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MINERAL WOOL MANUFACTURING
AP-42 Section 8.16
Reference Number
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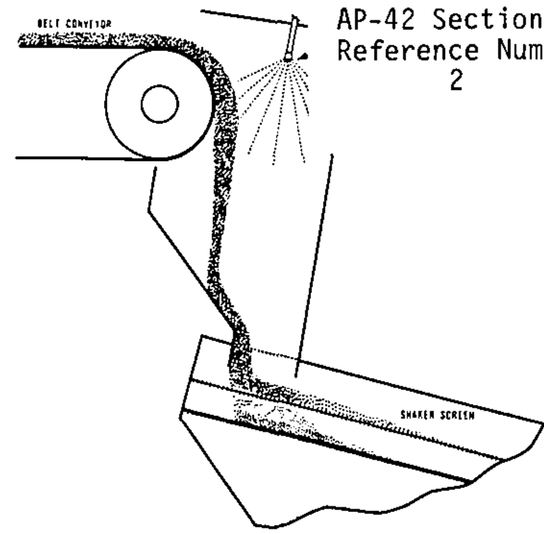

Figure 240. Nozzle arrangement for control of dust emissions from the inlet to the shaker screens.

The preferred dust collector device is a baghouse. Standard cotton sateen bags can be used at a filtering velocity of 3 fpm. For large plants that maintain continuous operation, compartmented collectors are required to allow for bag shaking. Most plants, however, have shutdown periods of sufficient frequency to allow the use of a noncompartmented collector. Virtually 100 percent collection can be achieved, and as mentioned previously, the dust is a salable product.

A combination of a dry centrifugal collector and a wet scrubber is sometimes used. In this case, only the centrifugal device collects material in a salable form. A centrifugal collector alone would allow a considerable amount of very fine dust to be emitted to the atmosphere. A scrubber of good design is required, therefore, to prevent such emissions.

MINERAL WOOL FURNACES

INTRODUCTION

The general product classification known as mineral wool was formerly divided into three categories: Slag wool, rock wool, and glass wool.

Slag wool, which was made from iron slag or copper slag, was first successfully manufactured in England in 1885, after earlier attempts had failed in the United States (Kirk and Othmer, 1947). The first manufacture of rock wool (which was made from natural rock) took place at Alexandria, Indiana, in 1897. Glass wool (made from glass cullet or high silica sand, or both) was later pioneered in Newark, Ohio, in 1931.

Today, however, straight slag wool and rock wool as such are no longer manufactured. A combination of slag and rock constitutes the cupola charge materials in more recent times, yielding a product generally classified as mineral wool, as contrasted with glass wool.

Mineral wool is made today in Los Angeles County with a cupola by using blast furnace slag, silica rock, and coke (to serve as fuel). It has been produced here in the past by using a reverberatory furnace charged with Borax ore tailings, dolomite, and lime rock heated with natural gas.

Types and Uses of Mineral Wool Products

Mineral wool consists of silicate fibers 5 to 7 microns in diameter (Allen et al., 1952) and about 1/2-inch long, and is used mainly for thermal and acoustical insulation. It has a density of about 6 pounds per cubic foot and is collected initially as a continuous loose blanket of fibers on a conveying belt. It is sold, however, as quilt, loose rolls, industrial felt, batts, or in a granulated form.

Batts are rectangular sections of mineral wool approximately 4 by 15 by 48 to 60 inches in size. These sections are covered on top and two sides with paper, and the bottom is covered with either an asphalt-coated paper or aluminum foil. Batts are used for thermal insulation in residential homes and for many other insulation needs.

Granulated mineral wool, which is handled pneumatically, is also used for home insulation. Quilt is normally 60 inches wide and 2 inches thick and contains the binder agent and paper cover. It is used primarily for industrial insulation. Loose rolls, which contain no binder agent and are sometimes enclosed in a fine mesh cover, are used for applications such as water heaters and house trailers. Industrial felt consists of wool blanket with binder agent but without a paper covering and has a slightly greater density than that of batts. It is used for items such as walk-in refrigerators and industrial ovens.

Mineral Wool Production

The cupola or furnace charge is heated to the molten state at about 3,000°F, after which it is fed by gravity into a device at the receiving end of a large blowchamber. This device may be a trough-like arrangement with several drains, or a cup-like receiver on the end of a revolving arm. The molten material is atomized by steam and blasted horizontally towards the other end of the blowchamber. When the cup or spinner device is used, the action of the steam is assisted by centrifugal force. The steam atomizes the molten rock into small globules that develop and trail long, fibrous tails as they travel towards the other end of the blowchamber. These fibers reportedly can be drawn mechanically or spun without steam, but this process is foreign to Los Angeles County.

Phenolic resin or a mixture of linseed oil and asphalt are examples of binding agents that can be atomized at the center of the steam ring by a separate steam jet to act as a binder for the fibers. Annealing oil can also be steam atomized near the steam ring to incorporate a quality of resilience to the fibers that prevents breakage.

A temperature between 150° and 250°F is maintained in the blowchamber. Blowers, which take suction beneath the wire mesh conveyor belt in the blowchamber, aid the fibers in settling on the belt. The mineral wool blanket of fibers is conveyed to an oven for curing the binding agent. Normally gas fired, the oven has a temperature of 300° to 500°F.

The mineral wool is next programmed through a cooler, as shown in the flow diagram in Figure 241. Usually consisting of an enclosure housing a blower, the cooler reduces the temperature of the blanket to prevent the asphalt, which is applied later to the paper cover, from melting.

To make batts, the blanket leaving the cooler is processed through a multibladed, longitudinal cutter to separate it into sections of desired widths. Brown paper and either asphalt-coated paper or aluminum foil are then applied to the sections of blanket. The asphalt-coated paper is passed through a bath of hot asphalt just before its application to the underside of each section. This asphalt film serves as a moisture barrier as well as a bonding agent against walls. The paper-covered sections are cut to desired lengths by a transverse saw, after which the finished product is packed for storage and shipment. The two cutters, paper and asphalt applicators, and conveyor systems are sometimes referred to collectively as a batt machine.

A granulated-wool production line differs from that just described in that the mineral wool blanket, after leaving the blowchamber, is fed to a shredder for granulation, then to a pelletizer. The pelletizer serves two functions, namely, to form small 1-inch-diameter wool pellets and to drop out small black particles called shot, which form as the molten slag cools in the blowchamber. A bagging operation completes the process. Since no binding agent is required, the curing oven is eliminated.

THE AIR POLLUTION PROBLEM

The major source of emissions is the cupola or furnace stack. Its discharge consists primarily of condensed fumes that have volatilized from the

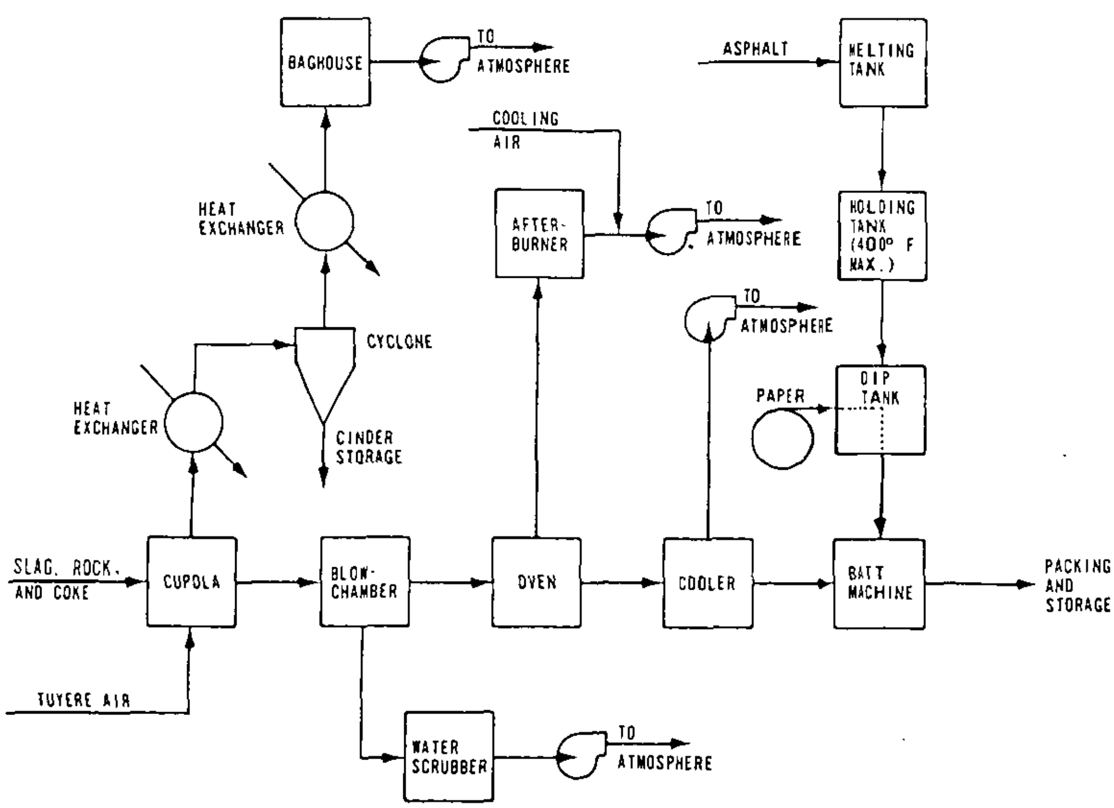

Figure 241. Flow diagram of mineral wool process.

molten charge, and gases such as sulfur oxides and fluorides. Amounting to as much as 100 pounds per hour and submicron in size, condensed fumes create a considerable amount of visible emissions and can be a public nuisance. Table 98 shows the weights of emissions discharged from uncontrolled cupolas and furnaces. A particle size distribution of the emissions is shown in Table 99.

Another source of air pollution is the blowchamber. Its emissions (see Table 100) consist of fumes, oil vapors, binding agent aerosols, and wool fibers. In terms of weight, a blowchamber may also emit as much as 100 pounds of particulate matter per hour at a production rate of 2 tons per hour if the blowchamber vent is uncontrolled. Approximately 90 percent of these emissions consists of mineral wool fibers.

Types of air contaminants from the curing oven are identical to those from the blowchamber except that no metallurgical fumes are involved. These emissions amount to approximately 8 pounds per hour at a production rate of 2 tons per hour, as seen in Table 101, since the amount of wool fibers discharged is much less than that for a blowchamber. From a visible standpoint, however, these pollutants may create opacities as high as 70 percent. Emissions from the cooler are only 4 or 5 pounds per hour at a production rate of 2 tons per hour (see Table 102). The asphalt applicator can also be a source of air pollution if the temperature of the melting or holding pot exceeds 400°F.

HOODING AND VENTILATION REQUIREMENTS

No special hooding arrangements as such are required in any of the exhaust systems employed in the control of pollution from mineral wool processes. The one possible exception is that canopy hoods may be used over the asphalt tanks if the emissions from these tanks are excessive and are vented to an air pollution control device.

The ventilation requirements for the various individual processes in a mineral wool system are categorized as follows:

1. Cupolas. Based on test data, exhaust requirements can be estimated to be 5,000 to 7,000 scfm for a cupola with a process weight of from 4,000 to 4,500 pounds per hour, on the assumption that no outside cooling air is introduced. The charge door should be kept in the closed position to obtain maximum benefit from the capacity of the exhaust fan. A barometric damper in the line between the cupola and the blower can be used to control the amount of gases pulled from the cupola. The objective is to remove all tuyere air plus an additional amount of air to maintain a slight negative pressure above the burden.

2. Reverberatory furnaces. Ventilation requirements are about 15,000 to 20,000 cfm (at 600°F) for a furnace sized to produce 1,500 to 3,000 pounds of mineral wool per hour. The heat in these furnace gases can be used in making steam before filtration.

3. Blowchambers. For a blowchamber with a size of about 4,500 cubic feet and with a capacity for processing 4,000 pounds of wool an hour, the minimum ventilation requirements are 20,000 to 25,000 scfm. All duct takeoffs must be located at the bottom of the blowchamber beneath the conveyor to create downdraft,

Table 98. DUST AND FUME DISCHARGES FROM MINERAL WOOL CUPOLAS AND FURNACES

Test data	Test No.				
	Cupola				Reverberatory furnace
	1	3	6A	13	19[a]
Process wt, lb/hr	3,525	4,429	-	3,625	3,050
Stack volume, scfm	4,550	4,545	4,510	4,760	2,740
Stack gas temp, °F[b]	309	295	314	338	625
Stack emissions, lb/hr	49.7	45.6	51.1	29.0	7.3
gr/scf	1.28	0.21	1.33	0.71	0.31
SO_2, mg/scf	32.6	-	-	-	-
Total SO_2, %	0.04	-	-	-	-
SO_3, mg/scf	18.5	-	-	-	-
CO, %	0.9	-	-	-	-

[a]An estimated 75 percent of the furnace gases was used for waste heat purposes and was not, therefore, included in the test.
[b]As measured after cooling, just upstream from control device.

which packs the newly formed wool fibers onto the conveyor. From this viewpoint, 35,000 scfm would be more desirable. In addition, this increased ventilation holds the blowchamber temperature down to tolerable limits, which determine the type of air pollution control equipment to be selected. If the plant is processing granulated wool instead of batts, downdraft is less important and satisfactory operation can be achieved with a 25,000-scfm exhaust system. If a lint cage is used to trap wool fibers in the discharge gases, frequent cleaning (four times an hour) of the cage is imperative for proper ventilation.

Table 99. PARTICLE SIZE ANALYSIS BY MICROSCOPE OF TWO SAMPLES TAKEN FROM THE DISCHARGE OF A MINERAL WOOL CUPOLA FURNACE

Test No. 9A

Size range, μ	Total count	Percent by number	Percent by wt
45 to 75	10	0.5	75.0
15 to 45	10	0.5	10.0
7.5 to 15	40	2.0	14.5
1 to 7.5	100	5.0	0.5
1	2,000	92.0	Nil

Tyler screen analysis: Retained on 200 mesh (74 μ): 33.8%
Retained on 325 mesh (44 μ): 20.3%
Retained on pan (44 μ): 49.9%

Ignition loss: 10%

Test No. 9B

Average particle size, μ	Total count	Percent by number	Percent by wt
200.	2	0.1	85.0
60	8	0.4	9.5
40	10	0.5	3.5
10	20	1.0	1.08
5	100	5.0	0.07
1	930	93.0	Nil

4. Curing ovens. Exhaust requirements for a 2,500-cubic-foot oven operating at 300° to 500°F and capable of processing 4,000 to 6,000 pounds of mineral wool an hour are about 5,000 scfm. Sufficient oven gases must be removed to prevent a pressure buildup so that leakage does not occur. In sizing the fan, consideration must be given to temperature rises and possibly also to the introduction of outside cooling air for proper fan operation, particularly if the oven discharge gases are incinerated.

5. Coolers. Coolers normally do not require air pollution control devices. If outside ambient air is used as the cooling medium, the ventilation requirements are 10,000 to 20,000 cfm for a cooler whose area is about 70 square feet.

6. Asphalt tanks. If temperature regulators are successfully used to control emissions, the ventilation requirements for melting, holding, and dip tanks will be about 75 cfm for each square foot of surface area. This value is for open tanks and for hoods having one open side. If the melting and holding tanks are closed, natural-draft stacks may be used.

Table 100. EMISSIONS FROM MINERAL WOOL BLOWCHAMBERS

	Test No.					
	1	6C	13	14	17	25
Process wt, lb/hr	3,525	-	3,625	3,525	3,700	4,120
Stack volume, scfm	11,100	17,200	15,760	28,728	19,750	15,400
Stack gas temp, °F	196	196	160	188	167	200
Blowchamber emissions, lb/hr	9.20	5.02	7.11	98.21	-	8.3
Type of control equipment	None	a	None	None	Lint cage	Two wet centrifugal water scrubbers in parallel
Dust concentration, gr/scf						
Inlet	0.097	0.034	0.0526	0.399	-	0.063
Outlet	0.097	0.011	0.0526	0.399	0.012	0.028
Dust emissions, lb/hr						
Inlet	9.20	5.02	7.11	98.21	-	8.30
Outlet	9.20	1.62	7.11	98.21	2.03	3.60
Control efficiency, %	-	67.90	-	-	-	57
SO_2, mg/scf	1.04	-	-	-	-	-
Total SO_2, %	0.0013	-	-	-	-	-
Aldehydes, mg/scf	1.03	-	-	-	-	-
[illegible]al aldehydes, %	0.0036	-	-	-	-	-
[illegible]nbustibles, %	-	-	-	-	-	-

[a]This control equipment consisted of a water scrubber followed in series by an electrical precipitator.

Table 101. EMISSIONS FROM MINERAL WOOL CURING OVENS

	Test No.					
	1	6E	13	18[a]	22	24
Process wt, lb/hr	3,525	-	3,625	3,050	5,180	3,500
Stack volume, scfm	4,740	6,130	4,862	1,642	8,000	4,870
Stack gas temp, °F	326	314	353	310	200	270
Oven emissions, lb/hr	8.95	22.30	5.20	2.27	15.20	5
Type of control equipment	None	b	None	None	Catalytic afterburner	Direct-flame afterburner
Dust concentration, gr/scf						
Inlet	0.22	0.42	0.125	0.161	0.221	0.119
Outlet	0.22	0.083	0.125	0.161	0.071	0.032
Dust emissions, lb/hr						
Inlet	8.95	22.30	5.20	2.27	15.20	5
Outlet	8.95	4.36	5.20	2.27	4.90	2.50
Control efficiency, %	-	81	-	-	68	50
SO_2, mg/scf	3.23	-	-	-	-	-
Total SO_2, %	0.0053	-	-	-	-	-
Aldehydes, mg/scf	1.24	-	-	-	-	-
Total aldehydes, lb/hr						
Inlet	-	-	-	-	1.90	2.20
Outlet	-	-	-	-	0.90	0.94
NO_2, lb/hr						
Inlet	-	-	-	-	0.60	0.15
Outlet	-	-	-	-	0.70	0.45
Afterburner temp, °F	-	-	-	-	840	1,230

[a]During this test the oven was heated with waste heat from a reverberatory furnace. The quantity of dust emissions appears low as a result of considerable leakage at the oven. Of the particulates collected, 95.4% were volatile or combustibles.

[b]This control equipment consisted of a water scrubber followed in series by an electrical precipitator.

Table 102. EMISSIONS FROM MINERAL WOOL COOLERS

	Test No.			
	1	17	18	19
Process wt, lb/hr	3,525	3,700	3,050	3,050
Stack volume, scfm	1,850	8,500	16,696	8,980
Stack gas temp, °F	128	273	170	288
Cooler emissions, lb/hr	0.75	2.55	3.58	8.39
gr/scf	0.047	0.035	0.025	0.109
SO_2, mg/scf	0.49	-	-	-
Total SO_2, %	0.0006	-	-	-
Aldehydes, mg/scf	0.304	-	-	-
Total aldehydes, %	0.0009	-	-	-

AIR POLLUTION CONTROL EQUIPMENT

Baghouse Collection and Cupola Air Contaminants

Baghouses have proved to be an effective and reliable means of controlling the discharge from mineral wool cupolas. An installation of this type is shown in Figure 242. Dacron or Orlon bags, which can withstand temperatures up to 275°F, should be used. Of these two synthetic fabrics, Dacron is now the more common, and features several advantages over Orlon, as discussed in Chapter 4. Glass fabric bags cannot be used, owing to the fluorides in the cupola effluent. (Results of a stack test disclose fluorides in a concentration 9.85 percent by weight in the particulate matter discharged from a cupola. The life of glass bags under these conditions is about 1 week.)

Provisions for automatic bag shaking should be included in the baghouse design. Sufficient cloth area should be provided so that the filtering velocity does not exceed 2.5 fpm.

Since the discharge temperature of the gas is about 1,000°F, heat-removing equipment must be used to prevent damage to the cloth bags. This can be accomplished with heat exchangers, evaporative coolers, radiant cooling columns, or by dilution with ambient air. The cooling device should not permit the temperature in the baghouse to fall below the dewpoint. Safety devices should be included to divert the gas stream and thus protect the baghouse from serious damage in the event of failure of the cooling system. In some instances it may also be desirable to include a cyclone or knockout trap someplace upstream of the baghouse to remove large chunks of hot metal that can burn holes in the bags even after passing through the cooling system.

The solution to a typical design problem involving a baghouse and an evaporative cooling system serving a cupola is described in Chapter 6.

Baghouses should be equally effective in controlling emissions from reverberatory furnaces. The comments made about cupolas are generally applicable to these furnaces. Excelsior-packed water scrubbers have been tried in Los Angeles County but did not comply with air pollution statutes relating to opacity limitations.

Afterburner Control of Curing Oven Air Contaminants

The effluent from the curing oven is composed chiefly of oil and binder particles. These emissions, while not a great contributor to air pollution in terms of weight, are severe in terms of opacity. Since they are combustible, a possible method of control is incineration. This method, in fact, has proved practical for the mineral wool plant.

Generally, afterburners are divided into two categories, depending upon the method of oxidation. These are direct-flame and catalytic. Important considerations for the direct-flame type (see Table 103) are flame contact, residence times, and temperature. The afterburner should be designed so that a maximum of mixing is obtained with the flame. The design should also provide sufficiently low gas stream velocities to achieve a minimum retention time of 0.3 second. An operating temperature of 1,200°F is the minimum requirement for efficient incineration. Figure 243 shows the effectiveness of the direct-flame type on curing oven emissions at different operating temperatures.

Table 103. DATA FOR A MINERAL WOOL CURING OVEN CONTROLLED BY A DIRECT-FLAME AFTERBURNER

Oven data
Type, gas fired, conveyorized
Operating temp, 350° to 450°F
Heat input, 4 million Btu/hr
Afterburner data
Type, direct flame, gas fired, two-pass
Flame contact device, deflector plate
Heat input, 5 million Btu/hr
Size, 4 ft dia x 9 ft length with 3 ft dia x 10 ft length Insulated retention tube
Gas temp inlet, 270°F
Operating temp, 1,240°F
Gas velocity, 37 ft/sec
Retention time, 0.3 sec
Collection efficiency (at 1,230°F)
On particulate matter, 50%
On aldehydes, 59%
On combustibles, 52%
On solvent soluble material, 68%

If a catalytic afterburner is used, the gas stream must be preheated to about 1,000°F. Some type of precleaner must be used to remove the mineral wool fibers and thus prevent fouling of the catalytic elements. Because of this problem, catalytic afterburners have not proved very satisfactory for this service.

Table 101 reflects a comparison of the effectiveness of both afterburner types as a control device on mineral wool curing ovens. Electrical precipitators have been used as an alternative means of controlling emissions from mineral wool curing ovens. The precipitator is, however, preceded by a water scrubber and high-velocity filter to remove the gummy material that would normally foul the ionizer and plate sections.