11.13 Glass Fiber Manufacturing

11.13.1 General[1-4]

Glass fiber manufacturing is the high-temperature conversion of various raw materials (predominantly borosilicates) into a homogeneous melt, followed by the fabrication of this melt into glass fibers. The 2 basic types of glass fiber products, textile and wool, are manufactured by similar processes. A typical diagram of these processes is shown in Figure 11.13-1. Glass fiber production can be segmented into 3 phases: raw materials handling, glass melting and refining, and wool glass fiber forming and finishing, this last phase being slightly different for textile and wool glass fiber production.

Raw Materials Handling -

The primary component of glass fiber is sand, but it also includes varying quantities of feldspar, sodium sulfate, anhydrous borax, boric acid, and many other materials. The bulk supplies are received by rail car and truck, and the lesser-volume supplies are received in drums and packages. These raw materials are unloaded by a variety of methods, including drag shovels, vacuum systems, and vibrator/gravity systems. Conveying to and from storage piles and silos is accomplished by belts, screws, and bucket elevators. From storage, the materials are weighed according to the desired product recipe and then blended well before their introduction into the melting unit. The weighing, mixing, and charging operations may be conducted in either batch or continuous mode.

Glass Melting And Refining -

In the glass melting furnace, the raw materials are heated to temperatures ranging from 1500 to 1700°C (2700 to 3100°F) and are transformed through a sequence of chemical reactions to molten glass. Although there are many furnace designs, furnaces are generally large, shallow, and well-insulated vessels that are heated from above. In operation, raw materials are introduced continuously on top of a bed of molten glass, where they slowly mix and dissolve. Mixing is effected by natural convection, gases rising from chemical reactions, and, in some operations, by air injection into the bottom of the bed.

Glass melting furnaces can be categorized by their fuel source and method of heat application into 4 types: recuperative, regenerative, unit, and electric melter. The recuperative, regenerative, and unit melter furnaces can be fueled by either gas or oil. The current trend is from gas-fired to oil-fired. Recuperative furnaces use a steel heat exchanger, recovering heat from the exhaust gases by exchange with the combustion air. Regenerative furnaces use a lattice of brickwork to recover waste heat from exhaust gases. In the initial mode of operation, hot exhaust gases are routed through a chamber containing a brickwork lattice, while combustion air is heated by passage through another corresponding brickwork lattice. About every 20 minutes, the airflow is reversed, so that the combustion air is always being passed through hot brickwork previously heated by exhaust gases. Electric furnaces melt glass by passing an electric current through the melt. Electric furnaces are either hot-top or cold-top. The former use gas for auxiliary heating, and the latter use only the electric current. Electric furnaces are currently used only for wool glass fiber production because of the electrical properties of the glass formulation. Unit melters are used only for the "indirect" marble melting process, getting raw materials from a continuous screw at the back of the furnace adjacent to the exhaust air discharge. There are no provisions for heat recovery with unit melters.

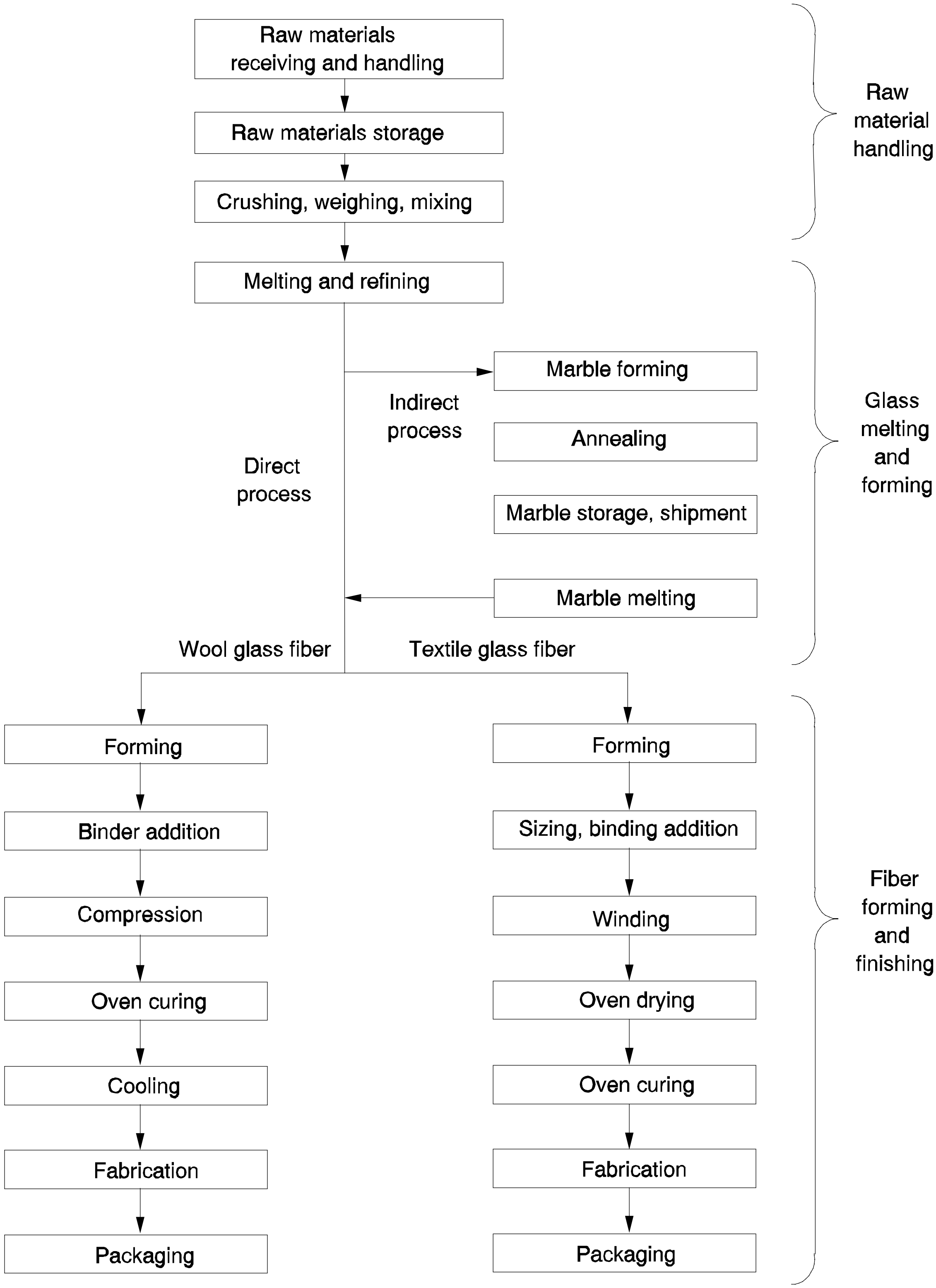

Figure 11.13-1. Typical flow diagram of the glass fiber production process.

In the "indirect" melting process, molten glass passes to a forehearth, where it is drawn off, sheared into globs, and formed into marbles by roll-forming. The marbles are then stress-relieved in annealing ovens, cooled, and conveyed to storage or to other plants for later use. In the "direct" glass fiber process, molten glass passes from the furnace into a refining unit, where bubbles and particles are removed by settling, and the melt is allowed to cool to the proper viscosity for the fiber forming operation.

Wool Glass Fiber Forming And Finishing -

Wool fiberglass is produced for insulation and is formed into mats that are cut into batts. (Loose wool is primarily a waste product formed from mat trimming, although some is a primary product, and is only a small part of the total wool fiberglass produced. No specific emission data for loose wool production are available.) The insulation is used primarily in the construction industry and is produced to comply with ASTM C167-64, the "Standard Test Method for Thickness and Density of Blanket- or Batt-Type Thermal Insulating Material".

Wool fiberglass insulation production lines usually consist of the following processes: (1) preparation of molten glass, (2) formation of fibers into a wool fiberglass mat, (3) curing the binder-coated fiberglass mat, (4) cooling the mat, and (5) backing, cutting, and packaging the insulation. Fiberglass plants contain various sizes, types, and numbers of production lines, although a typical plant has 3 lines. Backing (gluing a flat flexible material, usually paper, to the mat), cutting, and packaging operations are not significant sources of emissions to the atmosphere.

The trimmed edge waste from the mat and the fibrous dust generated during the cutting and packaging operations are collected by a cyclone and either are transported to a hammer mill to be chopped into blown wool (loose insulation) and bulk packaged or are recycled to the forming section and blended with newly formed product.

During the formation of fibers into a wool fiberglass mat (the process known as "forming" in the industry), glass fibers are made from molten glass, and a chemical binder is simultaneously sprayed on the fibers as they are created. The binder is a thermosetting resin that holds the glass fibers together. Although the binder composition varies with product type, typically the binder consists of a solution of phenol-formaldehyde resin, water, urea, lignin, silane, and ammonia. Coloring agents may also be added to the binder. Two methods of creating fibers are used by the industry. In the rotary spin process, depicted in Figure 11.13-2, centrifugal force causes molten glass to flow through small holes in the wall of a rapidly rotating cylinder to create fibers that are broken into pieces by an air stream. This is the newer of the 2 processes and dominates the industry today. In the flame attenuation process, molten glass flows by gravity from a furnace through numerous small orifices to create threads that are then attenuated (stretched to the point of breaking) by high velocity, hot air, and/or a flame. After the glass fibers are created (by either process) and sprayed with the binder solution, they are collected by gravity on a conveyor belt in the form of a mat.

The conveyor carries the newly formed mat through a large oven to cure the thermosetting binder and then through a cooling section where ambient air is drawn down through the mat. Figure 11.13-3 presents a schematic drawing of the curing and cooling sections. The cooled mat remains on the conveyor for trimming of the uneven edges. Then, if product specifications require it, a backing is applied with an adhesive to form a vapor barrier. The mat is then cut into batts of the desired dimensions and packaged.

Textile Glass Fiber Forming And Finishing -

Molten glass from either the direct melting furnace or the indirect marble melting furnace is temperature-regulated to a precise viscosity and delivered to forming stations. At the forming

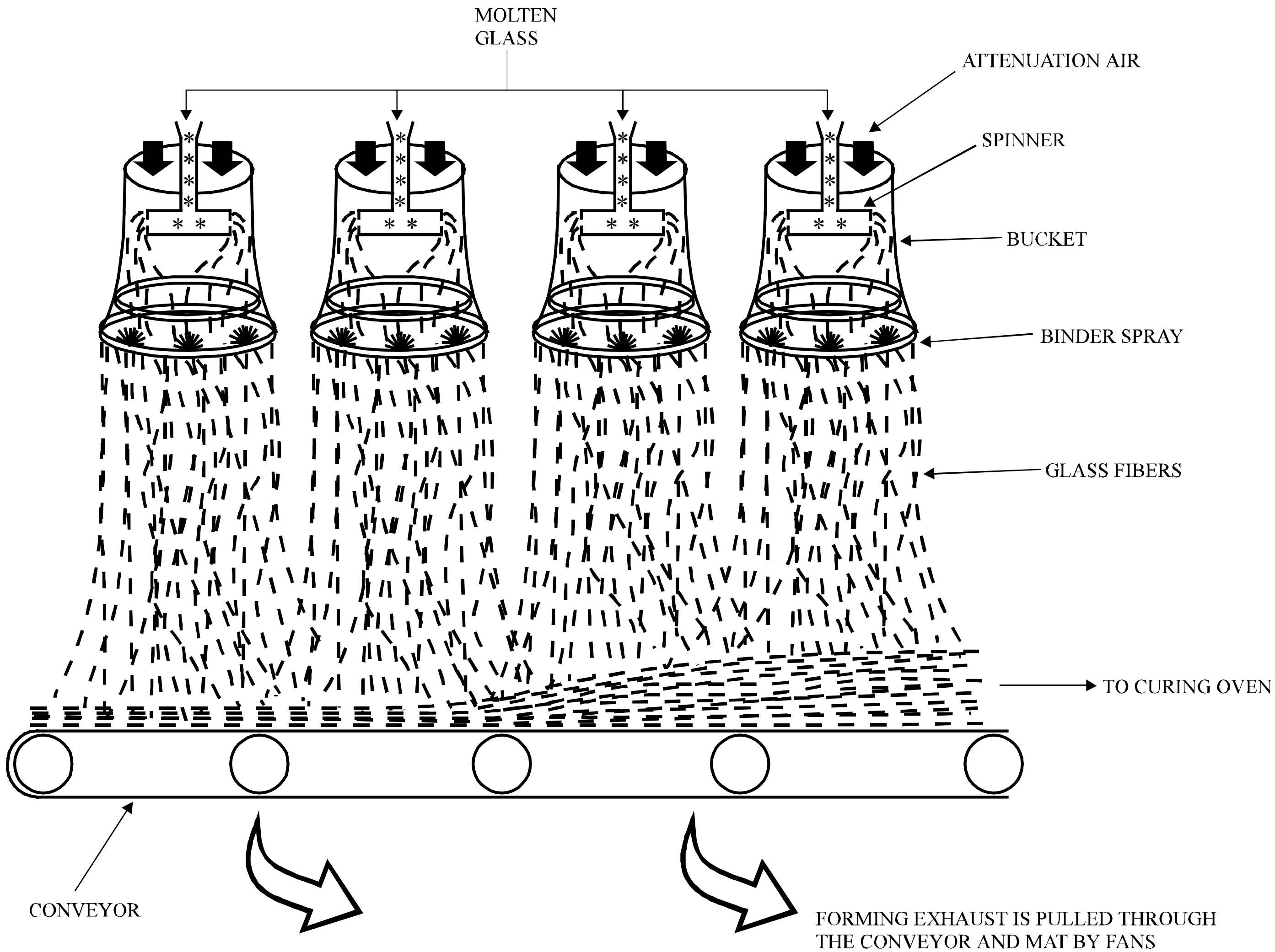

Figure 11.13-2. A typical spin process.

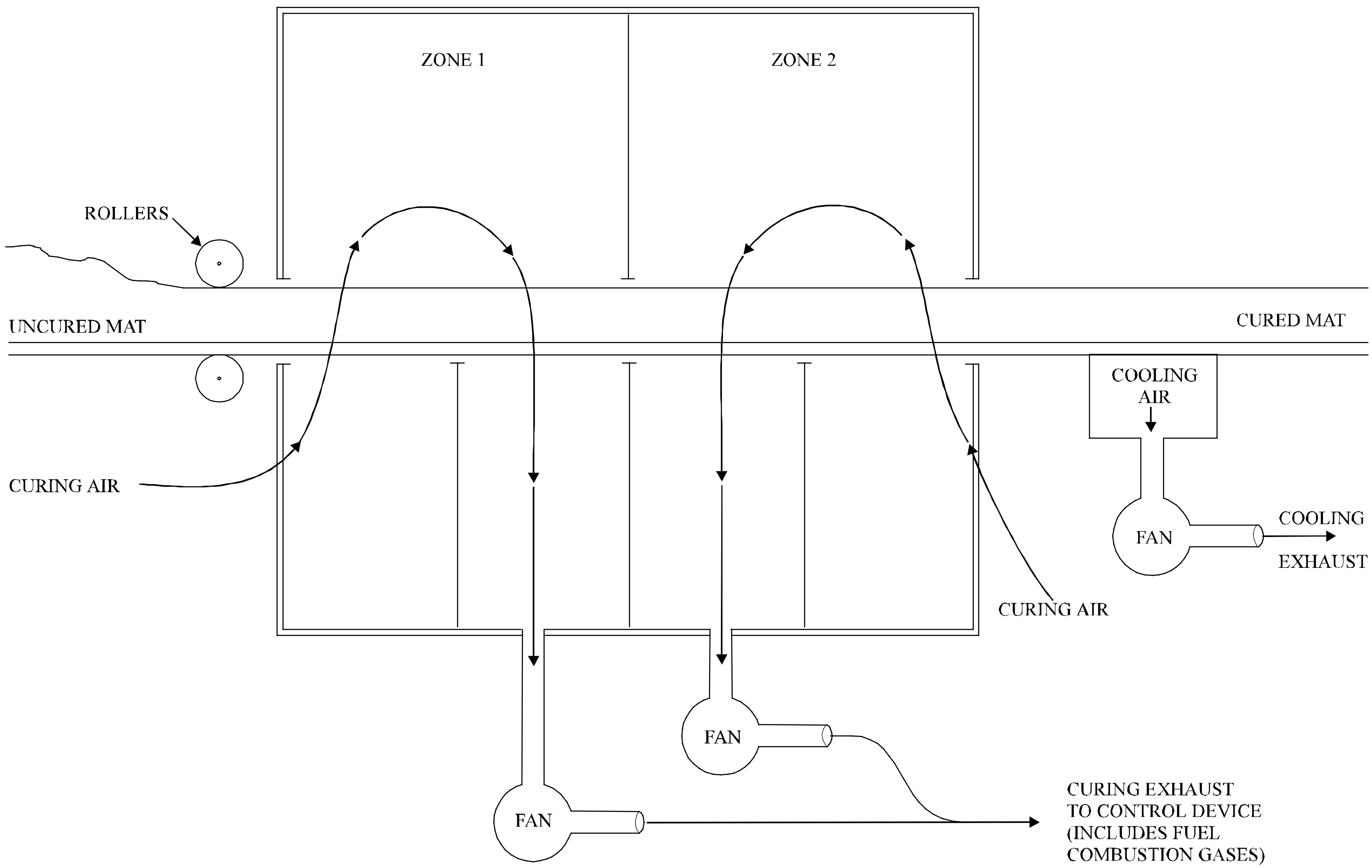

Figure 11.13-3. Side view of curing oven (indirect heating) and cooling section.

stations, the molten glass is forced through heated platinum bushings containing numerous very small openings. The continuous fibers emerging from the openings are drawn over a roller applicator, which applies a coating of a water-soluble sizing and/or coupling agent. The coated fibers are gathered and wound into a spindle. The spindles of glass fibers are next conveyed to a drying oven, where moisture is removed from the sizing and coupling agents. The spindles are then sent to an oven to cure the coatings. The final fabrication includes twisting, chopping, weaving, and packaging the fiber.

11.13.2 Emissions And Controls[1,3,4]

Emissions and controls for glass fiber manufacturing can be categorized by the 3 production phases with which they are associated. Emission factors for the glass fiber manufacturing industry are given in Tables 11.13-1, 11.13-2, and 11.13-3.

Raw Materials Handling -

The major emissions from the raw materials handling phase are fugitive dust and raw material particles generated at each of the material transfer points. Such a point would be where sand pours from a conveyor belt into a storage silo. The 2 major control techniques are wet or moist handling and fabric filters. When fabric filters are used, the transfer points are enclosed, and air from the transfer area is continuously circulated through the fabric filters.

Glass Melting And Refining -

The emissions from glass melting and refining include volatile organic compounds from the melt, raw material particles entrained in the furnace flue gas, and, if furnaces are heated with fossil fuels, combustion products. The variation in emission rates among furnaces is attributable to varying operating temperatures, raw material compositions, fuels, and flue gas flow rates. Of the various types of furnaces used, electric furnaces generally have the lowest emission rates, because of the lack of combustion products and of the lower temperature of the melt surface caused by bottom heating. Emission control for furnaces is primarily fabric filtration. Fabric filters are effective on particulate matter (PM) and sulfur oxides (SO_x) and, to a lesser extent, on carbon monoxide (CO), nitrogen oxides (NO_x), and fluorides. The efficiency of these compounds is attributable to both condensation on filterable PM and chemical reaction with PM trapped on the filters. Reported fabric filter efficiencies on regenerative and recuperative wool furnaces are for PM, 95+ percent; SO_x, 99+ percent; CO, 30 percent; and fluoride, 91 to 99 percent. Efficiencies on other furnaces are lower because of lower emission loading and pollutant characteristics.

Wool Fiber Forming And Finishing -

Emissions generated during the manufacture of wool fiberglass insulation include solid particles of glass and binder resin, droplets of binder, and components of the binder that have vaporized. Glass particles may be entrained in the exhaust gas stream during forming, curing, or cooling operations. Test data show that approximately 99 percent of the total emissions from the production line are emitted from the forming and curing sections. Even though cooling emissions are negligible at some plants, cooling emissions at others may include fugitives from the curing section. This commingling of emissions occurs because fugitive emissions from the open terminal end of the curing oven may be induced into the cooling exhaust ductwork and be discharged into the atmosphere. Solid particles of resin may be entrained in the gas stream in either the curing or cooling sections. Droplets of organic binder may be entrained in the gas stream in the forming section or may be a result of condensation of gaseous pollutants as the gas stream is cooled. Some of the liquid binder used in the forming section is vaporized by the elevated temperatures in the forming and curing processes. Much of the vaporized material will condense when the gas stream cools in the ductwork or in the emission control device.

Table 11.13-1 (Metric Units). EMISSION FACTORS FOR GLASS FIBER MANUFACTURING[a]

EMISSION FACTOR RATING: B

Source	Filterable[b]		Condensable PM[c]	
	PM	PM-10	Inorganic	Organic
	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg of Material Processed
Unloading and conveying (SCC 3-05-012-21)[d]	1.5	ND	ND	ND
Storage bins (SCC 3-05-012-22)[d]	0.1	ND	ND	ND
Mixing and weighing (SCC 3-05-012-23)[d]	0.3	ND	ND	ND
Crushing and batch charging (SCC 3-05-012-24)[d]	Neg	ND	ND	ND
Glass furnace - wool[e]				
Electric (SCC 3-05-012-03)	0.25	ND	ND	ND
Gas - regenerative (SCC 3-05-012-02)	11	ND	ND	ND
Gas - recuperative (SCC 3-05-012-01)	13 - 15	ND	ND	ND
Gas - unit melter (SCC 3-05-012-07)	4.5	ND	ND	ND
Glass furnace - textile[e]				
Gas - recuperative (SCC 3-05-012-12)	1	ND	ND	ND
Gas - regenerative (SCC 3-05-012-11)	8	ND	ND	ND
Gas - unit melter (SCC 3-05-012-13)	3	ND	ND	ND
Forming - wool				
Flame attenuation (SCC 3-05-012-08)[e]	1	ND	ND	ND
Forming - textile (SCC 3-05-012-14)[e]	0.5	ND	ND	ND
Oven curing - wool				
Flame attenuation (SCC 3-05-012-09)[e]	3	ND	ND	ND
Oven curing and cooling - textile (SCC 3-05-012-15)[e]	0.6	ND	ND	ND

Table 11.13-1 (cont.).

Source	Filterable[b]		Condensable PM[c]	
	PM	PM-10	Inorganic	Organic
	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg Of Material Processed
Rotary spin wool glass manufacturing (3-05-012-04)[f]				
R-19	17.81	ND	ND	4.25
R-11	19.61	ND	ND	3.19
Ductboard	27.72	ND	ND	8.55
Heavy density	4.91	ND	ND	1.16

[a] Factors are uncontrolled, unless otherwise noted. SCC = Source Classification Code. ND = no data. Neg = negligible.
[b] Filterable PM is that PM collected on or before to the filter of an EPA Method 5 (or equivalent) sampling train.
[c] Condensable PM is that PM collected in the impinger portion of a PM sampling train.
[d] Reference 1.
[e] Reference 5.
[f] Reference 4. Units are expressed kg/Mg of finished product.

Table 11.13-2 (English Units). EMISSION FACTORS FOR GLASS FIBER MANUFACTURING[a]

EMISSION FACTOR RATING: B

Source	Filterable[b]		Condensable PM[c]	
	PM	PM-10	Inorganic	Organic
	lb/ton Of Material Processed	lb/ton Of Material Processed	lb/ton Of Material Processed	lb/ton Of Material Processed
Unloading and conveying (SCC 3-05-012-21)[d]	3.0	ND	ND	ND
Storage bins (SCC 3-05-012-22)[d]	0.2	ND	ND	ND
Mixing and weighing (SCC 3-05-012-23)[d]	0.6	ND	ND	ND
Crushing and batch charging (SCC 3-05-012-24)[d]	Neg	ND	ND	ND
Glass furnace - wool[e]				
Electric (SCC 3-05-012-03)	0.5	ND	ND	ND
Gas - recuperative (SCC 3-05-012-02)	22	ND	ND	ND
Gas - regenerative (SCC 3-05-012-01)	25 - 30	ND	ND	ND
Gas - unit melter (SCC 3-05-012-07)	9	ND	ND	ND
Glass furnace - textile[e]				
Gas - recuperative (SCC 3-05-012-12)	2	ND	ND	ND
Gas - regenerative (SCC 3-05-012-11)	16	ND	ND	ND
Gas - unit melter (SCC 3-05-012-13)	6	ND	ND	ND
Forming - wool				
Flame attenuation (SCC 3-05-012-08)[e]	2	ND	ND	ND
Forming - textile (SCC 3-05-012-14)[e]	1	ND	ND	ND
Oven curing - wool				
Flame attenuation (SCC 3-05-012-09)[e]	6	ND	ND	ND
Oven curing and cooling - textile (SCC 3-05-012-15)[e]	1.2	ND	ND	ND

Table 11.13-2 (cont.).

Source	Filterable[b] PM lb/ton Of Material Processed	Filterable[b] PM-10 lb/ton Of Material Processed	Condensable PM[c] Inorganic lb/ton Of Material Processed	Condensable PM[c] Organic lb/ton Of Material Processed
Rotary spin wool glass manufacturing (SCC 3-05-012-04)[f]				
R-19	36.21	ND	ND	8.52
R-11	39.21	ND	ND	6.37
Ductboard	55.42	ND	ND	17.08
Heavy density	9.81	ND	ND	2.33

[a] Factors are uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data. Neg = negligible.
[b] Filterable PM is that PM collected on or before the filter of an EPA Method 5 (or equivalent) sampling train.
[c] Condensable PM is that PM collected in the impinger portion of a PM sampling train.
[d] Reference 1.
[e] Reference 5.
[f] Reference 4. Units are lb/ton of finished product.

Table 11.13-3 (Metric Units). EMISSION FACTORS FOR GLASS FIBER MANUFACTURING[a]

EMISSION FACTOR RATING: B

Source	SO_x	NO_x	CO
	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg Of Material Processed
Glass furnace - wool[b]			
Electric (SCC 3-05-012-03)	0.02	0.14	0.025
Gas - regenerative (SCC 3-05-012-01)	5	2.5	0.13
Gas - recuperative (SCC 3-05-012-02)	5	0.85	0.13
Gas - unit melter (SCC 3-05-012-07)	0.3	0.15	0.13
Glass furnace - textile[b]			
Gas - recuperative (SCC 3-05-012-12)	1.5	10	0.25
Gas - regenerative (SCC 3-05-012-11)	15	10	0.5
Gas - unit melter (SCC 3-05-012-13)	ND	10	0.45
Forming - wool[b]			
Flame attenuation (SCC 3-05-012-08)	NA	NA	NA
Forming - textile[b] (SCC 3-05-012-14)	NA	NA	NA
Oven curing - wool[b]			
Flame attenuation (SCC 3-05-012-09)	ND	1	1.8
Oven curing and cooling - textile[b] (SCC 3-05-012-15)	NA	1.3	0.75

[a] Factors are uncontrolled unless otherwise noted. SCC = Source Classification Code. ND = no data. NA = not applicable.
[b] Reference 5.

Table 11.13-4 (English Units). EMISSION FACTORS FOR GLASS FIBER MANUFACTURING[a]

EMISSION FACTOR RATING: B

Source	SO_x lb/ton Of Material Processed	NO_x lb/ton Of Material Processed	CO lb/ton Of Material Processed
Glass furnace - wool			
Electric (SCC 3-05-012-03)[b]	0.04	0.27	0.05
Gas - regenerative (SCC 3-05-012-01)	10	5	0.25
Gas - recuperative (SCC 3-05-012-02)	10	1.7	0.25
Gas - unit melter (SCC 3-05-012-07)	0.6	0.3	0.25
Glass furnace - textile			
Gas - recuperative (SCC 3-05-012-12)[b]	3	20	0.5
Gas - regenerative (SCC 3-05-012-11)	30	20	1
Gas - unit melter (SCC 3-05-012-13)	ND	20	0.9
Forming - wool			
Flame attenuation (SCC 3-05-012-08)[b]	NA	NA	NA
Forming - textile (SCC 3-05-012-14)[b]	NA	NA	NA
Oven curing - wool			
Flame attenuation (SCC 3-05-012-09)[b]	ND	2	3.5
Oven curing and cooling - textile (SCC 3-05-012-15)[b]	NA	2.6	1.5

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Reference 5.

Table 11.13-5 (Metric Units). EMISSION FACTORS FOR GLASS FIBER MANUFACTURING[a]

EMISSION FACTOR RATING: B

Source	VOC	Phenolics	Phenol	Formaldehyde	Fluorides
	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg Of Material Processed	kg/Mg Of Material Processed
Glass furnace - wool					
Electric (SCC 3-05-012-03)[b]	ND	ND	ND	ND	0.001
Gas - regenerative (SCC 3-05-012-01)	ND	ND	ND	ND	0.06
Gas - recuperative (SCC 3-05-012-02)	ND	ND	ND	ND	0.06
Gas - unit melter (SCC 3-05-012-07)	ND	ND	ND	ND	0.06
Glass furnace - textile[b]					
Gas - recuperative (SCC 3-05-012-12)	ND	ND	ND	ND	1
Gas - regenerative (SCC 3-05-012-11)	ND	ND	ND	ND	1
Gas - unit melter (SCC 3-05-012-13)	ND	ND	ND	ND	1
Forming - wool					
Flame attenuation (SCC 3-05-012-08)[b]	0.15	ND	ND	ND	ND
Forming - textile (SCC 3-05-012-14)[b]	Neg	ND	ND	ND	NA
Oven curing - wool					
Flame attenuation (SCC 3-05-012-09)[b]	3.5	ND	ND	ND	ND
Oven curing and cooling - textile (SCC 3-05-012-15)[b]	Neg	ND	ND	ND	ND
Rotary spin wool glass fiber manufacturing (SCC 3-05-012-04)[c]					
R-19	ND	3.21	0.96	0.75	ND
R-11	ND	6.21	0.92	1.23	ND
Ductboard	ND	10.66	3.84	1.80	ND
Heavy density	ND	0.88	0.53	0.43	ND

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data. NA = not applicable. Neg = negligible.
[b] Reference 5.
[c] Reference 4.

Table 11.13-6 (English Units). EMISSION FACTORS FOR GLASS FIBER MANUFACTURING[a]

EMISSION FACTOR RATING: B

Source	VOC lb/ton Of Material Processed	Phenolics lb/ton Of Material Processed	Phenol lb/ton Of Material Processed	Formaldehyde lb/ton Of Material Processed	Fluorides lb/ton Of Material Processed
Glass furnace - wool					
Electric (SCC 3-05-012-03)[b]	ND	ND	ND	ND	0.002
Gas - regenerative (SC 3-05-012-01)	ND	ND	ND	ND	0.12
Gas - recuperative (SCC 3-05-012-02)	ND	ND	ND	ND	0.11
Gas - unit melter (SCC 3-05-012-07)	ND	ND	ND	ND	0.12
Glass furnace - textile[b]					
Gas - recuperative (SCC 3-05-021-12)	ND	ND	ND	ND	2
Gas - regenerative (SCC 3-05-021-11)	ND	ND	ND	ND	2
Gas - unit melter (SCC 3-05-021-13)	ND	ND	ND	ND	2
Forming - wool					
Flame attenuation (SCC 3-05-021-08)[b]	0.3	ND	ND	ND	ND
Forming - textile (SCC 3-05-021-14)[b]	Neg	ND	ND	ND	NA
Oven curing - wool					
Flame attenuation (SCC 3-05-021-09)[b]	7	ND	ND	ND	ND
Oven curing and cooling - textile (SCC 3-05-021-15)[b]	Neg	ND	ND	ND	ND
Rotary spin wool glass fiber manufacturing (SCC 3-05-021-04)[c]					
R-19	ND	6.92	1.92	1.50	ND
R-11	ND	12.41	1.84	2.46	ND
Ductboard	ND	21.31	7.68	3.61	ND
Heavy duty	ND	1.74	1.04	0.85	ND

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data. NA = not applicable. Neg = negligible.
[b] Reference 5.
[c] Reference 4.

Particulate matter is the principal pollutant that has been identified and measured at wool fiberglass insulation manufacturing facilities. It was known that some fraction of the PM emissions results from condensation of organic compounds used in the binder. Therefore, in evaluating emissions and control device performance for this source, a sampling method, EPA Reference Method 5E, was used that permitted collection and measurement of both solid particles and condensed PM.

Tests were performed during the production of R-11 building insulation, R-19 building insulation, ductboard, and heavy-density insulation. These products, which account for 91 percent of industry production, had densities ranging from 9.1 to 12.3 kilograms per cubic meter (kg/m^3) (0.57 to 0.77 pounds per cubic foot [lb/ft^3]) for R-11, 8.2 to 9.3 kg/m^3 (0.51 to 0.58 lb/ft^3) for R-19, and 54.5 to 65.7 kg/m^3 (3.4 to 4.1 lb/ft^3) for ductboard. The heavy-density insulation had a density of 118.5 kg/m^3 (7.4 lb/ft^3). (The remaining 9 percent of industry wool fiberglass production is a variety of specialty products for which qualitative and quantitative information is not available.) The loss on ignition (LOI) of the product is a measure of the amount of binder present. The LOI values ranged from 3.9 to 6.5 percent, 4.5 to 4.6 percent, and 14.7 to 17.3 percent for R-11, R-19, and ductboard, respectively. The LOI for heavy-density insulation is 10.6 percent. A production line may be used to manufacture more than one of these product types because the processes involved do not differ. Although the data base did not show sufficient differences in mass emission levels to establish separate emission standards for each product, the uncontrolled emission factors are sufficiently different to warrant their segregation for AP-42.

The level of emissions control found in the wool fiberglass insulation manufacturing industry ranges from uncontrolled to control of forming, curing, and cooling emissions from a line. The exhausts from these process operations may be controlled separately or in combination. Control technologies currently used by the industry include wet ESPs, low- and high-pressure-drop wet scrubbers, low- and high-temperature thermal incinerators, high-velocity air filters, and process modifications. These added control technologies are available to all firms in the industry, but the process modifications used in this industry are considered confidential. Wet ESPs are considered to be best demonstrated technology for the control of emissions from wool fiberglass insulation manufacturing lines. Therefore, it is expected that most new facilities will be controlled in this manner.

Textile Fiber Forming And Finishing -

Emissions from the forming and finishing processes include glass fiber particles, resin particles, hydrocarbons (primarily phenols and aldehydes), and combustion products from dryers and ovens. Emissions are usually lower in the textile fiber glass process than in the wool fiberglass process because of lower turbulence in the forming step, roller application of coatings, and use of much less coating per ton of fiber produced.

References For Section 11.13

1. J. R. Schorr *et al.*, *Source Assessment: Pressed And Blown Glass Manufacturing Plants*, EPA-600/2-77-005, U. S. Environmental Protection Agency, Cincinnati, OH, January 1977.

2. *Annual Book Of ASTM Standards, Part 18*, ASTM Standard C167-64 (Reapproved 1979), American Society For Testing And Materials, Philadelphia, PA.

3. *Standard Of Performance For Wool Fiberglass Insulation Manufacturing Plants*, 50 FR 7700, February 25, 1985.

4. *Wool Fiberglass Insulation Manufacturing Industry: Background Information For Proposed Standards*, EPA-450/3-83-022a, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 1983.

5. *Screening Study to Determine Need for Standards of Performance for New Sources in the Fiber Glass Manufacturing Industry--Draft*, U. S. Environmental Protection Agency, Research Triangle Park, NC, December 1976.