN	5235.86		372560.46		6523.34		372560.46		379068.51	

TABLE X-8
POLLUTANT REDUCTION BENEFITS OF CONTROL SYSTEMS
COPPER SUBCATEGORY - NORMAL PLANT

PARAMETER	RAW WASTE			BPT (PSES O) COMBINED		BAT A (PSES A) COMBINED		BAT B (PSES B) COMBINED		BAT C (PSES C) COMBINED	
	METAL PREPARATION kg/yr	COATING kg/yr	COMBINED kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	3.50	0.26	3.76		3.76		3.53		3.76		3.53
114 ANTIMONY	0.00	17.72	17.72	17.53	0.19	17.54	0.18	17.59	0.13	17.60	0.12
115 ARSENIC	0.00	0.32	0.32	0.00	0.32	0.00	0.32	0.00	0.32	0.00	0.32
117 BERYLLIUM	0.00	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01
118 CADMIUM	0.08	2.15	2.23	1.93	0.30	1.95	0.28	2.05	0.18	2.06	0.17
119 CHROMIUM	0.09	0.36	0.45	0.15	0.30	0.17	0.28	0.19	0.26	0.20	0.25
120 COPPER	975.45	0.91	976.36	974.18	2.18	974.31	2.05	974.89	1.47	974.98	1.38
122 LEAD	2.70	11.13	13.83	13.38	0.45	13.41	0.42	13.53	0.30	13.55	0.28
124 NICKEL	0.42	7.37	7.79	5.65	2.14	5.78	2.01	6.96	0.83	7.01	0.78
125 SELENIUM	0.00	2.61	2.61	2.57	0.04	2.57	0.04	2.58	0.03	2.59	0.02
128 ZINC	3.12	25.49	28.61	27.48	1.13	27.55	1.06	27.75	0.86	27.80	0.81
ALUMINUM	0.26	42.33	42.59	38.42	4.17	38.67	3.92	39.81	2.78	39.98	2.61
COBALT	0.00	7.70	7.70	7.44	0.26	7.45	0.25	7.51	0.19	7.52	0.18
FLUORIDE	0.40	6.27	6.67	0.00	6.67	0.00	6.67	0.00	6.67	0.00	6.67
IRON	95.94	9.60	105.54	104.00	1.54	104.09	1.45	104.49	1.05	104.55	0.99
MANGANESE	0.34	11.46	11.80	11.01	0.79	11.06	0.74	11.27	0.53	11.31	0.49
PHOSPHORUS	1.82	1.10	2.92	0.00	2.92	0.00	2.92	0.00	2.92	0.00	2.92
OIL & GREASE	686.00	4.19	690.19	652.59	37.60	654.89	35.30	652.59	37.60	654.89	35.30
TSS	66.50	5698.72	5765.22	5720.10	45.12	5722.86	42.36	5755.44	9.78	5756.04	9.18
TOXIC METALS	981.86	68.07	1049.93	1042.87	7.06	1043.28	6.65	1045.54	4.39	1045.79	4.14
CONVENTIONALS	752.50	5702.91	6455.41	6372.69	82.72	6377.75	77.66	6408.03	47.38	6410.93	44.48
TOTAL POLLU.	1833.12	5849.44	7682.56	7576.43	106.13	7582.30	100.26	7616.65	65.91	7620.08	62.48
SLUDGE GEN				43437.45		43479.02		43723.86		43748.26	

PARAMETER	BAT D (PSES D)				BAT E (PSES E)				NSPS (PSNS) COMBINED	
	METAL PREPARATION		COATING		METAL PREPARATION		COATING			
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)		3.50		0.03		0.31		0.03		0.35
114 ANTIMONY	0.00	0.00	17.72	0.00	0.00	0.00	17.72	0.00	17.71	0.01
115 ARSENIC	0.00	0.00	0.31	0.01	0.00	0.00	0.31	0.01	0.20	0.12
117 BERYLLIUM	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01
118 CADMIUM	0.00	0.08	2.15	0.00	0.06	0.02	2.15	0.00	2.21	0.02
119 CHROMIUM	0.00	0.09	0.36	0.00	0.07	0.02	0.36	0.00	0.43	0.02
120 COPPER	974.08	1.37	0.90	0.01	975.33	0.12	0.90	0.01	976.23	0.13
122 LEAD	2.42	0.28	11.13	0.00	2.68	0.02	11.13	0.00	13.80	0.03
124 NICKEL	0.00	0.42	7.36	0.01	0.35	0.07	7.36	0.01	7.71	0.08
125 SELENIUM	0.00	0.00	2.61	0.00	0.00	0.00	2.61	0.00	2.61	0.00
128 ZINC	2.32	0.80	25.48	0.01	3.05	0.07	25.48	0.01	28.53	0.08
ALUMINUM	0.00	0.26	42.31	0.02	0.03	0.23	42.31	0.02	42.33	0.26
COBALT	0.00	0.00	7.70	0.00	0.00	0.00	7.70	0.00	7.68	0.02
FLUORIDE	0.00	0.40	5.99	0.28	0.00	0.40	5.99	0.28	3.40	3.27
IRON	94.96	0.98	9.59	0.01	95.85	0.09	9.59	0.01	105.44	0.10
MANGANESE	0.00	0.34	11.46	0.00	0.30	0.04	11.46	0.00	11.75	0.05
PHOSPHORUS	0.00	1.82	1.02	0.08	0.98	0.84	1.02	0.08	1.98	0.94
OIL & GREASE	651.00	35.00	3.89	0.30	682.90	3.10	3.89	0.30	686.73	3.46
TSS	57.40	9.10	5698.64	0.08	65.69	0.81	5698.64	0.08	5765.32	0.90
TOXIC METALS	978.82	3.04	68.02	0.05	981.54	0.32	68.02	0.05	1039.43	0.50
CONVENTIONALS	708.40	44.10	5702.53	0.38	748.59	3.91	5702.53	0.38	6452.05	4.36
TOTAL POLLU.	1782.18	50.94	5848.62	0.82	1827.29	5.83	5848.62	0.82	7674.06	9.5
SLUDGE GEN	12817.27		31140.19		13092.22		31140.19		11194.194	

TABLE X-9
TREATMENT PERFORMANCE
STEEL SUBCATEGORY

PARAMETER	RAW WASTE			BPT & PSES 0		BAT A & PSES A		BAT B & PSES B	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)	4926.77	1134.69	6061.46		6061.46		5015.84		6061.46
114 ANTIMONY	0.00	77333.66	77333.66	77030.59	303.07	77082.87	250.79	77127.57	206.09
115 ARSENIC	0.00	1384.32	1384.32	0.00	1384.32	0.00	1384.32	0.00	1384.32
117 BERYLLIUM	0.00	48.79	48.79	0.00	48.79	0.00	48.79	0.00	48.79
118 CADMIUM	44.34	9371.40	9415.74	8936.88	478.86	9019.49	396.25	9118.73	297.01
119 CHROMIUM	537.02	1554.53	2091.55	1606.63	484.92	1690.28	401.27	1667.25	424.30
120 COPPER	280.83	3962.34	4243.17	727.52	3515.65	1333.98	2909.19	1879.20	2363.97
122 LEAD	118.24	48580.62	48698.86	47971.48	727.38	48096.96	601.90	48213.94	484.92
124 NICKEL	71487.43	32150.31	103637.74	100182.71	3455.03	100778.71	2859.03	102304.22	1333.52
125 SELENIUM	472.97	11400.23	11873.20	11812.59	60.61	11823.04	50.16	11830.77	42.43
128 ZINC	492.68	111238.20	111730.88	109912.44	1818.44	110226.13	1504.75	110336.74	1394.14
ALUMINUM	1699.74	184736.61	186436.35	179708.13	6728.22	180868.77	5567.58	181950.87	4485.48
COBALT	256.19	33611.79	33867.98	33443.68	424.30	33516.87	351.11	33564.91	303.07
FLUORIDE	3429.03	27383.47	30812.50	0.00	30812.50	0.00	30812.50	0.00	30812.50
IRON	2635821.95	41895.02	2677716.97	2675231.77	2485.20	2675660.48	2056.49	2676019.76	1697.21
MANGANESE	9548.08	50033.02	59581.10	58308.19	1272.91	58527.77	1053.33	58732.50	848.60
PHOSPHORUS	26752.36	4821.30	31573.66	6842.90	24730.76	11109.03	20464.63	15086.49	16487.17
OIL & GREASE	60845.61	18276.45	79122.06	18507.46	60614.60	28963.66	50158.40	18507.46	60614.60
TSS	413848.68	24870324.91	25284173.59	25211436.07	72737.52	25223983.51	60190.08	25268413.79	15759.80
TOXIC METALS	73433.51	297024.40	370457.91	358180.84	12277.07	360051.46	10406.45	362478.42	7979.49
CONVENTIONALS	474694.29	24888601.36	25363295.65	25229943.53	133352.12	25252947.17	110348.48	25286921.25	76374.40
TOTAL POLLU.	3225635.15	25528106.97	28753742.12	28541659.04	212083.08	28572681.55	181060.57	28614754.20	138987.92
SLUDGE GEN				167423124.64		167720859.21		168093065.83	

PARAMETER	BAT C & PSES C		BAT D & PSES D				BAT E & PSES E			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)		5015.84		4926.77		89.07		439.89		89.07
114 ANTIMONY	77163.12	170.54	0.00	0.00	77330.63	3.03	0.00	0.00	77330.63	3.03
115 ARSENIC	0.00	1384.32	0.00	0.00	1354.04	30.28	0.00	0.00	1354.04	30.28
117 BERYLLIUM	0.00	48.79	0.00	0.00	30.98	17.81	0.00	0.00	30.98	17.81
118 CADMIUM	9169.96	245.78	0.00	44.34	9367.04	4.36	22.79	21.55	9367.04	4.36
119 CHROMIUM	1740.44	351.11	192.15	344.87	1548.30	6.23	506.23	30.79	1548.30	6.23
120 COPPER	2286.99	1956.18	0.00	280.83	3927.60	34.74	109.27	171.56	3927.60	34.74
122 LEAD	48297.59	401.27	0.00	118.24	48573.49	7.13	83.05	35.19	48573.49	7.13
124 NICKEL	102534.26	1103.48	70403.54	1083.89	32130.71	19.60	71390.65	96.78	32130.71	19.60
125 SELENIUM	11838.09	35.11	438.48	34.49	11399.61	0.62	469.89	3.08	11399.61	0.62
128 ZINC	110577.24	1153.64	0.00	492.68	111217.71	20.49	391.51	101.17	111217.71	20.49
ALUMINUM	182724.63	3711.72	0.00	1699.74	184670.70	65.91	1374.22	325.52	184670.70	65.91
COBALT	33617.19	250.79	9.85	246.34	33607.34	4.45	234.20	21.99	33607.34	4.45
FLUORIDE	0.00	30812.50	0.00	3429.03	26540.87	842.60	0.00	3429.03	26540.87	842.60
IRON	2676312.53	1404.44	2634442.45	1379.50	41870.08	24.94	2635698.78	123.17	41870.08	24.94
MANGANESE	58878.88	702.22	8858.33	689.75	50020.55	12.47	9486.50	61.58	50020.55	12.47
PHOSPHORUS	17930.58	13643.08	13351.55	13400.81	4579.03	242.27	25555.86	1196.50	4579.03	242.27
OIL & GREASE	28963.66	50158.40	11577.91	49267.70	17385.75	890.70	56446.71	4398.90	17385.75	890.70
TSS	25271132.41	13041.18	401039.08	12809.60	24870093.33	231.58	412704.97	1143.71	24870093.33	231.58
TOXIC METALS	363607.69	6850.22	71034.17	2399.34	296880.11	144.29	72973.39	460.12	296880.11	144.29
CONVENTIONALS	25300096.07	63199.58	412616.99	62077.30	24887479.08	1122.28	469151.68	5542.61	24887479.08	1122.28
TOTAL POLLU.	28633167.57	120574.55	3140313.34	85321.81	25525647.76	2459.21	3214474.63	11160.52	25525647.76	2459.21
SLUDGE GEN	168275233.63		32867630.37		135915905.97		33568317.77		135915905.97	

TABLE X-10
TREATMENT PERFORMANCE
CAST IRON SUBCATEGORY

PARAMETER	RAW WASTE COATING	BPT & PSES 0 COATING		BAT A & PSES A COATING		BAT B & PSES B COATING	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	6.62		6.62		6.08		6.62
114 ANTIMONY	451.18	450.85	0.33	450.88	0.30	450.95	0.23
115 ARSENIC	8.08	4.70	3.38	4.98	3.10	5.83	2.25
117 BERYLLIUM	0.28	0.00	0.28	0.00	0.28	0.00	0.28
118 CADMIUM	54.67	54.15	0.52	54.19	0.48	54.35	0.32
119 CHROMIUM	9.07	8.54	0.53	8.58	0.49	8.61	0.46
120 COPPER	23.12	19.28	3.84	19.59	3.53	20.54	2.58
122 LEAD	283.43	282.64	0.79	282.70	0.73	282.90	0.53
124 NICKEL	187.57	183.80	3.77	184.10	3.47	186.11	1.46
125 SELENIUM	66.51	66.44	0.07	66.45	0.06	66.46	0.05
128 ZINC	648.99	647.00	1.99	647.17	1.82	647.47	1.52
ALUMINUM	1077.79	1070.44	7.35	1071.04	6.75	1072.89	4.90
COBALT	196.10	195.64	0.46	195.67	0.43	195.77	0.33
FLUORIDE	159.76	65.76	94.00	73.42	86.34	97.13	62.63
IRON	244.42	241.71	2.71	241.93	2.49	242.57	1.85
MANGANESE	291.90	290.51	1.39	290.62	1.28	290.97	0.93
PHOSPHORUS	28.13	1.12	27.01	3.32	24.81	10.12	18.01
OIL & GREASE	106.63	40.43	66.20	45.83	60.80	40.43	66.20
TSS	145098.27	145018.83	79.44	145025.31	72.96	145081.06	17.21
TOXIC METALS	1732.90	1717.40	15.50	1718.64	14.26	1723.22	9.68
CONVENTIONALS	145204.90	145059.26	145.64	145071.14	133.76	145121.49	83.41
TOTAL POLLU.	148935.90	148641.84	294.06	148665.78	270.12	148754.16	181.74
SLUDGE GEN		789741.20		790016.55		790972.29	

PARAMETER	BAT C & PSES C COATING		BAT D & PSES D COATING		BAT E & PSES E COATING	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)		6.08		6.08		6.08
114 ANTIMONY	450.97	0.21	450.97	0.21	450.97	0.21
115 ARSENIC	6.01	2.07	6.01	2.07	6.01	2.07
117 BERYLLIUM	0.00	0.28	0.00	0.28	0.00	0.28
118 CADMIUM	54.37	0.30	54.37	0.30	54.37	0.30
119 CHROMIUM	8.64	0.43	8.64	0.43	8.64	0.43
120 COPPER	20.75	2.37	20.75	2.37	20.75	2.37
122 LEAD	282.94	0.49	282.94	0.49	282.94	0.49
124 NICKEL	186.23	1.34	186.23	1.34	186.23	1.34
125 SELENIUM	66.47	0.04	66.47	0.04	66.47	0.04
128 ZINC	647.59	1.40	647.59	1.40	647.59	1.40
ALUMINUM	1073.29	4.50	1073.29	4.50	1073.29	4.50
COBALT	195.80	0.30	195.80	0.30	195.80	0.30
FLUORIDE	102.24	57.52	102.24	57.52	102.24	57.52
IRON	242.72	1.70	242.72	1.70	242.72	1.70
MANGANESE	291.05	0.85	291.05	0.85	291.05	0.85
PHOSPHORUS	11.59	16.54	11.59	16.54	11.59	16.54
OIL & GREASE	45.83	60.80	45.83	60.80	45.83	60.80
TSS	145082.46	15.81	145082.46	15.81	145082.46	15.81
TOXIC METALS	1723.97	8.93	1723.97	8.93	1723.97	8.93
CONVENTIONALS	145128.29	76.61	145128.29	76.61	145128.29	76.61
TOTAL POLLU.	148768.95	166.95	148768.95	166.95	148768.95	166.95
SLUDGE GEN	791147.79		791147.79		791147.79	

TABLE X-11
TREATMENT PERFORMANCE
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE			BPT & PSES 0		BAT A & PSES A		BAT B & PSES B		BAT C & PSES C	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)	159.94	49.82	209.76		209.76		162.05		209.76		162.05
114 ANTIMONY	0.00	3395.43	3395.43	3384.94	10.49	3387.33	8.10	3388.30	7.13	3389.92	5.51
115 ARSENIC	0.00	60.78	60.78	0.00	60.78	0.00	60.78	0.00	60.78	5.68	55.10
117 BERYLLIUM	0.00	2.14	2.14	0.00	2.14	0.00	2.14	0.00	2.14	0.00	2.14
118 CADMIUM	0.48	411.46	411.94	395.37	16.57	399.14	12.80	401.66	10.28	404.00	7.94
119 CHROMIUM	2.08	68.25	70.33	53.55	16.78	57.37	12.96	55.65	14.68	58.99	11.34
120 COPPER	6.24	173.97	180.21	58.55	121.66	86.22	93.99	98.40	81.81	117.01	63.20
122 LEAD	347.87	2132.99	2480.86	2455.69	25.17	2461.41	19.45	2464.08	16.78	2467.90	12.96
124 NICKEL	0.00	1411.60	1411.60	1292.04	119.56	1319.23	92.37	1365.45	46.15	1375.95	35.65
125 SELENIUM	0.00	500.54	500.54	498.44	2.10	498.92	1.62	499.07	1.47	499.41	1.13
128 ZINC	33.59	4884.05	4917.64	4854.71	62.93	4869.02	48.62	4869.40	48.24	4880.37	37.27
ALUMINUM	1062.00	8111.09	9173.09	8940.26	232.83	8993.21	179.88	9017.87	155.22	9053.17	119.92
COBALT	0.00	1475.77	1475.77	1461.09	14.68	1464.43	11.34	1465.28	10.49	1467.67	8.10
FLUORIDE	140.75	1202.31	1343.06	0.00	1343.06	0.00	1343.06	0.00	1343.06	0.00	1343.06
IRON	15.51	1839.45	1854.96	1768.96	86.00	1788.52	66.44	1796.23	58.73	1809.59	45.37
MANGANESE	17.75	2196.76	2214.51	2170.46	44.05	2180.48	34.03	2185.14	29.37	2191.82	22.69
PHOSPHORUS	1357.41	211.69	1569.10	713.28	855.82	907.94	661.16	998.55	570.55	1128.32	440.78
OIL & GREASE	1095.59	802.45	1898.04	0.00	1898.04	277.54	1620.50	0.00	1898.04	277.54	1620.50
TSS	6378.41	1091963.08	1098341.49	1095824.37	2517.12	1096396.89	1944.60	1097796.11	545.38	1097920.16	421.33
TOXIC METALS	390.26	13041.21	13431.47	12993.29	438.18	13078.64	352.83	13142.01	289.46	13199.23	232.24
CONVENTIONALS	7474.00	1092765.53	1100239.53	1095824.37	4415.16	1096674.43	3565.10	1097796.11	2443.42	1098197.70	2041.83
TOTAL POLLU.	10457.68	1120843.81	1131301.49	1123871.71	7429.78	1125087.65	6213.84	1126401.19	4900.30	1127047.50	4253.99
SLUDGE GEN				5997345.56		6009932.64		6020528.84		6027891.10	

PARAMETER	BAT D & PSES D				BAT E & PSES E			
	METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)		159.94		2.11		14.28		2.11
114 ANTIMONY	0.00	0.00	3395.36	0.07	0.00	0.00	3395.36	0.07
115 ARSENIC	0.00	0.00	60.06	0.72	0.00	0.00	60.06	0.72
117 BERYLLIUM	0.00	0.00	1.72	0.42	0.00	0.00	1.72	0.42
118 CADMIUM	0.00	0.48	411.36	0.10	0.00	0.48	411.36	0.10
119 CHROMIUM	0.00	2.08	68.10	0.15	1.08	1.00	68.10	0.15
120 COPPER	0.00	6.24	173.15	0.82	0.67	5.57	173.15	0.82
122 LEAD	335.07	12.80	2132.82	0.17	346.73	1.14	2132.82	0.17
124 NICKEL	0.00	0.00	1411.14	0.46	0.00	0.00	1411.14	0.46
125 SELENIUM	0.00	0.00	500.53	0.01	0.00	0.00	500.53	0.01
128 ZINC	0.00	33.59	4883.56	0.49	30.31	3.28	4883.56	0.49
ALUMINUM	943.64	118.36	8109.53	1.56	1051.43	10.57	8109.53	1.56
COBALT	0.00	0.00	1475.66	0.11	0.00	0.00	1475.66	0.11
FLUORIDE	0.00	140.75	1182.35	19.96	5.66	135.09	1182.35	19.96
IRON	0.00	15.51	1838.86	0.59	11.51	4.00	1838.86	0.59
MANGANESE	0.00	17.75	2196.46	0.30	15.75	2.00	2196.46	0.30
PHOSPHORUS	922.37	435.04	205.95	5.74	1318.57	38.84	205.95	5.74
OIL & GREASE	0.00	1095.59	781.35	21.10	952.79	142.80	781.35	21.10
TSS	5962.57	415.84	1091957.59	5.49	6341.28	37.13	1091957.59	5.49
TOXIC METALS	335.07	55.19	13037.80	3.41	378.79	11.47	13037.80	3.41
CONVENTIONALS	5962.57	1511.43	1092738.94	26.59	7294.07	179.93	1092738.94	26.59
TOTAL POLLU.	8163.65	2294.03	1120785.55	58.26	10075.78	381.90	1120785.55	58.26
SLUDGE GEN	83742.02		5968154.23		104318.11		5968154.23	

TABLE X-12
TREATMENT PERFORMANCE
COPPER SUBCATEGORY

PARAMETER	RAW WASTE METAL PREPARATION kg/yr	RAW WASTE COATING kg/yr	RAW WASTE COMBINED kg/yr	BPT & PSES 0 COMBINED Removed kg/yr	BPT & PSES 0 COMBINED Discharged kg/yr	BAT A & PSES A COMBINED Removed kg/yr	BAT A & PSES A COMBINED Discharged kg/yr	BAT B & PSES B COMBINED Removed kg/yr	BAT B & PSES B COMBINED Discharged kg/yr
FLOW 1/yr (10^6)	7.00	0.51	7.51		7.51		7.07		7.51
114 ANTIMONY	0.00	34.76	34.76	34.38	0.38	34.41	0.35	34.50	0.26
115 ARSENIC	0.00	0.62	0.62	0.00	0.62	0.00	0.62	0.00	0.62
117 BERYLLIUM	0.00	0.02	0.02	0.00	0.02	0.00	0.02	0.00	0.02
118 CADMIUM	0.15	4.21	4.36	3.77	0.59	3.80	0.56	3.99	0.37
119 CHROMIUM	0.18	0.70	0.88	0.28	0.60	0.31	0.57	0.35	0.53
120 COPPER	1950.90	1.78	1952.68	1948.32	4.36	1948.58	4.10	1948.75	2.93
122 LEAD	5.39	21.84	27.23	26.33	0.90	26.38	0.85	26.63	0.60
124 NICKEL	0.84	14.45	15.29	11.01	4.28	11.26	4.03	13.64	1.65
125 SELENIUM	0.00	5.12	5.12	5.04	0.08	5.05	0.07	5.07	0.05
128 ZINC	6.23	50.00	56.23	53.98	2.25	54.11	2.12	54.50	1.73
ALUMINUM	0.51	83.03	83.54	75.20	8.34	75.69	7.85	77.98	5.56
COBALT	0.00	15.11	15.11	14.58	0.53	14.62	0.49	14.73	0.38
FLUORIDE	0.81	12.31	13.12	0.00	13.12	0.00	13.12	0.00	13.12
IRON	191.87	18.83	210.70	207.62	3.08	207.80	2.90	208.60	2.10
MANGANESE	0.67	22.49	23.16	21.58	1.58	21.68	1.48	22.11	1.05
PHOSPHORUS	3.64	2.17	5.81	0.00	5.81	0.00	5.81	0.00	5.81
OIL & GREASE	1372.00	8.21	1380.21	1305.11	75.10	1309.51	70.70	1305.11	75.10
TSS	133.00	11178.27	11311.27	11221.15	90.12	11226.43	84.84	11291.74	19.53
TOXIC METALS	1963.69	133.50	2097.19	2083.11	14.08	2083.90	13.29	2088.43	8.76
CONVENTIONALS	1505.00	11186.48	12691.48	12526.26	165.22	12535.94	155.54	12596.85	94.63
TOTAL POLLU.	3666.19	11473.92	15140.11	14928.35	211.76	14939.63	200.48	15008.70	131.41
SLUDGE GEN				85682.01		85762.37		86254.80	

PARAMETER	BAT C & PSES C COMBINED Removed kg/yr	BAT C & PSES C COMBINED Discharged kg/yr	BAT D & PSES D METAL PREPARATION Removed kg/yr	BAT D & PSES D METAL PREPARATION Discharged kg/yr	BAT D & PSES D COATING Removed kg/yr	BAT D & PSES D COATING Discharged kg/yr	BAT E & PSES E METAL PREPARATION Removed kg/yr	BAT E & PSES E METAL PREPARATION Discharged kg/yr	BAT E & PSES E COATING Removed kg/yr	BAT E & PSES E COATING Discharged kg/yr
FLOW 1/yr (10^6)		7.07		7.00		0.07		0.63		0.07
114 ANTIMONY	34.52	0.24	0.00	0.00	34.76	0.00	0.00	0.00	34.76	0.00
115 ARSENIC	0.00	0.62	0.00	0.00	0.60	0.02	0.00	0.00	0.60	0.02
117 BERYLLIUM	0.00	0.02	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01
118 CADMIUM	4.01	0.35	0.00	0.15	4.21	0.00	0.12	0.03	4.21	0.00
119 CHROMIUM	0.39	0.49	0.00	0.18	0.70	0.00	0.14	0.04	0.70	0.00
120 COPPER	1949.92	2.76	1948.17	2.73	1.75	0.03	1950.65	0.25	1.75	0.03
122 LEAD	26.66	0.57	4.83	0.56	21.83	0.01	5.34	0.05	21.83	0.01
124 NICKEL	13.73	1.56	0.00	0.84	14.43	0.02	0.70	0.14	14.43	0.02
125 SELENIUM	5.07	0.05	0.00	0.00	5.12	0.00	0.00	0.00	5.12	0.00
128 ZINC	54.60	1.63	4.62	1.61	49.98	0.02	6.09	0.14	49.98	0.02
ALUMINUM	78.31	5.23	0.00	0.51	82.98	0.05	0.04	0.47	82.98	0.05
COBALT	14.76	0.35	0.00	0.00	15.11	0.00	0.00	0.00	15.11	0.00
FLUORIDE	0.00	13.12	0.00	0.81	11.65	0.66	0.00	0.81	11.65	0.66
IRON	208.72	1.98	189.91	1.96	18.81	0.02	191.69	0.18	18.81	0.02
MANGANESE	22.17	0.99	0.00	0.67	22.48	0.01	0.58	0.09	22.48	0.01
PHOSPHORUS	0.00	5.81	0.00	3.64	1.98	0.19	1.93	1.71	1.98	0.19
OIL & GREASE	1309.51	70.70	1302.00	70.00	7.51	0.70	1365.70	6.30	7.51	0.70
TSS	11292.89	18.38	114.80	18.20	11178.09	0.18	131.36	1.64	11178.09	0.18
TOXIC METALS	2088.90	8.29	1957.62	6.07	133.39	0.11	1963.04	0.65	133.39	0.11
CONVENTIONALS	12602.40	89.08	1416.80	88.20	11185.60	0.88	1497.06	7.94	11185.60	0.88
TOTAL POLLU.	15015.26	124.85	3564.33	101.86	11472.00	1.92	3654.34	11.85	11472.00	1.92
SLUDGE GEN	86301.27		25634.23		61079.34		26181.64		61079.34	

TABLE X-13
TREATMENT PERFORMANCE
TOTAL CATEGORY

PARAMETER	RAW WASTE			BPT & PSES 0		BAT A & PSES A		BAT B & PSES B		BAT C & PSES C	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED		COMBINED	
	kg/yr	kg/yr	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	5093.71	1191.64	6285.35		6285.35		5191.04		6285.35		5191.04
114 ANTIMONY	0.00	81215.03	81215.03	80900.76	314.27	80955.49	259.54	81001.32	213.71	81038.53	176.50
115 ARSENIC	0.00	1453.80	1453.80	4.70	1449.10	4.98	1448.82	5.83	1447.97	11.69	1442.11
117 BERYLLIUM	0.00	51.23	51.23	0.00	51.23	0.00	51.23	0.00	51.23	0.00	51.23
118 CADMIUM	44.97	9841.74	9886.71	9390.17	496.54	9476.62	410.09	9578.73	307.98	9632.34	254.37
119 CHROMIUM	539.28	1632.55	2171.83	1669.00	502.83	1756.54	415.29	1731.86	439.97	1808.46	363.37
120 COPPER	2237.97	4161.21	6399.18	2753.67	3645.51	3388.37	3010.81	3947.89	2451.29	4374.67	2024.51
122 LEAD	471.50	51018.88	51490.38	50736.14	754.24	50867.45	622.93	50987.55	502.83	51075.09	415.29
124 NICKEL	71488.27	33763.93	105252.20	101669.56	3582.64	102293.30	2958.90	103869.42	1382.78	104110.17	1142.03
125 SELENIUM	472.97	11972.40	12445.37	12382.51	62.86	12393.46	51.91	12401.37	44.00	12409.04	36.33
128 ZINC	532.50	116821.24	117353.74	115468.13	1885.61	115796.43	1557.31	115908.11	1445.63	116159.80	1193.94
ALUMINUM	2762.25	194008.52	196770.77	189794.03	6976.74	191008.71	5762.06	192119.61	4651.16	192929.40	3841.37
COBALT	256.19	35298.77	35554.96	35114.99	439.97	35191.59	363.37	35240.69	314.27	35295.42	259.54
FLUORIDE	3570.59	28757.85	32328.44	65.76	32262.68	73.42	32255.02	97.13	32231.31	102.24	32226.20
IRON	2636029.33	43997.72	2680027.05	2677450.06	2576.99	2677898.73	2128.32	2678267.16	1759.89	2678573.56	1453.49
MANGANESE	9566.50	52544.17	62110.67	60790.74	1319.93	61020.55	1090.12	61230.72	879.95	61383.92	726.75
PHOSPHORUS	28113.41	5063.29	33176.70	7557.30	25619.40	12020.29	21156.41	16095.16	17081.54	19070.49	14106.21
OIL & GREASE	63313.20	19193.74	82506.94	19853.00	62653.94	30596.54	51910.40	19853.00	62653.94	30596.54	51910.40
TSS	420360.09	26118564.53	26538924.62	26463500.42	75424.20	26476632.14	62292.48	26522582.70	16341.92	26525427.92	13496.70
TOXIC METALS	75787.46	311932.01	387719.47	374974.64	12744.83	376932.64	10786.83	379432.08	8287.39	380619.79	7099.68
CONVENTIONALS	483673.29	26137758.27	26621431.56	26483353.42	138078.14	26507228.68	114202.88	26542435.70	78995.86	26556024.46	65407.10
TOTAL POLLU.	3239759.02	26809360.60	30049119.62	29829100.94	220018.68	29861374.61	187745.01	29904918.25	144201.37	29923999.28	125120.34
SLUDGE GEN				174295893.41		174606570.77		174990821.76		175180573.79	

PARAMETER	BAT D & PSES D				BAT E & PSES E			
	METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)		5093.71		97.33		453.80		97.33
114 ANTIMONY	0.00	0.00	81211.72	3.31	0.00	0.00	81211.72	3.31
115 ARSENIC	0.00	0.00	1420.71	33.09	0.00	0.00	1420.71	33.09
117 BERYLLIUM	0.00	0.00	32.71	18.52	0.00	0.00	32.71	18.52
118 CADMIUM	0.00	44.97	9836.98	4.76	22.91	22.06	9836.98	4.76
119 CHROMIUM	192.15	347.13	1625.74	6.81	507.45	31.83	1625.74	6.81
120 COPPER	1948.17	289.80	4123.25	37.96	2060.59	177.38	4123.25	37.96
122 LEAD	339.90	131.60	51011.08	7.80	435.12	36.38	51011.08	7.80
124 NICKEL	70403.54	1084.73	33742.51	21.42	71391.35	96.92	33742.51	21.42
125 SELENIUM	438.48	34.49	11971.73	0.67	469.89	3.08	11971.73	0.67
128 ZINC	4.62	527.88	116798.84	22.40	427.91	104.59	116798.84	22.40
ALUMINUM	943.64	1818.61	193936.50	72.02	2425.69	336.56	193936.50	72.02
COBALT	9.85	246.34	35293.91	4.86	234.20	21.99	35293.91	4.86
FLUORIDE	0.00	3570.59	27837.11	920.74	5.66	3564.93	27837.11	920.74
IRON	2634632.36	1396.97	43970.47	27.25	2635901.98	127.35	43970.47	27.25
MANGANESE	8858.33	708.17	52530.54	13.63	9502.83	63.67	52530.54	13.63
PHOSPHORUS	14273.92	13839.49	4798.55	264.74	26876.36	1237.05	4798.55	264.74
OIL & GREASE	12879.91	50433.29	18220.44	973.30	58765.20	4548.00	18220.44	973.30
TSS	407116.45	13243.64	26118311.47	253.06	419177.61	1182.48	26118311.47	253.06
TOXIC METALS	73326.86	2460.60	311775.27	156.74	75315.22	472.24	311775.27	156.74
CONVENTIONALS	419996.36	63676.93	26136531.91	1226.36	477942.81	5730.48	26136531.91	1226.36
TOTAL POLLU.	3152041.32	87717.70	26806674.26	2686.34	3228204.75	11554.27	26806674.26	2686.34
SLUDGE GEN	32977006.62		142736287.33		33698817.52		142736287.33	

TABLE X-14
SUMMARY TABLE
POLLUTANT REDUCTION BENEFITS
TOTAL CATEGORY

PARAMETER	RAW WASTE			BPT & PSES 0		BAT A & PSES A		BAT B & PSES B	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED	
	kg/yr	kg/yr	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
Steel Subcategory									
TOXIC METALS	73433.51	297024.40	370457.91	358180.84	12277.07	360051.46	10406.45	362478.42	7979.49
CONVENTIONALS	474694.29	24888601.36	25363295.65	25229943.53	133352.12	25252947.17	110348.48	25286921.25	76374.40
TOTAL POLLU.	3225635.15	25528106.97	28753742.12	28541659.04	212083.08	28572681.55	181060.57	28614754.20	138987.92
SLUDGE GEN				167423124.64		167720859.21		168093065.83	
Cast Iron Subcategory.									
TOXIC METALS	0.00	1732.90	1732.90	1717.40	15.50	1718.64	14.26	1723.22	9.68
CONVENTIONALS	0.00	145204.90	145204.90	145059.26	145.64	145071.14	133.76	145121.49	83.41
TOTAL POLLU.	0.00	148935.90	148935.90	148641.84	294.06	148665.78	270.12	148754.16	181.74
SLUDGE GEN				789741.20		790016.55		790972.29	
Aluminum Subcategory									
TOXIC METALS	390.26	13041.21	13431.47	12993.29	438.18	13078.64	352.83	13142.01	289.46
CONVENTIONALS	7474.00	1092765.53	1100239.53	1095824.37	4415.16	1096674.43	3565.10	1097796.11	2443.42
TOTAL POLLU.	10457.68	1120843.81	1131301.49	1123871.71	7429.78	1125087.65	6213.84	1126401.19	4900.30
SLUDGE GEN				5997345.56		6009932.64		6020528.84	
Copper Subcategory									
TOXIC METALS	1963.69	133.50	2097.19	2083.11	14.08	2083.90	13.29	2088.43	8.76
CONVENTIONALS	1505.00	11186.48	12691.48	12526.26	165.22	12535.94	155.54	12596.85	94.63
TOTAL POLLU.	3666.19	11473.92	15140.11	14928.35	211.76	14939.63	200.48	15008.70	131.41
SLUDGE GEN				85682.01		85762.37		86254.80	
Total Category									
TOXIC METALS	75787.46	311932.01	387719.47	374974.64	12744.83	376932.64	10786.83	379432.08	8287.39
CONVENTIONALS	483673.29	26137758.27	26621431.56	26483353.42	138078.14	26507228.68	114202.88	26542435.70	78995.86
TOTAL POLLU.	3239759.02	26809360.60	30049119.62	29829100.94	220018.68	29861374.61	187745.01	29904918.25	144201.37
SLUDGE GEN				174295893.41		174606570.77		174990821.76	

PARAMETER	BAT C & PSES C		BAT D & PSES D				BAT E & PSES E			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
Steel Subcategory										
TOXIC METALS	363607.69	6850.22	71034.17	2399.34	296880.11	144.29	72973.39	460.12	296880.11	144.29
CONVENTIONALS	25300096.07	63199.58	412616.99	62077.30	24887479.08	1122.28	469151.68	5542.61	24887479.08	1122.28
TOTAL POLLU.	28633167.57	120574.55	3140313.34	85321.81	25525647.76	2459.21	3214474.63	11160.52	25525647.76	2459.21
SLUDGE GEN	168275233.63		32867630.37		135915905.97		33568317.77		135915905.97	
Cast Iron Subcategory										
TOXIC METALS	1723.97	8.93	0.00	0.00	1723.97	8.93	0.00	0.00	1723.97	8.93
CONVENTIONALS	145128.29	76.61	0.00	0.00	145128.29	76.61	0.00	0.00	145128.29	76.61
TOTAL POLLU.	148768.95	166.95	0.00	0.00	148768.95	166.95	0.00	0.00	148768.95	166.95
SLUDGE GEN	791147.79				791147.79				791147.79	
Aluminum Subcategory										
TOXIC METALS	13199.23	232.24	335.07	55.19	13037.80	3.41	378.79	11.47	13037.80	3.41
CONVENTIONALS	1098197.70	2041.83	5962.57	1511.43	1092738.94	26.59	7294.07	179.93	1092738.94	26.59
TOTAL POLLU.	1127047.50	4253.99	8163.65	2294.03	1120785.55	58.26	10075.78	381.90	1120785.55	58.26
SLUDGE GEN	6027891.10		83742.02		5968154.23		104318.11		5968154.23	
Copper Subcategory										
TOXIC METALS	2088.90	8.29	1957.62	6.07	133.39	0.11	1963.04	0.65	133.39	0.11
CONVENTIONALS	12602.40	89.08	1416.80	88.20	11185.60	0.88	1497.06	7.94	11185.60	0.88
TOTAL POLLU.	15015.26	124.85	3564.33	101.86	11472.00	1.92	3654.34	11.85	11472.00	1.92
SLUDGE GEN	86301.27		25634.23		61079.34		26181.64		61079.34	
Total Category										
TOXIC METALS	380619.79	7099.68	73326.86	2460.60	311775.27	156.74	75315.22	472.24	311775.27	156.74
CONVENTIONALS	26556024.46	65407.10	419996.36	63676.93	26136531.91	1226.36	477942.81	5730.48	26136531.91	1226.36
TOTAL POLLU.	29923999.28	125120.34	3152041.32	87717.70	26806674.26	2686.34	3228204.75	11554.27	26806674.26	2686.34
SLUDGE GEN	175180573.79		32977006.62		142736287.33		33698817.52		142736287.33	

TABLE X-15
TREATMENT PERFORMANCE - DIRECT DISCHARGERS
STEEL SUBCATEGORY

PARAMETER	RAW WASTE			BPT		BAT A		BAT B		BAT C	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)	1625.71	370.83	1996.54		1996.54		1654.82		1996.54		1654.82
114 ANTIMONY	0.00	25273.55	25273.55	25173.72	99.83	25190.81	82.74	25205.67	67.88	25217.29	56.26
115 ARSENIC	0.00	452.41	452.41	0.00	452.41	0.00	452.41	0.00	452.41	0.00	452.41
117 BERYLLIUM	0.00	15.95	15.95	0.00	15.95	0.00	15.95	0.00	15.95	0.00	15.95
118 CADMIUM	14.63	3062.68	3077.31	2919.58	157.73	2946.58	130.73	2979.48	97.83	2996.22	81.09
119 CHROMIUM	177.20	508.04	685.24	525.52	159.72	552.85	132.39	545.48	139.76	569.40	115.84
120 COPPER	92.67	1294.94	1387.61	229.62	1157.99	427.81	959.80	608.96	778.65	742.23	645.38
122 LEAD	39.02	15876.72	15915.74	15676.16	239.58	15717.16	198.58	15756.02	159.72	15783.35	132.39
124 NICKEL	23589.05	10507.10	34096.15	32958.12	1138.03	33152.90	943.25	33656.91	439.24	33732.09	364.06
125 SELENIUM	156.07	3725.73	3881.80	3861.83	19.97	3865.25	16.55	3867.82	13.98	3870.22	11.58
128 ZINC	162.57	36353.95	36516.52	35917.56	598.96	36020.07	496.45	36057.32	459.20	36135.91	380.61
ALUMINUM	560.87	60374.09	60934.96	58718.80	2216.16	59098.11	1836.85	59457.52	1477.44	59710.39	1224.57
COBALT	84.54	10984.73	11069.27	10929.51	139.76	10953.43	115.84	10969.44	99.83	10986.53	82.74
FLUORIDE	1131.49	8949.24	10080.73	0.00	10080.73	0.00	10080.73	0.00	10080.73	0.00	10080.73
IRON	869754.85	13691.79	883446.64	882628.06	818.58	882768.16	678.48	882887.61	559.03	882983.29	463.35
MANGANESE	3150.63	16351.38	19502.01	19082.74	419.27	19154.50	347.51	19222.49	279.52	19270.34	231.67
PHOSPHORUS	8827.61	1575.66	10403.27	2257.39	8145.88	3651.60	6751.67	4972.68	5430.59	5902.16	4501.11
OIL & GREASE	20077.52	5972.96	26050.48	6085.08	19965.40	9502.28	16548.20	6085.08	19965.40	9502.28	16548.20
TSS	136559.64	8127913.87	8264473.51	8240515.03	23958.48	8244615.67	19857.84	8259282.51	5191.00	8260170.98	4302.53
TOXIC METALS	24231.21	97071.07	121302.28	117262.11	4040.17	117873.43	3428.85	118677.66	2624.62	119046.71	2255.57
CONVENTIONALS	156637.16	8133886.83	8290523.99	8246600.11	43923.88	8254117.95	36406.04	8265367.59	25156.40	8269673.26	20850.73
TOTAL POLLU.	1064378.36	8342884.79	9407263.15	9337478.72	69784.43	9347617.18	59645.97	9361554.99	45708.16	9367572.68	39690.47
SLUDGE GEN				54817825.08		54915127.54		55038491.86		55098026.36	

PARAMETER	BAT D				BAT E			
	METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)		1625.71		29.11		145.15		29.11
114 ANTIMONY	0.00	0.00	25272.56	0.99	0.00	0.00	25272.56	0.99
115 ARSENIC	0.00	0.00	442.51	9.90	0.00	0.00	442.51	9.90
117 BERYLLIUM	0.00	0.00	10.13	5.82	0.00	0.00	10.13	5.82
118 CADMIUM	0.00	14.63	3061.25	1.43	7.52	7.11	3061.25	1.43
119 CHROMIUM	63.40	113.80	506.00	2.04	167.04	10.16	506.00	2.04
120 COPPER	0.00	92.67	1283.59	11.35	36.06	56.61	1283.59	11.35
122 LEAD	0.00	39.02	15874.39	2.33	27.41	11.61	15874.39	2.33
124 NICKEL	23231.39	357.66	10500.70	6.40	23557.12	31.93	10500.70	6.40
125 SELENIUM	144.69	11.38	3725.53	0.20	155.05	1.02	3725.53	0.20
128 ZINC	0.00	162.57	36347.25	6.70	129.19	33.38	36347.25	6.70
ALUMINUM	0.00	560.87	60352.55	21.54	453.46	107.41	60352.55	21.54
COBALT	3.25	81.29	10983.27	1.46	77.28	7.26	10983.27	1.46
FLUORIDE	0.00	1131.49	8673.86	275.38	0.00	1131.49	8673.86	275.38
IRON	869299.65	455.20	13683.64	8.15	869714.21	40.64	13683.64	8.15
MANGANESE	2923.03	227.60	16347.30	4.08	3130.31	20.32	16347.30	4.08
PHOSPHORUS	4405.68	4421.93	1496.48	79.18	8432.80	394.81	1496.48	79.18
OIL & GREAS	3820.42	16257.10	5681.86	291.10	18626.02	1451.50	5681.86	291.10
TSS	132332.79	4226.85	8127838.18	75.69	136182.25	377.39	8127838.18	75.69
TOXIC METALS	23439.48	791.73	97023.91	47.16	24079.39	151.82	97023.91	47.16
CONVENTIONALS	136153.21	20483.95	8133520.04	366.79	154808.27	1828.89	8133520.04	366.79
TOTAL POLLU.	1036224.30	28154.06	8342081.05	803.74	1060695.72	3682.64	8342081.05	803.74
SLUDGE GEN	10845490.10		44418912.33		11076700.08		44418912.33	

TABLE X-16
TREATMENT PERFORMANCE - DIRECT DISCHARGERS
CAST IRON SUBCATEGORY

PARAMETER	RAW WASTE COATING	BPT COATING		BAT A COATING		BAT B COATING		BAT C COATING		BAT D COATING	
		Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)	2.90		2.90		2.66		2.90		2.66		2.66
114 ANTIMONY	197.65	197.51	0.14	197.52	0.13	197.55	0.10	197.56	0.09	197.56	0.09
115 ARSENIC	3.54	2.06	1.48	2.18	1.36	2.55	0.99	2.64	0.90	2.64	0.90
117 BERYLLIUM	0.12	0.00	0.12	0.00	0.12	0.00	0.12	0.00	0.12	0.00	0.12
118 CADMIUM	23.95	23.72	0.23	23.74	0.21	23.81	0.14	23.82	0.13	23.82	0.13
119 CHROMIUM	3.97	3.74	0.23	3.76	0.21	3.77	0.20	3.78	0.19	3.78	0.19
120 COPPER	10.13	8.45	1.68	8.59	1.54	9.00	1.13	9.09	1.04	9.09	1.04
122 LEAD	124.16	123.81	0.35	123.84	0.32	123.93	0.23	123.95	0.21	123.95	0.21
124 NICKEL	82.17	80.52	1.65	80.65	1.52	81.53	0.64	81.58	0.59	81.58	0.59
125 SELENIUM	29.14	29.11	0.03	29.11	0.03	29.12	0.02	29.12	0.02	29.12	0.02
128 ZINC	284.30	283.43	0.87	283.50	0.80	283.63	0.67	283.69	0.61	283.69	0.61
ALUMINUM	472.14	468.92	3.22	469.19	2.95	469.99	2.15	470.17	1.97	470.17	1.97
COBALT	85.90	85.70	0.20	85.71	0.19	85.76	0.14	85.77	0.13	85.77	0.13
FLUORIDE	69.99	28.81	41.18	32.22	37.77	42.56	27.43	44.83	25.16	44.83	25.16
IRON	107.07	105.88	1.19	105.98	1.09	106.26	0.81	106.33	0.74	106.33	0.74
MANGANESE	127.87	127.26	0.61	127.31	0.56	127.46	0.41	127.50	0.37	127.50	0.37
PHOSPHORUS	12.32	0.49	11.83	1.47	10.85	4.43	7.89	5.08	7.24	5.08	7.24
OIL & GREASE	46.71	17.71	29.00	20.11	26.60	17.71	29.00	20.11	26.60	20.11	26.60
TSS	63562.68	63527.88	34.80	63530.76	31.92	63555.14	7.54	63555.76	6.92	63555.76	6.92
TOXIC METALS	759.13	752.35	6.78	752.89	6.24	754.89	4.24	755.23	3.90	755.23	3.90
CONVENTIONALS	63609.39	63545.59	63.80	63550.87	58.52	63572.85	36.54	63575.87	33.52	63575.87	33.52
TOTAL POLLU.	65243.81	65115.00	128.81	65125.64	118.17	65164.20	79.61	65170.78	73.03	65170.78	73.03
SLUDGE GEN		345959.13		346081.56		346498.29		346576.29		346576.29	

PARAMETER	BAT E COATING	
	Removed	Discharged
	kg/yr	kg/yr
FLOW l/yr (10^6)		2.66
114 ANTIMONY	197.56	0.09
115 ARSENIC	2.64	0.90
117 BERYLLIUM	0.00	0.12
118 CADMIUM	23.82	0.13
119 CHROMIUM	3.78	0.19
120 COPPER	9.09	1.04
122 LEAD	123.95	0.21
124 NICKEL	81.58	0.59
125 SELENIUM	29.12	0.02
128 ZINC	283.69	0.61
ALUMINUM	470.17	1.97
COBALT	85.77	0.13
FLUORIDE	44.83	25.16
IRON	106.33	0.74
MANGANESE	127.50	0.37
PHOSPHORUS	5.08	7.24
OIL & GREASE	20.11	26.60
TSS	63555.76	6.92
TOXIC METALS	755.23	3.90
CONVENTIONALS	63575.87	33.52
TOTAL POLLU.	65170.78	73.03
SLUDGE GEN	346576.29	

TABLE X-17
TREATMENT PERFORMANCE - DIRECT DISCHARGERS
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE			BPT COMBINED		BAT A COMBINED		BAT B COMBINED		BAT C COMBINED	
	METAL PREPARATION kg/yr	COATING kg/yr	COMBINED kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	30.34	16.39	46.73		46.73		31.03		46.73		31.03
114 ANTIMONY	0.00	1117.04	1117.04	1114.70	2.34	1115.49	1.55	1115.45	1.59	1115.98	1.06
115 ARSENIC	0.00	20.00	20.00	0.00	20.00	4.17	15.83	4.11	15.89	9.45	10.55
117 BERYLLIUM	0.00	0.70	0.70	0.00	0.70	0.00	0.70	0.00	0.70	0.00	0.70
118 CADMIUM	0.09	135.37	135.46	131.77	3.69	133.01	2.45	133.17	2.29	133.94	1.52
119 CHROMIUM	0.39	22.45	22.84	19.10	3.74	20.36	2.48	19.57	3.27	20.67	2.17
120 COPPER	1.18	57.23	58.41	31.31	27.10	40.41	18.00	40.19	18.22	46.31	12.10
122 LEAD	65.99	701.72	767.71	762.10	5.61	763.99	3.72	763.97	3.74	765.23	2.48
124 NICKEL	0.00	464.39	464.39	437.75	26.64	446.70	17.69	454.11	10.28	457.56	6.83
125 SELENIUM	0.00	164.67	164.67	164.20	0.47	164.36	0.31	164.34	0.33	164.45	0.22
128 ZINC	6.37	1606.78	1613.15	1599.13	14.02	1603.84	9.31	1602.40	10.75	1606.01	7.14
ALUMINUM	201.46	2668.42	2869.88	2818.01	51.87	2835.44	34.44	2835.30	34.58	2846.92	22.96
COBALT	0.00	485.50	485.50	482.23	3.27	483.33	2.17	483.16	2.34	483.95	1.55
FLUORIDE	26.70	395.54	422.24	0.00	422.24	0.00	422.24	0.00	422.24	128.70	293.54
IRON	2.94	605.15	608.09	588.93	19.16	595.37	12.72	595.01	13.08	599.40	8.69
MANGANESE	3.37	722.70	726.07	716.26	9.81	719.55	6.52	719.53	6.54	721.73	4.34
PHOSPHORUS	257.50	69.64	327.14	136.48	190.66	200.54	126.60	200.03	127.11	242.74	84.40
OIL & GREASE	207.83	263.99	471.82	4.52	467.30	161.52	310.30	4.52	467.30	161.52	310.30
TSS	1209.96	359238.76	360448.72	359887.96	560.76	360076.36	372.36	360327.22	121.50	360368.04	80.68
TOXIC METALS	74.02	4290.35	4364.37	4260.06	104.31	4292.33	72.04	4297.31	67.06	4319.60	44.77
CONVENTIONALS	1417.79	359502.75	360920.54	359892.48	1028.06	360237.88	682.66	360331.74	588.80	360529.56	390.98
TOTAL POLLU.	1983.78	368740.05	370723.83	368894.45	1829.38	369364.44	1359.39	369462.08	1261.75	369872.60	851.23
SLUDGE GEN				1964201.35		1968707.32		1969400.96		1974192.90	

PARAMETER	BAT D				BAT E			
	METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)		30.34		0.69		2.71		0.69
114 ANTIMONY	0.00	0.00	1117.02	0.02	0.00	0.00	1117.02	0.02
115 ARSENIC	0.00	0.00	19.77	0.23	0.00	0.00	19.77	0.23
117 BERYLLIUM	0.00	0.00	0.56	0.14	0.00	0.00	0.56	0.14
118 CADMIUM	0.00	0.09	135.34	0.03	0.00	0.09	135.34	0.03
119 CHROMIUM	0.00	0.39	22.40	0.05	0.20	0.19	22.40	0.05
120 COPPER	0.00	1.18	56.96	0.27	0.12	1.06	56.96	0.27
122 LEAD	63.56	2.43	701.66	0.06	65.77	0.22	701.66	0.06
124 NICKEL	0.00	0.00	464.24	0.15	0.00	0.00	464.24	0.15
125 SELENIUM	0.00	0.00	164.67	0.00	0.00	0.00	164.67	0.00
128 ZINC	0.00	6.37	1606.62	0.16	5.75	0.62	1606.62	0.16
ALUMINUM	179.01	22.45	2667.91	0.51	199.45	2.01	2667.91	0.51
COBALT	0.00	0.00	485.47	0.03	0.00	0.00	485.47	0.03
FLUORIDE	0.00	26.70	389.01	6.53	1.06	25.64	389.01	6.53
IRON	0.00	2.94	604.96	0.19	2.18	0.76	604.96	0.19
MANGANESE	0.00	3.37	722.60	0.10	2.99	0.38	722.60	0.10
PHOSPHORUS	174.98	82.52	67.76	1.88	250.13	7.37	67.76	1.88
OIL & GREASE	0.00	207.83	257.09	6.90	180.73	27.10	257.09	6.90
TSS	1131.08	78.88	359236.97	1.79	1202.91	7.05	359236.97	1.79
TOXIC METALS	63.56	10.46	4289.24	1.11	71.84	2.18	4289.24	1.11
CONVENTIONALS	1131.08	286.71	359494.06	8.69	1383.64	34.15	359494.06	8.69
TOTAL POLLU.	1548.63	435.15	368721.01	19.04	1911.29	72.49	368721.01	19.04
SLUDGE GEN	15885.93		1963430.20		19788.29		1963430.20	

TABLE X-18
TREATMENT PERFORMANCE - DIRECT DISCHARGERS
TOTAL CATEGORY

PARAMETER	RAW WASTE			BPT		BAT A		BAT B		BAT C	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)	1656.05	390.12	2046.17		2046.17		1688.51		2046.17		1688.51
114 ANTIMONY	0.00	26588.24	26588.24	26485.93	102.31	26503.82	84.42	26518.67	69.57	26530.83	57.41
115 ARSENIC	0.00	475.95	475.95	2.06	473.89	6.35	469.60	6.66	469.29	12.09	463.86
117 BERYLLIUM	0.00	16.77	16.77	0.00	16.77	0.00	16.77	0.00	16.77	0.00	16.77
118 CADMIUM	14.72	3222.00	3236.72	3075.07	161.65	3103.33	133.39	3136.46	100.26	3153.98	82.74
119 CHROMIUM	177.59	534.46	712.05	548.36	163.69	576.97	135.08	568.82	143.23	593.85	118.20
120 COPPER	93.85	1362.30	1456.15	269.38	1186.77	476.81	979.34	658.15	798.00	797.63	658.52
122 LEAD	105.01	16702.60	16807.61	16562.07	245.54	16604.99	202.62	16643.92	163.69	16672.53	135.08
124 NICKEL	23589.05	11053.66	34642.71	33476.39	1166.32	33680.25	962.46	34192.55	450.16	34271.23	371.48
125 SELENIUM	156.07	3919.54	4075.61	4055.14	20.47	4058.72	16.89	4061.28	14.33	4063.79	11.82
128 ZINC	168.94	38245.03	38413.97	37800.12	613.85	37907.41	506.56	37943.35	470.62	38025.61	388.36
ALUMINUM	762.33	63514.65	64276.98	62005.73	2271.25	62402.74	1874.24	62762.81	1514.17	63027.48	1249.50
COBALT	84.54	11556.13	11640.67	11497.44	143.23	11522.47	118.20	11538.36	102.31	11556.25	84.42
FLUORIDE	1158.19	9414.77	10572.96	28.81	10544.15	32.22	10540.74	42.56	10530.40	173.53	10399.43
IRON	869757.79	14404.01	884161.80	883322.87	838.93	883469.51	692.29	883588.88	572.92	883689.02	472.78
MANGANESE	3154.00	17201.95	20355.95	19926.26	429.69	20001.36	354.59	20069.48	286.47	20119.57	236.38
PHOSPHOROS	9085.11	1657.62	10742.73	2394.36	8348.37	3853.61	6889.12	5177.14	5565.59	6149.98	4592.75
OIL & GREASE	20285.35	6283.66	26569.01	6107.31	20461.70	9683.91	16885.10	6107.31	20461.70	9683.91	16885.10
TSS	137769.60	8550715.31	8688484.91	8663930.87	24554.04	8668222.79	20262.12	8683164.87	5320.04	8684094.78	4390.13
TOXIC METALS	24305.23	102120.55	126425.78	122274.52	4151.26	122918.65	3507.13	123729.86	2695.92	124121.54	2304.24
CONVENTIONALS	158054.95	8556998.97	8715053.92	8670038.18	45015.74	8677906.70	37147.22	8689272.18	25781.74	8693778.69	21275.23
TOTAL POLLU.	1066362.14	8776868.65	9843230.79	9771488.17	71742.62	9782107.26	61123.53	9796181.27	47049.52	9802616.06	40614.73
SLUDGE GEN				57127985.56		57229916.42		57354391.11		57418795.55	

PARAMETER	BAT D				BAT E			
	METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW l/yr (10^6)		1656.05		32.46		147.86		32.46
114 ANTIMONY	0.00	0.00	26587.14	1.10	0.00	0.00	26587.14	1.10
115 ARSENIC	0.00	0.00	464.92	11.03	0.00	0.00	464.92	11.03
117 BERYLLIUM	0.00	0.00	10.69	6.08	0.00	0.00	10.69	6.08
118 CADMIUM	0.00	14.72	3220.41	1.59	7.52	7.20	3220.41	1.59
119 CHROMIUM	63.40	114.19	532.18	2.28	167.24	10.35	532.18	2.28
120 COPPER	0.00	93.85	1349.64	12.66	36.18	57.67	1349.64	12.66
122 LEAD	63.56	41.45	16700.00	2.60	93.18	11.83	16700.00	2.60
124 NICKEL	23231.39	357.66	11046.52	7.14	23557.12	31.93	11046.52	7.14
125 SELENIUM	144.69	11.38	3919.32	0.22	155.05	1.02	3919.32	0.22
128 ZINC	0.00	168.94	38237.56	7.47	134.94	34.00	38237.56	7.47
ALUMINUM	179.01	583.32	63490.63	24.02	652.91	109.42	63490.63	24.02
COBALT	3.25	81.29	11554.51	1.62	77.28	7.26	11554.51	1.62
FLUORIDE	0.00	1158.19	9107.70	307.07	1.06	1157.13	9107.70	307.07
IRON	869299.65	458.14	14394.93	9.08	869716.39	41.40	14394.93	9.08
MANGANESE	2923.03	230.97	17197.40	4.55	3133.30	20.70	17197.40	4.55
PHOSPHORUS	4580.66	4504.45	1569.32	88.30	8682.93	402.18	1569.32	88.30
OIL & GREASE	3820.42	16464.93	5959.06	324.60	18806.75	1478.60	5959.06	324.60
TSS	133463.87	4305.73	8550630.91	84.40	137385.16	384.44	8550630.91	84.40
TOXIC METALS	23503.04	802.19	102068.38	52.17	24151.23	154.00	102068.38	52.17
CONVENTIONALS	137284.29	20770.66	8556589.97	409.00	156191.91	1863.04	8556589.97	409.00
TOTAL POLLU.	1037772.93	28589.21	8775972.84	895.81	1062607.01	3755.13	8775972.84	895.81
SLUDGE GEN	10861376.03		46728918.82		11096488.37		46728918.82	

TABLE X-19
SUMMARY TABLE
POLLUTANT REDUCTION BENEFITS
DIRECT DISCHARGERS

PARAMETER	RAW WASTE			BPT		BAT A		BAT B		BAT C	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
Steel Subcategory											
TOXIC METALS	24231.21	97071.07	121302.28	117262.11	4040.17	117873.43	3428.85	118677.66	2624.62	119046.71	2255.57
CONVENTIONALS	156637.16	8133886.83	8290523.99	8246600.11	43923.88	8254117.95	36406.04	8265367.59	25156.40	8269673.26	20850.73
TOTAL POLLU.	1064378.36	8342884.79	9407263.15	9337478.72	69784.43	9347617.18	59645.97	9361554.99	45708.16	9367572.68	39690.47
SLUDGE GEN				54817825.08		54915127.54		55038491.86		55098026.36	
Cast Iron Subcategory											
TOXIC METALS	0.00	759.13	759.13	752.35	6.78	752.89	6.24	754.89	4.24	755.23	3.90
CONVENTIONALS	0.00	63609.39	63609.39	63545.59	63.80	63550.87	58.52	63572.85	36.54	63575.87	33.52
TOTAL POLLU.	0.00	65243.81	65243.81	65115.00	128.81	65125.64	118.17	65164.20	79.61	65170.78	73.03
SLUDGE GEN				345959.13		346081.56		346498.29		346576.29	
Aluminum Subcategory											
TOXIC METALS	74.02	4290.35	4364.37	4260.06	104.31	4292.33	72.04	4297.31	67.06	4319.60	44.77
CONVENTIONALS	1417.79	359502.75	360920.54	359892.48	1028.06	360237.88	682.66	360331.74	588.80	360529.56	390.98
TOTAL POLLU.	1983.78	368740.05	370723.83	368894.45	1829.38	369364.44	1359.39	369462.08	1261.75	369872.60	851.23
SLUDGE GEN				1964201.35		1968707.32		1969400.96		1974192.90	
Total Category											
TOXIC METALS	24305.23	102120.55	126425.78	122274.52	4151.26	122918.65	3507.13	123729.86	2695.92	124121.54	2304.24
CONVENTIONALS	158054.95	8556998.97	8715053.92	8670038.18	45015.74	8677906.70	37147.22	8689272.18	25781.74	8693778.69	21275.23
TOTAL POLLU.	1066362.14	8776868.65	9843230.79	9771488.17	71742.62	9782107.26	61123.53	9796181.27	47049.52	9802616.06	40614.73
SLUDGE GEN				57127985.56		57229916.42		57354391.11		57418795.55	

PARAMETER	BAT D				BAT E			
	METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/hr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
Steel Subcategory								
TOXIC METALS	23439.48	791.73	97023.91	47.16	24079.39	151.82	97023.91	47.16
CONVENTIONALS	136153.21	20483.95	8133520.04	366.79	154808.27	1828.89	8133520.04	366.79
TOTAL POLLU.	1036224.30	28154.06	8342081.05	803.74	1060695.72	3682.64	8342081.05	803.74
SLUDGE GEN	10845490.10		44418912.33		11076700.08		44418912.33	
Cast Iron Subcategory								
TOXIC METALS	0.00	0.00	755.23	3.90	0.00	0.00	755.23	3.90
CONVENTIONALS	0.00	0.00	63575.87	33.52	0.00	0.00	63575.87	33.52
TOTAL POLLU.	0.00	0.00	65170.78	73.03	0.00	0.00	65170.78	73.03
SLUDGE GEN			346576.29				346576.29	
Aluminum Subcategory								
TOXIC METALS	63.56	10.46	4289.24	1.11	71.84	2.18	4289.24	1.11
CONVENTIONALS	1131.08	286.71	359494.06	8.69	1383.64	34.15	359494.06	8.69
TOTAL POLLU.	1548.63	435.15	368721.01	19.04	1911.29	72.49	368721.01	19.04
SLUDGE GEN	15885.93		1963430.20		19788.29		1963430.20	
Total Category								
TOXIC METALS	23503.04	802.19	102068.38	52.17	24151.23	154.00	102068.38	52.17
CONVENTIONALS	137284.29	20770.66	8556589.97	409.00	156191.91	1863.04	8556589.97	409.00
TOTAL POLLU.	1037772.93	28589.21	8775972.84	895.81	1062607.01	3755.13	8775972.84	895.81
SLUDGE GEN	10861376.03		46728918.82		11096488.37		46728918.82	

TABLE X-20
PORCELAIN ENAMELING SUBCATEGORY COSTS
($ THOUSANDS)

		BPT*		BAT A*		BAT B*		BAT C*		BAT D*		BAT E*	
	CAPITAL IN PLACE	CAPITAL COSTS	ANNUAL COSTS	CAPITAL COSTS	ANNUAL COSTS	CAPITAL COSTS	ANNUAL COSTS	CAPITAL COSTS	ANNUAL COSTS	CAPITAL COSTS	ANNUAL COSTS	CAPITAL COSTS	ANNUAL COSTS
Steel Subcategory													
Normal Plant	101	237	126	250	128	315	144	329	168	741	259	614	211
Direct Dischargers	2933	5177	2692	5444	2740	7031	3130	7297	4728	13472	4716	11169	3840
Indirect Dischargers	4164	11397	6115	12047	6229	15015	6949	15762	7063	38390	13440	31828	10942
Total	7097	16574	8807	17491	8969	22046	10079	23059	11791	51862	18156	42997	14782
Cast Iron Subcategory													
Normal Plant	4	56	21	56	21	59	22	59	22	165	44	197	41
Direct Dischargers	9	135	57	135	57	142	59	142	59	355	95	424	88
Indirect Dischargers	18	257	91	257	93	270	95	270	95	801	214	957	199
Total	27	392	148	392	150	412	154	412	154	1156	309	1381	287
Aluminum Subcategory													
Normal Plant	41	150	38	159	40	193	48	203	50	438	132	298	116
Direct Dischargers	225	91	44	106	47	117	50	132	52	991	299	674	262
Indirect Dischargers	106	1105	262	1169	273	1428	336	1491	346	2516	760	1712	666
Total	331	1196	306	1275	320	1545	386	1623	398	3507	1059	2386	928
Category													
Direct Dischargers	3167	5403	2793	5685	2844	7290	3239	7571	4839	14818	5110	12267	4190
Indirect Dischargers	4288	12759	6468	13473	6595	16713	7380	17523	7504	41707	14414	34497	11807
Total	7455	18162	9261	19158	9439	24003	10619	25094	12343	56525	19524	46764	15997

* For indirect dischargers, costs apply to PSES options.

TABLE X - 21
STEEL SUBCATEGORY
BAT EFFLUENT LIMITATIONS

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
Metric Units - mg/m^2 of area processed or coated				
ANTIMONY	8.409	0.134	3.604	0.057
ARSENIC	83.688	1.329	34.436	0.547
CADMIUM	12.813	0.204	6.006	0.095
*CHROMIUM	16.818	0.267	6.807	0.108
COPPER	76.080	1.208	40.042	0.636
*LEAD	6.006	0.095	5.205	0.083
*NICKEL	56.459	0.897	40.042	0.636
SELENIUM	1.602	0.025	0.801	0.013
*ZINC	53.256	0.846	22.424	0.356
*ALUMINUM	182.191	2.894	74.478	1.183
COBALT	11.612	0.184	4.805	0.076
FLUORIDE	2330.444	37.015	953.000	15.137
*IRON	49.252	0.782	25.226	0.401
MANGANESE	17.218	0.273	13.614	0.216
English Units - lb/1,000,000 ft^2 of area processed or coated				
ANTIMONY	1.722	0.027	0.738	0.012
ARSENIC	17.141	0.272	7.053	0.112
CADMIUM	2.624	0.042	1.230	0.019
*CHROMIUM	3.445	0.055	1.394	0.022
COPPER	15.582	0.247	8.201	0.130
*LEAD	1.230	0.019	1.066	0.017
*NICKEL	11.564	0.184	8.201	0.130
SELENIUM	0.328	0.005	0.164	0.003
*ZINC	10.908	0.173	4.593	0.073
*ALUMINUM	37.316	0.593	15.254	0.242
COBALT	2.378	0.038	0.984	0.016
FLUORIDE	477.313	7.581	195.190	3.100
*IRON	10.088	0.160	5.167	0.082
MANGANESE	3.527	0.056	2.788	0.044

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE X - 22
CAST IRON SUBCATEGORY
BAT EFFLUENT LIMITATIONS

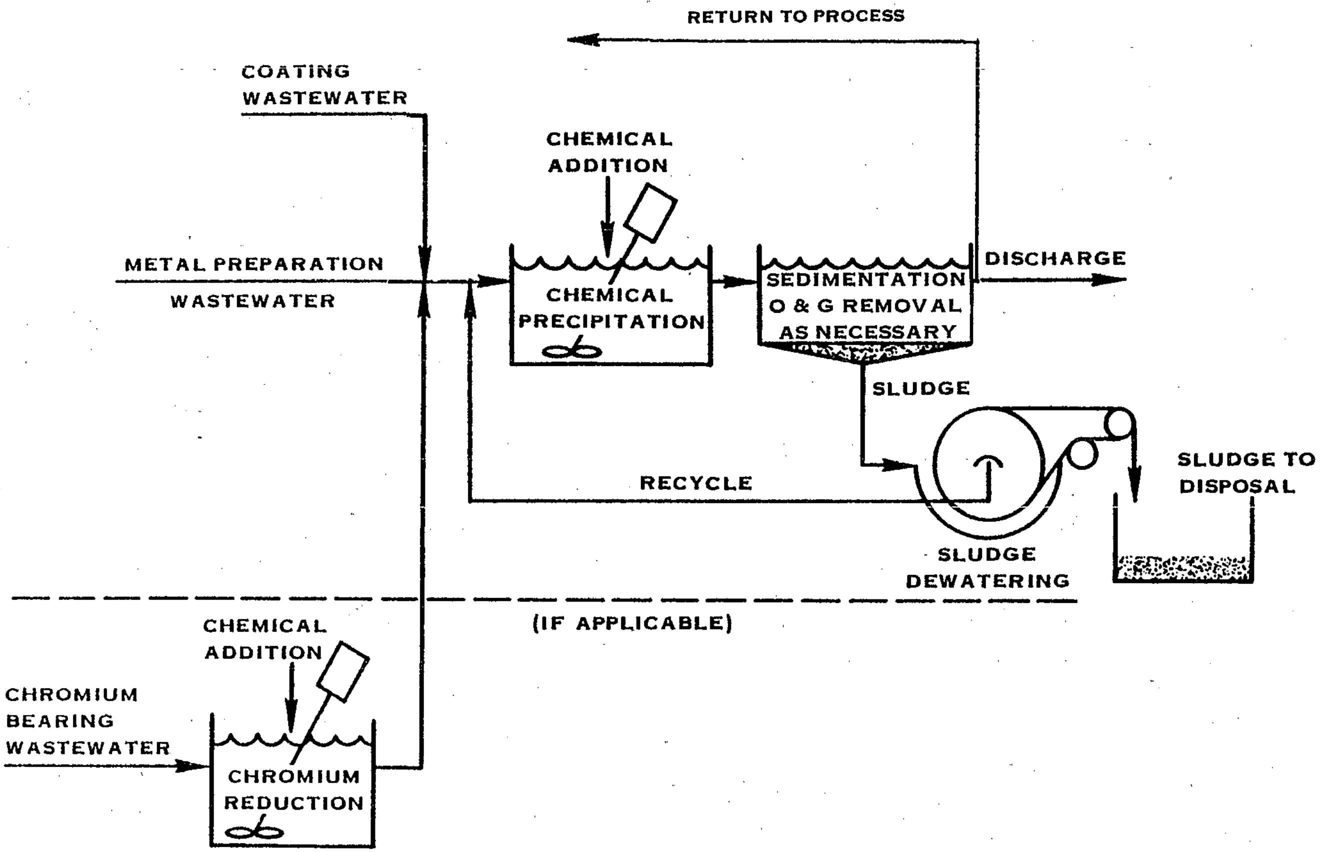
POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2 (lb/1,000,000 ft^2) of area coated			
ANTIMONY	0.134	(0.027)	0.057	(0.012)
ARSENIC	1.329	(0.272)	0.547	(0.112)
CADMIUM	0.204	(0.042)	0.095	(0.019)
*CHROMIUM	0.267	(0.055)	0.108	(0.022)
COPPER	1.208	(0.247)	0.636	(0.130)
*LEAD	0.095	(0.019)	0.083	(0.017)
*NICKEL	0.897	(0.184)	0.636	(0.130)
*ZINC	0.846	(0.173)	0.356	(0.073)
*ALUMINUM	2.894	(0.593)	1.183	(0.242)
COBALT	0.184	(0.038)	0.076	(0.016)
FLUORIDE	37.015	(7.581)	15.137	(3.100)
*IRON	0.782	(0.160)	0.401	(0.082)
MANGANESE	0.273	(0.056)	0.216	(0.044)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE X - 23
ALUMINUM SUBCATEGORY
BAT EFFLUENT LIMITATIONS

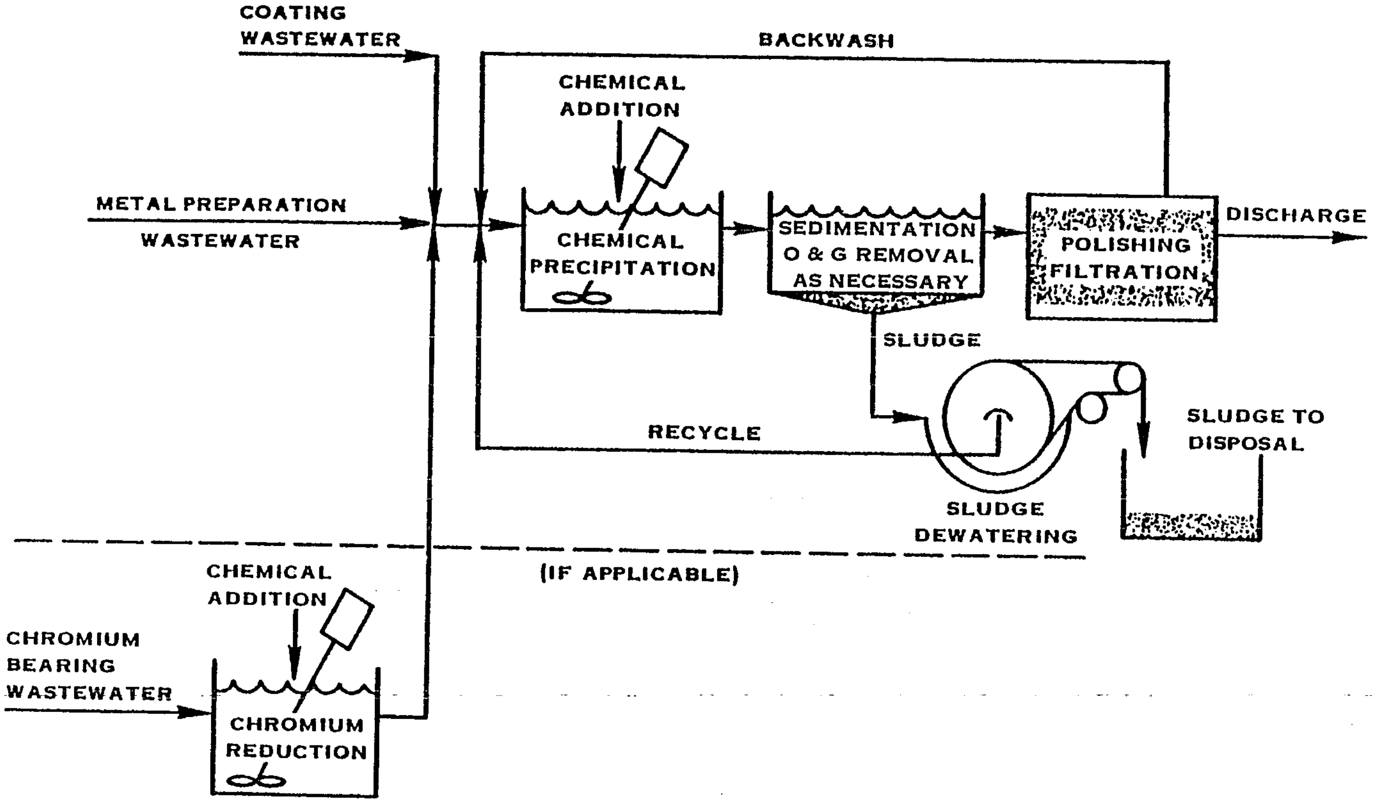
POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
	Metric Units - mg/m^2 of area processed or coated			
ANTIMONY	8.168	0.134	3.501	0.057
ARSENIC	81.293	1.329	33.451	0.547
CADMIUM	12.447	0.204	5.834	0.095
*CHROMIUM	16.336	0.267	6.612	0.108
COPPER	73.902	1.208	38.896	0.636
CYANIDE	11.280	0.184	4.668	0.076
*LEAD	5.834	0.095	5.056	0.083
*NICKEL	54.843	0.897	38.896	0.636
*ZINC	51.732	0.846	21.782	0.356
*ALUMINUM	176.977	2.894	72.347	1.183
COBALT	11.280	0.184	4.668	0.076
FLUORIDE	2263.747	37.015	925.725	15.137
*IRON	47.842	0.782	24.504	0.401
MANGANESE	16.725	0.273	13.225	0.216
	English Units - lb/1,000,000 ft^2 of area processed or coated			
ANTIMONY	1.673	0.027	0.717	0.012
ARSENIC	16.650	0.272	6.851	0.112
CADMIUM	2.549	0.042	1.195	0.019
*CHROMIUM	3.346	0.055	1.354	0.022
COPPER	15.136	0.247	7.967	0.130
CYANIDE	2.310	0.038	0.956	0.016
*LEAD	1.195	0.019	1.036	0.017
*NICKEL	11.233	0.184	7.967	0.130
*ZINC	10.596	0.173	4.461	0.073
*ALUMINUM	36.248	0.593	14.818	0.242
COBALT	2.310	0.038	0.956	0.016
FLUORIDE	463.652	7.581	189.603	3.100
*IRON	9.799	0.160	5.019	0.082
MANGANESE	3.426	0.056	2.709	0.044

* THIS POLLUTANT IS REGULATED AT PROMULGATION



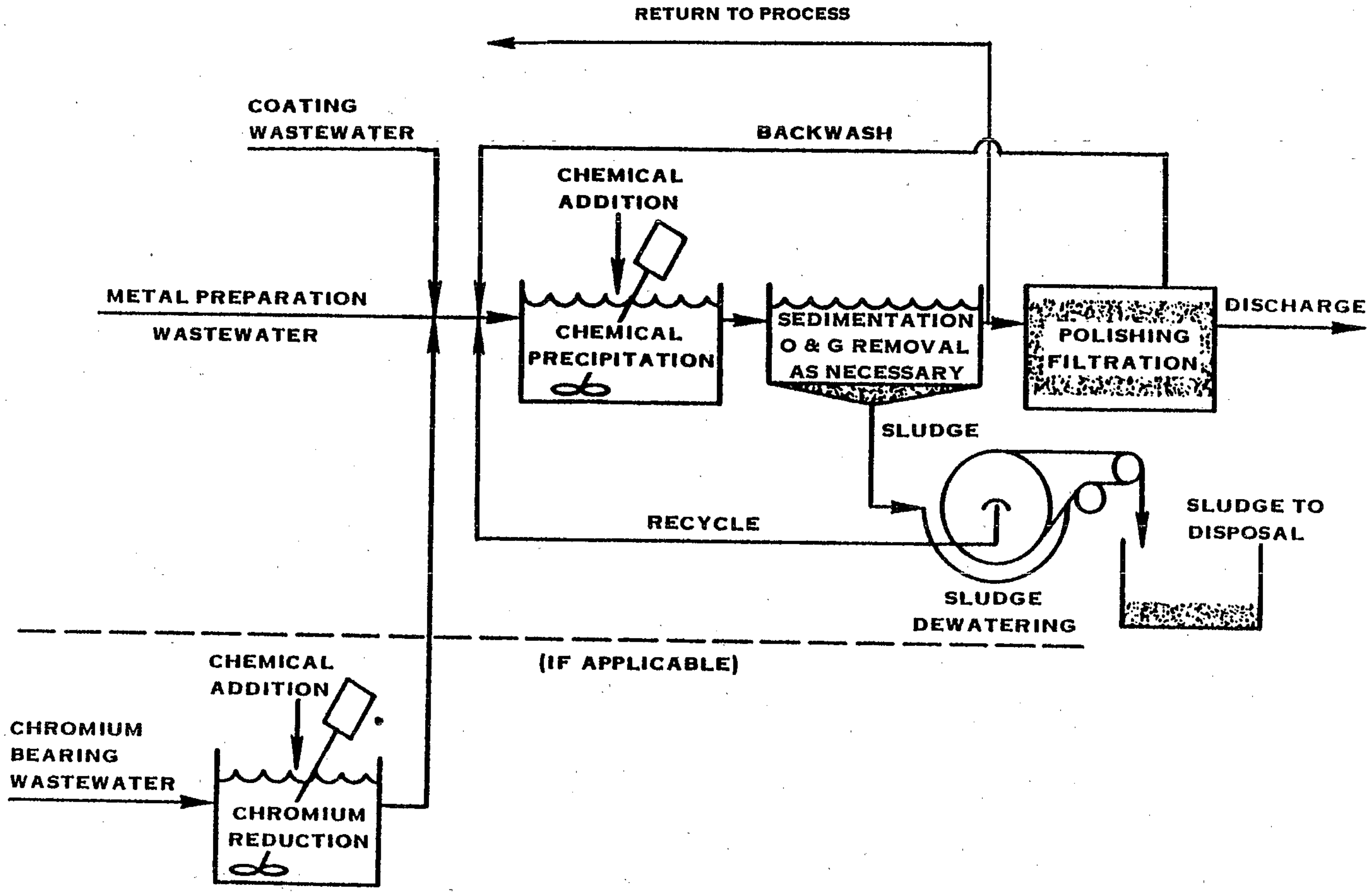
NOTE: CAST IRON SUBCATEGORY GENERATES NO METAL PREPARATION WASTEWATER

FIGURE X-1. EXISTING SOURCES BAT OPTION A



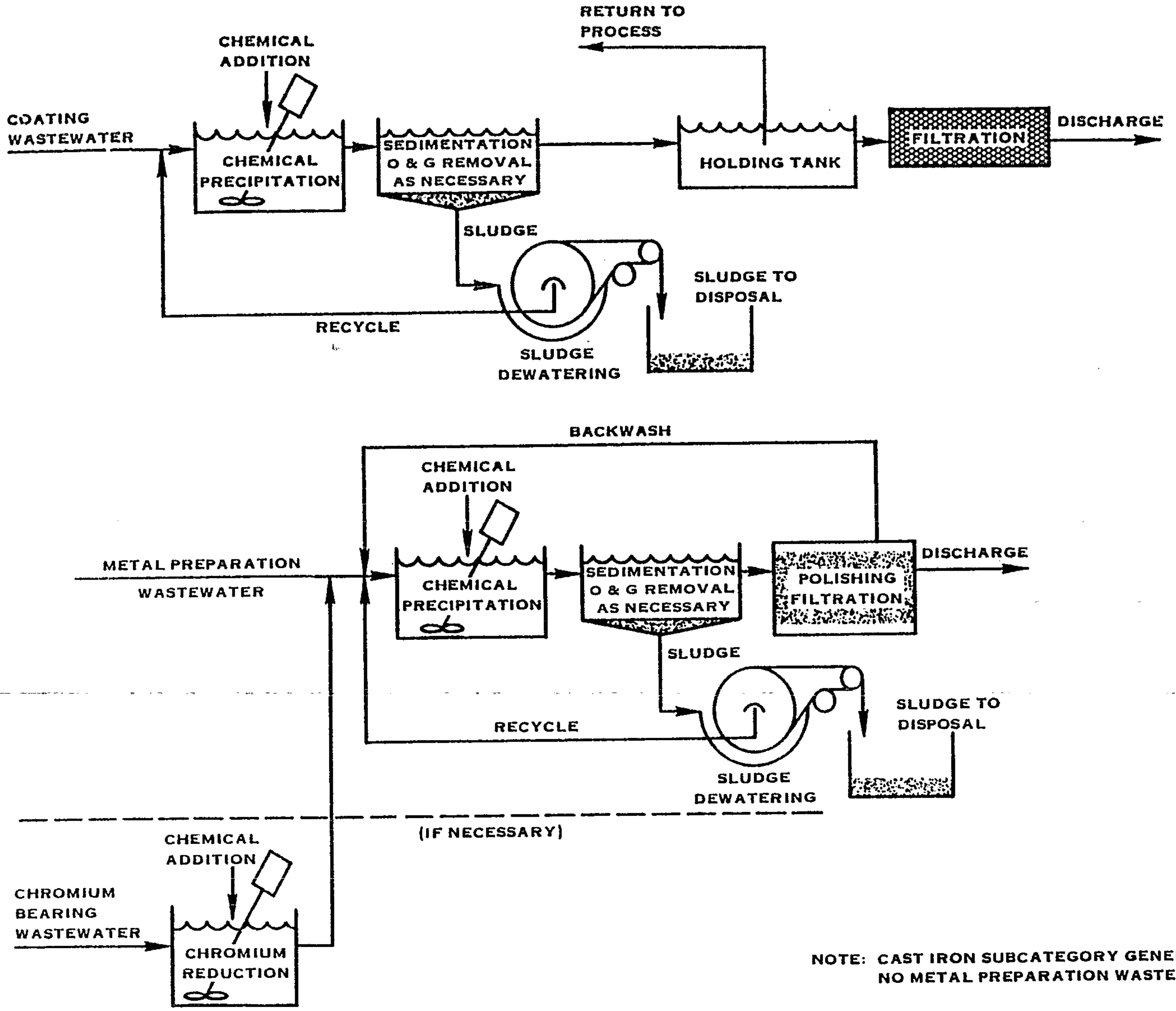
NOTE: CAST IRON SUBCATEGORY GENERATES NO METAL PREPARATION WASTEWATER

FIGURE X-2. EXISTING SOURCES BAT OPTION B



NOTE: CAST IRON SUBCATEGORY GENERATES NO METAL PREPARATION WASTEWATER
EQUALIZATION TANK IS UNNECESSARY FOR CAST IRON SUBCATEGORY.

FIGURE X-3. EXISTING SOURCES BAT OPTION C



NOTE: CAST IRON SUBCATEGORY GENERATES NO METAL PREPARATION WASTEWATER.

FIGURE X-4. EXISTING SOURCES BAT OPTION D

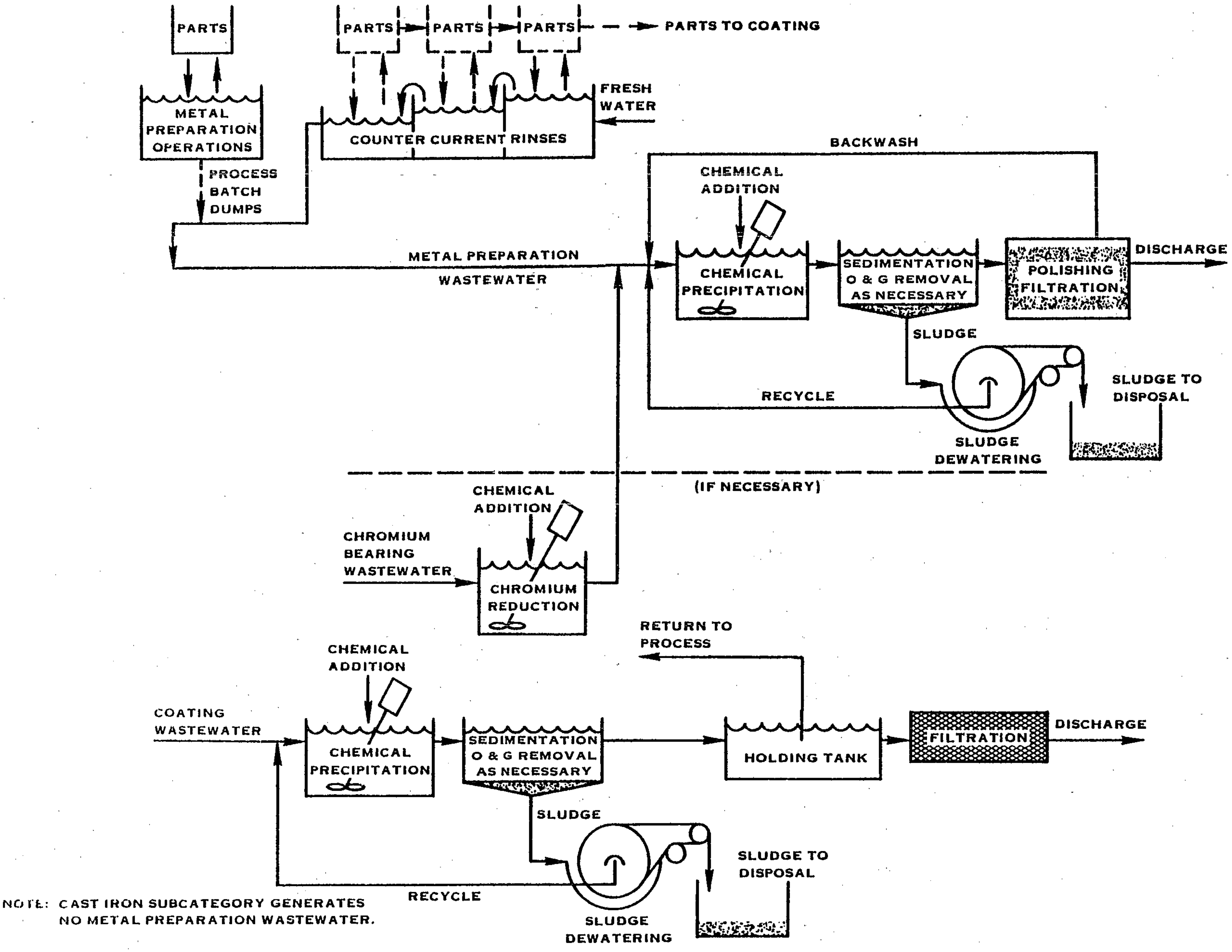


FIGURE X-5. EXISTING SOURCES BAT OPTION E

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

This section presents effluent characteristics attainable by new sources through the application of the best available demonstrated control technology (BDT), processes, operating methods, or other alternatives, including where practicable, a standard permitting no discharge of pollutants. The treatment system capable of achieving the NSPS is discussed, and the rationale for selecting it is outlined. The selection of pollutant parameters for specific regulation is discussed, and discharge limitations for the regulated pollutants are presented for each subcategory.

TECHNICAL APPROACH TO NSPS

Proposed NSPS Technology

The proposed NSPS model technology required use of dry electrostatic powder coating to achieve zero discharge from coating operations, and treatment of metal preparation wastewaters by: reduction of hexavalent chromium in segregated chromium-bearing wastewaters where necessary; oil skimming, equalization; lime, settle and filter end-of-pipe treatment; in-process water use reduction by use of three-stage countercurrent rinsing in metal preparation and rinse flow controls.

Industry comments on the proposed new source performance standards indicated that the dry powder enameling process is not appropriate for all products. Several commenters pointed out that a wide variety of colors are not available in powder coatings. Most commenters stated that powder cannot be applied to some steel product shapes or any aluminum products.

Final NSPS Technology

After careful consideration and review of public comment on the proposed model technology the Agency decided to modify the proposed NSPS model treatment system by not requiring electrostatic dry powder coating. Instead, in the BAT model technology for coating wastewaters is used for NSPS. Coating wastewaters are combined with metal preparation wastewaters and some of the treated water is reused for all coating operations except for ball mill wash out. After further consideration of the reduced flow from metal preparation wastewater, it was decided to eliminate the equalization tank prior to the rapid mix tank. The NSPS model treatment technology is equivalent to the promulgated BAT model treatment technology plus the use of three-stage countercurrent rinsing for metal preparation wastewaters and the addition of a polishing filter. The BAT technologies used in the selected NSPS treatment system have been discussed in Section X.

In summary form, the final NSPS model treatment technology is (see Figure XI, Page 431):

- hexavalent chromium reduction where necessary
- in-process wastewater flow reduction technology using three-stage countercurrent rinsing
- oil skimming
- chemical precipitation
- settling (clarifier)
- holding tank
- reuse of water for all coating needs except ball mill wash out
- polishing filter
- sludge densification

Polishing Filtration

Polishing filtration is included in the NSPS model technology and is well demonstrated within (as well as outside of) the category. Seven existing porcelain enameling plants report the use of polishing filtration and data from two of these are used in determining the treatment effectiveness of lime, settle and filter technology. The treatment effectiveness values now uses for lime, settle and filter technology are slighlty different from the proposal values because of reevaluation of the variability factors used to calculate one day and monthly average values as is described in Section VII.

The use of a filter as part of the treatment technology for new sources is not prevented by considerations of combined treatment of wastewaters. A new source can readily design wastewater collection systems to serve different categories with different treatment requirements.

NSPS Flow

We proposed NSPS based on the abnormal flow reduction achieved at plant no. 33617 which reportedly achieved a metal preparation wastewater flow of 1.44 l/m^2 using two-stage countercurrent rinsing. This was approximately 1/23 of the mean wastewater flow from metal preparation in the steel subcategory. Comments suggested that the metal preparation wastewater value for plant 33617 must be in error. We reevaluated the data from this plant and found that batch dumps of solutions had not been taken into account and that one of the rinses was in fact a 3-stage countercurrent cascade rinse. The recalculated wastewater flow for metal preparation in plant 33617 is 3.564 l/m^2 or 1/11.2 the steel subcategory sampled plant mean production normalized water use for metal preparation. No aluminum or copper subcategory plants currently employs three stage countercurrent rinsing, although one plant uses two stage countercurrent rinse; but the model technology for the steel subcategory can be used in the other two subcategories. The reduction in wastewater discharge from metal preparation is applicable in all three subcategories because the technology is independent of the basis metal being processed. Plant 18538 and 13330, used in Section VII to establish performance data for lime, settle and filter technology are porcelain enameling plants and provide the basis for the LS&F effluent concentrations listed in Table VII-20.

In the NSPS model technology we have used three stage countercurrent cascade rinsing to assure that the wastewater flow levels achieved by plant no. 33617 can be reliably achieved by other plants. Since plant no. 33617 used three stage rinse for only some of its rinsing their model technology assumption appears to be quite conservative.

COST OF NSPS

An estimate of capital and annual costs for NSPS was prepared for each subcategory. Results are presented in Table XI-1 which is based on January 1978 dollars.

TABLE XI-1

NSPS CAPITAL AND ANNUAL COSTS

Subcategory	Normal Plant Treatment System Flow (liters/hr)	Capital Costs $	Annual Costs $
Steel	4,276.4	259,830	72,090
Cast Iron	150.0	61,978	20,364
Aluminum	1,088.6	195,012	54,915
Copper	154.4	83,978	20,364

For calculating NSPS system costs the "normal plant" flow as derived in Section X was used. An average dcp plant annual subcategory production by operation was multiplied by a production normalized flow (with countercurrent rinse turndown for metal preparation) for each operation in each subcategory to obtain normal plant annual flow. Hourly flow was calculated by assuming plant operation for sixteen hours per day and 230 days per year. Control technology was sized for the "normal plant."

REGULATED POLLUTANT PARAMETERS

The raw wastewater concentrations from individual operations and from the subcategory total were examined to select pollutant parameters found most frequently and at the highest levels. In each subcategory, chromium, lead, nickel, zinc, aluminum, iron, oil and grease, TSS and pH were selected for regulation. This is a reduced list of pollutants for regulation from that proposed because maintaining pH of effluents within a narrow range at the optimum pH level, and then fixing a low TSS concentration assures removal of those toxic metals not selected for specific regulation.

Table VII-20 presents the achievable effluent concentrations of the regulated pollutants using the lime, settle, and filter technology. The mass-based discharge performance standards to be achieved by new direct dischargers are discussed by subcategory.

Steel Subcategory

New source performance standards for the steel subcategory metal preparation waste stream are based on the lowest flow achieved among the sampled plants. As explained above, Plant 33617 discharged an average metal preparation flow of 3.564 l/m^2 using a three-stage and a two-stage countercurrent rinse. This value is used as the metal preparation production normalized water use for steel. The coating water use is equal to the water use for ball mill wash out, 0.636 l/m^2, as discussed in Sections V and X.

When the achievable effluent concentrations for LS&F listed in Table VII-20 above for all pollutant parameters listed above are applied to the flows given above, the mass of pollutant allowed to be discharged per unit area of metal prepared and unit area of coating can be calculated. Table XI-2 on page 427 shows the NSPS derived from this calculation.

Cast Iron Subcategory

New source performance standards for the cast iron subcategory are based on the concentrations of regulated pollutants (mg/l) achievable by lime, settle, and filter technology (Table VII-20) and on the mean production normalized water use for coating, (i.e. ball mill wash out), 0.636 l/m^2, as discussed in Sections V and X when the achievable effluent concentrations for LS&F (Table VII-20) for all pollutant parameters listed above are applied to the flow given above, the mass of pollutant allowed to be discharged per unit area of coating can be calculated. Table XI-3 on page 428 shows the performance standards derived from this calculation.

Aluminum Subcategory

New source performance standards for the aluminum subcategory metal preparation wastewater stream are based on BPT flows reduced by the percent flow reduction achievable with the use of countercurrent rinses. As explained above, the achievable water usage is 1/11.2 of the mean usage of the sampled plants in the aluminum subcategory, or 3.473 l/m^2 (i.e. 38.896 l/m^2 from Section IX, divided by 11.2 equals 3.473 l/m^2). This flow will be used to calculate new source performance standards for the metal preparation waste stream. The coating water use is equal to the water used to wash out ball mills, 0.636 l/m^2.

When the achievable effluent concentrations for LS&F, table VII-20 for all pollutant parameters listed above are applied to the flows given above, the mass of pollutant allowed to be discharged per unit area of metal prepared and unit area of metal coated can be calculated. Table XI-4 on page 429 shows the performance standards derived from this calculation.

Copper Subcategory

New source performance standards for the copper subcategory metal preparation wastewater stream are based on the percent flow reduction achievable with the use of countercurrent rinses. As explained above, the achievable flow is 1/11.2 the mean for sampled plants in the copper subcategory, or 6.01 l/m^2 (i.e. 67.29 l/m^2, from Section V, Table V-24 divided by 11.2 equals 6.01 l/m^2). This flow will be used to calculate new source performance standards for the metal preparation wastewater streams. The coating water usage is equal to the water used to wash out ball mills, 0.636 l/m^2, as discussed in Sections V and X.

When the achievable effluent concentrations for LS&F, (Table VII-20) for all pollutant parameters listed above are applied to the flow given above, the mass of pollutant allowed to be discharged per unit area of metal prepared and unit area coated can be calculated. Table XI-5 on page 430 shows the performance standards derived from this calculation.

SUMMARY

NSPS standards may be achieved by use of the model technology, all parts of which have been demonstrated in porcelain enameling plants. Seven porcelain enameling plants have lime, settle and filter technology in place. Countercurrent rinsing is demonstrated at plant 33617. By transferring flow reduction technologies the NSPS limitations are achievable for all subcategories.

TABLE XI - 2
STEEL SUBCATEGORY
NEW SOURCE PERFORMANCE STANDARDS

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
	Metric Units - mg/m^2 of area processed or coated			
ANTIMONY	0.500	0.089	0.214	0.038
ARSENIC	4.969	0.884	2.038	0.363
CADMIUM	0.715	0.127	0.286	0.051
*CHROMIUM	1.323	0.235	0.536	0.095
COPPER	4.576	0.814	2.181	0.388
*LEAD	0.358	0.064	0.322	0.057
*NICKEL	1.966	0.350	1.323	0.235
SELENIUM	0.107	0.019	0.036	0.006
*ZINC	3.647	0.649	1.502	0.267
*ALUMINUM	10.832	1.927	4.433	0.789
COBALT	0.751	0.134	0.322	0.057
FLUORIDE	138.710	24.677	56.485	10.049
*IRON	4.397	0.782	2.252	0.401
MANGANESE	1.073	0.191	0.822	0.146
*OIL & GREASE	35.750	6.360	35.750	6.360
*TSS	53.625	9.540	39.325	6.996
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			
	English Units - $lb/1,000,000\ ft^2$ of area processed or coated			
ANTIMONY	0.102	0.018	0.044	0.008
ARSENIC	1.018	0.181	0.417	0.074
CADMIUM	0.146	0.026	0.059	0.010
*CHROMIUM	0.271	0.048	0.110	0.019
COPPER	0.937	0.167	0.447	0.079
*LEAD	0.073	0.013	0.066	0.012
*NICKEL	0.403	0.072	0.271	0.048
SELENIUM	0.022	0.004	0.007	0.001
*ZINC	0.747	0.133	0.308	0.055
*ALUMINUM	2.219	0.395	0.908	0.162
COBALT	0.154	0.027	0.066	0.012
FLUORIDE	28.410	5.054	11.569	2.058
*IRON	0.901	0.160	0.461	0.082
MANGANESE	0.220	0.039	0.168	0.030
*OIL & GREASE	7.322	1.303	7.322	1.303
*TSS	10.983	1.954	8.054	1.433
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XI - 3
CAST IRON SUBCATEGORY
NEW SOURCE PERFORMANCE STANDARDS

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2 ($lb/1{,}000{,}000\ ft^2$) of area coated			
ANTIMONY	0.089	(0.018)	0.038	(0.008)
ARSENIC	0.884	(0.181)	0.363	(0.074)
CADMIUM	0.127	(0.026)	0.051	(0.010)
*CHROMIUM	0.235	(0.048)	0.095	(0.019)
COPPER	0.814	(0.167)	0.388	(0.079)
*LEAD	0.064	(0.013)	0.057	(0.012)
*NICKEL	0.350	(0.072)	0.235	(0.048)
*ZINC	0.649	(0.133)	0.267	(0.055)
*ALUMINUM	1.927	(0.395)	0.789	(0.162)
COBALT	0.134	(0.027)	0.057	(0.012)
FLUORIDE	24.677	(5.054)	10.049	(2.058)
*IRON	0.782	(0.160)	0.401	(0.082)
MANGANESE	0.191	(0.039)	0.146	(0.030)
*OIL & GREASE	6.360	(1.303)	6.360	(1.303)
*TSS	9.540	(1.954)	6.996	(1.433)
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XI - 4
ALUMINUM SUBCATEGORY
NEW SOURCE PERFORMANCE STANDARDS

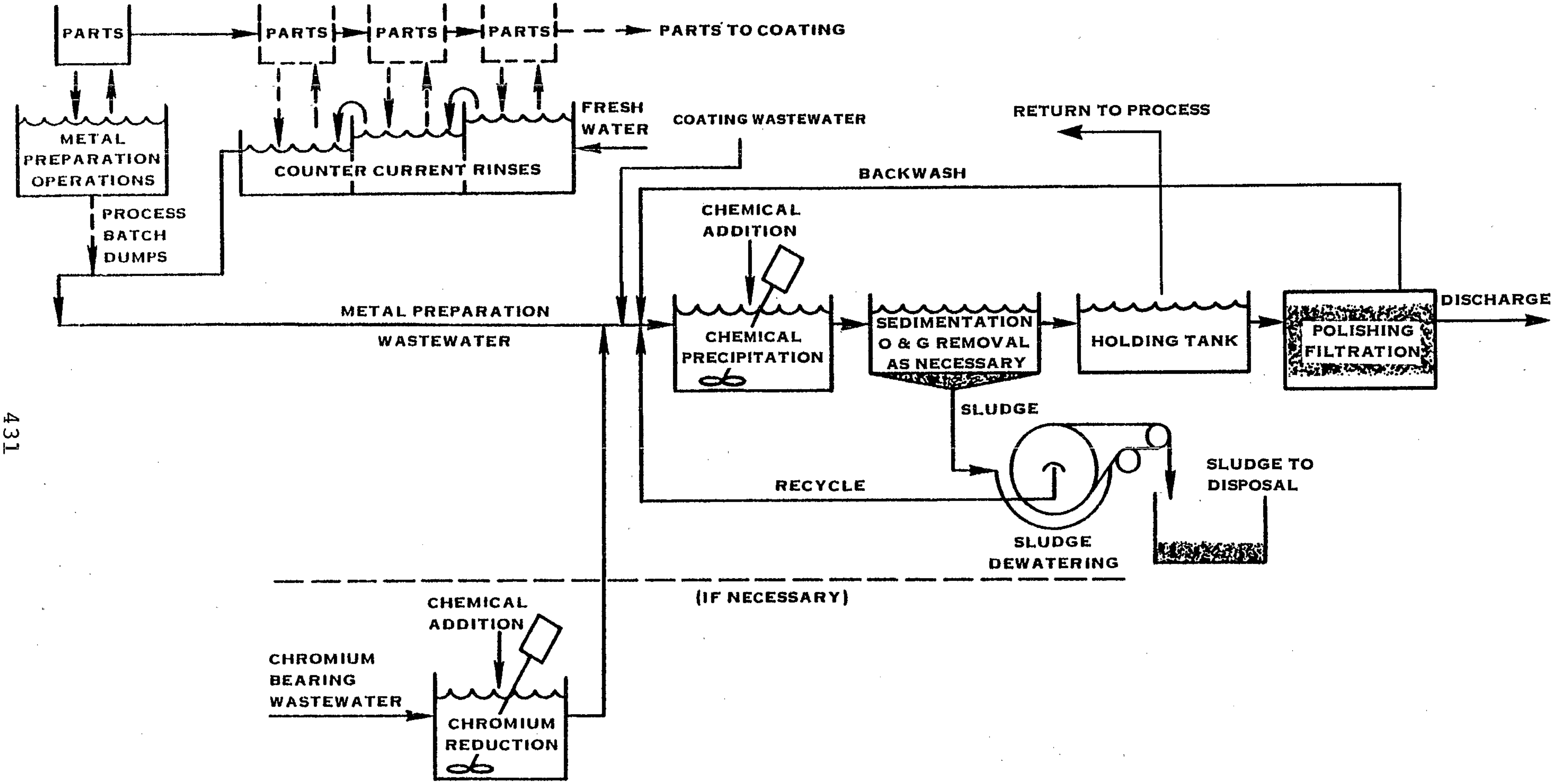
POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
	Metric Units - mg/m^2 of area processed or coated			
ANTIMONY	0.486	0.089	0.208	0.038
ARSENIC	4.827	0.884	1.980	0.363
CADMIUM	0.695	0.127	0.278	0.051
*CHROMIUM	1.285	0.235	0.521	0.095
COPPER	4.445	0.814	2.119	0.388
CYANIDE	0.695	0.127	0.278	0.051
*LEAD	0.347	0.064	0.313	0.057
*NICKEL	1.910	0.350	1.285	0.235
*ZINC	3.542	0.649	1.459	0.267
*ALUMINUM	10.523	1.927	4.307	0.789
COBALT	0.729	0.134	0.313	0.057
FLUORIDE	134.752	24.677	54.873	10.049
*IRON	4.272	0.782	2.188	0.401
MANGANESE	1.042	0.191	0.799	0.146
*OIL & GREASE	34.730	6.360	34.730	6.360
*TSS	52.095	9.540	38.203	6.996
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			
	English Units - lb/1,000,000 ft^2 of area processed or coated			
ANTIMONY	0.100	0.018	0.043	0.008
ARSENIC	0.989	0.181	0.406	0.074
CADMIUM	0.142	0.026	0.057	0.010
*CHROMIUM	0.263	0.048	0.107	0.019
COPPER	0.910	0.167	0.434	0.079
CYANIDE	0.142	0.026	0.057	0.010
*LEAD	0.071	0.013	0.064	0.012
*NICKEL	0.391	0.072	0.263	0.048
*ZINC	0.725	0.133	0.299	0.055
*ALUMINUM	2.155	0.395	0.882	0.162
COBALT	0.149	0.027	0.064	0.012
FLUORIDE	27.599	5.054	11.239	2.058
*IRON	0.875	0.160	0.448	0.082
MANGANESE	0.213	0.039	0.164	0.030
*OIL & GREASE	7.113	1.303	7.113	1.303
*TSS	10.670	1.954	7.825	1.433
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XI - 5
COPPER SUBCATEGORY
NEW SOURCE PERFORMANCE STANDARDS

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
Metric Units - mg/m^2 of area processed or coated				
ANTIMONY	0.841	0.089	0.361	0.038
ARSENIC	8.354	0.884	3.426	0.363
CADMIUM	1.202	0.127	0.481	0.051
*CHROMIUM	2.224	0.235	0.901	0.095
COPPER	7.693	0.814	3.666	0.388
*LEAD	0.601	0.064	0.541	0.057
*NICKEL	3.306	0.350	2.224	0.235
*ZINC	6.130	0.649	2.524	0.267
*ALUMINUM	18.210	1.927	7.452	0.789
COBALT	1.262	0.134	0.541	0.057
FLUORIDE	233.188	24.677	94.958	10.049
*IRON	7.392	0.782	3.786	0.401
MANGANESE	1.803	0.191	1.382	0.146
*OIL & GREASE	60.100	6.360	60.100	6.360
*TSS	90.150	9.540	66.110	6.996
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			
English Units - $lb/1,000,000\ ft^2$ of area processed or coated				
ANTIMONY	0.172	0.018	0.074	0.008
ARSENIC	1.711	0.181	0.702	0.074
CADMIUM	0.246	0.026	0.099	0.010
*CHROMIUM	0.456	0.048	0.185	0.019
COPPER	1.576	0.167	0.751	0.079
*LEAD	0.123	0.013	0.111	0.012
*NICKEL	0.677	0.072	0.456	0.048
*ZINC	1.256	0.133	0.517	0.055
*ALUMINUM	3.730	0.395	1.526	0.162
COBALT	0.258	0.027	0.111	0.012
FLUORIDE	47.761	5.054	19.449	2.058
*IRON	1.514	0.160	0.775	0.082
MANGANESE	0.369	0.039	0.283	0.030
*OIL & GREASE	12.309	1.303	12.309	1.303
*TSS	18.464	1.954	13.540	1.433
*pH	WITHIN THE RANGE OF 7.5 TO 10.0 AT ALL TIMES			

* THIS POLLUTANT IS REGULATED AT PROMULGATION



NOTE: CAST IRON SUBCATEGORY GENERATES NO METAL PREPARATION WASTEWATER.

FIGURE XI-1. NEW SOURCES SELECTED OPTION

SECTION XII

PRETREATMENT

This section applies to existing or new indirect dischargers only. An indirect discharger is a facility which introduces pollutants into publicly owned treatment works (POTW). The model control technologies for pretreatment of process wastewaters from existing sources and new sources are described.

PSES are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of publicly owned treatment works (POTW). They must be achieved within three years of promulgation. The Clean Water Act of 1977 requires pretreatment for toxic pollutants that pass through the POTW in amounts that would violate direct discharger effluent limitations or limit POTW sludge management alternatives, including the beneficial use of sludges on agricultural lands. The legislative history of the 1977 Act indicates that pretreatment standards are to be technology-based, analogous to the best available technology for removal of toxic pollutants. The general pretreatment regulations (40 CFR Part 403,), which serve as the framework for pretreatment regulations were published in 46 FR 9104 (January 28,1981).

Like PSES, PSNS are to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of the POTW. PSNS are to be issued at the same time EPA promulgates NSPS. New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies. The Agency considers the same factors in promulgating PSNS as it considers in promulgating PSES.

Most POTW consist of primary or secondary treatment systems which are designed to treat domestic wastewaters. Many of the pollutants contained in porcelain enameling wastewaters are not biodegradable and are therefore ineffectively treated by such systems. Furthermore, these pollutants have been known to interfere with the normal operations of these systems. Problems associated with the uncontrolled release of pollutant parameters identified in porcelain enameling process wastewaters to POTW were discussed in the first part of Section VI. The pollutant-by-pollutant discussion covered pass through, interference, and sludge usability.

EPA has generally determined there is pass through of pollutants if the percent of pollutants removed by a well operated POTW achieving secondary treatment is less than the percent removed by the BAT model treatment technology. POTW removals of the major toxic pollutants found in porcelain enameling wastewater are presented in Table XII-1. The average removal of toxic metals is about 31 percent. The BAT treatment technology removes more than 99 percent of toxic metals (See Table X-14, page 405). This difference in removal effectiveness clearly indicates pass through of toxic metals will occur unless porcelain enameling wastewaters are adequately pretreated.

PSES

The proposed PSES model technology was identical to the proposed BAT model technology.

Many of the comments applicable to BAT also applied to PSES. Some commenters questioned the necessity for any PSES. A number of comments objected to mass-based standards for PSES. Other comments suggested that a sump settling technology, which is less expensive than the model technology, be used as the basis for PSES to reduce the economic impact of the regulation.

For the final regulation, the Agency considered PSES options equivalent to those considered for BAT. Options PSES-0 is equivalent to BPT; Options A through E are identical to BAT Options A through E, descrbied in Section X.

Several changes were made in PSES in response to comments. The Agency has removed filtration from the model PSES technology for the reasons set forth in Section X. The Agency is promulgating concentration-based PSES rather than mass-based PSES. The Agency recognizes that mass-based standards are somewhat more difficult for a POTW to administer and believes that, for this regulation, mass-based standards are unnecessary because concentration based standards may be more easily implemented and in this specific case the resulting additional pollutant discharge will not be substantive.

The Agency has determined that there is no less stringent technology that could be the basis of pretreatment standards for small plants. EPA evaluated a less expensive, sump settling technology suggested by public comments for small indirect dischargers. The comments did not provide data for evaluation of the performance of settling sump technology and such data is not believed to exist. The few data about sump settlingg technology seem to confirm the suspicion that it is highly variable in its performance and not suitable for use as a reliable pollution control treatment system. Reduction of hexavalient chromium is not included and this would allow hexavalent chromium to pass through without removal. Additionally a typical sump would "channel or short circuit" so that effective removal would not be achieved. As a sump fills with solids this tendency to channel would be expected to increase, progressively reducing any benefit from ths sump.

On this basis, the Agency determined that this technology has not been adequately demonstrated in the industry and probably would not appreciably reduce the discharge of toxic pollutants.

The Agency's conclusion that the suggested sump settling technology would not reliably reduce the discharge of pollutants resulted in an exclusion from categorical PSES for small indirect dischargers.

Application of PSES to all indirect dischargers would have resulted in eight plant closures predominately among plants which produce less than 1600 m^2/day product and discharge less than 60,000 l/day. EPA determined that this would present a disproportionate impact on this segment of the category. The exclusion point is reasonable since the next projected plant closure is about twice the cutoff level. This cut-off exempts from the categorical PSES regulation 38 small indirect dischargers which represent about 5 percent of the total industry production and 7 percent of the production by indirect dischargers. Further details of the small plant analysis are presented in the economic analysis document. The elements of the control technology which formed the basis for PSES are identical to the elements of control technology upon which BAT is based. The BAT treatment system is required to limit the toxic pollutants which otherwise would pass through, interfere with, or prevent utilization of sludge from POTW.

This model technology requires combined treatment of wastewater with lime and settle, use of a holding tank, and reuse of all coating water needs except for ball mill wash out. Hexavalent chromium reduction may be required when necessary to allow chromium removal by lime and settle treatment. As with BAT, wastewater flows generated by metal preparation operations should meet the industry average as explained in Section IX of this document to achieve mass discharge limitations in those cases where a POTW desires to use mass based effluent limitations.

Tables XII-2, 3, and 4 present technology treatment performance for indirect dischargers in the steel, cast iron, and aluminum subcategories, respectively. Flows and pollutant mass discharges for small (exempt) plants are included as untreated (equal to raw wastewater values). The copper subcategory is not shown separately because the two existing plants are exempt from regulation as small dischargers.

Table XII-5 presents a summation of treatment performance data for all indirect dischargers in the Porcelain Enameling category. Table XII-6 presents a summary of treatment performance in terms of total toxic metals, total conventionals, and total pollutants for the steel, cast iron, and aluminum subcategories. A comparison of costs and pollutant removal benefits for indirect discharges can be made by comparing values from Tables XII-2 through XII-4 (pages 439-441) with those in table X-20 (page 411).

The Agency has considered the time for compliance for PSES. Few if any of the porcelain enameling plants have installed and are properly operating the treatment technology for PSES. Additionally, the readjustment of internal processing conditions to achieve reduced wastewater flows may require more time than for only the installation of end-of-pipe treatment equipment. Additionally, many plants in this and other industries will be installing the treatment equipment suggested as model technologies for this regulation and this may result in delays in engineering, ordering, installing, and operating this equipment. For all these reasons, the Agency has decided to set the PSES compliance date at three years after promulgation of this regulation.

REGULATED POLLUTANT PARAMETERS

The Agency reviewed the porcelain enameling wastewater concentrations, the BAT model treatment technology removals, and the POTW removals of major toxic pollutants found in porcelain enameling wastewaters to select the pollutants for regulation. The pollutants to be regulated are the same for each subcategory as were selected for BAT except that the nonconventional pollutants (aluminum and iron) are not regulated. Aluminum and iron compounds are frequently used as flocculation aids in POTW. Toxic metals are regulated to prevent pass through. Conventionals are not regulated because POTW remove these pollutant parameters. Table XII-7 on page 444 shows the concentration based pretreatment standards for existing sources in the steel, cast iron and aluminum subcategories.

In cases where POTW find it necessary to implement mass effluent pretreatment standards, they are derived by multiplying the concentration standards by the wastewater flow for the PSES A technology option. Tables XII-8 through XII-10 (pages 445-447) present the mass-based standards for the steel, cast iron, and aluminum subcategories.

PSNS

PSNS uses the same treatment system as NSPS and establishes mass-based effluent standards for all subcategories and therefore prescribes that wastewater flows from metal preparation operations in the steel, aluminum and copper subcategories meet the flows achievable with the use of three-stage countercurrent rinsing. The reasons for selecting added technology in the form of polishing filter and countercurrent rinsing are described in Section XI; NSPS. The achievable flow with three-stage countercurrent rinsing for each subcategory has been shown to be 1/11.2 the mean metal preparation flow at sampled plants in each subcategory (reference Section XI).

PSNS also requires that all water needed for coating operations except for ball mill wash out for all subcategories be recycled from the holding tank following liming and settling of the combined wastewaters. A polishing filter follows the holding tank. The toxic pollutants selected for regulation at PSNS are chromium, lead, nickel and zinc. Nonconventional pollutants, iron and aluminum, are not regulated at PSNS although the control technology recommended will remove these pollutants. Tables XII-11 through XII-14 (pages 448-451) present pretreatment mass discharge limitations for new sources.

PSNS pollutant reduction benefits for each subcategory were based on a normal plant production. The pollutant reduction benefits for each subcategory are presented in Tables XI-2 through XI-5. All pollutant parameter calculations were based on median raw wastewater concentrations for visited plants (Table V-24, page 108).

TABLE XII-1

POTW Removals of the Major Toxic Pollutants Found in Porcelain Enameling Wastewater

Pollutant		Percent Removal By Secondary POTW
118	cadmium	38
119	chromium, hexavalent	18
	chromium, trivalent	NA
120	copper	58
122	lead	48
124	nickel	19
128	zinc	65

Note: This data compiled from Fate of Priority Pollutants in Publicly Owned Treatment Works, USEPA, EPA No. 440/1-80-301, October 1980.

TABLE XII-2
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
STEEL SUBCATEGORY

PARAMETER	RAW WASTE			PSES O		PSES A		PSES B	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW 1/yr (10^6)	3301.06	763.85	4064.91		4064.91		3405.29		4064.91
114 ANTIMONY	0.00	52059.43	52059.43	48593.68	3465.75	48626.66	3432.77	48655.00	3404.43
115 ARSENIC	0.00	931.90	931.90	0.00	931.90	0.00	931.90	0.00	931.90
117 BERYLLIUM	0.00	32.85	32.85	0.00	32.85	0.00	32.85	0.00	32.85
118 CADMIUM	29.71	6308.63	6338.34	5637.14	701.20	5689.25	649.09	5752.12	586.22
119 CHROMIUM	359.82	1046.47	1406.29	1013.79	392.50	1066.56	339.73	1052.11	354.18
120 COPPER	188.16	2667.37	2855.53	454.32	2401.21	836.90	2018.63	1182.52	1673.01
122 LEAD	79.22	32703.47	32782.69	30261.57	2521.12	30340.72	2441.97	30414.88	2367.81
124 NICKEL	47898.38	21642.93	69541.31	63322.91	6218.40	63698.90	5842.41	64664.35	4876.96
125 SELENIUM	316.90	7674.40	7991.30	7452.63	538.67	7459.23	532.07	7464.13	527.17
128 ZINC	330.11	74883.27	75213.38	69335.61	5877.77	69533.49	5679.89	69603.89	5609.49
ALUMINUM	1138.87	124360.89	125499.76	113360.64	12139.12	114092.81	11406.95	114778.73	10721.03
COBALT	171.66	22626.76	22798.42	21097.51	1700.91	21143.69	1654.73	21174.17	1624.25
FLUORIDE	2297.54	18433.99	20731.53	0.00	20731.53	0.00	20731.53	0.00	20731.53
IRON	1766067.10	28202.87	1794269.97	1692383.19	101886.78	1692653.64	101616.33	1692881.44	101388.53
MANGANESE	6397.45	33681.21	40078.66	36798.56	3280.10	36937.08	3141.58	37066.84	3011.82
PHOSPHORUS	17924.75	3245.60	21170.35	4328.75	16841.60	7020.00	14150.35	9541.19	11629.16
OIL & GREASE	40768.09	12303.33	53071.42	11696.09	41375.33	18292.29	34779.13	11696.09	41375.33
TSS	277289.04	16742191.86	17019480.90	15905068.04	1114412.86	15912983.48	1106497.42	15941095.23	1078385.67
TOXIC METALS	49202.30	199950.72	249153.02	226071.65	23081.37	227251.71	21901.31	228789.00	20364.02
CONVENTIONALS	318057.13	16754495.19	17072552.32	15916764.13	1155788.19	15931275.77	1141276.55	15952791.32	1119761.00
TOTAL POLLU.	2161256.80	17184997.23	19346254.03	18010804.43	1335449.60	18030374.70	1315879.33	18057022.69	1289231.34
SLUDGE GEN				105675484.94		105863308.17		106099090.33	

PARAMETER	PSES C		PSES D				PSES E			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
FLOW 1/yr (10^6)		3405.29		3301.06		104.23		462.48		104.23
114 ANTIMONY	48677.43	3382.00	0.00	0.00	48783.40	3276.03	0.00	0.00	48783.40	3276.03
115 ARSENIC	0.00	931.90	0.00	0.00	854.19	77.71	0.00	0.00	854.19	77.71
117 BERYLLIUM	0.00	32.85	0.00	0.00	19.54	13.31	0.00	0.00	19.54	13.31
118 CADMIUM	5784.44	553.90	0.00	29.71	5909.12	399.51	14.41	15.30	5909.12	399.51
119 CHROMIUM	1098.29	308.00	121.56	238.26	976.73	69.74	320.26	39.56	976.73	69.74
120 COPPER	1439.78	1415.75	0.00	188.16	2477.70	189.67	69.13	119.03	2477.70	189.67
122 LEAD	30467.65	2315.04	0.00	79.22	30642.19	2061.28	52.54	26.68	30642.19	2061.28
124 NICKEL	64809.47	4731.84	44540.07	3358.31	20269.40	1373.53	45164.56	2733.82	20269.40	1373.53
125 SELENIUM	7468.75	522.55	277.40	39.50	7191.35	483.05	297.27	19.63	7191.35	483.05
128 ZINC	69755.61	5457.77	0.00	330.11	70160.80	4722.47	247.68	82.43	70160.80	4722.47
ALUMINUM	115266.85	10232.91	0.00	1138.87	116498.01	7862.88	869.39	269.48	116498.01	7862.88
COBALT	21207.15	1591.27	6.24	165.42	21200.91	1425.85	148.17	23.49	21200.91	1425.85
FLUORIDE	0.00	20731.53	0.00	2297.54	16743.08	1690.91	0.00	2297.54	16743.08	1690.91
IRON	1693066.13	101203.84	1666652.73	99414.37	26413.41	1789.46	1667447.53	98619.57	26413.41	1789.46
MANGANESE	37159.19	2919.47	5604.13	793.32	31555.06	2126.15	6001.53	395.92	31555.06	2126.15
PHOSPHORUS	11335.36	9834.99	8446.71	9478.04	2888.64	356.96	16167.65	1757.10	2888.64	356.96
OIL & GREASE	18292.29	34779.13	7324.64	33443.45	10967.65	1335.68	35710.44	5057.65	10967.65	1335.68
TSS	15942810.24	1076670.66	253713.22	23575.82	15689097.03	1053094.83	261093.53	16195.51	15689097.03	1053094.83
TOXIC METALS	229501.42	19651.60	44939.03	4263.27	187284.42	12666.30	46165.85	3036.45	187284.42	12666.30
CONVENTIONALS	15961102.53	1111449.79	261037.86	57019.27	15700064.68	1054430.51	296803.97	21253.16	15700064.68	1054430.51
TOTAL POLLU.	18068638.63	1277615.40	1986686.70	174570.10	16102648.21	1082349.02	2033604.09	127652.71	16102648.21	1082349.02
SLUDGE GEN	106214009.71		20793365.71		85741448.42		21236648.73		85741448.42	

TABLE XII-3
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
CAST IRON SUBCATEGORY

PARAMETER	RAW WASTE COATING	PSES O COATING		PSES A COATING		PSES B COATING	
	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	3.72		3.72		3.42		3.72
114 ANTIMONY	253.53	251.31	2.22	251.32	2.21	251.36	2.17
115 ARSENIC	4.54	2.62	1.92	2.77	1.77	3.25	1.29
117 BERYLLIUM	0.16	0.00	0.16	0.00	0.16	0.00	0.16
118 CADMIUM	30.73	30.19	0.54	30.21	0.52	30.30	0.43
119 CHROMIUM	5.10	4.76	0.34	4.79	0.31	4.80	0.30
120 COPPER	12.99	10.75	2.24	10.92	2.07	11.45	1.54
122 LEAD	159.26	157.54	1.72	157.57	1.69	157.68	1.58
124 NICKEL	105.40	102.45	2.95	102.62	2.78	103.74	1.66
125 SELENIUM	37.37	37.03	0.34	37.04	0.33	37.04	0.33
128 ZINC	364.69	360.64	4.05	360.73	3.96	360.90	3.79
ALUMINUM	605.64	596.66	8.98	597.00	8.64	598.03	7.61
COBALT	110.20	109.05	1.15	109.07	1.13	109.13	1.07
FLUORIDE	89.77	36.65	53.12	40.91	48.86	54.14	35.63
IRON	137.35	134.73	2.62	134.85	2.50	135.21	2.14
MANGANESE	164.03	161.94	2.09	162.00	2.03	162.19	1.84
PHOSPHORUS	15.81	0.62	15.19	1.85	13.96	5.64	10.17
OIL & GREASE	59.91	22.53	37.38	25.53	34.38	22.53	37.38
TSS	81535.59	80833.76	701.83	80837.36	698.23	80868.45	667.14
TOXIC METALS	973.77	957.29	16.48	957.97	15.80	960.52	13.25
CONVENTIONALS	81595.50	80856.29	739.21	80862.89	732.61	80890.98	704.52
TOTAL POLLU.	83692.07	82853.23	838.84	82866.54	825.53	82915.84	776.23
SLUDGE GEN		440203.05		440356.46		440889.43	

PARAMETER	PSES C COATING		PSES D COATING		PSES E COATING	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)		3.42		3.42		3.42
114 ANTIMONY	251.37	2.16	251.37	2.16	251.37	2.16
115 ARSENIC	3.35	1.19	3.35	1.19	3.35	1.19
117 BERYLLIUM	0.00	0.16	0.00	0.16	0.00	0.16
118 CADMIUM	30.31	0.42	30.31	0.42	30.31	0.42
119 CHROMIUM	4.82	0.28	4.82	0.28	4.82	0.28
120 COPPER	11.57	1.42	11.57	1.42	11.57	1.42
122 LEAD	157.71	1.55	157.71	1.55	157.71	1.55
124 NICKEL	103.80	1.60	103.80	1.60	103.80	1.60
125 SELENIUM	37.05	0.32	37.05	0.32	37.05	0.32
128 ZINC	360.97	3.72	360.97	3.72	360.97	3.72
ALUMINUM	598.25	7.39	598.25	7.39	598.25	7.39
COBALT	109.14	1.06	109.14	1.06	109.14	1.06
FLUORIDE	56.98	32.79	56.98	32.79	56.98	32.79
IRON	135.29	2.06	135.29	2.06	135.29	2.06
MANGANESE	162.24	1.79	162.24	1.79	162.24	1.79
PHOSPHORUS	6.46	9.35	6.46	9.35	6.46	9.35
OIL & GREASE	25.53	34.38	25.53	34.38	25.53	34.38
TSS	80869.23	666.36	80869.23	666.36	80869.23	666.36
TOXIC METALS	960.95	12.82	960.95	12.82	960.95	12.82
CONVENTIONALS	80894.76	700.74	80894.76	700.74	80894.76	700.74
TOTAL POLLU.	82924.07	768.00	82924.07	768.00	82924.07	768.00
SLUDGE GEN	440986.93		440986.93		440986.93	

TABLE XII-4
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
ALUMINUM SUBCATEGORY

PARAMETER	RAW WASTE			PSES O		PSES A		PSES B	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED	
	kg/yr	kg/yr	kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)	129.91	33.39	163.30		163.30		148.47		163.30
114 ANTIMONY	0.00	2275.67	2275.67	1050.07	1225.60	1050.81	1224.86	1051.88	1223.79
115 ARSENIC	0.00	40.74	40.74	0.00	40.74	0.00	40.74	0.00	40.74
117 BERYLLIUM	0.00	1.44	1.44	0.00	1.44	0.00	1.44	0.00	1.44
118 CADMIUM	0.39	275.77	276.16	119.31	156.85	120.49	155.67	122.70	153.46
119 CHROMIUM	1.68	45.74	47.42	13.46	33.96	14.65	32.77	14.59	32.83
120 COPPER	5.06	116.60	121.66	0.00	121.66	1.10	120.56	13.92	107.74
122 LEAD	282.56	1429.56	1712.12	861.16	850.96	862.94	849.18	865.67	846.45
124 NICKEL	0.00	946.07	946.07	374.63	571.44	383.09	562.98	414.09	531.98
125 SELENIUM	0.00	335.47	335.47	154.50	180.97	154.65	180.82	154.84	180.63
128 ZINC	27.28	3273.36	3300.64	1505.15	1795.49	1509.60	1791.04	1513.04	1787.60
ALUMINUM	862.60	5436.16	6298.76	3042.44	3256.32	3058.90	3239.86	3084.15	3214.61
COBALT	0.00	989.07	989.07	450.95	538.12	451.99	537.08	453.20	535.87
FLUORIDE	114.32	805.80	920.12	0.00	920.12	0.00	920.12	0.00	920.12
IRON	12.60	1232.82	1245.42	535.13	710.29	541.21	704.21	549.79	695.63
MANGANESE	14.42	1472.30	1486.72	670.14	816.58	673.25	813.47	678.03	808.69
PHOSPHORUS	1102.55	141.88	1244.43	431.16	813.27	491.67	752.76	584.47	659.96
OIL & GREASE	889.88	537.82	1427.70	0.00	1427.70	0.00	1427.70	0.00	1427.70
TSS	5180.81	731847.60	737028.41	342037.58	394990.83	342215.54	394812.87	343097.24	393931.17
TOXIC METALS	316.97	8740.42	9057.39	4078.28	4979.11	4097.33	4960.06	4150.73	4906.66
CONVENTIONALS	6070.69	732385.42	738456.11	342037.58	396418.53	342215.54	396240.57	343097.24	395358.87
TOTAL POLLU.	8494.15	751203.87	759698.02	351245.68	408452.34	351529.89	408168.13	352597.61	407100.41
SLUDGE GEN				1883635.56		1887053.83		1896031.94	

PARAMETER	PSES C		PSES D				PSES E			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr	Removed kg/yr	Discharged kg/yr
FLOW 1/yr (10^6)		148.47		129.91		18.56		41.35		18.56
114 ANTIMONY	1052.38	1223.29	0.00	0.00	1055.69	1219.98	0.00	0.00	1055.69	1219.98
115 ARSENIC	0.00	40.74	0.00	0.00	18.68	22.06	0.00	0.00	18.68	22.06
117 BERYLLIUM	0.00	1.44	0.00	0.00	0.54	0.90	0.00	0.00	0.54	0.90
118 CADMIUM	123.42	152.74	0.00	0.39	127.90	147.87	0.00	0.39	127.90	147.87
119 CHROMIUM	15.63	31.79	0.00	1.68	21.17	24.57	0.65	1.03	21.17	24.57
120 COPPER	19.70	101.96	0.00	5.06	53.83	62.77	0.40	4.66	53.83	62.77
122 LEAD	866.86	845.26	203.72	78.84	663.14	766.42	210.81	71.75	663.14	766.42
124 NICKEL	417.35	528.72	0.00	0.00	438.74	507.33	0.00	0.00	438.74	507.33
125 SELENIUM	154.94	180.53	0.00	0.00	155.63	179.84	0.00	0.00	155.63	179.84
128 ZINC	1516.45	1784.19	0.00	27.28	1518.40	1754.96	18.42	8.86	1518.40	1754.96
ALUMINUM	3095.12	3203.64	573.71	288.89	2521.41	2914.75	639.25	223.35	2521.41	2914.75
COBALT	453.94	535.13	0.00	0.00	458.81	530.26	0.00	0.00	458.81	530.26
FLUORIDE	0.00	920.12	0.00	114.32	367.58	438.22	3.46	110.86	367.58	438.22
IRON	553.94	691.48	0.00	12.60	571.74	661.08	7.00	5.60	571.74	661.08
MANGANESE	680.10	806.62	0.00	14.42	682.93	789.37	9.57	4.85	682.93	789.37
PHOSPHORUS	624.81	619.62	560.79	541.76	64.02	77.86	801.67	300.88	64.02	77.86
OIL & GREASE	0.00	1427.70	0.00	889.88	242.90	294.92	579.29	310.59	242.90	294.92
TSS	343135.80	393892.61	3625.11	1555.70	339510.69	392336.91	3855.36	1325.45	339510.69	392336.91
TOXIC METALS	4166.73	4890.66	203.72	113.25	4053.72	4686.70	230.28	86.69	4053.72	4686.70
CONVENTIONALS	343135.80	395320.31	3625.11	2445.58	339753.59	392631.83	4434.65	1636.04	339753.59	392631.83
TOTAL POLLU.	352710.44	406987.58	4963.33	3530.82	348473.80	402730.07	6125.88	2368.27	348473.80	402730.07
SLUDGE GEN	1897873.71		50913.53		1855613.42		63423.60		1855613.42	

TABLE XII-5
TREATMENT PERFORMANCE - INDIRECT DISCHARGERS
TOTAL CATEGORY

PARAMETER	RAW WASTE METAL PREPARATION kg/yr	 COATING kg/yr	 COMBINED kg/yr	PSES O COMBINED Removed kg/yr	 Discharged kg/yr	PSES A COMBINED Removed kg/yr	 Discharged kg/yr	PSES B COMBINED Removed kg/yr	 Discharged kg/yr
FLOW 1/yr (10^6)	3437.97	801.47	4239.44		4239.44		3564.69		4239.44
114 ANTIMONY	0.00	54623.39	54623.39	49895.06	4728.33	49928.79	4694.60	49958.24	4665.15
115 ARSENIC	0.00	977.80	977.80	2.62	975.18	2.77	975.03	3.25	974.55
117 BERYLLIUM	0.00	34.47	34.47	0.00	34.47	0.00	34.47	0.00	34.47
118 CADMIUM	30.25	6619.34	6649.59	5786.64	862.95	5839.95	809.64	5905.12	744.47
119 CHROMIUM	361.68	1098.01	1459.69	1032.01	427.68	1086.00	373.69	1071.50	388.19
120 COPPER	2144.12	2798.74	4942.86	465.07	4477.79	848.92	4093.94	1207.89	3734.97
122 LEAD	367.17	34314.13	34681.30	31280.27	3401.03	31361.23	3320.07	31438.23	3243.07
124 NICKEL	47899.22	22708.85	70608.07	63799.99	6808.08	64184.61	6423.46	65182.18	5425.89
125 SELENIUM	316.90	8052.36	8369.26	7644.16	725.10	7650.92	718.34	7656.01	713.25
128 ZINC	363.62	78571.32	78934.94	71201.40	7733.54	71403.82	7531.12	71477.83	7457.11
ALUMINUM	2001.98	130485.72	132487.70	116999.74	15487.96	117748.71	14738.99	118460.91	14026.79
COBALT	171.66	23741.14	23912.80	21657.51	2255.29	21704.75	2208.05	21736.50	2176.30
FLUORIDE	2412.67	19341.87	21754.54	36.65	21717.89	40.91	21713.63	54.14	21700.40
IRON	1766271.57	29591.87	1795863.44	1693053.05	102810.39	1693329.70	102533.74	1693566.44	102297.00
MANGANESE	6412.54	35340.03	41752.57	37630.64	4121.93	37772.33	3980.24	37907.06	3845.51
PHOSPHORUS	19030.94	3405.46	22436.40	4760.53	17675.87	7513.52	14922.88	10131.30	12305.10
OIL & GREASE	43029.97	12909.27	55939.24	11718.62	44220.62	18317.82	37621.42	11718.62	44220.62
TSS	282602.85	17566753.32	17849356.17	16327939.38	1521416.79	16336036.38	1513319.79	16365060.92	1484295.25
TOXIC METALS	51482.96	209798.41	261281.37	231107.22	30174.15	232307.01	28974.36	233900.25	27381.12
CONVENTIONALS	325632.82	17579662.59	17905295.41	16339658.00	1565637.41	16354354.20	1550941.21	16376779.54	1528515.87
TOTAL POLLU.	2173417.14	18031367.09	20204784.23	18444903.34	1759880.89	18464771.13	1740013.10	18492536.14	1712248.09
SLUDGE GEN				107999323.55		108190718.46		108436011.70	

PARAMETER	PSES C COMBINED Removed kg/yr	 Discharged kg/yr	PSES D METAL PREPARATION Removed kg/yr	 Discharged kg/yr	PSES D COATING Removed kg/yr	 Discharged kg/yr	PSES E METAL PREPARATION Removed kg/yr	 Discharged kg/yr	PSES E COATING Removed kg/yr	 Discharged kg/yr
FLOW 1/yr (10^6)		3564.69		126.72		126.72		510.83		126.72
114 ANTIMONY	49981.18	4642.21	0.00	0.00	50090.46	4532.93	0.00	0.00	50090.46	4532.93
115 ARSENIC	3.35	974.45	0.00	0.00	876.22	101.58	0.00	0.00	876.22	101.58
117 BERYLLIUM	0.00	34.47	0.00	0.00	20.08	14.39	0.00	0.00	20.08	14.39
118 CADMIUM	5938.17	711.42	0.00	30.25	6067.33	552.01	14.41	15.84	6067.33	552.01
119 CHROMIUM	1118.74	340.95	121.56	240.12	1002.72	95.29	320.91	40.77	1002.72	95.29
120 COPPER	1471.05	3471.81	0.00	2144.12	2543.10	255.64	69.53	2074.59	2543.10	255.64
122 LEAD	31492.22	3189.08	203.72	163.45	31463.04	2851.09	263.35	103.82	31463.04	2851.09
124 NICKEL	65330.62	5277.45	44540.07	3359.15	20811.94	1896.91	45164.56	2734.66	20811.94	1896.91
125 SELENIUM	7660.74	708.52	277.40	39.50	7384.03	668.33	297.27	19.63	7384.03	668.33
128 ZINC	71633.03	7301.91	0.00	363.62	72040.17	6531.15	266.10	97.52	72040.17	6531.15
ALUMINUM	118960.22	13527.48	573.71	1428.27	119617.67	10868.05	1508.64	493.34	119617.67	10868.05
COBALT	21770.23	2142.57	6.24	165.42	21768.86	1972.28	148.17	23.49	21768.86	1972.28
FLUORIDE	56.98	21697.56	0.00	2412.67	17167.64	2174.23	3.46	2409.21	17167.64	2174.23
IRON	1693755.36	102108.08	1666652.73	99618.84	27120.44	2471.43	1667454.53	98817.04	27120.44	2471.43
MANGANESE	38001.53	3751.04	5604.13	808.41	32400.23	2939.80	6011.10	401.44	32400.23	2939.80
PHOSPHORUS	11966.63	10469.77	9007.50	10023.44	2959.12	446.34	16969.32	2061.62	2959.12	446.34
OIL & GREASE	18317.82	37621.42	7324.64	35705.33	11236.08	1673.19	36289.73	6740.24	11236.08	1673.19
TSS	16366815.27	1482540.90	257338.33	25264.52	16109476.95	1457276.37	264948.89	17653.96	16109476.95	1457276.37
TOXIC METALS	234629.10	26652.27	45142.75	6340.21	192299.09	17499.32	46396.13	5086.83	192299.09	17499.32
CONVENTIONALS	16385133.09	1520162.32	264662.97	60969.85	16120713.03	1458949.56	301238.62	24394.20	16120713.03	1458949.56
TOTAL POLLU.	18504273.14	1700511.09	1991650.03	181767.11	16534046.08	1497321.01	2039729.97	133687.17	16534046.08	1497321.01
SLUDGE GEN	108552870.35		20844279.24		88038048.77		21300072.33		88038048.77	

TABLE XII-6
SUMMARY TABLE
POLLUTANT REDUCTION BENEFITS
INDIRECT DISCHARGERS

PARAMETER	RAW WASTE			PSES O		PSES A		PSES B	
	METAL PREPARATION	COATING	COMBINED	COMBINED		COMBINED		COMBINED	
				Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
Steel Subcategory									
TOXIC METALS	49202.30	199950.72	249153.02	226071.65	23081.37	227251.71	21901.31	228789.00	20364.02
CONVENTIONALS	318057.13	16754495.19	17072552.32	15916764.13	1155788.19	15931275.77	1141276.55	15952791.32	1119761.00
TOTAL POLLU.	2161256.80	17184997.23	19346254.03	18010804.43	1335449.60	18030374.70	1315879.33	18057022.69	1289231.34
SLUDGE GEN				105675484.94		105863308.17		106099090.33	
Cast Iron Subcategory									
TOXIC METALS	0.00	973.77	973.77	957.29	16.48	957.97	15.80	960.52	13.25
CONVENTIONALS	0.00	81595.50	81595.50	80856.29	739.21	80862.89	732.61	80890.98	704.52
TOTAL POLLU.	0.00	83692.07	83692.07	82853.23	838.84	82866.54	825.53	82915.84	776.23
SLUDGE GEN				440203.05		440356.46		440889.43	
Aluminum Subcategory									
TOXIC METALS	316.97	8740.42	9057.39	4078.28	4979.11	4097.33	4960.06	4150.73	4906.66
CONVENTIONALS	6070.69	732385.42	738456.11	342037.58	396418.53	342215.54	396240.57	343097.24	395358.87
TOTAL POLLU.	8494.15	751203.87	759698.02	351245.68	408452.34	351529.89	408168.13	352597.61	407100.41
SLUDGE GEN				1883635.56		1887053.83		1896031.94	
Total Category									
TOXIC METALS	51482.96	209798.41	261281.37	231107.22	30174.15	232307.01	28974.36	233900.25	27381.12
CONVENTIONALS	325632.82	17579662.59	17905295.41	16339658.00	1565637.41	16354354.20	1550941.21	16376779.54	1528515.87
TOTAL POLLU.	2173417.14	18031367.09	20204784.23	18444903.34	1759880.89	18464771.13	1740013.10	18492536.14	1712248.09
SLUDGE GEN				107999323.55		108190718.46		108436011.70	

PARAMETER	PSES C		PSES D				PSES E			
	COMBINED		METAL PREPARATION		COATING		METAL PREPARATION		COATING	
	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged	Removed	Discharged
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr
Steel Subcategory										
TOXIC METALS	229501.42	19651.60	44939.03	4263.27	187284.42	12666.30	46165.85	3036.45	187284.42	12666.30
CONVENTIONALS	15961102.53	1111449.79	261037.86	57019.27	15700064.68	1054430.51	296803.97	21253.16	15700064.68	1054430.51
TOTAL POLLU.	18068638.63	1277615.40	1986686.70	174570.10	16102648.21	1082349.02	2033604.09	127652.71	16102648.21	1082349.02
SLUDGE GEN	106214009.71		20793365.71		85741448.42		21236648.73		85741448.42	
Cast Iron Subcategory										
TOXIC METALS	960.95	12.82	0.00	0.00	960.95	12.82	0.00	0.00	960.95	12.82
CONVENTIONALS	80894.76	700.74	0.00	0.00	80894.76	700.74	0.00	0.00	80894.76	700.74
TOTAL POLLU.	82924.07	768.00	0.00	0.00	82924.07	768.00	0.00	0.00	82924.07	768.00
SLUDGE GEN	440986.93		0.00		440986.93		0.00		440986.93	
Aluminum Subcategory										
TOXIC METALS	4166.73	4890.66	203.72	113.25	4053.72	4686.70	230.28	86.69	4053.72	4686.70
CONVENTIONALS	343135.80	395320.31	3625.11	2445.58	339753.59	392631.83	4434.65	1636.04	339753.59	392631.83
TOTAL POLLU.	352710.44	406987.58	4963.33	3530.82	348473.80	402730.07	6125.88	2368.27	348473.80	402730.07
SLUDGE GEN	1897873.71		50913.53		1855613.42		63423.60		1855613.42	
Total Category										
TOXIC METALS	234629.10	26652.27	45142.75	6340.21	192299.09	17499.32	46396.13	5086.83	192299.09	17499.32
CONVENTIONALS	16385133.09	1520162.32	264662.97	60969.85	16120713.03	1458949.56	301238.62	24394.20	16120713.03	1458949.56
TOTAL POLLU.	18504273.14	1700511.09	1991650.03	181767.11	16534046.08	1497321.01	2039729.97	133687.17	16534046.08	1497321.01
SLUDGE GEN	108552870.35		20844279.24		88038048.77		21300072.33		88038048.77	

TABLE XII-7

PRETREATMENT STANDARDS FOR EXISTING SOURCES
(mg/l)

	Maximum for Any One Day	Maximum for Monthly Average
Antimony	0.21	0.09
Arsenic	2.09	0.86
Cadmium	0.32	0.15
Chromium*	0.42	0.17
Copper	1.90	1.00
Lead*	0.15	0.13
Nickel*	1.41	1.00
Selenium	0.04	0.02
Zinc*	1.33	0.56
Aluminum	4.55	1.86
Cobalt	0.29	0.12
Fluoride	58.2	23.8
Iron	1.23	0.63
Manganese	0.43	0.34

*These pollutants are regulated at promulgation.

TABLE XII - 8
STEEL SUBCATEGORY
PRETREATMENT STANDARDS FOR EXISTING SOURCES

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
	Metric Units - mg/m^2 of area processed or coated			
ANTIMONY	8.409	0.134	3.604	0.057
ARSENIC	83.688	1.329	34.436	0.547
CADMIUM	12.813	0.204	6.006	0.095
*CHROMIUM	16.818	0.267	6.807	0.108
COPPER	76.080	1.208	40.042	0.636
*LEAD	6.006	0.095	5.205	0.083
*NICKEL	56.459	0.897	40.042	0.636
SELENIUM	1.602	0.025	0.801	0.013
*ZINC	53.256	0.846	22.424	0.356
ALUMINUM	182.191	2.894	74.478	1.183
COBALT	11.612	0.184	4.805	0.076
FLUORIDE	2330.444	37.015	953.000	15.137
IRON	49.252	0.782	25.226	0.401
MANGANESE	17.218	0.273	13.614	0.216
	English Units - lb/1,000,000 ft^2 of area processed or coated			
ANTIMONY	1.722	0.027	0.738	0.012
ARSENIC	17.141	0.272	7.053	0.112
CADMIUM	2.624	0.042	1.230	0.019
*CHROMIUM	3.445	0.055	1.394	0.022
COPPER	15.582	0.247	8.201	0.130
*LEAD	1.230	0.019	1.066	0.017
*NICKEL	11.564	0.184	8.201	0.130
SELENIUM	0.328	0.005	0.164	0.003
*ZINC	10.908	0.173	4.593	0.073
ALUMINUM	37.316	0.593	15.254	0.242
COBALT	2.378	0.038	0.984	0.016
FLUORIDE	477.313	7.581	195.190	3.100
IRON	10.088	0.160	5.167	0.082
MANGANESE	3.527	0.056	2.788	0.044

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII - 9
CAST IRON SUBCATEGORY
PRETREATMENT STANDARDS FOR EXISTING SOURCES

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2 (lb/1,000,000 ft^2) of area coated			
ANTIMONY	0.134	(0.027)	0.057	(0.012)
ARSENIC	1.329	(0.272)	0.547	(0.112)
CADMIUM	0.204	(0.042)	0.095	(0.019)
*CHROMIUM	0.267	(0.055)	0.108	(0.022)
COPPER	1.208	(0.247)	0.636	(0.130)
*LEAD	0.095	(0.019)	0.083	(0.017)
*NICKEL	0.897	(0.184)	0.636	(0.130)
SELENIUM	0.025	(0.005)	0.013	(0.003)
*ZINC	0.846	(0.173)	0.356	(0.073)
ALUMINUM	2.894	(0.593)	1.183	(0.242)
COBALT	0.184	(0.038)	0.076	(0.016)
FLUORIDE	37.015	(7.581)	15.137	(3.100)
IRON	0.782	(0.160)	0.401	(0.082)
MANGANESE	0.273	(0.056)	0.216	(0.044)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII - 10
ALUMINUM SUBCATEGORY
PRETREATMENT STANDARDS FOR EXISTING SOURCES

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
Metric Units - mg/m^2 of area processed or coated				
ANTIMONY	8.168	0.134	3.501	0.057
ARSENIC	81.293	1.329	33.451	0.547
CADMIUM	12.447	0.204	5.834	0.095
*CHROMIUM	16.336	0.267	6.612	0.108
COPPER	73.902	1.208	38.896	0.636
CYANIDE	11.280	0.184	4.668	0.076
*LEAD	5.834	0.095	5.056	0.083
*NICKEL	54.843	0.897	38.896	0.636
SELENIUM	1.556	0.025	0.778	0.013
*ZINC	51.732	0.846	21.782	0.356
ALUMINUM	176.977	2.894	72.347	1.183
COBALT	11.280	0.184	4.668	0.076
FLUORIDE	2263.747	37.015	925.725	15.137
IRON	47.842	0.782	24.504	0.401
MANGANESE	16.725	0.273	13.225	0.216
English Units - lb/1,000,000 ft^2 of area processed or coated				
ANTIMONY	1.673	0.027	0.717	0.012
ARSENIC	16.650	0.272	6.851	0.112
CADMIUM	2.549	0.042	1.195	0.019
*CHROMIUM	3.346	0.055	1.354	0.022
COPPER	15.136	0.247	7.967	0.130
CYANIDE	2.310	0.038	0.956	0.016
*LEAD	1.195	0.019	1.036	0.017
*NICKEL	11.233	0.184	7.967	0.130
SELENIUM	0.319	0.005	0.159	0.003
*ZINC	10.596	0.173	4.461	0.073
ALUMINUM	36.248	0.593	14.818	0.242
COBALT	2.310	0.038	0.956	0.016
FLUORIDE	463.652	7.581	189.603	3.100
IRON	9.799	0.160	5.019	0.082
MANGANESE	3.426	0.056	2.709	0.044

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII - 11
STEEL SUBCATEGORY
PRETREATMENT STANDARDS FOR NEW SOURCES

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
Metric Units - mg/m^2 of area processed or coated				
ANTIMONY	0.500	0.089	0.214	0.038
ARSENIC	4.969	0.884	2.038	0.363
CADMIUM	0.715	0.127	0.286	0.051
*CHROMIUM	1.323	0.235	0.536	0.095
COPPER	4.576	0.814	2.181	0.388
*LEAD	0.358	0.064	0.322	0.057
*NICKEL	1.966	0.350	1.323	0.235
SELENIUM	0.107	0.019	0.036	0.006
*ZINC	3.647	0.649	1.502	0.267
ALUMINUM	10.832	1.927	4.433	0.789
COBALT	0.751	0.134	0.322	0.057
FLUORIDE	138.710	24.677	56.485	10.049
IRON	4.397	0.782	2.252	0.401
MANGANESE	1.073	0.191	0.822	0.146
English Units - lb/1,000,000 ft^2 of area processed or coated				
ANTIMONY	0.102	0.018	0.044	0.008
ARSENIC	1.018	0.181	0.417	0.074
CADMIUM	0.146	0.026	0.059	0.010
*CHROMIUM	0.271	0.048	0.110	0.019
COPPER	0.937	0.167	0.447	0.079
*LEAD	0.073	0.013	0.066	0.012
*NICKEL	0.403	0.072	0.271	0.048
SELENIUM	0.022	0.004	0.007	0.001
*ZINC	0.747	0.133	0.308	0.055
ALUMINUM	2.219	0.395	0.908	0.162
COBALT	0.154	0.027	0.066	0.012
FLUORIDE	28.410	5.054	11.569	2.058
IRON	0.901	0.160	0.461	0.082
MANGANESE	0.220	0.039	0.168	0.030

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII - 12
CAST IRON SUBCATEGORY
PRETREATMENT STANDARDS FOR NEW SOURCES

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	mg/m^2 ($lb/1,000,000\ ft^2$) of area coated			
ANTIMONY	0.089	(0.018)	0.038	(0.008)
ARSENIC	0.884	(0.181)	0.363	(0.074)
CADMIUM	0.127	(0.026)	0.051	(0.010)
*CHROMIUM	0.235	(0.048)	0.095	(0.019)
COPPER	0.814	(0.167)	0.388	(0.079)
*LEAD	0.064	(0.013)	0.057	(0.012)
*NICKEL	0.350	(0.072)	0.235	(0.048)
SELENIUM	0.019	(0.004)	0.006	(0.001)
*ZINC	0.649	(0.133)	0.267	(0.055)
ALUMINUM	1.927	(0.395)	0.789	(0.162)
COBALT	0.134	(0.027)	0.057	(0.012)
FLUORIDE	24.677	(5.054)	10.049	(2.058)
IRON	0.782	(0.160)	0.401	(0.082)
MANGANESE	0.191	(0.039)	0.146	(0.030)

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII - 13
ALUMINUM SUBCATEGORY
PRETREATMENT STANDARDS FOR NEW SOURCES

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
Metric Units - mg/m^2 of area processed or coated				
ANTIMONY	0.486	0.089	0.208	0.038
ARSENIC	4.827	0.884	1.980	0.363
CADMIUM	0.695	0.127	0.278	0.051
*CHROMIUM	1.285	0.235	0.521	0.095
COPPER	4.445	0.814	2.119	0.388
CYANIDE	0.695	0.127	0.278	0.051
*LEAD	0.347	0.064	0.313	0.057
*NICKEL	1.910	0.350	1.285	0.235
SELENIUM	0.104	0.019	0.035	0.006
*ZINC	3.542	0.649	1.459	0.267
ALUMINUM	10.523	1.927	4.307	0.789
COBALT	0.729	0.134	0.313	0.057
FLUORIDE	134.752	24.677	54.873	10.049
IRON	4.272	0.782	2.188	0.401
MANGANESE	1.042	0.191	0.799	0.146
English Units - $lb/1,000,000\ ft^2$ of area processed or coated				
ANTIMONY	0.100	0.018	0.043	0.008
ARSENIC	0.989	0.181	0.406	0.074
CADMIUM	0.142	0.026	0.057	0.010
*CHROMIUM	0.263	0.048	0.107	0.019
COPPER	0.910	0.167	0.434	0.079
CYANIDE	0.142	0.026	0.057	0.010
*LEAD	0.071	0.013	0.064	0.012
*NICKEL	0.391	0.072	0.263	0.048
SELENIUM	0.021	0.004	0.007	0.001
*ZINC	0.725	0.133	0.299	0.055
ALUMINUM	2.155	0.395	0.882	0.162
COBALT	0.149	0.027	0.064	0.012
FLUORIDE	27.599	5.054	11.239	2.058
IRON	0.875	0.160	0.448	0.082
MANGANESE	0.213	0.039	0.164	0.030

* THIS POLLUTANT IS REGULATED AT PROMULGATION

TABLE XII - 14
COPPER SUBCATEGORY
PRETREATMENT STANDARDS FOR NEW SOURCES

POLLUTANT OR POLLUTANT PROPERTY	MAXIMUM FOR ANY ONE DAY		MAXIMUM FOR MONTHLY AVERAGE	
	Metal Preparation	Coating Operations	Metal Preparation	Coating Operations
Metric Units - mg/m^2 of area processed or coated				
ANTIMONY	0.841	0.089	0.361	0.038
ARSENIC	8.354	0.884	3.426	0.363
CADMIUM	1.202	0.127	0.481	0.051
*CHROMIUM	2.224	0.235	0.901	0.095
COPPER	7.693	0.814	3.666	0.388
*LEAD	0.601	0.064	0.541	0.057
*NICKEL	3.306	0.350	2.224	0.235
SELENIUM	0.180	0.019	0.060	0.006
*ZINC	6.130	0.649	2.524	0.267
ALUMINUM	18.210	1.927	7.452	0.789
COBALT	1.262	0.134	0.541	0.057
FLUORIDE	233.188	24.677	94.958	10.049
IRON	7.392	0.782	3.786	0.401
MANGANESE	1.803	0.191	1.382	0.146
English Units - lb/1,000,000 ft^2 of area processed or coated				
ANTIMONY	0.172	0.018	0.074	0.008
ARSENIC	1.711	0.181	0.702	0.074
CADMIUM	0.246	0.026	0.099	0.010
*CHROMIUM	0.456	0.048	0.185	0.019
COPPER	1.576	0.167	0.751	0.079
*LEAD	0.123	0.013	0.111	0.012
*NICKEL	0.677	0.072	0.456	0.048
SELENIUM	0.037	0.004	0.012	0.001
*ZINC	1.256	0.133	0.517	0.055
ALUMINUM	3.730	0.395	1.526	0.162
COBALT	0.258	0.027	0.111	0.012
FLUORIDE	47.761	5.054	19.449	2.058
IRON	1.514	0.160	0.775	0.082
MANGANESE	0.369	0.039	0.283	0.030

* THIS POLLUTANT IS REGULATED AT PROMULGATION

SECTION XIII

BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY

INTRODUCTION

The 1977 Amendments added Section 301(b)(2)(E) to the Act establishing "best conventional pollutant control technology" [BCT] for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are those defined in Section 304(a)(4) [biological oxygen demanding pollutants (BOD%), total suspended solids (TSS), fecal coliform, and pH], and any additional pollutants defined by the Administrator as "conventional" [oil and grease, 44 FR 44501, July 30, 1979].

BCT is not an additional limitation but replaces BAT for the control of conventional pollutants. In addition to other factors specified in section 304(b)(4)(B), the Act requires that BCT limitations be assessed in light of a two part "cost-reasonableness" test. American Paper Institute v. EPA, 660 F.2d 954 (4th Cir. 1981). The first test compares the cost for private industry to reduce its conventional pollutants with the costs to publicly owned treatment works for similar levels of reduction in their discharge of these pollutants. The second test examines the cost-effectiveness of additional industrial treatment beyond BPT. EPA must find that limitation are "reasonable" under both tests before establishing them as BCT. In no case may BCT be less stringent than BPT.

EPA published its methodology for carrying out the BCT analysis on August 29, 1979 (44 FR 50732). In the case mentioned above, the Court of Appeals ordered EPA to correct data errors underlying EPA's calculation of the first test, and to apply the second cost test. (EPA had argued that a second cost test was not required.)

EPA has determined that the BAT technology is capable of removing significant amounts of conventional pollutants. However, EPA has not yet proposed or promulgated a revised BCT methodology in response to the American Paper Institute v. EPA decision mentioned earlier. Thus, it is not now possible to apply the BCT cost test to this technology option. Accordingly, EPA is defferring a decision on the appropriate BCT limitations until EPA finalizes the revised BCT methodology.

SECTION XIV

ACKNOWLEDGEMENTS

This document has been prepared by the staff of the Effluent Guidelines Division with assistance from technical contractors, other EPA Offices and other persons outside of EPA. This Section is intended to acknowledge the contribution of the several persons who have contributed to the development of this report.

The collection and organization of information for use in this report were performed by Hamilton Standard, Division of United Technologies Corporation under Contract No. 68-01-5827. Some sections of this report are edited versions of the proposed development document and supplemental information prepared by Hamilton Standard. Hamilton Standard's effort was managed by Daniel J. Lizdas and Robert Blaser and included significant contributions by Messer. Paul Barnett, Peter Formica, Remy Helm, Richard Kearns, Jack Nash, Ms Vivian Sandland, Ms Gail Kitchin, John Vounats, Mark Hellstein, Armand Ruby, Robert Patulak, Don Smith, Jeffrey Wehner, Peter Wilk, and Peter Williams.

Ellen Seigler of the Office of General Counsel provided legal advise to the project. Debra Maness was economic project officer for the project. Henry Kahn provided statistical analysis and assistance for the project. Alexandra Tarnay provided environmental evaluations and word processing was provided by Pearl Smith, Carol Swann and Glenda Nesby.

Technical direction and supervision of the project have been provided by Ernst Hall. Technical project officers are Ben Honaker, Catherine Campbell, James Berlow and John Whitescarver and Robert Hardy performed specific technical assignments. (Where more than one EPA employee is listed for a specific function the most recent is listed first).

In preparation of this final document, the Agency has been assisted by Versar Inc., under contract 68-01-6469. Under specific direction from Agency personnel, Versar rechecked calculations and tabulations, made technical and editorial revisions to specific parts of sections and prepared camera ready copy of tables and figures. Versars effort was managed by Lee McCandless, Jerome Strauss and Jean Moore with contributions from John Maier, Martin Bondy, Nathan Graves and John Whitescarver, Robert Hardy and Jon Clarke of Whitescarver Associates (a subcontractor on this contract). Manuscript preparation was performed by Nan Dewey, Lucy Gentry and Sally Gravely of Versar Inc.

SECTION XV

REFERENCES

1. "The Surface Treatment and Finishing of Aluminum and Its Alloys" by S. Werrick, PhD, Metal Finishing Abstracts, Third Edition, Robert Draper Ltd., Teddington, 1964.

2. Guidebook & Directory, Metal Finishing, 1974, 1975, 1977 and 1978. American Metals and Plastics Publications Inc., One University Plaza Hackensack, New Jersey 90601.

3. The Science of Surface Coatings, edited by Dr. H. W. Chatfield, 1962.

4. Metals Handbook, Volume 2 8th Edition, American Society for Metals, Metals Park, Ohio.

5. Journal of Metal Finishing: "Pretreatment for Water-Borne Coatings" - April, 1977
"Guidelines for Wastewater Treatment" - September, 1977
"Guidelines for Wastewater Treatment" - October, 1977
"Technical Developments in 1977 for Organic (Paint) Coatings, Processes and Equipment" - February, 1978
"Technical Developments in 1977, Inorganic (Metallic) Finishes, Processes and Equipment" - February, 1978
"The Organic Corner" by Joseph Mazia, - April, 1978
"The Organic Corner" by Joseph Mazia, - May, 1978
"The Economical Use of Pretreatment Solutions" - May, 1978
"The Organic Corner" by Joseph Mazia, - June, 1978
"Selection of a Paint Pretreatment System, Part I" - June, 1978 "The Organic Corner," by Joseph Mazia - September, 1978

6. How Do Phosphate Coatings Reduce Wear on Movings Parts, W. R. Cavanagh.

7. Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition, 1963, Interscience Publishers, New York

8. Encyclopedia of Polymer Science and Technology, Second Edition, 1963, Interscience Publishers, New York

9. Handbook of Environmental Data on Organic Chemicals, Verschueren, Karel, Van Nostrand Reinhold Co., New York 1977

10. Handbook of Chemistry, Lange, Norbert, Adolph, McGraw Hill, New York 1973

11. Dangerous Properties of Industrial Materials, Sax N. Irving, Van Nostrand Reinhold Co. New York

12. Environmental Control in the Organic and Petrochemical Industries, Jones, H. R, Noyes Data Corp. 1971

13. Hazardous Chemicals Handling and Disposal, Howes, Robert and Kent, Robert, Noyes Data Corp., Park Ridge, New Jersey 1970

14. Industrial Pollution, Sax, N. Irving, Van Nostrand Reinhold Co., New York 1974

15. "Treatability of 65 Chemicals - Part A - Biochemical Oxidation of Organic Compounds", June 24, 1977, Memorandum, Murray P. Strier to Robert B. Schaffer

16. "Treatability of Chemicals - Part B - Adsorption of Organic Compounds on Activated Carbon," December 8, 1977, Memorandum, Murray P. Strier to Robert B. Schaffer

17. "Treatability of the Organic Priority Pollutants - Part C - Their Estimated (30 day avg) Treated Effluents Concentration - A Molecular Engineering Approach", June 1978, Memorandum, Murray P. Strier to Robert B. Schaffer

18. Water Quality Criteria Second Edition, edited by Jack Edward McKee and Harold W. Wolf, 1963 The Resources Agency of California, State Water Quality Control Board, Publication No. 3-A

19. The Condensed Chemical Dictionary, Ninth Edition, Revised by Gessner G. Hawley, 1977

20. Wastewater Treatment Technology, James W. Patterson

21. Unit Operations for Treatment of Hazardous Industrial Wastes, Edited by D. J. Denyo, 1978

22. "Development Document For Proposed Existing Source Pretreatment Standards For The Electroplating Point Source Category", February 1978, EPA440/1-78/085

23. "Industrial Waste and Pretreatment in the Buffalo Municipal System", EPA contract #R803005, Oklahoma, 1977

24. "Pretreatment of Industrial Wastes", Seminar Handout, U.S. EPA, 1978

25. "Sources of Metals in Municipal Sludge and Industrial Pretreatment as a Control Option", ORD Task Force on Assessment of Sources of Metals in Sludges and Pretreatment as a Control Option, U.S., EPA 1977

26. "Effects of Copper on Aerobic Biological Sewage Treatment", Water Pollution Control Federation Journal, February 1963 p 227-241

27. Wastewater Engineering, 2nd edition, Metcalf and Eddy

28. Chemical Technology, L.W. Codd, et. al., Barnes and Noble, New York, 1972

29. "Factors Influencing the Condensation of 4-aminoantipyrene with derivatives of Hydroxybenzene - II. Influence of Hydronium Ion Concentration on Absorbtivity," Samuel D. Faust and Edward W. Mikulewicz, Water Research, 1967, Pergannon Press, Great Britain

30. "Factors Influencing the Condensation of 4-aminoantipyrene with derivatives of Hydroxylbenzene - I. a Critique," Samuel D. Faust and Edward W. Mikulewicz, Water Research, 1967, Pergannon Press, Great Britain 30. Scott, Murray C., "Sulfex™ - A New Process Technology for Removal of Heavy Metals from Waste Streams, " presented at 1977 Purdue Industrial Waste Conference, May 10, 11, and 12, 1977.

31. "Sulfex™ Heavy Metals Waste Treatment Process," Technical Bulletin, Vol. XII, code 4413-2002 (Permutit®) July, 1977.

32. Scott, Murray C., "Treatment of Plating Effluent by Sulfide Process," Products Finishing, August, 1978.

33. Lonouette, Kenneth H., "Heavy Metals Removal," Chemical Engineering, October 17, pp. 73-80.

34. Curry, Nolan A., "Philogophy and Methodology of Metallic Waste Treatment," 27th Industrial Waste Conference.

35. Patterson, James W., Allen, Herbert E. and Scala, John J., "Carbonate Precipitation for Heavy Metals Pollutants," Journal of Water Pollution Control Federation, December, 1977 pp. 2397-2410.

36. Bellack, Ervin, "Arsenic Removal from Potable Water," Journal American Water Works Association, July, 1971.

37. Robinson, A. K. "Sulfide -vs- Hydroxide Precipitation of Heavy Metals from Industrial Wastewater," Presented at EPA/AES First Annual conference on Advanced Pollution Control for the Metal Finishing Industry, January 17-19, 1978.

38. Sorg, Thomas J., "Treatment Technology to meet the Interim Primary Drinking Water regulations for Inorganics," Journal American Water Works Association, February, 1978, pp. 105-112.

39. Strier, Murray P., "Suggestions for Setting Pretreatment Limits for Heavy Metals and Further Studies of POTW's memorandum to Carl J. Schafer, Office of Quality Review, U.S. E.P.A., April 21, 1977.

40. Rohrer, Kenneth L., "Chemical Precipitants for Lead Bearing Wastewaters," Industrial Water Engineering, June/July, 1975.

41. Jenkins, S. H., Keight, D.G. and Humphreys, R.E., "The Solubilities of Heavy Metal Hydroxides in Water, Sewage and Sewage Sludge-I. The Solubilities of Some Metal Hydroxides," International Journal of Air and Water Pollution, Vol. 8, 1964,pp. 537-556.

42. Bhattacharyya, O., Jumawan, Jr., A.B., and Grieves, R.B., "Separation of Toxic Heavy Metals by Sulfide Precipitation," Separation Science and Technology, 14(5), 1979, pp. 441-452.

43. Patterson, James W., "Carbonate Precipitation Treatment for Cadmium and Lead," presented at WWEMA Industrial Pollutant conference, April 13, 1978.

44.. "An Investigation of Techniques for Removal of Cyanide from Electroplating Wastes," Battelle Columbus Laboratories, Industrial Pollution Control Section, November, 1971.

45. Patterson, James W. and Minear, Roger A., "Wastewater Treatment Technology," 2nd edition (State of Illinois, Institute for Environmental Quality) January, 1973.

46. Chamberlin, N.S. and Snyder, Jr., H.B., "Technology of Treating Plating Waste," 10th Industrial Waste Conference.

47. Hayes, Thomas D. and Theis, Thomas L., "The Distribution of Heavy Metals in Anacrobic Digestion," Journal of Water Pollution Control Federation, January, 1978. pp. 61-72.

48. Chen, K.Y., Young, C.S., Jan, T.K. and Rohatgi, N., "Trace Metals in Wastewater Effluent," Journal of Water Pollution Control Federation, Vol. 46, No. 12, December, 1974, pp. 2663-2675.

49. Neufeld, Ronald D., Gutierrez, Jorge and Novak, Richard A., A Kinetic Model and Equilibrium Relationship for Metal Accumulation," Journal of Water Pollution Control Federation, March, 1977, pp. 489-498.

50. Stover, R.C., Sommers, L.E. and Silviera, D.J., "Evaluation of Metals in Wastewater Sludge," Journal of Water Pollution Control Federation, Vol. 48, No. 9, September, 1976, pp. 2165-2175.

51. Neufeld, Howard D. and Hermann, Edward R., "Heavy Metal Removal by Activated Sludge," Journal of Water Pollution Control Federation, Vol. 47, No. 2, February, 1975, pp. 310-329.

52. Schroder, Henry A. and Mitchener, Marian, "Toxic Effects of Trace Elements on the Reproduction of Mice and Rats," Archieves of Environmental Health, Vol. 23, August, 1971, pp. 102-106.

53. Venugopal, B. and Luckey, T.D., "Metal Toxicity in Mannals .2," (Plenum Press, New York, N.Y.), 1978.

54. Polson, C.J. and Tattergall, R.N., "Clinical Toxicology," (J.B. Lipincott Company), 1976.

55. Hall, Ernst P. and Barnes, Deveraeaux, "Treatment of Electroplating Rinse Waters and Effluent Solutions," presented to the American Institute of Chemical Engineers, Miami Beach, Fl., November 12, 1978.

56. Mytelka, Alan I., Czachor, Joseph S., Guggino, William B. and Golub, Howard, "Heavy Metals in Wastewater and Treatment Plant Effluents," Journal of Water Pollution control Federation, Vol. 45, No. 9, September, 1973, pp. 1859-1884.

57. Davis, III, James A., and Jacknow, Joel, "Heavy Metals in Wastewater in Three Urban Areas, "Journal of Water Pollution Control Federation, September, 1975, pp. 2292-2297.

58. Klein, Larry A., Lang, Martin, Nash, Norman and Kirschner, Seymour L., "Sources of Metals in New York City Wastewater," Journal of Water Pollution Control Federation, Vol. 46, No. 12, December, 1974, pp. 2653-2662.

59. Brown, H.G., Hensley, C.P., McKinney, G.L. and Robinson, J.L., "Efficiency of Heavy Metals Removal in Municipal Sewage Treatment Plants," Environmental Letters, 5 (2), 1973, pp. 103-114.

60. Ghosh, Mriganka M. and Zugger, Paul D., "Toxic Effects of Mercury on the Activated Sludge Process," Journal of Water Pollution Control Federation, Vol. 45, No. 3, March, 1973, pp. 424-433.

61. Mowat, Anne, "Measurement of Metal Toxicity by Biochemical Oxygen Demand," Journal of Water Pollution Control Federation, Vol. 48, No. 5, May, 1976, pp. 853-866.

62. Oliver, Barry G. and Cosgrove, Ernest G., "The Efficiency of Heavy Metal Removal by a Conventional Activated Sludge Treatment Plant," Water Re-search, Vol. 8, 1074, pp. 869-874. 63. Porcelain Enamels, Second Edition, 1961, by Andrew I. Andrews, PhD, The Garrard Press.

63. Porcelain Enamels, Second Edition, 1961, by Andrew I. Andrews, Ph. D., The Garrard Press.

64. Ambient Water Quality Criteria for Antimony, PB-117319, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

65. Ambinet Water Quality Criteria for Arsenic, PB-117327, Criteria and Standards Division, Office of WAter Regulations and Standards (45 FR 79318-79379, November 28, 1980).

66. Ambient Water Quality Criteria for Beryllium, PB-117814, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

67 Ambient Water Quality Criteria for Cadmium, PB117368, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 78318-79379, November 28, 1980).

68. Ambient Water Quality Criteria for Chlorinated Ethanes, PB117400, and Standards (45 FR 79318-79379, November 28, 1980).

69. Ambient Water Quality Criteria for Chromium, PB117467, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

70. Ambient WAter Quality Criteria for Copper, PB117475, Criteria and Standards Division Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

71. Ambient Water Quality Criteria for Lead, PB117681, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

72. Ambient Water Quality Criteria for Nickel, PB117715, Criteria and Standards Division, Office of WAter Regulations and Standards (45 FR 79318-79379, November 28, 1980).

73. Ambient Water Quality Criteria for Chlorinated Ethanes, PB117400, and Standards (45 FR 79318-79379, November 28, 1980).

74. Ambient Water Quality Criteria for Selenium, PB-117814, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

75. Ambient Water Quality Criteria for Toluene, PB117855, Criteria and Standards Division, office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

76. Ambient Water Quality Criteria for Trichloroethylene, PB117871, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

77. Ambient Water Quality Criteria for Zinc, PB117897, Criteria and Standards Division, Office of Water Regulations and Standards (45 FR 79318-79379, November 28, 1980).

SECTION XVI

GLOSSARY

Abrasive Blasting - Cleaning process utilizing a mixture of grit and air forced under pressure against a surface, prior to enameling.

Accumulation - In reference to biological systems, the concentration of a substance which collects in a tissue or organism and which does not disappear over time.

Acidity - The quantitative capacity of aqueous solutions to react with hydroxyl ions. It is measured by titration with a standard solution of a base to a specified end point. Usually expressed as milligrams per liter of calcium carbonate.

Act - The Federal Water Pollution Control Act (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-217).

Adsorption - The adhesion of an extremely thin layer of molecules of a gas or liquid to the surfaces of solids (e.g., granular activated carbon) or liquids.

Algicide - Chemicals used in bodies of water for the control of phytoplankton (algae).

Alkaline Cleaning - A process for cleaning basis materials in which mineral deposits, animal fats and oils are removed from the surface. Solutions at high temperatures containing caustic soda ash, alkaline silicates, alkaline phosphates and ionic and nonionic detergents are commonly used.

Alkalinity - The capacity of water to neutralize acids, a property imparted by the water's content of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. It is expressed in milligrams per liter of equivalent calcium carbonate.

Annealing - Heating operation following the shaping of metal parts to normalize the crystalline structure. Annealing may also moderately burn off surface oil to prepare the surface for porcelain enameling.

Backwashing - The process of cleaning a filter or ion exchange column by reversing the flow of water.

Baffles - Deflector vanes, guides, grids, grating, or similar devices constructed or placed in flowing water or sewage to (1) check or effect a more uniform distribution of velocities; (2) absorb energy; (3) divert, guide, or agitate the liquids; and (4) check eddy currents.

Baking - A heating/drying process carried out in an enclosure where the temperature is maintained in excess of 150°C.

Ball Milling - Process for grinding enamels utilizing vitreous china balls in a rotating cylindrical mill.

Basis Material or Metal - That substance of which the workpieces are made and that receives the coating and the treatments in preparation for coating.

BAT - Best Available Technology Economically Achievable under The Clean Water Act, Section 304(b)(2)(B).

BCT - Best Conventional Pollutant Control Technology under the Clean Water Act, Section 304(b)(4) of the Act.

BDT - Best demonstrated control technology processes, operating methods, or other alternatives, including where practicable, a standard permitting no discharge of pollutants under Section 306(a)(1) of the Act.

Bentonites - Highly colloidal clay materials that are added to enamel slips to improve their susceptibility to the action of electrolytes.

Biochemical Oxygen Demand (BOD) - (1) The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions. (2) Standard test used in assessing wastewater strength.

Biodegradable - The part of organic matter that can be oxidized by bioprocesses; e.g., biodegradable detergents, food wastes, animal manure, etc.

Biological Wastewater Treatment - Forms of wastewater treatment in which bacterial or biochemical action is intensified to stabilize, oxidize, and nitrify the unstable organic matter present.

BPT - Best Practicable Control Technology Currently Available.

Buffer - Any of certain combinations of chemicals used to stabilize the pH values or alkalinities of solutions.

Cake, Sludge - The material resulting from air drying or dewatering sludge (usually forkable or spadable).

Calibration - The determination, checking, or correction of the graduation of any instrument giving quantitative measurements.

Captive Operation - A manufacturing operation carried out in a facility to support other manufacturing, fabrication, or assembly operations.

Carcinogenic - Referring to the ability of a substance to cause cancer.

Central Treatment Facility - Treatment plant which co-treats process wastewaters from more than one manufacturing operation or co-treats process wastewaters with noncontact cooling water, or with nonprocess wastewaters (e.g., utility blowdown, miscellaneous runoff, etc).

Centrifugation - The removal of water from a sludge and water slurry by introducing the water and sludge slurry into a centrifuge. The sludge is driven outward with the water remaining near the center.

Charge - The dry components of slip which are loaded into a ball mill for grinding.

Chemical Coagulation - The destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical.

Chemical Oxygen Demand (COD) - (1) A test based on the principle that all organic compounds, with few exceptions, can be oxidized to carbon dioxide and water by the action of strong oxidizing agents under acid conditions. Organic matter is converted to carbon dioxide and water regardless of the biological assimilability of the substances. One of the chief limitations of this test is its inability to differentiate between biologically oxidizable and biologically inert organic matter. The major advantage of this test is the short time required for evaluation (2 hrs). (2) The amount of oxygen required for the chemical oxidization of organics in a liquid.

Chemical Oxidation (Including Cyanide) - The addition of chemical agents to wastewater for the purpose of oxidizing pollutant material.

Chemical Precipitation - (1) Precipitation induced by addition of chemicals. (2) The process of softening water by the addition of lime and soda ash as the precipitants.

Chlorination - The application of chlorine to water or wastewater generally for the purpose of disinfection, but frequently for accomplishing other biological or chemical results.

Chromate Conversion Coating - A process whereby a metal is either sprayed with or immersed in an aqueous acidified chromate solution consisting mostly of chromic acid and water soluble salts of chromic acid together with various catalysts or activators (such as cyanide).

Clarifier - A unit which provides for removing undissolved materials from a liquid, specifically by sedimentation.

Clean Water Act - The Federal Water Pollution Control Act Amendments of 1972 (33 U.S.C. 1251 et seq.), as amended by the Clean Water Act of 1977 (Public Law 95-217)

Colloids - A finely divided dispersion of one material called the "dispersed phase" in another material which is called the "dispersion medium". Colloids are not separated by gravity, thus a solid in liquid colloid cannot be separated by sedimentation.

Compatible Pollutant - A specific substance in a waste stream which alone can create a potential pollution problem, yet is used to the advantage of a certain treatment process when combined with other wastes.

Composite Wastewater Sample - A combination of individual samples of water or wastewater taken at selected intervals and mixed in proportion to flow or time to minimize the effect of the variability of an individual sample.

Concentration Factor - Refers to the biological concentration factor which is the ratio of the concentration within the tissue or organism to the concentration outside the tissue or organism.

Concentration, Hydrogen Ion - The weight of hydrogen ions in grams per liter of solution. Commonly expressed as the pH value that equals the logarithm of the reciprocal of the hydrogen ion concentration.

Contamination - A general term signifiying the introduction into water of microorganisms, chemicals, wastes or sewage which render the water unfit for its intended use.

Contractor Removal - The disposal of oils, spent solutions, or sludge by means of a scavenger service.

Conversion Coating - A chemical treatment or electrochemical modification of the metal surface so that the coating formed is an integral part of the parent metal.

Cooling Tower - A device used to cool water used in manufacturing processes before returning the water for reuse.

Cover Coat - The final coat of porcelain enamel.

Degreasing - The process of removing greases and oils from the surface of the base material.

Dewatering - A process whereby water is removed from sludge.

Dip Coating - Method of enamel application in which a part is submerged in a tank of enamel slip, withdrawn, and drained or centrifuged to remove excess slip.

Dissolved Solids - Theoretically the anhydrous residues of the dissolved constituents in water. Actually the term is defined by the method used in determination. In water and wastewater treatment, the Standard Methods tests are used.

Dragout - The solution that adheres to the part or workpiece and is carried past the edge of the tank.

Drawing Compound - Oils, waxes, or greases added to facilitate stamping and forming of metal.

Drying Beds - Areas for dewatering of sludge by evaporation and seepage.

Dump - The intermittent discharge of process wastes for purposes of replenishment of chemicals or maintenance.

Effluent - The quantities, rates, and chemical, physical, biological, and other constituents of waters which are discharged from point sources.

Emergency Procedures - The various special procedures necessary to protect the environment from wastewater treatment plant failures caused by power outages, chemical spills, equipment failures, major storms, floods, etc.

Emulsion Breaking - Decreasing the stability of dispersion of one liquid in another.

Enamel - Combination of frit, inorganic pigments, clays and other ingredients which are blended, in a ball mill, applied to ware surface, and fused at high temperatures to produce a glass-like coating.

Enameling Iron - Type of steel made especially for application of porcelain enamel coatings.

End-of-Pipe Treatment - The reduction and/or removal of pollutants from wastewaters by treatment just prior to actual discharge. from wastewater

Equalization - The process whereby waste streams from different sources varying in pH, chemical constituents, and flow rates are collected in a common container for metering into the waste treatment system. The effluent stream from this equalization tank will have a fairly constant flow and pH level, and will contain a homogenous chemical mixture which prevents an unnecessary shock to the waste treatment system.

Feeder, Chemical, Dry - A mechanical device for applying dry chemicals to water and sewage at a rate controlled manually or automatically by the rate of flow.

Feeder, Chemical, Solution - A mechanical device for applying chemicals in liquid to water and sewage at a rate controlled manually or automatically by the rate of flow.

Filter - A barrier through which solid particles cannot pass, used for the separation of undissolved solids from a liquid.

Filter, Intermittent - A natural or artificial bed of sand or other granular medium to which sewage is added in intermittent flooding doses. As the sewage passes through the bed, solids are retained in the bed.

Filter, Rapid Sand - A filter for the purification of water which has been previously treated (usually by coagulation and sedimentation). Wastewater passes through a filtering medium consisting of a layer of sand or prepared anthracite coal or other suitable material, usually from 24 to 30 inches thick and resting on a supporting bed of gravel or a porous medium such as carborundum. The filtrate is removed by a drain system. The filter is cleaned periodically by reversing the flow of the water through the filtering medium. Sometimes supplemented by mechanical or air agitation during backwashing to remove mud and other solids that are lodged in the sand.

Filter, Trickling - A filter consisting of an artificial bed of coarse material, such as broken stone, clinkers, slats, or brush. Sewage is applied to the bed in drops, films, or spray, from troughs, drippers, moving distributors or fixed nozzles. Wastewater trickles through the medium, forming bacterial slimes which clarify and oxidize the sewage.

Filter, Vacuum - A filter consisting of a cylindrical drum mounted on a horizontal axis. The drum is covered with a filter cloth and revolves with a partial submergence in liquid. A vacuum is maintained under the cloth for the larger part of a revolution to extract moisture, and the cake is scraped off continuously.

Filtration - The process of separating undissolved solids from a liquid using a barrier through which solid particles cannot pass.

Flash - See Nickel Flash

Float Gauge - A device for measuring the elevation of the surface of a liquid, the actuating element of which is a buoyant float that rests on the surface of the liquid and rises or falls with it. The elevation of the surface is measured by a chain or tape attached to the float.

Floc - A very fine, fluffy mass formed by the aggregation of fine suspended particles.

Flocculator - An apparatus designed for the formation of floc in water or sewage.

Flocculation - In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gentle stirring by either mechanical or hydraulic means. In biological wastewater treatment where coagulation is not used, agglomeration may be accomplished biologically.

Flow Coat - Method of enamel application during which enamel is pumped through nozzles to flood the item with coating material (slip).

Flow-Proportioned Sample - A sample taken in proportion to flow.

Frit - Specially formulated glass in granular or flake form.

Fusion - The heating of an enamel-coated item to a continuous, uniform glass film.

Grab Sample - A single sample of wastewater taken at neither set time nor flow.

Grease - In wastewater, a group of substances including fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oil, and certain other nonfatty materials.

Grease Skimmer - A device for removing grease or scum from the surface of wastewater in a tank.

Ground Coat - First coat of porcelain enamel.

Hardness - A characteristic of water, imparted by salts of calcium, magnesium, and iron such as bicarbonates, carbonates, sulfates, chlorides, and nitrates that cause curdling of soap, deposition of scale in boilers, damage in some industrial processes, and sometimes objectionable taste. Hardness may be determined by a standard laboratory procedure or computed from the amounts of calcium and magnesium as well as iron, aluminum, manganese, barium, strontium, and zinc in the water, and is expressed as equivalent calcium carbonate.

Heavy Etch - Removal of 2.0 grams per square foot or more of total iron from the base metal.

Heavy Metals - A general name given to the ions of metallic elements such as copper, zinc, chromium, and nickel. They are normally removed from wastewater by forming an insoluble precipitate (usually a metallic hydroxide).

Heavy Nickel Deposition - Deposition of 0.07 grams per square foot or more of total nickel on the basis metal.

Holding Tank - A tank for temporary storage of liquids.

Industrial Wastes - The wastes generated by industrial processes as distinct from domestic or sanitary wastes.

Influent - Water or other liquid, either raw or partly treated, flowing into a reservoir basin or treatment plant.

In-Process Control Technology - Technology used to regulate chemical and rinse water use in process operations in order to conserve chemicals and rinse water and reduce wastewater discharge.

Ion Exchange - A reversible chemical reaction between a solid (ion exchanger) and a fluid (usually a water solution) by means of which ions may be interchanged from one substance to another. The superficial physical structure of the solid is not affected.

Lagoon - A man-made pond or lake for holding wastewater to allow for settling of suspended solids. Lagoons are also used as retention ponds after chemical clarification to polish the effluent and to safeguard against upsets in the clarifier; for stabilization of organic matter by biological oxidation; for storage of sludge; and for cooling of water.

Landfill - The disposal of waste solids by dumping at an approved site and covering with earth.

Lime - Any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite) which is composed almost wholly of calcium carbonates or a mixture of calcium and magnesium carbonates.

Lime, Settle - Precipitation of dissolved solids in wastewater using lime and the subsequent gravity-induced deposition of the suspended matter.

Lime, Settle, Filter - Lime, settle treatment of wastewater followed by additional suspended solids removal using a filter.

Limiting Orifice - A device that limits flow by constriction to a relatively small area.

Make-Up Water - Total amount of water used by a process on process step, not including recycled water.

Mil - A unit of thickness. 0.001 inch.

Milligrams Per liter (mg/l) - A weight per unit volume designation used in water and wastewater analysis.

Mixed Media Granular Bed Filtration - A filter which uses two or more filter materials of differing specific gravities selected to produce a filter uniformly graded from coarse to fine.

Mutagenic - The ability of a substance to increase the frequency or extent of mutation.

National Pollutant Discharge Elimination System (NPDES) - The Federal mechanism for regulating point source discharge to waters of the United States by means of permits.

Neutralization - (1) Chemical addition of either acid or base to a solution such that the pH is adjusted to approximately 7. (2)

Pretreatment operation used on steel to neutralize in an alkaline bath any traces of acid left from pickling.

Nickel Flash - A chemical preparation process in which nickel compounds are reduced to metallic nickel and deposited on the surface of the treated item, while iron is oxidized to the ferrous ion.

Noncontact Cooling Water - Water, used for cooling, which does not come into direct contact with any raw material, intermediate product, waste product, or finished product.

NPDES - National Pollutant Discharge Elimination System.

NSPS - New Source Performance Standards.

Orthophosphate - An acid or salt containing phosphorus as PO^3.

Outfall - The point or location where sewage or drainage discharges from a sewer, drain, or conduit.

Parshall Flume - A calibrated device developed by Parshall for measuring the flow of liquid in an open conduit. It consists essentially of a contracting length, a throat, and an expanding length. At the throat is a sill over which the flow passes at critical depth. The upper and lower heads are each measured at a definite distance from the sill. The lower head cannot be measured unless the sill is submerged more than about 67 percent.

pH - The negative of the logarithm of the hydrogen ion concentration. The concentration is the weight of hydrogen ions, in grams per liter of solution. Neutral water, for example, has a pH value of 7. At pH lower than 7, a solution is acidic. At pH higher than 7, a solution is alkaline.

pH Adjustment - A means of maintaining the optimum pH through the use of chemical additives.

Pickling - Chemical preparation operation which etches the surface of the treated item, removing rust, scale and some basis metal.

Pollutant - Dredged spoil, solid wastes, incinerator residue, sewage, garbage, sewage sludge, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal and agricultural waste discharged into water.

Pollutant Parameters - Those constituents of wastewater determined to be detrimental to public health or the environment and, therefore, requiring control.

Pollution Load - A measure of the unit mass of a wastewater in terms of its solids or oxygen-demanding characteristics or in terms of harm to receiving waters.

Polyelectrolytes - Substances used as a coagulants or coagulant aids in water and wastewater treatment. They are synthetic or natural polymers containing ionic constituents, and may be cationic, anionic, or nonionic.

POTW - Publicly Owned Treatment Works.

Powder Coating - Coating application method in which a heated part is dusted with enamel in powder form. Upon striking the workpiece, the powder melts and adheres to the part; the part is subsequently fired.

Prechlorination - (1) Chlorination of water prior to filtration. (2) Chlorination of sewage prior to treatment.

Precipitate - The discrete particles of material rejected from a liquid solution.

Precipitation - The rejection of discrete particles of material from a liquid solution by chemical or physical changes.

Precipitation, Chemical - (1) Precipitation induced by addition of chemicals. (2) The process of softening water by the addition of lime and soda ash as the precipitants.

Pressure Filtration - The process of solid/liquid phase separation effected by passing the more permeable liquid phase through a mesh which is impenetrable to the solid phase.

Pretreatment - Any wastewater treatment process used to reduce pollution load partially before the wastewater is introduced into a main sewer system or delivered to a treatment plant for substantial reduction of the pollution load.

Primary Treatment - A process to remove substantially all floating and settleable solids in wastewater and partially reduce the concentration of suspended solids.

Priority Pollutants - The 129 specific pollutants established by the EPA from the 65 pollutants and classes of pollutants as outlined in the consent decree of June 8, 1976.

Processed Area - The dimensional area directly involved in a particular processing step (expressed in terms of square feet and square meters).

Process Wastewater - Any water which, during manufacturing or processing, comes into direct contact with or results from the production or use of any raw materials, intermediate product, finished product, by-product, or waste product.

Process Water - Water prior to its direct contact use in a process or operation. (This water may be any combination of raw water, service water, or either process wastewater or treatment facility effluent to be recycled or reused).

PSES - Pretreatment Standards for Existing Sources.

PSNS - Pretreatment Standards for New Sources.

Publicly Owned Treatment Works - A central treatment works serving a municipality.

Raw Water - Plant intake water prior to any treatment or use.

Reaction Cell - A chamber in which the chemical reactant is rapidly recirculated to prevent chemical depletion, facilitate sludge removal and automatically provide chemical replenishment control.

Rectangular Weir - A weir having a notch that is rectangular in shape.

Recycled Water - Process wastewater or treatment facility effluent which is recirculated to the same process.

Reduction Practices - (1) Reduction of water use to lower the volume of wastemean the reduction of water use to lower the volume of wastewater requiring treatment or (2) the use of chemical reductant materials to lower the valence state of a specific wastewater pollutant.

Reduction Treatment - The opposite of oxidation treatment wherein a reductant (chemical) is used to lower the valence state of a pollutant to a less toxic form e.g.; the use of SO_2 to "reduce" chromium +6 to chromium +3 in an acidic solution.

Retention Time - The time allowed for solids to collect in a settling tank. Theoretically retention time is equal to the volume of the tank divided by the flow rate. The actual retention time is determined by the purpose of the tank and is designed to allow time for completion of a chemical reaction such as reduction of hexavalent chromium or the destruction of cyanide.

Reused Water - Process wastewater or treatment facility effluent which is further used in a manufacturing process.

Sanitary Sewer - A sewer that carries liquid and water borne wastes from residences, commercial buildings, industrial plants, and institutions together with minor quantities of ground, storm, and surface waters that are not admitted intentionally to a municipal treatment plant.

Sanitary Wastes - Wastewater generated by non-industrial processes; e.g., showers, toilets, food preparation operations.

Scrubber - General term used in reference to a "Wet" Air Pollution Control Device.

Secondary Settling Tank - A tank through which effluent from some prior treatment process flows for the purpose of removing settleable solids.

Secondary Wastewater Treatment - The treatment of wastewater by biological methods after primary treatment by sedimentation.

Sedimentation - The gravity-induced deposition of suspended matter carried by water, wastewater, or other liquids. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material. Also called settling.

Service Water - Raw water which has been treated prior to its use in a process or operation; i.e., make-up water.

Settling - See Sedimentation.

Sewage, Storm - Liquid flowing in sewers during or following a period of heavy rainfall.

Sewer - A pipe or conduit, generally closed, but normally not flowing full, for carrying sewage and other waste liquids.

Settleable Solids - (1) That matter in wastewater which will not stay in suspension during a preselected settling period, such as one hour, but settles to the bottom. (2) In the Imhoff cone test, the volume of matter that settles to the bottom of the cone in one hour.

Silk Screening - Coating method in which an enamel is spread onto a workpiece through a stencil screen.

Single Coat - The application of only one coat of porcelain enamel. This may be a finish coat in the "Direct-on" process.

Skimming Tank - A tank so designed that floating matter will rise and remain on the surface of the wastewater until removed, while the liquid discharges continuously under certain walls or scum boards.

Slip - A suspension of ceramic material in either water or oil.

Sludge - A suspension slurry or solid matter produced in a wastewater treatment process.

Sludge Conditioning - A process employed to prepare sludge for final disposal. Can be thickening, digesting, heat treatment, etc.

Sludge Disposal - The final disposal of solid wastes.

Sludge Thickening - The increase in solids concentration of sludge in a sedimentation or digestion tank.

Solvent - A liquid capable of dissolving one or more other substances.

Spills - A chemical or material spill is an unintentional discharge of more than 10 percent of the daily use of a regularly used substance. In the case of a rarely used (one per year or less) chemical or substance, a spill is that amount that would result in 10 percent added loading to the normal air, water or solid waste loadings measured as the closest equivalent pollutant.

Spray Booth - Structure used to contain airborne particles of enamel which do not adhere to ware.

Stabilization Lagoon - A shallow pond for storage of wastewater before discharge. Such lagoons may serve only to detain and equalize wastewater composition before regulated discharge to a stream, but often they are used for biological oxidation.

Stabilization Pond - A type of oxidation pond in which biological oxidation of organic matter is effected by natural or artificially accelerated transfer of oxygen to the water from air.

Suspended Solids - (1) Solids that are in suspension in water, wastewater, or other liquids, and which are largely removable by laboratory filtering. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater" and referred to as non-filterable residue.

Total Cyanide - The total content of cyanide including simple and/or complex ions. In analytical terminology, total cyanide is the sum of cyanide amenable to chlorination and that which is not, according to standard analytical methods.

Total Solids - The total amount of solids in a wastewater in both solution and suspension.

Toxicity - A measure of the ability of a substance to cause injury to an organism through chemical activity.

Treatment Efficiency - Usually refers to the removal from wastewater of a specific pollutant or group of pollutants by a specific wastewater treatment step or treatment plant.

Treatment Facility Effluent - Treated process wastewater.

Turbidity - (1) A condition in water or wastewater caused by the presence of suspended matter, resulting in the scattering and absorption of light rays. (2) A measure of fine suspended matter in liquids. (3) An analytical quantity usually reported in arbitrary turbidity units determined by measurements of light diffraction.

Turbulent Flow - (1) The flow of a liquid past an object such that the velocity at any fixed point in the fluid varies irregularly. (2) A type of liquid flow in which there is an unsteady motion of the particles and the motion at a fixed point varies in no definite manner. Sometimes called eddy flow, sinuous flow.

Uverite - Trade name for an antimony titanium fluorine complex used in white cover enamels.

Vacuum Filtration - See Filter, Vacuum.

Water Balance - An accounting of all water entering and leaving a unit process or operation in either a liquid or vapor form or via raw material, intermediate product, finished product, by-product, waste product, or via process leaks, so that the difference in flow between all entering and leaving streams is zero.

Weir - (1) A diversion dam. (2) A device that has a crest and some containment of known geometric shape, such as a V, trapezoid, or rectangle and is used to measure flow of liquid. The liquid surface is exposed to the atmosphere. Flow is related to upstream height of water above the crest, to position of crest with respect to downstream water surface, and to geometry of the weir opening.

METRIC UNITS

CONVERSION TABLE

MULTIPLY (ENGLISH UNITS) by TO OBTAIN (METRIC UNITS)

ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	[F	0.555([F-32)*	[C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
ton (short)	ton	0.907	kkg	metric ton (1000 kilograms
yard	yd	0.9144	m	meter

* Actual conversion, not a multiplier

*U.S. GOVERNMENT PRINTING OFFICE : 1983 0-381-545/3802