EPA 440/1-75/034a

Group I, Phase II

Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the

PRESSED AND BLOWN GLASS

Segment of the

GLASS MANUFACTURING

Point Source Category

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

JANUARY 1975

DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

for the

PRESSED AND BLOWN GLASS SEGMENT OF THE GLASS MANUFACTURING POINT SOURCE CATEGORY

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ABSTRACT

This document presents the findings of an extensive study of the pressed and blown glass manufacturing industry by Sverdrup & Parcel and Associates, Inc., for the Environmental Protection Agency for the purpose of developing effluent limitations and guidelines, Federal standards of performance, and pretreatment standards for the industry for the purpose of implementing Sections 301, 304(b) and (c), 306(b) and 307(b) and (c) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311 and 1314(b) and (c), 1316(b) and 1317(c); 86 Stat. 816 et seq.).

Effluent limitations and guidelines contained herein set forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best available technology economically achievable which must be achieved by existing point sources by July 1, 1977, and July 1, 1983, respectively. The standards of performance for new sources contained herein are based on the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

The development of data and recommendations in this document relate to the pressed and blown glass segment of the glass manufacturing point source category. This segment is further divided into six subcategories on the basis of production processes and waste water characteristics.

Separate effluent limitations are developed for each subcategory on the basis of the raw waste loading and the degree of treatment attainable by suggested model systems. This technology includes in-plant modifications, recirculation, precipitation, coagulation, sedimentation, flotation, stripping, filtration, and adsorption.

Supportive data and rationale for the development of the effluent limitations guidelines and standards of performance are contained in this document. A portion of the pressed and blown glass segment, the machine pressed and blown glass industry and the remainder of the glass tubing industry, is the subject of further analysis at the present time. The results of this study will be presented as a supplement to this document at a later date.

The remaining subcategories of the glass manufacturing point source category not contained in this document comprise the flat glass segment. The flat glass segment is the subject of a previous study (<u>Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the FLAT GLASS Segment of the Glass</u>

Manufacturing Point Source Category, Effluent Guidelines Division, U.S. Environmental Protection Agency, EPA-440/1-74-001-c, January, 1974). Regulations pertaining to the flat glass segment were set forth in February of 1974 (Federal Register, Volume 39, Number 32, page 5712, February 14, 1974).

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SECTION I

CONCLUSIONS

The pressed and blown glass segment of the glass manufacturing category has been classified into six subcategories. The first three subcategories include only the forming of products from molten glass while the last three include both the forming and finishing of glass products. The subcategorization is based on (a) production process and (b) waste water characteristics. Factors such as raw materials, age and size of production facilities, and applicable treatment technology do not provide significant bases for differentiation. The subcategories indicated are as follows:

1. Glass Container Manufacturing
2. Machine Pressed and Blown Glass Manufacturing
3. Glass Tubing Manufacturing
   a. Glass Tubing - Danner process
4. Television Picture Tube Envelope Manufacturing
5. Incandescent Lamp Envelope Manufacturing
   a. Forming
   b. Frosting
6. Hand Pressed and Blown Glass Manufacturing
   a. Leaded and Hydrofluoric Acid Finishing
   b. Non-Leaded and Hydrofluoric Acid Finishing
   c. Non-Hydrofluoric Acid Finishing

Recommended effluent limitations to be achieved by July 1, 1977, and July 1, 1983, are summarized in Section II for all of the above subcategories except the machine pressed and blown glass manufacturing subcategory. The machine pressed and blown glass manufacturing subcategory and the remainder of the glass tubing manufacturing subcategory are the subject of further study. The results of this study will be presented in a supplement to this document to be published at a later date.

SECTION II
RECOMMENDATIONS

It is recommended that the following effluent limitations be applied as the best practicable control technology currently available (BPCTCA) which must be achieved by existing point sources by July 1, 1977; the best available technology economically achievable (BATEA) which must be achieved by existing point sources by July 1, 1983; and the standards of performance for new sources (NSPS):

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

BPCTCA - Glass Container Manufacturing Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	60.0	30.0
TSS	140.0	70.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.06	0.03
TSS	0.14	0.07
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BATEA - Glass Container Manufacturing Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	1.6	0.8
TSS	1.6	0.8
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.0016	0.0008
TSS	0.0016	0.0008
pH	Within the range 6.0 to 9.0.	

NSPS - Glass Container Manufacturing Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	1.6	0.8
TSS	1.6	0.8
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.0016	0.0008
TSS	0.0016	0.0008
pH	Within the range 6.0 to 9.0.	

BPCTCA - Machine Pressed and Blown Glass Manufacturing Subcategory

This subcategory is the subject of further study; the results of this analysis will be presented at a later date.

BATEA - Machine Pressed and Blown Glass Manufacturing Subcategory

This subcategory is the subject of further study; the results of this analysis will be presented at a later date.

NSPS - Machine Pressed and Blown Glass Manufacturing Subcategory

This subcategory is the subject of further study; the results of this analysis will be presented at a later date.

BPCTCA - Glass Tubing (Danner) Manufacturing Subcategory

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Effluent Limitations: Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
TSS	460.0	230.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
TSS	0.46	0.23
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BATEA - Glass Tubing (Danner) Manufacturing Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
TSS	0.4	0.2
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
TSS	0.0004	0.0002
pH	Within the range 6.0 to 9.0.	

NSPS - Glass Tubing (Danner) Manufacturing Subcategory

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
TSS	0.4	0.2
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
TSS	0.0004	0.0002
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BPCTCA - Television Picture Tube Envelope Manufacturing Subcategory*

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	260.0	130.0
TSS	300.0	150.0
Fluoride	140.0	70.0
Lead	9.0	4.5
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.26	0.13
TSS	0.30	0.15
Fluoride	0.14	0.07
Lead	0.009	0.0045
pH	Within the range 6.0 to 9.0.	

*The fluoride and lead limitations are applicable to the abrasive polishing and acid polishing waste water streams, while the TSS, oil, and pH limitations are applicable to the entire process waste water stream.

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BATEA - Television Picture Tube Envelope Manufacturing Subcategory*

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	260.0	130.0
TSS	260.0	130.0
Fluoride	120.0	60.0
Lead	0.9	0.45
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.26	0.13
TSS	0.26	0.13
Fluoride	0.12	0.06
Lead	0.0009	0.00045
pH	Within the range 6.0 to 9.0.	

*The fluoride and lead limitations are applicable to the abrasive polishing and acid polishing waste water streams, while the TSS, oil, and pH limitations are applicable to the entire process waste water stream.

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

NSPS - Television Picture Tube Envelope Manufacturing Subcategory*

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	260.0	130.0
TSS	260.0	130.0
Fluoride	120.0	60.0
Lead	0.9	0.45
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.26	0.13
TSS	0.26	0.13
Fluoride	0.12	0.06
Lead	0.0009	0.00045
pH	Within the range 6.0 to 9.0.	

*The fluoride and lead limitations are applicable to the abrasive polishing and acid polishing waste water streams, while the TSS, oil, and pH limitations are applicable to the entire process waste water stream.

BPCTCA - Incandescent Lamp Envelope
Manufacturing Subcategory

(a) Any manufacturing plant which produces incandescent lamp envelopes shall meet the following limitations with regard to the forming operations.

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	230.0	115.0
TSS	230.0	115.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.23	0.115
TSS	0.23	0.115
pH	Within the range 6.0 to 9.0.	

BPCTCA - Incandescent Lamp Envelope
Manufacturing Subcategory (Continued)

(b) Any manufacturing plant which frosts incandescent lamp envelopes shall meet the following limitations with regard to the finishing operations.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of product frosted	
Fluoride	230.0	115.0
Ammonia	----No limitation----	
TSS	460.0	230.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of product frosted	
Fluoride	0.23	0.115
Ammonia	----No limitation----	
TSS	0.46	0.23
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BATEA - Incandescent Lamp Envelope Manufacturing Subcategory

(a) Any manufacturing plant which produces incandescent lamp envelopes shall meet the following limitations with regard to the forming operation.

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Effluent Limitations: Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	90.0	45.0
TSS	90.0	45.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.09	0.045
TSS	0.09	0.045
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BATEA - Incandescent Lamp Envelope Manufacturing Subcategory (Continued)

(b) Any manufacturing plant which frosts incandescent lamp envelopes shall meet the following limitations with regard to the finishing operations.

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Effluent Limitations: Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of product frosted	
Fluoride	104.0	52.0
Ammonia	240.0	120.0
TSS	80.0	40.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of product frosted	
Fluoride	0.104	0.052
Ammonia	0.24	0.12
TSS	0.08	0.04
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

NSPS - Incandescent Lamp Envelope Manufacturing Subcategory

(a) Any manufacturing plant which produces incandescent lamp envelopes shall meet the following limitations with regard to the forming operations.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of furnace pull	
Oil	90.0	45.0
TSS	90.0	45.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of furnace pull	
Oil	0.09	0.045
TSS	0.09	0.045
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

NSPS - Incandescent Lamp Envelope Manufacturing Subcategory (Continued)

(b) Any manufacturing plant which frosts incandescent lamp envelopes shall meet the following limitations with regard to the finishing operations.

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Effluent Limitations: Average of daily values for thirty consecutive days shall not exceed
(Metric units)	g/kkg of product frosted	
Fluoride	104.0	52.0
Ammonia	240.0	120.0
TSS	80.0	40.0
pH	Within the range 6.0 to 9.0.	
(English units)	lb/1000 lb of product frosted	
Fluoride	0.104	0.052
Ammonia	0.24	0.12
TSS	0.08	0.04
pH	Within the range 6.0 to 9.0.	

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BPCTCA - Hand Pressed and Blown Glass Manufacturing Subcategory

(a) Any plant which melts raw materials, produces hand pressed or blown leaded glassware, employs hydrofluoric acid finishing techniques, and discharges greater than 50 gallons per day of process waste water, shall meet the following limitations.

Effluent <u>Characteristic</u>	Effluent <u>Limitations</u>
Lead	No limitation
Fluoride	No limitation
TSS	No limitation
pH	No limitation

(b) Any plant which melts raw materials, produces non-leaded hand pressed or blown glassware, discharges greater than 50 gallons per day of process waste water, and employs hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent <u>Characteristic</u>	Effluent <u>Limitations</u>
Fluoride	No limitation
TSS	No limitation
pH	No limitation

(c) Any plant which melts raw materials, produces leaded or non-leaded hand pressed or blown glassware, discharges greater than 50 gallons per day of process waste water, and does not employ hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent <u>Characteristic</u>	Effluent <u>Limitations</u>
TSS	No limitation
pH	No limitation

RECOMMENDED EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE (Continued)

BATEA - Hand Pressed and Blown Glass Manufacturing Subcategory

(a) Any plant which melts raw materials, produces hand pressed or blown leaded glassware, discharges greater than 50 gallons per day of process waste water, and employs hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
	mg/l	
Lead	0.2	0.1
Fluoride	26.0	13.0
TSS	20.0	10.0
pH	Within the range 6.0 to 9.0.	

(b) Any plant which melts raw materials, produces non-leaded hand pressed or blown glassware, discharges greater than 50 gallons per day of process waste water, and employs hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
	mg/l	
Fluoride	26.0	13.0
TSS	20.0	10.0
pH	Within the range 6.0 to 9.0.	

BATEA - Hand Pressed and Blown Glass
Manufacturing Subcategory (Continued)

(c) Any plant which melts raw materials, produces leaded or non-leaded hand pressed or blown glassware, discharges greater than 50 gallons per day of process waste water, and does not employ hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Effluent Limitations: Average of daily values for thirty consecutive days shall not exceed
	mg/l	
TSS	20.0	10.0
pH	Within the range 6.0 to 9.0.	

NSPS - Hand Pressed and Blown Glass
Manufacturing Subcategory

(a) Any plant which melts raw materials, produces hand pressed or blown leaded glassware, discharges greater than 50 gallons per day of process waste water, and employs hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent Characteristic	Effluent Limitations: Maximum for any one day	Effluent Limitations: Average of daily values for thirty consecutive days shall not exceed
	mg/l	
Lead	0.2	0.1
Fluoride	26.0	13.0
TSS	20.0	10.0
pH	Within the range 6.0 to 9.0.	

NSPS - Hand Pressed and Blown Glass
Manufacturing Subcategory (Continued)

(b) Any plant which melts raw materials, produces non-leaded hand pressed or blown glassware, discharges greater than 50 gallons per day of process waste water, and employs hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
	mg/l	
Fluoride	26.0	13.0
TSS	20.0	10.0
pH	Within the range 6.0 to 9.0.	

(c) Any plant which melts raw materials, produces leaded or non-leaded hand pressed or blown glassware, discharges greater than 50 gallons per day of process waste water, and does not employ hydrofluoric acid finishing techniques shall meet the following limitations.

Effluent Characteristic	Effluent Limitations	
	Maximum for any one day	Average of daily values for thirty consecutive days shall not exceed
	mg/l	
TSS	20.0	10.0
pH	Within the range 6.0 to 9.0.	

SECTION III

INTRODUCTION

PURPOSE AND AUTHORITY

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best *practicable control technology currently available* as *defined* by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on 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, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) of the Act. Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish *regulations providing guidelines for effluent limitations setting* forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operation methods, and other alternatives. The regulations set forth effluent limitations guidelines pursuant to Section 304(b) of the Act for certain subcategories of the glass and asbestos manufacturing point source category. They include the glass container manufacturing, glass tubing (Danner) manufacturing, television picture tube envelope manufacturing, incandescent lamp envelope manufacturing, and hand pressed and blown glass manufacturing subcategories. The machine pressed and blown glass manufacturing industry and the remainder of the glass tubing manufacturing industry are the subject of further study; regulations pertaining to these industries will be published at a later date.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b)(1)(A) of the Act, to propose regulations establishing Federal standards of performance for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973 (38 F.R. 1624), a list of 27 point source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the glass manufacturing point source category which was included with the list published on January 16, 1973. The pressed and blown glass industry, which this document addresses, is a segment of the glass manufacturing point source category as are the insulation fiberglass and flat glass industries which have been previously studied.

Section 307(c) of the Act requires the Administrator to promulgate pretreatment standards for new sources at the same time that standards of performance for new sources are promulgated pursuant to Section 306. Section 307(b) of the Act requires the establishment of pretreatment standards for pollutants introduced into publicly owned treatment works. The regulations set forth pretreatment standards for new sources and for existing sources pursuant to Sections 307(b) and (c) of the Act for the pressed and blown glass segment of the glass manufacturing point source category.

The guidelines presented in this document identify (in terms of the chemical, physical, and biological characteristics of pollutants) the level of pollutant reductions attainable through the application of *the best practicable control technology currently available and the* best available technology economically achievable. The guidelines also specify factors which must be considered in identifying the technology levels and in determining the control measures and practices which are to be applicable within given industrial categories or classes.

In addition to technical factors, the Act requires that a number of other factors be considered, such as the costs or cost-benefits and the non-water quality environmental impacts (including energy requirements) resulting from the application of such technologies.

SUMMARY OF METHODS USED FOR DEVELOPMENT OF THE EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

Methodology

The effluent limitations guidelines and standards of performance proposed herein were developed in the following manner. The point source category was first categorized for the purpose of determining whether separate limitations and standards are appropriate for different segments within the point source category. Such subcategorization was based upon raw material used, product produced, manufacturing process employed, and other factors. The raw waste characteristics for each subcategory were then identified. This included an analysis of (1) the source and volume of water used in the process employed and the sources of waste and waste water in the plant; and (2) the constituents (including thermal) of all waste waters, including toxic constituents and other constituents which result in taste, odor, and color in water or aquatic organisms. The constituents of waste waters which should be subject to effluent limitations guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each subcategory was identified. This included an identification of each distinct control and treatment technology, including both in-plant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification in terms of the amount of constituents (including thermal) and the chemical, physical, and biological characteristics of pollutants, of the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations and reliability of each treatment and control technology, and the required implementation time were also identified. In addition, the non-water quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation were also identified. The energy requirements of each of the control and treatment technologies were identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the "best practicable control technology currently available", "best available technology economically achievable", and the "best available demonstrated control technology, processes, operating methods, or other alternatives". In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements), and other factors.

Basis for Guideline Development

The data for identification and analyses were derived from a number of sources. These sources included EPA and industry-supplied information; published literature; and on-site visits, interviews, and sampling at typical or exemplary plants throughout the United States. References used in the guidelines for effluent limitations and standards of performance on new sources reported herein are included in Section XIII of this document.

Several types of waste water data were analyzed. These include: RAPP data, information supplied by industry and State pollution control agencies, and data derived from the sampling of typical or exemplary plants. The data retrieval form illustrated in Figure 1 was developed to aid in the collection of data during interviews and plant visits and was supplied to the industry to indicate the types of information required for the study.

The data were analyzed with the aid of a computer program which provided the capability for summing the data for each plant where multiple discharges existed, averaging the data for each plant where multiple data sets were available, and comparing and averaging the data for all plants within each subcategory to determine values characteristic of a typical plant. Input to the computer for each plant consisted primarily of the plant production rate, the waste water flow rate, the concentration of each constituent of the plant intake water, the average and maximum concentrations of each constituent in the waste water, and some descriptive information regarding existing waste treatment methods, subcategory type, and sampling methods.

An example of the computer printout is the hypothetical summary of effluent oil and grease concentration data for glass container plants without treatment illustrated in Figure 2. The pounds per day increase, mg/l increase, and pounds added per day per production unit are calculated. Data from all of the plants listed are summarized in terms of the average, standard deviation (SIGMA), and minimum and maximum values for the data listed. The weighted average listed on the final line was used when the data from a single plant was summarized. Multi-sample data summaries, such as weekly or monthly averages, were thereby averaged in proportion to the number of individual samples included in the summary.

The name and location of the plants for which data were available are listed in Tables 1 and 2, and their geographic location is indicated on Figures 3 and 4. Seventy-eight plants supplied some type of usable information or data for computer analysis. RAPP data were available and used for 52 plants.

Thirteen plants covering various manufacturing processes were visited. The subcategories are listed in Table 3 along with the type of data collected. Seven plants were sampled, including two

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EPA GLASS INDUSTRY STUDY

Data Retrieval Form No. 3

November 1973

I GENERAL

A. Company Name

B. Plant Name and Location

C. Contact - Company Personnel

- Plant Personnel

D. Telephone No.

II MANUFACTURING PROCESS CHARACTERIZATION (Separate sheet for each process)

A. Products manufactured

B. Type of equipment and machinery used

C. General flow diagram of manufacturing process (See attachment)

D. Age

1. Age of Plant

2. Age of major manufacturing equipment

3. Estimated life of major manufacturing equipment

E. Production

1. Yearly average tons fill/day (total plant)

2. Approximate percent of yearly production requiring fabrication where water is used

a. Grinding

b. Acid Polishing

-1-

c. Etching

d. Scrubbers

e. Other (Specify)

2. Actual production on days wastewater samples were collected (See III F.) for each day sampled give:

a. Tons Fill

b. Production for finishing steps requiring water

	Pieces	Pounds
1) Grinding		
2) Acid Polishing		
3) Etching		
4) Scrubbers		
5) Other (Specify)		

F. Energy Requirements

(One of the requirements of the study is a statement of the percentage increase in energy required for wastewater treatment as compared to the energy required for glass production. Express energy requirements as horsepower, BTU or other convenient units required to produce a unit of glass. If possible, list melting tank fuel separate from other energy requirements.)

G. Operating Schedule

1. Normal hr/day and day/week

2. Maximum hr/day

3. Maximum day/week

H. Approximate Number of Employees (by shift)

I. Water Requirements

1. Total volume and source (city water, well water, etc.)

-2-

FIGURE 1

DATA RETRIEVAL FORM

2. Uses

   a. Process

   b. Cooling

   c. Plant Cleanup

   d. Boiler

   e. Scrubbers

   f. Other (define use)

3. Attach any available information on Raw Water Quality (See III E.)

4. Pretreatment Requirements

   a. Volume Treated

   b. Reason for Treatment

   c. Describe Treatment System and Operation

   d. Type and Quantity of Chemicals Used

   e. Attach any available information on Treated Water Quality (See III E.)

III PROCESS WASTEWATER

A. Wastewater Sources

For each sewer that leaves company property, list manufacturing steps that contribute measurable wastewater and give the average, minimum and maximum flow from each source expressed as gal/day. Completely segregated sanitary sewers may be neglected. Estimated flow rates should be so indicated.

Source	Average	Minimum	Maximum
Total Sewer			

FIGURE 1 (CONTD.)

B. Is wastewater discharged to a surface stream or storm sewer or to a city sanitary sewer system?

C. Are wastewater characteristics appreciably different during startup and shutdown as compared to normal operation?

D. Quantity and point of application of oil, cleaning agents and other chemicals used which might enter the wastewater stream.

E. Treatment Methods

1. Wastewater source and volume

2. Reason for Treatment

3. Describe treatment system and operation

4. Type and quantity of chemicals used

F. Wastewater Quality

(Attach any available data on water quality, both <u>before</u> and <u>after</u> treatment, such as pH, BOD, COD, solids, heavy metals, temperature, etc. Identify with respect to the <u>sources</u> listed in part A of this section. Indicate the <u>type</u> of sample (grab, ___ hour composite, etc.) and give the <u>production</u> during the sampling period as outlined in Part II E.

G. Describe inplant methods of water conservation and/or waste reduction presently in use or anticipated.

H. Identify any air pollution, noise or solid waste resulting from treatment or other control methods. How is solid waste disposed of?

I. Describe water pollution control methods being considered for future application.

J. Cost information (related to water pollution control)

1. Treatment plant and/or equipment cost

2. Operating Costs (personnel, maintenance, etc.)

3. Power Costs

4. Estimated Equipment Life

IV COOLING WATER

A. Process steps requiring cooling water

B. Heat rejection requirements (BTU/hour)

C. Type of cooling system (once-through or recycle)

D. Water temperatures and flow rate

1. Input

2. Output

3. Flow Rate

E. Cooling tower or spray pond (circle which)

1. Blowdown Rate

2. Blowdown Control Method

3. Type and quantity of water treatment chemicals used

4. Attach any available information on blowdown water quality (See III E.)

F. Type and quantity of chemicals used for once-through cooling water treatment

V BOILER

A. Capacity

B. Attach any available information on blowdown rate and quality (See III E.)

FIGURE 1 (CONTD.)

PART A AND B PARAMETERS OF INTAKE WATER AND DISCHARGE. BREAKDOWN BY PLANT

MGD	GPD/ P-UNIT	INF. CONC. MG/L	EFF. AVE. MG/L	CONC. MAX MG/L	LB/DAY INCREASE AVE	LB/DAY INCREASE MAX	MG/L INCREASE AVE	MG/L INCREASE MAX	UNIT/DAY	LBS ADDED PER PRODUCT UNIT AVE	LBS ADDED PER PRODUCT UNIT MAX	SAMPLE TYPE	
ITEM NO. 550. OIL AND GREASE													
NAME= PLANT A					PRODUCTION= 450. TONS/DAY,NONE,GC							1 DATA POINTS	
0.56	1244.44	1.	17.	18.	74.7264	79.3968	16.	17.	450.	0.16605	0.17643	COMP,24 HR, 6-18-72	
NAME= PLANT B					PRODUCTION= 525. TONS/DAY,NONE,GC							1 DATA POINTS	
0.435	828.571	2.	6.	7.	14.5116	18.1395	4.	5.	525.	0.02764	0.03455	GRAB, 1-15-74	
NAME= PLANT C					PRODUCTION= 500. TONS/DAY,NONE,GC							1 DATA POINTS	
0.17	340.	1.5	7.1	8.4	7.93968	9.78281	5.6	6.9	500.	0.01587	0.01956	COMP,24 HR, 1-25-74	
NAME= PLANT D					PRODUCTION= 600. TONS/DAY,NONE,GC							1 DATA POINTS	
0.81	1350.	0.	11.	14.	74.3094	94.5756	11.	14.	600.	0.12384	0.15762	GRAB, 1-5-74	
1.975	3763.01	4.5	41.1	47.4	171.487	201.895	36.6	42.9	2075.	0.33342	0.38818		TOTAL
0.49375	940.754	1.125	10.275	11.85	42.8717	50.4737	9.15	10.725	518.75	0.08335	0.09704		AVER.
0.26625	459.42	0.85391	4.97016	5.09477	36.6405	42.7503	5.46107	5.7011	62.5	0.07334	0.0814		SIGMA
0.81	1350.	2.	17.	18.	74.7264	94.5756	16.	17.	600.	0.16605	0.17643		MAX.
0.17	340.	0.	6.	7.	7.93968	9.78281	4.	5.	450.	0.01587	0.01956		MIN.
0.49375	940.754	1.125	10.275	11.85	42.8717	50.4737	9.15	10.725	518.75	0.08335	0.09704		WT.AV.

FIGURE 2

SAMPLE COMPUTER FORMAT

TABLE 1

GLASS CONTAINER PLANTS

COMPANY NAME	PLANT LOCATION
Anchor Hocking	Jacksonville, Fla. Houston, Texas Gurnee, Ill. Connellsville, Pa. Salem, N. J. Winchester, Ind. San Leandro, Calif.
Ball	Mundelein, Ill. El Monte, Calif.
Brockway Glass	Muskogee, Okla. Clarksburg, W. Va. Lapel, Ind. Ada, Okla. Freehold, N. J. Zanesville, Ohio
Chattanooga Glass	Chattanooga, Tenn. Corsicana, Texas Gulfport, Miss. Mt. Vernon, Ohio Keyser, W. Va.
Columbine Glass	Wheat Ridge, Colo.
Foster-Forbes Glass	Marion, Ind.
Gayner Glass Works	Salem, N. J.
Glass Containers	Indianapolis, Ind. Danville, Conn. Jackson, Miss. Parker, Pa. Marienville, Pa. Knox, Pa. Forest Park, Ga. Palestine, Texas Antioch, Calif. Gas City, Ind. Hayward, Calif. Vernon, Calif.

TABLE 1 (Contd.)

GLASS CONTAINER PLANTS

COMPANY NAME	PLANT LOCATION
Glenshaw Glass	Glenshaw, Pa.
Kerr Glass Mfg.	Millville, N. J. Plainfield, Ill. Dunkirk, Ind. Santa Ana, Calif. Sand Springs, Okla.
Latchford Glass	Los Angeles, Calif.
Laurens Glass	Henderson, N. C. Laurens, S. C. Ruston, La.
Liberty Glass	Sapulpa, Okla.
Madera Glass	Madera, Calif.
Maryland Glass	Baltimore, Md.
Metro Containers	Jersey City, N. J. Carteret, N. J. Dolton, Ill. Washington, Pa.
Midland Glass	Shakopee, Minn.
Northwestern Glass	Seattle, Wash.
Obear-Nestor	E. St. Louis, Ill. Lincoln, Ill.
Pierce Glass	Port Allegany, Pa.
Owens-Illinois	Huntington, W. Va. Fairmont, W. Va. Alton, Ill. Streator, Ill. Gas City, Ind. Bridgeton, N. J. Waco, Texas Oakland, Calif.

TABLE 1 (Contd.)

GLASS CONTAINER PLANTS

COMPANY NAME	PLANT LOCATION
Owens-Illinois (Contd.)	Clarion, Pa.
	Los Angeles, Calif.
	Brockport, N. J.
	Charlotte, Mich.
	New Orleans, La.
	Atlanta, Ga.
	North Bergen, N. J.
	Lakeland, Fla.
	Portland, Ore.
	Tracy, Calif.
Puerto Rico Glass	San Juan, P. R.
Thatcher Glass Mfg.	Lawrenceburg, Ind.
	Saugus, Calif.
	Elmira, N. Y.
	Whoaton, N. J.
	Tampa, Fla.
	Streator, Ill.

TABLE 2

PRESSED AND BLOWN GLASS PLANTS

COMPANY NAME	PLANT LOCATION
	Machine Pressed and Blown Glassware Plants
Anchor Hocking	Lancaster, Ohio (Plant #1) Lancaster, Ohio (Plant #2)
Brockway Glass	Clarksburg, W. Va.
Corning Glass Works	Corning, N. Y. Muskogee, Okla. Greenville, Ohio Danville, Va. Harrodsburg, Ky.
Federal Glass	Columbus, Ohio
General Electric	Niles, Ohio Somerset, Ky.
Owens-Illinois	Toledo, Ohio Walnut, Calif.
	Tubing Plants
Corning Glass Works	Blacksburg, Va. Danville, Ky.
General Electric	Bucyrus, Ohio Logan, Ohio Jackson, Miss. Bridgeville, Pa.
GTE-Sylvania	Greenland, N. H.
Westinghouse Electric	Fairmont, W. Va.
	Television Picture Tube Envelope Plants
Corning Glass Works	Albion, Mich. Bluffton, Ind. State College, Pa.
Owens-Illinois	Columbus, Ohio Pittston, Pa.

TABLE 2 (Contd.)

PRESSED AND BLOWN GLASS PLANTS

COMPANY NAME	PLANT LOCATION
	Incandescent Lamp Envelope Plants
Corning Glass Works	Central Falls, R.I.
	Wellsboro, Pa.
General Electric	Lexington, Ky.
	Niles, Ohio
	Cleveland, Ohio
	Hand Pressed & Blown Glassware Plants
The Beaumont Co.	Morgantown, W.Va.
Blenko Glass	Milton, W.Va.
Canton Glass Division	Hartford City, Ind.
Colonial Glass	Deanville, W.Va.
Crescent Glass	Wellsburg, W.Va.
Davis-Lynch Glass	Star City, W.Va.
Elite Co.	New York, N.Y.
EMC Glass	Decatur, Texas
Erie Glass	Parkridge, Ill.
Erskine Glass	Wellsburg, W.Va.
Fenton Art Glass	Williamstown, W.Va.
Fostoria Glass	Moundsville, W.Va.
Gillender Brothers	Port Jervis, N.Y.
Glassworks, Inc.	Huntington Beach, Ca.
Harvey Industries	Clarksburg, W.Va.
Imperial Glass	Bellaire, Ohio
Jeannette Shade & Novelty	Jeannette, Pa.
Johnson Glass and Plastic	Chicago, Ill.
Kanawha Glass	Dunbar, W.Va.
Kessler, Inc.	Bethpage, L.I.
Kopp Glass, Inc.	Pittsburgh, Pa.
Lenox Crystal, Inc.	Mt. Pleasant, Pa.
Lewis County Glass	Jane Lew, W.Va.
Louie Glass	Weston, W.Va.
Minners Glass	Salem, W.Va.
Overmyer-Perram Glass	Tulsa, Okla.
Pennsboro Glass	Pennsboro, W.Va.
Pilgrim Glass	Ceredo, W.Va.
Raylite Glass	Southgate, Ca.
St. Clair Glassworks	Elwood, Ind.
Scandia Glassworks	Kenova, W.Va.
Scott Depot Glass	Fort Smith, Ark.
Seneca Glass	Morgantown, W.Va.
Sinclair Glass	Hartford City, Ind.
Sloan Glass, Inc.	Culloden, W.Va.
Smith Glass	Mt. Pleasant, Pa.

TABLE 2 (Contd.)

PRESSED AND BLOWN GLASS PLANTS

Company Name	Hand Pressed & Blown Glassware Plants
Super Glass	Brooklyn, N.Y.
Viking Glass	New Martinsville, W.Va.
Viking Glass	Huntington, W.Va.
Westmoreland Glass	Grapeville, Pa.
Wheaton Industries	Millville, N.J.
West Virginia Glass Specialty	Weston, W.Va.

FIGURE 3

LOCATION OF PARTICIPATING GLASS CONTAINER MANUFACTURING PLANTS

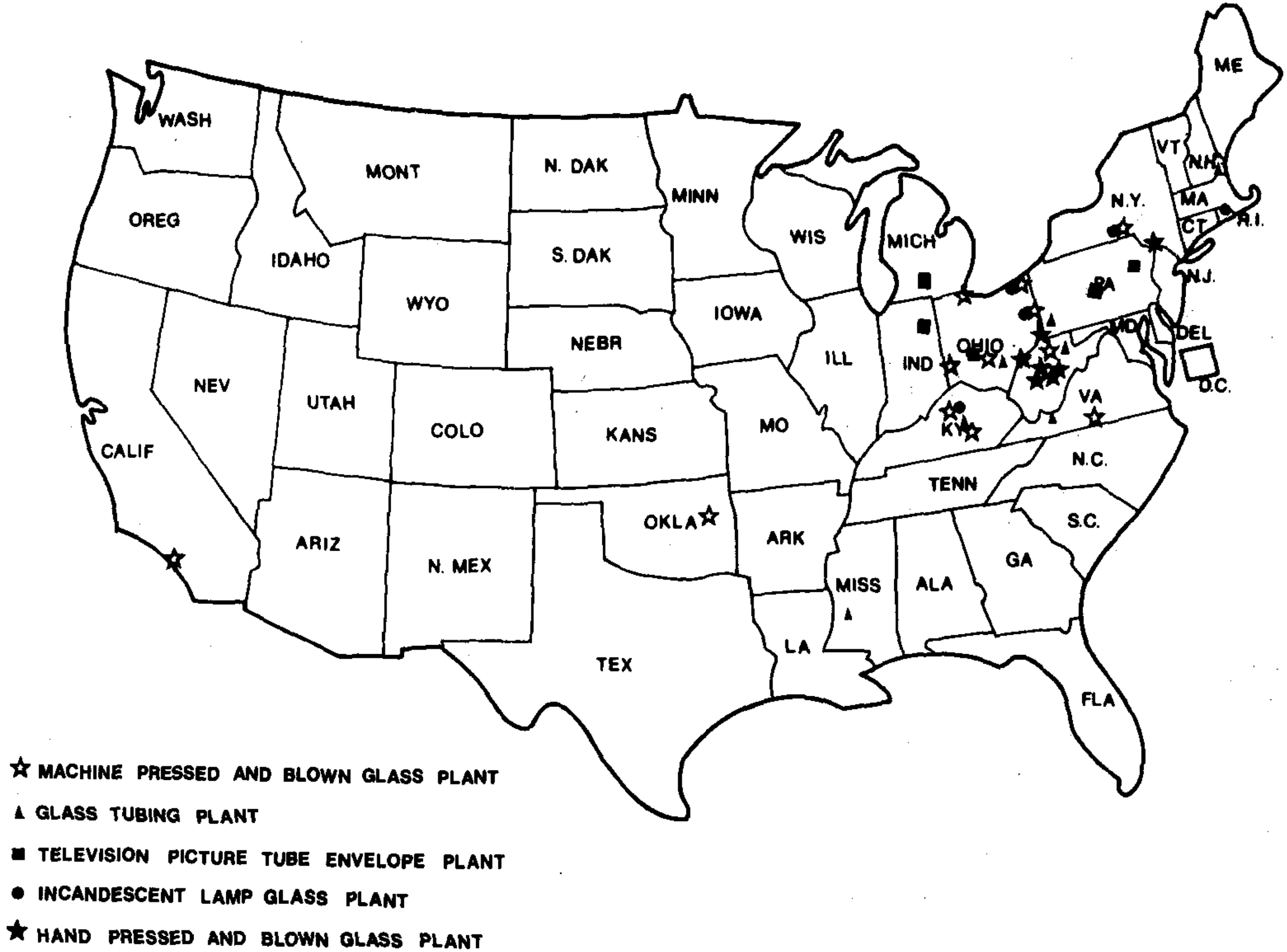

FIGURE 4

LOCATION OF PARTICIPATING PRESSED AND BLOWN GLASS MANUFACTURING PLANTS

TABLE 3

PLANTS VISITED

Plant Types	No. of Plants	Type of Data Obtained	
Glass Container	3	(1)	(2)
Machine Pressed and Blown	2	(1)	(2)
Tubing	1		(2)
TV Picture Tube Envelope	2	(1)	(2)
Incandescent Lamp Envelope	1	(1)	(2)
Hand Pressed and Blown	4	(1)	(2)

(1) - Individual process or subcategory.

(2) - End-of-pipe including all process and auxiliary wastes.

glass container plants, one machine pressed and blown glass plant, one television picture tube envelope plant, one incandescent lamp envelope plant, and two hand pressed and blown glass plants. Plant sampling provided significant data on raw and treated waste water volumes and characteristics and verified the data obtained from the industry.

GENERAL DESCRIPTION OF THE INDUSTRY

Production Classification

The U.S. Bureau of Census, Census of Manufacturers, classifies the glass container manufacturing and pressed and blown glass manufacturing industries as Standard Industrial Classifications (SIC) group code numbers 3221 and 3229, respectively. Both group numbers are under the more general category of Stone, Clay, Glass, and Concrete Products (Major Group 32) and, more specifically, under Glass and Glassware, Pressed or Blown (Group Number 322). The four-digit classification code (3221) covers industrial establishments engaged in manufacturing glass containers for commercial packing and bottling, and for home canning. The classification code (3229) comprises all industrial establishments primarily engaged in manufacturing glass and glassware, pressed, blown, or shaped from glass produced in the same establishment. Establishments also covered by code (3229) include those manufacturing textile glass fibers and pressed lenses for vehicular lighting, beacons, and lanterns. Effluent limitations guidelines and new source performance standards for textile glass fiber manufacturing have previously been promulgated by the EPA.

Origin and History

The origin and history of glass is thought to have begun with the Egyptians in 4000 B.C. The first glass articles manufactured by the Egyptians were small, decorative, glass-covered objects. The first true glass vessels - small bottles, goblets, or vases - come from the Egyptian royal graves of the period around 1555-1350 B.C. The glass vessels were made by the sand core technique in which a sand core is stuck to a metal rod, fired or fritted, and coated by a thick layer of viscous glass. Further forming was accomplished by reheating and using simple tools such as pinchers, but not by blowing.

Glass blowing originated in the Eastern Mediterranean at the beginning of the first century B.C. The glass blow-pipe was introduced to the Western Mediterranean around 30 B.C. The blow-pipe method of forming glass was used from this time on and has only gradually been replaced by mechanical processes since the end of the 19th Century.

The glass pressing machine was introduced in America in 1827. In this process the molten glass is pressed into a mold manually with a plunger. Several other glass manufacturing innovations occurred in the 19th Century. The first successful bottle-blowing machine was invented by Ashley of England in 1888. Several other bottle-making machines were developed during the next years. In 1889 Michael J. Owens conceived the first fully automatic bottle machine, which in less than 20 years revolutionized glass container manufacturing. Another major manufacturing breakthrough was the introduction of the Corning ribbon machine in the early 1900's. The ribbon machine can manufacture as many as 2200 bulbs per minute. The Hartford I.S. (Individual Section) machine, developed in 1925, remains the most popular method for manufacturing glass containers. Techniques for forming glass containers and machine pressed products have essentially remained the same since the 1920's. Most recent developments in the glass industry are in the application of glass into new areas such as conductive coatings, electrical components, and photosensitive glasses.

Description of Manufacturing Methods

There are four manufacturing steps that are common to the entire pressed and blown glass industry. The four steps include weighing and mixing of raw materials, melting of raw materials, forming of molten glass, and annealing of formed glass products. Forming methods vary substantially, depending on the product and subcategory, and range from hand blowing to centrifugal casting of picture tube funnels. Following forming and annealing, the glass may be prepared for shipment or may be further processed in what is referred to as finishing. There is little or no finishing involving waste water in the glass container and machine pressed and blown manufacturing, while extensive finishing is required in television picture tube envelope, incandescent lamp envelope, and hand pressed and blown glassware manufacturing. Finishing of glass tubing is not covered by this study.

PRODUCTION AND PLANT LOCATION

There are approximately 30 firms with a total of 140 plants presently manufacturing glass containers in the United States. The eight largest firms in the industry produce about 78 percent of the glass container shipments and operate two-thirds of the individual plants. Plants are located throughout the United States to service regional customers, but a large number are concentrated in the northeastern United States. The industry originally located in the Northeast because convenient sources of raw materials and fuel were available.

The glass container industry employs over 70,000 persons and has a daily processing capacity of 50,500 metric tons (55,500 tons) of glass pulled. The average glass container plant capacity is 388 metric tons (427 tons). Plants range in size from 122 metric tons (134 tons) per day to 1320 metric tons (1450 tons) per day (Table 4).

There are about 50 machine pressed and blown glass manufacturing plants in the United States and the average capacity is 91 metric tons (100 tons) pulled per day. Machine pressed and blown ware

TABLE 4

PRESSED AND BLOWN GLASS MANUFACTURING
PRODUCTION DATA (a)

	Number of Plants	Average Plant Size (metric tons/day)	Range (metric tons/day)	Average Plant Size (tons/day)	Range (tons/day)
GC	140	388	122 - 1320	427	134 - 1450
MPB	50	91	40 - 349	100	44 - 384
TB	30	100	40 - 164	110	44 - 180
TV	10	208	142 - 255	229	156 - 280
L	18	192	141 - 245	212	155 - 270
HPB	50	3.6	0.7 - 6.5	4.0	0.8 - 7.2

(a) All production figures except HPB based on weight of glass pulled from furnace in tons; HPB based on weight of finished product.

GC - Glass Containers
MPB - Machine Pressed and Blown
TB - Tubing
TV - Television Picture Tube Envelope
L - Incandescent Lamp Envelope
HPB - Hand Pressed and Blown

plant capacities range from 40 metric tons (44 tons) to 349 metric tons (384 tons).

About 30 plants manufacture glass tubing in the United States. Production, expressed as furnace pull per day, ranges from 40 metric tons (44 tons) per day to 164 metric tons (180 tons) per day and averages 100 metric tons (110 tons).

Approximately 10 television picture tube envelope factories are located in the United States. The average amount of glass pulled per day is 208 metric tons (229 tons). Plant production varies from 142 metric tons (156 tons) pulled per day to 255 metric tons (280 tons) pulled per day.

Incandescent lamp envelopes are manufactured at 18 plants in the United States. Plant production in terms of furnace pull ranges from 141 metric tons (155 tons) per day to 245 metric tons (270 tons) per day. The average plant production is 193 metric tons (212 tons) per day.

Hand pressed and blown glass manufacturing plants are small and primarily located in West Virginia, western Pennsylvania, and Ohio. Approximately fifty handmade glassware plants are located in the United States. A number of hand pressed and blown ware plants also have facilities to manufacture machine-made glassware. The average amount of finished product produced per day at a hand pressed and blown ware plant is 3.6 metric tons (4.0 tons). The range of production varies from 0.7 metric tons (0.8 tons) per day to 6.5 metric tons (7.2 tons) per day.

GENERAL PROCESS DESCRIPTION

Pressed and blown glass and glassware are covered in this study. The pressed and blown glass industry has been characterized as glass container, machine pressed and blown glass, glass tubing, television picture tube envelope, incandescent lamp envelope, and hand pressed and blown glass manufacturing. Pressed and blown glass manufacturing consists of raw material mixing, melting, forming, annealing, and, in some cases, finishing.

The basic unit of production for all subcategories, except hand pressed and blown glass manufacturing, is the metric ton (or ton in English units) and is based on the amount of glass drawn from the melting tank. These units were chosen because they relate directly to plant size and waste water production and will be readily available to enforcement personnel. The number of metric tons (tons) of finished product is a more convenient unit for hand pressed and blown glass manufacturing because waste water characteristics are related to finishing operations rather than metric tons (tons) pulled from the furnace. The number or pieces produced is also a common unit, but does not appear to correlate with waste water production as well as the number of metric tons (tons) of finished product.

Raw Materials-

Soda-lime glass is used to some extent in all subcategories except television picture tube envelope manufacturing. The basic composition of the batch mix remains the same; however, there may be minor variations in raw material composition depending on the manufacturer and the product. Sand (silica) is the major ingredient and accounts for about 70 percent of the batch. Another major ingredient is soda (sodium oxide) or soda ash which is about 13 to 16 percent of the batch. Soda and sometimes small quantities of potash (potassium oxide) are added as fluxing agents which reduce the viscosity of the mixture greatly below that of the silica. This permits the use of lower melting temperatures and thereby improves the process by which undissolved gases are removed from the molten glass. Lime (calcium oxide) and small amounts of alumina (aluminum oxide) and magnesia (magnesium oxide) are added to improve the chemical durability of the glass; iron or other materials may be added as coloring agents. The usual batch also has between 10 and 50 percent cullet. The quantity of cullet added depends on the availability and allowable levels in the total batch.

Cullet is waste glass that is produced in the glass manufacturing process. Principal sources are product rejects, breakage, or intentional wasting of molten glass to produce cullet. The addition of cullet improves the melting qualities of the batch because of its tendency to melt faster than the other ingredients, thus providing starting points from which the melting can proceed.

Other glass types used by pressed and blown glass manufacturers include lead-alkali silicate glass and borosilicate glass. Lead oxide replaces the lime of the soda-lime glass to form lead-alkali silicate glasses. The lead oxide acts as a fluxing agent and lowers the softening point below that of the soda-lime glass. The lead oxide also improves the working qualities of the glass when the lead oxide proportion is less than about 50 percent. Lead-alkali silicate glass is used in the production of television picture tube envelopes and lead crystal. Lead apparently limits radiation in the television picture tube application.

Boric oxide acts as the fluxing agent for silica in borosilicate glasses. Boric oxide has less effect than soda in lowering the viscosity of silica and in raising the coefficient of expansion. A higher melting temperature is required for borosilicate glasses than for soda-lime and lead-alkali silicate glasses. The borosilicate glass is also more difficult to fabricate than the other two glass types. The primary advantages of borosilicate glass are its coefficients of expansion and its greater resistance to the corrosive effects of acids. The lower coefficient of expansion allows the glass to be used at higher temperatures. Borosilicate glass is used for machine pressed products such as lenses and reflectors, for some incandescent lamp envelopes, and for tubing that is to be fabricated into laboratory and scientific glassware.

Raw Material Storage and Mixing-

Raw materials are shipped to the glass manufacturers in bulk quantities. The raw materials are conveyed automatically to large storage silos or holding bins. Cullet is transported from the points where it is produced, and then sent to segregated storage areas according to the type and color of the cullet.

Batch weighing and mixing is usually done according to formulas which are based on either 454 kilograms (1000 pounds) of glass or on 454 kilograms (1000 pounds) of sand. The type of mixing systems used at the pressed and blown glass manufacturing plants range from hand batching at small hand pressed and blown glass plants to fully automatic systems. Water is also added to the batch at some plants to reduce segregation of the batch and to control dust emissions during mixing. After mixing, the glass batch is charged into the glass furnace manually or automatically. Furnace charging can be either continuous or intermittent.

Melting-

Melting is done in three types of units, according to the amount of glass required. Continuous furnaces are standard at the glass container, machine pressed and blown, glass tubing, television picture tube envelope, and incandescent lamp envelope plants, but clay pots and day tanks are used in the manufacture of hand pressed and blown ware.

Pots and day tanks are well suited for the variable composition and small quantities of glass required in handmade glass plants. The multi-pot furnace is the primary method of melting in these plants. Eight or more pots may be grouped in a circular arrangement as part of one furnace. Temperatures as high as 1400 degrees centigrade (2550 degrees Fahrenheit) may be achieved. Pot capacities range from 9 kilograms (20 pounds) to 1820 kilograms (two tons). A day tank is a single furnace and is somewhat larger than a pot, generally having a capacity of several metric tons (tons). Both pots and day tanks are batch fed at the end of the working day and allowed to melt overnight.

Continuous tanks range in holding capacity from 0.9 to 1270 metric tons (one to 1400 tons), and outputs may be as high as 273 kkg/day (300 tons/day). The continuous tank consists of two areas, a melting chamber and a fining chamber. The chambers are separated by an internally cooled wall built across the tank. The fining chamber allows gas bubbles to leave the melt. Extensions from the fining chamber called forehearths are used to condition the glass before forming.

Forming-

Several methods are used to form pressed and blown glassware. These include blowing, pressing, drawing, and casting.

Blowing--The individual section (I.S.) forming machine is the most widely used method for making glass containers. Forming of the glass container involves several blowing steps. The molten glass is cut into gobs by a set of shear cutters as the glass leaves the forehearth of the melting tank. Chutes direct the gobs into blank molds. The shear cutter and chutes are lubricated and cooled with a spray of emulsified oil. The molten glass gob is settled with compressed air and preformed with a counter blow. The preformed gob (parison) is then inverted and transferred into a blow mold where the glass container is finished by final blowing.

A pressing and blowing action is used to form wide-mouthed containers. The molten glass gob is cut and delivered to the mold, and the gob is then pressed and puffed. The preformed gob is inverted for final blowing to complete the forming of the container.

A few Owens machines are still in use but these are slowly being replaced by I. S. machines, owing to the higher production and lower operating expense associated with these units. The Owens machine consists of a number of molds arranged around a central axis. The entire machine rotates and glass is sucked by vacuum into the parison mold. The parison is then transfered to the blow mold for final blowing. Shear or chute sprays are not required for these machines.

Incandescent lamp glass envelopes are formed using a ribbon machine. The ribbon machine employs modified blowing techniques to form the envelopes. The molten glass is discharged from the melting tank in a continuous stream and passes between two water cooled rollers. One roller is smooth while the other has a circular depression. The ribbon produced by the rollers is then redirected horizontally on a plate belt. The plate belt runs at the same speed as the forming rollers. Each plate on the plate belt has an opening and the pill shaped glass portion of the ribbon sags through the openings due to gravity. The glass ribbon is met by a continuous belt of blow heads; the blow heads aid the sag of the glass by properly timed compressed air impulses. After the glass has been premolded, it is enclosed by blow molds which are brought up under the premolded glass on a continuous belt. The blow molds are pasted and rotate about their own axis to obtain seamless smooth surfaces. Both the blow heads and molds are lubricated with a spray of emulsified oil (shear spray). The formed envelopes (bulbs) are separated from the ribbon by scribing the neck of the bulb and tapping the bulb against a metal bar. Residual glass is collected as cullet.

Hand blow glassware is made using a blowpipe. Molten glass is gathered on the end of the blowpipe and, utilizing lung power or compressed air, is blown into its final shape. After the main section is formed, additional parts such as handles and stems can be added. This is accomplished by gathering a piece of molten glass, joining it to the molded piece,and then forming the joined pieces with special glassworking tools.

Pressing--Much glassware is manufactured using presses. A press mold consists of three sections: the mold bottom, the plunger, and an enclosing ring that seals the mold between the mold bottom and the plunger. Pressing is done manually in the handmade subcategory or by machine in the remainder of the industry.

In manual pressing of glassware, molten glass is collected on a steel rod and allowed to drop into the mold bottom. When the proper amount of glass is deposited in the mold, the glass remaining on the rod is separated from that in the mold by cutting with a pair of shears. The plunger is then forced into the mold with sufficient pressure to fill the mold cavities. The glass is allowed to set-up before the plunger is withdrawn and the pressed glass is removed from the mold.

Machine pressing is done on a circular steel table. The glass is fed to the presses in pulses from a refractory bowl following the forehearth of the melting tank. The molten glass is cut into gobs by oil-lubricated shear cutters beneath the orifice of the refractory bowl. The motions of the shear cutters and the press table are synchronized such that the gobs fall into successive molds on the press table. After the gob is received in the mold, it moves to the next station on the press table, where it is pressed by a plunger. In the remaining stations, the pressed glass is allowed to cool before it is removed from the press and conveyed to the annealing lehr.

The mold bottoms are usually cooled by air jets and the plunger sections are cooled with non-contact cooling water. The mold temperature is critical; if the mold is too hot, the molded piece will stick to the mold and if it is too cold, the piece may have an uneven surface. In some cases, the mold is sprayed with water prior to receiving the glass. The steam formed when the molten glass is introduced helps prevent sticking. Machine pressed glass products include tableware, lenses, reflectors, and television picture tube faceplates.

Shear Spray--In the manufacture of most machine-made pressed or blown glass products, blow heads, molds, and shearcutters are lubricated and cooled with a spray of emulsified oil (shear spray). This may be made up of petroleum or synthetic oils of an animal of vegetable nature. The trend in recent years has been to utilize synthetic biodegradable shear spray oils.

Drawing--Glass tubing may be formed using three different processes. In the Danner process, a regulated amount of glass falls upon the surface of a rotating mandrel which is inclined to the horizontal. Air is blown through the center of the mandrel continuously to maintain the bore and the diameter of the tubing as it is drawn away from the mandrel. The tubing is pulled away from the mandrel on rollers by the gripping action of an endless chain. Tubing dimensions are controlled by the drawing speed and the quantity of air blown through the center of the mandrel. The tubing is scribed by a cutting stone that is accelerated to the drawing speed and pressed vertically against the tubing and then cut by bending against a spring controlled roller.

The Vello and Updraw processes can also be used to form tubing. In the Vello process, the molten glass passes downward through the annular space between a vertical mandrel and a refractory ring set in the bottom of a special forehearth section of the melting tank. The tubing is drawn away from the Vello machine and cut in a manner similar to that used for the Danner Process.

The Updraw process is used to make large diameter tubing and glass pipe. In the Updraw process, the tubing is drawn upward from a refractory cone. Air is blown up through the cone to control dimensions and cool the tubing. The tubing is cut into lengths at the top of the draw.

Casting--Television picture tube envelope funnels are formed by casting. Molten glass is cut into gobs by oil-lubricated shear cutters. The glass gob is then dropped into the mold. The mold is spun sufficiently fast that the centrifugal force causes the glass to flow up the sides of the mold to form a wall of uniform thickness. A sharp-edged wheel is used to trim the upper edge of the funnel at the end of the spinning operation.

Cullet Quenching-

Cullet is waste glass that is produced both intentionally and inadvertently. Cullet results from breakage, wasting of molten and formed glass during production interruptions or machine maintenance, rejection of formed pieces because of imperfections, and intentional wasting. Wasting of glass during production interruptions is necessary to maintain a steady flow of glass through the melting furnace. All portions of the pressed and blown glass segment except for hand pressed and blown glass manufacturing are effected by this requirement. Cullet is conveyed from the manufacturing operation by chutes into carts or tanks located in the furnace basement.

A continuous stream of water is discharged through the chutes and into the quench carts and tanks to cool or quench the hot glass. Excess water overflows from the quench cart or tank and is discharged into the sewer. When the cart or tank is filled with glass, it is removed from the quench stream, allowed to drain, and conveyed to a storage area where the cullet is dumped. In some plants, quench carts have been replaced by water-filled vibrating conveyors that automatically remove cullet to the storage area. Cullet is segregated according to type and color.

Annealing-

After the glass is formed, annealing is required to relieve strains that might weaken the glass or cause it to fail. The entire piece of glassware is brought to a uniform temperature high enough to permit the release of internal stresses and then cooled at a uniform rate to prevent new strains from developing. Annealing is done in long continuous ovens called lehrs. The dimensions of the lehr depend upon the type of glass to be annealed.

Finishing-

Following annealing, the pressed and blown glass is either finished or inspected, packaged, and shipped. Glassware from all subcategories may, in some cases, be finished but many finishing steps require no water and produce no waste water. This study includes the major waste water producing finishing steps that are normally employed at the same location where the glass is produced. These are television picture tube envelope finishing, incandescent lamp envelope frosting, and hand pressed and blown glass finishing.

Television picture tube envelopes--Television picture tube envelopes are manufactured in two pieces, referred to as the screen and funnel. Both pieces require the addition of components prior to annealing and several finishing steps which follow annealing. After forming and prior to annealing, the seam on the screen is fire polished and mounting pins are installed employing heat. The mounting pins are required for proper alignment when the electronic components are placed into the picture tube.

The stem portion and an anode to be used as a high voltage source are added to the funnel prior to annealing. Both components are fused onto the funnel using heat.

Following annealing, screens and funnels are visually inspected for gross defects such as large stones, blisters and entrapped gas bubbles. The screen dimensions and mounting pin locations are then gaged to check for exactness of assembly. The funnel portion is not gaged until all finishing steps are completed.

Screens and funnels are finished separately using different equipment. The first finishing step applied to the television screen section is abrasive polishing. Polishing is required to assure a flawless and parallel surface alignment so that an undistorted picture will be produced when the tube is assembled. The edge of both the screen and funnel must be perfectly smooth so that a perfect seal will be formed when the two sections are glued together. The seal must be sufficiently tight to hold a vacuum.

Abrasive polishing is accomplished in four steps using rough and smooth garnet, pumice, and rouge or serium oxide. The abrasive compounds are in a slurry form and are applied to the screen surface by circular polishing wheels of varying texture. Between each polishing step the screen is rinsed with water. The slurry solutions are generally recycled through hydroclones or settling tanks and only fine material too small to be useful for grinding or polishing is wasted. Following abrasive polishing, the screen edge is ground, beveled, and rinsed with water. This edge is then dipped in a hydrofluoric acid solution to polish and remove surface irregularities. This step may be referred to in the industry as fortification. Following rinsing, which removes residual acid, and drying, the screen receives a final inspection.

The front edge of the funnel is polished with a diamond wheel polisher. The polishing surface is bathed in oil and, therefore, the funnel must be rinsed with water to remove the oily residue. The edge of the funnel is then beveled and dipped in a combination of hydrofluoric and sulfuric acids to polish or fortify. Following the acid dip, the funnel is rinsed with water and dried before final gaging and inspection.

Incandescent lamp envelopes--An incandescent lamp envelope may be defined as the glass portion of a light bulb. Generally, envelopes are not manufactured in the same plant where the bulbs are assembled, and assembly is not covered by this study. Envelopes may be clear, coated, or frosted, but either by habit or for esthetic reasons, frosted bulbs are the most popular with consumers. Frosting improves the light diffusing capabilities of the envelope. Generally, lamp envelopes are frosted at the plant where the envelope is produced and coatings are applied where the bulb is assembled.

After annealing, the lamp envelopes are placed in racks for processing through the frosting operation. The envelope interior is sprayed successively with several frosting solutions. The specific formulation of these solutions is proprietary, but primary constituents include hydrofluoric acid and other fluoride compounds, ammonia, water, and soda ash. Residual frosting solution is removed in several rinse stages.

Hand pressed and blown--The manufacture of hand pressed and blown glass involves several finishing steps including: crack-off, washing, grinding and polishing, cutting, acid polishing, and acid etching. The extent to which these methods are employed varies substantially from plant to plant. Many plants use only a few of the finishing methods. Washing and grinding and polishing are the most prevalent.

Crack-off is required to remove excess glass that is left over from the forming of hand blown glassware. Crack-off can be done manually or by machine. When a machine is used for stemware, the stemware is inserted into the crack-off machine in an inverted position. The bowl of the stemware is scribed by a sharp edge, the scribed edge passes by several gas flames and the excess glass is broken off. The scribed surface is then beveled on a circular grinding medium similar to sandpaper. Carborundum sheets are used in most cases. The grinding surface is sprayed with water for lubrication and to flush away glass and abrasive particles.

Hydrofluoric acid polishing of the beveled edge may follow crack-off. This operation involves rinsing the glassware in dilute hydrofluoric acid and city water, and in some cases, a final deionized water rinse.

Miscellaneous washing is employed throughout a handmade glass plant and is associated with many finishing steps. Generally the glassware receives a final washing before packaging and shipment. In many cases this is done by hand in a small sink and the glassware is hand-dried.

Mechanical washers are used in the larger plants. These units may include several washes and rinses. In one such system, a recirculating acid rinse is followed by a caustic rinse, a city water rinse, and finally a steam spray to heat the glassware and thus facilitate drying.

Abrasive grinding is used to remove sharp surfaces from the formed glass products. Grinding is accomplished using a large circular stone wheel. The glassware is placed in a rack and weights are added to hold it against the rotating stone. The grinding surface is lubricated with slowly dripping water.

Abrasive polishing is used to polish the glass surfaces and edges of some types of handmade glassware. The glassware is placed in a bath of abrasive slurry and brushed by circular mechanical brushes or polishing belts. After polishing, the ware is rinsed with water in a sink and dried.

Cutting as applied to handmade glassware manufacturing may be defined as the grinding of designs onto the glassware or as the removal of excess glass left over from forming. Designs may be placed onto the glassware manually or by machine. In mechanical design cutting, the ware is placed on a cutting machine and is rotated in a circular motion. Designs are cut into the surface at the desired points using a cutting edge. In the second form of cutting, a saw may be used to remove excess glass from some handmade products. Water is used in both machine design cutting and sawing to lubricate the cutting surface and to remove cutting residue.

Acid polishing may be employed to improve the appearance or to remove the rough edges from glassware. Automatic machines or manually dipped racks may be employed. In the manual operation, the glassware is placed in racks and treated with one or more hydrofluoric acid dips followed by rinsing. The complexity and number of steps is determined by the product. Many plants use a one- or two-step acid treatment followed by two rinses. At least one plant has a more complicated system using a series of hydrofluoric acid, sulfuric acid, and water rinses.

Some of the larger plants employ automatic polishing techniques. The glassware is loaded into acid-resistant plastic drums and placed in the treatment vessel. Acid contact and rinsing is accomplished automatically according to a preset cycle.

Complicated designs may be etched onto handmade stemware with hydrofluoric acid. The design is first made on a metal template and is transferred from the template to a piece of tissue paper by placing a combination of beeswax and lampblack in the design and then pressing the tissue paper against the design. The tissue paper is placed on the stemware and then removed leaving the pattern in wax. All parts of the ware except for the pattern are then coated with wax. The wax-coated stemware is placed in racks and immersed in a tank of hydrofluoric acid where the exposed surfaces are etched. Following a rinse to remove residual acid, the ware is placed in a hot water tank where the wax melts and floats to the surface for skimming and recycling. Several additional washes and rinses are required to clean the ware and to remove salt deposits from the etched surfaces. In some cases a nitric acid bath may be used to dissolve these deposits. Deionized water may be used for the final rinse to prevent spotting.

Miscellaneous finishing--Numerous finishing steps that do not produce waste water are employed throughout the industry. These are not of direct concern to this study and therefore are not covered in detail. These finishing operations may be generally classified as decorating or, in the container industry, as labeling. In most cases, some form of paint or coating is applied and then baked onto the glass surface. This procedure is referred to as glazing in the handmade industry.

SECTION IV

INDUSTRY CATEGORIZATION

The pressed and blown glass manufacturing industry, covered by this study, includes a large and diverse group of products produced by distinctly different manufacturing methods; these methods generate waste waters with differing waste characteristics. Subcategorization into smaller segments was necessary in order to develop meaningful and workable effluent limitations and guidelines and new source performance standards.

The following factors were given major consideration with respect to subcategorization:

1. Raw materials

2. Age and size of production facilities

3. Products and production processes

4. Waste water characteristics

5. Applicable treatment methods

It is concluded that six subcategories are necessary to adequately subdivide the industry and that, owing to variable finishing requirements, several of these subcategories should be further segmented. The subcategories and the identified further segmentation are as follows:

1. Glass Container Manufacturing

2. Machine Pressed and Blown Glass Manufacturing

3. Glass Tubing Manufacturing

   a. Glass Tubing - Danner process

4. Television Picture Tube Envelope Manufacturing

5. Incandescent Lamp Envelope Manufacturing

    a. Forming
    b. Frosting

6. Hand Pressed and Blown Glass Manufacturing

    a. Leaded and Hydrofluoric Acid Finishing
    b. Non-Leaded and Hydrofluoric Acid Finishing
    c. Non-Hydrofluoric Acid Finishing

Production methods and waste water characteristics are the primary bases for subcategorization. Further segmentation within a subcategory is necessary because of processing differences and/or because of variable finishing requirements. For example, the forming and frosting unit operations involved in the incandescent lamp envelope manufacturing subcategory are vastly different both in terms of water usage and waste characteristics. However, the basic necessity for further segmentation is derived from the fact that not all facilities which produce (form) incandescent lamp envelopes will frost equal fractions of the formed envelopes. This necessitates the use of separate limitations applicable to each of the two major unit operations in order that any producer of incandescent lamp envelopes may be properly characterized.

During the comment period following the proposal of regulations pertaining to effluents discharged by plants which make up the pressed and blown glass segment of the glass manufacturing point source category, considerable additional data was submitted with regard to the machine pressed and blown glass manufacturing subcategory. This additional data and other information are being studied at the present time. Also, more information is being gathered concerning the manufacture of glass tubing. The results of these further analyses will be presented at a later date in a supplemental document. Available data pertaining to the machine pressed and blown glass manufacturing subcategory and the glass tubing (Danner) manufacturing subcategory are presented in Section V of this document. However, recommended effluent limitations pertaining to the machine pressed and blown glass manufacturing and the glass tubing (other than by the Danner process) manufacturing subcategories will be included in the supplemental document.

Raw Materials

Several types of glass are required in the pressed and blown glass industry. Soda-lime glass is used wherever possible, as it is the least expensive to produce. Borosilicate glass is required where the thermal coefficient of soda-lime glass is not satisfactory. Borosilicate glass is used for some machine pressed and blown products, tubing that is to be made into scientific glassware, and for some incandescent lamp envelopes. Lead-alkali silicate glass is required for television picture tube envelopes and for many types of handmade glassware.

Available data do not show any relationship between raw materials and waste water characteristics except where leaded glass is finished, such as in a television picture tube or handmade glass plant. The soluble and insoluble lead is discharged as a result of cutting, grinding and polishing, or hydrofluoric acid treatment. Because lead is discharged as a result of finishing operations and apparently is not discharged as a result of forming, raw materials do not provide a significant basis for subcategorization.

Age and Size of Production Facilities

Many pressed and blown glass manufacturing processes and techniques have been used since the early part of this century. Improvements in automation and water conservation have been made over the years but because furnaces are rebuilt every three to six years, these improvements have generally been applied to new and old plants alike.

Waste water volume and characteristics expressed per unit of production do not vary significantly with respect to plant size. Equipment of the same type and size is generally used throughout the industry to manufacture a given product. Plant size or production output is increased by operating more units in parallel. For these reasons, the age or size of production facilities provides no basis for subcategorization.

Products and Production Processes

The pressed and blown glass industry is readily categorized into distinct products and production processes. Each product is unique to a particular subcategory. These differences in production methods provide a basis for subcategorization. Glass container manufacturing is characterized by multi-blow forming techniques; machine pressed and blown glass manufacturing by the automated press or multi-blow forming techniques; tubing manufacturing by mandrel forming and drawing; television picture tube envelope manufacturing by funnel casting and abrasive and acid polishing; incandescent lamp envelope manufacturing by ribbon machine forming and frost finishing; and hand pressed and blown glass manufacturing by hand blowing and hand pressing and by numerous finishing steps applied to the glassware. The typical plant production, expressed as metric tons per day, for these manufacturing methods also varies significantly.

All of the manufacturing methods except those employed for handmade glassware may be broadly classified as machine pressing or blowing, but subcategorization is necessary because of the distinct variation in manufacturing methods, typical production rates, and waste water characteristics. The machine pressed and blown subcategory is intended to cover the forming of products not covered under the other subcategories. This portion of the industry is the subject of further study at the present time. Results of this analysis and a further analysis of the entire glass tubing industry will be published at a later date.

Further categorization of the incandescent lamp envelope manfacturing subcategory is necessary because not all of the products formed are finished. The percentage of incandescent lamp envelopes frosted varies from plant to plant. Forming waste water characteristics are influenced by the metric tons pulled from the furnace, while frosting waste water characteristics are governed by the metric tons of product frosted.

Further categorization of the hand pressed and blown glass manufacturing subcategory is necessary to take into account the various finishing operations which are applied to the various types of glass. Certain plants apply hydrofluoric acid finishing techniques to either leaded or unleaded glass while other plants do not utilize hydrofluoric acid. The further categorization is recommended in order that effluent limitations guidelines be applied only to those parameters which are consistent with the discharge from an individual hand pressed and blown glass manufacturing plant.

Waste Water Characteristics

Waste water volumes and characteristics are directly related to the manufacturing method and the quantity and quality of the product produced. Forming waste waters may generally be characterized in terms of oil and suspended solids. Finishing waste characteristics are variable and depend upon the finishing technique employed. Some finishing wastes contain only suspended solids, while others contain suspended solids, fluoride, lead, or ammonia. The volume of waste water expressed in terms of production is substantially different within each of the subcategories. Waste water characteristics form a basis for subcategorization.

Applicable Treatment Methods

Treatment methods are essentially the same throughout the pressed and blown glass segment. Gravity separation methods are used to remove oil from forming waste water; precipitation with lime addition, followed by coagulation and sedimentation is employed to remove fluoride, lead, and suspended solids from finishing wastes. Treatment methods are not a basis for subcategorization because of similarities of the treatment within the pressed and blown glass segment.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

Water is used to some extent in all of the subcategories covered by this study. Cooling water is required at all plants. Water is used in the glass container manufacturing, machine-pressed and blown glass manufacturing, and glass tubing manufacturing subcategories for non-contact cooling and cullet quenching. The television picture tube envelope manufacturing, incandescent lamp envelope manufacturing, and hand pressed and blown glass manufacturing subcategories use water for non-contact cooling, cullet quenching, and also for product rinsing following the various finishing steps specific to each subcategory.

Water used in-plant is obtained from various sources including the city water supply, surface, or ground water. City water is used in almost all cases, except where a plant-owned source is available.

AUXILIARY WASTES

For the purpose of this study, non-contact cooling, boiler, and water treatment waste waters are considered auxiliary wastes as distinguished from process waste waters. Process waste water is defined as water that has come into direct contact with the glass, and results from a number of sources involving both forming and finishing.

Pretreatment requirements depend upon the raw water quality and the intended water use. Cooling water pretreatment practices may range from no treatment to coagulation - sedimentation, filtration, softening, or deionization. Treatment is normally applied to prevent fouling of the cooling system by clogging, corrosion, or scaling. Boiler water treatment depends on boiler requirements. Treatment normally involves the removal of suspended solids and at least a portion of the dissolved solids. The waste waters developed from pretreatment systems are highly variable and depend upon the characteristics of the water being treated.

Auxiliary waste waters generated by the pressed and blown glass industry are similar to those throughout industry using the same cooling, boiler, and water pretreatment systems. Owing to highly variable volumes and characteristics, auxiliary waste waters are not included in the effluent limitations and standards of performance developed for process wastes. Auxiliary wastes will be studied at a later date and characterized separately for industry in general. The values thus obtained will be added to the limitations for process waste water to determine the effluent limitations and standards of performance for the total plant.

It is general practice within the pressed and blown glass segment that both auxiliary and process wastes are discharged together and not segregated. The bulk of the data received pertaining to this industry segment applied to the combined process and auxiliary waste water streams. For this reason, data presented in this section and in other sections of this document are carefully referred to as pertaining to combined non-segregated waste water streams or segregated waste water streams, whichever is appropriate.

GLASS CONTAINER MANUFACTURING

Glass container manufacturing consists of melting raw materials and then forming the molten glass using a blow-mold technique. The major process steps and points of water usage are shown in Figure 5. A detailed description of the manufacturing process is given in Section III.

Process Water and Waste Water

Process water is used for cullet quenching and non-contact cooling of the batch feeders, melting furnaces, forming machines, and other auxiliary equipment. At some plants, a small amount of water is also added to the batch to control dust. The volume discharged depends on the quantity of once-through cooling water and on the water conservation procedures employed at the glass container plant. The typical flow is representative of a plant using some once-through cooling water and practicing reasonable water conservation.

Batch Wetting-

Water is added to the batch for dust suppression at some plants in all of the subcategories covered by this study, but the practice is not considered typical for the industry. When water is added, it is generally at a rate of about 11.5 l/metric ton (2.75 gal/ton).

Cooling-

Non-contact cooling water is used to cool batch feeders, melting furnaces, forming machines, and other auxiliary equipment. The typical flow of cooling water is 1380 l/metric ton (330 gal/ton). This represents 47 percent of the total flow. Reported and calculated heat rejection rates vary from 361,000 kg-cal/metric ton (1,300,000 BTU/ton) to 13,900 kg-cal/metric ton (50,000 BTU/ton). Owing to the wide variation and absence of sufficient information to explain the differences, it is not possible to define a typical heat rejection value. The average value is 97,300 kg-cal/metric ton (350,000 BTU/ton).

Cullet Quenching-

Cullet quench water is required to dissipate the heat of molten glass that is intentionally wasted or discharged during production interruptions, or to quench hot pieces which are imperfect. Some plants use non-contact cooling water for the dual purposes of furnace and equipment cooling and cullet quenching. The typical cullet quench water flow is 1540 l/metric ton (370 gal/ton) or 53 percent of the total flow.

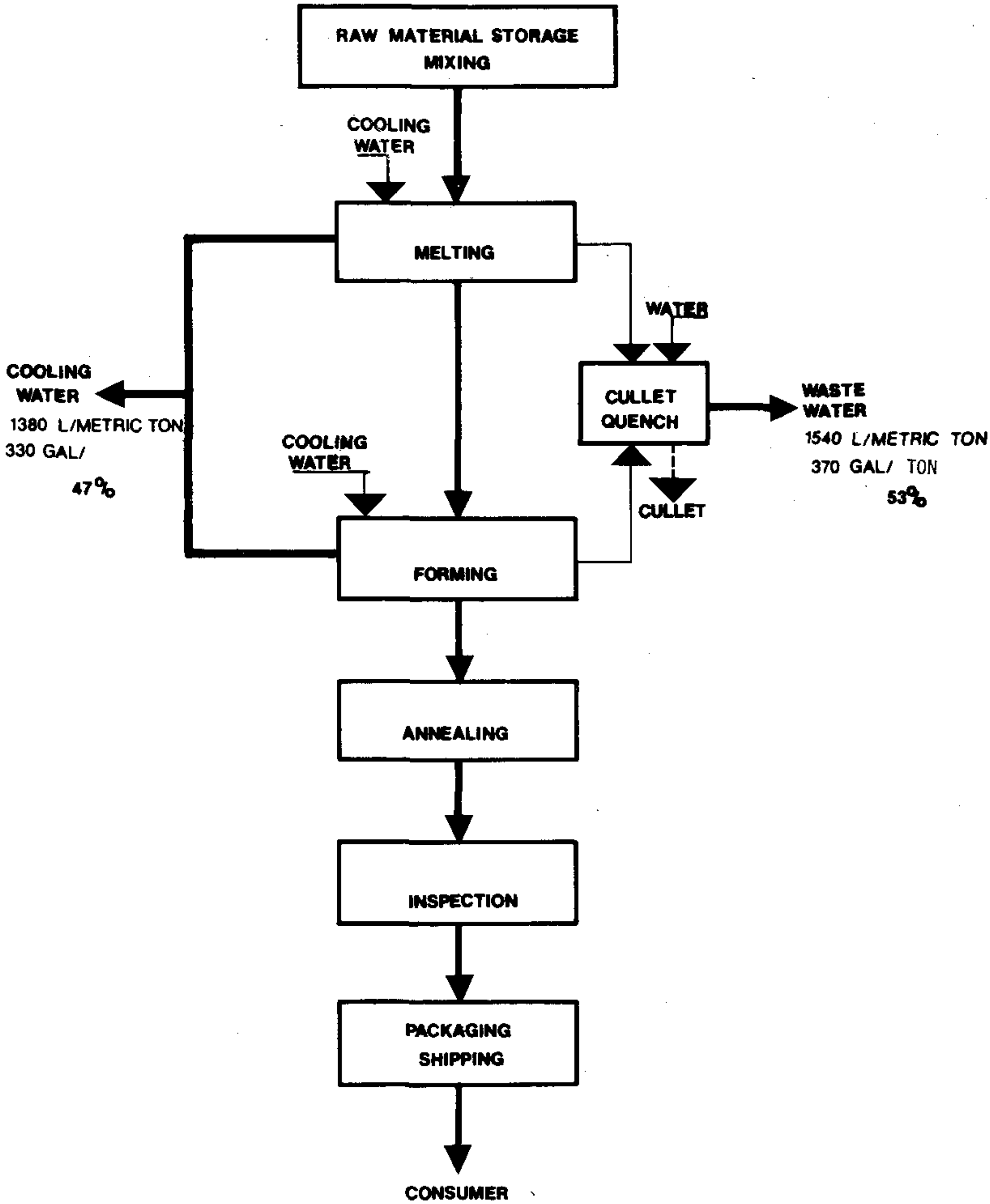

FIGURE 5

GLASS CONTAINER MANUFACTURING

Miscellaneous Wastes-

Repair and maintenance departments are required in all glass container plants. Waste water is produced in the maintenance departments from the cleaning of production machinery. The machinery is inspected, cleaned, and repaired at specific intervals. The cleaning operation includes steam cleaning of large parts and caustic batch cleaning of items such as molds. The waste water from the maintenance department is of very low volume and is primarily occasional rinse water from the cleaning operations.

Several glass container plants have corrugator facilities to manufacture boxes. Wastes developed from the corrugator facilities are of low volume and include cleanup water from the gluing and ink labeling equipment, lubricating oil, and steam condensate. The wastes are usually contained at the plant site and treated or discharged to a municipal sewer system. The corrugator box manufacturing operation is not covered in the SIC codes under study in this report.

Waste Water Volume and Characteristics

Typical characteristics for the combined non-contact cooling and cullet quench waste water streams for a glass container plant are listed in Table 5. In all cases, except for pH, the values listed are the quantities added to the water as a result of glass container manufacturing; concentrations in the influent water have been subtracted. The significant parameters are oil and suspended solids. BOD and COD are a result of oil in the waste water; control of oil therefore controls oxygen demand.

Flow-

The quantity of waste water produced in the manufacture of glass containers is highly variable. Flows range from near zero to 6250 l/metric ton (1500 gal/ton) or from near zero to 2460 cu m/day (.65 mgd). Some plants have indicated no discharge, but are apparently discharging an unknown quantity of blowdown. This blowdown may be in the form of water carried with the cullet and fed to the furnace during batching. The typical flow is 2920 l/metric ton (700 gal/ton). The amount of water usage depends, to a certain extent, on the raw water source and age of the plant. Glass container plants receive water from various sources including plant-owned wells, surface water, and municipal water systems. The amount of water conservation and recirculation is considerably greater at plants that use water from a municipal system. Plant age is another factor which may affect water usage. Newer plants may use somewhat less water because of more attention to water conservation.

Biochemical Oxygen Demand-

A small amount of BOD is added to the waste water as shear spray or lubricating oil. Shear spray is an oil-water emulsion used to cool and lubricate the shears and the chutes that convey the glass to the

TABLE 5

RAW WASTE WATER (a)
GLASS CONTAINER MANUFACTURING

Flow	2920	l/metric ton	700	gal/ton	
Temperature	6°C		11°F		
pH	7.5				
BOD	0.0145	kg/metric ton	0.029	lb/ton	5 mg/l
COD	0.145	kg/metric ton	0.29	lb/ton	50 mg/l
Suspended Solids	0.07	kg/metric ton	0.14	lb/ton	24 mg/l
Oil	0.03	kg/metric ton	0.06	lb/ton	10 mg/l

(a) Representative of typical glass container manufacturing waste water. Absolute value given for pH, increase over plant influent level given for other parameters.

I.S. machine. Many plants now use a synthetic biodegradable shear spray to reduce the effects of oil on the receiving stream. Excess shear spray eventually finds its way into the cullet quench water. Another potential source of BOD is leakage of lubricating oils into the cooling water system. The typical raw waste water loading is 0.0145 kg/metric ton (0.029 lb/ton) of BOD_5.

Chemical Oxygen Demand-

The COD is contributed by the same sources that contribute BOD, namely shear spray oil and lubricating oil. The typical plant waste water contains 0.145 kg/metric ton (0.29 lb/ton) of COD.

Suspended Solids-

Suspended solids enter the plant waste water as the result of cullet quenching and plant cleanup. The cullet quench water picks up fine glass particles; additional suspended solids are added during cleanup of the I.S. machine area. A typical plant generates 0.07 kg/metric ton (0.14 lb/ton) of suspended solids.

Oil-

Oil is added to the plant waste water as shear spray oil and leaking lubricants. The typical oil loading is 0.03 kg/metric ton (0.06 lb/ton).

Other Parameters-

Some information is available on the temperature and pH of glass container plant waste waters. The average rise in temperature over the plant influent water is 6°C (11°F). The typical pH of the waste water is 7.5 and reported values range from 6.5 to 8.6.

Discussion-

Glass container plant operation is continuous (24 hr/day, 7 day/week); and, therefore, waste water flows are relatively constant. No significant variations in waste water volume or characteristics occur during plant startup or shutdown, and there are no known toxic materials in the waste water. The melting tanks must be drained every three to five years for rebuilding and excessive quantities of cullet quench water are produced for one or two days during this period. In larger plants with several furnaces, this discharge may occur several times a year. The very limited data available indicate that temperature is the only significant parameter and that receiving stream standards may necessitate cooling of the quench water in some cases.

MACHINE PRESSED AND BLOWN GLASS MANUFACTURING

Machine pressed and blown glass manufacturing consists of melting raw materials and then forming the molten glass using presses or other techniques to manufacture tableware, lenses, reflectors, sealed headlamp glass parts, and other products not covered in the other subcategories. The major process steps and points or water usage are listed in Figure 6. The manufacturing of machine pressed and blown products is more fully explained in Section III.

Process Water and Waste Water

Water is used in the manufacturing of machine pressed and blown products primarily for non-contact cooling and cullet quenching. Cullet quenching is the cooling of molten glass or hot rejects with water. Some plants use a portion of the non-contact cooling water for cullet quenching. Water may also be added to the batch for dust suppression and an oil-water emulsion is used for shear spraying. The following discussion of water usage is based upon a summary of data gathered prior to proposal of regulations for the pressed and blown glass segment of the glass manufacturing category. More information has been received and is being gathered for further analysis. The results of this study will be presented in a supplemental document at a later date.

Cooling-

Non-contact cooling water is required to cool batch feeders, melting furnaces, presses, and other auxiliary equipment. The typical flow of non-contact cooling water, based on all data received prior to publication of the proposed regulations for this subcategory, is 2710 l/metric ton (650 gal/ton). Non-contact cooling water amounts to 48 percent of the combined flow from this subcategory. Although no heat-rejection data is available for machine pressed and blown glass plants, it is expected that heat rejection requirements are similar to those of glass container plants.

Cullet Quenching-

Quench water is required at all machine pressed and blown glass plants to cool intentionally wasted molten glass during production interruptions and to quench hot pieces that are wasted or rejected because of imperfections. The configuration of equipment is similar to a glass container plant. Quench water and waste glass are discharged into chutes and flow to a cart located in the furnace basement. Excess quench water overflows the cart and is discharged to the sewer. The typical quantity of water used for cullet quenching, based on all data received prior to publication of the proposed regulations for this subcategory, is 2920 l/metric ton (700 gal/ton). This accounts for 52 percent of the total flow.

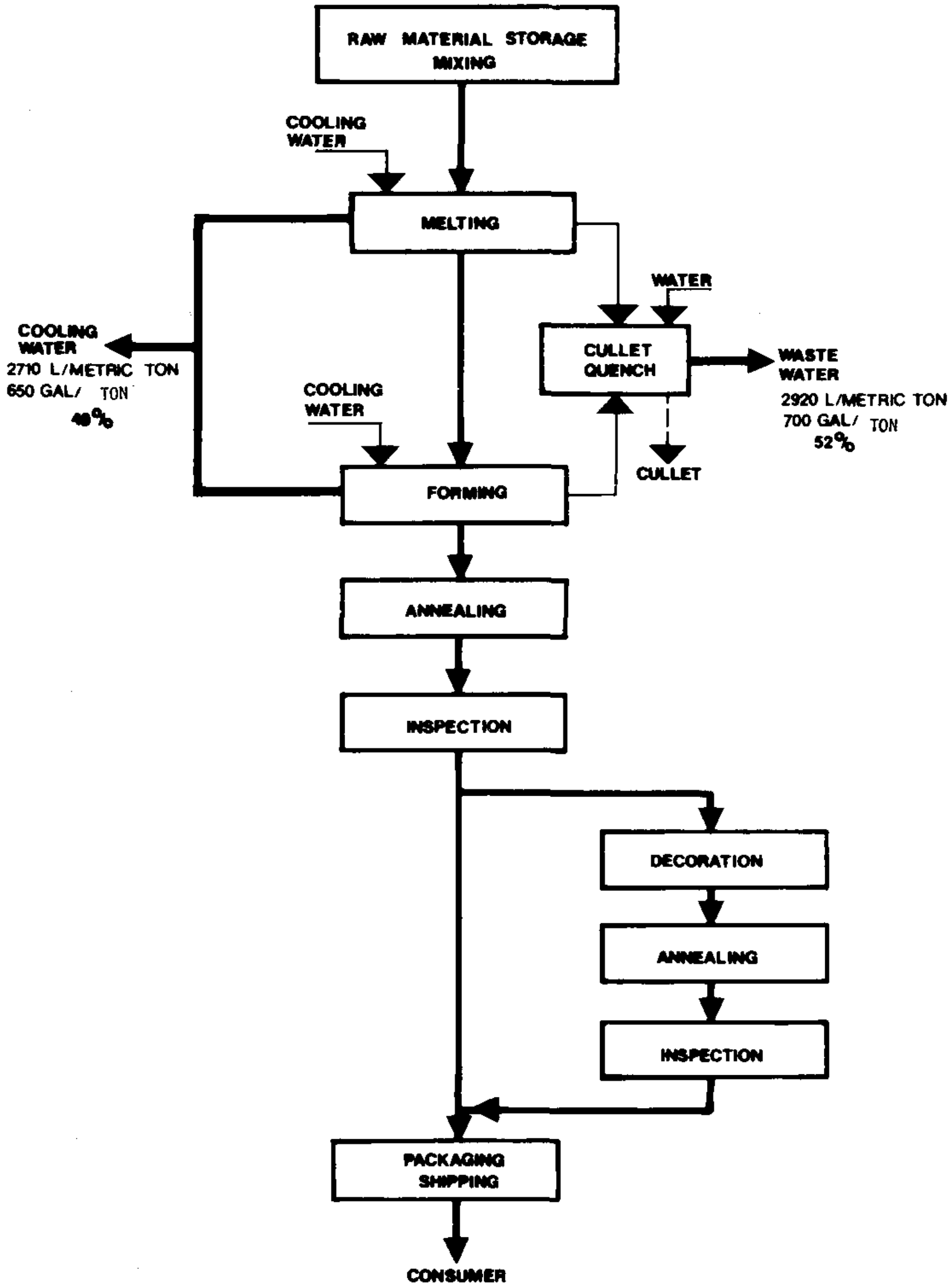

FIGURE 6

MACHINE PRESSED AND BLOWN GLASS MANUFACTURING

Miscellaneous Waste Water Sources-

Some machine pressed and blown glass plants have small plating shops where molds are periodically cleaned and chrome-plated. Low volumes of rinse waters are periodically discharged, but no evidence of chromium contamination was found in the data collected during this study. Chromium discharges should be regulated by the effluent limitations developed for plating wastes (17, 25).

Finishing may be employed at some machine pressed and blown glass plants, but most of the finishing techniques produce no waste water. The great majority of the finishing steps can be classified as decorating and involve painting or coating and re-annealing. Other finishing steps may produce small quantities of waste water, but these are not covered in this study. It is recommended that where treatment is required, the technology developed for hand pressed and blown glass finishing be applied.

Waste Water Volume and Characteristics

Typical characterisits of the combined non-contact cooling and cullet quench waste water streams, based on all information received prior to publication of the proposed regulations for this subcategory, are listed in Table 6. In all cases, except for pH, the values listed are the quantities added to the water as a result of the manufacture of machine pressed and blown glass products. Background concentrations in the influent water have been subtracted. Oil and suspended solids are the significant parameters. The COD is contributed by the oil.

Flow-

A variable volume of water is used during the manufacture of machine pressed and blown glass products. Flows ranging from 2,210 to 27,500 l/metric ton (530 to 6,600 gal/ton) or 87 to 2,650 cu m/day (0.023 to 0.7 mgd) were indicated. The typical combined flow of non-contact cooling water and cullet quench water, based on all information received prior to publication of the proposed regulations for this subcategory, is 5,630 l/ metric ton (1,350 gal/ton). The variation in water usage depends on the amount of once-through non-contact cooling used and also on the water conservation practiced at the various machine pressed and blown glass plants. Cullet quench water and non-contact cooling water are generally combined prior to discharge.

TABLE 6

RAW WASTE WATER (a)
MACHINE PRESSED AND BLOWN GLASS MANUFACTURING

Flow	5630	l/metric ton	1350	gal/ton	
Temperature	10°C		18°F		
pH	7.8				
BOD	0.028	kg/metric ton	0.056	lb/ton	5 mg/l
COD	0.28	kg/metric ton	0.56	lb/ton	50 mg/l
Suspended Solids	0.14	kg/metric ton	0.28	lb/ton	25 mg/l
Oil	0.056	kg/metric ton	0.11	lb/ton	10 mg/l

(a) Representative of typical machine pressed and blown glass manufacturing waste water. Absolute value given for pH, increase over plant influent level given for other parameters.

COD-

The typical COD added to the waste water, based on all information submitted prior to publication of the proposed regulations for this subcategory, is 0.28 kg/metric ton (0.56 lb/ton). The COD results primarily from shear spray and lubricating oil leaks.

Suspended Solids-

The suspended solids are fine glass particles picked up by the cullet quench water. The typical suspended solids loading, based on all information submitted prior to publication of the proposed regulations for this subcategory, is 0.14 kg/metric ton (0.28 lb/ton).

Oil-

Oil is added to the waste water as shear spray and lubricating oil. Water-soluble oil is used to lubricate the gob shear cutters and the glass gob chute. The shear spray oil flows from the gob chute and enters the cullet quench water. Lubricating oil leaks may also contaminate the cooling water and cullet quench water. The typical quantity of oil discharged, based on all information submitted prior to publication of the proposed regulations for this subcategory, is 0.056 kg/metric ton (0.11 lb/ton).

Other Parameters-

Some information is also available on BOD, pH, and temperature. The typical pH is 7.8 and the typical temperature rise is 10°C (18°F). The temperature increase resulting from cullet quenching alone is not known. This data appears in Table 6.

Discussion-

Machine pressed and blown glassware plants are operated on various schedules, some continuously, while others operate for an 8 hr/day, 5 day/week. Continuous operation is desirable because furnace heat must be maintained. Some glass must be wasted during the off periods to maintain the flow of glass through the furnace; therefore, cullet quench water is always required. No sifnificatn variations in waste volume or characteristics are experienced during plant start-up or shutdown, and there are no known toxic materials in process waste water resulting from the manufacture of machine pressed and blown glassware. Excessive quench water volumes will be produced when a tank is drained for rebuilding or for a change in the composition in this waste water source.

GLASS TUBING (DANNER) MANUFACTURING

The manufacture of glass tubing consists of melting raw materials and forming the molten glass on a rotating mandrel or other forming device. The partially formed tubing is then drawn into lengths and cut by scribing or by themal shock. The major process steps and points of water usage are illustrated in Figure 7. The glass tubing manufacturing process is more fully explained in Section III. The following discussion pertains to the manufacture of glass tubing by the Danner process which involves the melting of raw materials in a furnace and the mechanical drawing of the tubing from the furnace horizontally. As defined in this document, the Danner process requires intermittent rather than continuous quenching of cullet. The ramainder of the glass tubing industry is being studied at the present time. Other processes such as the Vello and Updraw processes and the production of tubing suitable for the manufacture of scientific glassware are being studied in further detail. The results of this analysis will be published in a supplemental document at a later date.

Process Water and Waste Water

The only process water used in the manufacturing of glass tubing by the Danner process is for cullet quenching. Cullet quenching is infrequent compared with that amount common to the other pressed and blown glass manufacturing subcategories and is done only when a break or disruption occurs in the drawing process. During this period, glass is wasted at the same rate that tubing is drawn so that a constant flow through the furnace is maintained.

Cooling-

Cooling water is primarily used for non-contact cooling of furnace walls and mandrel transmissions. The typical flow of non-contact cooling water is 7920 l/metric ton (1900 gal/ton) and accounts for about 95 percent of total plant water usage.

Cullet Quenching-

Cullet quenching is required only when there is a break or disruption in the drawing process. During a stoppage, molten glass continues to run over the mandrel or forming device, but is formed into a ribbon by two rollers that are cooled by a spray of water. The cullet ribbon and quench water drop to a segregated storage area in the melting tank basement. The quenching system is activated only when required. The typical flow is 420 l/metric ton (100 gal/ton) and accounts for five percent of the total typical flow.

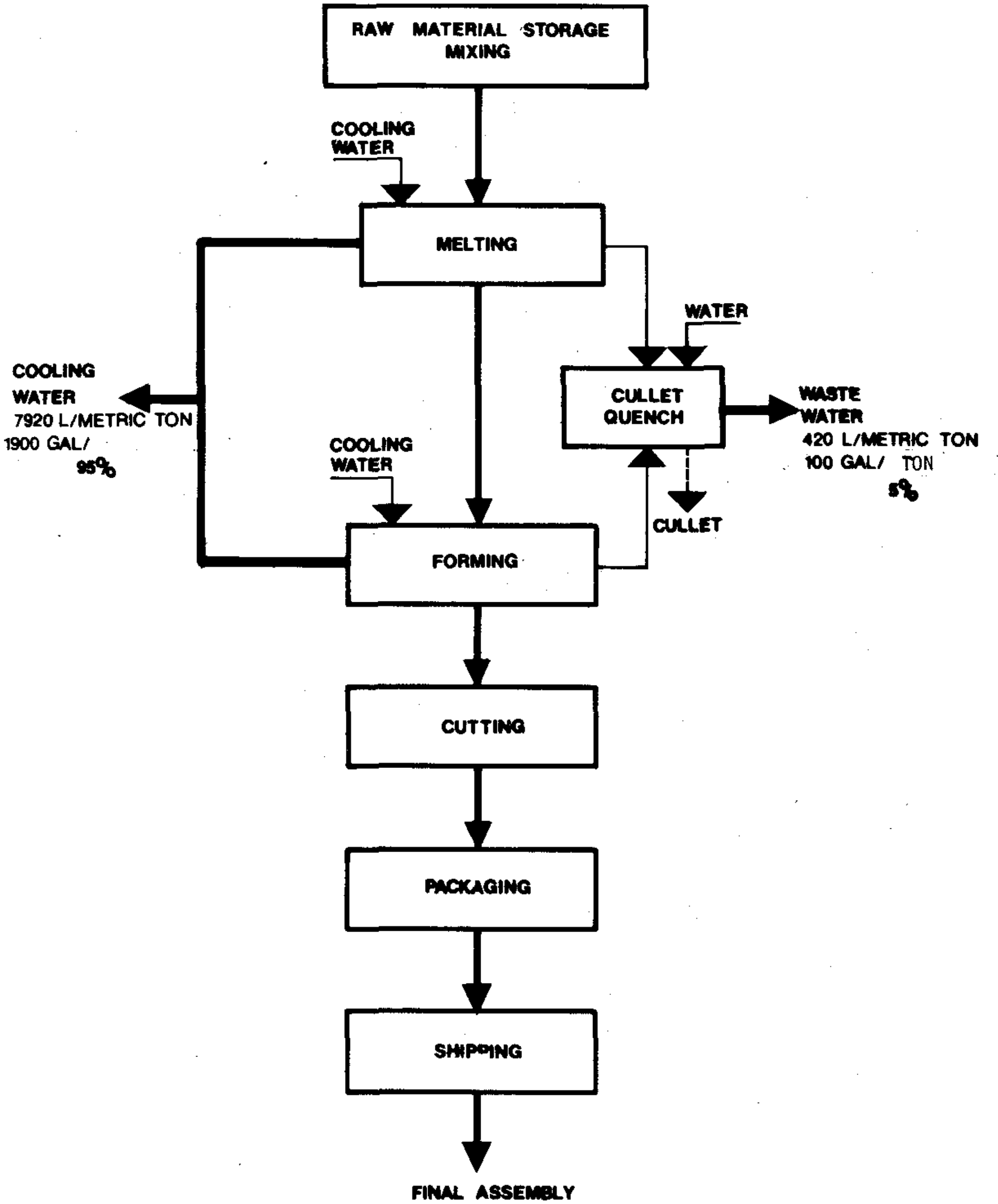

FIGURE 7

GLASS TUBING MANUFACTURING

Waste Water Volume and Characteristics

Some typical characteristics of the combined non-contact cooling and cullet quench waste waters resulting from glass tubing manufacturing by the Danner process are listed in Table 7. In all cases, except for pH, the values listed are the quantities added to the water as a result of the manufacturing process. Background levels in the influent water have been subtracted. Oil and suspended solids are the significant waste water parameters. COD is contributed by the oil.

Flow-

In most plants, non-contact cooling water and cullet quench water streams are discharged as a combined waste stream. Flows range from 3,340 l/metric ton (800 gal/ton) to 9,910 l/metric ton (2,380 gal/ton). The typical flow is 8,340 l/metric ton (2,000 gal/ton). The high flow is due to the use of once-through non-contact cooling water.

COD-

Chemical oxygen demand results from oil contamination of the non-contact cooling water. The typical COD is 0.08 kg/metric ton (0.16 lb/ton). This corresponds to a concentration of 10 mg/l at the typical flow and is not considered significant.

Suspended Solids-

Suspended solids are added to the waste water during cullet quenching. Fine glass and miscellaneous solid particles are picked up in the quench tank and discharge trenches leading to the sewer. The typical suspended solids loading is 0.225 kg/metric ton (0.45 lb/ton).

Oil-

The typical oil loading is 0.085 kg/metric ton (0.17 lb/ton). Oil enters the waste stream from lubricating oil leaks in the non-contact cooling water system. The manufacturing methods used to form glass tubing do not require shears and, therefore, the oil associated with shear spraying is not a factor in this system.

Other Parameters-

Some additional information is available on the temperature and pH of glass tubing (Danner) manufacturing waste waters. The waste water temperature increase due to the manufacture of glass tubing by the Danner process is 4.5°C.

TABLE 7

RAW WASTE WATER (a)
GLASS TUBING (DANNER) MANUFACTURING

Flow	8340	l/metric ton	2000	gal/ton	
Temperature	4.5°C		8°F		
pH	7.9				
COD	0.08	kg/metric ton	0.16	lb/ton	10 mg/l
Suspended Solids	0.225	kg/metric ton	0.45	lb/ton	27 mg/l
Oil	0.085	kg/metric ton	0.17	lb/ton	10 mg/l

(a) Representative of typical glass tubing (Danner) manufacturing waste waters. Absolute value given for pH; increase over plant influent level given for other parameters.

(8°F). The waste water pH is 7.9 and is in the acceptable range of six to nine.

Discussion-

No significant variations in waste water volume or characteristics are experienced during plant start-up or shutdown, and there are no known toxic materials in the waste water resulting from glass tubing manufacturing. As with all continuous furnaces, periodic furnace drainage requires large volumes of cullet quench water; however, temperature is the only significant pollutant parameter associated with this waste water source.

TELEVISION PICTURE TUBE ENVELOPE MANUFACTURING

Television picture tube envelope manufacturing consists of melting the raw materials, forming the screen and funnel sections, adding the components necessary for the final assembly of the picture tube, and polishing the necessary screen and funnel surfaces. The major process steps and points of water usage are illustrated in Figure 8. A detailed description of the manufacturing process is given in Section III.

Process Water and Waste Water

Water is used in television picture tube manufacturing for cooling, quenching, abrasive polishing, edge grinding, and acid polishing.

Cooling Water and Cullet Quenching-

Non-contact cooling water is required in the forming section of the plant for the batch feeders, furnaces, presses, annealing lehrs, and other auxiliary equipment such as compressors and pumps. Once-through systems are used in all of the plants that submitted data. In most cases, a portion of the water discharged from the above sources is used as quench water to cool molten glass during manufacturing interruptions or to quench defective pieces from the forming operations. In at least one plant, cooling water is recirculated as rinse water later in the manufacturing process.

The typical flow for both the non-contact cooling and cullet quench water streams is 4040 l/metric ton (970 gal/ton). Each of these sources accounts for 32.5 percent of the total plant flow. Reported flows for the combined forming waste water stream range from 7230 l/metric ton (1740 gal/ton) to 24,600 l/metric ton (5910 gal/ton). The typical flow for a plant practicing reasonable water conservation is 8080 l/metric ton (1940 gal/short ton) and accounts for approximately 65 percent of total water usage.

Abrasive Polishing-

The funnel portion of the picture tube is abrasively polished using a diamond wheel machine with an oil lubricated grinding surface. After grinding, the funnel is rinsed with water.

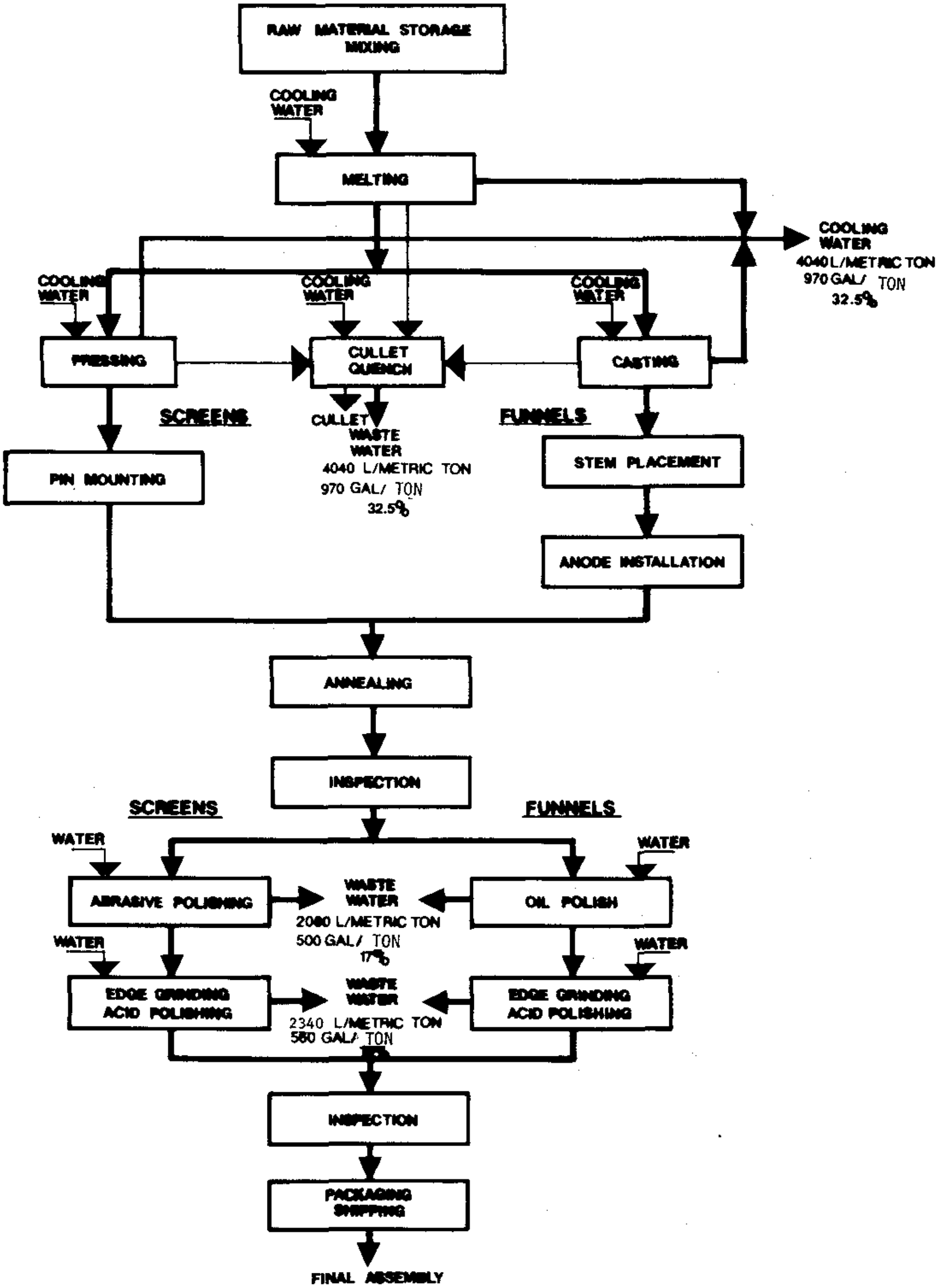

FIGURE 8

TELEVISION PICTURE TUBE ENVELOPE MANUFACTURING

The outer face of the picture tube screen is also abrasively polished. The screen face plate is polished in a step process using garnet, pumice, and rouge; all of the grinding compounds are in the form of a slurry. Between grindings with the various compounds, each screen is rinsed with water. The grinding compound slurry is recycled and only the blowdown from the slurry system is discharged. After the face has been ground, the connecting edge is ground and then beveled. The typical flow of abrasive waste water is 2080 l/metric ton (500 gal/ton) and is 17 percent of the total flow.

Edge Grinding and Acid Polishing-

Following abrasive polishing and beveling, the connecting edges of both the funnel and screen are acid polished or fortified. The funnel is dipped into a combination of sulfuric acid and hydrofluoric acid. The two sections are then rinsed with water to remove the residual acid. Constant overflow-type rinse tanks are generally used. The acid polishing step removes irregularities from the joining surfaces and allows a perfect seal when the screen and funnel are joined. Fume scrubbers are required in the acid polishing area and contribute significant amounts of fluoride to the waste water. The combined typical waste water flow for funnel and screen acid polishing is 2340 l/metric ton (560 gal/ton) or 18 percent of the total flow.

Waste Water Volume and Characteristics

Typical characteristics for the combined non-contact cooling, cullet quenching, abrasive, and acid polishing waste waters resulting from television picture tube envelope manufacturing are listed in Table 8. In all cases, except for pH, the values listed are the quantities added to the water as a result of the process. Background levels in the influent water have been subtracted. The significant parameters are suspended solids, oil, dissolved solids, fluoride, and lead.

Flow-

Total waste water flows, including non-contact cooling water, range from 11,100 to 24,600 l/metric ton (2670 to 5910 gal/ton) or 1590 to 4620 cu m/day (0.42 to 1.22 mgd). The typical flow is 12,500 l/metric ton (3000 gal/ton). The variation in flow rate depends primarily upon the amount of water used for once-through cooling.

Suspended Solids-

Suspended solids are added to the waste water in the form of glass particles and grinding slurry solids from edge grinding and abrasive polishing. Typical plant waste water contains 4.2 kg/metric ton (8.4 lb/ton) of suspended solids.

TABLE 8

RAW WASTE WATER (a)
TV PICTURE TUBE ENVELOPE MANUFACTURING

Flow	12,500 l/metric ton	3000 gal/ton	
Temperature (b)	14°C	25°F	
pH	6-9		
COD	0.435 kg/metric ton	0.87 lb/ton	35 mg/l
Suspended Solids	4.2 kg/metric ton	8.4 lb/ton	335 mg/l
Dissolved Solids	3.25 kg/metric ton	6.5 lb/ton	260 mg/l
Oil	0.125 kg/metric ton	0.25 lb/ton	10 mg/l
Fluoride	1.8 kg/metric ton	3.6 lb/ton	143 mg/l
Lead	0.385 kg/metric ton	0.77 lb/ton	30 mg/l

(a) Represents typical TV picture tube envelope manufacturing process waste water prior to treatment. Absolute value given for pH; increase over plant influent level given for other parameters.

(b) Indication of approximate level only; insufficient data are available to define typical value.

Dissolved Solids-

Dissolved solids are contributed to the waste water stream from acid polishing and abrasive polishing. The typical loading is 3.25 kg/metric ton (6.5 lb/ton) of dissolved solids.

Fluoride-

Fluoride is contributed by the rinse waters following acid polishing, fume scrubbing, and the periodic dumping of the concentrated acid. Hydrofluoric acid is used to polish the edges of both the screen and funnel portions of the picture tube envelope. The typical loading is 1.8 kg/metric ton (3.6 lb/ton) of fluoride.

Lead-

Lead results from both abrasive and acid polishing. It is not clear if the lead in the abrasive waste stream is truly dissolved or in the form of colloidal particles, but standard analytical procedures show a significant concentration. Lead in the acid waste is assumed to result from the dissolution of the glass. The typical quantity of lead added to the waste water is 0.385 kg/metric ton (0.77 lb/ton).

Oil-

Oil is added to the waste water as shear spray drippage into the quench water during forming operations, as lubrication leaks, and as funnel rinse water. The typical oil loading is 0.125 kg/metric ton (0.25 lb/ton).

Other Parameters-

Some information is also available on temperature, pH, and COD. The typical increase in COD is 0.435 kg/metric ton (0.87 lb/ton). The low organic content indicated by the COD is not considered significant. Owing to the segregation of the various waste streams, a typical value for the pH of the combined waste streams from a picture tube envelope plant is not available. Typical pH values for the various process streams are acid polishing, 3.0; abrasive polishing, 9.5; cooling and quenching, 7.6. The cooling and quenching water contributes 65 percent of the combined plant flow. Owing to this high flow, it is estimated that the raw waste water pH should be in the range of six to nine.

Discussion-

Television picture tube envelope manufacturing plants generally operate continuously and no significant variations in waste water volume or characteristics are experienced during plant start-up or shutdown. An additional source of waste water from a picture tube envelope plant may be chrome plating waste water resulting from mold repair. This is a very low volume waste and is usually batch treated at the plant or trucked from the plant for disposal. Available data indicate no chromium is added to the waste water.

Where applicable, the effluent limitations developed for plating wastes should be used (17, 25).

INCANDESCENT LAMP ENVELOPE MANUFACTURING

Incandescent lamp envelope manufacturing consists of melting raw materials and forming the molten glass with ribbon machines into clear incandescent lamp envelopes. Many of the clear envelopes are then frosted or etched with a hydrofluoric acid solution. The major process steps and points of water usage are listed in Figure 9. The incandescent lamp envelope manufacturing process is more fully explained in Section III.

Process Water and Waste Water

Process water is used in the manufacturing of incandescent lamp envelopes for cullet quenching and for rinsing frosted bulbs. The frosting waste water stream is the major source of pollutants and contains high concentrations of both fluoride and ammonia. Cullet quench water is required to cool the wasted molten glass and to quench imperfect lamp envelopes. Quenching practices are similar to those of other pressed and blown glass plants.

Cullet Quenching-

Non-contact cooling water from batch feeders, melting furnaces, ribbon machines, and other auxiliary equipment is used as a source of quench water. Additional waste water is contributed by the emulsified oil solution that is sprayed on the ribbon machine blowpipes and bulb molds. The excess of this oil-water emulsion flows to the cullet quenching area and is discharged with the quench water. Cullet quenching contributes approximately 53 percent of the total waste water flow in the typical plant.

Frosting-

Frosting imparts an etched surface inside the lamp envelope that improves the light diffusing capabilities of the light bulb. The frosting solution contains hydrofluoric acid, fluoride compounds, ammonia, and other constituents, but the exact formulation is proprietary. The percentages of lamp envelopes frosted at a given plant range from 40 to 100 percent.

In the frosting operations, the solution is sprayed on the inside of the bulb and then removed by several countercurrent water rinses. High fluoride and ammonia concentrations in the rinse water result from frosting solution carry-over. Fume scrubbers are required in the frosting area and contribute significant amounts of fluoride and ammonia to the frosting waste water. Frosting waste water accounts for approximately 47 percent of the total flow in a plant where 100 percent of the envelopes are frosted.

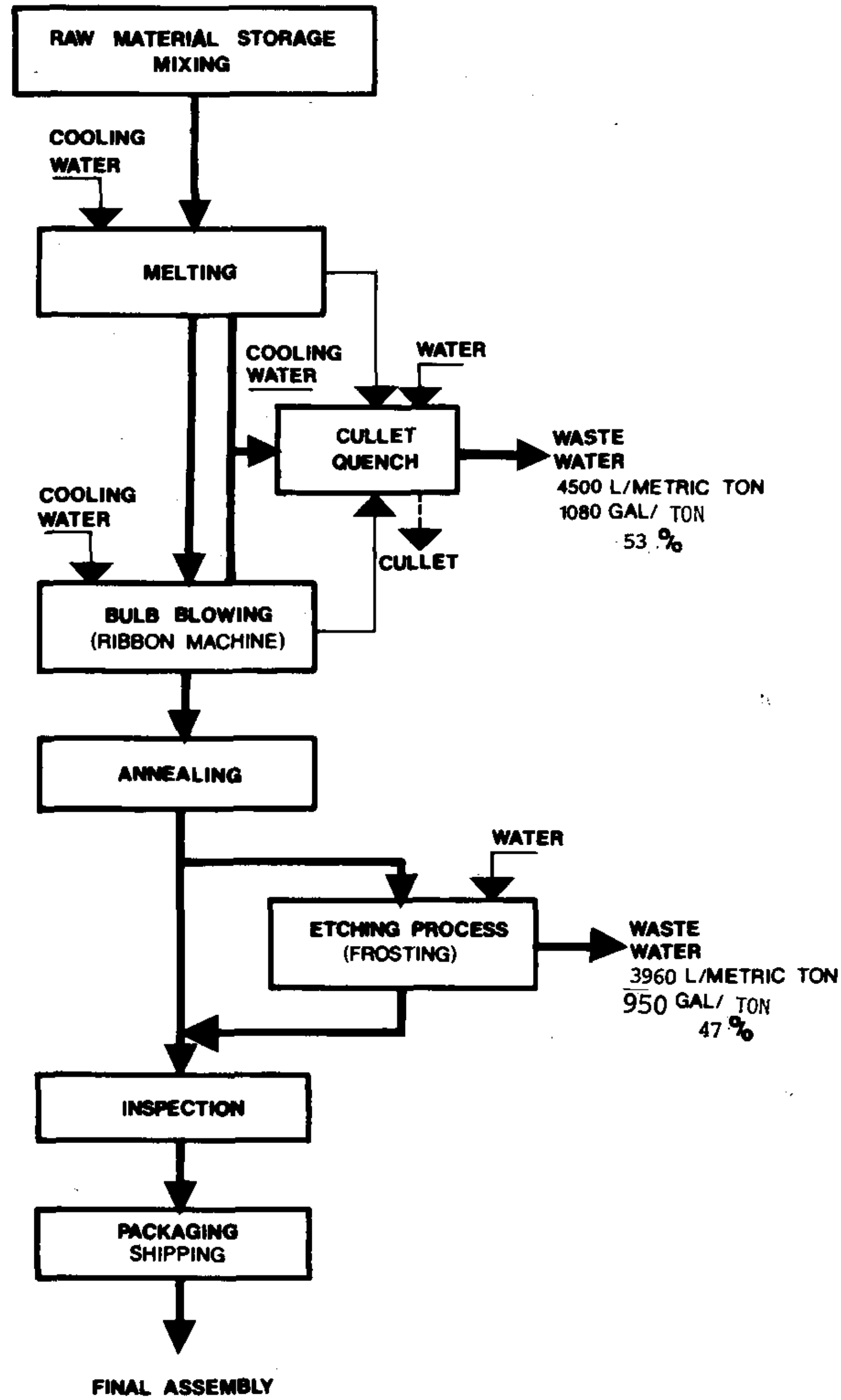

FIGURE 9

INCANDESCENT LAMP GLASS MANUFACTURING

Waste Water Volume and Characteristics

Cullet quenching waste water and frosting waste water from an incandescent lamp envelope manufacturing plant must be classified and characterized separately because the percentage of bulbs frosted varies from plant to plant. The discharge from each of these sources must be added to obtain the total plant discharge. Cullet quenching waste water is characterized by low concentrations of oil, suspended solids, and COD, while the frosting waste contains high concentrations of fluoride and ammonia. Typical waste water volumes and characteristics are summarized in Table 9.

Flow-

The typical cullet quenching waste water flow is 4500 l/metric ton (1080 gal/ton) and the typical frosting waste water flow is 3960 l/metric ton frosted (950 gal/ton frosted). The flow is variable in accordance with water conservation practices and the quantity of once-through cooling water used. Reported combined quenching and frosting waste water flows range from 5420 l/metric ton pulled (1300 gal/ton pulled) to 8340 l/metric ton pulled (2000 gal/ton pulled) or 570 to 1670 cu m/day (0.15 to 0.44 mgd).

Suspended Solids-

Suspended solids are generated by cullet quenching and by frosting of lamp envelopes. Fine glass particles are discharged with the cullet quench water and a significant concentration of suspended solids is contributed by the frosting rinse water. The typical suspended solids produced by cullet quenching is 0.11 kg/metric ton (0.23 lb/ton) and by frosting is 0.40 kg/metric ton frosted (0.79 lb/ton frosted).

Oil-

Oil is contained in significant concentrations only in the cullet quench water and results from the residual emulsified oil used to spray the ribbon machine blowtips and from lubricating oil leaks. The typical loading is 0.11 kg/metric ton (0.23 lb/ton).

Fluoride-

Fluoride is contributed to the waste water by the frosting solution carry-over and the discharge of fume scrubbing equipment. Spent frosting solution is usually regenerated and reused or disposed of separately and is not discharged to the waste water stream. The typical fluoride content of the frosting waste water is 11.1 kg/metric ton (22.2 lb/ton).

Ammonia-

Ammonia is added to the plant waste water as a result of frosting solution carry-over and the discharge from fume scrubbing equipment.

TABLE 9

RAW WASTE WATER (a)
INCANDESCENT LAMP ENVELOPE MANUFACTURING

Cullet Quenching

Flow	4500	l/metric ton	1080	gal/ton	
Temperature	8°C		14°F		
pH	8.6				
COD	0.11	kg/metric ton	0.23	lb/ton	25 mg/l
Suspended Solids	0.11	kg/metric ton	0.23	lb/ton	25 mg/l
Oil	0.11	kg/metric ton	0.23	lb/ton	25 mg/l

Frosting

Flow	3960	l/metric ton	950	gal/ton	
Temperature	38°C		100°F		
pH	3.0				
COD	0.099	kg/metric ton	0.20	lb/ton	25 mg/l
Suspended Solids	0.40	kg/metric ton	0.79	lb/ton	100 mg/l
Fluoride	11.1	kg/metric ton	22.2	lb/ton	2800 mg/l
Ammonia	2.6	kg/metric ton	5.1	lb/ton	650 mg/l

(a) Representative of typical incandescent lamp envelope manufacturing waste water. Absolute value given for pH and frosting temperature; increase over plant influent level given for other parameters.

Ammonia is one of the major constituents of the frosting solution and is apparently necessary in order to get the desired frosted effect. A considerable amount of ammonia vapors are picked up by the frosting area fume scrubber and then discharged to the waste water flow. The typical discharge is 2.6 kg/metric ton (5.1 lb/ton).

Other Parameters-

Some information pertaining to COD, pH, and temperature is also included in Table 9. The typical COD concentration in both the cullet quench and frosting waste water streams is only 25 mg/l and is not considered significant. The temperature increase during cullet quenching is similar to that obtained in the other subcategories. Frosting rinse water is heated and the 38°C (100°F) discharge temperature remains fairly constant.

Discussion-

Lamp glass envelope plants usually operate 24 hrs/day and 5 days/week. Clear bulb production is continuous throughout the week. The frosting operation is intermittent and is related to consumer demand. No significant variations in the waste water volume or characteristics of cullet quench or frosting waste waters are experienced during plant start-up or shutdown. Fluoride and ammonia nitrogen discharged at the concentrations typical of the raw waste water are toxic and should be reduced. The furnaces are drained every 3 to 5 years for rebuilding and require excessive cullet quench water during the draining period.

HAND PRESSED AND BLOWN GLASS MANUFACTURING

Hand pressed and blown glass manufacturing consists of melting raw materials and forming the molten glass with hand presses or by hand blowing to make high quality stemware, tableware, and decorative glass products. The major process steps and points of water usage are listed in Figure 10. The hand pressed and blown glass manufacturing process is more fully explained in Section III of this report.

Process Water and Waste Water

Process water and waste water are used almost entirely for finishing in the hand pressed and blown glass industry. Negligible quantities of water are used for forming; non-contact cooling water is not required. There are at least eight finishing steps that may be employed in the handmade industry. Some plants employ several finishing steps while others use only one or two. Finishing steps that require water and produce waste water include: crack-off and polishing, grinding and polishing, machine cutting, alkali washing, acid polishing and acid etching. Several handmade plants also have machine presses. Waste waters resulting from machine forming are covered in the machine pressed and blown subcategory. Some of the

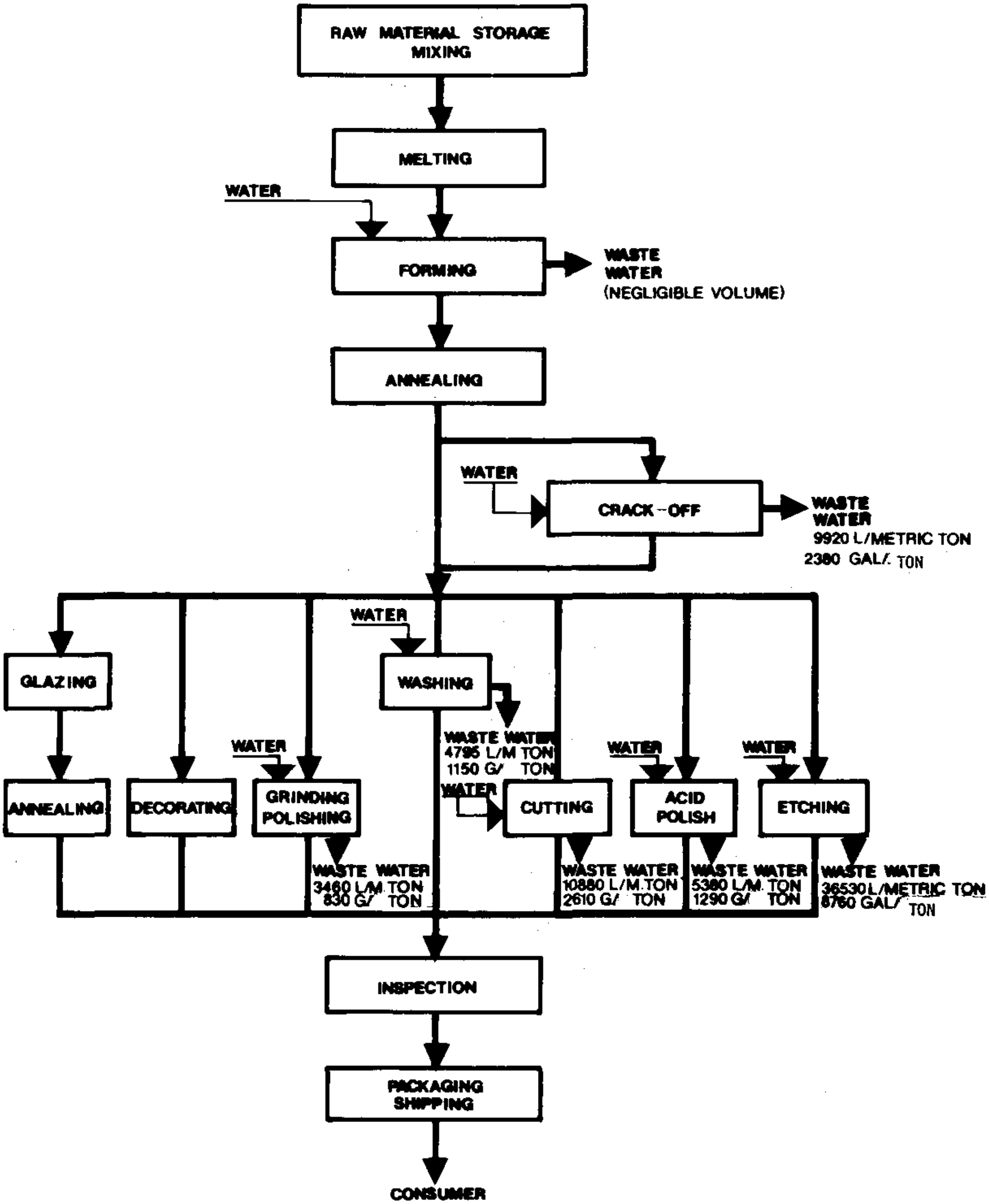

FIGURE 10

HAND PRESSED AND BLOWN GLASS MANUFACTURING

machine pressed products are finished using the methods covered under this subcategory.

Data on waste water volumes and characteristics from the hand pressed and blown glass industry are almost nonexistent. Almost all of the data presented in this report were collected during the sampling program.

Forming-

A negligible amount of water is required for quenching and for partial cooling of the glass during some types of forming. Small water-filled tanks are used at some plants to collect waste glass and rejects. Wheelbarrows with no water may be used at other plants. Some types of glassware are blown in a mold partially submerged in water. Small tanks, approximately 19 liters (5 gallons) in size, are used. The quench tanks and forming tanks are drained periodically.

Crack-Off-

Crack-off is required to remove excess glass left over from the hand blowing of stemware. Crack-off can be done either manually or by machine. The top portion of the stemware is scribed, the scribed surface heated, the excess glass removed, and the cut edge ground on a carborundum or other type abrasive surface. The grinding surface is sprayed by a continuous stream of water for cooling and to remove grinding residue. Grinding may be followed by acid polishing to remove the scratches and is considered part of the crack-off operation in this presentation. Polishing is accomplished by two hydrofluoric acid rinses followed by two water rinses. The combined cutoff and acid polishing waste water flow is 9920 l/metric ton (2380 gal/ton).

Grinding and Polishing-

Abrasive grinding and polishing are common finishing steps and may be used to repair imperfect glassware. Water is required for cooling and lubrication when grinding wheel stones and belt polishers are used. Abrasive polishing may also be used and involves mechanical brushing with an abrasive slurry. The residual slurry is removed in a booth or wash sink. The grinding and polishing flow rates observed were 3460 l/metric ton (830 gal/ton).

Cutting-

Designs may be cut into tableware or stemware. Water is required for lubrication and cooling of the cutting surface and to flush away glass particles. The observed flow from the machine cutting operation was 10,880 l/metric ton (2610 gal/ton).

Acid Polishing-

Acid polishing is another finishing operation that may be applied to handmade glassware. This improves the appearance of the glassware and removes rough edges. The glassware is dipped in hydrofluoric acid and then rinsed with water. The type of equipment used for acid polishing ranges from highly automated equipment to hand-dipped tubs and, consequently, the required volume of water varies. The observed acid polishing flow for a plant utilizing countercurrent rinsing was 5380 l/metric ton (1290 gal/ton).

Acid Etching-

Designs are etched onto some stemware. A pattern is stenciled on tissue paper using a proprietary mixture. The tissue is placed on the glass and then removed to leave the pattern. All parts of the ware, except for the pattern, are then coated with a wax mixture. At this point the glassware is ready for etching. Etching involves a number of steps including dipping in the etching solutions, rinsing, wax removal, additional rinsing, treatment with a cleaning solution, rinsing, nitric acid treatment to remove spots from the acid carry-over, and final rinsing. The waste waters result from the various rinsing steps. The acid and cleaning solution tanks are not drained. The observed flow from this type of system is 36,500 l/metric ton (8760 gal/ton).

Alkali Washing-

Final washing, prior to packing and shipment may be required for some products. An acid-alkali cleaning system is used for this purpose in at least one plant. The glassware first passes through an acid wash and then an alkali rinse followed by several hot water rinses. The flow from this unit is 4795 l/metric ton (1150 gal/ton).

Miscellaneous Finishing-

Finishing steps that do not involve water or waste water are employed at many handmade glass plants and are generally referred to as glazing or decorating. Paint or some other coating is applied to the glassware and in many cases is baked onto the glass surface by reannealing.

Miscellaneous Waste Water Sources-

Abrasive mold cleaning is employed at some plants. An abrasive slurry is sprayed on the molds at high pressure in a process similar to sandblasting. A small but undefined volume of high-suspended solids waste is produced. Following cleaning, the molds may be dipped in a rust preventative solution. This tank is not drained to the sewer.

Fume scrubbers are required in the acid treatment areas and contribute significant fluoride to the acid polishing and etching waste waters.

Waste Water Volume and Characteristics

Observed waste water characteristics for the finishing steps described above are listed in Table 10. In all cases, except for pH and some of the temperatures, the values listed are the quantities added to the water as a result of the manufacture of hand pressed and blown glassware. Concentrations in the influent water have been subtracted.

Flow-

Waste water flows from hand pressed and blown glass manufacturing plants are highly variable and depend upon the quantity of glass finished and the finishing method employed. Reported values range from 0.15 cu m/day (40 gal/day) to 38 cu m/day (10,000 gal/day). Owing to the variation in finishing methods and the percentage of product finished, it is impossible to define a typical flow for the industry.

Suspended Solids-

Grinding, polishing, and cutting are major sources of suspended solids. Lesser quantities are generated by the other finishing steps. Machine cutting and grinding and polishing contribute approximately 28 kg/metric ton (56 lb/ton) and 15 kg/metric ton (30 lb/ton) to the waste waters respectively.

Fluoride-

Fluoride discharges result from crack-off and hydrofluoric acid polishing, hydrofluoric acid polishing, and hydrofluoric acid etching. Loadings expressed in terms of production vary significantly from 1.93 kg/metric ton (3.85 lb/ton) for crack-off and polishing to 10.6 kg/metric ton (21.3 lb/ton) for acid polishing, and 17 kg/metric ton (34 lb/ton) for acid etching. The differences are caused, at least in part, by variations in acid strength. The crack-off polishing solution is much less concentrated than the acid polishing or acid etching solutions.

Lead-

Lead is contained in all leaded glass finishing waste waters. It is not clear if the lead in the abrasive waste streams is truly dissolved or is in the form of small glass particles, but standard analytical procedures show a significant concentration. Lead in the acid wastes is assumed to be in a soluble form.

Other Parameters-

Other parameters that may be of significance include pH, temperature, dissolved solids, and nitrate. Raw waste water pH values vary significantly depending on the source. No pH value is available for grinding and polishing but it is assumed the pH will be in the range

TABLE 10

RAW WASTE WATER (a)
HAND PRESSED AND BLOWN GLASS MANUFACTURING

Crack-Off and Polishing					
Flow	9920	l/metric ton	2380	gal/ton	
Temperature	2.8°C		5°F		
pH	3				
Suspended Solids	0.35	kg/metric ton	0.71	lb/ton	36 mg/l
Lead	0.010	kg/metric ton	0.019	lb/ton	0.96 mg/l
Fluoride	1.93	kg/metric ton	3.85	lb/ton	194 mg/l
Grinding and Polishing					
Flow	3460	l/metric ton	830	gal/ton	
Temperature	2.8°C		5°F		
Suspended Solids	15	kg/metric ton	30	lb/ton	4350 mg/l
Lead	0.086	kg/metric ton	0.17	lb/ton	25 mg/l
Machine Cutting					
Flow	10,880	l/metric ton	2610	gal/ton	
Temperature	1.6°C		3°F		
pH	10				
Suspended Solids	28	kg/metric ton	56	lb/ton	2580 mg/l
Lead	1.1	kg/metric ton	2.2	lb/ton	100 mg/l

TABLE 10 (Contd.)

Alkali Washing

Flow	4795	l/metric ton	1150	gal/ton	
Temperature (b)	57°C		135°F		
pH	11				
Suspended Solids	0.08	kg/metric ton	0.16	lb/ton	17 mg/l

Acid Polishing

Flow	5380	l/metric ton	1290	gal/ton	
Temperature (b)	46°C		114°F		
pH	2				
Suspended Solids	1.2	kg/metric ton	2.4	lb/ton	220 mg/l
Lead	0.17	kg/metric ton	0.33	lb/ton	31 mg/l
Fluoride	10.6	kg/metric ton	21.3	lb/ton	1980 mg/l

Etching

Flow	36,530	l/metric ton	8760	gal/ton	
Temperature (b)	33°C		91°F		
pH	4				
Suspended Solids	0.29	kg/metric ton	0.58	lb/ton	8 mg/l
Lead	0.29	kg/metric ton	0.58	lb/ton	8 mg/l
Fluoride	17	kg/metric ton	34	lb/ton	460 mg/l

(a) Representative of observed hand pressed and blown glass manufacturing waste water. Absolute value given for pH, increase over plant influent level for other parameters.

(b) Controlled temperature required for the process; therefore, absolute temperature given.

of 8 to 10. Temperature increases are insignificant except where heated rinse waters are used. Dissolved solids are not reported, but significant concentrations may be anticipated in the acid polishing and etching waste waters. Nitrates are discharged as a result of the rinsing steps following etching. Insufficient data is available to define the levels of discharge.

Discussion-

Hand pressed and blown glass manufacturing plants generally operate only one or two shifts per day, five days per week, and finishing is done only as necessary and varies with product demand. Rarely is all the finishing equipment available at a given plant in use at the same time. For these reasons, it is impossible to generalize the hand pressed and blown industry in terms of a typical plant.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

Subcategories with the most significant pollution problems in the pressed and blown glass industry are television picture tube envelope manufacturing, incandescent lamp envelope manufacturing, and portions of the hand pressed and blown glass manufacturing subcategory. The primary sources of the waste water constituents are cullet quenching, rinsing following abrasive and acid polishing of television picture tube envelopes, rinsing following frosting of incandescent lamp envelopes, and rinsing of handmade glassware following hydrofluoric acid polishing and etching.

The major parameters of pollutional significance for the combined group of subcategories are:

1. Fluoride
2. Ammonia
3. Lead
4. Oil
5. COD
6. pH
7. Suspended Solids
8. Dissolved Solids
9. Temperature (Heat)

These parameters are not present in the waste water from every subcategory, and may be of more significance in one subcategory than in another. Tables 11, 12, and 13 list the concentrations of each parameter by subcategory. Fluoride, lead, and ammonia discharged at the levels present in certain waste water streams associated with the manufacture of television picture tube envelopes, incandescent lamp envelopes, and some hand pressed and blown ware are known to be toxic to aquatic life.

FLUORIDE

As the most reactive non-metal, fluorine is never found free in nature but as a constituent of fluorite or fluorspar, calcium fluoride, in sedimentary rocks and also of cryolite, sodium aluminum fluoride, in igneous rocks. Owing to their origin only in certain types of rocks and only in a few regions, fluorides in high concentrations are not a common constituent of natural surface

TABLE 11

CONCENTRATION OF WASTE WATER PARAMETERS
PRESSED AND BLOWN GLASS MANUFACTURING

	TYPICAL RAW WASTE WATER CONCENTRATION (a)			
	Glass Container	Machine Pressed and Blown	Tubing	Television Picture Tube Envelope
Temperature °C	6	8	4.5	8
pH	7.5	7.8	7.9	
BOD, mg/l	5	5		
COD, mg/l	50	50	10	35
Suspended Solids, mg/l	24	25	27	335
Oil, mg/l	10	10	10	10
Dissolved Solids, mg/l				260
Fluoride, mg/l				143
Lead, mg/l				30

(a) Increase over background concentration for all parameters except for pH.

TABLE 12

CONCENTRATION OF WASTE WATER PARAMETERS
INCANDESCENT LAMP GLASS MANUFACTURING

	TYPICAL RAW WASTE WATER CONCENTRATION (a)	
	Cullet Quenching	Frosting Rinse Water
Temperature °C	8	38(b)
pH	8.6	3.0
COD, mg/l	25	25
Suspended Solids, mg/l	25	100
Oil, mg/l	25	
Fluoride, mg/l		2800
Ammonia, mg/l		650

(a) Increase over background concentration for all parameters except for pH.

(b) Controlled temperature required for the process; therefore, absolute temperature given.

TABLE 13

CONCENTRATION OF WASTE WATER PARAMETERS
HAND PRESSED AND BLOWN GLASS MANUFACTURING

	TYPICAL RAW WASTE WATER CONCENTRATION (a)					
	Crack-Off and Polishing	Grinding and Polishing	Machine Cutting	Alkali Washer	Acid Polishing	Acid Etching
Temperature °C	2.8	2.8	1.6	57	46	33
pH	3.2		10.0	11.2	2.2	4.0
Suspended Solids, mg/l	36	4350	2580	17	220	8
Fluoride, mg/l	194				1980	462
Lead, mg/l	.96	.43	100		31	7.9

(a) Representative of observed hand pressed and blown glass manufacturing waste water. Increase over background concentration for all parameters except for pH.

waters, but they may occur in detrimental concentrations in ground waters.

Fluorides are used as insecticides, for disinfecting brewery apparatus, as a flux in the manufacture of steel, for preserving wood and mucilages, for the manufacture of glass and enamels, in chemical industries, for water treatment, and for other uses.

Fluorides in sufficient quantity are toxic to humans, with doses of 250 to 450 mg giving severe symptoms or causing death.

There are numerous articles describing the effects of fluoride-bearing waters on dental enamel of children; these studies lead to the generalization that water containing less than 0.9 to 1.0 mg/l of fluoride will seldom cause mottled enamel in children, and for adults, concentrations less than 3 or 4 mg/l are not likely to cause endemic cumulative fluorosis and skeletal effects. Abundant literature is also available describing the advantages of maintaining 0.8 to 1.5 mg/l of fluoride ion in drinking water to aid in the reduction of dental decay, especially among children.

Chronic fluoride poisoning of livestock has been observed in areas where water contained 10 to 15 mg/l fluoride. Concentrations of 30 - 50 mg/l of fluoride in the total ration of dairy cows is considered the upper safe limit. Fluoride from waters apparently does not accumulate in soft tissue to a significant degree and it is transferred to a very small extent into the milk and to a somewhat greater degree into eggs. Data for fresh water indicate that fluorides are toxic to fish at concentrations higher than 1.5 mg/l.

Fluoride is contained at various concentrations in the waste waters of television picture tube envelope manufacturing, incandescent lamp envelope manufacturing, and some hand pressed and blown glass plants. Typical concentrations range from 143 mg/l for the television picture tube envelope manufacturing subcategory to 2800 mg/l for the process waste water stream resulting from the frosting of incandescent lamp envelopes.

AMMONIA

Ammonia is a common product of the decomposition of organic matter. Dead and decaying animals and plants along with human and animal body wastes account for much of the ammonia entering the aquatic ecosystem. Ammonia exists in its non-ionized form only at higher pH levels and is the most toxic in this state. The lower the pH, the more ionized ammonia is formed and its toxicity decreases. Ammonia, in the presence of dissolved oxygen, is converted to nitrate (NO_3) by nitrifying bacteria. Nitrite (NO_2), which is an intermediate product between ammonia and nitrate, sometimes occurs in quantity when depressed oxygen conditions permit. Ammonia can exist in several other chemical combinations including ammonium chloride and other salts.

Nitrates are considered to be among the poisonous ingredients of mineralized waters, with potassium nitrate being more poisonous than sodium nitrate. Excess nitrates cause irritation of the mucous linings of the gastrointestinal tract and the bladder; the symptoms are diarrhea and diuresis, and drinking one liter of water containing 500 mg/l of nitrate can cause such symptoms.

Infant methemoglobinemia, a disease characterized by certain specific blood changes and cyanosis, may be caused by high nitrate concentrations in the water used for preparing feeding formulae. While it is still impossible to state precise concentration limits, it has been widely recommended that water containing more than 10 mg/l of nitrate nitrogen (NO_3-N) should not be used for infants. Nitrates are also harmful in fermentation processes and can cause disagreeable tastes in beer. In most natural water the pH range is such that ammonium ions (NH_4^+) predominate. In alkaline waters, however, high concentrations of un-ionized ammonia in undissociated ammonium hydroxide increase the toxicity of ammonia solutions. In streams polluted with sewage, up to one half of the nitrogen in the sewage may be in the form of free ammonia, and sewage may carry up to 35 mg/l of total nitrogen. It has been shown that at a level of 1.0 mg/l un-ionized ammonia, the ability of hemoglobin to combine with oxygen is impaired and fish may suffocate. Evidence indicates that ammonia exerts a considerable toxic effect on all aquatic life within a range of less than 1.0 mg/l to 25 mg/l, depending on the pH and dissolved oxygen level present.

Ammonia can add to the problem of eutrophication by supplying nitrogen through its breakdown products. Some lakes in warmer climates, and others that are aging quickly are sometimes limited by the nitrogen available. Any increase will speed up the plant growth and decay process.

Ammonia is a primary constituent of the raw waste water from the frosting of incandescent lamp envelopes. The typical ammonia concentration is 650 mg/l. It is current practice that this waste is discharged at a very high pH (alkaline). At the high pH, a considerable amount of ammonia is in the un-ionized form and as discussed above can present serious environmental problems. It is recommended that this discharge should be controlled to ensure environmental protection. At the present time, however, there is no known waste treatment facility operating on ammonia-bearing waste waters generated by the pressed and blown glass manufacturing industry segment. Many types of systems which remove ammonia have been demonstrated in other industry segments; one of the most promising of these ammonia removal techniques is the steam stripping of ammonia from waste waters. However, the presence of high concentrations of calcium, the result of treatment for fluoride removal from acid polishing and etching waste waters, could cause scaling problems during ammonia stripping if proper design and preventative measures are not taken into consideration. The application of ammonia removal technology to the effluent from incandescent lamp envelope manufacturing requires further development prior to implementation by this industry segment and hence, is not considered to be currently available technology. Plants which contribute to a water quality problem may find it necessary to develop the appropriate technology to alleviate the problem.

LEAD

Major concentrations of lead are contributed to television picture tube envelope manufacturing and handmade glass manufacturing waste waters from the abrasive polishing of television picture tube envelopes and the hydrofluoric acid polishing and etching of leaded handmade glassware. Lead at high concentrations is toxic to aquatic life. The U.S. Public Health Service Drinking Water Standards recommend levels of lead in drinking water supplies of not greater than 0.05 mg/l. Typical raw waste water concentrations are on the order of 10 mg/l for handmade plants; concentrations on the order of 30 mg/l are typical for television picture tube envelope manufacturing.

OIL

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to exhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and coats of water animals and fowls. Oil and grease in a water can result in the formation of objectionable surface solids preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

Oil is a constituent of the waste water from all subcategories except hand pressed and blown glass manufacturing. The typical oil concentration ranges from 10 mg/l for glass container manufacturing to 25 mg/l for cullet quenching during the manufacture of incandescent lamp envelopes. The oil is added to waste water as shear spray oil, by lubricating oil leaks, and by finishing operations such as oil polishing of television picture tube envelopes.

CHEMICAL OXYGEN DEMAND

COD is contributed by process waste waters from each subcategory. The COD concentrations range from 10 mg/l for glass tubing manufacturing to 50 mg/l for glass container and machine pressed and blown glass manufacturing. In most cases the COD is a result of the oil concentration and can be controlled by limiting the oil. Because BOD concentrations are low, COD is a more accurate measure of organic content for pressed and blown glass manufacturing.

pH

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium, and lead. The hydrogen ion concentration can affect the "taste" of the water. 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. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. 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. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

The pH of the waste water from cullet quenching is within the acceptable range of 6-9. Waste waters produced by rinishing of acid polished glass and the frosting of incandescent lamp envelopes is acidic and in the pH range from 2-3. Most plants treat the acidic waste waters to remove fluoride. Lime is added to a pH level of about 11-12. Some plants discharge the treated effluent at this alkaline pH, while other plants use acid to neutralize the treated effluent back to an acceptable level of about 7.

TOTAL SUSPENDED SOLIDS

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair, and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water used in the textile, pulp and paper, beverage, and dairy products industries and can cause difficulties at laundries, for dyeing operations, for photographic processes, for cooling systems, and at power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, 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 and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Suspended solids are contributed to the process waste waters from all subcategories. Typical suspended solids concentrations range from 25 mg/l for machine pressed and blown glass manufacturing to 335 mg/l for television picture tube envelope manufacturing.

DISSOLVED SOLIDS

In natural waters the dissolved solids consist mainly of carbonates, chlorides, sulfates, phosphates, and possibly nitrates of calcium, magnesium, sodium, and potassium, with traces of iron, manganese and other substances.

Many communities in the United States and in other countries use water supplies containing 2000 to 4000 mg/l of dissolved salts, when no better water is available. Such waters are not palatable, may not quench thirst, and may have a laxative action on new users. Waters containing more than 4000 mg/l of total salts are generally considered unfit for human use, although in hot climates such higher salt concentrations can be tolerated whereas they could not be in temperate climates. Waters containing 5000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants. It is generally agreed that the salt concentration of good, palatable water should not exceed 500 mg/l.

Limiting concentrations of dissolved solids for fresh-water fish may range from 5,000 to 10,000 mg/l, according to species and prior acclimatization. Some fish are adapted to living in more saline waters, and a few species of fresh-water forms have been found in natural waters with a salt concentration of 15,000 to 20,000 mg/l. Fish can slowly become acclimatized to higher salinities, but fish in waters of low salinity cannot survive sudden exposure to high salinities, such as those resulting from discharges of oil-well brines. Dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life, primarily because of the antagonistic effect of hardness on metals.

Waters with total dissolved solids over 500 mg/l have decreasing utility as irrigation water. At 5,000 mg/l water has little or no value for irrigation.

Dissolved solids in industrial waters can cause foaming in boilers and cause interference with cleaness, color, or taste of many finished products. High contents of dissolved solids also tend to accelerate corrosion.

Specific conductance is a measure of the capacity of water to convey an electric current. This property is related to the total concentration of ionized substances in water and water temperature. This property is frequently used as a substitute method of quickly estimating the dissolved solids concentration.

Acid polishing of television picture tube envelopes and handmade glassware and frosting of incandescent lamp envelopes are the main sources of the dissolved solids in the raw waste water from plants within the pressed and blown glass segment. Dissolved solids are also added to the waste water by the addition of lime for fluoride removal and the addition of acid for pH control. Dissolved solids concentrations range from 260 mg/l for television picture tube envelope manufacturing to several thousand milligrams per liter for the process waste water stream from the frosting of incandescent lamp envelopes. The control and treatment technologies presented in Section VII of this document do not reduce the level of dissolved solids discharged. Therefore, no effluent limitations guidelines are established for this parameter.

TEMPERATURE

Temperature is one of the most important and influential water quality characteristics. Temperature determines those species that may be present; it activates the hatching of young, regulates their activity, and stimulates or suppresses their growth and development; it attracts, and may kill when the water becomes too hot or becomes chilled too suddenly. Colder water generally suppresses development. Warmer water generally accelerates activity and may be a primary cause of aquatic plant nuisances when other environmental factors are suitable.

Temperature is a prime regulator of natural processes within the water environment. It governs physiological functions in organisms and, acting directly or indirectly in combination with other water quality constituents, it affects aquatic life with each change. These effects include chemical reaction rates, enzymatic functions, molecular movements, and molecular exchanges between membranes within and between the physiological systems and the organs of an animal.

Chemical reaction rates vary with temperature and generally increase as the temperature is increased. The solubility of gases in water varies with temperature. Dissolved oxygen is decreased by the decay or decomposition of dissolved organic substances and the decay rate increases as the temperature of the water increases reaching a maximum at about 30°C (86°F). The temperature of stream water, even during summer, is below the optimum for pollution-associated bacteria. Increasing the water temperature increases the bacterial multiplication rate when the environment is favorable and the food supply is abundant.

Reproduction cycles may be changed significantly by increased temperature because this function takes place under restricted temperature ranges. Spawning may not occur at all because temperatures are too high. Thus, a fish population may exist in a heated area only by continued immigration. Disregarding the decreased reproductive potential, water temperatures need not reach lethal levels to decimate a species. Temperatures that favor competitors, predators, parasites, and disease can destroy a species at levels far below those that are lethal.

Fish food organisms are altered severely when temperatures approach or exceed 90°F. Predominant algal species change, primary production is decreased, and bottom associated organisms may be depleted or altered drastically in numbers and distribution. Increased water temperatures may cause aquatic plant nuisances when other environmental factors are favorable.

Synergistic actions of pollutants are more severe at higher water temperatures. Given amounts of domestic sewage, refinery wastes, oils, tars, insecticides, detergents, and fertilizers more rapidly deplete oxygen in water at higher temperatures, and the respective toxicities are likewise increased.

When water temperatures increase, the predominant algal species may change from diatoms to green algae, and finally at high temperatures to blue-green algae, because of species temperature preferentials. Blue-green algae can cause serious odor problems. The number and distribution of benthic organisms decreases as water temperatures increase above 90°F, which is close to the tolerance limit for the population. This could seriously affect certain fish that depend on benthic organisms as a food source.

The cost of fish being attracted to heated water in winter months may be considerable, due to fish mortalities that may result when the fish return to the cooler water.

Rising temperatures stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by putrefactive processes, thus affecting the esthetic value of a water course.

In general, marine water temperatures do not change as rapidly or range as widely as those of freshwaters. Marine and estuarine fishes, therefore, are less tolerant of temperature variation. Although this limited tolerance is greater in estuarine than in open water marine species, temperature changes are more important to those fishes in estuaries and bays than to those in open marine areas, because of the nursery and replenishment functions of the estuary that can be adversely affected by extreme temperature changes.

The significant increases in water temperatures result from cullet quenching and the heating of rinse waters used in some finishing steps. Typical temperature increases for cullet quenching are 5.6°C (10°F) to 8.4°C (15°F). The absolute temperatures of etching and alkali washing waste waters range from 33°C (91°F) to 57°C (135°F). The temperature measurements were taken directly from the process and are much greater than at the end of the pipe before the receiving stream. Natural cooling in the sewer and dilution with non-contact cooling water tend to reduce temperatures to about 5.6°C (10°F) over ambient. An acceptable temperature discharge limit must be based upon the volume and the water quality criteria of the receiving stream. For this reason, no attempt has been made to propose standards to limit effluent temperatures.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

As concluded in Section VI, the primary pollutants from the pressed and blown glass segment are oil, fluoride, ammonia, lead, and suspended solids. Oil is contributed to the waste water from all subcategories except hand pressed and blown glass manufacturing. Fluoride and lead are added by the finishing steps for television picture tube envelopes and hand pressed and blown glass. Fluoride and ammonia are carried over into the waste water following frosting of incandescent lamp envelopes. Suspended solids are a result of grinding, acid treatment, and cullet quenching.

The industry is currently treating its waste waters to reduce or eliminate most of the pollutants. Oil is reduced by using gravity separators such as belt skimmers and API separators. Treating for fluoride and lead involves the addition of lime, rapid mixing, flocculation, and sedimentation of the resulting reaction products. Several glass container plants recycle non-contact cooling and cullet quench water. Treatment for ammonia removal is presently not practiced in the industry segment.

This section is divided into two parts. The first part is a general description of the applicable treatment technologies that will reduce or eliminate the pollutants from pressed and blown glass manufacturing waste waters. The next section gives a detailed description of treatment schemes that may be used to meet the proposed effluent limitations and guidelines. The transfer of treatment technologies from other industry categories is necessary in some cases.

APPLICABLE TREATMENT TECHNOLOGY

Suspended Solids Removal

Two common methods of suspended solids removal are sedimentation and filtration. Sedimentation can be accomplished with or without chemical addition in a sump or catch basin arrangement, in a settling tank or pond, or in a clarifier. Filtration can occur by passage of a waste water stream through sand, mixed media, or diatomaceous earth.

Sedimentation Methods-

Sump or Catch Basin. Solids removal can occur in a sump or catch basin arrangement and can reduce the solids loading to another part of the treatment system and allow for materials recovery. The basic principle is that the velocity of the waste water stream is reduced and forces resulting from density differences between the suspended solids and the waste water come into affect and the solids settle out.

This in-plant method of waste control can be designed with a scraper mechanism to remove the bottom sludge and with a skimmer to achieve a removal of floating oil.

Settling Tank or Pond. The same principles as apply to sumps and catch basins apply to settling tanks and ponds. However, when used as end-of-pipe treatment, larger detention times may be employed with chemical addition and sludge recycle to attain greater efficiencies of suspended solids removal.

Clarifier. A substantial portion of suspended solids may be removed by clarification. Settling involves the provision of a sufficiently large tank in order that the velocity of the waste water discharge stream be reduced sufficiently to allow for suspended solids to settle out. Mild mechanical agitation is added to assist in the settling process and in the removal of suspended solids. Chemical addition and sludge recycle may also be employed to increase treatment efficiency.

Settled solids from the bottom of the clarification unit in the form of a sludge may be pumped to a rotary vacuum filter, where the slurry is concentrated by removal of water which is returned to the clarifier. The outside surface of the filter cylinder is covered with a filter medium (screen or cloth). The lower portion of the filter is suspended in the liquid slurry. As the drum rotates, the vacuum which is maintained within the cylinder forces liquid into the cylinder while leaving a solids layer on the outside of the filter medium. As the drum rotates, a scraper mechanism removes solids from the surface of the filter medium. This method of solids thickening has been widely used in both industrial and municipal waste water treatment.

Filtration Methods-

Sand and Mixed-Media Filtration. A variety of filters can be employed to remove suspended solids from a treated waste water: slow sand filters, rapid sand filters, and mixed media filters. The effluent from a sand filter is of a high quality. A summary of available information indicates that an effluent suspended solids concentration of less than 10 mg/l can be expected to occur from the sand filtration of wastes similar in nature to those of the pressed and blown glass industry segment.

A slow sand filter is a specially prepared bed of sand or other mineral fines on which doses of waste water are applied and from which effluent is removed by an under-drainage system. A rapid sand filter may operate under pressure in a closed vessel or may be built in open concrete tanks. It is primarily a water treatment device and thus would be used for final treatment. Mixed media filters are special versions of rapid sand filters that permit deeper bed penetration by gradation of particle sizes in the bed.

The slow sand filter removes solids primarily at the surface of the filter. The rapid sand filter is operated to allow a deeper penetration of suspended solids into the sand bed and thereby achieve solids removal through a greater cross section of the bed. The rate of filtration of the rapid filter is greater than that of the slow sand filter. Thus, the rapid sand filter requires substantially less area than the slow sand filter. The larger area required for the latter means a higher initial investment cost. The rapid sand filters operate essentially unattended with pressure loss controls and piping installed for automatic backwashing. They are contained in concrete structures or in steel tanks. Slow sand filters require hand or machine labor to breakup the crust which develops on the surface. The frequency of this operation varies depending on the quality of pretreatment and the gradation of the sand.

In a rapid sand filter, as much as 80 percent of the head loss can occur in the upper few inches of the filter. One approach to increase the effective filter depth is the use of more than one media in the filter. Other filter media have included coarse coal, heavy garnet or ilmenite media, and sand.

Diatomaceous Earth Filtration. Diatomaceous earth filters have found use as: (1) mobile units for water purification and (2) stationary units for swimming pools and general water supplies. Skeletons of diatoms mined from deposits compose the diatomaceous earth. The filter medium is a layer of diatomaceous earth built upon a porous septum. The resulting pre-coat is supported by the septum, which serves also as a drainage system. Water is strained through the pre-coat unless the applied water contains so much turbidity that the unit will maintain itself only if additional diatomaceous earth, called body feed, is introduced into the incoming water to preserve the open texture of the layer.

Diatomaceous earth is generally of finer texture than sand and has been reported to reduce suspended solids effluent concentrations to 5 mg/l or less. Diatomaceous earth filtration is being used to treat the effluent from at least one glass container manufacturing facility. No long-term data have been generated but short term data show a suspended solids effluent concentration of 7.1 mg/l indicating that levels of less than 10 mg/l should be readily attainable.

Oil Removal

Oil is usually removed in two steps. In the primary treatment step, floatable or free oils are removed by gravity separation. The second step involves breaking any oil-water emulsions and separating the remaining oil.

Primary Treatment-

Primary treatment makes use of the difference in specific gravity of oil and water. The oily waste water is retained in a holding basin, the oil and water being allowed to separate; the separated oil is skimmed from the waste water surface. The efficiency of the gravity separator device depends upon both the proper holding basin hydraulic design and the retention time in the basin. Typically, 60 to 90 percent of the influent free oil can be removed with gravity separation units.

Secondary Treatment-

Oil emulsions can be broken by either chemical or physical methods. Physical methods include high rate filtration through sand and gravel filters, high rate filtration with coagulant, and diatomaceous earth filtration. High rate filter pilot plant studies in the oil industry using an influent emulsified oil concentration of 230 mg/l indicated that an effluent concentration of 15 mg/l can be achieved with filtration, and a 10 mg/l effluent level can be achieved using coagulant-assisted filtration.

Oil-adsorptive diatomaceous earth filtration has been used to reduce oil and suspended solids effluent concentrations to 5 mg/l. The diatomaceous earth filtration system consists of the filter, precoat tank, and a slurry tank for continuous feeding of the diatomaceous earth. About 0.9 kg (2 lb) of diatomaceous earth is required per 0.45 kg (1 lb) of oil removed, and the filtration rates range from 20.4 to 40.7 l/min/sq m (0.5 to 1 gpm/sq ft). Dry discharge diatomaceous earth filters require no backwashing, and the sludge requires no dewatering. Diatomaceous earth filtration is being used to treat the blowdown from at least one cullet quench recycle system at a glass container plant. No long-term data have been generated but short-term data show an oil effluent concentration of 7.6 mg/l indicating that levels of less than 10 mg/l should be readily attainable.

Chemical treatment is a primary method used to break oil emulsions by destabilizing the dispersed oil droplets or destroying the emulsifying agents. The treatment may consist of chemical addition, rapid mixing, flocculation and settling, or flotation.

Air flotation can be used to separate the oil and water and will also result in the removal of suspended solids. It is a relatively recent technology in the glass industry and, therefore, is not in widespread use. However, air flotation is being used to treat emulsified oil-water streams in the flat glass industry and it has been indicated that at least one glass container plant will employ this treatment technology in the near future.

The air flotation system operates by mixing the waste water with compressed air in a pressurized tank. The waste water flows to the flotation tank where the pressure is released, thereby generating numerous, small air bubbles which effect the flotation of the suspended material by one of three mechanisms: 1) adhesion of the air bubbles to the particles of matter, 2) trapping of the air bubbles in the floc structures of suspended material as the bubbles rise, and 3) adsorption of the air bubbles as the floc structure is formed from the suspended matter. In most cases, bottom sludge removal facilities are also provided.

Improved performance of the air flotation system is achieved by coagulation of the suspended matter prior to treatment. This is done by pH adjustment or the addition of coagulant chemicals, or both. Aluminum sulfate, iron sulfate, lime, and polyelectrolytes are used as coagulants at varying concentrations up to 300 to 400 mg/l in the raw waste. These chemicals are essentially totally removed in the dissolved air flotation unit, thereby adding little or no load to the waste water stream. Typical effluent oil concentrations range from 10 to 15 mg/l.

Chemical coagulation and sedimentation can also be used to remove the oil. In this process, the oil is adsorbed onto the coagulant floc. Oil in television picture tube abrasive waste water is removed in this manner. Removal efficiencies are similar to those for chemical assisted air flotation; however less area is required for the air flotation equipment.

Fluoride Removal

The waste waters from pressed and blown glass plants are contaminated with fluoride by carry-over into the rinse waters following hydrofluoric acid treatment. The fluoride is either in the form of hydrogen fluoride (HF) or fluoride ion (F^-), depending on the pH of the waste water. The high fluoride concentrations in the waste waters from television picture tube envelope manufacturing, incandescent lamp envelope frosting, and hydrofluoric acid polishing and etching of hand pressed and blown glass should be reduced to an acceptable level to prevent any toxic action of the fluoride on aquatic life in the receiving body of water. There are two methods to treat these waste waters, which may be classified as the additive and the adsorptive methods.

Additive Methods-

In the additive methods, chemicals are added to the waste water and the fluoride either forms a precipitate or is adsorbed onto a precipitate. The fluoride removal efficiencies depend upon the detention time in, as well as the effectiveness of, the clarification unit used to separate the precipitate. The chemicals used include lime and aluminum sulfate, but lime treatment is the most practical method for treatment of waste waters with high concentrations of fluoride. The lime is added to the waste water as slurry, is rapidly mixed, and reacts with the fluoride during flocculation to form calcium fluoride. The calcium fluoride precipitate is then settled out in a clarification unit. Suspended solids are also removed by the lime treatment process.

Calcium fluoride has a maximum theoretical solubility of about 8 mg/l as fluoride and concentrations above this theoretical solubility limit form a precipitate. Therefore, the effluent concentrations can be lowered by adding calcium ion concentrations in excess of the stoichiometric requirements which results in raising the pH during treatment to a value in the range of 9 to 11. Typical treated effluent fluoride concentrations range from 10 mg/l to 30 mg/l.

The calcium fluoride precipitate formed during reaction with lime has a very small particle size, and the flocculation and clarification steps must therefore be optimized to remove the maximum amount of fluoride. Factors to be considered include the flocculation time, clarifier type and detention time, and post-sedimentation filtration. Longer flocculation periods allow greater agglomeration of the precipitate particles. Improved separation of the calcium fluoride precipitate from the water can be accomplished by increasing the clarifier detention time, using a solids contact clarifier, or recirculating sludge. In a solids contact clarifier, the treated waste water flows down through a center skirt in the clarifier and up through a sludge blanket formed at the bottom of the clarifier.

Filtering the clarifier effluent can reduce fluoride concentrations to about 10 mg/l by removing additional calcium fluoride particles. Sand or graded media filters similar to those used in water treatment plants can be used.

High concentrations of aluminum sulfate have also been used to reduce low fluoride concentrations in soft waters, but this method is considered both technically and economically unfeasible for the primary or secondary treatment of high fluoride wastes.

Adsorptive Methods-

Treatment of fluorides by the adsorptive methods involves passing the waste water through a contact bed, the fluoride being removed by general or specific ion-exchange or chemical reaction with a solid-bed matrix. Adsorptive methods may be used for treating low level fluoride wastes and polishing the effluent from the lime process. The requirement for frequent bed regeneration makes the adsorptive methods economically infeasible for treating high fluoride concentration wastes. Activated alumina, hydroxylapatite, and ion exchange resins have been used as the adsorptive media, but activated alumina has been determined to be the least expensive and the most suitable for the pressed and blown glass industry segment.

Activated alumina has been used since the 1950's in municipal water treatment plants to reduce the fluoride content of ground waters from 8 mg/l to 1 mg/l. In laboratory studies, the effluent from a lime precipitation system treating a high fluoride content waste (1000-3000 mg/l) was reduced from 30 mg/l to 2 mg/l using activated alumina adsorption. A pH in the alkaline range was found not to affect the ion exchange operation. The influent waste water should be filtered before activated alumina adsorption to prevent premature fouling of the exchange resin and to prevent shortened periods between regeneration cycles.

An activated alumina filter can be either gravity or pressure operated. The gravity filter is similar to those used in municipal water treatment plants, and consists of the activated alumina media, underdrains, wash troughs, and a regenerant distributor. The pressurized column is similar to those used in conventional ion exchange treatment systems.

Regenerating the activated alumina can be accomplished with a caustic solution, sulfuric acid, hydrochloric acid, or alum. Caustic regeneration is being practiced at most water treatment plants. Water and dilute acid rinses are used to remove residual caustic from the bed following regeneration. The residual spent caustic regenerant can be bled into the lime precipitation system and can be neutralized with the lime treatment effluent. If a mineral acid such as hydrochloric acid is used as the column regenerant, it may be necessary to include separate neutralization facilities and sludge handling equipment to treat the spent regenerant stream.

Ammonia Removal

Ammonia removal methods include air and steam stripping, biological nitrification/denitrification, breakpoint chlorination, and selective ion exchange. Air and steam stripping appear to be the most viable methods for the incandescent lamp envelope manufacturing subcategory. A discussion of these treatment techniques follows.

Ammonia Stripping-

Ammonia exists in solution in two forms, as the ammonium ion, and as dissolved ammonia gas. The equilibrium may be explained by the following equation:

$$NH_4^+ = H^+ + NH_3(g)$$

The reaction is pH-dependent with only ammonium ions present at pH 7, while only dissolved ammonia exists at pH 12; as the temperature rises the reaction proceeds toward the production of ammonia gas. At a pH approaching 12, ammonia gas can be removed from solution by heating the solution and using an inert gas such as air or steam as a stripping medium.

Steam Stripping. Many oil refineries, petrochemical plants, and the nitrogen fertilizer industry use steam stripping for ammonia removal. There are many different stripping designs in existence, but most involve the downward flow of waste water through a packed or trayed column countercurrent to an ascending flow of steam. Other stripping media such as flue or fuel gases are also employed.

Steam stripping is used in the petroleum industry to remove ammonia from sour water. In columns ranging in size from 1.07 to 1.52 m (3.5 to 5 ft) in diameter and 5.18 to 9.14 m (17 to 30 ft) in height, and at temperatures ranging from 110 to 127°C (230 to 260°F), ammonia removal efficiencies range from 86 to 96.4 percent. Various designs are used including trayed columns with from 6 to 13 plates or packed columns containing 3.66 vertical meters (12 vertical feet) of Raschig-rings. Ammonia concentrations in sour water range from 1000 to 9800 mg/l at a pH ranging from 8.0 to 9.25. It should be noted that sour water strippers are designed for removing hydrogen sulfide rather than ammonia. The optimum pH range of ammonia removal is within the range of 10.8 to 11.5 which is considerably higher than the ranges described above. The removal efficiencies will greatly increase as the pH is adjusted to within the optimum range.

Steam stripping in the nitrogen fertilizer manufacturing industry is used to remove ammonia from process condensate. Packed columns have yielded effluent ammonia concentrations in the 20 to 30 mg/l range at feed rates varying from 7.6 to 10.7 l/sec (120 to 170 gpm). A typical column might be 0.914 m (3 ft) in diameter and 12.2 m (40 ft) high. Stainless steel Pall rings have been used as packing material. Another system uses a trayed stripping column 1.37 m (4.5 ft) in diameter, and 12.2 m (40 ft) high. The unit will handle 44 l/sec (700 gpm) of feed and produces an ammonia effluent concentration of less than 5 mg/l.

Air Stripping. The ammonia stripping (air) tower is an economical, simple, and easy-to-control system. The process involves raising the pH of the waste water stream to within the range of 10.8 to 11.5, the formation and reformation of water droplets in a packed stripping tower, and providing maximum air-to-water contact by circulating air through the tower. Two serious limitations have been encountered with air strippers: operational problems can occur at ambient air temperatures below 0°C (32°F), calcium carbonate scaling has developed, which can cause a loss in treatment efficiency due to a reduction in the amount of air circulated. The temperature limitation is not a drawback in warm climates. The scaling problem may be controlled or eliminated by installing water sprays to wash them away. Complete accessibility to the tower packing will permit mechanically scraping the packing. A dilute acid rinse can be used to remove calcium carbonate scale.

Most research and development of the various air stripping systems has involved treating raw domestic waste waters. At air-to-liquid loadings of 3.74 cu m/l (500 cu ft/gal) and at a pH of 11, one study reports ammonia removals of 92 percent (from domestic sewage) in a 2.13 m (7 ft) tower packed with 1.27 cm (0.5 in.) Raschig rings loaded at a rate of 12.2 l/min/sq m (0.3 gpm/sq ft). In a 7.6 m (25 ft) high, 1.83 m (6 ft) wide, and 1.22 m (4 ft) deep tower packed with redwood slats, ammonia removals of 95 percent (from domestic sewage) were achieved at a pH of 11.5 and an air-to-liquid loading of 3.0 cu m/l (400 cu ft/gal).

A full-scale ammonia stripping tower has been built at South Tahoe to remove ammonia from domestic sewage. This tower is of cross-flow design and is equipped with a two-speed reversible 7.32 m (24 ft) diameter horizontal fan and packed with treated hemlock slats. Its overall dimensions are 9.75 m (32 ft) by 19.5 m (64 ft) by 14.3 m (47 ft) high, and the tower is designed to treat 14,200 cu m/day (3.75 mgd) of water. Treatment efficiencies have been reported to closely parallel that of the pilot scale tower from which it was designed, but problems have limited winter-time operation. Ammonia removal efficiencies on the order of 90 to 95 percent are being consistently achieved in warm weather operation.

A study of air stripping of ammonia from petroleum refinery waste waters in the 100 mg/l range reported ammonia removal efficiencies of greater than 95 percent at all pH values above 9.0 in a closely packed aeration tower with an air-to-liquid ratio of 3.59 cu m/l (480 cu ft/gal).

Ammonia treatment efficiencies have been reported as being consistently good when the temperature of the waste water being treated is maintained above 20°C (67°F). However, the colder air and water temperatures in winter have been observed to have a pronounced effect on the ammonia stripping efficiency. It was determined that during winter operating conditions, at an air-to-liquid ratio of 3.59 cu m/l (480 cu ft/gal) and a loading rate of 81.5 l/min sq m (2.0 gpm/sq ft), temperature drops of from 8 to 10°C (14-18°F) occurred when waste water influent was introduced at temperatures in the 13 to 20°C (55-67°F) range.

All the reported cold air operational problems should be noted as having been associated with the stripping of ammonia from the effluent from a domestic sewage treatment plant. This effluent would be relatively cold during winter operating conditions. The effluent from an incandescent lamp envelope manufacturing plant, however, is at an approximate temperature of 38°C (100°F), even during winter operating conditions.

It is unclear whether the conventional air stripping of ammonia is practicable technology during winter operating conditions for the incandescent lamp envelope manufacturing subcategory. Theoretically, the rate at which ammonia strips is a function of the difference in partial pressures of the ammonia dissolved in the liquid phase and that of the gaseous phase. Therefore, at the high ammonia concentrations experienced in the incandescent lamp envelope manufacturing segment (approaching 650 mg/l), it is not clear whether the driving force for ammonia stripping will be sufficiently hindered during cold weather to render this technology impractical.

The ammonia concentrations experienced in the domestic treatment field are in the range of 12 to 30 mg/l, and the driving force for stripping is considerably lower at these concentrations. Whether the 38°C (100°F) effluent temperatures will be sufficient to overcome the low air temperatures experienced in northern climates during winter operations is indeterminable at this time. There is sufficient justification for further research of the application of this technique to industrial waste waters.

The most recent advance in the area of ammonia stripping includes an ammonia recovery step. Preliminary results indicate that most of the problems usually associated with stripping towers have been overcome. This process involves the air stripping of ammonia in a closed cycle with the gas stream recycled rather than outside air being used in a single pass manner. The stripped ammonia is then absorbed in an absorbing liquid which is maintained at a low pH to convert dissolved ammonia gas to ammonium ion. The absorbent liquid initially is water with acid added to maintain a low pH. If sulfuric acid is added, an ammonium sulfate salt solution is formed which builds up in concentration; thus, ammonia is ultimately discharged from the stripping unit as a liquid or solid blowdown.

Advantages of this system are that the usual scaling problems associated with ammonia stripping will be eliminated because carbon dioxide (which can react with calcium and hydroxide ions to form calcium carbonate scale) is eliminated from the stripping air during the first few passes as nearly all outside air is excluded. The problem of tower freezing is also eliminated due to the exclusion of outside air in significant quantities. The treatment system will normally operate at a temperature approaching that of the waste water itself. It is estimated that the cost of this method of treatment is approximately 1.5 to 2.0 times as much as conventional air stripping. However, this cost can be offset somewhat if the concentrated ammonia is sold as a by-product, such as fertilizer. It is predicted that process optimization and sale of the by-product could yield a cost of approximately the same as that associated with conventional air stripping, which is usually considerably less than that associated with other nitrogen removal techniques.

It is apparent from the above discussion that while the air stripping of ammonia is not currently demonstrated in the glass manufacturing category, there is sufficient information available to justify further study of the application of this ammonia removal technique. This further study could lead to an economical and easily operated procedure of ammonia removal and/or recovery.

Selective Ion Exchange-

In recent years, a considerable amount of experimental work has been done with clinoptilolite, a naturally occurring zeolite that is selective for the ammonium ion in the presence of calcium and magnesium. The experimental work has been done primarily with domestic sewage where typical ammonia removals ranging from 93 to 97 percent were achieved for influent ammonia nitrogen concentrations of 10 to 20 mg/l. The secondary treated sewage was filtered through a multimedia filter before ammonia removal to prevent plugging of the exchange media.

The clinoptilolite can be regenerated by a lime slurry or by an electrolytic method. A mixture of NaCl and $CaCl_2$ in a solution adjusted to a pH of about 11 with lime is used to regenerate the clinoptilolite. The spent regenerant can then be air stripped to remove the ammonia. Scaling can occur in the exchange columns with the lime slurry regeneration method. The electrolytic method uses a mixture of calcium, sodium, magnesium, and potassium chlorides for eluting the ammonia from the beds. The regenerant is then introduced into an electrolytic cell in which chlorine is produced and reacts with the ammonia to produce nitrogen gas. The electrolytic renovation of spent regenerant is economically competitive with air stripping and does not require atmospheric disposal of the ammonia.

A high frequency of regeneration and resultant disposal of concentrated regenerant will be required at the high ammonia levels present in the incandescent lamp envelope frosting waste waters. Further research is required to determine if selective ion exchange and regenerant recovery can be feasible as a secondary method for treating frosting waste waters following primary removal by stripping.

Nitrification and Denitrification-

Nitrification. Nitrification is the biological conversion of nitrogen in organic or inorganic compounds from a more reduced to a more oxidized state. In the field of water pollution control, nitrification usually is referred to as the process in which ammonium ions (NH_4^+) are oxidized to nitrite and nitrate sequentially. In the nitrification step, aerobic bacteria convert the ammonia nitrogen to nitrates. The nitrification step is carried out in an aeration chamber with a longer retention time and lower loading than a conventional activated sludge unit. The following equations describe the reactions which occur during the nitrification step:

$$2NH_3 + 3O_2 = 2NO_2^- + 2H^+ + 2H_2O$$
$$2NO_2^- + O_2 = 2NO_3$$

Factors that affect the nitrification process include concentration of nitrifying organisms, temperature, pH, dissolved oxygen concentration, and the concentration of any inhibiting compounds. Adequate process design and operating control are necessary for consistent results.

The nitrifying organisms of significance in waste management are autotrophic with Nitrosomonas being the major bacterial genera that are involved. Nitrifying bacteria are ubiquitous in the soil although they may not be part of untreated wastes. Nitrifying organisms are aerobic and adequate dissolved oxygen (DO) in the aeration system is necessary. DO concentrations should be above 1 to 2 mg/l to assure consistent nitrification. Nitrification is affected by the temperature of the system. Available information provides conflicting data on the performance of nitrification systems at low temperatures. Although detailed studies are lacking, it should be possible to achieve nitrification at low temperatures and compensate for slower nitrifying organism growth rates by maintaining a longer solids detention time and hence a larger nitrifying active mass in the system.

The optimum pH for nitrification of municipal sewage has been indicated to be between 7.5 and 8.5. Nitrification can proceed at low pH levels, but at less than optimum rates. During nitrification, hydrogen ions are produced and the pH decreases, the magnitude of the decrease being related to the buffer capacity of the system. A decrease in pH is a practical measure of the onset of nitrification.

High concentrations of un-ionized ammonia (NH_3) and un-ionized nitrous acid (HNO_2) can inhibit nitrification. These compounds can be in the influent waste water or can be generated as part of the nitrification process. The concentrations of un-ionized ammonia and nitrous acid that are inhibitory and operational approaches to avoid such inhibition have been documented. Using these approaches it should be possible to operate nitrification systems that produce consistent results even with waste waters having high nitrogen concentrations.

While research on nitrification has been conducted for a number of years, most pilot and full-scale studies have been initiated since 1970. Even though there has been a relatively short time frame of evaluation, nitrification is already a very readily described process for which treatment system designs can be implemented. Most of the applications have been on municipal effluents, but concentrations of ammonia in these effluents have ranged between 20 mg/l and 800 mg/l. Like any other "tertiary" level of treatment, nitrification requires more operational attention than has generally been given to simple biological treatment, but the applicability of the process to many types of effluents appears very reasonable.

Nitrification/Denitrification. This two-step process of nitrification and denitrification is of primary importance for removal of the residual ammonia, nitrite, and nitrates in secondary treatment systems. Removal of the above soluble nitrogen forms can be virtually complete, with nitrogen gas as the end product. This process differs from ammonia stripping and nitrification in that the latter processes convert or remove only the ammonia content of a waste water.

As described earlier, nitrification is carried out under controlled process conditions by aerating the waste water sufficiently to assure the conversion of the nitrogen in the waste water to the nitrite-nitrate forms. The denitrification process reduces the oxidized nitrogen compounds (nitrites and nitrates) to nitrogen gas and nitrogen oxides thereby reducing the nitrogen content of the waste water as the gases escape from the liquid.

Denitrification takes place in the absence of dissolved oxygen. Additional important factors affecting denitrification include carbon source and temperature. Denitrification is brought about by heterotrophic facultative bacteria. Generally, high denitrification rates require the addition of a biodegradable carbon source such as sugar, ethyl alcohol, acetic acid, or methenol. Methanol is the least expensive and performs satisfactorily in that it reacts rapidly and provides for a minimal growth of new organisms. Investigators working on this process have found that a 30-percent excess of methanol over the stoichiometric amount is required, or about 3 mg of methanol to 1 mg of nitrate. The following reaction takes place if methanol is used as the carbon source and proper conditions are maintained:

$$6NO_3^- + 5CH_3OH = 3N_2 + 5CO_2 + 7H_2O + 6OH^-$$

Denitrification does not take place until the dissolved oxygen concentration of the waste water is near or at zero. The organisms responsible for denitrification are ubiquitous and can adapt to pH levels within the range of about 6.0 to 9.0. As with any biochemical process, denitrification exhibits a temperature dependency although within the range of 20°C to 30°C, little effect has been observed. Denitrification activity decreased when the temperature decreased to 10°C. Denitrification can be operated at low temperatures by designing systems with long solids retention times (SRT). For denitrification systems, an SRT of at least 3 to 4 days at 20°C and 30°C and 8 days at 10°C has been recommended. Nitrate reduction efficiency in denitrification can be controlled by adjusting the SRT of the process to assure adequate numbers of denitrifying organisms and adequate denitrification rates as environmental conditions change.

In a sequential nitrification/denitrification process, the waste water from the denitrification step may be sent to a second aeration basin, following denitrification, where the nitrogen gases are stripped from the waste stream. The sludge from each stage is settled and recycled to preserve the organisms required for each step in the process. The processes of nitrification and denitrification can occur simultaneously in aeration systems in which both aerobic and anaerobic portions occur.

Although nitrification/denitrification has not been applied to pressed an blown glass manufacturing waste water as yet, the process has been evaluated in a number of bench and pilot scale studies on a variety of wastes. Anaerobic processes evaluated as part of the denitrification sequence have included anaerobic ponds, an anaerobic activated sludge system, oxidation ditches, and anaerobic filters. Efficient nitrogen removals from agricultural subsurface drainage water were accomplished with an anaerobic filter. In Germany, the successful elimination of nitrogen from sewage and digester supernatant was achieved by first nitrifying the wastes and then denitrifying in a separate vessel. Two- and three-stage systems have been shown to be feasible for the nitrification/denitrification process. A pilot model of a three-stage system using this process was developed at the Cincinnati Water Research Laboratory of the EPA and is being built at Manassas, Virginia.

The nitrification and denitrification methods of nitrogen removal have been used primarily to treat municipal waste waters. Pilot plant work using frosting waste water must be conducted to determine the feasibility of the method in treating the frosting wastes. Such factors as the high ammonia levels (650 mg/l), shock loads, biological upsets, and supplemental chemical addition might preclude the nitrification/denitrification method as a viable method for treating frosting waste waters alone. However, it may prove economical for a facility to treat its combined sanitary and industrial waste waters in a nitrification or nitrification/denitrification system as is being done in at least one facility which handles wastes similar in nature to those characterisic of the incandescent lamp envelope manufacturing subcategory.

Breakpoint Chlorination-

When chlorine is added to waste water containing ammonia nitrogen, the ammonia reacts with the chlorine to produce chloramines. The further addition of chlorine up to a "breakpoint" results in converting the chloramines to nitrogen oxide which is released as a gas to the atmosphere. Ammonia nitrogen in domestic sewage can be reduced to a level of 0.1 mg/l if adequate mixing, dosing, and pH control are maintained. The following equations illustrate the reactions:

$$NH_3 + HOCl = NH_2Cl \text{ (monochloramine)} + H_2O$$
$$NH_3 + 2HOCl = NHCl_2 \text{ (dichloramine)} + 2H_2O$$
$$NH_2Cl + NHCl_2 + HOCl = N_2O + 4HCl$$

Breakpoint chlorination is a well understood and well documented technology. Applications have centered on tertiary treatment of secondary municipal wastes, although the concept has been found to be useful as a "polishing" mode in conjunction with ammonia stripping. It appears from the literature that the process offers a possible alternative for ammonia control of ammonia concentrations similar to those encountered in municipal secondary effluents.

Approximately eight to ten parts of chlorine to one part of ammonia-N are required to reach the chlorine breakpoint. The high chlorine dosage results in excessive chemical costs at high ammonia levels in the waste water. Additional adverse effects of breakpoint chlorination include high chlorine residuals and mineralization in the form of chlorides. The high chlorine residuals can be reduced by carbon contactors before discharge to the receiving body of water. Breakpoint chlorination, however, will probably not prove viable for treating frosting waste because of excessive chemical costs due to high concentrations of ammonia. However, as a polishing step subsequent to air or steam stripping, breakpoint chlorination could prove to be a viable means of attaining water quality-related limitations.

Lead Removal

Lead is contributed by the waste waters from the television picture tube envelope and hand pressed and blown glass manufacturing subcategories. The lead is primarily in the form of particulates removed during grinding and polishing of lead crystal and the funnel section of television picture tube envelopes, and soluble lead resulting from hydrofluoric acid polishing of leaded glass. The primary methods used to remove lead from waste waters include plain sedimentation, lime precipitation and sedimentation, and filtration. Suspended solids are also removed in the lead treatment processes.

Plain sedimentation is relatively effective in removing particulate lead but not dissolved lead. Improved settling is obtained by pH adjustment to a neutral pH and by lengthened detention time in the clarification unit.

The lime precipitation process is the most common method used to treat dissolved lead wastes. In the lead precipitation process, lead is precipitated as the carbonate ($PbCO_3$) or the hydroxide ($Pb(OH)_2$). Conflicting values are given for the optimum pH for precipitating the lead hydroxide: the suggested pH values range from 6.0 to 10.0. Improved removal efficiencies can be obtained by adding ferrous sulfate to the lime precipitation process. Treatment efficiencies exceeding 95 percent have been achieved with lime precipitation plus sedimentation both in full scale and pilot plant operations.

In pilot plant work and in full scale studies at a municipal water treatment plant, filtering through a dual media filter was shown to futher reduce the lead content following lime precipitation and sedimentation. Effluent levels were reduced almost an order of magnitude by sedimentation and filtration rather than by sedimentation only. The additional removals are obtained by removing poorly settling lead hydroxide particles that are carried over from the clarification units.

The lead wastes from the pressed and blown glass segment are treated in conjunction with the fluoride waste waters. The point of application of the lead waste varies; at one picture tube envelope plant the lead wastes are treated by coagulation and then allowed to settle with the lime treated wastes. At another picture tube plant, the lime treated fluoride wastes are settled in a primary clarifier and the lead abrasive wastes are added to the treated fluoride wastes and settled again. The effluent from the two-stage system contains about 1 mg/l of lead. The lead wastes settle readily because the lead is in the particulate form.

SUGGESTED TREATMENT TECHNOLOGY

As was indicated in the previous section, several treatment technologies are usually available to reduce a given pollutant parameter. This section discusses the application of specific methods of treatment which may be employed for each subcategory to achieve the effluent limitations and new source performance standards recommended in Sections IX, X, and XI. These technologies are not to be construed as the only means for achieving the stated effluent levels, but are considered to be feasible methods of treatment based on available information. The cost estimates developed in Section VIII are based on these technologies.

Glass Container Manufacturing

As was stated in Section V, waste water results from forming and cullet quenching in the manufacture of glass containers. In most plants, these waste waters are combined with non-contact cooling water prior to discharge; however, in some cases a portion of the cooling water is used for cullet quenching. Oil and suspended solids are the only significant parameters contained in this waste water. The quantity of pollutants discharged may be reduced by recycling the cullet quench water and treating the blowdown using dissolved air flotation followed by diatomaceous earth filtration as illustrated in Figure 11.

Existing Treatment and Control (Alternative A)-

Both in-plant techniques and end-of-pipe methods have been employed to reduce pollutant discharge. Many plants have achieved low effluent levels with only in-plant methods, and the presence of end-of-pipe treatment systems has not necessarily assured a high quality effluent. A number of plants without end-of-pipe treatment are achieving low discharge levels while several plants with treatment are discharging at rather high levels.

The typical combined cooling and cullet quench water flow for a glass container plant is 2,920 l/metric ton (700 gal/ton) with 53 percent of the total flow being process water. Suspended solids discharges of 70 g/metric ton (0.14 lb/ton) and oil discharges of 30 g/metric ton (0.06 lb/ton) are presently being achieved by 70 percent of the 40 plants for which data are available. These values correspond to 24 mg/l for suspended solids and 10 mg/l for oil at the typical flow.

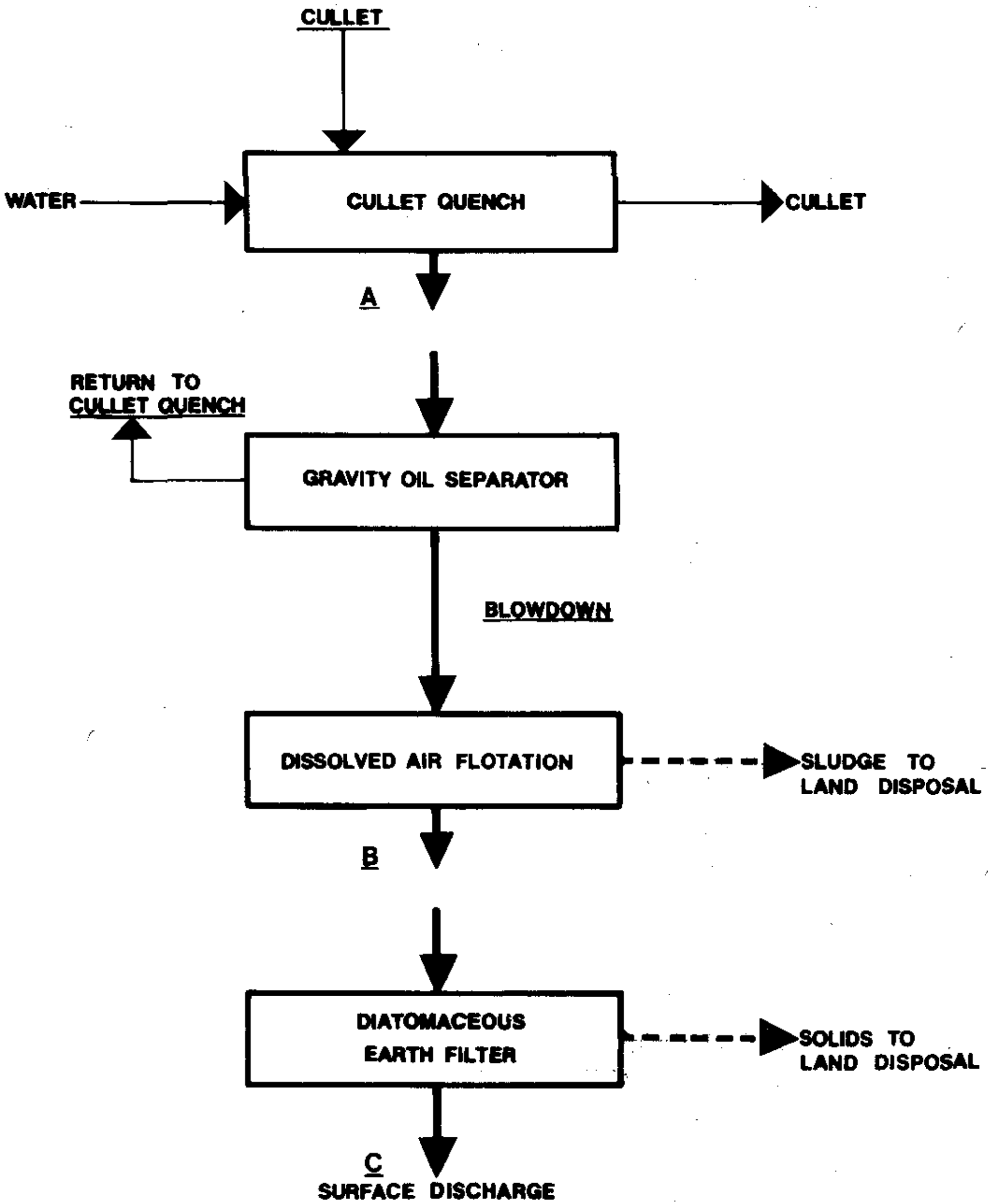

FIGURE 11

WASTE WATER TREATMENT

GLASS CONTAINER MANUFACTURING

MACHINE PRESSED AND BLOWN GLASS MANUFACTURING

These effluent levels should be readily achievable by all plants with a minimum of in-plant modification or end-of-pipe treatment. In-plant modifications to reduce pollutant discharge include shear spray collection of forming machine shop oil, or modified cleanup procedures. Many plants collect and recycle shear spray. Pans are placed around the shears to collect as much of the excess spray as possible. The collected material is filtered and returned to the shear spray make-up tank. Approximately 70 percent of the shear spray can be recovered in this manner. In some plants, troughs are built around the forming machines to collect the oily runoff resulting from excess lubrication and leaks. The oily waste flows by gravity to a storage tank and is periodically hauled away for reclamation or disposal.

It is the practice of many plants to periodically hose down the area around the forming machines. It may be possible to use a dry removal method for at least part of the cleanup. One of the oil adsorptive sweeping compounds might be used and disposed of as solid waste, thereby eliminating some of the oil discharged into the waste water system.

End-of-pipe treatment might involve some type of sedimentation system with oil removal capability. This will serve to reduce suspended solids and free oil but will not significantly reduce emulsified oil. Although end-of-pipe treatment systems are presently being used by some plants, it would appear that in-plant techniques will be more effective and less expensive to achieve the suggested effluent levels.

Recycle with Dissolved Air Flotation of Blowdown (Alternative B)-

Effluent levels can be further reduced by segregating the cullet quench water from the cooling water system, recycling the cullet quench water through a gravity separator and treating the blowdown using dissolved air flotation. Suspended solids and oil will build up in the recirculation system, but the dissolved solids concentration will probably be limiting. A conservative value of 5 percent blowdown is assumed, based on the operating dissolved solids level of approximately 1700 mg/l in an existing recycle system. Dissolved solids levels of 4000-5000 mg/l are probably acceptable, but supportive data are not presently available. A cooling tower is not considered necessary. Existing recycle systems use only a tank that serves as the recycling pump wet well and from which oil is removed using a belt skimmer.

Segregation of the non-contact cooling water and recycle with a 5 percent blowdown will reduce the typical contact water discharge flow to 77 l/metric ton (18.5 gal/ton). Blowdown from the recycle system can be treated to 2 g/metric ton (0.004 lb/ton) using dissolved air flotation. COD is expected to be reduced in proportion to the oil removed. The sludge production is approximately 1900 l/day (500 gal/day) at 3 percent solids concentration.

Several glass container plants are presently recycling cullet quench water to conserve water, but none are treating the blowdown using dissolved air flotation. This technology is practiced in the flat glass industry and should be readily transferable to the pressed and blown glass industry. It has been reported that a new glass container plant will employ this technology but at the present time no operating data has been generated and no pilot or bench-scale data has been submitted to the Agency.

At least one plant has recently begun treating a portion of the recycling quench water using diatomaceous earth filtration. Long-term operating data for this system are not available. It is possible that diatomaceous earth filtration will not be effective for the high oil concentrations in a recycling system or that excessive diatomaceous earth usage will be required. For this reason, the proposed model system includes dissolved air flotation, prior to diatomaceous earth filtration, to lessen the oil loading to the diatomaceous earth filter.

Diatomaceous Earth Filtration (Alternative C)-

Diatomaceous earth filtration may be employed to further reduce the oil and suspended solids in the dissolved air flotation discharge stream to less than 10 mg/l or 0.8 g/metric ton (0.0016 lb/ton). Approximately 50 l/day (13 gal/day) of 15 percent solids sludge is produced. This technology has been commonly employed for steam condensate treatment and should be readily transferable to the pressed and blown glass industry. As stated above, at least one plant is presently employing the diatomaceous earth filtration technology.

Rather than treat to such a low effluent level, it may be feasible for a plant to consider complete recycle or discharge of the blowdown into the batch. Several container manufacturers are investigating this possibility and a number of plants have achieved nearly complete recycle. More data than was available for this study will be necessary to evaluate the feasibility of zero discharge through application of this technique.

Machine Pressed and Blown Glass Manufacturing

Owing to similar manufacturing techniques, waste water resulting from machine pressing and blowing of glass is similar to glass container manufacturing waste water. Oil and suspended solids are the significant pollutant parameters and their discharge may be reduced by recycling the cullet quench water and then treating the blowdown. The machine pressed and blown glass manufacturing subcategory is the subject of further study at the present time. The results of this study will be presented in a supplemental document at a later date.

Glass Tubing (Danner) Manufacturing

Process waste water in the glass tubing (Danner) manufacturing subcategory results from cullet quenching during periods when normal production has been interrupted. In most plants, cullet quench water is combined with non-contact cooling water prior to discharge. Suspended solids is the only significant pollutant in the quench water along with small quantities of tramp oil. Recycle with treatment of the blowdown, as illustrated in Figure 12, is a feasible method of treatment.

Existing Treatment and Control (Alternative A)-

Owing to the high quality and erratic discharge of cullet quench water, no plants presently treat this source of waste water. All four of the plants for which data are available presently achieve a discharge of less than 225 g/metric ton (0.45 lb/ton) of suspended solids, and 85 g/metric ton (0.17 lb/ton) of oil. This corresponds to 27 mg/l of suspended solids and 10 mg/l of oil at the typical combined cullet quench water and non-contact cooling water flow of 8,340 l/metric ton (2,000 gal/ton).

Recycle with Diatomaceous Earth Filtration of Blowdown (Alternative B)-

Because cullet quench water accounts for only five percent of the combined flow, it is possible to further reduce the oil and suspended solids levels by segregating the cullet quench water from the non-contact cooling water, recycling the quench water through a cooling tower, and treating the blowdown using diatomaceous earth filtration. A flow over the cooling tower of 12.6 l/second (200 gpm) for the typical plant is assumed. Assuming a five percent blowdown, the discharge will be 21 l/metric ton (5 gal/ton). The minimum allowable blowdown is unknown because this technology is not presently employed in the glass tubing industry, but five percent is considered a conservative estimate. Suspended solids will probably be limiting because only negligible dissolved solids increases were noted in the available data. It is anticipated that at least a portion of the suspended solids can be removed in a glass trap associated with the collection sump.

It may be possible to use a tank rather than a cooling tower provided sufficient water can be stored to sufficiently dissipate the heat in the glass to be quenched. Information to calculate the required storage volume is not available and, therefore, a cooling tower is assumed for the purpose of this analysis.

Blowdown from the recycling system can be treated at a constant rate using diatomaceous earth filtration. Approximately 15 l/day (4 gal/day) of 15 percent solids sludge will be produced. Diatomaceous earth filtration is used to treat boiler condensate and is readily transferable to the glass tubing (Danner) manufacturing subcategory. Refer to earlier portions of this section for more detailed information.

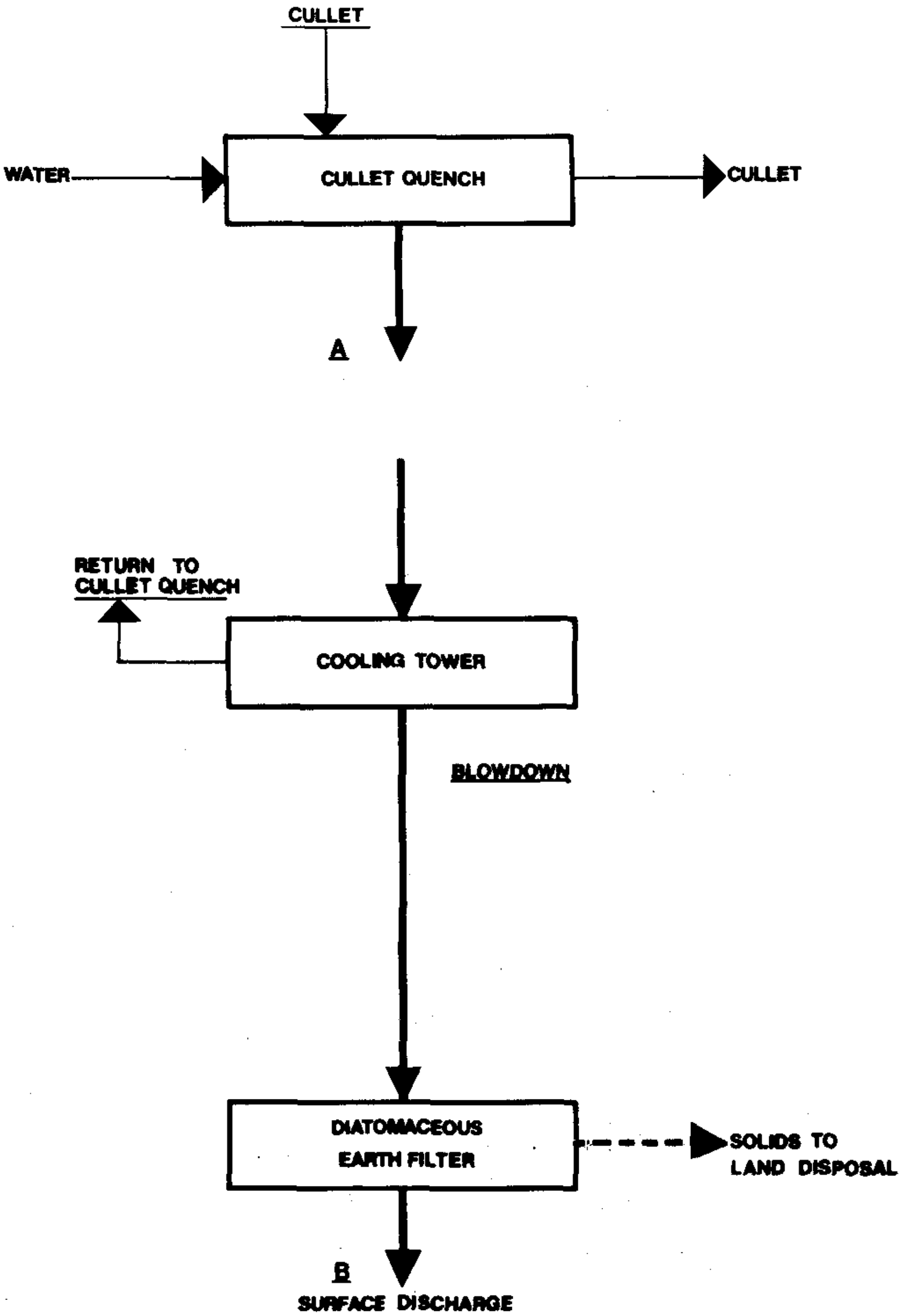

FIGURE 12

WASTE WATER TREATMENT

GLASS TUBING MANUFACTURING

Treatment of the blowdown from the cullet quench recirculation system by sand filtration or disposal of the blowdown in the batch are other alternatives; the latter will allow for zero waste water discharge. The typical blowdown is approximately 1.5 percent by weight of the furnace fill, well within the range of the three percent of water added when batch wetting is used.

Television Picture Tube Envelope Manufacturing

Waste waters are produced during both the forming and finishing of television picture tube envelopes. Cullet quench water contains low concentrations of oil and suspended solids and does not require further treatment. Finishing waste water, produced by acid and abrasive polishing of television picture tube screens and funnels, contains high concentrations of suspended solids, fluoride, and lead. The acid and abrasive wastes are presently treated using lime precipitation, coagulation, and sedimentation but effluent levels can be further reduced by sand filtration followed by activated alumina adsorption. These treatment technologies are illustrated in Figure 13.

Existing Treatment and Control (Alternative A)-

Television picture tube envelope manufacturing plants employ in-plant methods of water conservation and end-of-pipe treatment for fluoride, lead, and suspended solids removal. Because many of the plants have been built within the last 10 years and all within the last 25 years, relatively good water conservation is practiced. Abrasive grinding slurries are recycled to recover usable abrasive material and only the particles too small to be of further value are discharged. Rinse waters are recycled where possible by using countercurrent or overflow type rinse tanks. Some final rinses are once through because a high quality water is required to prevent spotting. It may be possible to recycle this water for less critical uses. Spent acid solutions are either bled into the treatment system at a slow rate or returned to the manufacturer for recovery and recycling.

All of the plants, for which information was available, treat abrasive and acid polishing waste waters by lime precipitation followed by combined coagulation and sedimentation of the calcium fluoride precipitate and abrasive waste suspended solids. The pH is reduced where necessary and sulfuric acid is generally used. Vacuum filtration is the most common method of dewatering, and the sludge is disposed of as landfill. One plant reports sludge production of 20.9 metric tons/day (23 tons/day). The cullet quench waters are combined with non-contact cooling water prior to discharge and are not treated. The typical combined non-contact cooling and cullet quench water flow is 8,080 l/metric ton (1,940 gal/ton) and suspended solids and oil concentrations are below 5 mg/l. When combined with the treatment plant effluent, the total typical flow is 12,500 l/metric ton (3,000 gal/ton).

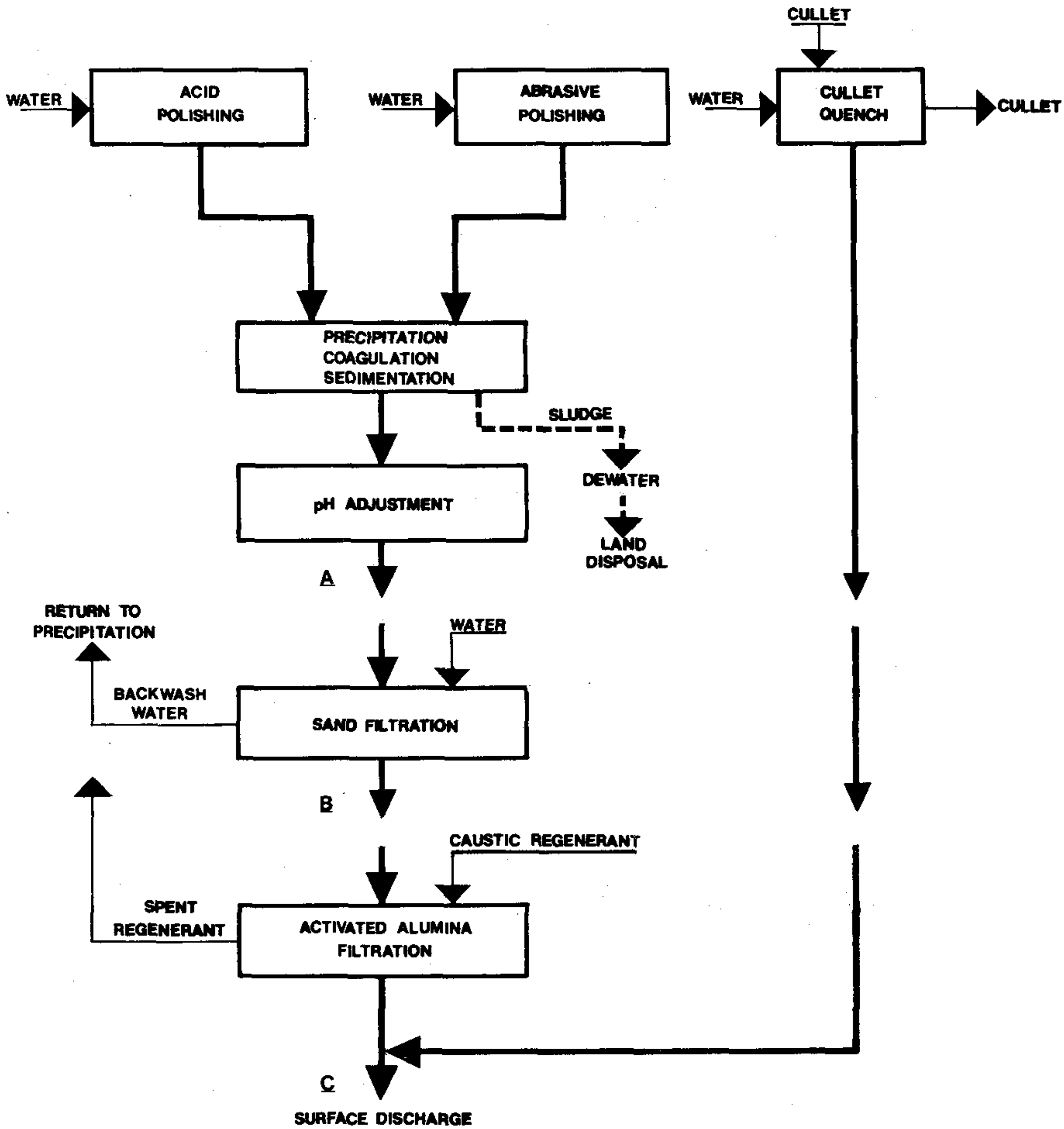

FIGURE 13

WASTE WATER TREATMENT

TELEVISION PICTURE TUBE ENVELOPE MANUFACTURING

Effluent levels of 150 g/metric ton (0.30 lb/ton) for suspended solids, 130 g/metric ton (0.26 lb/ton) for oil, 70 g/metric ton (0.14 lb/ton) for fluoride, and 4.5 g/metric ton (0.0090 lb/ton) for lead can be achieved using existing treatment methods and equipment. These values are equivalent to concentrations in the treatment plant effluent of 15 mg/l of fluoride and 1 mg/l of lead and concentrations in the combined treated and cullet quench water streams of 10 mg/l for oil and 12 mg/l for suspended solids. The fluoride and lead concentrations in the combined flow are 5.6 mg/l and 0.36 mg/l, respectively. Of the four television picture tube envelope manufacturing plants for which data were available, three of the four presently achieve the above discharge level for suspended solids, two of three for oil, three of four for fluoride, and all meet the discharge level for lead. All plants can achieve these levels by upgrading the operation of existing treatment systems and by improving housekeeping to minimize pollutant discharge from the forming area.

Sand Filtration (Alternative B)-

Fluoride and lead precipitates that are not removed during sedimentation may be further reduced by filtering the lime treated effluent using sand or graded media. The filter backwash can be returned to the head of the lime treatment system and, therefore, no additional sludge handling equipment is required. Filtration will reduce the fluoride to less than 13 mg/l, the lead to 0.1 mg/l, and the suspended solids to less than 10 mg/l. The total plant discharge, including the treated effluent and the cullet quench water, will be reduced to 130 g/metric ton (0.26 lb/ton) for suspended solids, 60 g/metric ton (0.12 lb/ton) for fluoride, and .45 g/metric ton (0.0009 lb/ton) for lead. The concentration of pollutants in the total typical plant discharge for this level of treatment will be 10 mg/l for suspended solids, 10 mg/l for oil, 4.8 mg/l for fluoride, and 0.036 mg/l for lead.

Filtration of waste water is not presently practiced in the pressed and blown glass industry, but is a commonly employed treatment method used in the water treatment industry, usually following lime softening.

Activated Alumina Filtration (Alternative C)-

Reduction of fluoride to less than 2.0 mg/l can be accomplished by passing the effluent from the sand filter through a bed of activated alumina. The activated alumina may be regenerated with sodium hydroxide (rinsing with sulfuric acid may be necessary to reduce causticity) or mineral acid. If sodium hydroxide is used, the regenerant may be returned to the head of the lime treatment system for removal of the fluoride. If a mineral acid such as hydrochloric acid is used, it may be necessary to include separate neutralization and sludge handling facilities to treat the spent regenerant stream. The costs presented in Section VIII of this document reflect the use of hydrochloric acid as the regenerant and include separate neutralization and sludge handling facilities. With this technology, the fluoride discharge will be reduced to 9 g/metric ton (0.018 lb/ton) and the concentration of fluoride in the total typical plant discharge will be 0.72 mg/l.

Activated alumina is not presently used in the pressed and blown glass segment, but has been successfully used for many years at several potable water treatment plants in the United States. Experiments have indicated that the higher pH associated with lime treatment will not adversely affect the fluoride removal capability.

All plants should be able to reduce the average effluent of fluoride waste waters to 2.0 mg/l using this technology.

Incandescent Lamp Envelope Manufacturing

Waste waters are produced during both forming and frosting in the manufacture of incandescent lamp envelopes. Cullet quench waters contain small quantities of oil and suspended solids, and frosting waste waters contain moderate concentrations of suspended solids and high concentrations of fluoride and ammonia. Frosting wastes are presently treated for fluoride removal, but ammonia removal techniques are currently not employed. Treatment methods that may be employed to reduce the level of pollutants discharged by the incandescent lamp envelope manufacturing subcategory are illustrated in Figure 14.

Existing Treatment and Control (Alternative A)-

Most of the treatment methods presently in use in the incandescent lamp envelope manufacturing subcategory can be considered end-of-pipe methods. Cullet quench waters are discharged untreated or at some plants belt type oil skimmers are used to skim free oil from pump or discharge sumps. Frosting waste waters are treated in all cases using lime precipitation for fluoride and suspended solids removal; however, this sytem is ineffective for ammonia removal. Some ammonia discharge is eliminated by separate disposal of the concentrated etching solution. At least one plant recovers the salts from this solution by evaporating most of the water and then allowing the sludge to air dry. Other plants truck the spent frosting solution to permanent storage.

The percentage of lamp envelopes frosted varies from plant to plant and, therefore, the cullet quench and frosting waste waters from this subcategory must be categorized separately. Pollutants discharged in the cullet quench water as a result of forming will be expressed in terms of metric tons (tons) pulled from the furnace while the pollutant parameters contributed by frosting will be expressed in terms of the metric tons (tons) pulled for the frosting line. This value is calculated by multiplying the metric tons (tons) pulled by the percentage of the plant output that is frosted. A plant frosting 85 percent of its production has been assumed for cost estimating purposes and is presented in Section VIII.

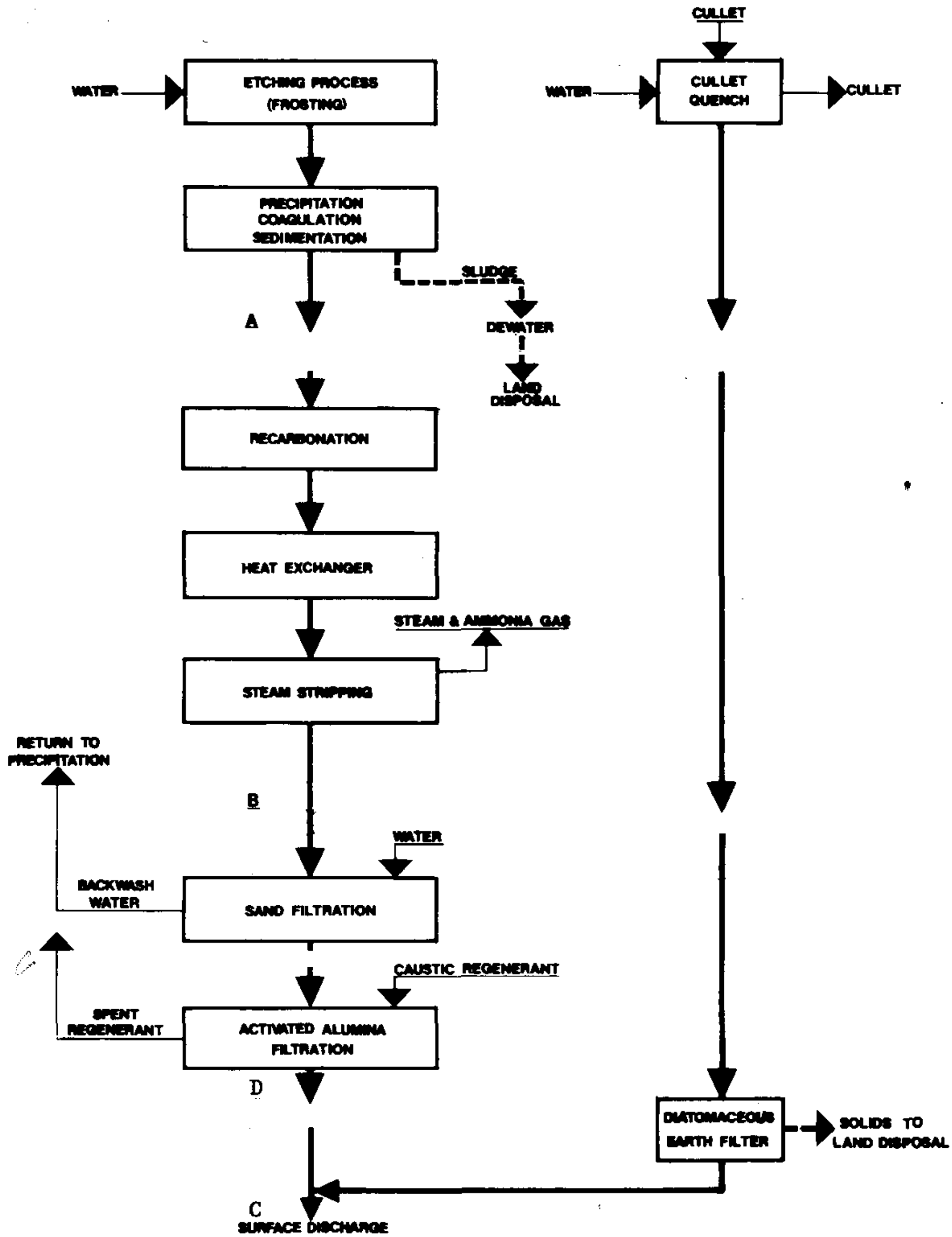

FIGURE 14

WASTE WATER TREATMENT

INCANDESCENT LAMP GLASS MANUFACTURING

Little information is available on the quality of quench water, but it is apparent that all plants can achieve a level of 115 g/metric ton (0.23 lb/ton) suspended solids and oil. This is equivalent to 25 mg/l at the typical cullet quench water flow of 4,500 l/metric ton (1,080 gal/ton). Plants not presently achieving these levels can apply many of the methods for improved housekeeping described for the glass container manufacturing subcategory. Much of the oil and suspended solids originates in the ribbon machine area. Careful attention to coolant spray and lubrication techniques should eliminate excessive oil discharges. It might be necessary, in some cases, to collect the highly contaminated waste waters that occur during clean-up for separate disposal or treatment in the lime treatment system.

Frosting waste waters are treated using lime to precipitate calcium fluoride, followed by flocculation and sedimentation. The effluent pH is lowered to at least 9.0 at most plants and neutralization is considered typical. It is possible, using existing equipment to treat frosting waste waters to levels of 230 g/metric ton frosted (0.46 lb/ton frosted) for suspended solids and 115 g/metric ton frosted (0.23 lb/ton frosted) for fluoride. These levels are equivalent to 58 mg/l, and 29 mg/l, respectively, at the typical flow of 3,960 l/metric ton frosted (950 gal/ton frosted). The typical fluoride concentration of 29 mg/l is higher than can be achieved with equivalent treatment technology in the television and handmade subcategories because of apparent interference by one or more constituents of the frosting solution. The data indicate consistently higher effluents from incandescent lamp envelope plants than are obtained in television picture tube envelope plants.

A typical plant that frosts 85 percent of its production would have a total effluent concentration of 39 mg/l for suspended solids, 15 mg/l for oil, 12.4 mg/l for fluoride, and 275 mg/l for ammonia. When the combined forming and frosting waste waters are considered, two of the five plants for which data are available are presently achieving the recommended level for suspended solids, three are achieving the recommended level for oil, two are achieving the recommended level for fluoride, and no plant significantly reduces ammonia.

Plants that are not achieving these effluent levels can upgrade their treatment systems using the methods discussed earlier in the treatment technology section. It is likely that, in many cases, excessive fluoride discharge is associated with poor suspended solids removal. Improvements to optimize suspended solids removal such as careful control of flocculation, addition of polyelectrolytes or other coagulant aids, sludge recycle, and reduced weir overflow rates may be employed in an existing waste water treatment plant with a minimum of modification.

Sand Filtration and Ammonia Removal (Alternative B)-

Fluoride in the frosting waste waters may be further reduced using sand filtration. The filter backwash may be returned to the head of the lime precipitation system for treatment and disposal. Suspended solids can be reduced to 40 g/metric ton frosted (0.080 lb/ton frosted) and fluoride to no more than 52 g/metric ton frosted (0.104 lb/ton frosted) using this technology. These loadings are equivalent to 10 mg/l and 13 mg/l, respectively, at the typical frosting waste water flow rate. This technology is not presently employed in the pressed and blown glass industry, but has been used for many years for potable water treatment.

The ammonia in the frosting waste water can be reduced to a more acceptable level by steam stripping. This and other ammonia removal technologies are discussed in detail in the treatment technology section. One possible configuration is recarbonation, followed by a heat exchanger, and then the stripping column.

Recarbonation will stabilize the excess calcium in the lime treatment discharge and control pH. Further experimentation will be required to determine the optimum location of the recarbonation step. Ammonia removal efficiency increases as the pH increases, but the calcium may precipitate in the stripping column and the heat exchanger and form calcium carbonate scale. It is probable that a trade-off exists between ammonia removal efficiency and scaling. It is possible that recarbonation will be more advantageous subsequent to steam stripping. Purchased CO_2 is assumed in the cost estimate, but the melting furnace stack gas is rich in CO_2 and should be considered as a possible source. The heat exchanger will preheat the water entering the stripper while cooling the water being discharged, thus minimizing fuel requirements.

A packed or tray type column can be used. It is estimated that one pound of steam will be required for each gallon of water treated. Additional plant boiler capacity to meet this requirement is assumed to be a necessary expense. The waste heat discharged up the melting tank stack may be a potential source of heat, but this possibility can only be hypothesized pending further investigation by the industry. The stripped ammonia vapor discharge may be above the threshold of odor, in which case it should be vented to the atmosphere through the melting tank stacks. Refer to Section VIII for a more detailed discussion of this subject.

Frosting waste water ammonia levels can be reduced from 2.6 kg/metric ton frosted (5.2 lb/ton frosted) to 0.12 kg/metric ton frosted (0.24 lb/ton frosted) using this technology. This corresponds to an effluent concentration of 30 mg/l at the typical flow.

The alternative methods of ammonia removal discussed earlier in this section should also be carefully investigated before an ammonia removal system is chosen. Air stripping has been employed with some success in several domestic sewage treatment plants and may have potential in the glass industry. Ion-exchange appears to have potential as a polishing step following air or steam stripping, but is still in the experimental stage and, therefore, has not been recommended. Steam stripping is a demonstrated technology and is presently being successfully used for ammonia removal in both the petroleum and fertilizer industries.

Diatomaceous Earth Filtration (Alternative C)-

The oil and suspended solids in the cullet quench water can be reduced using diatomaceous earth filtration. The cullet quench water troughs can be intercepted and the water filtered through an oil adsorptive diatomaceous earth media. A dry discharge type filter will produce a sludge cake suitable for landfill. Approximately 0.54 cu m/day (0.7 cu yd/day) of 15 percent solids sludge will be produced. With this technology, the oil and suspended solids concentrations can be reduced to less than 10 mg/l or 23 g/metric ton (0.045 lb/ton). A similar treatment technology is presently practiced in at least one glass container plant.

Activated Alumina Filtration (Alternative D)-

Fluoride in the frosting waste water may be further reduced using activated alumina filtration. It may be possible for the activated alumina to serve the dual function of filtering suspended solids and adsorbing fluoride, but this is doubtful at the anticipated suspended solids loading. The activated alumina regenerant can be returned to the head of the lime precipitation system for treatment and disposal if sodium hydroxide is used as the regenerant. If hydrochloric acid is used, it may prove necessary to provide separate facilities to neutralize the spent regenerant waste stream. The costs presented in Section VIII reflect the use of hydrochloric acid as the regenerant and include the costs associated with separate neutralization and sludge handling facilities. Fluoride can be reduced to 7.9 g/metric ton frosted (0.016 lb/ton frosted) using this technology. This loading is equivalent to 2 mg/l of fluoride at the typical frosting waste water flow rate.

This technology is not presently employed in the pressed and blown glass industry, but has been used for many years for potable water treatment.

Hand Pressed and Blown Glass Manufacturing

Significant sources of waste water in the hand pressed and blown glass manufacturing subcategory result from finishing operations. At least six waste water producing processes are presently used in the industry. These have been classified as crack-off and hydrofluoric acid polishing, grinding and polishing, machine cutting, alkali washing, hydrofluoric acid polishing, and hydrofluoric acid etching. Some plants employ all of the finishing steps, while others use only one or two, but grinding and polishing is probably the most frequently used. Owing to the variation in finishing steps, it is impossible to generalize the industry in terms of a typical plant.

The waste water constituents requiring treatment are suspended solids, fluoride, and lead, but all of these are not contained in each type of waste water. High and low pH values have also been observed, and neutralization may be required in some cases. Figure 15 illustrates the sequence of treatments that might be employed for a waste water containing all of these constituents. This type of treatment system would apply to those plants which employ hydrofluoric acid finishing techniques to leaded or unleaded glass. Figure 16 illustrates the sequence of treatments that might be employed to a waste containing only suspended solids. This system would be applicable to those plants which produce leaded or unleaded glass and do not employ hydrofluoric acid finishing techniques.

Very limited data were available from the hand pressed and blown industry; therefore, the information presented in this subsection is almost entirely the result of plant visits and field sampling done as part of this study. Owing to the small size of the companies within the industry, the low waste water volumes, the lack of significant quantities of cooling water that could be used for dilution, and the very limited data available, achievable effluent levels in the hand pressed and blown glass manufacturing subcategory are expressed in terms of milligrams per liter (mg/l).

Tables 14 and 15 present a summary of the current operating practices of the hand pressed and blown glass manufacturing subcategory. Forty-two plants were contacted with regard to treatment practices, type of glass produced, and finishing techniques employed. It should be noted that the majority (69%) of the plants either discharge to municipal systems or do not discharge process waste water. Treatment practices for the remaining 31% of the subcategory vary from no treatment to sedimentation to batch lime precipitation.

Plants which employ hydrofluoric acid finishing techniques would have potential problems with regard to fluoride, suspended solids, and, in the case of leaded glass production, lead. Plants which do not employ hydrofluoric acid finishing techniques would have potential problems with regard to suspended solids. A treatment system for the removal of lead and fluoride from waste water would include batch lime precipitation, sand filtration, and ion exchange, while for removal of suspended solids would include coagulation, sedimentation, and sand filtration. For this reason, two treatment schemes are discussed; the first is applicable to those plants which employ acid finishing techniques to leaded or unleaded glass, while

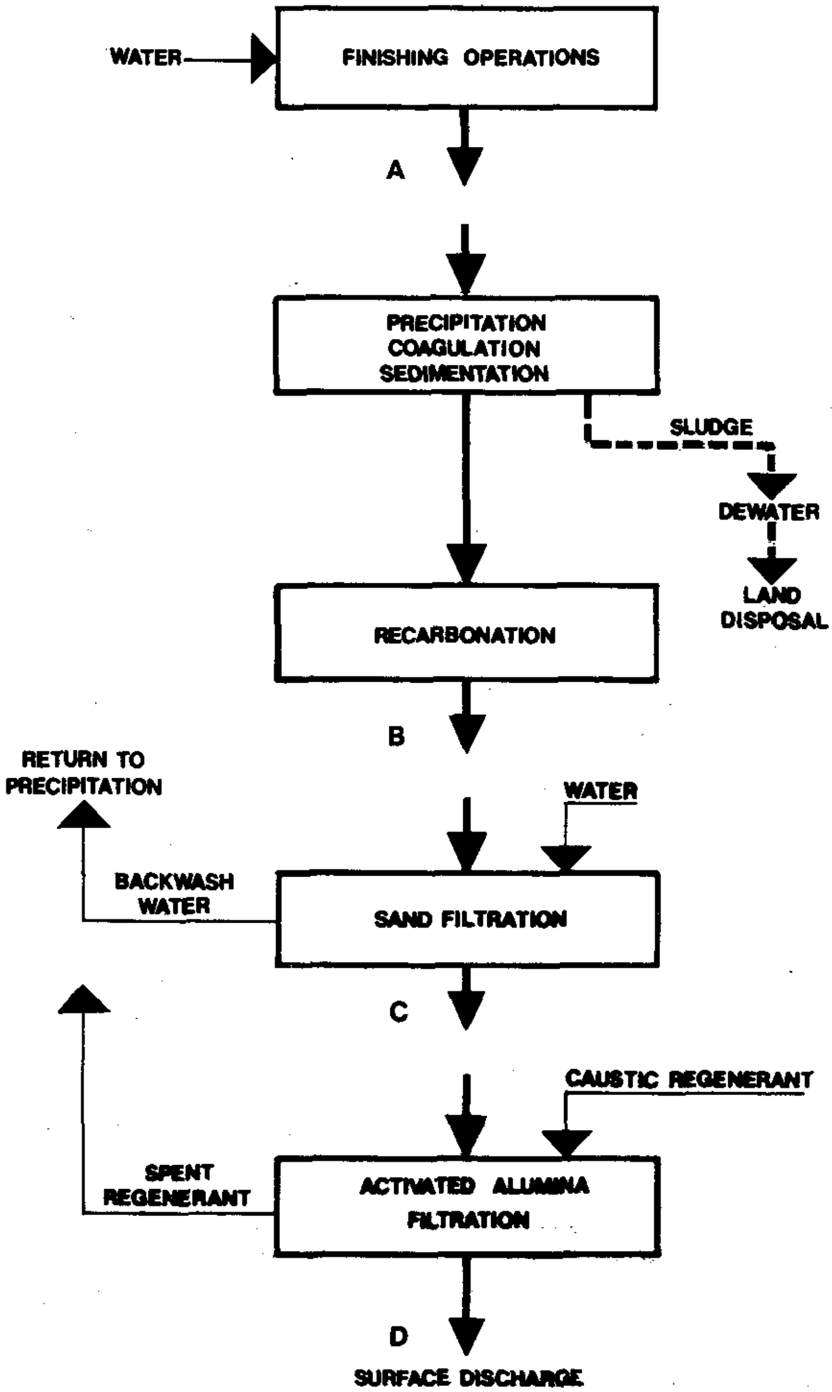

FIGURE 15

WASTE WATER TREATMENT

HAND PRESSED AND BLOWN GLASS MANUFACTURING

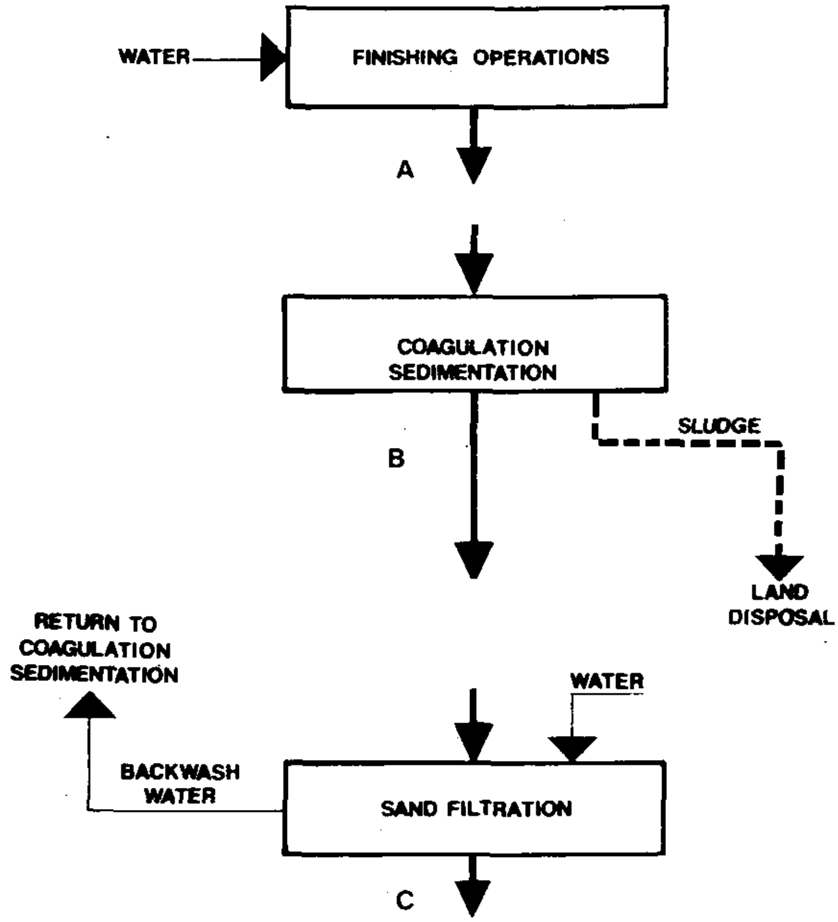

FIGURE 16

WASTE WATER TREATMENT

HAND PRESSED AND BLOWN GLASS MANUFACTURING

TABLE 14

Current Treatment Practices Within the Hand Pressed and Blown Glass Manufacturing Subcategory

Treatment Practice	No. of Plants	Percentage of Subcategory
No Discharge	6	14.3
Treatment with Surface Discharge	7	16.7
No Treatment with Surface Discharge	6	14.3
Municipal Discharge	23	54.7
Total in Survey	42	100.0

TABLE 15

Current Operating Practices Within the Hand Pressed and Blown Glass Manufacturing Subcategory

Type of Glass Produced	No.	Percentage
Leaded Glass	4	9.5
Non-Leaded Glass	38	90.5
	42	100.0

Finishing Techniques	No.	Percentage
Employ HF	19	45.3
Do Not Employ HF	23	54.7
	42	100.0

the second is applicable to those plants which do not employ acid finishing techniques.

Treatment System Applicable to Plants which Employ Hydrofluoric Acid Finishing Techniques

Existing Treatment and Control (Alternative A)-

Very few hand pressed and blown glass plants are presently treating waste waters; however, a few plants have lime precipitation systems for fluoride and lead removal. In most cases, flows are low, less than 38 cu m/day (10,000 gpd). Significant quantities of pollutants may be discharged, however, and could have a detrimental effect on a small receiving stream.

Batch Precipitation and Recarbonation (Alternative B)-

Fluoride, lead, and suspended solids concentrations can be significantly reduced using batch lime precipitation followed by coagulation, sedimentation, and recarbonation for pH reduction and calcium stabilization. Using this system, the daily flow of waste water might be collected in a tank equipped with a stirring mechanism. At the end of the day, lime and polyelectrolyte would be added to precipitate fluoride or lead where removal of these constituents was required. The tank would be slowly stirred for a sufficient time to allow optimum flocculation and then allowed to settle overnight. The following day the supernatant would be transferred to a second tank for recarbonation and additional sedimentation, and the sludge would be transferred to a holding tank where additional thickening would take place before the sludge was disposed of as landfill or to permanent storage. Acid could be used in place of recarbonation for pH reduction, but dissolved solids levels would be increased rather than decreased. The achievable percent solids in the sludge would depend on the type of material treated and coagulant used. It is estimated that 10 to 15 percent solids can be achieved in a lime precipitation system. Effluent levels of 25 mg/l for suspended solids, 20 mg/l for fluoride, and 1.0 mg/l for lead are achievable using a batch system. At least one handmade plant is presently using batch lime precipitation, but is not neutralizing the effluent pH.

Sand Filtration (Alternative C)-

Precipitates and other particulates not removed by gravity separation can be further reduced by sand or graded media filtration. Additional suspended solids, fluoride, and lead can be removed using this technology. Effluent levels can be reduced to less than 13 mg/l for fluoride, 10 mg/l for suspended solids, and 0.1 mg/l for lead. Backwash waters can be returned to the batch treatment system for further treatment. No hand pressed and blown plants presently practice this technology, but filtration is widely used in the water treatment industry.

Activated Alumina Filtration (Alternative D)-

Activated alumina filtration is an available technology for further reducing fluoride concentrations. Following sand filtration, the waste water may be passed through a bed of activated alumina to reduce the fluoride concentration to 2 mg/l. Hydrochloric acid may be used for regeneration; separate neutralization and sludge handling facilities are provided for. This technology is not presently employed in the hand pressed and blown glass industry, but can be transferred from the water treatment industry.

Treatment System Applicable to Plants Which Do Not Employ Hydrofluoric Acid Finishing Techniques

Existing Treatment and Control (Alternative A) -

Many plants, where grinding and abrasive polishing are done, collect finishing waste water in trenches with small traps which catch the gross solids. These are periodically cleaned and disposed of as a solid waste. In most cases flows are low, less than 11.4 cu m/day (3000 gpd). The typical flow is 1.89 cu m/day (500 gpd).

Batch Coagulation and Sedimentation (Alternative B) -

Suspended solids concentrations can be significantly reduced using batch coagulation and sedimentation. Using this sytem, the daily flow of waste water might be collected in a tank equipped with a stirring mechanism. Alum or some other coagulant would be added and the tank stirred slowly for a sufficient time to allow solids to settle. The following day the supernatant would be discharged and the sludge transferred to a holding tank where additional thickening would take place prior to sludge disposal. An effluent level of 25 mg/l for suspended solids is achievable using a batch coagulation and sedimentation system. Many handmade glass plants employ sedimentation systems for solids control.

Sand Filtration (Alternative C) -

Particulates not removed by gravity separation can be further reduced by sand or graded media filtration. Additional suspended solids can be removed to an effluent level of 10 mg/l. Backwash waters can be returned to the batch treatment system for further treatment.

SECTION VIII

COST, ENERGY, AND NONWATER QUALITY ASPECTS

COST AND REDUCTION BENEFITS OF ALTERNATIVE TREATMENT AND CONTROL TECHNOLOGIES

Investment and operating costs for the alternative waste water treatment and control technologies described in Section VII are presented here.

The cost data include the traditional expenditures for equipment purchase, installation, and operation and where necessary, solid waste disposal. No significant production losses due to the installation of water pollution control equipment are anticipated. The costs are based on a typical plant for all subcategories except for hand pressed and blown glass manufacturing, where two hypothetical plants are presented. It is assumed that one is a producer of leaded glass to which many finishing steps are applied including hydrofluoric acid finishing; this represents a maximum raw waste load discharge and the model treatment system is representative of any hand pressed and blown glass plant which employs hydrofluoric acid finishing techniques. The other hypothetical plant is representative of any hand pressed and blown glass plant which does not employ hydrofluoric acid finishing techniques. Owing to wide variations in production methods and waste water characteristics, it is impossible to define a typical plant for the handmade industry.

Investment costs include all the equipment, excavations, foundations, buildings, etc., necessary for the pollution control system. Land costs are not included because the small additional area required is readily available at existing plants.

Costs have been expressed as August, 1971, dollars and have been adjusted using the national average Water Quality Office - Sewage Treatment Plant Cost Index. The cost of capital was assumed to be 8 percent and is based on information collected from several sources including the Federal Reserve Bank. Depreciation is assumed to be 20 year straight-line or 5 percent of the investment cost. Operating costs include labor, material, maintenance, etc., exclusive of power costs. Energy and power costs are listed separately. Six subcategories have been defined in the development document and costs for a typical plant(s) in each subcategory will be covered separately.

Glass Container Manufacturing

The typical glass container manufacturing plant may be located in any part of the country and may be 50 or more years old. The daily production is approximately 454 metric tons (500 tons). Cullet quenching and non-contact cooling water are not segregated. Costs and effluent quality for the three treatment alternatives are summarized in Table 16.

Alternative A - Existing Treatment and Control-

Alternative A involves no additional treatment. These effluent levels are readily achievable by all plants within this subcategory through normal maintenance and clean-up operations within the plant and represent the raw waste loadings expected from a glass container plant. Improved housekeeping techniques may be required at some plants to achieve the typical effluent levels, while others may elect to provide end-of-pipe treatment in the form of some type of sedimentation system with oil removal capabilities. It is felt however, that in-plant techniques will be a more effective and a less expensive means of achieving effluent levels.

Costs. No additional cost.

Reduction Benefits. Upgrading of all effluent discharges to this level.

Alternative B - Recycle with Dissolved Air Flotation of Blowdown-

Alternative B involves segregation of non-contact cooling water from cullet quench water. The cullet quench water is recycled back to cullet quench process through a gravity oil separator, and blowdown is treated using dissolved air flotation. The blowdown is 5 percent of the total cullet quench water flow.

Costs. Incremental investment costs are $285,000 and total annual costs are $56,100 over Alternative A.

Reduction Benefits. The incremental reductions of oil and suspended solids compared to Alternative A are 93 percent and 97 percent, respectively.

Alternative C - Diatomaceous Earth Filtration-

Alternative C provides further treatment of the effluent from Alternative B by diatomaceous earth filtration.

Costs. Incremental investment costs are $27,000 and total annual costs are $10,800 over Alternative B.

Reduction Benefits. The incremental reductions of oil and suspended solids compared to Alternative B are 60 percent. Total reductions of oil and suspended solids are 97.3 and 98.9 percent, respectively.

TABLE 16

WATER EFFLUENT TREATMENT COSTS
GLASS CONTAINER MANUFACTURING

Alternative Treatment or Control

	($1000) A	B	C
Investment	0	285.	312.
Annual Costs:			
Capital Costs	0	22.8	25.
Depreciation	0	14.3	15.7
Operating and Maintenance Costs (excluding energy and power costs)	0	17.2	23.
Energy and Power Costs	0	1.8	3.2
Total Annual Cost	0	56.1	66.9

Effluent Quality:

Effluent Constituents	Raw Waste Load	Resulting Effluent Levels		
Flow (l/metric ton)	2920	2920	77	77
Oil (g/metric ton)	30	30	2	0.8
Suspended Solids (g/metric ton)	70	70	2	0.8
Flow (l/sec)	15.3	15.3	.41	.41
Oil (mg/l)	10	10	25	10
Suspended Solids (mg/l)	24	24	25	10

Machine Pressed and Blown Glass Manufacturing

The machine pressed and blown glass manufacturing subcategory is the subject of further study at the present time. The results of this study including the cost, energy, and non-water quality aspects of selected pollution control technologies will be presented at a later date.

Glass Tubing (Danner) Manufacturing

The typical glass tubing (Danner) manufacturing plant may be located in any part of the country and is at least 10 years old. The daily production at the plant is approximately 90.9 metric tons (100 tons). Costs and effluent quality for the two treatment alternatives are summarized in Table 17.

The remainder of the glass tubing industry is the subject of further study at the present time. The results of this study including the cost, energy, and non-water quality aspects of selected pollution control technologies will be presented at a later date.

Alternative A - Existing Treatment and Control-

Alternative A involves no additional treatment. There are no plants at present which treat cullet quench water and all plants for which data are available achieve these effluent levels.

Costs. No additional costs.

Reduction Benefits. None.

Alternative B - Recycle with Diatomaceous Earth Filtration of Blowdown-

Alternative B involves the recirculation of the cullet quench water stream through a cooling tower. The cooling tower blowdown is treated by diatomaceous earth filtration.

Costs. Incremental investment costs are $97,600 and total annual costs are $22,700 over Alternative A.

Reduction Benefits. Almost complete oil and suspended solids removal is obtained.

TABLE 17

WATER EFFLUENT TREATMENT COSTS
GLASS TUBING (DANNER) MANUFACTURING

Alternative Treatment or Control Technologies	($1000) A	($1000) B
Investment	0	97.6
Annual Costs:		
Capital Costs	0	7.8
Depreciation	0	4.9
Operating & Maintenance Costs (excluding energy and power costs)	0	9.7
Energy and Power Costs	0	0.3
TOTAL ANNUAL COST	0	22.7

Effluent Quality:

Effluent Constituents	Raw Waste Load	Resulting Effluent Levels	
Flow (l/metric ton)	8340	8340	21
Oil (g/metric ton)	80	80	0.2
Suspended Solids (g/metric ton)	230	230	0.2
Flow (l/sec)	8.8	8.8	.022
Oil (mg/l)	10	10	10
Suspended Solids (mg/l)	27	27	10

Television Picture Tube Envelope Manufacturing

The typical television picture tube envelope manufacturing plant can be located in any part of the country and is at least 10 years old. The daily production of the plant is 227 metric tons (250 tons). Costs and effluent quality for the three treatment alternatives are summarized in Table 18. The effluent values are for the combined cullet quench and finishing waste water streams.

Alternative A - Existing Treatment and Control-

Alternative A involves no additional treatment. Lime addition, precipitation, coagulation, sedimentation, and pH adjustment are presently used throughout the industry for removal of fluoride, lead, and suspended solids from finishing wastes. Cullet quench water is not treated.

Costs. No additional cost.

Reduction Benefits. Total reductions of suspended solids, fluoride, and lead are 96, 96, and 99 percent, respectively. The waste water pH is adjusted to neutrality.

Alternative B - Sand Filtration-

Alternative B includes sand filtration of the effluent from the lime precipitation system of Alternative A. Filter backwash water is recycled back to the lime precipitation system.

Costs. Incremental investment costs are $67,000 and total annual costs are $18,400 over Alternative A.

Reduction Benefits. The incremental reductions of suspended solids, fluoride, and lead over Alternative A are 13.3, 14.3, and 90 percent, respectively. Total reductions of suspended solids, fluoride, and lead are 96.9, 96.7, and 99.9 percent, respectively.

Alternative C - Activated Alumina Filtration-

Alternative C involves the activated alumina filtration of the effluent from Alternative B. Following sand filtration the fluoride-bearing waste water stream is passed through a bed of activated alumina to further reduce the remaining fluoride.

TABLE 18

WATER EFFLUENT TREATMENT COSTS
TELEVISION PICTURE TUBE ENVELOPE MANUFACTURING

Alternative Treatment or Control Technologies:	($1000) A	B	C
Investment	0	67.0	560
Annual Cost:			
Capital Costs	0	5.4	44.8
Depreciation	0	3.4	28.1
Operating & Maintenance Costs (excluding energy & power costs)	0	8.7	65.8
Energy & Power Costs	0	0.9	2.1
TOTAL ANNUAL COSTS	0	15.4	140.8

Effluent Quality:

Effluent Constituents	Raw Waste Load	Resulting Effluent Levels		
Flow (l/metric ton)	12,500	12,500	12,500	12,500
Oil (g/metric ton)	130	130	130	130
Suspended Solids (g/metric ton)	4,200	150	130	130
Fluoride (g/metric ton)	1,800	70	60	9
Lead (g/metric ton)	390	4.5	0.45	0.45
Flow (l/sec)	33	33	33	33
Oil (mg/l)	10	10	10	10
Suspended Solids (mg/l)	335	12	10	10
Fluoride (mg/l)	143	5.6	4.8	0.72
Lead (mg/l)	30	0.36	.036	.036

Costs. Incremental investment costs are $493,000 and total annual costs are $122,400 over Alternative B.

Reduction Benefits. The incremental reduction of fluoride over Alternative B is 85 percent. Total reductions of suspended solids, fluoride, and lead are 96.9, 99.5, and 99.9 percent, respectively.

Incandescent Lamp Envelope Manufacturing

The typical incandescent lamp envelope manufacturing plant may be located in any part of the country and is at least 50 years old. Daily production is 159 metric tons (175 tons). Frosted envelopes account for eighty-five percent of the plant production, and clear envelopes make up the remainder of the plant production. Cost and effluent quality for the four treatment alternatives are summarized in Table 19. Effluent characteristics are given for the combined cullet quench and frosting waste water flows.

Alternative A - Existing Treatment and Control-

Alternative A involves no additional treatment. Lime addition, coagulation, precipitation, and sedimentation are presently used throughout the industry for removal of fluoride and suspended solids from frosting wastes. Oil skimmers are employed for oil removal from cullet quench water. Some plants may have to improve housekeeping techniques to meet these effluent levels.

Costs. No additional costs.

Reduction Benefits. Total reductions of suspended solids and fluoride are 31 and 99 percent, respectively.

Alternative B - Sand Filtration and Ammonia Removal-

Alternative B involves the addition of sand filtration and of an ammonia removal technique to reduce the fluoride and ammonia level in the effluent from the Alternative A system. This alternative includes steam stripping as the ammonia removal technique and also includes recarbonation and a heat exchanger. Recarbonation may be required for pH adjustment and also to prevent scaling in the stripping unit. A heat exchanger is used in conjunction with the steam stripping unit to maximize the efficiency of stripping and to reduce the discharge temperature of the treated waste water.

TABLE 19

WATER EFFLUENT TREATMENT COSTS
INCANDESCENT LAMP ENVELOPE MANUFACTURING

Alternative Treatment or Control Technologies:

	($1000) A	B	C	D
Investment	0	547	620	963
Annual Cost:				
Capital Costs	0	43.8	49.6	77.0
Depreciation	0	27.4	31.0	48.2
Operating & Maintenance Costs (excluding energy & power costs)	0	76.4	85.7	125.1
Energy & Power Costs	0	134.3	136.2	136.8
TOTAL ANNUAL COSTS	0	282	302	387.1

Effluent Quality:

Effluent Constituents	Raw Waste Load	Resulting Effluent Levels			
Flow(l/metric ton formed)	4500	4500	4500	4500	4500
(l/metric ton frosted)	3960	3960	3960	3960	3960
Oil(g/metric ton formed)	115	115	115	23	23
Suspended Solids					
(g/metric ton formed)	115	115	115	23	23
(g/metric ton frosted)	400	230	40	40	40
Fluoride(g/metric ton)	11,100	115	52	52	8
Ammonia(g/metric ton)	2600	2600	120	120	120
Flow (l/sec)	14.5	14.5	14.5	14.5	14.5
Oil (mg/l)	15	15	15	3	3
Suspended Solids (mg/l)	58	39	19	7	7
Fluoride (mg/l)	1200	12.4	5.6	5.6	0.9
Ammonia (mg/l)	281	281	13	13	13

Costs. Incremental investment costs are $547,000 and total annual costs are $282,000 over Alternative A.

Reduction Benefits. The incremental reduction of ammonia compared to Alternative A is 95 percent. The treated waste water pH is adjusted to 9.0. Total reductions of suspended solids and fluoride are 66.7 and 99.5 percent, respectively.

Alternative C - Diatomaceous Earth Filtration-

Alternative C involves diatomaceous earth filtration of the cullet quench water. The frosting waste waters are not treated above that level represented as Alternative B.

Costs. Incremental investment costs are $73,000 and total annual costs are $20,600 over Alternative C.

Reduction Benefits. Incremental reductions are 47.3 percent for suspended solids and 61 percent for oil. Total reductions of oil, suspended solids, fluoride, and ammonia are 61, 82, 99.5, and 95 percent, respectively.

Alternative D - Activated Alumina Filtration-

This alternative includes activated alumina filtration of the frosting waste water effluent from Alternative B. Following sand filtration, the waste water is passed through a bed of activated alumina to reduce the remaining fluoride in the waste water.

Costs. Incremental investment costs are $343,000 and total annual costs are $84,600 over Alternative B.

Reduction Benefits. An incremental reduction of 85 percent for fluoride results. Total reductions of fluoride and suspended solids are 99.9 and 82 percent, respectively.

Hand Pressed and Blown Glass Manufacturing

No typical plant can be developed for the hand pressed and blown glass manufacturing subcategory because of the wide variation in finishing steps applied to the handmade glass. The hypothetical plants assumed for cost estimating purposes may be located in any part of the country and are at least 50 years old. The first plant is one of the largest in the country and has a daily finished product output of 5.9 metric tons (6.5 tons). The plant employs all the finishing steps available at handmade glass plants and is representative of those plants which produce leaded or unleaded glass and employ hydrofluoric acid finishing techniques. The second hypothetical plant is representative of those handmade glass plants which produce leaded or unleaded glass and do not employ hydrofluoric acid finishing techniques. The cost and effluent quality for the treatment alternatives applicable to each hypothetical plant are listed in Tables 20 and 21.

Treatment System Applicable to Plants Which Employ Hydrofluoric Acid Finishing Techniques

Alternative A - Existing Treatment and Control-

Alternative A is no waste water treatment or control. Many plants do not need waste water treatment or control because of the absence of waste-producing finishing steps or because of the low volume of discharge. Some plants have lime precipitation treatment facilities for the reduction of fluoride from hydrofluoric acid polishing and acid etching wastes. It is felt that for any plant discharging less than 0.19 cu m/day (50 gallons/day) of waste water, treatment is impractical as other means of disposal are considerably less expensive (i.e., land retention or dust suppression).

Costs. None.

Reduction Benefits. None.

Alternative B - Batch Precipitation and Recarbonation-

This alternative includes a batch lime precipitation system for reduction of suspended solids, fluoride, and lead from finishing waste waters. The lime precipitation system effluent is recarbonated with carbon dioxide gas to adjust the treated waste water to a neutral pH from the alkaline pH of the lime treatment process.

Costs. Incremental investment costs are $284,000 and total annual costs are $55,100 over Alternative A.

Reduction Benefits. Total reductions of suspended solids, fluoride, and lead are 95, 95, and 91 percent, respectively. The pH of the acidic waste is raised to an alkaline pH of 11-12 during lime treatment and then is lowered to a pH of 9 by recarbonation.

Alternative C - Sand Filtration-

Alternative C involves the sand filtration of the effluent from Alternative B. The sand filtration system is similar to those employed at municipal water treatment works.

Costs. Incremental investment costs are $41,000 and total annual costs are $8400 over Alternative B.

TABLE 20

WATER EFFLUENT TREATMENT COSTS
HAND PRESSED AND BLOWN GLASS MANUFACTURING

Alternative Treatment or Control Technologies:	($1000) A	B	C	D
Investment	0	284	325	410
Annual Costs:				
Capital Costs	0	22.7	26.0	32.8
Depreciation	0	14.2	16.2	20.4
Operating & Maintenance Costs (excluding energy & power costs)	0	15.6	18.6	21.6
Energy & Power Costs	0	2.6	2.7	2.8
TOTAL ANNUAL COST	0	55.1	63.5	77.6

Effluent Quality:

Effluent Constituents	Raw Waste Load	Resulting Effluent Levels			
Flow (l/sec)	0.61	0.61	0.61	0.61	0.61
pH	2	2	9	9	9
Suspended Solids (mg/l)	544	544	25	10	10
Fluoride (mg/l)	422	422	20	13	2
Lead (mg/l)	11.4	11.4	1	0.1	0.1

TABLE 21

WATER EFFLUENT TREATMENT COSTS
HAND PRESSED AND BLOWN GLASS MANUFACTURING
SUSPENDED SOLIDS REMOVAL

Alternative Treatment or Control	A	($1000) B	C
Investment	0	48.7	54.3
Annual Costs:			
Capital Costs	0	3.9	4.3
Depreciation	0	2.4	2.7
Operating & Maintenance Costs (excluding energy & power costs)	0	5.3	8.0
Energy and Power Costs	0	0.3	0.3
TOTAL ANNUAL COST	0	11.9	15.3

Effluent Quality:

Effluent Constituents	Raw Waste Load	Resulting Effluent Levels		
Flow -- cu m/day	1.89	1.89	1.89	1.89
Suspended Solids(mg/l)	9600	9600	25	10

Reduction Benefits. Incremental reductions over Alternative B for suspended solids, fluoride, and lead are 60, 35, and 90 percent, respectively. Total reductions of suspended solids, fluoride, and lead are 98.2, 96.9, and 99.1 percent, respectively. The waste water pH is adjusted to 9.

<u>Alternative</u> <u>D</u> - Activated Alumina Filtration-

This alternative includes activated alumina filtration of the effluent from Alternative C. Activated alumina filtration is employed for further reduction of the effluent fluoride concentration.

Costs. Incremental investment costs are $84,500 and total annual costs are $14,100 over Alternative C.

Reduction Benefits. The incremental reduction of fluoride is 85 percent over Alternative C. Total reductions of suspended solids, fluoride, and lead are 98.2, 99.5, and 99.1 percent, respectively.

<u>Treatment System Applicable to Plants Which Do Not Employ Hydrofluoric Acid Finishing Techniques</u>

<u>Alternative</u> <u>A</u> - Existing Treatment and Control -

Alternative A involves no waste water treatment or control. Many plants do not need waste water treatment or control because of the absence of waste-producing finishing steps or because of the low volume of discharge. Many plants employ some type of sedimentation system for solids control. It is felt that for any plant discharging less than 0.19 cu m/day (50 gallons/day) of waste water, treatment is impractical as other means of disposal are considerably less expensive (i.e., land retention or dust suppression).

The raw waste water suspended solids expressed in terms of grams (pounds) per production unit or concentration is impossible to typify, owing to the wide range of production methods employed in the subcategory. Approximately 9600 mg/l was assumed for calculating sludge production, but the influent suspended solids concentration is not directly related to treatment costs. The typical flow is 1.89 cu m/day (500 gpd).

Costs. None.

Reduction Benefits. None.

<u>Alternative</u> <u>B</u> - Batch Coagulation and Sedimentation -

The daily waste water discharge is collected in one of two mixing tanks (one tank is treated and discharged while the other is filling). At the end of the day coagulants are added, and the mixture is flocculated. The treated waste water is discharged following overnight sedimentation. Sludge is collected in a holding tank and eventually discharged as landfill.

Costs. Incremental investment costs are $48,700 and total annual costs are $11,900 over Alternative A.

Reduction Benefits. Suspended solids reduced to 25 mg/l.

Alternative C - Sand Filtration -

Discharge from Alternative B is passed through sand filters for additional suspended solids reduction. Filter backwash is returned to the head of the system.

Costs. Incremental investment costs are $5600 and total annual costs are $3400 over Alternative B.

Reduction Benefits. Suspended solids reduced to 10 mg/l.

BASIS OF TOTAL INDUSTRY COST ESTIMATES

The effluent limitations guidelines presented in this document pertain to surface dischargers and therefore, only surface dischargers are considered impacted by the recommended guidelines. There are: (a) 55 known glass container, (b) 23 known machine pressed and blown glass, (c) 9 known glass tubing, (d) 4 known television picture tube envelope, (e) 3 known incandescent lamp envelope, and (f) 13 known hand pressed and blown glass manufacturing surface dischargers. This estimate is based on RAPP applications, industry supplied data, and a survey of the pressed and blown glass segment. Tables 22 through 27 list the known surface dischargers for each subcategory of the pressed and blown glass segment of the glass manufacturing category.

ENERGY REQUIREMENTS OF TREATMENT AND CONTROL TECHNOLOGIES

Large quantities of energy are used in the pressed and blown glass industry to produce the high temperatures required for glass melting and annealing. Approximately 1,670,000 kilogram-calories/metric ton (6,000,000 BTU/ton) are required to melt the raw materials for the manufacture of glass containers. This energy requirement is considered typical for the pressed and blown glass industry. The additional energy required to implement the treatment technologies is less than 1 percent of the process requirements for each of the subcategories with the exception of the incandescent lamp envelope manufacturing subcategory. The treatment alternatives requiring relatively little additional energy include: cullet quench recycle systems, the lime precipitation process, and sand or activated alumina filtration. The energy requirements for these systems range from 124,000 to 537,000 kilogram-calories/day (492,000 to 2,130,000 BTU/day).

TABLE 22

KNOWN SURFACE DISCHARGERS
GLASS CONTAINER MANUFACTURING SUBCATEGORY

Company	No. of Plants
Anchor Hocking Corporation	7
Ball Corporation	1
Brockway Glass Company, Inc.	11
Chattanooga Glass Company	3
Diamond Glass Company	1
Foster-Forbes Glass Company	1
Gayner Glass Works	1
Glass Containers Corporation	7
Glenshaw Glass Company	2
Indian Head, Inc.	2
Kerr Glass Manufacturing Corporation	2
Laurens Glass Company	1
Maryland Glass Corporation	1
Midland Glass Company	1
Obear-Nester Glass Company	1
Owens-Illinois	8
Puerto Rico Glass Corporation	1
Star City Glass Company	1
Thatcher Glass Manufacturing Company	2
Universal Glass Products Company	1
TOTAL	55

TABLE 23

KNOWN SURFACE DISCHARGERS
MACHINE PRESSED AND BLOWN GLASS MANUFACTURING
SUBCATEGORY

Company	No. of Plants
Anchor Hocking Corporation	3
Corning Glass Works	14
Federal Glass Company	1
General Electric-Mahoning	1
Mid-Atlantic Glass Company	1
Owens-Illinois	2
L.E. Smith Glass Company	1
TOTAL	23

TABLE 24

KNOWN SURFACE DISCHARGERS
GLASS TUBING MANUFACTURING SUBCATEGORY

Company	No. of Plants
Corning Glass Works	2
General Electric Company	4
GTE - Sylvania, Inc.	1
RCA	1
Westinghouse Electric Corporation	1
TOTAL	9

TABLE 25

KNOWN SURFACE DISCHARGERS
TELEVISION PICTURE TUBE ENVELOPE MANUFACTURING SUBCATEGORY

Company	No. of Plants
Corning Glass Works	2
Owens-Illinois	2
TOTAL	4

TABLE 26

KNOWN SURFACE DISCHARGERS
INCANDESCENT LAMP ENVELOPE MANUFACTURING
SUBCATEGORY

Company	No. of Plants
Corning Glass Works	2
General Electric Company	1
TOTAL	3

TABLE 27

KNOWN SURFACE DISCHARGERS
HAND PRESSED AND BLOWN GLASS MANUFACTURING
SUBCATEGORY

Company	No. of Plants
Blenko Glass Company	1
Colonial Glass Company	1
Davis-Lynch Glass Company	1
Fenton Art Glass Company	1
Fostoria Glass Company	1
Gillender Brothers, Incorporated	1
Imperial Glass Corporation	1
Kanahwa Glass Company	1
Lewis County Glass Company	1
Pennsboro Glass Company	1
Pilgrim Glass Corporation	1
Wheaton Industries	1
West Virginia Glass Specialty Company	1
TOTAL	13

Steam stripping of incandescent lamp envelope frosting waste waters for ammonia removal will require the greatest energy requirement of the proposed treatment alternatives. Steam stripping of the typical flow will require approximately 54,000,000 kilogram-calories/day (214,000,000 BTU/day) and is equivalent to 9120 liters/day (2410 gallons/day) of No. 2 fuel oil. This energy requirement is about 8 percent of that required for the total manufacturing process. Industry supplied data indicate that approximately 605,000,000 kilogram-calories/day (2,400,000,000 BTU/day) of energy per plant are required in the total incandescent lamp envelope manufacturing process. The energy requirement for steam stripping is not excessive, when compared to the total energy consumed in the manufacturing process. It may be feasible to use melting tank stack gas as a source of heat, thereby eliminating the necessity for additional fuel, but further investigation is necessary to determine the practicability of such a system.

NON-WATER QUALITY ASPECTS OF TREATMENT AND CONTROL TECHNOLOGIES

Air Pollution

The incandescent lamp envelope manufacturing subcategory is the only subcategory that may pose an air pollution problem. Ammonia removal by steam stripping is recommended for control of high ammonia discharges from the frosting waste stream. It is possible that the steam and ammonia gas from the stripping unit could be vented to the atmosphere through the furnace exhaust stack. The ammonia concentration of the combined stack discharge is not expected to exceed 35 mg/cu m (46 ppmv), which is the threshold odor limit for ammonia. Because the ammonia concentration will be below the threshold odor level, steam stripping should not cause a significant air pollution problem.

There are no significant air or noise pollution problems directly associated with the treatment and control technologies of the other subcategories. The waste waters and sludges are odorless and no nuisance conditions result from their treatment or handling.

Solid Waste Disposal

Three types of waste solids are produced by the treatment systems developed for the pressed and blown glass industry. These are: (1) gravity oil separator and dissolved air flotation skimmings, (2) spent diatomaceous earth, and (3) lime precipitation sludges associated with fluoride waste water treatment.

The skimmings and spent diatomaceous earth result from the treatment of cullet quench waste waters. The skimmings have a three percent solids content and the production of skimmings ranges from 21.4 to 49.1 kg/day (47 to 108 lb/day) or 720 to 1630 l/day (190 to 430 gal/day). The oily skimmings can be disposed of by an oil reclamation firm, used as road oil, or can be incinerated.

Spent diatomaceous earth has an estimated moisture content of 85 percent, but does not flow. This material is stable and should be suitable for landfill. Estimated production of diatomaceous earth waste ranges from 0.042 to 0.53 cu m/day (1.5 to 19 cu ft/day). The lower figure results from the treatment of the blowdown for the cullet quench system and the higher figure is the result of treating the entire cullet quench waste water stream at an incandescent lamp envelope plant.

The lime precipitation process for fluoride removal produces the largest volume and most difficult sludge to handle. Vacuum filtration is used at almost all plants to reduce the sludge volume. The volume of sludge production ranges from 277 kg/day (610 lbs/day) for a handmade glass plant to 20.9 metric ton/day (23 tons/day) at a television picture tube envelope manufacturing plant. The television picture tube envelope manufacturing plant is treating a combination of abrasive grinding wastes and fluoride containing rinse waters.

Most lime precipitation sludge is currently disposed of as landfill. Several attempts have been made to convert the sludge into a salable material, but no markets have been found for these products. Currently, further research is being conducted to develop a saleable by-product from the sludge.

SECTION IX

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations that must be achieved by July 1, 1977, are to specify the degree of effluent reduction attainable through the application of the best practicable control technology currently available. Best practicable control technology currently available is generally based upon the average of the best existing performance by plants of various sizes, ages, and unit processes within the industrial category or subcategory.

Consideration must also be given to:

a. The total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application;

b. the size and age of equipment and facilities involved;

c. the processes employed;

d. the engineering aspects of the application of various types of control techniques;

e. process changes;

f. non-water quality environmental impact (including energy requirements).

Also, best practicable control technology currently available emphasizes treatment facilities at the end of a manufacturing process, but also includes the control technologies within the process itself when the latter are considered to be normal practice within the industry.

A further consideration is the degree of economic and engineering reliability that must be established for the technology to be "currently available". As a result of demonstration projects, pilot plants, and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of commencement of construction or installation of the control facilities.

IDENTIFICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Current treatment practices constitute the best practicable control technology currently available. The best practicable control technology currently available for the subcategories of the pressed and blown segment is summarized below. Recommended effluent limitations are summarized in Table 28. These limitations are 30-day averages based on any 30 consecutive calendar days. Maximum daily averages are two times the monthly averages.

Glass Container Manufacturing

No additional control technology is proposed for the glass container manufacturing subcategory. Oil skimmers are presently employed at some plants, but many plants do not require treatment. Improved housekeeping techniques may be required at some plants to meet the limitations. Effluent limitations for suspended solids are 70 g/metric ton (0.14 lb/ton); for oil, 30 g/metric ton (0.06 lb/ton); and pH, between 6.0 and 9.0.

Machine Pressed and Blown Glass Manufacturing

The machine pressed and blown glass manufacturing subcategory is the subject of further study at the present time. The results of this study, including recommended limitations representative of best practicable control technology currently available, will be published at a later date in a supplement to this document.

Glass Tubing (Danner) Manufacturing

No additional control technology is proposed for the glass tubing (Danner) subcategory. Most plants presently do not provide treatment because the raw waste water pollutant concentrations are already at low levels. Improved housekeeping may be required at some plants to achieve the limitations. Effluent limitations for suspended solids are 230 g/metric ton (0.46 lb/ton) and for pH, between 6.0 and 9.0.

The remainder of the glass tubing manufacturing subcategory, including those plants which manufacture glass tubing by the Vello and Updraw processes or those plants which manufacture glass tubing suitable for the manufacture of scientific glassware, is the subject of further study at the present time. The results of this study will be published at a later date in a supplement to this document.

Television Picture Tube Envelope Manufacturing

The control technology on which the recommended limitations are based involves lime addition, coagulation, sedimentation, and pH adjustment. This technology is currently practiced throughout the industry for the treatment of finishing waste waters. Effluent limitations for suspended solids are 150 g/metric ton (0.30 lb/ton); for oil, 130 g/metric ton (0.26 lb/ton); for fluoride, 70 g/metric ton (0.14 lb/ton); for lead, 4.5 g/metric ton (0.009 lb/ton); and pH, between 6.0 and 9.0.

TABLE 28

RECOMMENDED 30-DAY AVERAGE EFFLUENT LIMITATIONS USING
BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

	Suspended Solids	Oil	Fluoride	Lead	Ammonia	pH
Glass Container						
g/metric ton	70	30	-	-	-	6-9
(lb/ton)	0.14	0.06	-	-	-	
Machine Pressed & Blown Glass*						
g/metric ton	-	-	-	-	-	-
(lb/ton)	-	-	-	-	-	
Glass Tubing (Danner)*						
g/metric ton	230	-	-	-	-	6-9
(lb/ton)	0.46	-	-	-	-	
Television Picture Tube Envelope						
g/metric ton	150	130	70	4.5	-	6-9
(lb/ton)	0.30	0.26	0.14	0.009	-	
Incandescent Lamp Envelopes						
Forming						
g/metric ton	115	115	-	-	-	6-9
(lb/ton)	0.23	0.23	-	-	-	
Frosting						
g/metric ton frosted	230	-	115	-	-	6-9
(lb/ton)	0.46	-	0.23	-	-	
Hand Pressed & Blown Glass						
Leaded & Hydrofluoric Acid Finishing						
mg/l	-	-	-	-	-	-
Non-Leaded & Hydrofluoric Acid Finishing						
mg/l	-	-	-	-	-	
Non-Hydrofluoric Acid Finishing						
mg/l	-	-	-	-	-	-

*The machine pressed and blown glass manufacturing subcategory and the remainder of the glass tubing subcategory are the subject of further study. Results of this study will be presented at a later date.

Incandescent Lamp Envelope Manufacturing

The control technology on which the recommended limitations are based involves a lime precipitation system for fluoride and suspended solids removal. The lime precipitation treatment is practiced throughout the industry for frosting waste water treatment. Recarbonation is also included in the control technology for adjustment of the treated waste water pH to a range of 6 to 9. Effluent limitations are listed separately for forming and frosting because there is a wide variation in the percentage of envelopes that are frosted. The forming limitations are based on furnace pull production and the frosting limitations are based on the portion of the furnace pull production that is frosted. Effluent limitations for the waste waters resulting from forming are 115 g/metric ton (0.23 lb/ton) for both suspended solids and oil. Frosting waste water effluent limitations for suspended solids are 230 g/metric ton (0.46 lb/ton); for fluoride, 115 g/metric ton (0.23 lb/ton); and pH, between 6.0 and 9.0.

Hand Pressed and Blown Glass Manufacturing

After careful review of the available data with respect to plants within the hand pressed and blown glass manufacturing subcategory, it has been determined that treatment requirements could seriously impact plants within this subcategory. Therefore, no best practicable control technology currently available effluent limitations are imposed upon the hand pressed and blown glass manufacturing subcategory. Plants which contribute to a water quality problem may find it necessary to develop an appropriate technology to alleviate the problem.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Based on the information contained in Sections III through VIII of this document, a determination has been made of the degree of effluent reduction attainable through the application of the best practicable control technology currently available for the pressed and blown glass segment of the glass manufacturing category. The effluent reductions are summarized here:

Fluoride

Fluoride is a principal pollutant constituent in waste waters resulting from the manufacture of television picture tube envelopes, frosted incandescent lamp envelopes, and from the hydrofluoric acid polishing and etching of handmade glass. Application of the best practicable control technology currently available will reduce fluoride by 96 percent for television picture tube envelope manufacturing and 99 percent for incandescent lamp envelope manufacturing.

Lead

Lead is contributed to television picture tube envelope plant and handmade glass plant waste waters by finishing steps applied to the picture tube envelope and leaded handmade glassware. Application of the best practicable control technology currently available will reduce lead levels in television picture tube envelope manufacturing waste waters by 99 percent.

Oil

Oil is a constituent of the waste waters from all subcategories except the hand pressed and blown glass manufacturing. Belt oil skimmers and baffled skimming basins are employed at some plants, but many plants do not provide treatment. Analysis of the data indicates no discernible difference between the effluent oil concentration of plants employing oil skimming and plants without treatment. No additional waste water treatment or control is proposed because of the low oil concentrations in the raw waste water. Some plants may need to improve housekeeping techniques to meet the proposed effluent levels.

Oxygen Demanding Materials

Oxygen demand in the pressed and blown glass segment is related to the oil content of the waste water. Since no additional waste water treatment or control for oil removal is proposed, the BOD and COD will not be reduced. The BOD and COD are already low by conventional standards.

pH

Waste waters resulting from acid treatment of glassware have a pH of 2 to 3. The acidic wastes are treated to remove fluoride and other pollutants by lime addition, typically to a pH of 11-12. At some waste water treatment plants, the alkaline treated waste waters are adjusted to a neutral pH. This control technology will be applied to the television picture tube envelope and incandescent lamp envelope manufacturing subcategories to achieve an effluent pH of 6 to 9.

Suspended Solids

Suspended solids are contributed to the process waste waters from all subcategories. Application of the best practicable control technology currently available will reduce suspended solids levels for television picture tube envelope manufacturing and incandescent lamp envelope manufacturing by 96 and 31 percent, respectively. The cullet quench water stream is not treated for the incandescent lamp envelope subcategory and, therefore, lower removal percentages are obtained. Suspended solids remain at the present levels for the glass container manufacturing and the glass tubing (Danner) manufacturing subcategories.

Dissolved Solids

Dissolved solids are contributed to the waste waters from the pressed and blown glass segment by acid treatment of glass and frosting of incandescent lamp envelopes. The proposed control technologies do not reduce dissolved solids.

Temperature

Process waste waters from all subcategories may show some temperature increase because of cullet quenching, acid polishing, and frosting of incandescent lamp envelopes. Application of the best practicable control technology currently available will not result in significant temperature reduction.

RATIONALE FOR THE SELECTION OF BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

Engineering Aspects of Application

In all cases, this control technology has been applied in the pressed and blown glass segment or in another industry where the characteristics of the water treated are sufficiently similar to provide a high degree of confidence that the technology can be transferred to the pressed and blown glass industry. The derivation and rationale for selection of the control technologies are described in detail in Sections V and VII. These may be briefly summarized as follows:

Glass Container Manufacturing-

No additional waste water treatment or control will be required at the majority of glass container plants to achieve this level. Some plants presently employ oil skimmers, but many plants do not provide treatment. In analysis of the data, no discernible difference could be established between plants with oil skimming treatment and plants without treatment. Collection of I.S. machine oil leakage, control of shear spray oil drippage, and other housekeeping techniques may be required at some plants to meet the effluent limitations.

Glass Tubing (Danner) Manufacturing-

Most plants presently do not provide waste water treatment and are meeting the effluent limitations. It might be necessary for some plants to improve housekeeping techniques to achieve the effluent limitations.

Television Picture Tube Envelope Manufacturing-

Lime precipitation, coagulation, sedimentation, and pH adjustment are currently practiced throughout the industry to treat waste waters from the finishing of television picture tube envelopes. The majority of plants meet the effluent limitations, but those that do not may be required to upgrade waste water treatment practices and in-plant housekeeping controls to meet the effluent limitations.

Incandescent Lamp Envelope Manufacturing-

Lime precipitation, coagulation, and sedimentation are currently practiced throughout the industry for removal of fluoride and suspended solids from frosting waste waters. Cullet quench waste waters are also treated at most plants. None of the plants provide treatment for ammonia removal.

At least two plants are meeting the fluoride effluent limitations. By implementation of improvements in the treatment facilities such as increased flocculation, longer retention time in the clarification unit, and improved clarifier design, the remaining plants should be able to meet the fluoride and suspended solids limitations levels.

Water pH adjustment by recarbonation has been practiced for many years in conventional water treatment plants. This method can also be applied for pH adjustment of treated frosting waste waters.

Hand Pressed and Blown Glass Manufacturing-

At least one hand pressed and blown glass plant is employing the batch lime precipitation method to remove suspended solids, fluoride, and lead from finishing waste waters. Most plants presently do not provide treatment other than sedimentation basins; those with waste water producing finishing steps may have to employ treatment to meet water quality standards.

Total Cost of Application

Based on the information presented in Section VIII of this document, the industry, as a whole, will not have to invest significant amounts of money to achieve the effluent limitations prescribed herein. Plants currently have the equipment necessary to attain the effluent limitations and in all cases, it is expected that the application of improved housekeeping techniques and operating procedures will enable all plants in the pressed and blown glass industry segment to achieve the best practicable control technology currently available effluent limitations guidelines.

Size and Age of Equipment

The size of plants within the same subcategory does not vary enough to substantiate differences in control technology based on size. Most pressed and blown glass plants have actively developed and implemented new production methods so that the age of equipment and facilities does not provide a basis for differentiation in the application of this control technology.

Processes Employed

All plants in a given subcategory use very similar manufacturing processes and produce similar waste water discharges. The control technology for a given subcategory is compatible with all of the manufacturing processes presently used in that subcategory.

Process Changes

No process changes are required to implement this control technology, and major changes in the production processes are not anticipated. Therefore, the waste water volume and characteristics should remain the same for the foreseeable future.

Non-Water Quality Environmental Impact

There is no evidence that application of the best practicable control technology currently available will result in any unusual air pollution or solid waste disposal problems. The control technologies which represent the best practicable control technology currently available are currently used in either the pressed and blown glass industry or other industries without adverse environmental effects. The pressed and blown glass industry consumes enormous amounts of energy for melting raw materials and annealing. The energy required to apply this control technology represents only a small increment of the present total energy requirements of the industry.

SECTION X

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE EFFLUENT LIMITATIONS GUIDELINES

INTRODUCTION

The effluent limitations that must be achieved by July 1, 1983, are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable. This control technology is not based upon an average of the best performance within an industrial category, but is determined by identifying the very best control and treatment technology employed by a specific plant within the industrial category or subcategory, or where it is readily transferrable from one industry process to another.

Consideration must also be given to:

a. The total cost of application of this control technology in relation to the effluent reduction benefits to be achieved from such application;

b. the size and age of equipment and facilities involved;

c. the processes employed;

d. the engineering aspects of the application of this control technology;

e. process changes;

f. non-water quality environmental impact (including energy requirements).

Best available technology economically achievable also considers the availability of in-process controls as well as control or additional end-of-pipe treatment techniques. This control technology is the highest degree that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including "no discharge" of pollutants.

Although economic factors are considered in this development, the costs for this level of control are intended to be the top-of-the-line of current technology subject to limitations imposed by economic and engineering feasibility. However, this control technology may be characterized by some technical risk with respect to performance and with respect to certainty of costs. Therefore, this control technology may necessitate some industrially sponsored development work prior to its application.

IDENTIFICATION OF BEST AVAILABLE CONTROL TECHNOLOGY ECONOMICALLY ACHIEVABLE

In-plant control measures as well as end-of-pipe treatment techniques contribute to the best available technology economically achievable. Water recycle and reuse will tend to reduce the cost of end-of-pipe treatment facilities.

The best available technology economically achievable for the subcategories of the pressed and blown glass industry is summarized in the following paragraphs. Recommended effluent limitations are summarized in Table 29. These limitations are 30-day averages based on any 30 consecutive days. The maximum daily average is two times the monthly average.

Glass Container Manufacturing

The control technology includes segregation of non-contact cooling water from the cullet quench water. The cullet quench water is recycled back to the cullet quench process through a gravity oil separator. Cullet quench system blowdown is treated by dissolved air flotation followed by diatomaceous earth filtration. The blowdown is 5 percent of the total cullet quench water flow. Effluent limitations for suspended solids and oil are 0.8 g/metric ton (0.0016 lb/ton).

Machine Pressed and Blown Glass Manufacturing

The machine pressed and blown glass manufacturing subcategory is the subject of further study at the present time. The results of this study, including the recommended best available technology economically achievable effluent limitations, will be presented in a supplement to this document at a later date.

Glass Tubing (Danner) Manufacturing

The best available technology economically achievable involves the recirculation of the cullet quench water through a cooling tower. The cooling tower blowdown is treated by diatomaceous earth filtration. The blowdown is estimated at 5 percent of the total cullet quench water flow. Effluent limitations for suspended solids are 0.2 g/metric ton (0.0004 lb/ton).

Television Picture Tube Envelope Manufacturing

The control technology specified includes lime precipitation, sedimentation, and pH adjustment of all finishing waste waters, as described in Section IX, followed by sand filtration. Cullet quench water is not treated. Effluent limitations for suspended solids are 130 g/metric ton (0.26 lb/ton); for oil, 130 g/metric ton (0.26 lb/ton); for fluoride, 60 g/metric ton (0.12 lb/ton); for lead, 0.45 g/metric ton (0.0009 lb/ton); and pH, between 6.0 and 9.0.

TABLE 29

RECOMMENDED 30-DAY AVERAGE EFFLUENT LIMITATIONS USING BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

	Suspended Solids	Oil	Fluoride	Lead	Ammonia	pH
Glass Container						
g/metric ton	0.8	0.8	-	-	-	6-9
(lb/ton)	0.0016	0.0016	-	-	-	
Machine Pressed & Blown Glass*						
g/metric ton	-	-	-	-	-	-
(lb/ton)	-	-	-	-	-	
Glass Tubing (Danner)*						
g/metric ton	0.2	0.2	-	-	-	6-9
(lb/ton)	0.0004	0.0004	-	-	-	
Television Picture Tube Envelope						
g/metric ton	130	130	60	0.45	-	6-9
(lb/ton)	0.26	0.26	0.12	0.0009	-	
Incandescent Lamp Envelopes						
Forming						
g/metric ton	45	45	-	-	-	6-9
(lb/ton)	0.09	0.09	-	-	-	
Frosting						
g/metric ton	40	-	52	-	120	6-9
(lb/ton)	0.08	-	0.104	-	0.24	
Hand Pressed & Blown Glass						
Leaded & Hydrofluoric Acid Finishing						
mg/l	10	-	13	0.1	-	6-9
Non-Leaded & Hydrofluoric Acid Finishing						
mg/l	10	-	13	-	-	6-9
Non-Hydrofluoric Acid Finishing						
mg/l	10	-	-	-	-	6-9

*The machine pressed and blown glass manufacturing subcategory and the remainder of the glass tubing subcategory are the subject of further study. Results of this study will be presented at a later date.

Incandescent Lamp Envelope Manufacturing

The best available technology economically achievable involves the treatment of frosting waste waters by lime precipitation, sedimentation and recarbonation, as described in Section IX, followed by sand filtration and ammonia removal by steam stripping. In addition to this control technology, diatomaceous earth filtration is used to treat the cullet quench waste waters. Effluent limitations for waste waters resulting from the forming of incandescent lamp envelopes are 45 g/metric ton (0.09 lb/ton) for suspended solids and oil. Frosting waste water effluent limitations for suspended solids are 40 g/metric ton (0.08 lb/ton); for fluoride, 52 g/metric ton (0.104 lb/ton); for ammonia, 120 g/metric ton (0.24 lb/ton); and pH, between 6.0 and 9.0.

Hand Pressed and Blown Glass Manufacturing

The best available technology economically achievable includes batch lime precipitation, sedimentation, and recarbonation, followed by sand filtration. Effluent limitations for suspended solids, fluoride, and lead are 10, 13, and 0.1 mg/l, respectively. The pH of the effluent waste water must be adjusted to the range between 6.0 and 9.0.

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Based on the information contained in Sections III through VIII of this document, a determination has been made of the degree of effluent reduction attainable through the application of the best available technology economically achievable. Recycle of cullet quench water is attainable for the glass container and glass tubing (Danner) manufacturing subcategories. The effluent reductions attainable through application of the specified control and treatment technologies are summarized here.

Fluoride

The application of the best available technology economically achievable will reduce fluoride discharges from television picture tube envelope manufacturing by 96.7 percent and from incandescent lamp envelope manufacturing by 99.5 percent. The effluent fluoride concentration for handmade glass plants which employ hydrofluoric acid finishing techniques is reduced to 13 mg/l by application of this technology. The incremental reduction over the levels achieved using the best practicable control technology currently available for television picture tube envelope manufacturing and incandescent lamp envelope manufacturing are 14.3 and 55.1 percent, respectively.

Ammonia

A primary constituent of the raw waste water from the frosting of incandescent lamp envelopes is ammonia. Ammonia levels will be reduced by 95 percent in the incandescent lamp envelope manufacturing subcategory through the application of the best available technology economically achievable. The incremental increase over the application of the best practicable control technology currently available (BPCTCA) is also 95 percent as no limitations for ammonia were established for BPCTCA.

Lead

With the implementation of the best available technology economically achievable effluent limitations, the lead discharged as a result of television picture tube envelope manufacturing is reduced by 99.9 percent and the incremental increase in removal over the level achieved using the best practicable control technology currently available is 90 percent. The lead concentration for handmade glass plants which employ hydrofluoric acid finishing techniques is reduced to a concentration of 0.1 mg/l using this technology.

Oil

With the implementation of the best available technology economically achievable effluent limitations, oil in glass container manufacturing waste waters is reduced by 97.3 percent and from incandescent lamp envelope manufacturing waste waters by 61 percent. The incremental reductions over the best practicable control technology currently available are equal to the total reductions listed above. The lower reduction achieved for the incandescent lamp envelope manufacturing subcategory is due to a larger discharge volume because the waste water is not recirculated as proposed in the other three subcategories.

Oxygen Demanding Materials

Oxygen demand is related to the waste water oil concentration in the pressed and blown glass industry and, therefore, the reductions in oxygen demand will be in proportion to the oil removals listed above.

pH

Waste waters resulting from glass container manufacturing and glass tubing (Danner) manufacturing are presently in the pH range of 6-9. This technology includes the adjustment of pH in the television picture tube, incandescent lamp envelope, and hand pressed and blown glass manufacturing subcategories to a range from 6-9.

Suspended Solids

The application of the best available technology economically achievable will reduce suspended solids for glass container manufacturing, glass tubing (Danner) manufacturing, television picture tube envelope manufacturing, and incandescent lamp envelope manufacturing by 98.9, 99.9, 96.9, and 82.4 percent, respectively. Incremental increases in removal over the level achieved using the best practicable control technology currently available are 13.3 percent for television picture tube envelope manufacturing and 74.6 percent for incandescent lamp envelope manufacturing. The lower incremental reduction achieved for television picture tube envelope manufacturing is due to the low suspended solids in the treated waste water. Suspended solids are reduced to a concentration of 10 mg/l in the hand pressed and blown glass manufacturing subcategory by application of this technology.

Other Pollutant Constituents

Temperature and dissolved solids are not significantly reduced by application of the best available technology economically achievable.

RATIONALE FOR THE SELECTION OF BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

Total Cost of Application

Based upon the information contained in Section VIII of this document, the industry as a whole is estimated to have to invest approximately $22,500,000 to achieve the effluent limitations prescribed herein. The increased annual costs to the industry are estimated at approximately $5,304,000.

Size and Age of Equipment and Facilities

As discussed in Section IX, differences in size and age of equipment and facilities do not play a significant role in the application of this control technology.

Process Employed

The manufacturing processes employed within each subcategory of the industry are similar and will not influence the applicability of this control technology.

Engineering Aspects of Application

This level of technology is presently being achieved by several glass container plants and can be readily applied to the glass tubing (Danner) manufacturing subcategory. The specified waste water treatment and control systems are now employed in other industries and this technology is readily transferrable to the pressed and blown glass segment. The derivation and rationale for selection of the control technology are described in detail in Section VII. These may be briefly summarized as follows:

Glass Container Manufacturing-

Cullet quench water recycle systems are presently employed at a number of glass container plants. The recycle systems have been in operation for several years without major operational difficulties.

The technologies for treating the blowdown are presently used by at least one glass container plant and also used in the flat glass industry. This technology is readily transferrable to the remainder of the segment.

Glass Tubing (Danner) Manufacturing-

Recycle of cullet quench water is feasible because the pollutant concentrations are at low levels in the quench water. Non-contact cooling water is already recycled at a number of plants within the industry.

Television Picture Tube Envelope Manufacturing-

Rapid sand filtration is a thoroughly proven technology that is used extensively in the water treatment industry. This technology can be applied in the television picture tube envelope, incandescent lamp envelope, and hand pressed and blown glass manufacturing subcategories to further reduce effluent suspended solids, fluoride, and lead concentrations.

Incandescent Lamp Envelope Manufacturing-

Steam stripping is currently being used in the petroleum refining, petrochemical, and fertilizer industries. The ammonia waste water stream concentrations and volumes are similar to those occurring in the incandescent lamp envelope manufacturing subcategory. Effluent concentrations equal to those necessary to achieve the effluent limitations are being achieved in the fertilizer industry and, therefore, can be anticipated when this technology is transferred to the incandescent lamp envelope manufacturing subcategory.

Both diatomaceous earth filtration and recarbonation are proven water treatment methods and can be readily applied to the treatment of waste waters resulting from incandescent lamp envelope manufacturing.

Process Changes

No process changes are required to implement this technology and plant operations and production will not be significantly affected during the installation of the treatment equipment.

Non-Water Quality Environmental Aspects

The application of this control technology is not expected to create any new air or land pollution problems. The ammonia stripped from incandescent lamp envelope manufacturing waste waters is expected to be vented to the atmosphere, although methods are available to recover ammonia as a salable product. Techniques are available to reduce the concentration of ammonia in the air to below the threshold of odor. Energy requirements will not increase significantly above the levels of the best practicable control technology currently available in most of the subcategories because the additional energy requirements are primarily for pumping within the treatment system. The one exception is the incandescent lamp envelope manufacturing subcategory where, if no excess steam or other heat source to produce steam is available, an 8.2 percent increase in energy requirements could result.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS

INTRODUCTION

In addition to guidelines reflecting the best practicable control technology currently available and the best available technology economically achievable, applicable to existing point source discharges by July 1, 1977, and July 1, 1983, respectively, the Act requires that performance standards be established for new sources. The term "new source" is defined in the Act to mean "any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance". New source technology shall be evaluated by adding to the consideration underlying the identification of best available technology economically achievable a determination of what higher levels of pollution control are available through the use of improved production processes and/or treatment techniques. Thus, in addition to considering the best in-plant and end-of-process control technology, identified in best available technology economically achievable, new source technology is to be based upon an analysis of how the level of effluent may be reduced by changing the production process itself. Alternative processes, operating methods or other alternatives must be considered. However, the end result of the analysis will be to identify effluent standards which reflect levels of control achievable through the use of improved production processes (as well as control technology), rather than prescribing a particular type of process or technology which must be employed. A further determination which must be made for new source technology is whether a standard permitting no discharge of pollutants is practicable.

Specific Factors to be Taken into Consideration

At least the following factors should be considered with respect to production processes which are to be analyzed in assessing new source technology:

a. the type of process employed and process changes;

b. operating methods;

c. batch as opposed to continuous operations;

d. use of alternative raw materials and mixes of raw materials;

e. use of dry rather than wet processes (including substitution of recoverable solvents for water); and

f. recovery of pollutants as by-products.

NEW SOURCE PERFORMANCE STANDARDS FOR THE PRESSED AND BLOWN GLASS SEGMENT OF THE GLASS MANUFACTURING CATEGORY

Because of the large number of specific improvements in management practices, design of equipment, and process and systems that have some potential of development, it is not possible to determine, within reasonable accuracy, the potential waste reductions achievable through their application in new sources. However, the implementation of those in-plant and end-of-pipe controls described in Section VII, Control and Treatment Technology, would enable new sources to achieve the effluent discharge levels defined in Section X as the best available technology economically achievable.

The short lead time for application of new source performance standards (less than a year versus approximately three and nine years for other guidelines) affords little opportunity to engage in extensive development and testing of new procedures. The single justification for more restrictive limitations for new sources than for existing sources would be one of relative economics of installation in new plants versus modification of existing plants. There is no data to indicate that the economics of the application of in-plant and end-of-pipe technologies described in Section VII, Control and Treatment Technology, would be significantly weighted in favor of new sources. The only cost reductions for new plants would be those savings resulting from not having to segregate existing process waters from non-contact cooling waters, whereas in existing plants, this may be necessary.

The attainment of zero discharge of process waste water pollutants is feasible for some facilities within the pressed and blown glass segment if process waste water is recirculated to a sufficient degree to allow discharge of the blowdown to the batching operation. Water is used in the batching operation to reduce segregation of the batch and to control dust emissions during mixing. This water evaporates during the melting operation and is not discharged. Several plants in the industry are achieving zero discharge of process waste water pollutants by this or similar means. However, it is not apparent that all plants within the industry can attain zero discharge of pollutants by this means; it has been reported that during times in which soda ash is in short supply, liquid caustic must be substituted. All the water needed in the batching operation is supplied by the liquid caustic. Thus, the blowdown from the process water recirculation system would have to be discharged unless sufficient land was available to allow for evaporation or seepage of this waste water stream.

In view of the aforegoing, it is recommended that the effluent limitations for new sources be the same as those determined to be best available control technology economically achievable, presented in Section X.

PRETREATMENT CONSIDERATIONS

Plants which make up the pressed and blown glass segment of the glass manufacturing point source category discharge waste waters containing both pollutants which will be adequately treated by a publicly owned treatment works and pollutants which will pass through inadequately treated. The following is a discussion of each of the applicable pollutant parameters and recommendations as to their adequate treatment by a publicly owned treatment works:

Fluoride

Fluoride results from the use of hydrofluoric acid to frost incandescent lamp envelopes, to acid polish glass in the manufacture of television picture tube envelopes, and to polish and etch handmade glassware in the finishing operations associated with hand pressed and blown glass manufacturing. It is expected that fluoride will pass through a publicly owned treatment works untreated. It is, therefore, recommended that pretreatment requirements for point sources be established to ensure the treatment of fluoride bearing waste waters. It is further recommended that pretreatment requirements for existing sources be set at those levels established as the best practicable control technology currently available and for new sources at those levels established as new source performance standards. These levels are readily attainable by the proven methods of treatment discussed in Section VII.

Ammonia

Ammonia is contributed to waste water by the frosting of incandescent bulbs. It is anticipated that ammonia discharged to a publicly owned treatment works will be oxidized to nitrite and then nitrate during the treatment process and, therefore, will not pass through untreated.

Oil

Oil emulsions of a mineral or biodegradable animal or vegetable nature are utilized as shear spray within the pressed and blown glass segment of the glass manufacturing category. This shear spray oil and leakage of machine lubricating oils contribute to the waste loading in the glass container manufacturing, television picture tube envelope manufacturing and the incandescent lamp envelope manufacturing subcategories. It has been determined that animal and vegetable oils can be adequately removed in publicly owned treatment works, whereas mineral oil may not be readily removed and may pass through untreated. Therefore, it is appropriate that separate pretreatment regulations be established for these categories of oils.

It is recommended that mineral oil discharges from existing sources be maintained at a level of less than 100 mg/l to reflect the capability of publicly owned treatment works. It has also been determined that many existing sources are attaining the best practicable control technology currently available effluent limitations through in-plant controls with no end-of-pipe treatment. It is expected that new sources should be able to attain this same level of in-plant control. Therefore, it is recommended that new sources be required to maintain mineral oil discharges at levels reflecting the best practicable control technology currently available.

Lead

Lead is contributed to waste waters during the abrasive grinding and polishing and hydrofluoric acid treatment of leaded glassware. Data indicate that the greatest concentration of lead is that contained in suspended solids. Control of suspended solids is expected to control lead discharges from pressed and blown glass manufacturing plants.

Suspended Solids and pH

Suspended solids and pH are expected to be adequately treated in a publicly owned treatment works. There are no unusual suspended solids loadings anticipated that would hinder the operation of a publicly owned treatment works. Extreme variations in pH can exist at those facilities which use hydrofluoric acid to etch or polish glass. Facilities in the television picture tube envelope, the incandescent lamp envelope, and the hand pressed and blown glass manufacturing subcategories employ finishing techniques which utilize hydrofluoric acid.

SECTION XII

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SECTION XIV

GLOSSARY

<u>Act</u>

The Federal Water Pollution Control Act as amended.

<u>Activated Alumina</u>

An insoluble, granular media that adsorbs fluoride as the waste water percolates through the media.

<u>Annealing</u>

Prevention or removal of objectionable stresses by controlled cooling from a suitable temperature.

<u>API Separator</u>

A free oil separator based on the design recommendations of the American Petroleum Institute.

<u>Batch</u>

The raw materials, properly proportioned and mixed, for delivery to the furnace.

<u>Blowdown</u>

A discharge from a system, designed to prevent a buildup of some material, as in a boiler to control dissolved solids.

<u>Blowpipe</u>

The pipe used by a glassmaker for gathering molten glass and blowing the glass by mouth.

<u>Casting</u>

The forming method used to make television picture tube envelope funnels. The funnel mold is spun and centrifugal force causes the molten glass to form in the funnel shape.

<u>Category and Subcategory</u>

Divisions of a particular industry which possess different traits which affect water quality and treatability.

<u>Cooling Water</u>

Water used primarily for dissipation of process heat. Can be both contact or non-contact, and is usually the latter.

Crack-off

The process of severing a glass article by breaking, as by scratching and then heating.

Cullet

Waste or broken glass, usually suitable as an addition to the raw material batch.

Cullet Quench

The process of dissipating the heat from cullet by the addition of water.

Diatomaceous Earth

The skeletal remains of tiny aquatic plants, commonly used as a filter medium to remove suspended solids from fluids. Specially treated diatomaceous earth can be obtained for the removal of emulsified oil from water.

Envelope

The glass portion of a picture tube or light bulb that encloses the electrical components of the assembled product.

Etching

The process of placing designs in high quality stemware by hydrofluoric acid attack of the glass.

Forehearth

A section of a melting tank, from which glass is taken for forming.

Frosting

The process used in the incandescent lamp envelope industry to give the inside surface of an envelope a matted surface. This improves the light diffusing property of the envelope.

Gob

A portion of hot glass delivered by a feeder, after being cut from the molten glass stream by shear cutters.

I.S. Machine

The individual section machine is the machine most commonly used to form glass containers.

Lehr

A long tunnel-shaped oven for annealing glass by continuous passage.

New Source

Any building, structure, facility, or installation from which there is or may be a discharge of pollutants and whose construction is commenced after the publication of the proposed regulations.

Process Water

Any water which comes into direct contact with the intermediate or final product. Includes contact cooling, washing, grinding and polishing, etc.

Ribbon Machine

The machine used to form incandescent lamp envelopes.

Surface Waters

Navigable waters. The waters of the United States including the territorial seas.

Tons Frosted

Calculated by multiplying the tons pulled by the percentage of plant production frosted.

Tons Pulled

Tons of glass drawn from the melting furnace.

Washer

A process device used for water cleaning of the product.

Waste Water

Process water or contact cooling water which has become contaminated with process waste and is considered no longer usable.

TABLE 31

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

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