VULCAN-Cincinnati, Inc.

Note: This is a reference cited in *AP 42, 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 reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference maybe from a previous version of the section and no longer cited. The primary source should always be checked.

SCREENING STUDY FOR BACKGROUND INFORMATION AND SIGNIFICANT EMISSIONS FROM FIBER GLASS MANUFACTURING

CONTRACT NO. 68-02-0299
TASK ORDER NO. 4

Prepared for
Environmental Protection Agency
Office of Air Quality Planning and Standards
Industrial Studies Branch

by

Vulcan-Cincinnati, Inc.
Cincinnati, Ohio

December 4, 1972

VULCAN-Cincinnati, Inc.

Prepared by C. T. Liu
Process Engineer

Approved by M. N. Magnus
Project Manager

Approved by D. Garrett
Director of Process Engineering

513-542-7000

684-2200 FTS

VULCAN-Cincinnati, Inc.

December 4, 1972

CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	PROCESS DESCRIPTION	3
2.1	The Glass Composition	3
2.2	The Glass Batch	6
2.3	The Melting Process	7
2.4	Forming Operation	9
2.5	Curing Operation	11
2.6	Cooling & Fabrication	13
3.0	EMISSION FROM FIBER GLASS MANUFACTURING PLANTS	14
3.1	From Batch Plants	14
3.2	From Glass Melting Furnace	14
3.3	From Forming Operation	16
3.4	From Ovens and Cooling	16
4.0	CONTROL TECHNOLOGY AVAILABLE FOR FIBER GLASS MANUFACTURING PLANTS	17
4.1	In Batch Plant	17
4.2	For Glass Melting Furnace	18
4.3	In Forming Operation	19
4.4	In Curing Operation	20
5.0	ESTIMATED NATIONWIDE EMISSION	21

CONTENTS (continued)

		Page
6.0	FIBER GLASS MANUFACTURING PLANTS UTILIZING BEST EMISSION CONTROL TECHNOLOGY	24
6.1	Owens-Corning Fiberglas Corporation	24
6.2	Johns-Manville Fiber Glass Incorporated	30
6.3	PPG Industries	30
7.0	STATES' REGULATIONS PERTAINING TO PARTICULATE EMISSIONS AND ECONOMIC IMPACT TO THE INDUSTRY	31
8.0	PRODUCTION AND GROWTH OF FIBER GLASS INDUSTRY	38
8.1	A List of Fiber Glass Manufacturers	38
8.2	Production and Growth Trends	38
9.0	SAMPLING AND TESTING	43
9.1	Particulate Sampling	43
9.2	Total Fluoride and Gaseous Fluoride	43
9.3	Total Sulfur Oxides and Gaseous Sulfur Oxides	44
9.4	Nitrogen Oxides	44
9.5	Carbon Monoxide	45
9.6	Total and Gaseous Boron	45
9.7	Aldehydes	46
9.8	Phenols	47
9.9	Owens-Corning Sampling Test Procedures	47
10.0	REFERENCES	58

CONTENTS (continued)

		Page
	FIGURES	
Figure 1.1	Fiber Glass Plant, 1972	2
Figure 2.1	Block Flow Diagram of Fiber Glass Manufacturing	4
Figure 8.1	Glass Fiber Industry Production	42-A
	TABLES	
Table 2.1	Approximate Composition of Fiber Glasses	5
Table 5.1	Uncontrolled Total Emission Factors for Fiber Glass Manufacture	22
Table 5.2	Estimated Nationwide Emission Rate for Fiber Glass Manufacture	23
Table 6.1	List of Contacts in the U.S.	25
Table 6.2	List of Contacts in Foreign Countries	26
Table 7.1	Regulations Applicable to General Process Sources	32
Table 7.2	Regulation Applicable to Visible Emission Particulate	35
Table 7.3	Estimated Cost of Controlling Air Pollutant from Glass Wool Manufacturing Industry	37
Table 8.1	List of Fiber Glass Manufacturers	40
Table 8.2	Glass Fiber Industry Shipments	42

December 4, 1972

CONTENTS (continued)

		Page
	AIR POLLUTION CONTROL SURVEY REPORTS	
Report No. 1	Owens-Corning Fiberglas Corporation	Appendix
Report No. 2	Owens-Corning Fiberglas Corporation	Appendix
Report No. 3	Johns-Manville Fiber Glass Inc.	Appendix
Report No. 4	PPG Industries	Appendix
Report No. 5	PPG Industries	Appendix

December 4, 1972

1.0 INTRODUCTION

Total atmospheric emissions from the manufacture of fiber glass amount to approximately 17,700 tons per year on a nationwide basis. The emissions resulting from the manufacture of fiber glass in the United States are mainly in the form of particulate matter.

There are ten manufacturers of fiber glass with a total of thirty-three operating plants [1] in the U.S. in 1972 as defined by SIC Code 3229 [2] for textile fibers and 3296 [2] for wool fibers. Four companies represent the bulk of production. Plants range in size from 30 to 3000 employees. The distribution of plants by state is shown in Figure 1.1 (see page 2). Production is presently running at about 70% of capacity. [3]

In 1970 the value of shipments of these products was $200,000,000 for textile fibers and $363,000,000 for wool fibers. [4] Chapter 8.0 describes sales and trends in greater detail.

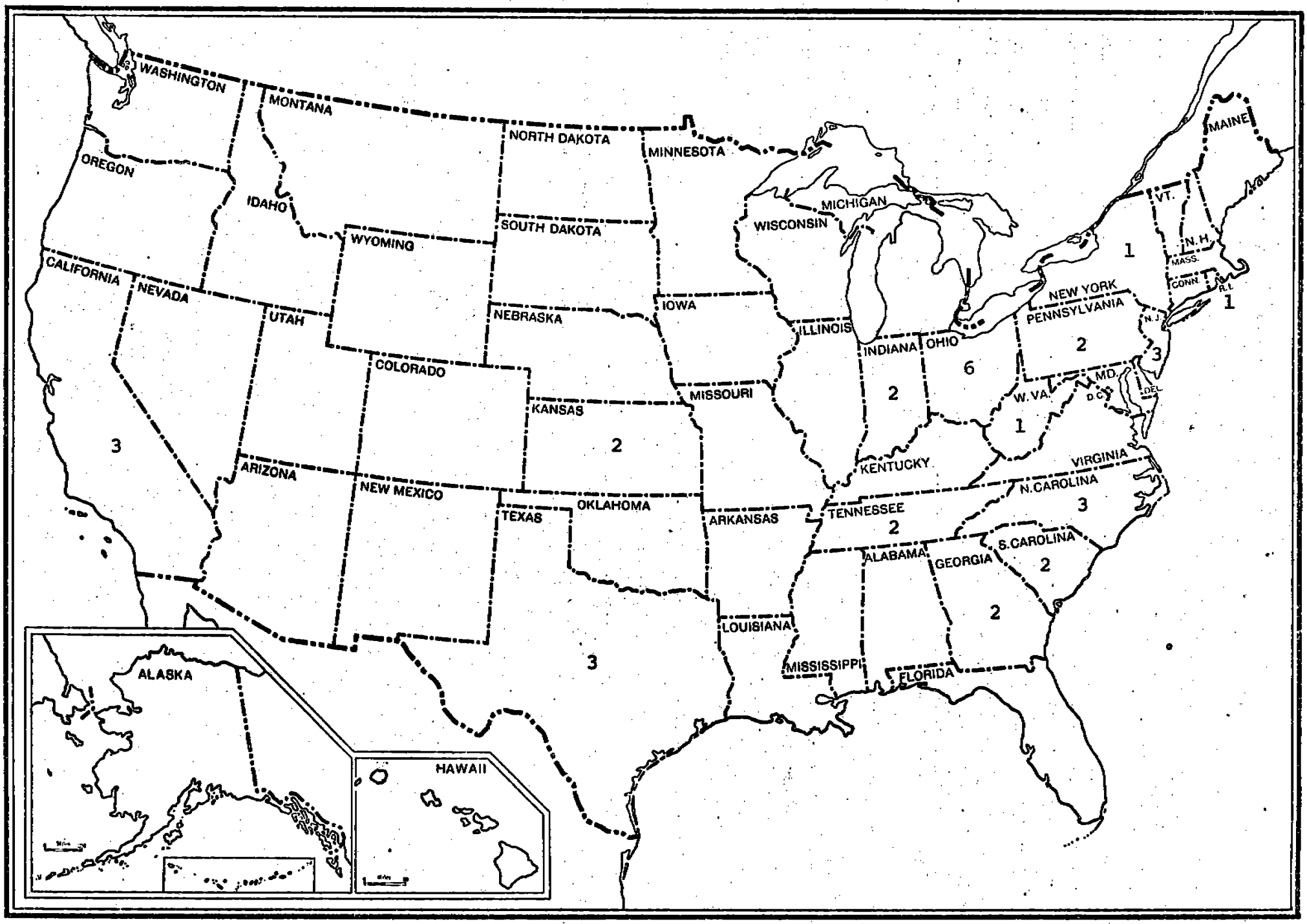


Figure 1.1 Fiber Glass Plants, 1972

2.0 PROCESS DESCRIPTION

Fiber glass is manufactured by melting various raw materials to form glass, drawing the molten glass into fibers, and coating the fibers with an organic material. A block flow diagram of manufacture is shown in Figure 2.1 (see page 4).

In a general way, fiber glass can be categorized as textile fibers and wool fibers. Textile fibers are usually continuous filaments, often referred to as yarns, and are formed in continuous or unending fibers, whereas the wool fibers are formed in varying lengths.

2.1 The Glass Composition[5]

Many glass compositions (see Table 2.1 page 5) have been used to make commerical fiber glass. The one most used in this country is E glass, a low alkali lime-alumina boro-silicate. E glass is used for textile, electrical insulation, plastic reinforcement and mats. T glass, a low cost soda-line glass, is used where high durability is not required, e.g., coarse fiber mats for air filters and thermal and acoustic insulation. Products requiring high acid resistance, such as mats for storage battery retaniners,

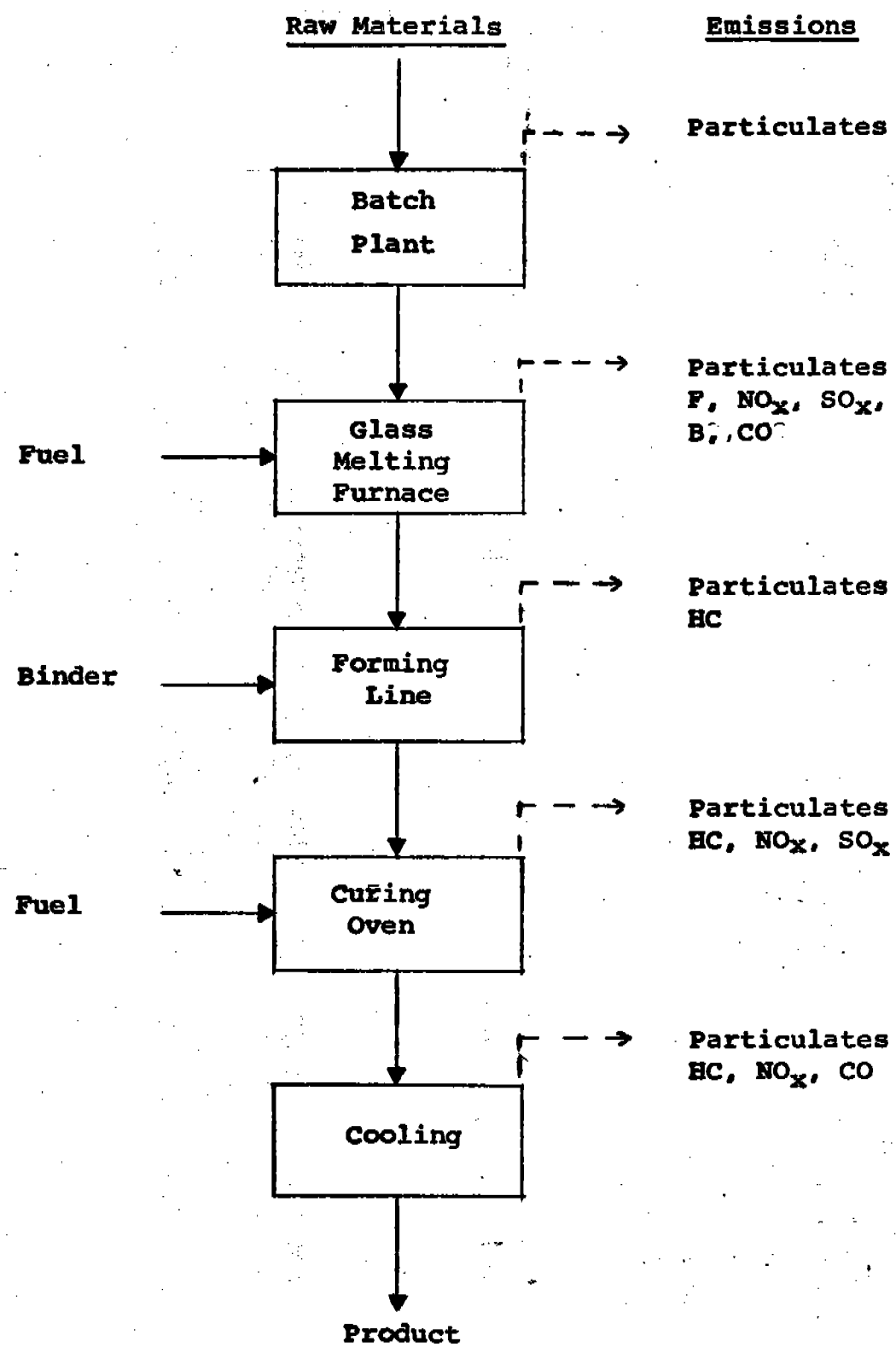


Figure 2.1 Block Flow Diagram of Fiber Glass Manufacturing

December 4, 1972

TABLE 2.1

APPROXIMATE COMPOSITION OF FIBER GLASSES,[5] % BY WT.

Type of Glass	E	T	C	SF	F
Principle Use	Fiber Reinforcement	Fiber Insulation	Acid-Resistant Fiber	Fiber Insulation	High-Strength Fiber
SiO_2	54.0	59.	65.	59.5	65.
Al_2O_3	14.0	4.5	4.	5.	25.
B_2O_3	10.0	3.5	5.5	7.	
Na_2O		11.	8.	14.5	
K_2O		0.5	0.5		
MgO	4.5	5.5	3.		10.
CaO	17.5	16.	14.		
Others				4% ZrO_2+	
				8% TiO_2+	
				F -	

acid chemical filters, filter cloths, and anode bags, utilize C glass, a soda-lime borosilicate. SF glass, which has excellent weathering resistance, is used in fine and ultrafine wool products such as very low-density thermal and acoustic insulators, paper additives, and high efficiency all-glass filter papers. S glass, shows unusually high strength and Young's modulus, and is being product-tested for aerospace applications.

2.2 The Glass Batch

Systems for batch mixing and conveying materials for making glass normally are commerical equipment of standard design. This equipment is usually housed in a structure separate from the glass melting furnace in what is commonly referred to as a "batch plant". In most batch plants, the storage bins are located on top, and the weigh hoppers and mixers are below them to make use of gravity flow.

Major bulk raw materials are usually conveyed from railroad hopper cars or hopper trucks through dump pits by a conveying system to the elevated storage bins. Minor ingredients are usually delivered to the plant in paper bags or cardboard drums and transferred by hand to small bins.

Ingredients comprising a batch of glass are dropped by gravity from the storage bins into weigh hoppers and then released to fall into the mixer. Raw materials are blended in the mixer and then conveyed to a charge bin located alongside the melting furnace. Glass furnaces may be charged manually or automatically, and continuously or intermittently.

2.3 The Melting Process [6] [7]

The glass-forming reaction takes place in a large rectangular gas or oil-fired reverberatory furnace. These melting furnaces are equipped with either regenerative or recuperative heat-recovery systems. After being refined, the molten glass is passed to a forehearth where the glass is either formed into marbles for subsequent remelting or passed directly through orifices (bushings) to form a filament.

All furnaces have two compartments. In the first compartment called the melter, the dry ingredients are mixed in correct proportions and are continuously fed onto a molten mass of glass having a temperature near 2800°F. Glass flows from the melter into the second compartment commonly referred to as the refiner, where it is mixed for homogenity and heat conditioned to eliminate bubbles and stones.

The temperature in transfer to the second compartment, is gradually lowered to 2300-2400°F. The amount of glass circulating within the melter and refiner is about 10 times the amount withdrawn for production.

Regenerative firing systems consist of dual chambers filled with brick checkerwork. While the products of the combustion from the melter pass through and heat one chamber, combustion air is preheated in the opposite chamber. The functions of each chamber are interchanged during the reverse flow of air and combustion products. Reversals occur every 15 to 20 minutes for maximum conservation of heat.

In the recuperative system, heat transfer takes place continuously between gas and air in adjacent passages. Designers of large glass furnaces have generally avoided the latter system in the past because it can lead to leaking or clogging problems. However, some manufacturers like the more accurate temperature control inherent in recuperative operation and are using carefully designed recuperative furnaces.

Electric induction systems installed on regenerative furnaces are designed to increase maximum pull rates by as

much as 50 percent. These systems are called boosters. Source test results indicate that pull rates can be increased without any appreciable increase in dust carryover or particulate emissions. Furnace temperatures may also be reduced by boosters, preventing refractory damage at peak operations.

Electric induction can also be used exclusively for melting the glass for wool product manufacture. Although melting glass by electricity is a more costly process than melting glass by natural gas or fuel oil, it is a more thermally efficient process since heat can be applied directly into the body of the glass. Design of this type of furnace is simplified since regenerative checkerworks and large ductwork are not required. First costs and maintenance expenses are substantially lower than for a comparable size regenerative furnace. An electric furnace has been proven competitive with regenerative furnaces in areas with low electric power cost.

2.4 Forming Operation

2.4.1 Glass Wool Forming Operation

Glass wool and mats are produced in large volume

by feeding directly from a glass tank through platinum bushings, attenuating with high-pressure steam jets into the staple fiber, and collecting as mats. They are sprayed with lubricant and binders, deposited on belts, oven dried, cut and packed. Flame blowing produces the finest diameter fibers for use as fiber paper and paper reinforcement. In this process the coarse single fibers are mechanically drawn from an orifice and fed into a high-velocity gas flame. The result is staple fibers with diameter less than a millionth of an inch.

2.4.2 Textile Fibers Forming Operation

In earlier continuous filament operation, glassmakers formed the melter-refiner products into marbles. These were inspected for quality, then remelted in an electric furnace for filament drawing. Their present know-how in glass technology, as built into ingredient batching and furnace design, permits bypassing the marbles step, except in the case of very fine fibers (less than 0.00025 inch diameter).[7]

Molten glass from the forehearth passes through platinum bushings. The air blower below the bushings pulls and attenuates the glass streams into the staple fibers which are collected in a revolving perforated drum. They are gathered through a collecting tube and wound as a "sliver" onto a spool rotating at higher speeds than the collecting drum. The "slivers" are later twisted and piled into coarse or fine high-count yarn.

2.5 Curing Operation

2.5.1 Glass Wool Curing

The glass wool fibers coated with uncured binders and lubricants proceed to a conveyor where they collect in the desired mass and depth as required for the ultimate product being formed. The density of the fiber mass or blanket on the conveyor is controlled by the fiber production rate and the speed of the conveyor.

A straight-line conveyor is used to produce the mat, batt, and pack products because all fabricating operations can be accomplished from the beginning to the end of the conveyor line.

As the glass blanket is conveyed away from the collecting area, it enters a curing oven where the thermosetting binder is cured at temperatures ranging from 400°F to 500°F. Certain products must be restricted to an established thickness and density and this is accomplished in the curing oven by pressure rolls and plates.

2.5.2 Textile Fiber Curing and Fabrication (7) (18)

The tubes from the winding operation are inspected and weighed. Depending upon the end use, the tubes go to the curing oven or to the yarn conditioning room.

In the curing oven, the thermosetting binder is cured at elevated temperatures and from here the tubes go to the spinning room and are wound into yarns for shipment or after spinning the strands are chopped and packaged for shipment.

The tubes not destined for the curing oven go to the yarn conditioning room. Here they are stored under conditions of high humidity to allow the binder to set. Minimum retention time varies with the binder used and can be 1-16 hours.

2.6 Cooling and Fabrication

Glass Wool Cooling and Fabrication

Following the curing operation the blanket is air cooled and the edges are trimmed and vapor barriers of paper or foil are applied. Some products are slit and cut to specified dimensions while others continue to the end of the conveyor in blanket form where they are rolled into packages.

of complex physical and chemical reactions that occur during the melting process. Particulates are entrained by the fastmoving stream of flames and combustion gases. Particulates swept from the melters are either collected in the checkerwork and gas passages or exhausted to the atmosphere.

Based on data obtained at glass container plants, about 30 to 40 percent by weight of this particulate matter is less than 5 microns in diameter.

Particulate emissions from the glass-melting furnace are affected by basic furnace deisgn, type of fuel (oil or gas) used, raw material size and composition, and type and volume of the furnace heat-recovery system. Reverberatory furnaces generally generate more particulate emission, while the dust emission from electric induction furnaces is negligible.

For a given furnace and a given batch composition, particulate emissions from glass furnaces may be reduced by improvement of conditions:[9]

(1) Use of feed batches with proper moisture content.

(2) Change in sand size from fine to coarser.

(3) Eliminating a highly decrepitating limestone.

(4) Batch charger design factors.

(5) Use of caustic soda solution replacing a portion of soda ash.

By combination and manipulation of the various means of reducing carryover, an optimum solution can be achieved in any given problem situation.

3.3 From Forming Operation

Emissions from the forming line are caused by evaporation and subsequent condensation of the resin binder that is sprayed on the hot glass fibers as they emerge from the forming nozzles. This fine condensed particulate material, which escapes from the operation is largely sub-micron in size. The particulate emissions from the forming line are most affected by the composition and quantity of the binder and by the spraying techniques used to coat the fibers; very fine spray and volatile binders increase emissions.

3.4 From Ovens and Cooling

The curing ovens vaporize additional amounts of resin binder, this resin condenses upon cooling and causes a visible emission. The amount of emissions depends largely on oven temperature and binder composition.

4.0 CONTROL TECHNOLOGY AVAILABLE FOR FIBER GLASS MANUFACTURING PLANTS

Control equipment and techniques are available to reduce the particulate and gaseous emissions from fiber glass manufacturing plants.

4.1 In Batch Plant

Dust control equipment can be installed on conveying systems that use open conveyor belts. A considerable reduction in the size of the dust control equipment can be realized by totally enclosing all conveying equipment and sealing all covers and access openings with gaskets of polyurethane foam. In fact, by totally enclosing all conveying equipment, exhaust systems become unnecessary, and relatively small filter vents or dust cabinets can be attached directly to the conveying equipment and storage bins. On the other hand, exhaust systems are required for ventilating the weigh hoppers and mixers. Because dust emissions contain particles only a few microns in diameter, cyclone and centrifugal scrubbers are not as effective as fabric filters for collecting these small particles.

4.2 For Glass Melting Furnace

Air pollution control equipment can be installed on reverberatory furnaces where particulate emissions or opacities cannot be reduced to required amounts through changes in furnace design and operating conditions. A low pressure, wet, centrifugal scrubber shows an overall efficiency of only 52 percent. The low efficiency demonstrates the inherent inability of the low pressure, wet, centrifugal scrubbers to collect particulates of sub-micron size. On the other hand, baghouses show collection efficiency of particulates between 80%-95% based on data from Owens-Corning[11] for tests conducted in 1971 and 1972.

The emissions from the reverberatory glass furnaces are not only particulates, but also gases, such as fluorides (in some instances - no fluorides), nitrogen oxide and sulfur oxides dependent upon the raw material and fuel composition.[8] Technology and equipment for satisfactory control of total emission from reverberatory furnace is not commercially developed. This is a significant area where research and development work is required, especially in older plants which may not be readily converted to electric induction heating.

4.3 In Forming Operation

Control of the fine condensed fume from the forming lines presents a more difficult problem. A change in resin composition, a change in method of application, and reduction of forming zone temperatures appear to be logical as first attempts to reduce emissions.

Many effluents from forming operations produce submicron, organic, sticky particulates that are difficult to filter. They may be associated with odors. These effluents were reduced by scrubbers, electrostatic precipitators, incinerator or high energy filter. High energy scrubbers require very high power consumption for fans or may cause a secondary, expensive-to-solve water pollution problem. Electrostatic precipitators tend to foul when collecting tacky materials. Incineration becomes costly for large volume effluents. Johns-Manville claims that submicron effluents from ovens and forming chambers of glass fiber lines can be filtered with removal efficiencies of particulate matter between 70% and 85% by glass fiber mats alone or mats impregnated with asbestos fiber. (10)

4.4 In Curing Operation

The small volume of gas evolved from the curing ovens would permit use of gas-fired afterburners to reduce visible emission but not odor. To effectively control visible emissions and odor from the curing oven exhaust, an incinerator rather than an afterburner would be required.[11] In addition, the heat from the incinerator could be utilized to heat the oven.

December 4, 1972

5.0 ESTIMATED NATIONWIDE EMISSION

The extent of uncontrolled particulate emissions from fiber glass manufacturing were presented in the U.S. Environmental Protection Agency's preliminary document entitled "Air Pollutant Emission Factors" published in 1970. As mentioned in the above referenced document, due to lack of sufficient emission data and the variability in emissions due to process variables, the reliability of those emission factors are questionable.

Substantial environmental sampling programs have been conducted recently by Owens-Corning at six glass wool plants and five textile fiber plants. All known uncontrolled process emission data measured up to January 1, 1972[11] are summarized in Table 5.1 (see page 22).

The nationwide emission from both textile fiber glass and glass wools manufacturers are estimated and presented in Table 5.2 (see page 23) based on 1970 production and emission factors listed in Table 5.1

December 4, 1972

TABLE 5.1

UNCONTROLLED TOTAL EMISSION FACTORS
FOR
FIBER GLASS MANUFACTURE

Process	Emissions, lb/ton Product	
	Textile	Wool
Glass Furnace		
Regeneration	70.4	39.2
Recuperative	83.9	42.1
Electric Induction	*	1.1
Forming Line	1.6	57.6
Curing Oven	5.6	9.0
Cooling	N/A	2.4
Average (each forming line)	84	96

N/A = Not Applicable

* This process is in the experimental stage.

December 4, 1973

TABLE 5.2

ESTIMATED NATIONWIDE EMISSION RATE
FOR
FIBER GLASS MANUFACTURE

The emission factor method of calculation is based on the following equation

$$E = \frac{P(ef)(1-C_c\ C_t)}{2,000}$$

where

E is the emission rate, tons/yr

ef is the emission factor (uncontrolled), lb/ton

P is the production rate, tons/yr

C_c is the average operating efficiency of control equipment

C_t is the percentage of the production capacity on which control equipment has been installed

	Textile Fibers	Glass Wools
ef (Refer to Table 5.1)	84	96
P (Refer to Table 8.2, 1970)	233500	613500
C_c	0	0.95
C_t	0	0.50
E (Calculated)	9800	7900

Note: The numbers for C_c and C_t are based on the survey reports found in the appendix. For textile fibers, the industry has not developed the technology (see section 6.1.2)

6.0 FIBER GLASS MANUFACTURING PLANTS UTILIZING BEST EMISSION CONTROL TECHNOLOGY

Vulcan-Cincinnati, Incorporated has communicated with eight fiber glass manufacturers as listed in Table 6.1 (see page 25) and received valuable information from three leading manufacturers; namely, Owens-Corning Fiberglas Corporation, Johns-Manville Fiber Glass Incorporated and PPG Industries. The condensed survey reports are attached in the Appendix for reference.

Vulcan-Cincinnati, Incorporated has also communicated with fourteen foreign glass fiber manufacturers as listed in Table 6.2 (see pages 26 & 27) and has not received any valuable information from them.

6.1 Owens-Corning Fiberglas Corporation

6.1.1 Glass Wool Plant

The Fairburn, Georgia plant is a new facility which began production in July 1971. It incorporates the latest emission control measures. This plant is equipped with an electric melt furnace, the emission from which is negligible as compared with direct fired, regenerative or recuperative furnaces with conventional control. No environmental control equipment is required

Table 6.1

LIST OF CONTACTS IN THE U.S.

Name of Firm	Person Contacted	Address	Telephone No.
Owens-Corning Fiberglas Corporation	W. L. Krentz & Sam Thomas	Fiberglas Tower, Toledo, Ohio 43569	419-259-3000
Johns-Manville Fiber Glass Incorp.	Don E. Hiller & Joseph Goldfield	Greenwood Plaza, Denver, Colo. 80217	303-770-1000
PPG Industries	Lear Powell	One Gateway Center, Pittsburgh, Pa. 15222	412-434-3131
Certain-Teed Saint Gobin Insul. Corp.	Eugene Nowicki	Valley Forge, Pa. 19481	215-687-5500
United Merchants & Mfrs., Inc.	Russell Ross	535 Connor Street, Statesville, N.C. 28677	704-872-5221
Ferro Corporation	Henry Abbott	Fiber Glass Road, Nashville, Tenn. 37211	615-255-7471
Reichhold chemicals, Inc.	Robert Levell	State Rt. 664, Bremen, Ohio 43107	614-569-4175
Kaiser Glass Fiber Corporation	Bill Lademer	6230 N. Irwindale Ave. Irwindale, Cal. 91706	213-334-0288

December 4, 1972

TABLE 6.2

LIST OF CONTACTS IN FOREIGN COUNTRIES

Belgium

Isovarbel S.A. 10 boulevard Saint-Lazare, Brussels - 3

Owens-Corning Fiberglas (Europe) S.A. 178 chaussee de la Hulpe, Brussels - 17

Finland

Sulfiittimuuraus Oy, Porvoo

France

Laboratoire d'Etudes & de Recherches Chimiques, 80 boulevare Haussmann, Paris 8e

Moulinage et Retorderie de Chavanoz S.A. Chavanoz (Isere)

Societe du Verre Textile, 82 rue du Faubourg-Saint-Honore, Paris 8e

German Federal Republic

Aachen-Gerresheimer Textileglas-Ges.mbH "GEVETEX", Theaterstr. 8, 51 Aachen

Glaswerk Schuller GmbH, Faserweg, 698 Wertheim-Glashutte

TABLE 6.2 (CONT'D)

December 4, 1972

Great Britain

Arnold Designs Ltd. Chalford, Strcud. Glos

Versil Ltd. Rayner mills, Liversedge, Yorks

Italy

Balzar Modigiani S.p.A. vis G. B. Pirelll 30, Milan

Netherlands

Silenka Aku-Pittsburg N.V. Rijksweg West 22, Westerbroek

Sweden

Scandinavian Glasfiber Ad, Falkenberg (continuous glass fibre)

Fibres de Verre S.A. 2 Chemin des Magnolias, Lausanne

for the electric furnace to meet the current regulation for particulates. By changing process conditions, using a scrubber and a baffled penthouse, the particulate removal efficiency in the forming line can reach 88%. The particulate emission leaving the oven is treated by incineration with removal efficiency of 97%. The emission from cooling line is controlled by water scrubbing with removal efficiency of 85%.

6.1.2 Textile Fibers Plants

The application of an electric melt furnace in a textile fibers plant is still in the experimental stage. Technology and equipment available for satisfactory control of textile reverberatory furnace emissions is not commercially developed. No environmental control equipment is necessary for the forming line and oven, in order to meet current regulations.

6.1.3 Control Equipment Cost

As shown in the Appendix Survey Report No. 1 - Section VI, Owens-Corning presented a typical cost of environmental control equipment for a new glass wool plant using an electric furnace of approximately

$1,115,000. The estimated cost for replacement of conventional gas fired furnace with electric melt unit was $1,945,000.

Owens-Corning has six glass wool plants. Among them, three plants are using electric furnaces and the other three plants are still using reverberatory furnaces. They are planning to replace those conventional gas fired furnaces with electric melt units.

From the above data supplied by Owens-Corning, it is estimated that the total additional investment in environmental equipment is in the range of 8 to 10 million dollars. This is arrived at by multiplying 3 plants by $1,115,000 for control equipment and adding the product of 3 plants by $1,945,000 for electric melt furnaces. Owens-Corning detail plans are not known. However, their decisions are guided by criteria of meeting state and local pollution regulations.

Concerning textile fiber plants, total emission control equipment is still under research and development.

Currently, Owens-Corning has a R & D program to develop an electric furnace for textile fiber plant service. If this is successful, and as indicated in

section 6.1.2 no other emission controls are needed, then the magnitude of cost for controls would be 10 million dollars. This is arrived at by multiplying $2,000,000 estimate for an electric furnace by 5 plants.

6.2 Johns-Manville Fiber Glass Incorporated

The Winder, Georgia Fiber Glass Insulation Plant was selected because it is typical of Johns-Manville's new fiber glass plants. This plant starts with glass marbles, so there is no furnace emission problem. No control equipment has been installed in the forming line. A HEAF (High Energy Air Filter) is to be installed at oven exhaust discharge, with an average removal efficiency of 75%. (95% removal of particulates and 45% removal of condensibles).

6.3 PPG Industries

One insulation plant located at Shelbyville, Indiana and one textile fiber glass plant located at Lexington, North Carolina was selected for survey study. No environmental control equipment has been installed for either plant. The emission data survey study is presently underway under direction of University of North Carolina - Department of Environmental Engineering (See in the appendix survey reports No. 4 and No. 5 - Section III and Section V).

December 4, 1972

7.0 STATES' REGULATIONS PERTAINING TO PARTICULATE EMISSIONS AND ECONOMIC IMPACT TO THE INDUSTRY

All significant particulate emissions from fiber glass manufacturers are vented from the process. Thus the exhaust is amenable to quantitative measurement and objective regulation. Manufacturing plants are located in 14 states as shown in Figure 1.1 (page 2). Tables 7.1 and 7.2 summarize the regulations applicable to general process sources, allowable emission rates and visible emission for those 14 states.

As shown in Table 7.3, (see page 37) it is estimated that the additional investment costs of the air pollution control equipment for the glass wool industry will be 28 million dollars. The annual cost including operating and maintenance, interest and depreciation will be 18.4 million dollars or 1.4 cents per pound of product which is equivalent to 4.4% increase of selling price.

TABLE 7.1

REGULATIONS APPLICABLE TO GENERAL PROCESS SOURCES
RATE OF ALLOWABLE EMISSION LBS PARTICULATE/HR

	PROCESS WEIGHT RATE, LB/HR									
	100	1,000	5,000	10,000	20,000	40,000	60,000	120,000	200,000	1,000,000
California[3]										
Georgia	0.55	2.58	7.58	12.00	19.20	30.50	40.00	68.50[5]	89.7[6]	262.00[7]
Indiana	0.55	2.53	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
Kansas	0.55	2.58	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
New Jersey[12]										

[3]each county has its own regulation.

[5]for existing plants only; 46.3 lbs Particulate/hr for new plants.

[6]for existing plants only; 51.2 lbs Particulate/hr for new plants.

[7]for existing plants only; 69.0 lbs Particulate/hr for new plants.

[12]Maximum Allowable Emission Rate for Particles

Potential Emission Rate from Source Operation (lbs/hr)	Allowable Emission Rate (Based on 99%, Efficiency of collection) (lbs/hr)	Source Gas Emitted from Source Operation (Std. cu.ft./min.)	Allowable Emission Rate (Based on 0.02 gr/scfm x lbs/hr)
50 or less	0.5	3000 or less	0.5
100	1.0	70,000	12.0
1000	10.0	175,000 or greater	30.0
3000 or greater	30.0		

TABLE 7.1 (CONT'D)

December 4, 1972

	PROCESS WEIGHT RATE, LB/HR									
	100	1,000	5,000	10,000	20,000	40,000	60,000	120,000	200,000	1,000,000
New York[14]	0.50	2.30	6.70	10.80	12.40	27.20	36.10	51.80	56.20	71.10
N. Carolina	0.55	2.58	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
Ohio	0.55	2.58	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
Pennsylvania[15]										
Rhode Island	0.55	2.58	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00

[14]applies to sources with an environmental rating of B or C. Emissions from source with A or D rating are at discretion of the Dept. of Environmental Conservation.

[15]if E 150,000 dry standard cubic ft/min, emissions should not exceed 0.04 gr/dry standard cubic ft.
if 150,000 E 300,000 dry stnadard cubic ft/min. $A = 6000E^{-1}$
if E 300,000 dry stnadard cubic ft/min, emissions should not exceed 0.02 gr/dry standard cubic ft.

TABLE 7.1 (CONT'D)

December 4, 1972

	PROCESS WEIGHT RATE, LB/HR									
	100	1,000	5,000	10,000	20,000	40,000	60,000	120,000	200,000	1,000,000
S. Carolina	0.55	2.58	7.58	12.00	19.20	30.50	40.00	46.30	51.20	69.00
Tennessee[8]	0.55	2.34	6.34	9.70	15.00	23.00	29.60	33.30	36.10	46.70
Texas		1.60	7.70	15.20	30.10	59.70	67.40	-	95.20	123.90[16]
W. Virginia[18]										

[8]for new plants only; existing plants = 0.55 for 100 lbs/hr
2.58 for 1000 lbs/hr
7.58 for 5000 lbs/hr
12.00 for 10,000 lbs/hr
19.20 for 20,000 lbs/hr
30.50 for 40,000 lbs/hr
40.00 for 60,000 lbs/hr
46.30 for 120,000 lbs/hr
51.20 for 200,000 lbs/hr
69.00 for 1,000,000 lbs/hr

[16]for 500,000 lbs/hr.

[18]state did not include a general process curve.

December 4, 1972

TABLE 7.2

REGULATIONS APPLICABLE TO VISIBLE EMISSION PARTICULATE

	FUEL BURNING[1] % OPACITY	INCINERATION[1] % OPACITY	INDUSTRIAL PROCESS % OPACITY
California[4]			
Georgia	20[3]	20[3]	10[6]
Indiana	40	40	40
Kansas	20[3]	20	20[3]
New Jersey	20[17]	20	20
New York	20[18]	20[18]	20[19]
N. Carolina	20[3]		20[3]

[1]when presence of uncombined water is the only reason for failure of emissions to meet limitation, these requirements shall not apply.

[3]for new equipment; 40% for existing equipment.

[4]each county has its own regulations.

[6]for new Portland Cement Plants, new nitric acid plants, new sulfuric acid plants; 40% for existing conical burners.

[17]for _ 200 million BTU/hr capacity, no visible emissions are allowed for sources with 200 million BTU/hr capacity.

[18]for a period of 3 or more minutes during any continuous 60 minute period, 40% for any time period for N. Y. City, Nassau and Westchester Co's.

[19]for charging coke ovens after December 31, 1974.

TABLE 7.2 (CONT'D)

December 4, 1972

	FUEL BURNING % OPACITY	INCINERATION % OPACITY	INDUSTRIAL PROCESS % OPACITY
Ohio	20	20	20
Pennsylvania	60[22]	60[22]	60[22]
Rhode Island	20	20	20
S. Carolina	20[3]	20[3]	20[3]
Tennessee	20[24]	20[24]	20[24]
Texas	20[25]	20[25]	-
West Virginia	20[28]	20	20

[3]for new equipment; 40% for existing equipment.

[22]20% for a period or periods aggregating more than 3 minutes in any one hour.

[24]for sources constructed after August 9, 1969; 40% for sources constructed on or before August 9, 1969; 20% for all sources after August 9, 1975.

[25]for sources beginning construction after January 31, 1972; 30% for existing sources.

[28]from September 1, 1972 until June 30, 1975 for units not meeting weight emission standards and 10% capacity thereafter; 10% for units meeting weight emission standards.

December 4, 1972

TABLE 7.3

ESTIMATED COST OF CONTROLLING AIR POLLUTANTS FROM GLASS WOOL MANUFACTURING INDUSTRY

Estimated Production, 1972	1332 Million Pounds
Sales, 1972	421 Million Dollars
Unit Selling Price, 1972	31.6 cents/pound
Estimated Additional Investment	28 Million Dollars
Estimated Annual Cost	
Operating and Maintenance	12.7 Million Dollars
Interest	2.2
Depreciation	3.5
Total	18.4
Additional Unit Cost	1.4 cents/pound
Increasing in Selling Price	4.4 %

Assumptions:

(1) Owens-Corning's survey report is used as a basis for investment and operating cost estimate.

(2) The interest rate is 8 percent per annum.

(3) The depreciation period is 8 years.

The average annual growth rate over the past ten years of textile fibers was 12.2% and that of glass wools was 4.2% based on the General Electric Mark I computer program entitled "Growth".

The production forecast of textile fiber is based on PREDICAST 1972 (see Table 8.2 page 42).

The G.E. Program "Growth" computes the projected production of glass wool for the next five years (see Table 8.2 page 42) on the basis of a production curve derived from the annual productions for the past ten years.

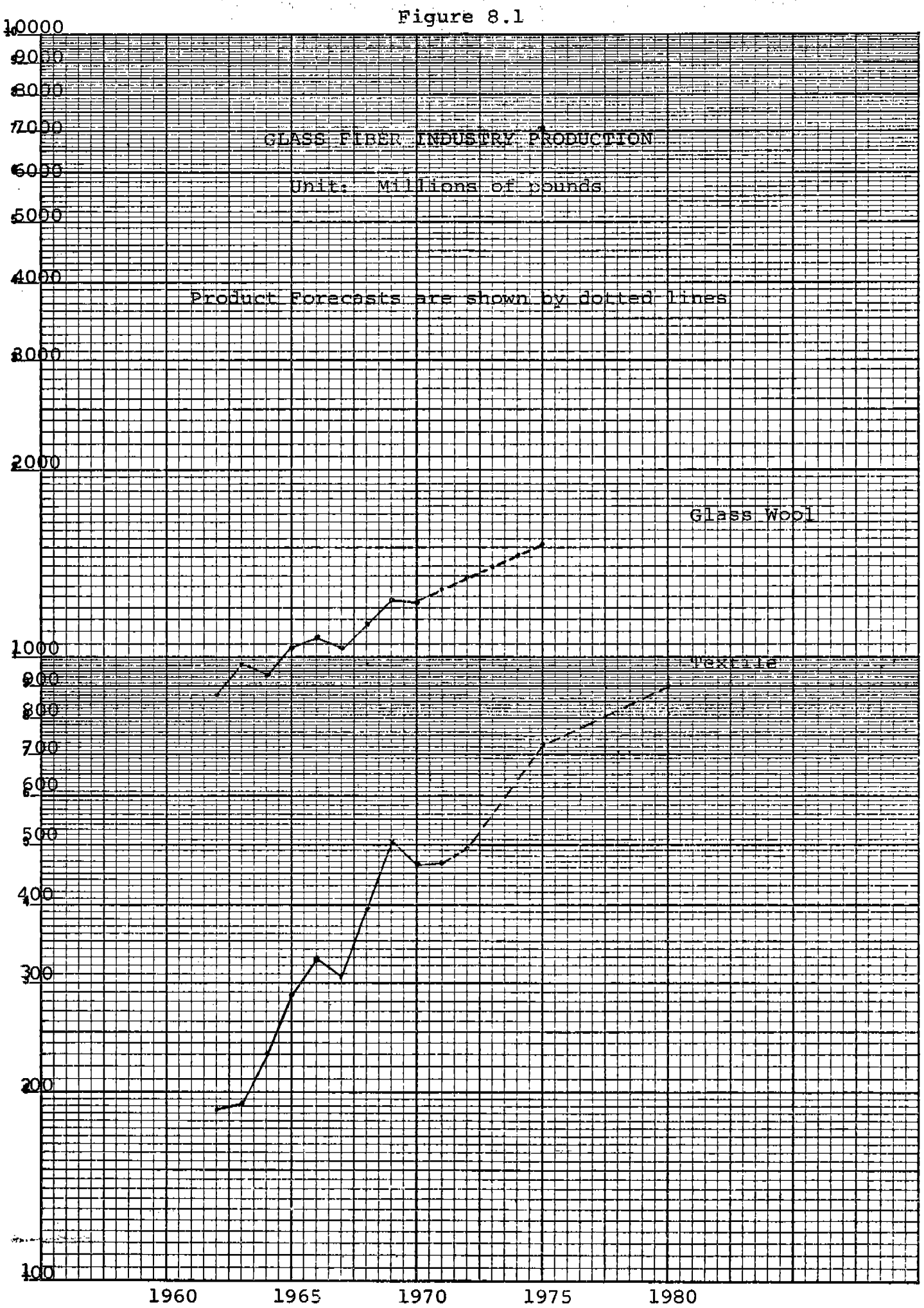
In 1970 the total U.S. sales of textile fibers was $200,000,000 and for glass wools it was $363,000,000.

TABLE 8.1

LIST OF FIBER GLASS MANUFACTURERS

Location	Plant Name	Street Address	No. of Employees
California			
Irwindale	Kaiser Glass Fiber Corp.	6230 N. Irwindale Ave.	60
Corona	Johns-Manville Fiber Glass Corp.	1251 Old Magnolia Ave.	350
Santa Clara	Owens-Corning Fiberglas Corp.	960 Central Expressway	900
Georgia			
Fairburn	Owens-Corning Fiberglas Corp.	7000 Mclarin Road	267
Winder	Johns-Manville Fiber Glass Incorp.		
Indiana			
Shelbyville	PPG Industries	Elizabeth Street	500
Richmond	Johns-Manville Products Corp.	814 Richmond Ave.	170
Kansas			
Kansas City	Certain-Teed Products Corp.	3000 Fairfax	1020
Kansas City	Owens-Corning Fiberglas Corp.	110 Sunshine Road	1000
New Jersey			
Berlin	Certain-Teed Saint Gobin Insul.	New Brooklyn & New Freedom	275
Berlin	Johns-Manville Products Corp.	Williamstown Junction	210
Barrington	Owens-Corning Fiberglas Corp.	Fiber Glass Road	1200
New York			
Rochester	Dolomite Glass Fibers Inc.	1037 Jay Street	30
North Carolina			
Shelby	PPG Industries Inc.	Washburn Switch Road	1500
Lexington	PPG Industries Inc.	New Jersey Road	750
Statesville	United Merchants & Mfrs. Inc.	535 Connor Road	1150

Figure 8.1


GLASS FIBER INDUSTRY PRODUCTION
Unit: Millions of pounds
Product Forecasts are shown by dotted lines
Glass Wool
Textile
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
1960
1965
1970
1975
1980

9.0 SAMPLING AND TESTING

9.1 Particulate Sampling

Sampling for particulates must be carried out under isokinetic sampling conditions. The method is described in Federal Register August, 1971.[12] An investigation or a decision should be made of the effect of fluorides or gaseous fluorine on the "pyrex" glass probe specified in this method. Substitution of a teflon probe or other non-reactive material of construction should be considered.

9.2 Total Fluoride and Gaseous Fluoride

Sampling and analysis for total fluoride and gaseous fluoride can be carried out using the procedure described in "Source Testing Manual" of the Los Angeles Air Pollution Control District.[13] Collection of the sample is by continuous sampling with an impinger absorption train which includes a Whatman thimble to separate gaseous from solid fluoride compounds. Analysis is performed by separation of the fluorides, after addition of perchloric acid, as hydrofluosilicic acid by steam distillation. Estimation

phenoldisulfonic acid reagent and ammonium hydroxide. Total oxides of nitrogen in industrial effluents where the concentration range is five to several parts per million can be determined by this method. (16)

9.5 Carbon Monoxide

Rather than determination by chemical techniques or by adsorption methods such as the Orsat method, an on-stream monitoring of carbon monoxide by nondispersive infrared analytical instrumentation should be satisfactory. Provision to remove materials that could etch the samples cells, such as fluorides, by e.g., caustic scrubbing of the sample stream would be necessary. The instrument, with different path length cells can be used to cover a wide range of expected concentrations.

9.6 Total and Gaseous Boron

Sampling for total and gaseous boron compounds is felt to be possible by isokinetic sampling using an impinger train with a Whatman thimble preceding the impingers. Fixation of boron compounds could probably be done by a caustic solution in the impinger.

Analysis of the collected samples by atomic absorption spectroscopy, in the low parts per million range appears possible. (17)

9.7 Aldehydes

Sampling for aldehydes is carried out by a grab sampling technique using evacuated flasks. Impinger methods are more applicable to atmospheric monitoring.

Analysis is performed by reacting the collected aldehydes with sodium bisulfite forming bisulfite addition compounds. Excess bisulfite is destroyed with iodine solution. The bisulfite is then liberated from the addition compounds by pH adjustment equivalent to the aldehydes present in the sample. Titration of the liberated bisulfite is then carried out using standard iodine.

The lower limit, using 2-liter gas samples is stated to be 1 ppm.[19]

In the event only formaldehyde is to be determined or differentiated from total aldehydes an aliquot portion of the original aldehyde-bisulfite solution can be taken and formaldehyde determined using the colorimetric chromatopic acid procedure.

The lower limit of this method is also stated to 1 ppm using a 2-liter gas sample.

9.8 Phenols

Sampling for phenols may be carried out using an impinger train. The sample is absorbed in 1N sodium hydroxide solution.

The phenols in the collected sample are steam distilled and the phenols in the distillate determined by a gas chromatographic method.[20]

An aliquot portion of the sodium hydroxide solutions can also be taken and the phenols determined colorimetrically as the oxidation product formed by the reaction with p-aminodimethylaniline.[21]

9.9 Owens-Corning Sampling and Test Procedures

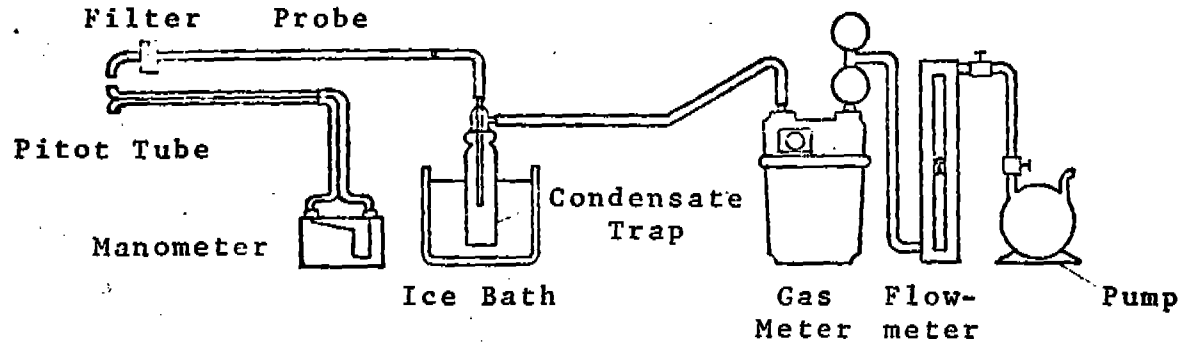
Sampling techniques used in Owens-Corning Fiberglas Corporation are the modified EPA procedures.[11] These procedures have been developed by their consultant, George D. Clayton and Assoicates, in conjunction with Owens-Corning Fiberglas Corporation personnel and have been approved by state and federal agencies/agency personnel in authority at the plants under test. Analytical methods are those as published in ASTM Standard Methods, Intersociety Committee, and others.

December 4, 1972

The next nine pages of this report are the specific procedures for sampling and analysis of the various emissions as prepared by George D. Clayton and Associates for Owens-Corning Fiberglas Corporation

PARTICULATE

Sampling Train



Sampling Method

The sampling train consisted of a sampling nozzle, a filter holder containing a 47-mm glass fiber, Type A filter, a stainless steel probe, clear polyvinyl chloride tubing, and a condensate trap immersed in an ice bath. The sampled gas was drawn through a calibrated dry test meter, where the temperature and pressure of the gas were measured, and the flowrate meter by means of a vacuum pump.

After each test the filter was placed in an appropriate container for transport to the laboratory.

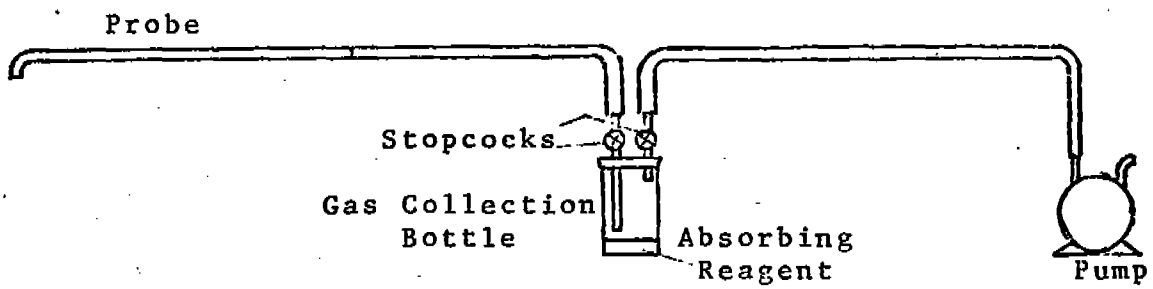
The volume of condensed water was measured and the equivalent volume of water vapor was calculated. The volume of metered gas was determined from the initial and final readings of the gas meter. The average meter pressure and temperature were used to calculate the sampled gas volume at standard conditions.

Analytical Method

The preweighed filter was placed in an oven and brought to constant weight at 105°C. It was then reweighed on an analytical balance having a sensitivity of 0.01 milligram to determine the weight gain.

NITROGEN OXIDES

Sampling Train



Sampling Method

Exhaust gas samples were drawn by a pump through a probe and tubing to a gas collection bottle of known volume and with stopcocks at the inlet and outlet, and then through a flowrate meter.

Exhaust gas thoroughly flushed the contents of the gas collection bottle to insure that air was completely displaced. Subsequently, stopcocks at the container inlet and outlet were closed after sampling.

A 20-ml quantity of 0.025N sodium hydroxide had been added to the gas sampling bottle prior to sampling. After the exhaust gas sample was collected, the bottle was shaken intermittently for 15 minutes to ensure the complete absorption of the nitrogen oxides by the absorbing reagent. The samples were then transferred to polyethylene bottles and shipped to the laboratory for analysis.

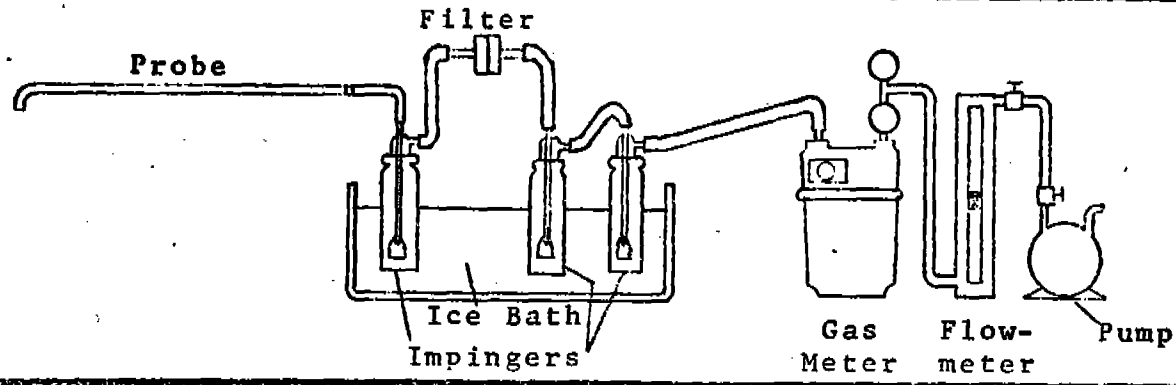
Analytical Method

The samples were analyzed by the method published in "The Determination of Toxic Substances in Air - A Manual of ICI Practice," W. Heffer & Sons, Ltd., Cambridge, England, Revised Ed., 1965, pp. 172-174. This method is based upon the absorption of nitrous fumes (nitrogen dioxide and nitric oxide) in the 0.025 molar caustic solution, followed by the reaction of the resulting nitrite with a Griess-Ilsovay reagent (sulfanilic acid and alpha-naphthylamine in acetic acid solution) to produce a red color whose intensity is proportional to the concentration of the nitrite produced in the absorbent by the collected sample.

The absorbance values of the sample solutions, measured at 530 millimicrons in a 1-cm cell, were referred to a standard curve prepared by the application of the method to standard samples of sodium nitrite. The gaseous concentration of nitrogen oxides was calculated in parts per million of NO_2.

SULFUR DIOXIDE AND TRIOXIDE

Sampling Train



Sampling Method

The sampling train consisted of a sampling nozzle, stainless steel probe, prefilter (glass wool or Type A filter) to remove particulate matter, polyvinyl chloride tubing, a Greenburg-Smith impinger containing eighty percent isopropyl alcohol, a filter holder containing a glass fiber, Type A filter and two additional Greenburg-Smith impingers, each containing 100 milliliters of a three percent hydrogen peroxide reagent. The three impingers and final condensate trap were immersed in an ice bath.

The sampled gas was drawn through a calibrated dry gas meter where the temperature and pressure of the gas were measured and then through a flowrate meter by means of a vacuum pump.

After each test, ambient air was purged through the impingers to remove any sulfur dioxide captured in the isopropyl alcohol.

The contents of the first impinger (containing isopropyl alcohol) and the tubing and impinger rinsings were transferred to a sample bottle, and the Type A filter was removed from the filter holder and placed in the same sample bottle. The contents of the second and third impingers containing the hydrogen peroxide solution and the impinger rinsings were transferred to separate sample bottles.

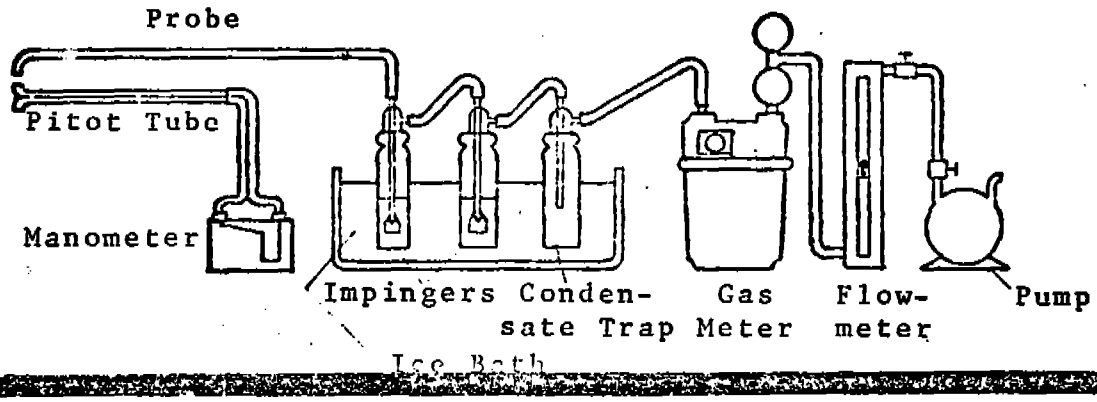
The volume of condensed water was measured and the equivalent volume of water vapor was calculated. The volume of metered gas was determined from the initial and final readings of the gas meter. The average meter pressure and temperature were used to calculate the sampled gas volume at standard conditions.

Analytical Method

An aliquot portion of the isopropyl alcohol sample solution was transferred to an Erlenmeyer flask. 2 to 4 drops of thorin indicator were added, and the solution was titrated with standardized barium perchlorate to a pink endpoint. The results were reported as sulfur trioxide. An aliquot portion of the hydrogen peroxide sample solution was transferred to an Erlenmeyer flask. Isopropyl alcohol was added to make an 80% isopropyl alcohol solution, and 2 to 4 drops of thorin indicator were added. The solution was then titrated with standardized barium perchlorate solution to a pink endpoint. The results were reported as sulfur dioxide.

TOTAL SULFUR OXIDES

Sampling Train



Sampling Method

The sampling train consisted of a sampling nozzle, a stainless steel probe, polyvinyl chloride tubing, and two Greenburg-Smith impingers connected in series, each containing 100 milliliters of 1N sodium hydroxide. The impingers and a condensate trap were immersed in an ice bath.

The sampled gas was drawn by means of a vacuum pump through a calibrated dry gas meter, where the temperature and pressure of the gas were measured, and then through a flowrate meter.

After each test the impinger contents and the rinsings of the impingers, nozzle, probe and tubing were transferred to sample bottles for transport to the laboratory. The volume of condensed water was measured and the equivalent volume of water vapor was calculated. The volume of metered gas was determined from the initial and final readings of the gas meter. The average meter pressure and temperature were used to calculate the sampled gas volume at standard conditions.

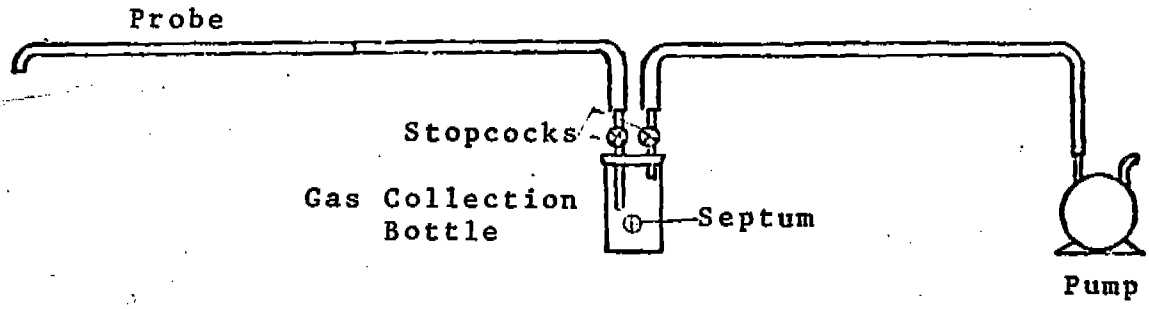
Analytical Method

The total volume of the sample solution was determined and an aliquot portion was transferred to a beaker. A three percent hydrogen peroxide reagent was added, and the solution was boiled to destroy excess peroxide. The sample was acidified with hydrochloric acid and heated to boiling, and hot 10 percent barium chloride reagent was added with stirring. After settling, the supernatant liquid was tested with additional barium chloride solution to insure complete precipitation of barium sulfate.

After digestion at 60°C, the samples were filtered through Whatman No. 42 paper and the precipitate was washed to remove all traces of chloride ion. The filters were transferred to weighed platinum crucibles, dried, and ignited to constant weight at 800°C. After cooling, the crucibles were reweighed on an analytical balance and the quantity of sulfur oxides was determined from the weight of barium sulfate. The gaseous concentration of sulfur oxides was calculated as parts per million of sulfur dioxide.

CARBON MONOXIDE

Sampling Train



Sampling Method

Exhaust gas samples were drawn by a vacuum pump through a probe and tubing to a gas sample container constructed with stopcocks at the inlet and outlet, and finally through a flowrate meter.

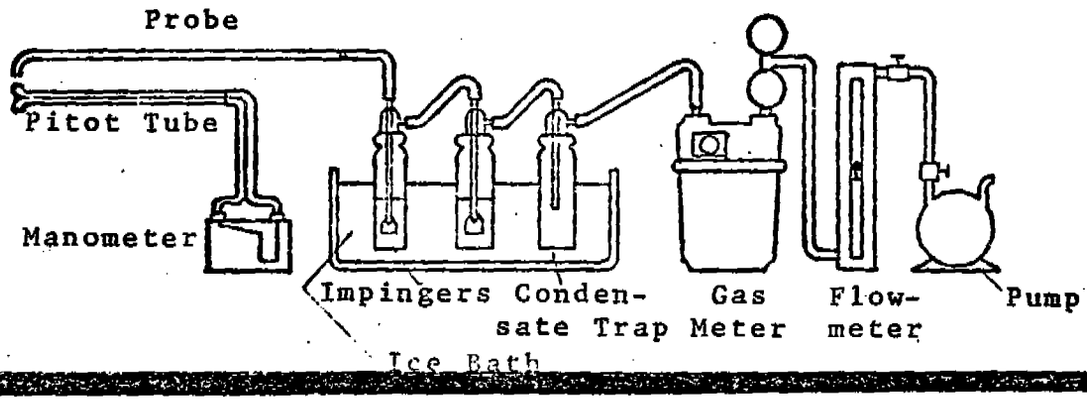
Exhaust gas thoroughly flushed the contents of the gas collection container to ensure that air was completely displaced. Stopcocks at the container inlet and outlet were closed after shutting off the vacuum pump.

Analytical Method

The exhaust gas sample was analyzed for carbon monoxide with the use of a colorimetric indicator tube. A measured volume of the sampled gas was drawn through a tube inserted through a septum in the side of the container. A color change of the chemical indicator in the tube was compared with a reference chart to determine the concentration of carbon monoxide in the exhaust gas.

TOTAL FLUORIDES

Sampling Train



Sampling Method

The sampling train consisted of a sampling nozzle, a stainless steel probe, polyvinyl chloride tubing, and two Greenburg-Smith impingers connected in series, each containing 100 milliliters of 1N sodium hydroxide. The impingers and a condensate trap were immersed in an ice bath.

The sampled gas was drawn by means of a vacuum pump through a calibrated dry gas meter, where the temperature and pressure of the gas were measured, and then through a flowrate meter.

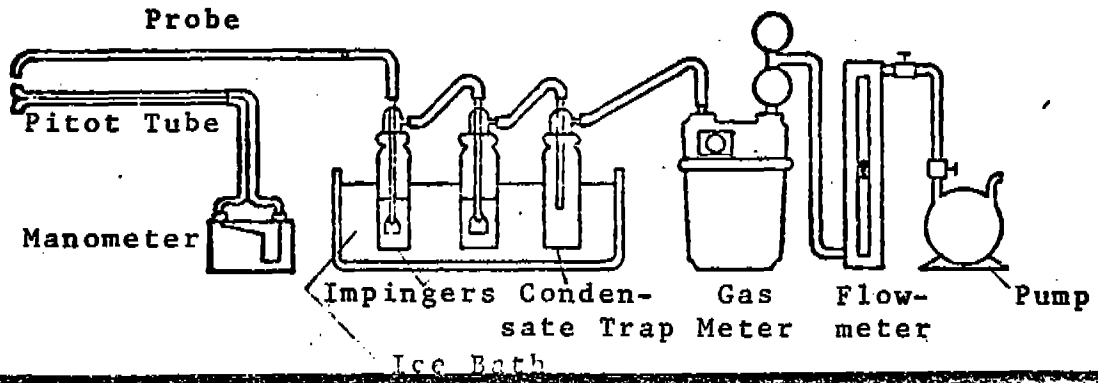
After each test the impinger contents and the rinsings of the impingers, nozzle, probe and tubing were transferred to sample bottles for transport to the laboratory. The volume of condensed water was measured and the equivalent volume of water vapor was calculated. The volume of metered gas was determined from the initial and final readings of the gas meter. The average meter pressure and temperature were used to calculate the sampled gas volume at standard conditions.

Analytical Method

The total volume of the sample solution was measured and a 10.0-ml portion was transferred to a 50-ml Griffin beaker to which a 4.0-ml quantity of 0.2-molar sodium citrate reagent was added. The pH of the solution was adjusted to 7.5 using dilute acid and base and an expanded scale pH meter. The final volume was adjusted to 20.0 ml with 0.2-molar sodium citrate. The fluoride ion potential of the solution was measured using the millivolt mode of a Sargent Model DR pH meter and an Orion fluoride specific ion electrode used in conjunction with an Orion single junction reference electrode. The fluoride content of the sample was calculated by reference to a standard curve prepared by application of the procedure to a series of samples of known fluoride content.

TOTAL BORON

Sampling Train



Sampling Method

The sampling train consisted of a sampling nozzle, a stainless steel probe, polyvinyl chloride tubing, and two Greenburg-Smith impingers connected in series, each containing 100 milliliters of 1N sodium hydroxide. The impingers and a condensate trap were immersed in an ice bath.

The sampled gas was drawn by means of a vacuum pump through a calibrated dry gas meter, where the temperature and pressure of the gas were measured, and then through a flowrate meter.

After each test the impinger contents and the rinsings of the impingers, nozzle, probe and tubing were transferred to sample bottles for transport to the laboratory. The volume of condensed water was measured and the equivalent volume of water vapor was calculated. The volume of metered gas was determined from the initial and final readings of the gas meter. The average meter pressure and temperature were used to calculate the sampled gas volume at standard conditions.

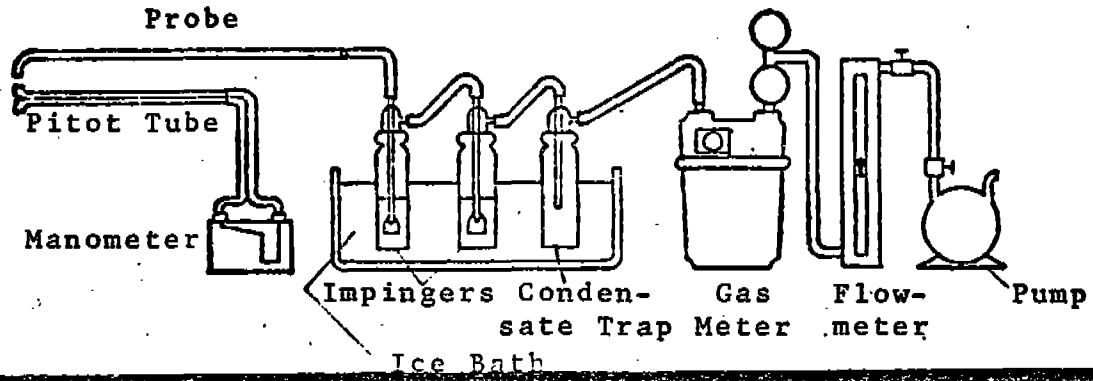
Analytical Method

An aliquot portion of the sample was transferred to a beaker and its pH was adjusted to 9.0 $\pm$ 0.2. The absorbance of boron in the sample solution was measured by atomic absorption spectrophotometry using a nitrous oxide-acetylene flame and the 2498 Å resonance line of boron.

Boron standards, prepared by the addition of known quantities of boric acid to a set of sodium chloride solutions whose sodium concentration was the same as that in the samples, were subjected to the above procedure to provide a reference curve for the calculation of the boron concentration in the samples.

PHENOLS

Sampling Train



Sampling Method

The sampling train consisted of a sampling nozzle, a stainless steel probe, polyvinyl chloride tubing, and two Greenburg-Smith impingers connected in series, each containing 100 milliliters of 1N sodium hydroxide. The impingers and a condensate trap were immersed in an ice bath.

The sampled gas was drawn by means of a vacuum pump through a calibrated dry gas meter, where the temperature and pressure of the gas were measured, and then through a flowrate meter.

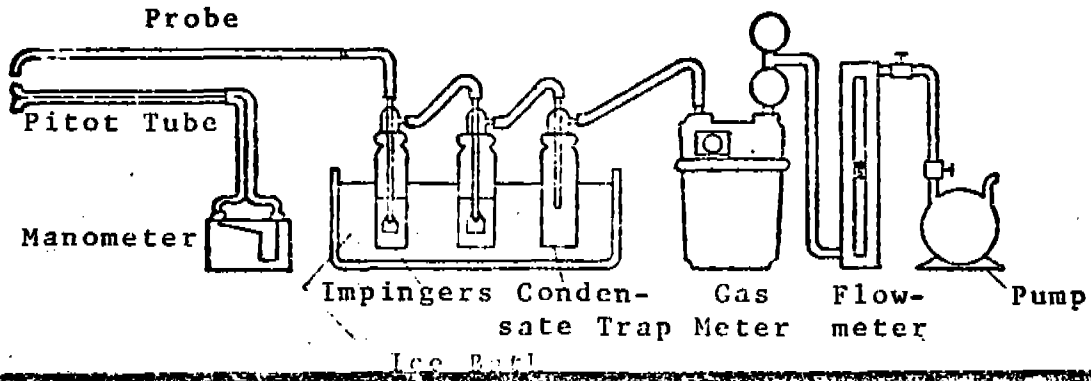
After each test the impinger contents and the rinsings of the impingers, nozzle, probe and tubing were transferred to sample bottles for transport to the laboratory. The volume of condensed water was measured and the equivalent volume of water vapor was calculated. The volume of metered gas was determined from the initial and final readings of the gas meter. The average meter pressure and temperature were used to calculate the sampled gas volume at standard conditions.

Analytical Method

After sampling, a 1-ml quantity of 10 percent copper sulfate was added to the sample, which was kept refrigerated to prevent loss of phenol. In the laboratory the pH of a 50-ml portion was adjusted to less than 4 with a 50 percent phosphoric acid reagent. The phenol was steam distilled from an all-glass still. After distilling all but approximately 10-ml of the solution, a 10-ml quantity of distilled water was added to the still and heating was resumed until an additional 10-ml volume of distillate was collected. The total volume of the distillate was recorded and a 6-microliter portion was analyzed by gas chromatography using a 5 percent Carbowax 20M liquid phase on a Diatoport 80-100 S solid support in a 1/4-inch stainless steel column operating at 170°C and a hydrogen flame ionization detector. The phenol concentration in the distillate was obtained in terms of parts per million in solution by referring the phenol peak area to those phenol standards prepared at the same time.

ALDEHYDES

Sampling Train



Sampling Method

The sampling train consisted of a sampling nozzle, a stainless steel probe, polyvinyl chloride tubing, and two Greenburg-Smith impingers connected in series, each containing 100 milliliters of 1% sodium bisulfite. The impingers and a condensate trap were immersed in an ice bath.

The sampled gas was drawn by means of a vacuum pump through a calibrated dry gas meter, where the temperature and pressure of the gas were measured, and then through a flowrate meter.

After each test the impinger contents and the rinsings of the impingers, nozzle, probe and tubing were transferred to sample bottles for transport to the laboratory. The volume of condensed water was measured and the equivalent volume of water vapor was calculated. The volume of metered gas was determined from the initial and final readings of the gas meter. The average meter pressure and temperature were used to calculate the sampled gas volume at standard conditions.

Analytical Method

A portion of the sample was transferred to an Erlenmeyer flask, and a 2-ml volume of one percent starch solution was added. The excess bisulfite ion was then destroyed by the addition of 0.1N iodine solution to the first appearance of a strong blue color. The resulting sulfur dioxide was removed by blowing dried, filtered air into the flask. The excess iodine was removed by adding 0.05N sodium thiosulfate, whose excess was destroyed by adding a 0.005N iodine reagent. After cooling the sample in an ice bath, a 50-ml portion of a completely chilled sodium carbonate buffer reagent was added to the chilled sample and a 15-minute period was allowed for the decomposition of the aldehyde-bisulfite complex. The liberated bisulfite was then titrated with the 0.005N iodine while keeping the sample flask in the ice bath. The amount of total aldehydes equivalent to the liberated bisulfite was calculated; the gaseous concentration of aldehydes was calculated in parts per million of formaldehyde.

10.0 REFERENCES

1. Dun and Bradstreet Computer File, 1972.

2. Census of Manufacturers, U.S. Department of Commerce, Bureau of Census.

3. March 6, 1972 Chemical and Engineering News.

4. Annual Survey of Manufacturers, U.S. Department of Commerce, Bureau of Census.

5. Kirk-Othmer "Encylcopedia of Chemical Technology:, Vol. 10 Second Edition.

6. "Air Pollution Engineering Manual", Danielson, J. A. (ed.) U.S. DHEW, PHS National Center of Air Pollution Control, Cincinnati, Ohio, PHS Publication No. 999-AP-40, 1967.

7. Chopey, N. P., "New Plant Features Latest Look in Making Glass Fibers", Chemical Engineering, May 15, 1961, pp. 136-139.

8. Teller, A. J., "Control of Emissions from Glass Manufacture", Ceramic Bulletin, Vol. 51, No. 8, 1972, pp. 637-640.

9. Mills, H. W. and Jansinski, J., "Evaluating Batch Changes", The Glass Industry, May, 1970, pp. 223-227.

10. Goldfield, J., "Glass Fiber Matts to Reduce Effluents from Industrial Processes", Paper No. 69-203 for Representation at the 62nd. Annual Meeting Air Pollution Control Association, June 22-26, 1969, N. Y. City.

11. Private Communication between Vulcan-Cincinnati, Inc. and Owens-Corning Fiberglas Corporation.

12. Federal Register, Vol. 36, No. 159, August, 1971, Method No. 5.

13. Source Testing Manual, Air Pollution Control Dist., Los Angeles County, California, pp. 82-85.

14. Federal Register, Vol. 36, No. 159, August, 1971, Method No. 6.

15. Laboratory Methods, No. 10, Air Pollution Control Dist., Los Angeles County, California, pp. 85-90.

16. Laboratory Methods, No. 10, Air Pollution Control Dist., Los Angeles County, California, pp. 79-82.

17. (6) Perkin-Elmer Corporation, Atomic Absorption Newsletter, 6, 35 (1967).

18. Pittsburg Plate Glass Co. - Fiber Glass Division Publication - "How Fiber Glass Is Made".

19. Source Testing Manual, Los Angeles Air Pollution Control District, pp. 72-79.

20. George D. Clayton & Associates Method No. Kr-11 as prepared for Owens-Corning Fiberglas Corporation.

21. Jacobs, Morris B., The Chemical Analysis of Air Pollutants, Vol. X, pp. 269, Interscience Publishers, New York - London, 1960.

VULCAN-Cincinnati, Inc.

December 4, 1972

AIR POLLUTION CONTROL SURVEY
REPORT NO. 1

I. GENERAL INFORMATION

1. Name of Company - Owens-Corning Fiberglas Corporation

2.

Plant Location	Area
Barrington, New Jersey	Urban
Fairburn, Georgia	Rural
Kansas City, Kansas	Metropolitan
Newark, Ohio	Metropolitan
Santa Clara, California	Urban
Waxahachie, Texas	Rural

3. Production

Type of Product	Capacity lbs/Yr.
Glass Wool	150,000,000 to 393,000,000 #/yr.

II. BRIEF PROCESS CONDITIONS (WHICH AFFECT THE EMISSIONS)

4. Raw Material Size and Composition

Sand	420 u to 44 u
Nephelinesynite	420 u to 44 u
Limestone	1190 u to 44 u
Burnt Dolomite	1190 u to 44 u

Note: Sections II, III, IV and VI are averages for all plants, Section V is for a specific plant.

Soda Ash	590 u to 74 u
Razorite	1190 u to 44 u
Barytes	279 u to 44 u

5. Type of Furnace - direct fired, regenerative, recuperative and electric

6. Type of Fuel - oil, gas and electricity

7. Fiber Diameter - 0.00021 to 0.00030 inch

8. Composition and Quantity of Binder

   Phenol, formaldehyde, Urea and water

9. Binder Spraying Techniques - Air atomization and liquid pressure

10. Oven Temperature and Product Cooling

    Oven Temperature - 350° - 550°F

    Cooling Temperature - 90° - 120°F

III. EMMISSION FACTORS WITHOUT CONTROL (lb. per ton of Material Processed)

	Source	Furnace	Forming	Oven	Cooling
12.	Particulates	0.5-65	60-160	1.0-77	1.0-4.0
13.	Phenol	N/A	5-8	0.01-0.35	0.01-0.07
14.	Aldehyde	N/A	1.5-7	0.4-0.8	0.02-2.5
15.	Gaseous Boron	0.05-2	N/A	N/A	N/A

16.	Total Boron	0.1-4	N/A	N/A	N/A
17.	Gaseour Fluoride	0.05-0.12	N/A	N/A	N/A
18.	Total Fluoride	0.06-0.25	N/A	N/A	N/A
19.	Gaseous Sulfur Oxides	0.02-4.5	N/A	N/D	N/A
20.	Total Sulfur Oxides	0.02-14.5	N/A	N/D	N/A
21.	Nitrogen Oxides	0.2-4	N/A	0.8-4	0.1-0.3
22.	Carbon Monoxide	0.05-0.5	N/A	1.0-3.5	0.1-0.3
23.	Silicon	N/D	N/D	N/D	N/D
24.	Lead	N/A	N/A	N/A	N/A
25.	Arsenic	N/A	N/A	N/A	N/A

N/A = Not Applicable

N/D = No Data Available

IV. EMISSION DATA AFTER CONTROL EQUIPMENT (lb. per ton of Material Processed)

26.	Source	Furnace	Forming	Oven	Cooling
27.	Particulates	0.5-8.0	2.0-3.0	1.0-5.5	0.1-2.5
28.	Phenol	N/A	1.0-7.5	0.01-0.2	<.01
29.	Aldehyde	N/A	1.0-2.0	0.2-0.4	0.02-0.1
30.	Gaseous Boron	N/D	N/A	N/A	N/A
31.	Total Boron	0.04-0.65	N/A	N/A	N/A

32.	Gaseous Fluoride	0.02-0.10	N/A	N/A	N/A
33.	Total Fluoride	0.02-0.2	N/A	N/A	N/A
34.	Gaseous Sulfur Oxides	N/D	N/A	N/D	N/A
35.	Total Sulfur Oxides	0.01-10	N/A	N/D	N/A
36.	Nitrogen Oxides	0.01-0.5	N/A	N/D	N/D
37.	Carbon Monoxide	0.04-0.06	N/A	0.5-2.5	N/D
38.	Silicon	N/D	N/D	N/D	N/D
39.	Lead	N/A	N/A	N/A	N/A
40.	Arsenic	N/A	N/A	N/A	N/A

N/A = Not Applicable

N/D = No Data Available

V. CONTROL EQUIPMENT OF FAIRBURN GEORGIA PLANT

		Furnace	Forming	Oven	Cooling
41.	Equipment Type	Electric Melt	Process Change & Scrubber Penthouse	Incinerator	Scrubber
42.	Operating Data				
	Emission Type	Part.	Part.	Part.	Part.
	Particle Size	N/A	(0.2 u median est.)		
	Concentration (gr/SCF)				
	Before Treatment	0.02-0.95	0.12-0.32	0.05-0.2	0.02-0.04

After Treatment	0.01-0.03	0.02-0.04	.01	.01
Air Volume (SCFM)	4,000-8,000	14,000-127,000	2,000-6,000	4,000-12,000
Removal Efficiency	97%	88%	97%	85%

VI. TYPICAL COST OF ENVIRONMENTAL CONTROL EQUIPMENT FOR ONE WOOL PRODUCTION LINE

	Capital Investment	Operating Cost/Yr
Batch Dust	$ 30,000	$ 1,600
Forming Scrubbers	150,000	12,000
Shaker Screens	180,000	25,000
Binder Reclaim	100,000	
Penthouse	100,000	N/D
Mixing Chamber	35,000	175,000
Incinerator	220,000	475,000
Cooling Section Scrubbers	120,000 **	9,000 **
Fabrication Penclones	180,000	7,500
	$1,115,000*	$705,100

*Estimated cost for replacement of conventional gas fired furnace with electric melt unit = $1,945,100

**Not including treatment of scrubbing water.

VII. AVAILABLE METHODS FOR TESTING AND ANALYSIS

Sampling techniques have been developed by our consultant in conjunction with Owens-Corning Fiberglas Corporation personnel and have been approved by state and federal agencies/agency personnel in authority at the plants under test. Analytical methods are those as published in ASTM, Standard Methods, Intersociety Committee, and others.

VULCAN Cincinnati, Inc

December 4, 1972

AIR POLLUTION CONTROL SURVEY
REPORT NO. 2

I. GENERAL INFORMATION

1. Name of Company - Owens-Corning Fiberglas Corporation

2.

Plant Location	Area
Ashton, Rhode Island	Urban
Aiken, South Carolina	Rural
Anderson, South Carolina	Rural
Huntingdon, Pennsylvania	Urban
Jackson, Tennessee	Rural

3. Production

Type of Product	Capacity lbs/Yr.
Glass Fiber Textile	31,776,000 to 156,672,000 #/yr.

II. BRIEF PROCESS CONDITIONS (WHICH AFFECT THE EMISSIONS)

4. Raw Material Size and Composition

Flint	149 u to 44 u
Clay	<44 u
Limestone	210 u to <44 u
Soda Ash	420 u to 74 u
Boric Acid	590 u to 44 u
Flourite	74 u to <44 u
Salt Cake	149 u to 44 u
Dolomite	420 u to 105 u

Note: Sections II, III, IV are typical of all the plants.

5. Type of Furnace - regenerative and recuperative

6. Type of Fuel - oil and gas

7. Fiber Diameter - 0.00035 to 0.00080 inch

8. Composition and Quantity of Binder

   Polyester, Epoxy, Polyvinyl Acetate, Starch, Ammonia, Water

9. Binder Spraying Techniques - Direct Roller Application

10. Oven Temperature and Product Cooling

    Oven Temperature - 120° - 500°F

    Cooling Temperature - Ambient

III. EMISSION FACTORS WITHOUT CONTROL (lb. per ton of Material Processed)

	Source	Furnace	Forming	Oven	Cooling
12.	Particulates	20-60	0.01-1.6	0.01-54	5-6
13.	Phenol	N/A	N/A	N/A	N/A
14.	Aldehyde	N/A	N/A	N/A	N/A
15.	Gaseous Boron	0.1-2.5	N/A	N/A	N/A
16.	Total Boron	0.7-21.5	N/A	N/A	N/A
17.	Gaseous Fluoride	0.01-2.1	N/A	N/A	N/A
18.	Total Fluoride	4.0-17.1	N/A	N/A	N/A
19.	Gaseous Sulfur Oxides	6.2-47.8	N/A	N/A	N/A

20.	Total Sulfur Oxides	7-50	N/A	N/A	N/A
21.	Nitrogen Oxides	2.5-181	N/A	0.4-45	21.5-43
22.	Carbon Monoxide	0.1-5.5	N/A	0.2-12	5.4-9
23.	Silicon	N/D	N/D	N/D	N/D
24.	Lead	N/A	N/A	N/A	N/A
25.	Arsenic	N/A	N/A	N/A	N/A

N/A - Not Applicable

N/D - No Data Available

IV. CONTROL EQUIPMENT

Furnace - No technology available for control of textile furnace emissions

Forming - No environmental control equipment required to meet current regulations

Oven - No environmental control equipment required to meet current regulations

V. AVAILABLE METHODS FOR TESTING AND ANALYSIS

Sampling techniques have been developed by our consultant in conjunction with Owens-Corning Fiberglas Corporation personnel and have been approved by state and federal agencies/agency personnel in authority at the plants under test. Analytical methods are those published in ASTM, Standard Methods, Intersociety Committee, and others.

VULCAN-Cincinnati, Inc.

December 4, 1972

AIR POLLUTION CONTROL SURVEY
REPORT NO. 3

I. GENERAL INFORMATION

1. Name of Plant - Johns-Manville

2. Plant Address - Winder, Gerogia 30680
   1 mile from rural area of 5,000 population

3. Production

Type of Product	Capacity lbs/Yr.	Production lbs/Yr.
Glass Wool	(Confidential)	18,000,000
Glass Fiber Textile	None	None

II. BRIEF PROCESS CONDITIONS (WHICH AFFECT THE EMISSIONS)

4. Raw Material Size and Composition

   Glass Marbles

   Liquid Resin Suspensions

5. Type of Furnace - None

6. Type of Fuel - gas for attenuating burners

7. Fiber Diameter - (Confidential Information)

8. Composition and Quantity of Binder

   Phenol formaldehyde

   10% of Finished Product Weight

9. Binder Spraying Techniques - Airless spray

10. Oven Temperature and Product Cooling

    Temperature - 350°F

    Product Cooling - None

III. EMISSION DATA

		TOTAL FOR TWO MACHINES	
11. Source	Furnace	Forming Line	Curing Oven
12. Air Volume (SCFM)	None	230,000	30,000
13. Particulate Components		0.02	0.025
14. Particulate Components		N/D	N/D
15. Gaseous Components		N/D	N/D

N/D - No Data Available

IV. CONTROL EQUIPMENT

	Furnace	Forming Line	Curing Oven
16. Equipment			
Type	None	None	HEAF*
Located at			Exhaust Disch.

* To be installed.

	Furnace	Forming Line	Curing Oven
17. Operating Data			
Emission			
Type			Part. Resin
Particle Size			N/D
Concentration			
Before Treatment			0.025
After Treatment			0.006
Air Volume			35,000
Removal Efficiency			75%**
18. Cost Data			
Installed Cost			$70,000 (Average cost per machine)
Utilities Requirements			
Electric Power, KW			150
Media Cost, $/Year			$2,700
Maintenance, $/Year			$2,000

** The HEAF removal efficiency for particulate is better than 95% and for condensibles better than 45% giving an average removal efficiency for the two of 75%.

V. AVAILABLE METHODS FOR TESTING AND ANALYSIS

Use standard EPA train as manufactured by Research Appliance Corporation.

VI. JOHNS-MANVILLE FIBER GLASS INSULATIONS PLANTS

Plant Location

Cleburne, Texas
Corona, California
Defiance G-26, Ohio
Defiance G-28, Ohio
Defiance G-30, Ohio
Parkersburg, West Virginia
Penbryn, New Jersey
Richmond, Indiana
Winder, Georgia

VULCAN Cincinnati, Inc.

December 4, 1972

AIR POLLUTION CONTROL SURVEY
REPORT NO. 4

I. GENERAL INFORMATION

1. Name of Plant - PPG Industries Works #50

2. Plant Address - 240 Elizabeth Street, Shelbyville, Indiana
   Plant is located in town of Shelbyville with 18,000 people. Within 10 mile radius 23,000 people estimated.

3. Production

Type of Product	Capacity lbs/Yr.	Production lbs/Yr.
Glass Wool	46 million lbs	43 million lbs

II. BRIEF PROCESS CONDITIONS (WHICH AFFECT THE EMISSIONS)

4. Raw Material Size and Composition

WORKS 50

	Particle Size		Chemical Composition
	Mesh	% Retained	
Sand	120	75%	99.% SiO_2
Nepheline Syenite	200	15%	59.% SiO_2 24.% Al_2O_3 15.% Na_2O
Rasorite	200	90%	65.% B_2O_3
Soda Ash	100	80%	58.% Na_2O
Dolomite	200	25%	30.% CaO 19.% MgO
Fluorspar	200	30%	95.% CaF_2 2.5% $CaCo_3$ 2.5% SiO_2

5. Type of Furnace - Standard Glass Tank-Furnace

6. Type of Fuel - Gas

7. Fiber Diameter - $15. \times 10^{-5}$ to $35. \times 10^{-5}$

8. Composition and Quantity of Binder

   Phenal-Formaldehyde Average 25,000 gals/day

9. Binder Spraying Techniques - Atomizing sprays at 30 psi

10. Oven Temperature and Product Cooling

    From 275° to 550°F depending on product being produced

III. EMISSION DATA

Survey presently underway under direction of University of North Carolina - Department of Environmental Engineering.

IV. CONTROL EQUIPMENT

No equipment has been installed.

V. AVAILABLE METHODS FOR TESTING AND ANALYSIS

Testing methods are under development with the assistance of the University of North Carolina - Department of Environmental Engineering.

VULCAN Cincinnati, Inc.

December 4, 1972

AIR POLLUTION CONTROL SURVEY
REPORT No. 5

I. GENERAL INFORMATION

1. Name of Plant - PPG Industries Works #53

2. Plant Address - Box 949, Lexington, North Carolina 27292
   Plant is located in rural area. Within 10 mile radius 25,000 people estimated.

3. Production

Type of Product	Capacity lbs/Yr.	Production lbs/Yr.
Glass Fiber Textile	59 million lbs	55 million lbs

II. BRIEF PROCESS CONDITIONS (WHICH AFFECT THE EMISSIONS)

4. Raw Material Size and Composition

WORKS #53

	Particle Size		Chemical Composition
	Mesh	% Retained	
Silica	325	2%	99.% SiO_2
Clay	325	1%	45.% SiO_2
Limestone	200	25%	55.% CaO MgO
			2.% SiO_2
Boric Acid	100	80%	58.% B_2O_3
Fluorspar	200	30%	98.% CaF
Sodium Sulfate	100	80%	40.% Na_2O
Ammonium Sulfate	100	40%	96.% $(NH_4)_2SO_4$

5. Type of Furnace - Direct Melt Tank - Furnace

6. Type of Fuel -Gas

7. Fiber Diameter - 17.5×10^{-5} to 52.5×10^{-5}

8. Composition and Quantity of Binder

   Starch base binders - dried for water removal - no air pollution

9. Binder Spraying Techniques - friction application no spraying involved.

10. Oven Temperature and Product Cooling

    Not applicable

III. EMISSION DATA

Survey presently underway - under direction of University of North Carolina - Department of Environmental Engineering.

IV. CONTROL EQUIPMENT

No control equipment installed.

V. AVAILABLE METHODS FOR TESTING AND ANALYSIS

Testing methods are under development with the assistance of the University of North Carolina Department of Environmental Engineering.