11.18 Mineral Wool Manufacturing

11.18.1 General[1,2]

Mineral wool often is defined as any fibrous glassy substance made from minerals (typically natural rock materials such as basalt or diabase) or mineral products such as slag and glass. Because glass wool production is covered separately in AP-42 (Section 11.13), this section deals only with the production of mineral wool from natural rock and slags such as iron blast furnace slag, the primary material, and copper, lead, and phosphate slags. These materials are processed into insulation and other fibrous building materials that are used for structural strength and fire resistance. Generally, these products take 1 of 4 forms: "blowing" wool or "pouring" wool, which is put into the structural spaces of buildings; batts, which may be covered with a vapor barrier of paper or foil and are shaped to fit between the structural members of buildings; industrial and commercial products such as high-density fiber felts and blankets, which are used for insulating boilers, ovens, pipes, refrigerators, and other process equipment; and bulk fiber, which is used as a raw material in manufacturing other products, such as ceiling tile, wall board, spray-on insulation, cement, and mortar.

Mineral wool manufacturing facilities are included in Standard Industrial Classification (SIC) Code 3296, mineral wool. This SIC code also includes the production of glass wool insulation products, but those facilities engaged in manufacturing textile glass fibers are included in SIC Code 3229. The 6-digit Source Classification Code (SCC) for mineral wool manufacturing is 3-05-017.

11.18.2 Process Description[1,4,5]

Most mineral wool produced in the United States today is produced from slag or a mixture of slag and rock. Most of the slag used by the industry is generated by integrated iron and steel plants as a blast furnace byproduct from pig iron production. Other sources of slag include the copper, lead, and phosphate industries. The production process has 3 primary components--molten mineral generation in the cupola, fiber formation and collection, and final product formation. Figure 11.18-1 illustrates the mineral wool manufacturing process.

The first step in the process involves melting the mineral feed. The raw material (slag and rock) is loaded into a cupola in alternating layers with coke at weight ratios of about 5 to 6 parts mineral to 1 part coke. As the coke is ignited and burned, the mineral charge is heated to the molten state at a temperature of 1300 to 1650°C (2400 to 3000°F). Combustion air is supplied through tuyeres located near the bottom of the furnace. Process modifications at some plants include air enrichment and the use of natural gas auxiliary burners to reduce coke consumption. One facility also reported using an aluminum flux byproduct to reduce coke consumption.

The molten mineral charge exits the bottom of the cupola in a water-cooled trough and falls onto a fiberization device. Most of the mineral wool produced in the United States is made by variations of 2 fiberization methods. The Powell process uses groups of rotors revolving at a high rate of speed to form the fibers. Molten material is distributed in a thin film on the surfaces of the rotors and then is thrown off by centrifugal force. As the material is discharged from the rotor, small globules develop on the rotors and form long, fibrous tails as they travel horizontally. Air or steam may be blown around the rotors to assist in fiberizing the material. A second fiberization method, the Downey process, uses a spinning concave rotor with air or steam attenuation. Molten material is

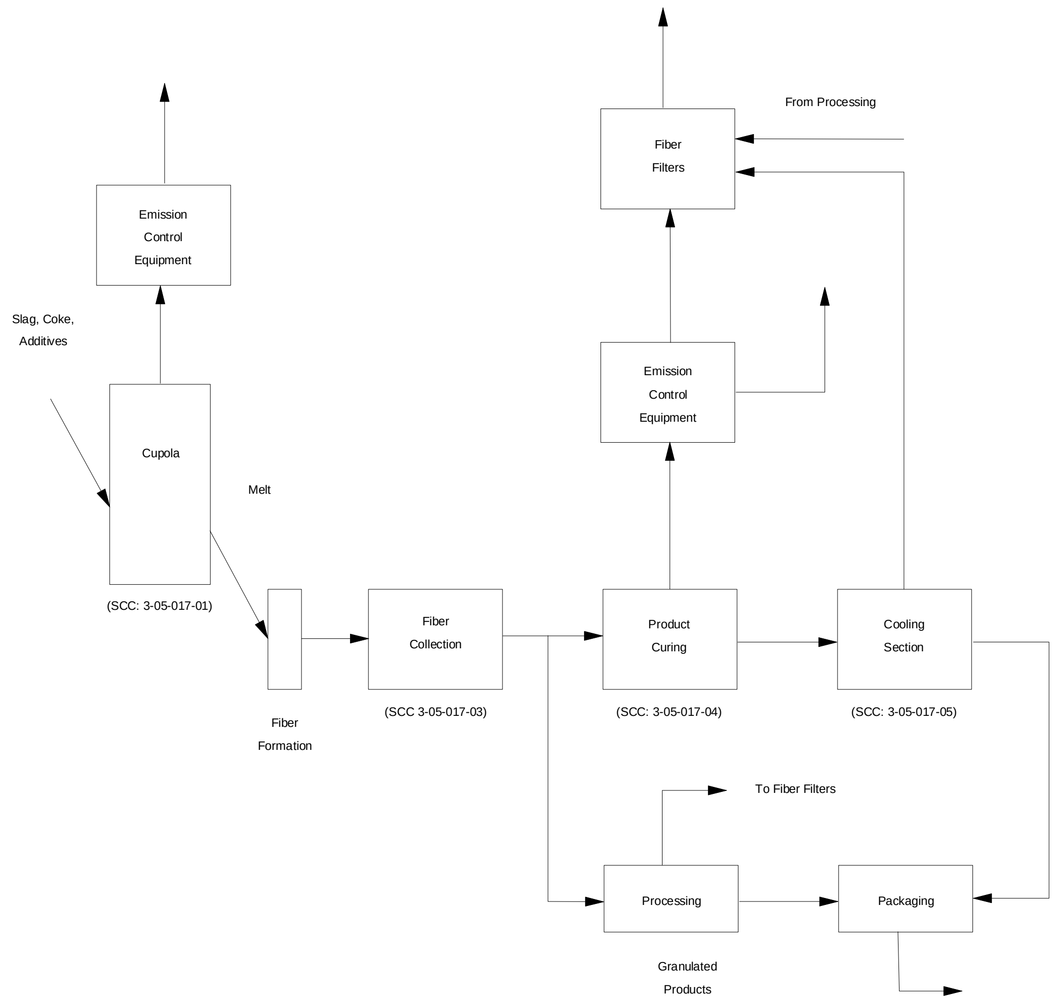

Figure 11.18-1. Mineral wool manufacturing process flow diagram.
(Source Classification Codes in parentheses.)

distributed over the surface of the rotor, from which it flows up and over the edge and is captured and directed by a high-velocity stream of air or steam.

During the spinning process, not all globules that develop are converted into fiber. The nonfiberized globules that remain are referred to as "shot." In raw mineral wool, as much as half of the mass of the product may consist of shot. As shown in Figure 11.18-1, shot is usually separated from the wool by gravity immediately following fiberization.

Depending on the desired product, various chemical agents may be applied to the newly formed fiber immediately following the rotor. In almost all cases, an oil is applied to suppress dust and, to some degree, anneal the fiber. This oil can be either a proprietary product or a medium- weight fuel or lubricating oil. If the fiber is intended for use as loose wool or bulk products, no further chemical treatment is necessary. If the mineral wool product is required to have structural rigidity, as in batts and industrial felt, a binding agent is applied with or in place of the oil treatment. This binder is typically a phenol-formaldehyde resin that requires curing at elevated temperatures. Both the oil and the binder are applied by atomizing the liquids and spraying the agents to coat the airborne fiber.

After formation and chemical treatment, the fiber is collected in a blowchamber. Resin- and/or oil-coated fibers are drawn down on a wire mesh conveyor by fans located beneath the collector. The speed of the conveyor is set so that a wool blanket of desired thickness can be obtained.

Mineral wool containing the binding agent is carried by conveyor to a curing oven, where the wool blanket is compressed to the appropriate density and the binder is baked. Hot air, at a temperature of 150 to 320°C (300 to 600°F), is forced through the blanket until the binder has set. Curing time and temperature depend on the type of binder used and the mass rate through the oven. A cooling section follows the oven, where blowers force air at ambient temperatures through the wool blanket.

To make batts and industrial felt products, the cooled wool blanket is cut longitudinally and transversely to the desired size. Some insulation products are then covered with a vapor barrier of aluminum foil or asphalt-coated kraft paper on one side and untreated paper on the other side. The cutters, vapor barrier applicators, and conveyors are sometimes referred to collectively as a batt machine. Those products that do not require a vapor barrier, such as industrial felt and some residential insulation batts, can be packed for shipment immediately after cutting.

Loose wool products consist primarily of blowing wool and bulk fiber. For these products, no binding agent is applied, and the curing oven is eliminated. For granulated wool products, the fiber blanket leaving the blowchamber is fed to a shredder and pelletizer. The pelletizer forms small, 1-inch diameter pellets and separates shot from the wool. A bagging operation completes the processes. For other loose wool products, fiber can be transported directly from the blowchamber to a baler or bagger for packaging.

11.18.3 Emissions And Controls[1,13]

The sources of emissions in the mineral wool manufacturing industry are the cupola; binder storage, mixing, and application; the blow chamber; the curing oven; the mineral wool cooler; materials handling and bagging operations; and waste water treatment and storage. With the exception of lead, the industry emits the full range of criteria pollutants. Also, depending on the particular types of slag and binding agents used, the facilities may emit both metallic and organic hazardous air pollutants (HAPs).

The primary source of emissions in the mineral wool manufacturing process is the cupola. It is a significant source of particulate matter (PM) emissions and is likely to be a source of PM less than 10 micrometers (µm) in diameter (PM-10) emissions, although no particle size data are available. The cupola is also a potential source of HAP metal emissions attributable to the coke and slags used in the furnace. Coke combustion in the furnace produces carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen oxide (NO_x) emissions. Finally, because blast furnace slags contain sulfur, the cupola is also a source of sulfur dioxide (SO_2) and hydrogen sulfide (H_2S) emissions.

The blowchamber is a source of PM (and probably PM-10) emissions. Also, the annealing oils and binders used in the process can lead to VOC emissions from the process. Other sources of VOC emissions include batt application, the curing oven, and waste water storage and treatment. Finally, fugitive PM emissions can be generated during cooling, handling, and bagging operations. Tables 11.18-1 and 11.18-2 present emission factors for filterable PM emissions from various mineral wool manufacturing processes; Tables 11-18.3 and 11.18-4 show emission factors for CO, CO_2, SO_2, and sulfates; and Tables 11.18-5 and 11.18-6 present emission factors for NO_x, N_2O, H_2S and fluorides.

Mineral wool manufacturers use a variety of air pollution control techniques, but most are directed toward PM control with minimal control of other pollutants. The industry has given greatest attention to cupola PM control, with two-thirds of the cupolas in operation having fabric filter control systems. Some cupola exhausts are controlled by wet scrubbers and electrostatic precipitators (ESPs); cyclones are also used for cupola PM control either alone or in combination with other control devices. About half of the blow chambers in the industry also have some level of PM control, with the predominant control device being low-energy wet scrubbers. Cyclones and fabric filters have been used to a limited degree on blow chambers. Finally, afterburners have been used to control VOC emissions from blow chambers and curing ovens and CO emissions from cupolas.

Table 11.18-1 (Metric Units). EMISSION FACTORS FOR MINERAL WOOL MANUFACTURING[a]

Process	Filterable PM[b]	
	kg/Mg Of Product	EMISSION FACTOR RATING
Cupola[c] (SCC 3-05-017-01)	8.2	E
Cupola with fabric filter[d] (SCC 3-05-017-01)	0.051	D
Reverberatory furnace[e] (SCC 3-05-017-02)	2.4	E
Batt curing oven[e] (SCC 3-05-017-04)	1.8	E
Batt curing oven with ESP[f] (SCC 3-05-017-04)	0.36	D
Blow chamber[c] (SCC 3-05-017-03)	6.0	E
Blow chamber with wire mesh filter[g] (SCC 3-05-017-03)	0.45	D
Cooler[e] (SCC 3-05-017-05)	1.2	E

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code.
[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.
[c] References 1,12. Activity level is assumed to be total feed charged.
[d] References 6,7,8,10,11. Activity level is total feed charged.
[e] Reference 12.
[f] Reference 9.
[g] Reference 7. Activity level is mass of molten mineral feed charged.

Table 11.18-2 (English Units). EMISSION FACTORS FOR MINERAL WOOL MANUFACTURING[a]

Process	Filterable PM[b]	
	lb/ton Of Product	EMISSION FACTOR RATING
Cupola[c] (SCC 3-05-017-01)	16	E
Cupola with fabric filter[d] (SCC 3-05-017-01)	0.10	D
Reverberatory furnace[e] (SCC 3-05-017-02)	4.8	E
Batt curing oven[e] (SCC 3-05-017-04)	3.6	E
Batt curing oven with ESP[f] (SCC 3-05-017-04)	0.72	D
Blow chamber[c] (SCC 3-05-017-03)	12	E
Blow chamber with wire mesh filter[g] (SCC 3-05-017-03)	0.91	D
Cooler[e] (SCC 3-05-017-05)	2.4	E

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code.

[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.

[c] Reference 1,12. Activity level is assumed to be total feed charged.

[d] References 6,7,8,10,11. Activity level is total feed charged.

[e] Reference 12.

[f] Reference 9.

[g] Reference 7. Activity level is mass of molten mineral feed charged.

Table 11.18-3 (Metric Units). EMISSION FACTORS FOR MINERAL WOOL MANUFACTURING[a]

Source	CO^b		$CO_2{}^b$		SO_2		SO_3	
	kg/Mg Of Total Feed Charged	EMISSION FACTOR RATING	kg/Mg Of Total Feed Charged	EMISSION FACTOR RATING	kg/Mg Of Total Feed Charged	EMISSION FACTOR RATING	kg/Mg Of Total Feed Charged	EMISSION FACTOR RATING
Cupola (SCC 3-05-017 01)	125	D	260	D	4.0[c]	D	3.2[d]	E
Cupola with fabric filter (SCC 3-05-017-01)	NA		NA		NA		0.077[b]	E
Batt curing oven (SCC 3-05-017-04)	ND		ND		0.58[d]	E	ND	
Blow chamber (SCC 3-05-017-03)	ND		80[e]	E	0.43[d]	E	ND	
Cooler (SCC 3-05-017-05)	ND		ND		0.034[d]	E	ND	

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. NA = not applicable. ND = no data.
[b] Reference 6.
[c] References 6,10,11.
[d] Reference 12.
[e] Reference 9.

Table 11.18-4 (English Units). EMISSION FACTORS FOR MINERAL WOOL MANUFACTURING[a]

Source	CO^b		CO_2[b]		SO_2		SO_3	
	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING
Cupola (SCC 3-05-017-01)	250	D	520	D	8.0[a]	D	6.3[d]	E
Cupola with fabric filter (SCC 3-05-017-01)	NA		NA		NA		0.15[b]	E
Batt curing oven (SCC 3-05-017-04)	ND		ND		1.2[d]	E	ND	
Blow chamber (SCC 3-05-017-03)	ND		160[e]	E	0.87[d]	E	ND	
Cooler (SCC 3-05-017-05)	ND		ND		0.068[d]	E	ND	

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. NA = not applicable. ND = no data.
[b] Reference 6.
[c] References 6,10,11.
[d] Reference 12.
[e] Reference 9.

Table 11.18-5 (Metric Units). EMISSION FACTORS FOR MINERAL WOOL MANUFACTURING[a]

Process	NO_x		N_2O		H_2S		Fluorides	
	kg/Mg Of Total Feed Charged	EMISSION FACTOR RATING	kg/Mg Of Total Feed Charged	EMISSION FACTOR RATING	kg/mg Of Total Feed Charged	EMISSION FACTOR RATING	kg/Mg Of Total Feed Charged	EMISSION FACTOR RATING
Cupola (SCC 3-05-017-01)	0.8[b]	E	ND		1.5[b]	E	ND	
Cupola with fabric filter (SCC 3-05-017-01)	ND		ND		ND		0.019[c]	D
Cupola with fabric filter (SCC 3-05-017-01)	ND		ND		ND		0.19[d]	D
Batt curing oven (SCC 3-05-017-14)	ND		0.079	E	ND		ND	

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data.
[b] Reference 1.
[c] References 10-11. Coke only used as fuel.
[d] References 10-11. Fuel combination of coke and aluminum smelting byproducts.

Table 11.18-6 (English Units). EMISSION FACTORS FOR MINERAL WOOL MANUFACTURING[a]

Process	NO_x		N_2O		H_2S		Fluorides	
	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING	lb/ton Of Total Feed Charged	EMISSION FACTOR RATING
Cupola (SCC 3-05-017-01)	1.6[b]	E	ND		3.0[b]	E	ND	
Cupola with fabric filter (SCC 3-05-017-01)	ND		ND		ND		0.038[c]	D
Cupola with fabric filter (SCC 3-05-017-01)	ND		ND		ND		0.38[d]	D
Batt curing oven (SCC 3-05-017-14)	ND		0.16	E	ND		ND	

[a] Factors represent uncontrolled emissions unless otherwise noted. SCC = Source Classification Code. ND = no data.
[b] Reference 1.
[c] References 10-11. Coke only used as fuel.
[d] References 10-11. Fuel combination of coke and aluminum smelting byproducts.

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