AP42 Section: **11.14** **Frit Manufacturing**

Title: **Comments and Correspondence to 1997 supplement**

Note: This material is related to a section in *AP42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the file number, the AP42 chapter and then the section. The file name "rel01_c01s02.pdf" would mean the file relates to AP42 chapter 1 section 2. The document may be out of date and related to a previous version of the section. The document has been saved for archival and historical purposes. The primary source should always be checked. If current related information is available, it will be posted on the AP42 webpage with the current version of the section.

CONTACT REPORT--MRI Project No. 4604-02

From: Richard Marinshaw, Environmental Engineering Department

Date of Contact: May 2, 1997

Contacted by: Telephone

Company/Agency: Bayer Corporation
5601 Eastern Avenue
Baltimore, Maryland 21224-2791

Telephone Number: (410) 633-9550

Person(s) Contacted/Title(s)

John Jozefowski, Manager, Manufacturing and Logistics

CONTACT SUMMARY:

Mr. Jozefowski was contacted for clarification of the process operating rates during the January 11 to 15, 1994 emission test conducted on the frit smelters at the Bayer Corporation (formerly, the Miles Industrial Chemicals Division) facility in Baltimore, Maryland. Mr. Jozefowski stated that during the subject emission test, six frit smelters were operating. The emissions from all six smelters were ducted to the same fabric filter. The emission factors developed from the emission test should be based on the total process rate for all six smelters (i.e., the sum of the individual process operating rates). These process rates, as documented during a telephone conversation with Mr. Jozefowski on November 11, 1994 were as follows:

January 11

Smelter	Rate, lb/hr
C1	1,600
C3	1,500
C5	1,500
C6	1,500
C7	1,800
C8	1,400
Total	9,300

January 12

Smelter	Rate, lb/hr
C1	1,800
C3	1,500
C5	1,500
C6	1,500
C7	2,300
C8	1,400
Total	10,000

Based on this information, the emission factors developed from the January 1994 emission test should be based on process rates of 9,300 lb/hr and 10,000 lb/hr for January 11 and 12, respectively.

CONTACT REPORT--MRI Project No. 4602-81

From: Richard Marinshaw, Environmental Engineering Department

Date of Contact: November 11, 1994

Contacted by: Telephone

Company/Agency: Miles Industrial Chemicals Division
5601 Eastern Avenue
Baltimore, Maryland 21224-2791

Telephone Number: (410) 633-9550

Person(s) Contacted/Title(s)

John Jozefowski, Manager, Manufacturing and Logistics

CONTACT SUMMARY:

Mr. Jozefowski was contacted for information on process operating rates during the January 11 to 15, 1994 emission test conducted on the frit smelters at the Miles Industrial Chemicals Division facility in Baltimore, Maryland. Mr. Jozefowski stated that during the test, six frit smelters were operating at the following production rates:

January 11

Smelter	Rate, lb/hr
C1	1,600
C3	1,500
C5	1,500
C6	1,500
C7	1,800
C8	1,400

CALLED 4/28/97
N/IM

CALLED 4/29/97
N/LM

January 12

Smelter	Rate, lb/hr
C1	1,800
C3	1,500
C5	1,500
C6	1,500
C7	2,300
C8	1,400

Mr. Jozefowski did not have the operating rates for January 15.

MILES

Industrial Chemicals Division

Pigments, Enamels and Ceramics

Miles Inc.
5601 Eastern Avenue
Baltimore, MD 21224-2791
Phone: 410 633-9550
Fax: 410 631-4395

September 22, 1994

Mr. Ronald E. Myers
Emission Factors and Methodologies Section
Emission Inventory Branch
Office of Air Quality Planning and Standards
United States Environmental Protection Agency
Research Triangle Park, NC 27711

Dear Sir:

Subject: Compilation of Air Pollution Emission Factors Industry Comments.

In response to your letter to Mr. Peter Koxholt, and our subsequent telephone conversation, I am forwarding to you for your review a copy of the test results for Miles Baltimore site's dry gas cleaning system. This series of tests were performed by International Technology Corporation (ITC) in January 1994 and were forwarded to the Maryland Department of the Environment as a condition of the annual operating permit. These tests were performed on a single point emission source connected to a common manifold and baghouses for the site's continuous smelters.

I have two additional comments on the Draft AP-42, Section 11:14 as follows.

1. **Frit should be described as a homogenous melted mixture rather than a mixture.**

2. **This site's smelting furnaces (smelters) operate at temperatures to 2700°F.**

If I can be of further assistance, please contact me by telephone at (410) 631-4322 or by fax at (410) 631-4395.

John E. Jozefowski
Manager, Manufacturing & Logistics

JEJ24/bbs

Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 424-6424
Telex 24-5454

November 1, 1977

Ms. Pamela Canova
Requests and Information Section
National Air Data Branch
Environmental Protection Agency
Research Triangle Park
North Carolina 27711

Dear Ms. Canova:

In response to your letter of October 15, 1977, I have provided remarks on your glass manufacturing draft which you may want to consider. I have also enclosed some articles from Tooley's Handbook of Glass Manufacture and a copy of the source assessment document on pressed and blown glass.

The write-up is basically sound, but could use some changes in wording in order to minimize any confusion on the part of the readers. You may also want to recheck your emission rates. Some rates are available (e.g., HC and CO) and others may not be considered negligible.

Very truly yours,

Richard Schorr

J. Richard Schorr, Manager
Materials Application Section

JRS:iw

Encs.

TABLE XX B-I

Sheet Glass Distribution by Process—1937

Process	Plants	Furnaces	Machines	% Production
Fourcault	16	27	120	40
Colburn	2	11	19	30
Pennvernon*	3	7	25	30

* Registered trademark of the Pittsburgh Plate Glass Company.

though the mechanical cylinder blowing process contributed to large-scale production, it was an *intermittent system*, relatively slow and laborious, and resulted in considerable waste of time and material. The product was not of particularly good quality.

With the adoption of the flat sheet methods, machine cylinder operations shrank rapidly until 1929 when the last cylinder machine was shut down. Of the nearly 600 million square feet of sheet glass produced in 1925 by 42 plants (a decrease from 100 in 1899), 59% was produced by machine cylinder, 29% by Colburn, 10% by Fourcault and 2% by hand cylinder. By 1929 the number of operating plants dropped to 16, ten of which were using the continuous flat sheet processes. In 1937, eleven companies with 21 plants, possessing a production capacity of about one billion square feet had the distribution indicated in Table XX B-I.

4. Fourcault Method

Continuous flat sheet drawing systems developed rapidly after 1913 in the United States and Europe. In the Fourcault method, the sheet is drawn vertically through a slotted refractory shape called a "debiteuse" in a continuous ribbon as shown in Fig. XX B, 2. The main problem encountered in drawing such a sheet was the tendency of "necking down" to a slender rod or fiber. This difficulty was overcome through chilling the ribbon edges by passing them between paired knurled small rolls that "gripped" the sheet edges a short distance above the debiteuse. The surface of the glass made in this way has what is called a fire finish or polish, which is the brilliant surface achieved by allowing the

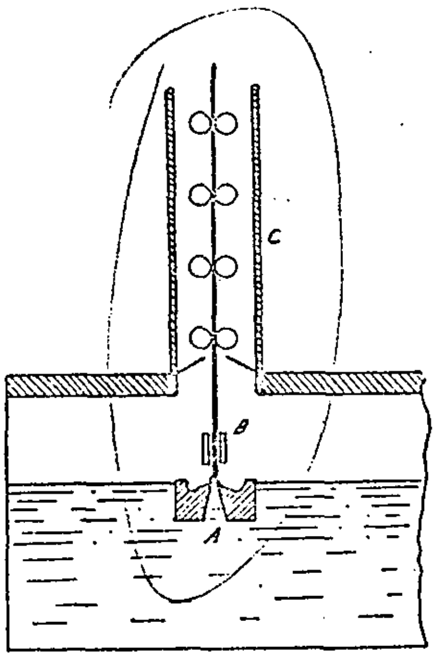


FIG. XX B, 2. Fourcault process continuous flat sheet drawing machine. A. Depressed debiteuse; B. Sheet coolers; C. Drawing machine and vertical lehr.

..en glass to cool to rigidity ..hout coming in contact with ..thing solid while it is soft. How- ..r, the solidified ribbon possesses ..rtain limited amount of wavi- ..which cannot be avoided. These ..egularities arise from small dif- ..ences in viscosity due to chemi- .. and thermal inhomogeneities.

Periods of excellent production, ..well as those of mediocre and ..en poor quality, are experienced. ..ese variations can be attributed ..part to:

- .. Corrosion of refractories.
- .. Deterioration of machine performance.
- .. Shifting of the normal convection currents of the glass and of the atmosphere in the drawing kiln.
- .. Human control factors.

The debiteuse used in the Four- ..ult process is a specially shaped ..fractory clay block with a scien- ..ically designed opening through ..hich the ribbon of any thickness .. "strength" is drawn vertically. ..e shape is furnished as a blank in .. unburned state by the glass ..use refractories manufacturer. ..e purchaser cuts out and finishes .. slot to his individual require- ..ents. The piece is then carefully ..d and ready when needed for ..rect transfer to the drawing ..amber without recooling.

In the drawing chamber, the deb- ..euse floats because of the greater ..ity of the glass, but is forced ..wn to the prescribed level by ad- ..table arms. Its delivery slot is ..otected from flooding by a raised ..m so that no glass can overflow ..e surface. A tongue of glass fills .. entire slot width and, because of the downward pressure on the debiteuse, is extruded up from below. The length of the slot in the debiteuse determines the sheet width. The sheet thickness is affected by four factors:

(1) Temperature of glass in the drawing chamber—the higher it is the thinner the sheet.

(2) Debiteuse float level in glass—the deeper it is submerged the thicker the sheet or the faster the draw.

(3) Sheet coolers—the closer they are to the sheet and the lower the temperature of circulating water, the thicker the sheet.

(4) The speed of draw—the faster the machine rate, the thinner the sheet.

Under the proper operating conditions, the drawing machine serves only to carry the extruded glass of a given thickness from the slot. (Table XX B-II.)

TABLE XX B-II

Rates of Draw (Fourcault 80" Ribbon)[10]

Thickness (inches)	Drawing Speed (in./min.)
0.03	140
0.09	64
0.125	45
0.22	18
0.50	6

The sheet is started by contacting the hot glass with an iron "bait." Surface tension and viscosity compel the glass to follow the bait as it is withdrawn by the machine, thus forming a ribbon of flat glass. The two sets of edge rolls create a constant side pull that maintains uniform width. As the glass moves upward past the sheet

coolers and further from the pool and debiteuse, it loses heat rapidly. This cooling causes the sheet to contract somewhat and tends to gather in slight ripples hotter, softer glass which follows. The sheet becomes rigid without losing this objectionable waviness. Irregularities and cracks in the debiteuse slot, temperature variations in the drawing chamber and coolers, drafts, and fluctuations in machine speed are other factors, all of which combine to cause the waves and "batter" that are characteristic of all drawn sheet glass.

Close control and ideal conditions lead to periods of high quality production. Under these conditions, it might be considered difficult to identify smaller sizes from genuine plate glass. However, such quality, as a rule, is the exception in certain areas of the sheet. The machine does not really form the sheet. The sheet is formed by the physical properties of molten glass as it is pulled from the kiln. The machine does the pulling and keeps the sheet of even width and thickness.

Compared to the machine cylinder method, the Fourcault process was a continuous system and practically all the melted glass entered the final sheet. In addition, it completely eliminated several necessary operations of the cylinder method, such as capping, splitting and flattening—an appreciable part of the total labor costs. However, due to the temperature conditions of the drawing chamber and the tendency of all glasses to devitrify, the Fourcault process must be periodically stopped and the drawing chambers heated to a high.. the accum.. After this.. peratures.. chines ba.. Also, due.. sion of .. replaced ..

One, tw.. times, fi.. "canal" .. tank. As.. be built.. quently, .. or as m.. chines r.. ously o.. widths .. but ma.. Dependi.. chines .. thickne.. daily ca.. tons pe..

5.

Whil.. his con.. ing pro.. Americ.. depend.. form .. Colbur.. drawin.. develo.. As pr.. Owens.. molte.. its pa.. the dr.. heate.. prepa.. pull f.. ing r.. flatte..

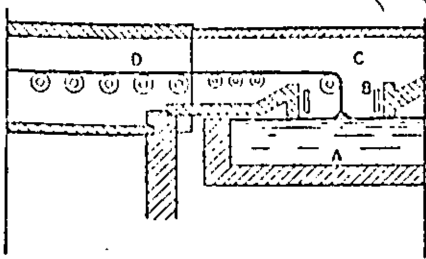


FIG. XX B, 3. LOF-Colburn process continuous flat sheet drawing machine A. Shallow drawing pot; B. Sheet coolers; C. Bending roll (or rollers); D. Horizontal lehr.

a horizontal lehr for annealing (Fig. XX B, 3).

The use of a debiteuse or other refractory shape to create the sheet is unnecessary. Normally, sheet widths from 100 up to 158 inches are drawn in thicknesses ranging from 0.035 to 0.22 inches. Obviously, uniformity of temperature and glass composition and constant machine speeds are prime considerations in maintaining such a wide sheet of uniform thickness. One or usually, two machines handle the production from a Colburn process tank.

TABLE XX B-III

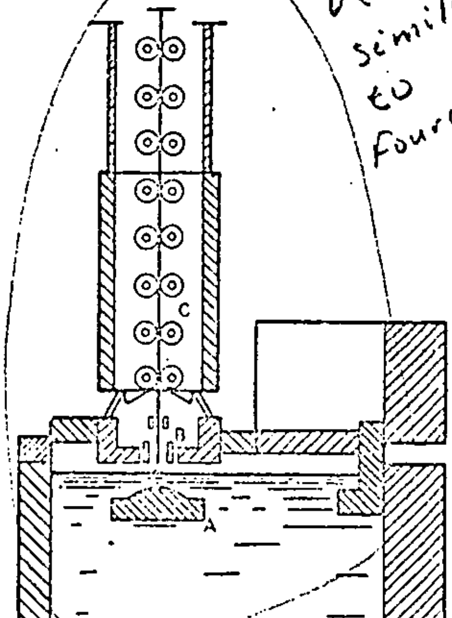
LOF-Colburn Drawing Speeds[10]
(Width 128 inches)
(Production approximately 80,000 sq. ft./24 hours on 0.08 inch basis)

Thickness (inches)	Speed (inches)
0.04	180
0.315	16
1.25	1.5

The annual net production from Colburn process tanks is approximately thirty million square feet. On the average about 110 tons of glass are drawn daily from 800-ton tanks.

6. The Pennvernon Method

The Pennvernon process for making a continuous flat sheet was introduced about 1925 by the Pittsburgh Plate Glass Company. It is a vertical drawing process similar to the Fourcault, except that the floating slotted debiteuse is replaced by a submerged solid "draw bar." This horizontal refractory slab with a longitudinal rib is positioned several inches below the glass surface in the drawing chamber and its function is to assist in conditioning the glass, to determine the line of origin of the sheet, and to control convection currents in the drawing chamber (Fig. XX B, 4). Usually



very similar to Fourcault

FIG. XX B, 4. Pittsburgh Plate Glass Company Pennvernon process continuous flat sheet drawing machine. A. Submerged drawbar; B. Sheet coolers; C. Vertical drawing machine and lehr.
Courtesy Pittsburgh Plate Glass Co.

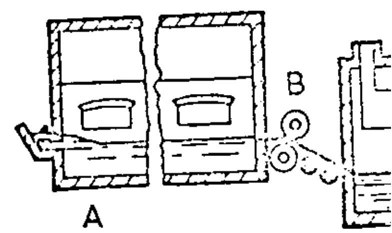


FIG. XX B, 5. Pilkington float process melting tank; B. Rolling machine; C. M
Courtesy Pilkington Brothers Limited.

four machines handle the produ from a Pennvernon process ta normal size (1200-1400 tons) d ing about 250 tons per day.

7. Float Glass Process

This new method for prod sheet glass reportedly combine high surface brilliance of fir ished sheet glass with the fla and freedom from distortio ground and polished plate without resort to the regular chanical grinding and polishin erations. It has been develop England by Pilkington Bros. a development moves in the tion of the glass maker's sought goal of combining th finish surface and relatively lo of sheet glass production wi flatness and freedom from d tion characteristic of plate gla

In this "float" process, glass is fed continuously to a zontal pair of water-cooled The continuous ribbon of d thickness thus formed is con directly to an enclosed cont

8.13 Glass Manufacturing   by Pam Canova

8.13.1 General[1,2,3,4]

Commercially produced glass can be classified as either soda-lime, lead, fused silica, borosilicate, or 96% silica. Soda-lime glass, which constitutes 77 ~~90%~~ of total glass production, will be discussed in this section. Soda-lime glass consists of sand, limestone, soda ash, and cullet (broken glass). The manufacture of glass can be broken down into four ~~three~~ phases: (1) preparation of raw materials, (2) melting in a furnace, ~~and~~ (3) forming) and (4) finishing. Figure 1 shows an overall flow diagram for glass manufacturing.

The products of the glass manufacturing industry are categorized as flat glass, container glass, or pressed and blown glass. The procedure for manufacturing glass is the same for all three categories except for forming and finishing. Flat glass, which comprises 24 ~~16%~~ of total glass production, is formed by either the float, drawing, or rolling process. Container glass and pressed and blown glass, which comprise 51 ~~63%~~ and 25 ~~21%~~ respectively of total glass production, utilize either pressing, blowing, or pressing and blowing to form the desired product.

As raw materials are received, they are crushed and stored in separate, elevated bins. The raw materials are transferred through a gravity feed system to the weigher and mixer, where the material and cullet are mixed to ensure homogeneous melting. The mixture is then transferred by conveyor to the batch storage bin where it remains until being dropped into the furnace feeder which in turn supplies the necessary raw material to the melting furnace. All equipment used in handling and preparing the raw material is housed separately from the furnace and is usually referred to as the batch plant. Figure 2 shows a flow diagram of a batch plant.

In the glass industry, this implies no heat recovery It should be deleted

The type of furnace most commonly utilized is a ~~direct-fired~~ continuous, regenerative furnace capable of producing between 50 and 300 tons (45 and 272 metric tons) of glass per day. A furnace may have either side or end ports connecting brick checkers to the inside of the melter. The purpose of the checkers is to conserve fuel by utilizing the heat of the combustion products in one side of the furnace to preheat combustion air in the other side. As material enters the melting furnace through the feeder, it floats on the top of the molten glass already in the furnace. As it melts, it passes to the ~~rear~~ front of the melter and eventually flows through a throat connecting the melter and the refiner. In the refiner, the molten glass is ~~mixed to assure homogeneity and~~ heat conditioned for ~~durability~~ delivery to the forming process. Temperatures in the furnace range from 2700°F (1482°C) in the melter to 2200°F (1204°C) in the refiner. Figure 3 shows a side port and an end port regenerative furnace.

After refining, the molten glass leaves the furnace through forehearths (except for the float process which goes directly to the tin bath) and goes to be shaped by either pressing, blowing, pressing and blowing, drawing, rolling, or floating, depending upon the desired product. Pressing and blowing is performed mechanically using blank molds and glass cut into gobs by a set of shears. In the drawing process, molten glass is drawn upward through rollers which ~~form and control the thickness of the sheet glass~~ guide the sheet glass. The thickness of the sheet is determined by the speed of the draw and the configuration of the machine. The rolling process is similar to the drawing process except that the glass is drawn horizontally by plain or patterned rollers and, for plate glass, requires grinding and polishing. The float process utilizes a molten tin bath over which the glass is drawn and formed into a finely finished surface requiring no grinding or polishing. Temperatures during these processes range from 1472°F (800°C) to 2012°F (1100°C). The product ~~then~~ undergoes finishing (decorating or coating) and annealing (removing unwanted stress areas in the glass), and is then inspected and prepared for shipp~~ing~~ment to market. Any damaged or undesirable glass is transferred back to the batch plant to be used as cullet.

~~There is NO forehearth in the float process. The glass goes directly from refiner to Tin bath~~

This is not true. The speed of the draw ~~and the configuration of the drawbar~~ determine thickness. The rollers are used for guiding the sheet (see attached)

8.13.2 Emissions and Controls[1,2,3,4]

The main pollutant emitted by the batch plant is particulates in the form of dust. This can be controlled, with approximately 99-100% efficiency, by enclosing all possible dust sources and using baghouses or cloth filters for collection. Another way to control dust emissions, also with an efficiency approaching 100%, is by treating the batch to reduce the amount of fine particles present. Forms of preparation would be pre-sintering, briquetting, pelletizing, or liquid alkali treatment.

particulates from glass melting furnaces are condensates
$Na_2O + SO_3 = Na_2SO_4$

The melting furnace contributes over 99% of the total emissions from the glass plant. In the furnace, both particulates and gaseous pollutants are emitted. Particulates result from volatization of materials in the melt that combine with gases to form condensates. ~~in the flue system~~ ~~Particulates are produced when carbon dioxide bubbles propel particles out of the melting batch.~~ These are either collected in the checker-work and gas passages, or escape to the atmosphere. Serious problems arise when the checkers are not properly cleaned in that slag can form, clogging the passages and eventually deteriorating the condition and efficiency of the furnace. Nitrogen oxides form when N_2 and O_2 react in the high temperatures of the furnace. Sulfur oxides result from the decomposition of the sulfates in the batch and the fuel. Proper maintenance and firing of the furnace can control emissions, while, at the same time, add to the efficiency of the furnace and reduce operational costs. Low-pressure, wet, centrifugal scrubbers have been used to control particulates and SO_x, but their low efficiency of approximately 52% indicates their inability to collect particulates of submicron size. High energy Venturi scrubbers are approximately 95% effective in reducing particulate and SO_x emissions. The effect on NO_x is unknown. Baghouses, which have up to 99% particulate collection efficiency, have been used on small, regenerative furnaces, but, due to fabric corrosion, require careful temperature control. Electrostatic precipitators have shown to have an efficiency of up to 99% in the collection of particulates.

Emissions from the forming and finishing phase depend upon the type of glass being manufactured. For container and press and blow machines, the majority of emissions result from the gob ~~shears~~ coming into contact with the machine lubricant. Emissions in the form of a dense white cloud, which can exceed 40% opacity, are generated by flash vaporization of hydrocarbon greases and oils. Grease and oil lubricants are being replaced by silicone emulsions and water-soluble oils which may virtually eliminate the smoke. For flat glass, the only contributor to air pollutant emissions is gas combustion in the annealing lehr which is totally enclosed except for entry and exit openings. Since emissions are small and operational prodecures are efficient, no controls are utilized.

Table 8.13-1 lists controlled and uncontrolled emission factors for glass manufacturing.

Not exactly correct. Oils & Sprays are put into molds and sleeves to facilitate release of glassware. The smoke is a mixture of organics that may or may not be eliminated by using emulsions

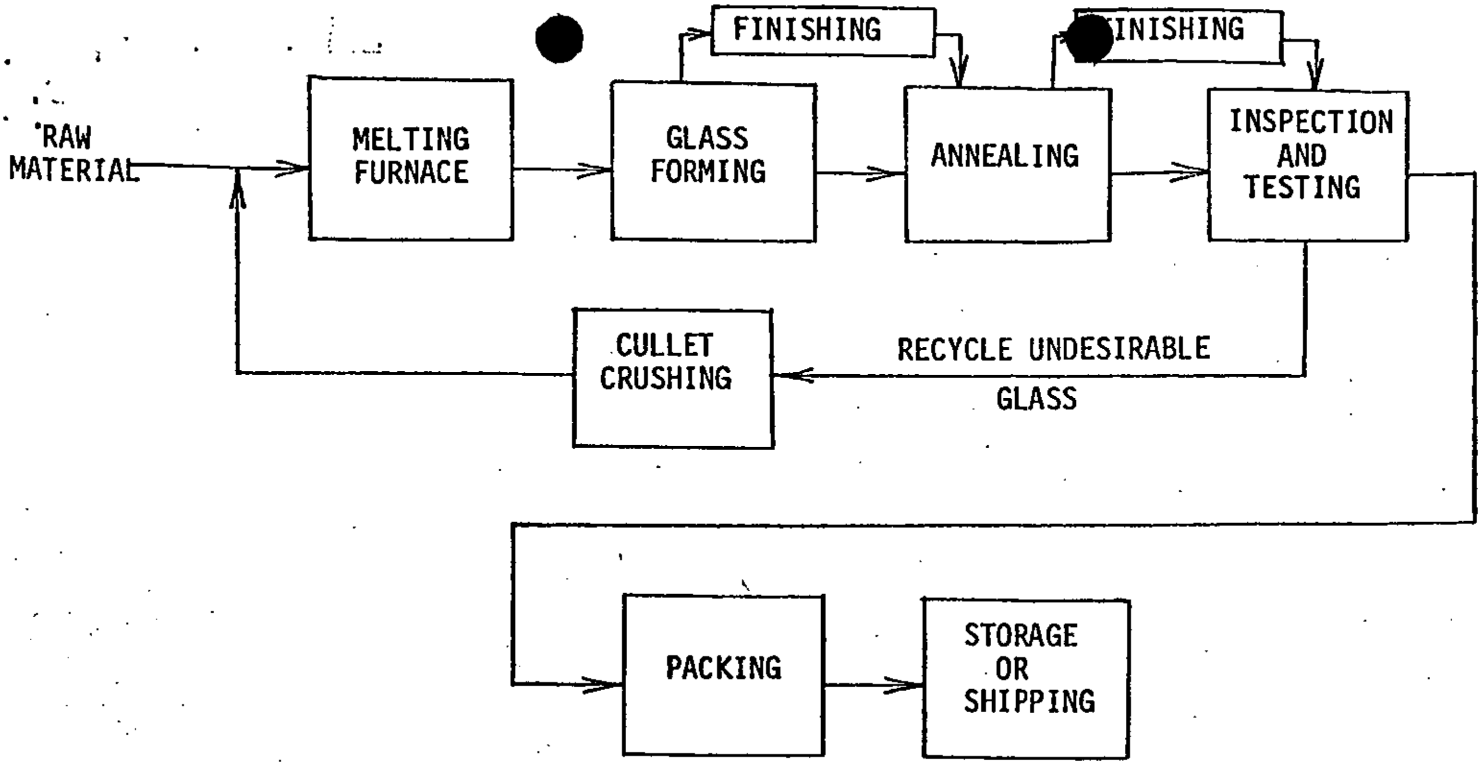


Figure 1: Flow diagram for glass manufacturing.

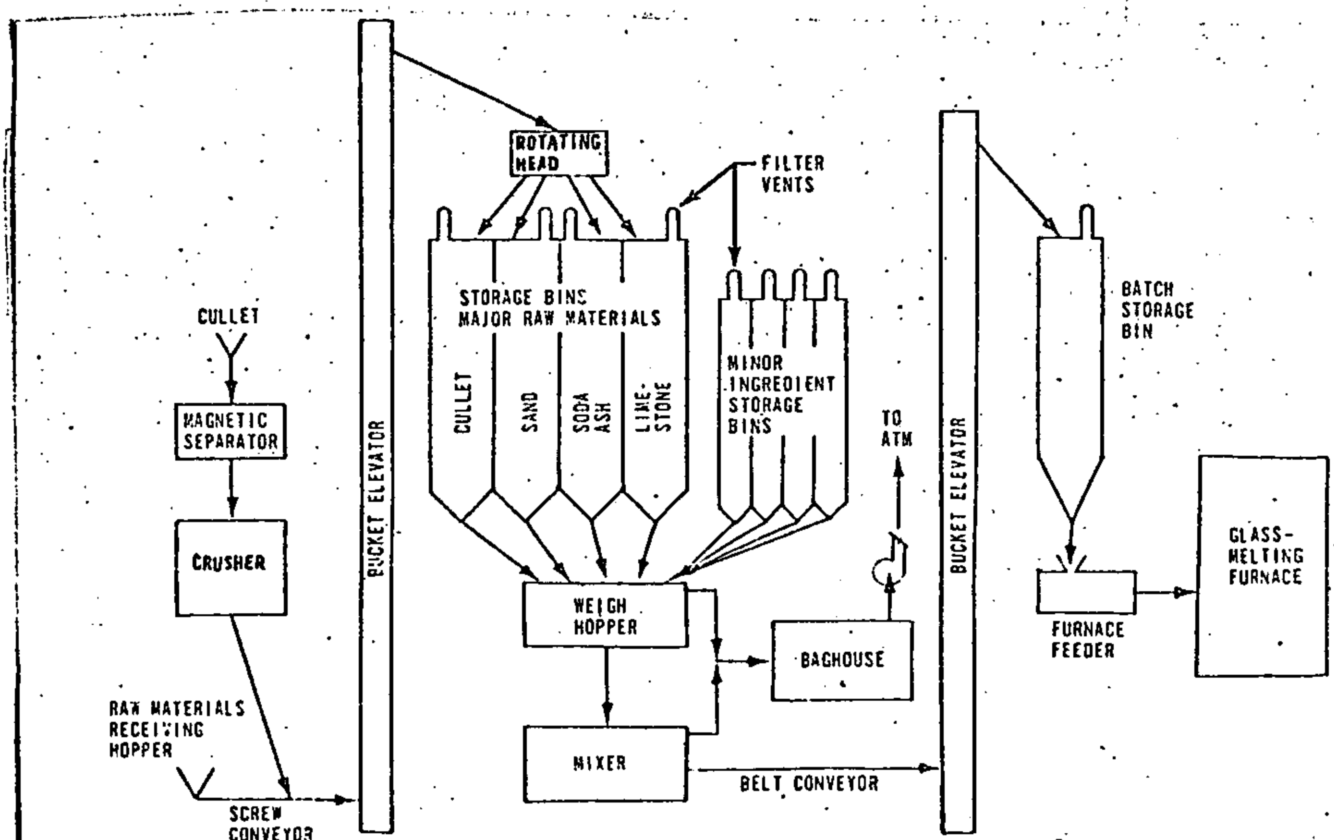
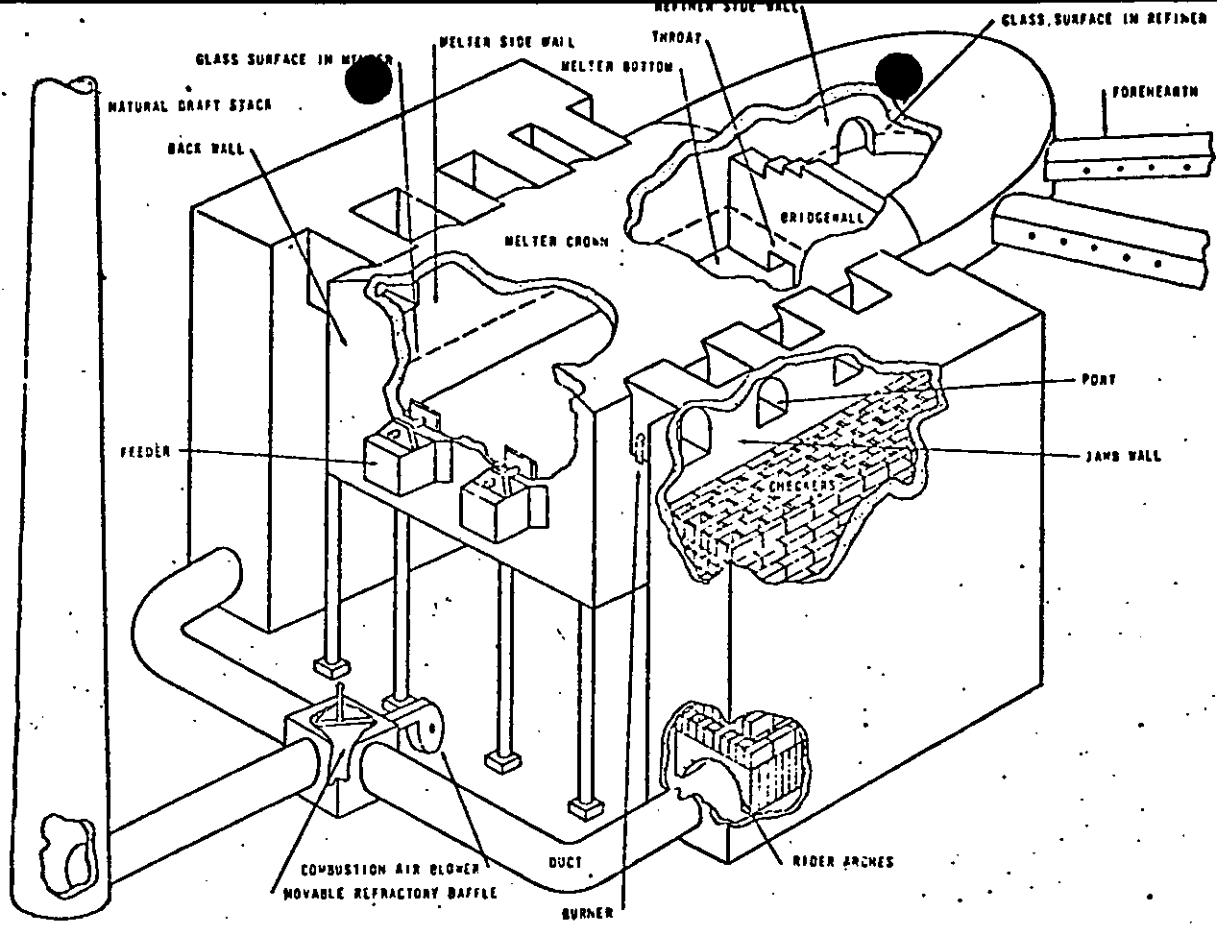
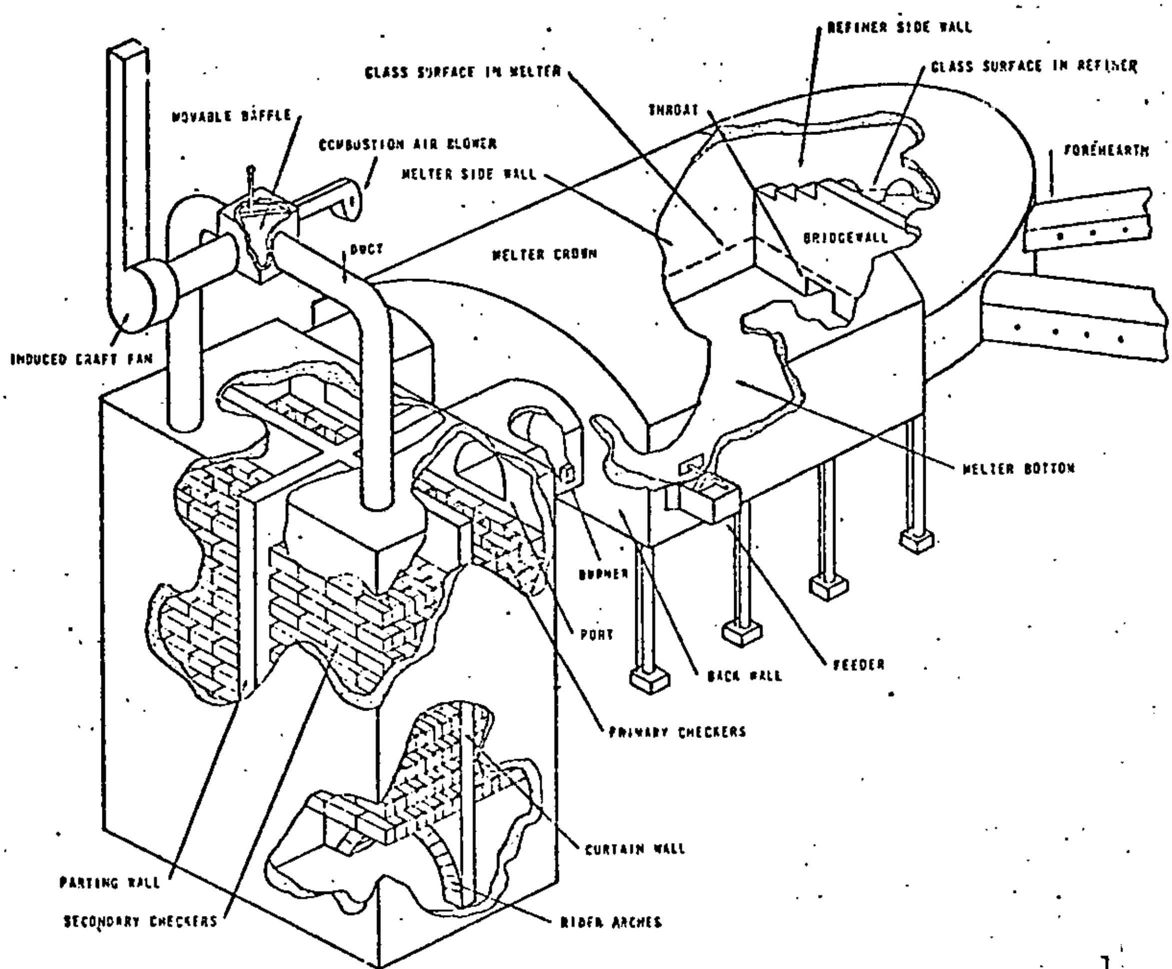


Figure 2: Flow diagram of a batch plant.[1]



Side port ~~direct-fired,~~ continuous, regenerative furnace.[1]



End port ~~direct-fired,~~ continuous, regenerative furnace.[1]

Table 8.13-1. Emission Factors for Glass [illegible]
Emission Factor Rating: [illegible]

Procedure	Particulate[c] lb/ton	Particulate[c] kg/MT	lb/to[illegible]
Raw Materials Handling[d] (All types of glass)	Negl[e]	Negl	0
M[illegible]ing Furnace[f]			
Container			
Uncontrolled	1.4(0.9-1.9)	0.7(0.4-0.9)	3.4(2.0-[illegible]
W/Low energy scrubber[g]	0.7	0.4	1.7
W/Venturi scrubber[h]	0.1	<0.1	0.2
W/Baghouse[i]	Negl	Negl	3.4
W/Electrostatic precipitator[i]	Negl	Negl	3.4
Flat			
Uncontrolled	2(0.8-3.2)	1(0.4-1.6)	3(2.2-3.[illegible]
W/Low energy scrubber[g]	1	0.5	1.5
W/Venturi scrubber[h]	Negl	Negl	0.2
W/Baghouse[i]	Negl	Negl	3
W/Electrostatic precipitator[i]	Negl	Negl	3
Pressed and Blown			
Uncontrolled	5.7	2.9	0.6
W/Low energy scrubber[g]	2.7	1.4	0.3
W/Venturi scrubber[h]	0.3	0.1	Negl
W/Baghouse[i]	Negl	Negl	0.6
W/Electrostatic precipitator[i]	Negl	Negl	0.6
Forming and Finishing (All types of glass)	Negl	Negl	Negl

[a]Emission factors are expressed as pounds of pollutant per ton, and kilograms of pollutant per metric ton, of glass produced.

[b]When literature references reported ranges in emission rates, these ranges are shown in parentheses along with the average emission factor. Single emission factors are averages of literature data for which no ranges were reported.

[c]Particulates are submicron in size.

[d]Emission factors for Raw Materials Handling are not separated into types of glass produced since batch preparation is the same for all types. Particulate emissions are negligible because almost all plants utilize some form of control (i.e. baghouses or scrubbers).

[e]Negligible.

[f]Control efficiencies for the various devices are applied only to the average emission factor.

[g]Approximately 52% efficient in reducing particulate and SO_x emissions. Effect on NO_x is unknown.

[h]Approximately 95% efficient in reducing particulate and SO_x emissions. Effect on NO_x is unknown.

[i]Approximately 99% efficient in reducing particulate emissions.

[j]~~This comparatively large emission factor is probable due to the small size of the melting furnace used for producing pressed and blown glass.~~

[k]~~Data not available~~.

j Particulate emission factors were calculated using data for furnaces melting soda lime and lead glasses. No data were available for borosilicate or opal glasses.

k Hydrocarbon emission factors for container and pressed and blown glass are from the decorating process. (over)

for container and pressed and blown glass, tin chloride, hydrated tin chloride, and HCl are also emitted, at a rate of less than 0.1 lbs/ton (<0.1 kg/MT) each during surface treatment process

Emissions can be controlled by incineration, absorption, or condensation, however, efficiency percentages are not known.

References for Section 8.13.

1. Netzley, A. B. and J. L. McGinnity. Glass Manufacture. In: Air Pollution Engineering Manual. Danielson, J. A. (ed.). U. S. DHEW, PHS, National Center for Air Pollution Control. Cincinnati, Ohio. PHS Publication Number AP-40. May 1973. p. 765-782.

2. Reznik, Richard B. Source Assessment: Flat Glass Manufacturing Plants. Prepared for Environmental Protection Agency, Research Triangle Park, N.C. Publication Number EPA-600/2-76-032b. March 1976.

3. Schorr, J. R., D. T. Hooie, P. R. Sticksel, and Clifford Brockway. Source Assessment: Glass Container Manufacturing Plants. Prepared for Environmental Protection Agency, Research Triangle Park, N.C. Publication Number EPA-600/2-76-269. October 1976.

4. Tripler, A. B., Jr. and G. R. Smithson, Jr. A Review of Air Pollution Problems and Control in the Ceramic Industries. Battelle Memorial Institute, Columbus, Ohio. Presented at 72nd Annual Meeting American Ceramic Society. May 1970.

Dr. Richard Schorr
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201

Dear Dr. Schorr:

Per my conversation with your secretary, I am sending you a draft of the revised AP-42 section on glass manufacturing. Please review it and make any notations as to technical accuracy which you feel needs to be changed. As we have tentatively set a deadline for our next supplement, I would appreciate having the draft back in about two weeks if your schedule permits.

Sincerely yours,

Pamela Canova
Engineer Trainee
Requests and Information Section
National Air Data Branch

Enclosure

NADB:PCANOVA:byl:rm647:MU:x5395:10/12/77

8.13 Glass Manufacturing

by Pam Canova

8.13.1 General[1,2,3,4]

Commercially produced glass can be classified as either soda-lime, lead, fused silica, borosilicate, or 96% silica. Soda-lime glass, which constitutes 90% of total glass production, will be discussed in this section. Soda-lime glass consists of sand, limestone, soda ash, and cullet (broken glass). The manufacture of glass can be broken down into three phases: (1) preparation of raw materials, (2) melting in a furnace, and (3) forming and finishing. Figure 1 shows an overall flow diagram for glass manufacturing.

The products of the glass manufacturing industry are categorized as flat glass, container glass, or pressed and blown glass. The procedure for manufacturing glass is the same for all three categories except for forming and finishing. Flat glass, which comprises 16% of total glass production, is formed by either the float, drawing, or rolling process. Container glass and pressed and blown glass, which comprise 63% and 21% respectively of total glass production, utilize either pressing, blowing, or pressing and blowing to form the desired product.

As raw materials are received, they are crushed and stored in separate, elevated bins. The raw materials are transferred through a gravity feed system to the weigher and mixer, where the material and cullet are mixed to ensure homogeneous melting. The mixture is then transferred by conveyor to the batch storage bin where it remains until being dropped into the furnace feeder which in turn supplies the necessary raw material to the melting furnace. All equipment used in handling and preparing the raw material is housed separately from the furnace and is usually referred to as the batch plant. Figure 2 shows a flow diagram of a batch plant.

The type of furnace most commonly utilized is a direct-fired, continuous, regenerative furnace capable of producing between 50 and 300 tons (45 and 272 metric tons) of glass per day. A furnace may have either side or end ports connecting brick checkers to the inside of the melter. The purpose of the checkers is to conserve fuel by utilizing the heat of the combustion products in one side of the furnace to preheat combustion air in the other side. As material enters the melting furnace through the feeder, it floats on the top of the molten glass already in the furnace. As it melts, it passes to the rear of the melter and eventually flows through a throat connecting the melter and the refiner. In the refiner, the molten glass is mixed to assure homogeneity and heat conditioned for durability. Temperatures in the furnace range from 2700°F (1482°C) in the melter to 2200°F (1204°C) in the refiner. Figure 3 shows a side port and an end port regenerative furnace.

After refining, the molten glass leaves the furnace through forehearths and goes to be shaped by either pressing, blowing, pressing and blowing, drawing, rolling, or floating, depending upon the desired product. Pressing and blowing is performed mechanically using blank molds and glass cut into gobs by a set of shears. In the drawing process, molten glass is drawn upward through rollers which form and control the thickness of the sheet glass. The rolling process is similar to the drawing process except that the glass is drawn horizontally by plain or patterned rollers and, for plate glass, requires grinding and polishing. The float process utilizes a molten tin bath over which the glass is drawn and formed into a finely finished surface requiring no grinding or polishing. Temperatures during these processes range from 1472°F (800°C) to 2012°F (1100°C). The product then undergoes finishing (decorating or coating) and annealing (removing unwanted stress areas in the glass), and is then inspected and prepared for shipping to market. Any damaged or undesirable glass is transferred back to the batch plant to be used as cullet.

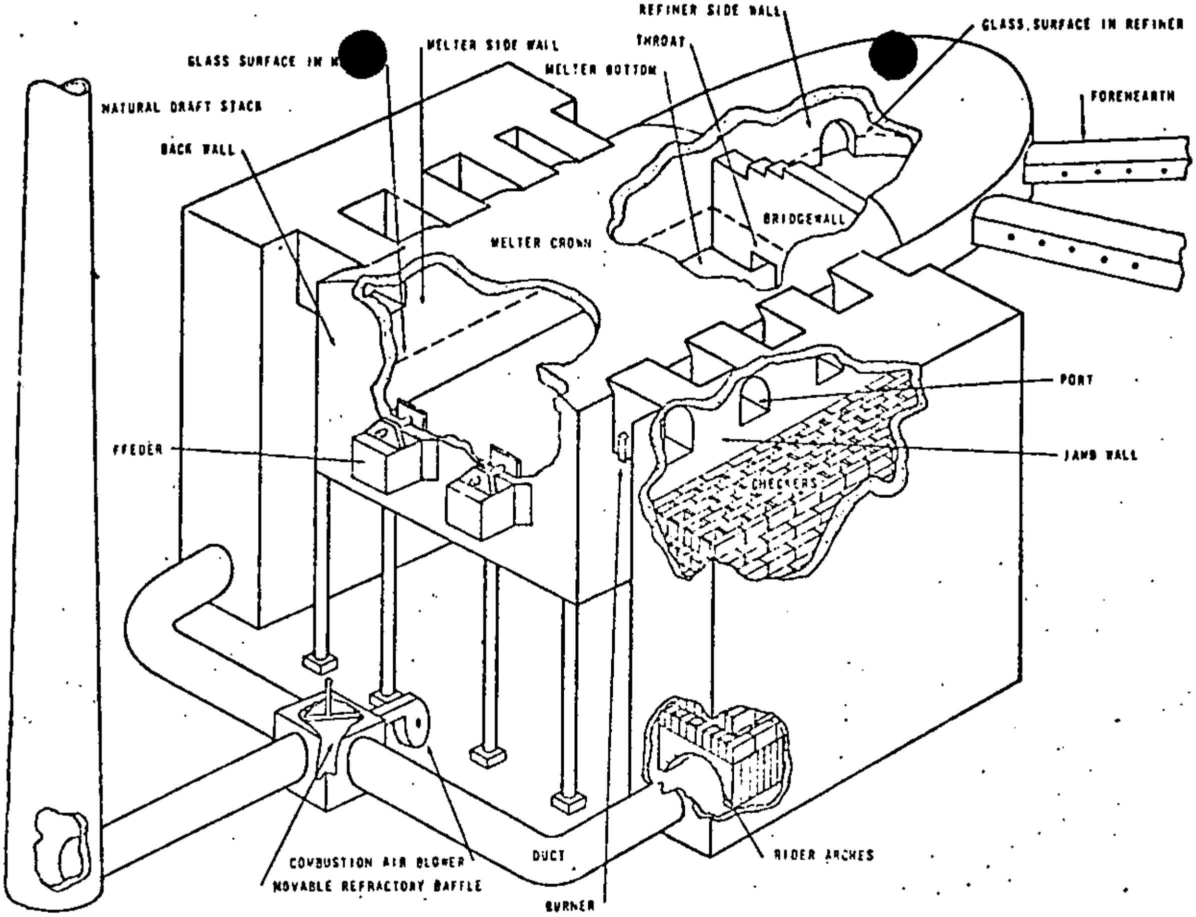
8.13.2 Emissions and Controls[1,2,3,4]

The main pollutant emitted by the batch plant is particulates in the form of dust. This can be controlled, with approximately 99-100% efficiency, by enclosing all possible dust sources and using baghouses or cloth filters for collection. Another way to control dust emissions, also with an efficiency approaching 100%, is by treating the batch to reduce the amount of fine particles present. Forms of preparation would be pre-sintering, briquetting, pelletizing, or liquid alkali treatment.

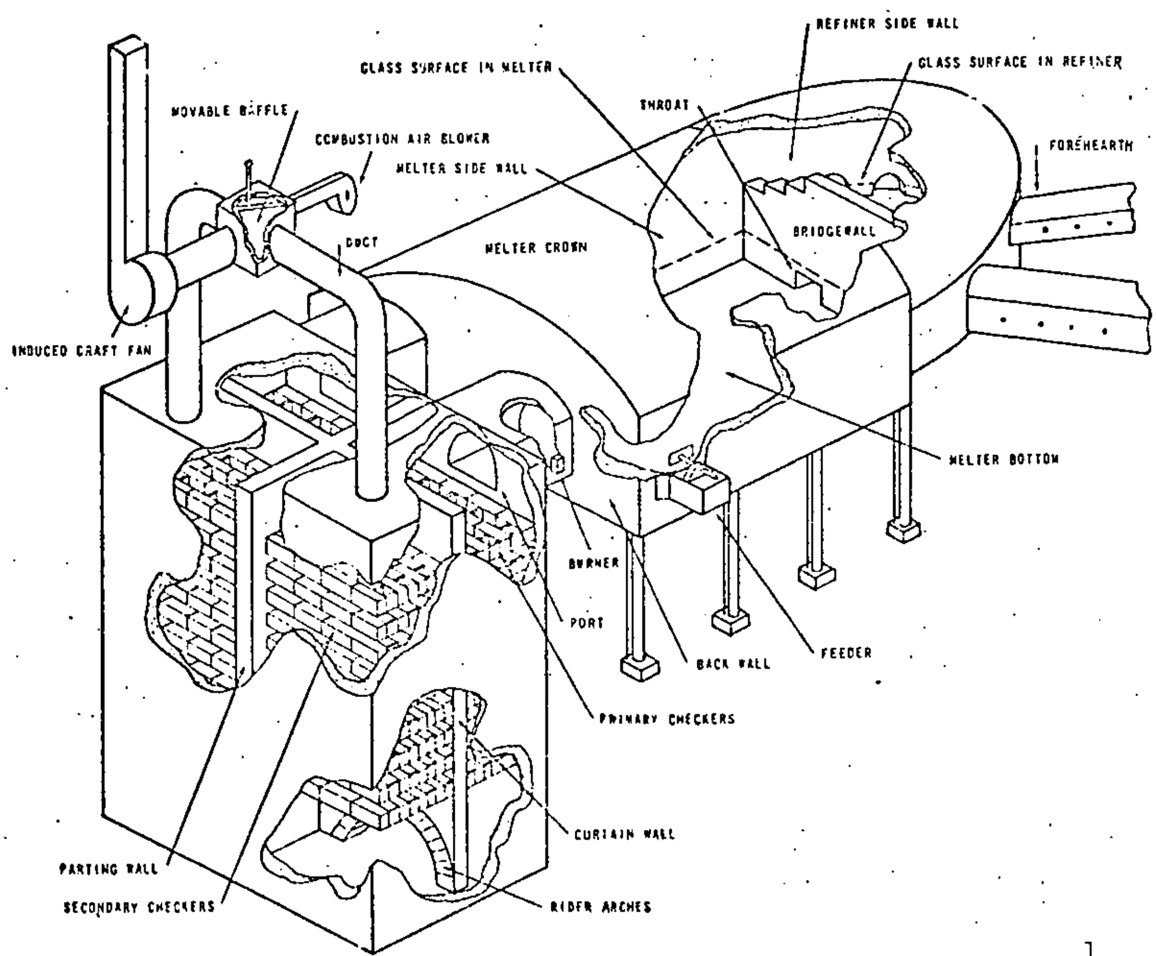
The melting furnace contributes over 99% of the total emissions from the glass plant. In the furnace, both particulates and gaseous pollutants are emitted. Particulates are produced when carbon dioxide bubbles propel particles out of the melting batch. These are either collected in the checker-work and gas passages, or escape to the atmosphere. Serious problems arise when the checkers are not properly cleaned in that slag can form, clogging the passages and eventually deteriorating the condition and efficiency of the furnace. Nitrogen oxides form when N_2 and O_2 react in the high temperatures of the furnace. Sulfur oxides result from the decomposition of the sulfates in the batch and the fuel. Proper maintenance and firing of the furnace can control emissions, while, at the same time, add to the efficiency of the furnace and reduce operational costs. Low-pressure, wet, centrifugal scrubbers have been used to control particulates and SO_x, but their low efficiency of approximately 52% indicates their inability to collect particulates of submicron size. High energy Venturi scrubbers are approximately 95% effective in reducing particulate and SO_x emissions. The effect on NO_x is unknown. Baghouses, which have up to 99% particulate collection efficiency, have been used on small, regenerative furnaces, but, due to fabric corrosion, require careful temperature control. Electrostatic precipitators have shown to have an efficiency of up to 99% in the collection of particulates.

Emissions from the forming and finishing phase depend upon the type of glass being manufactured. For container and press and blow machines, the majority of emissions result from the gob shears coming into contact with the machine lubricant. Emissions in the form of a dense white cloud, which can exceed 40% opacity, are generated by flash vaporization of hydrocarbon greases and oils. Grease and oil lubricants are being replaced by silicone emulsions and water-soluble oils which virtually eliminate the smoke. For flat glass, the only contributor to air pollutant emissions is gas combustion in the annealing lehr which is totally enclosed except for entry and exit openings. Since emissions are small and operational prodecures are efficient, no controls are utilized.

Table 8.13-1 lists emission factors for glass manufacturing.



Side port direct-fired, continuous, regenerative furnace.[1]



End port direct-fired, continuous, regenerative furnace.[1]

Figure 3

[a]Emission factors are expressed as pounds of pollutant per ton, and kilograms of pollutant per metric ton, of glass produced.

[b]When literature references reported ranges in emission rates, these ranges are shown in parentheses along with the average emission factor. Single emission factors are averages of literature data for which no ranges were reported.

[c]Particulates are submicron in size.

[d]Emission factors for Raw Materials Handling are not separated into types of glass produced since batch preparation is the same for all types.

[e]Negligible.

[f]Control efficiencies for the various devices are applied only to the average emission factor.

[g]Approximately 52% efficient in reducing particulate and SO_x emissions. Effect on NO_x is unknown.

[h]Approximately 95% efficient in reducing particulate and SO_x emissions. Effect on NO_x is unknown.

[i]Approximately 99% efficient in reducing particulate emissions.

[j]This comparatively large emission factor is probable due to the small size of the melting furnace used for producing pressed and blown glass.

[k]Data not available.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

Mr. Philip C. James
President
National Glass Association
8200 Greensboro Drive, Suite 302
McLean, Virginia 22102

Dear Mr. James:

The Emission Factor and Inventory Group of the U. S. Environmental Protection Agency (EPA) is currently updating the document *Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources* (known more commonly as AP-42). As part of this process, we are now seeking additional emission data and updated process descriptions for sections that are being revised.

Enclosed is a copy of the existing Section 8.13, Glass Manufacturing (Enclosure 1). As you can see from the enclosed copy, the AP-42 section is based on data that are more than 15 years old and may not reflect current manufacturing processes and the emissions associated with those processes. Also enclosed (Enclosure 2) is a list of more recent emission test reports that we are planning to use to revise the AP-42 section on glass manufacturing. If you are aware of additional emission data that we could use to develop emission factors for glass manufacturing, we would appreciate your assistance in obtaining copies of the data. Please note that the emission factors presented in AP-42 generally are based upon results from validated tests or other emission evaluations that are similar to EPA reference test methods. We also would appreciate comments on the process description and description of emissions and controls included in the enclosed AP-42 section.

We would appreciate a response to this request by March 3, 1995. If you have any questions or need additional information regarding this effort, I can be reached by telephone at (919) 541-5407 or by fax at (919) 541-0684. I look forward to hearing from you soon.

Sincerely,

Ronald E. Myers
Emission Factor and Inventory Group
Emission, Monitoring, and Analysis Division

2 Enclosures

IDENTICAL LETTER SENT TO THE FOLLOWING ADDRESSEES

Mr. Lewis D. Andrews
President
Glass Packaging Institute
1627 K Street, N.W., Suite 800
Washington, D.C. 20006

Mr. William J. Burch
Administrator
Primary Glass Manufacturers Council
3310 S.W. Harrison Street
Topeka, Kansas 66611-2279

8.13 GLASS MANUFACTURING

8.13.1 General[1-5]

Commercially produced glass can be classified as soda-lime, lead, fused silica, borosilicate, or 96 percent silica. Soda-lime glass, since it constitutes 77 percent of total glass production, is discussed here. Soda-lime glass consists of sand, limestone, soda ash, and cullet (broken glass). The manufacture of such glass is in four phases: (1) preparation of raw material, (2) melting in a furnace, (3) forming, and (4) finishing. Figure 8.13-1 is a diagram for typical glass manufacturing.

The products of this industry are flat glass, container glass, and pressed and blown glass. The procedures for manufacturing glass, except forming and finishing, are the same for all products. Container glass and pressed and blown glass, 51 and 25 percent, respectively, of total soda-lime glass production, use pressing, blowing, or pressing and blowing to form the desired product. Flat glass, which is the remainder, is formed by float, drawing, or rolling processes.

As the sand, limestone and soda ash raw materials are received, they are crushed and stored in separate elevated bins. These materials are then transferred through a gravity feed system to a weigher and mixer, where the material is mixed with cullet to ensure homogeneous melting. The mixture is conveyed to a batch storage bin, where it is held until it is dropped into the feeder to the melting furnace. All equipment used in handling and preparing the raw material is housed separately from the furnace and is usually referred to as the batch plant. Figure 8.13-2 is a flow diagram of a typical batch plant.

The furnace most commonly used is a continuous regenerative furnace capable of producing between 45 and 272 megagrams (Mg) (50 and 300 tons) of glass per day. A furnace may have either side or end ports that connect brick checkers to the inside of the melter. The purpose of brick checkers (Figures 8.13-3 and 8.13-4) is to conserve fuel by collecting furnace exhaust gas heat which, when the air flow is reversed, is used to preheat the furnace combustion air. As material enters the melting furnace through the feeder, it floats on the top of the molten glass already in the furnace. As it melts, it passes to the front of the melter and eventually flows through a throat leading to the refiner. In the refiner, the molten glass is heat-conditioned for delivery to the forming process. Figures 8.13-3 and 8.13-4 show side-port and end-port regenerative furnaces.

After refining, the molten glass leaves the furnace through forehearths (except in the float process, in which molten glass moves directly to the tin bath) and goes to be shaped by pressing, blowing, pressing and blowing, drawing, rolling, or floating to produce the desired product. Pressing and blowing are performed mechanically, using blank molds and glass cut into sections (gobs) by a set of shears. In the drawing process, molten glass is drawn upward in a sheet through rollers, with the thickness of the sheet determined by the speed of the draw and the configuration of the draw bar. The rolling process is similar to the drawing process except that the glass is drawn horizontally on plain or patterned rollers and, for plate glass, requires grinding and polishing. The float process is different from the drawing process, having a molten tin bath over which the glass is drawn and formed into a finely finished surface requiring no grinding or polishing. The end product undergoes finishing (decorating or coating) and annealing (removing unwanted stress areas in the glass) as required and is then inspected and prepared for shipment to market. Any damaged or undesirable glass is transferred back to the batch plant to be used as cullet.

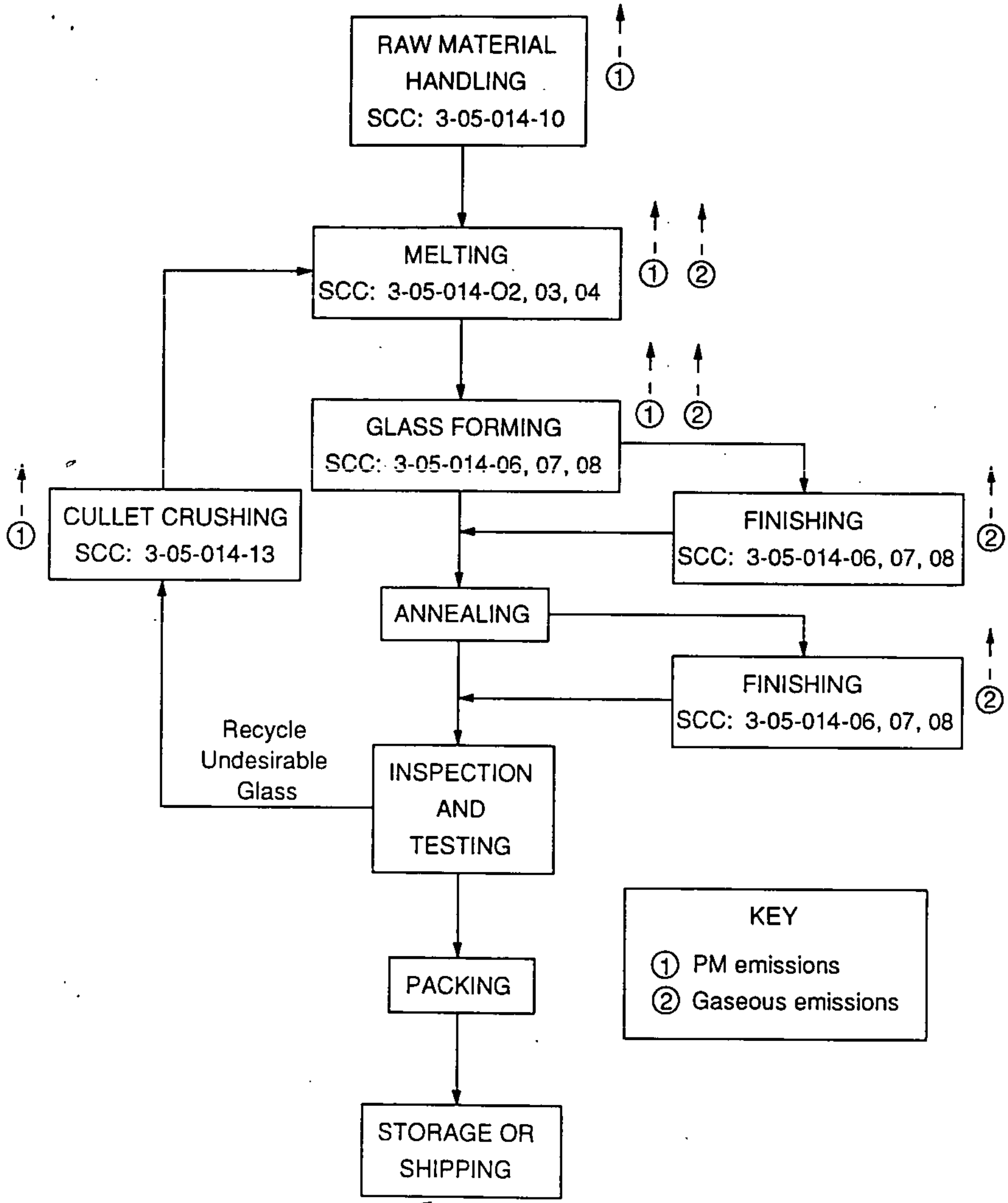


Figure 8.13-1. Process flow diagram for the glass manufacturing.

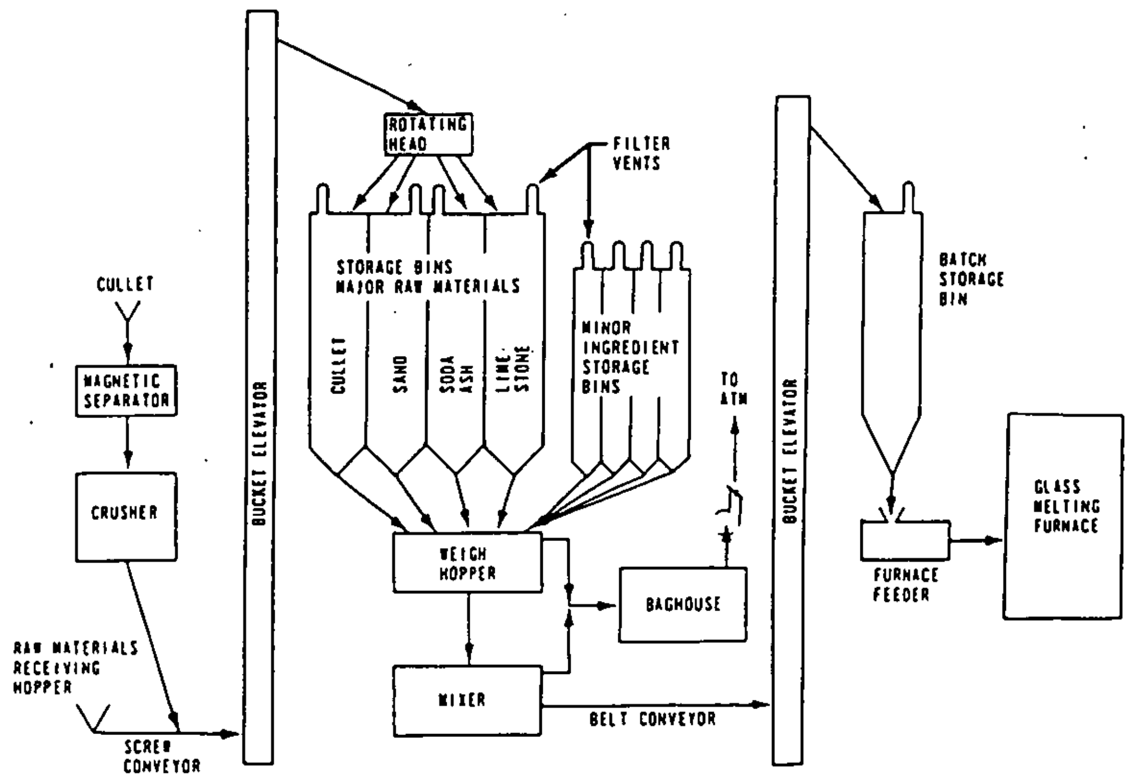


Figure 8.13-2. General diagram of a batch plant.

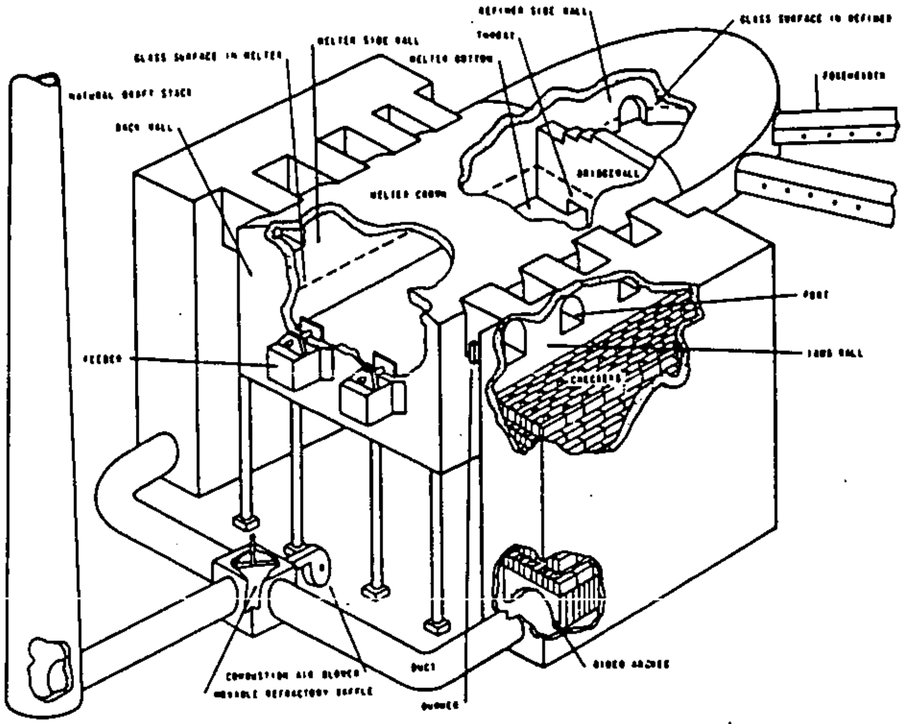


Figure 8.13-3. Side port continuous regenerative furnace.

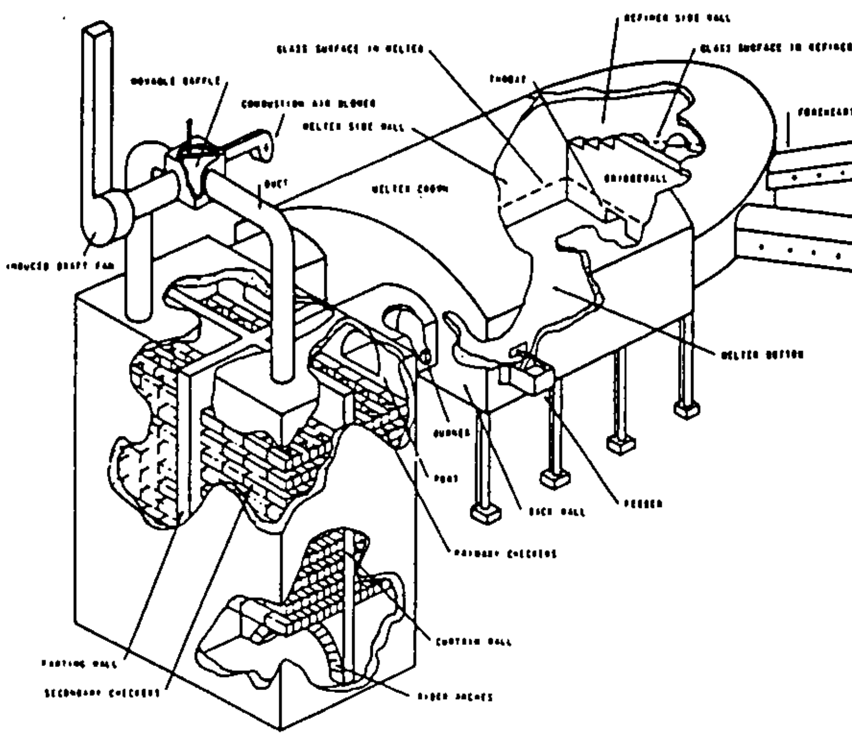


Figure 8.13-4. End port continuous regenerative furnace.

8.13.2 Emissions and Controls[1-5]

The main pollutant emitted by the batch plant is particulate matter (PM) in the form of dust. This dust can be controlled with 99 to 100 percent efficiency by enclosing all possible dust sources and using baghouses or cloth filters. Another way to control dust emissions, also with an efficiency approaching 100 percent, is to treat the batch to reduce the amount of fine particles present by presintering, briquetting, pelletizing, or liquid alkali treatment.

The melting furnace contributes over 99 percent of the total emissions from a glass plant, both PM and gaseous pollutants. Particulate matter results from volatilization of materials in the melt that combine with gases and form condensates. These either are collected in the checker work and gas passages or are emitted to the atmosphere. Serious problems arise when the checkers are not properly cleaned, in that slag can form, clog the passages, and eventually deteriorate the condition and efficiency of the furnace. Nitrogen oxides (NO_x) form when nitrogen and oxygen react in the high temperatures of the furnace. Sulfur oxides (SO_x) result from the decomposition of the sulfates in the batch and sulfur in the fuel. Proper maintenance and firing of the furnace can control emissions, add to the efficiency of the furnace, and reduce operational costs. Low-pressure wet centrifugal scrubbers have been used to control PM and SO_x, but their inefficiency (approximately 50 percent) indicates their inability to collect particulate matter of submicron size. High-energy venturi scrubbers are approximately 95 percent effective in reducing PM and SO_x emissions. Their effect on NO_x emissions is unknown. Baghouses, with up to 99 percent PM collection efficiency, have been used on small regenerative furnaces, but fabric corrosion requires careful temperature control. Electrostatic precipitators have an efficiency of up to 99 percent in collecting particulate matter. Table 8.13-1 presents emission factors for emissions of SO_x, NO_x, carbon monoxide (CO), and volatile organic compounds (VOC's) from glass manufacturing. Emission factors for emissions of PM and lead are presented in Table 8.13-2. Table 8.13-3 presents particle size distributions and corresponding emission factors for uncontrolled and controlled glass melting furnaces.

Emissions from the forming and finishing phase depend upon the type of glass being manufactured. For container, press, and blow machines, the majority of emissions results from the gob's coming into contact with the machine lubricant. Emissions, in the form of a dense white cloud that can exceed 40 percent opacity, are generated by flash vaporization of hydrocarbon greases and oils. Grease and oil lubricants are being replaced by silicone emulsions and water-soluble oils, which may virtually eliminate this smoke. For flat glass, the only contributor to air pollutant emissions is gas combustion in the annealing lehr (oven), which is totally enclosed except for product entry and exit openings. Because emissions are small and operational procedures are efficient, no controls are used on flat glass processes.

TABLE 8.13-1 (METRIC UNITS)
EMISSION FACTORS FOR GLASS MANUFACTURING[a,b]

All Emission Factors in Kg/Mg of Material Processed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Source (SCC)	SOx		NOx		CO		VOC	
Raw materials handling all types of glass (3-05-014-10)[c]	0	B	0	B	0	B	0	B
Container glass								
Melting furnace (3-05-014-02)[d]	1.7 (1.0-2.4)	B	3.1 (1.6-4.5)	B	0.1 (0-0.2)	B	0.1 (0-0.2)	B
Melting furnace with low energy scrubber (3-05-014-02)[d,e]	0.9	B	3.1	B	0.1	B	0.1	B
Melting furnace with venturi scrubber (3-05-014-02)[d,f]	0.1	B	3.1	B	0.1	B	0.1	B
Melting furnace with baghouse (3-05-014-02)[d,g]	1.7	B	3.1	B	0.1	B	0.1	B
Melting furnace with ESP (3-05-014-02)[d,h]	1.7	B	3.1	B	0.1	B	0.1	B
Forming and finishing (3-05-014-06)[i,j]	Neg.		Neg.				4.4	B
Flat glass								
Melting furnace (3-05-014-03)[d]	1.5 (1.1-1.9)	B	4.0 (2.8-5.2)	B	<0.1	B	<0.1	B
Melting furnace with low energy scrubber (3-05-014-03)[d,e]	0.8	B	4.0	B	<0.1	B	<0.1	B
Melting furnace with venturi scrubber (3-05-014-03)[d,f]	0.1	B	4.0	B	<0.1	B	<0.1	B
Melting furnace with baghouse (3-05-014-03)[d,g]	1.5	B	4.0	B	<0.1	B	<0.1	B
Melting furnace with ESP (3-05-014-03)	1.5	B	4.0	B	<0.1	B	<0.1	B
Forming and finishing (3-05-014-07)[d,h]	Neg.		Neg.		Neg.		Neg.	
Pressed and blown glass								
Melting furnace uncontrolled (3-05-014-04)[d]	2.8 (0.5-5.4)	B	4.3 (0.4-10.0)	B	0.1 (0.1-0.2)	B	0.2 (0.1-0.3)	B
Melting furnace with low energy scrubber (3-05-014-04)[d,e]	1.3	B	4.3	B	0.1	B	0.2	B
Melting furnace with venturi scrubber (3-05-014-04)[d,f]	0.1	B	4.3	B	0.1	B	0.2	B
Melting furnace with baghouse (3-05-014-04)[d,g]	2.8	B	4.3	B	0.1	B	0.2	B
Melting furnace with ESP (3-05-014-04)[d,h]	2.8	B	4.3	B	0.1	B	0.2	B
Forming and finishing (3-05-014-08)[i,j]	Neg.		Neg.		Neg.		4.5	B
Lead glass manufacturing all processes (3-05-014-__)	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 8.13-1 (ENGLISH UNITS)
EMISSION FACTORS FOR GLASS MANUFACTURING[a,b]

All Emission Factors in Lb/Ton of Material Processed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Source (SCC)	SOx		NOx		CO		VOC	
Raw materials handling all types of glass (3-05-014-10)[c]	0	B	0	B	0	B	0	B
Container glass								
Melting furnace (3-05-014-02)[d]	3.4 (2.0-4.8)	B	6.2 (3.3-9.1)	B	0.2 (0-0.5)	B	0.2 (0-0.4)	B
Melting furnace with low energy scrubber (3-05-014-02)[d,e]	1.7	B	6.2	B	0.2	B	0.2	B
Melting furnace with venturi scrubber (3-05-014-02)[d,f]	0.2	B	6.2	B	0.2	B	0.2	B
Melting furnace with baghouse (3-05-014-02)[d,g]	3.4	B	6.2	B	0.2	B	0.2	B
Melting furnace with ESP (3-05-014-02)[d,h]	3.4	B	6.2	B	0.2	B	0.2	B
Forming and finishing (3-05-014-06)[i,j]	Neg.		Neg.		Neg.		8.7	B
Flat glass								
Melting furnace flat glass (3-05-014-03)[d]	3.0 (2.2-3.8)	B	8.0 (5.6-10.4)	B	<0.1	B	<0.1	B
Melting furnace with low energy scrubber (3-05-014-03)[d,e]	1.5	B	8.0	B	<0.1	B	<0.1	B
Melting furnace with venturi scrubber (3-05-014-03)[d,f]	0.2	B	8.0	B	<0.1	B	<0.1	B
Melting furnace with baghouse (3-05-014-03)[d,g]	3.0	B	8.0	B	<0.1	B	<0.1	B
Melting furnace with ESP (3-05-014-03)[d,h]	3.0	B	8.0	B	<0.1	B	<0.1	B
Forming and finishing (3-05-014-07)	Neg.		Neg.		Neg.		Neg.	
Pressed and blown glass								
Melting furnace (3-05-014-04)[d]	5.6 (1.1-10.9)	B	8.5 (0.8-20.0)	B	0.2 (0.1-0.3)	B	0.3 (0.1-1.0)	B
Melting furnace with low energy scrubber (3-05-014-04)[d,e]	2.7	B	8.5	B	0.2	B	0.3	B
Melting furnace with venturi scrubber (3-05-014-04)[d,f]	0.3	B	8.5	B	0.2	B	0.3	B
Melting furnace with baghouse (3-05-014-04)[d,g]	5.6	B	8.5	B	0.2	B	0.3	B
Melting furnace with ESP (3-05-014-04)[d,h]	5.6	B	8.5	B	0.2	B	0.3	B
Forming and finishing (3-05-014-08)[i,j]	Neg.	B	Neg.	B	Neg.	B	9.0	B
Lead glass manufacturing all processes (3-05-014-__)	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 8.13-1 (ENGLISH UNITS) (continued)

Neg. = Negligible.

ND = No data.

[a]Factors represent uncontrolled emissions unless otherwise noted.

[b]References 2-3,5. Ranges in parentheses, where available.

[c]Not separated into types of glass produced, since batch preparation is the same for all types. Particulate emissions are negligible because almost all plants utilize some form of control (i.e., baghouse, scrubbers, centrifugal collectors).

[d]Control efficiencies for the various devices are applied only to the average emission factor.

[e]Approximately 52% efficiency in reducing particulate and sulfur oxides emissions. Effect on nitrogen oxides is unknown.

[f]Approximately 95% efficiency in reducing particulate and sulfur oxide emissions. Effect on nitrogen oxides is unknown.

[g]Approximately 99% efficiency in reducing particulate emissions.

[h]Calculated using data for furnaces melting soda lime and lead glasses. No data available for borosilicate or opal glasses.

[i]Organic emissions are from decorating process. Can be controlled by incineration, absorption or condensation, but efficiencies are not known.

[j]For container and pressed and blown glass, tin chloride, hydrated tin chloride and hydrogen chloride are also emitted during surface treatment process at a rate of <0.1 kg/Mg (0.2 lb/ton) each.

TABLE 8.13-2 (METRIC UNITS)
EMISSION FACTORS FOR GLASS MANUFACTURING [a,b]

All Emission Factors in Kg/Mg of Material Processed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Source (SCC)	Filterable[c] PM		Lead	
Raw material handling all types of glass (3-05-014-10)[d]	Neg.		ND	
Container glass				
Melting furnace (3-05-014-02)[e]	0.7 (0.4-0.9)	B	ND	
Melting furnace with low energy scrubber (3-05-014-02)[e,f]	0.4	B	ND	
Melting furnace with venturi scrubber (3-05-014-02)[e,g]	<0.1	B	ND	
Melting furnace with baghouse (3-05-014-02)[e,h]	Neg.		ND	
Melting furnace with ESP (3-05-014-02)[e,i]	Neg.		ND	
Forming and finishing (3-05-014-06)[j]	Neg.			
Flat glass				
Melting furnace (3-05-014-03)[e]	1.0 (0.4-1.6)	B	ND	
Melting furnace with low energy scrubber (3-05-014-03)[e,f]	0.5	B	ND	
Melting furnace with venturi scrubber (3-05-014-03)[e,g]	Neg.		ND	
Melting furnace with baghouse (3-05-014-03)[e,h]	Neg.		ND	
Melting furnace with ESP (3-05-014-03)[e,i]	Neg.		ND	
Forming and finishing (3-05-014-07)	Neg.			
Pressed and blown glass				
Melting furnace (3-05-014-04)[e]	8.4 (0.5-12.6)	B	ND	
Melting furnace with low energy scrubber (3-05-14-04)[e,f]	4.2	B	ND	
Melting furnace with venturi scrubber (3-05-014-04)[e,g]	0.5	B	ND	
Melting furnace with baghouse (3-05-014-04)[e,h]	0.1	B	ND	
Melting furnace with ESP (3-05-014-04)[e,i]	0.1	B	ND	
Forming and finishing (3-05-014-08)[j]	Neg.		ND	
Lead glass manufacturing all processes (3-05-014-__)[k]	ND		2.5	B

Neg. = Negligible.
ND = No data.
[a] Factors represent uncontrolled emissions unless otherwise noted.
[b] References 2-3, 5. Ranges in parentheses, where available.
[c] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.
[d] Not separated into types of glass produced, since batch preparation is the same for all types. Particulate emissions are negligible because almost all plants utilize some form of control (i.e., baghouse, scrubbers, centrifugal collectors).
[e] Control efficiencies for the various devices are applied only to the average emission factor.
[f] Approximately 52% efficiency in reducing particulate and sulfur oxides emissions. Effect on nitrogen oxides is unknown.
[g] Approximately 95% efficiency in reducing particulate and sulfur oxide emissions. Effect on nitrogen oxides is unknown.
[h] Approximately 99% efficiency in reducing particulate emissions.
[i] Calculated using data for furnaces melting soda lime and lead glasses. No data available for borosilicate or opal glasses.
[j] For container and pressed and blown glass, tin chloride, hydrated tin chloride and hydrogen chloride are also emitted during surface treatment process at a rate of <0.1 kg/Mg (0.2 lb/ton) each.
[k] References 6-7. Particulate containing 23% lead.

TABLE 8.13-2 (ENGLISH UNITS)
EMISSION FACTORS FOR GLASS MANUFACTURING [a,b]

All Emission Factors in Lb/Ton of Material Processed Unless Noted
Ratings (A-E) Follow Each Emission Factor

Source (SCC)	Filterable[c] PM		Lead	
Raw material handling all types of glass (3-05-014-10)[d]	Neg.		ND	
Container glass				
Melting furnace (3-05-014-02)[e]	1.4 (0.9-1.9)	B	ND	
Melting furnace with low energy scrubber (3-05-014-02)[e,f]	0.7	B	ND	
Melting furnace with venturi scrubber (3-05-014-02)[e,g]	<0.1	B	ND	
Melting furnace with baghouse (3-05-014-02)[e,h]	Neg.		ND	
Melting furnace with ESP (3-05-014-02)[e,i]	Neg.		ND	
Forming and finishing (3-05-014-06)[j]	Neg.			
Flat glass				
Melting furnace (3-05-014-03)[e]	2.0 (0.8-3.2)	B	ND	
Melting furnace with low energy scrubber (3-05-014-03)[e,f]	1.0	B	ND	
Melting furnace with venturi scrubber (3-05-014-03)[e,g]	Neg.		ND	
Melting furnace with baghouse (3-05-014-03)[e,h]	Neg.		ND	
Melting furnace with ESP (3-05-014-03)[e,i]	Neg.		ND	
Forming and finishing (3-05-014-07)	Neg.			
Pressed and blown glass				
Melting furnace (3-05-014-04)[e]	17.4 (1.0-25.1)	B	ND	
Melting furnace with low energy scrubber (3-05-14-04)[e,f]	8.4	B	ND	
Melting furnace with venturi scrubber (3-05-014-04)[e,g]	0.9	B	ND	
Melting furnace with baghouse (3-05-014-04)[e,h]	0.2	B	ND	
Melting furnace with ESP (3-05-014-04)[e,i]	0.2	B	ND	
Forming and finishing (3-05-014-08)[j]	Neg.		ND	
Lead glass manufacturing all processes (3-05-014-__)[k]	ND		5	B

Neg. = Negligible.
ND = No data.
[a]Factors represent uncontrolled emissions unless otherwise noted.
[b]References 2-3, 5. Ranges in parentheses, where available.
[c]Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.
[d]Not separated into types of glass produced, since batch preparation is the same for all types. Particulate emissions are negligible because almost all plants utilize some form of control (i.e., baghouse, scrubbers, centrifugal collectors).
[e]Control efficiencies for the various devices are applied only to the average emission factor.
[f]Approximately 52% efficiency in reducing particulate and sulfur oxides emissions. Effect on nitrogen oxides is unknown.
[g]Approximately 95% efficiency in reducing particulate and sulfur oxide emissions. Effect on nitrogen oxides is unknown.
[h]Approximately 99% efficiency in reducing particulate emissions.
[i]Calculated using data for furnaces melting soda lime and lead glasses. No data available for borosilicate or opal glasses.
[j]For container and pressed and blown glass, tin chloride, hydrated tin chloride and hydrogen chloride are also emitted during surface treatment process at a rate of <0.1 kg/Mg (0.2 lb/ton) each.
[k]References 6-7. Particulate containing 23% lead.

TABLE 8.13-3 PARTICULATE MATTER SIZE-SPECIFIC EMISSION FACTORS FOR MELTING FURNACES IN GLASS MANUFACTURING[a,b]

EMISSION FACTOR RATING: E

Diameter, microns	Cumulative % less than diameter		Emission factor[c]	
	Uncontrolled	ESP controlled[d]	kg/Mg	lb/ton
2.5	91	53	0.64	1.2
6.0	93	66	0.65	1.3
10	95	75	0.66	1.3

[a]References 8-11.
[b]Factors represent uncontrolled emissions unless otherwise noted.
[c]Uncontrolled size specific emission factors based on mass particulate emission factor of 0.7 kg/Mg glass produced, from Table 8.13-2. Size specific emission factor = mass particulate emission factor x particle size distribution in percent/100. After ESP control, size specific emission factors are negligible.
[d]Reference 8. Based on a single test.

TABLE 8.13-3 PARTICULATE MATTER SIZE-SPECIFIC EMISSION FACTORS FOR MELTING FURNACES IN GLASS MANUFACTURING[a,b]

EMISSION FACTOR RATING: E

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2.5	91	53	0.64	1.2
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10	95	75	0.66	1.3

[a]References 8-11.
[b]Factors represent uncontrolled emissions unless otherwise noted.
[c]Uncontrolled size specific emission factors based on mass particulate emission factor of 0.7 kg/Mg glass produced, from Table 8.13-2. Size specific emission factor = mass particulate emission factor x particle size distribution in percent/100. After ESP control, size specific emission factors are negligible.
[d]Reference 8. Based on a single test.

References for Section 8.13

1. J. A. Danielson, (ed.), Air Pollution Engineering Manual, 2nd Ed., AP-40, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1973. Out of Print.

2. Richard B. Reznik, Source Assessment: Flat Glass Manufacturing Plants, EPA-600/20-76-032b, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1976.

3. J. R. Schoor, et al., Source Assessment: Glass Container Manufacturing Plants, EPA-600/2-76-269, U.S. Environmental Protection Agency, Washington, DC, October 1976.

4. A. B. Tripler, Jr. and G. R. Smithson, Jr., A Review of Air Pollution Problems and Control in the Ceramic Industries, Battelle Memorial Institute, Columbus, OH, presented at the 72nd Annual Meeting of the American Ceramic Society, May 1970.

5. J. R. Schorr, et al., Source Assessment: Pressed and Blown Glass Manufacturing Plants, EPA-600/77-005, U.S. Environmental Protection Agency, Washington, DC, January 1977.

6. Control Techniques for Lead Air Emissions, EPA-450/2-77-012, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 1977.

7. Confidential test data, Pedco-Environmental Specialists, Inc., Cincinnati, OH.

8. H. J. Taback, Fine Particle Emissions from Stationary and Miscellaneous Sources in the South Coast Air Basin, PS-293-923, National Technical Information Service, Springfield, VA, February 1979.

9. Emission test data from Environmental Assessment Data Systems, Fine Particle Emission Information System (FPEIS), Series Report No. 219, U.S. Environmental Protection Agency, Research Triangle Park, NC, June 1983.

10. Environmental Assessment Data Systems, op. cit., Series No. 223.

11. Environmental Assessment Data Systems, op. cit., Series No. 225.

ENCLOSURE 2

EMISSION TEST REPORTS FOR GLASS MANUFACTURING

Facility name	City	State	Test date
American National Can Co.	Wilson	NC	10/13/89
American National Can Co.	Wilson	NC	09/30/91
Ball-Incon Glass	Dunkirk	IN	05/25/94
Corning Asahi Video Prducts Co	State College	PA	11/10/88
Corning Asahi Video Prducts Co	State College	PA	11/29/89
Corning Glass Works	State College	PA	09/09/88
Corning Glass Works	State College	PA	04/26/89
Dynasil Corp.	Berlin	NJ	05/23/91
Foster Forbes Glass Div.	Millville	NJ	05/03/90
Kimble Glass	Vineland	NJ	12/20/90
Kimble Glass	Vineland	NJ	07/30/91
Occidental Chemical Corp.	Jersey City	NJ	02/07/89
Occidental Chemical Corp.	Oxnard	CA	05/25/93
Owens-Brockway Glass Container	Oakland	CA	05/16/90
Owens-Brockway Glass Container	Oakland	CA	03/06/92
Owens-Brockway Glass Container	Oakland	CA	11/13/92
Owens-Brockway Glass Container	Oakland	CA	01/28/93
PQ Corporation	Baltimore	MD	12/19/90
PQ Corporation	Baltimore	MD	07/24/91
Potters Industries, Inc.	Apex	NC	09/02/87
Potters Industries, Inc.	Apex	NC	08/16/88
Potters Industries, Inc.	Apex	NC	10/11/88
Potters Industries, Inc.	Apex	NC	08/24/89
Wheaton Industries	Millville	NJ	08/29/91

Primary Glass Manufacturers Council

P G M C

February 24, 1995

Ronald Myers
USEPA
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Dear Mr. Myers:

I am in receipt of your letter addressed to William Birch regarding the updating of the "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources" (commonly referred to as AP-42).

The Primary Glass Manufacturers Council is extremely interested in this document and we need to have some time to review the data and consider a response. It would be very helpful if you could allow us an additional 60 days to respond to your request.

Thank you for your assistance in this matter.

Sincerely,

James C. Benney

James C. Benney
Technical Director

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February 27, 1992

Mr. Ron Myers
Emission Factor and Methodologies
Section
Emission Inventory Branch
U.S. Environmental Protection Agency
Office of Air Quality Planning & Standards
Research Triangle Park, NC 27711

Dear Mr. Myers:

This letter is in follow-up to your request to review the publication, Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, otherwise known as AP-42.

A group of our members specifically reviewed Section 8.13, Glass Manufacturing, and at this time, offer no additional changes to the data and information contained in the current version of AP-42.

We would appreciate having the opportunity to review other documents in the future that pertain to the glass and glazing industry.

Thank you. Please call me if you have any questions.

Sincerely,

Carolyn Lugbill

Carolyn A. Lugbill, Director
Government & Industry Affairs