

11.16 Gypsum Manufacturing

11.16.1 Process Description¹⁻²

Gypsum is calcium sulfate dihydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), a white or gray naturally occurring mineral. Raw gypsum ore is processed into a variety of products such as a portland cement additive, soil conditioner, industrial and building plasters, and gypsum wallboard. To produce plasters or wallboard, gypsum must be partially dehydrated or calcined to produce calcium sulfate hemihydrate ($\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$), commonly called stucco.

A flow diagram for a typical gypsum process producing both crude and finished gypsum products is shown in Figure 11.16-1. In this process gypsum is crushed, dried, ground, and calcined. Not all of the operations shown in Figure 11.16-1 are performed at all gypsum plants. Some plants produce only wallboard, and many plants do not produce soil conditioner.

Gypsum ore, from quarries and underground mines, is crushed and stockpiled near a plant. As needed, the stockpiled ore is further crushed and screened to about 50 millimeters (2 inches) in diameter. If the moisture content of the mined ore is greater than about 0.5 weight percent, the ore must be dried in a rotary dryer or a heated roller mill. Ore dried in a rotary dryer is conveyed to a roller mill, where it is ground to the extent that 90 percent of it is less 149 micrometers (μm) (100 mesh). The ground gypsum exits the mill in a gas stream and is collected in a product cyclone. Ore is sometimes dried in the roller mill by heating the gas stream, so that drying and grinding are accomplished simultaneously and no rotary dryer is needed. The finely ground gypsum ore is known as landplaster, which may be used as a soil conditioner.

In most plants, landplaster is fed to kettle calciners or flash calciners, where it is heated to remove three-quarters of the chemically bound water to form stucco. Calcination occurs at approximately 120 to 150°C (250 to 300°F), and 0.908 megagrams (Mg) (1 ton) of gypsum calcines to about 0.77 Mg (0.85 ton) of stucco.

In kettle calciners, the gypsum is indirectly heated by hot combustion gas passed through flues in the kettle, and the stucco product is discharged into a "hot pit" located below the kettle. Kettle calciners may be operated in either batch or continuous mode. In flash calciners, the gypsum is directly contacted with hot gases, and the stucco product is collected at the bottom of the calciner.

At some gypsum plants, drying, grinding, and calcining are performed in heated impact mills. In these mills hot gas contacts gypsum as it is ground. The gas dries and calcines the ore and then conveys the stucco to a product cyclone for collection. The use of heated impact mills eliminates the need for rotary dryers, calciners, and roller mills.

Gypsum and stucco are usually transferred from one process to another by means of screw conveyors or bucket elevators. Storage bins or silos are normally located downstream of roller mills and calciners but may also be used elsewhere.

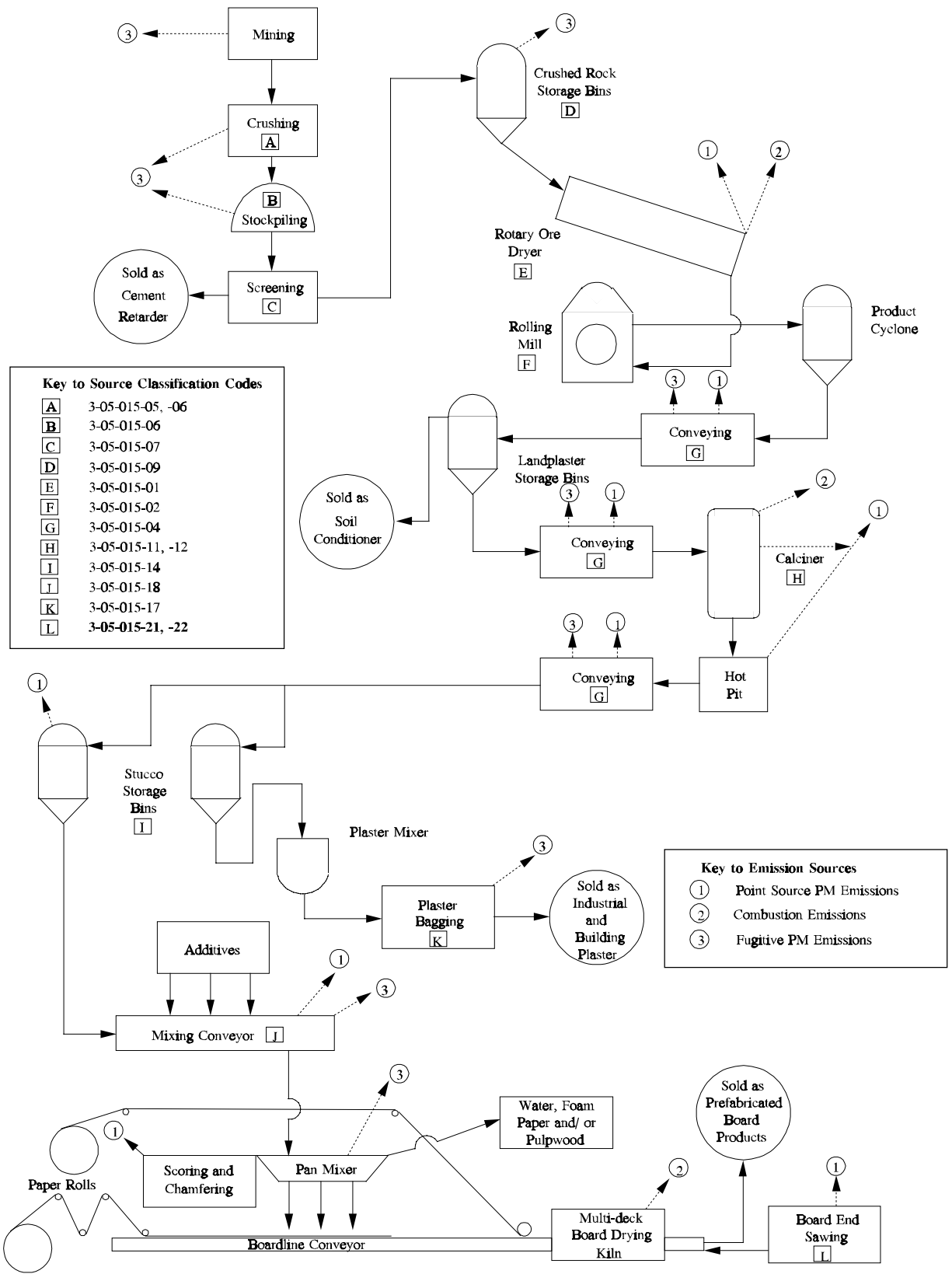


Figure 11.16-1. Overall process flow diagram for gypsum processing.²

In the manufacture of plasters, stucco is ground further in a tube or ball mill and then batch-mixed with retarders and stabilizers to produce plasters with specific setting rates. The thoroughly mixed plaster is fed continuously from intermediate storage bins to a bagging operation.

In the manufacture of wallboard, stucco from storage is first mixed with dry additives such as perlite, starch, fiberglass, or vermiculite. This dry mix is combined with water, soap foam, accelerators and shredded paper, or pulpwood in a pin mixer at the head of a board forming line. The slurry is then spread between 2 paper sheets that serve as a mold. The edges of the paper are scored, and sometimes chamfered, to allow precise folding of the paper to form the edges of the board. As the wet board travels the length of a conveying line, the calcium sulfate hemihydrate combines with the water in the slurry to form solid calcium sulfate dihydrate, or gypsum, resulting in rigid board. The board is rough-cut to length, and it enters a multideck kiln dryer, where it is dried by direct contact with hot combustion gases or by indirect steam heating. The dried board is conveyed to the board end sawing area and is trimmed and bundled for shipment.

11.16.2 Emissions And Controls^{2,7}

Potential emission sources in gypsum processing plants are shown in Figure 11.16-1. While particulate matter (PM) is the dominant pollutant in gypsum processing plants, several sources may emit gaseous pollutants also. The major sources of PM emissions include rotary ore dryers, grinding mills, calciners, and board end sawing operations. Particulate matter emission factors for these operations are shown in Table 11.16-1 and 11.16-2. In addition, emission factors for PM less than or equal to 10 μm in aerodynamic diameter (PM-10) emissions from selected processes are presented in Tables 11.16-1 and 11.16-2. All of these factors are based on output production rates. Particle size data for ore dryers, calciners, and board end sawing operations are shown in Tables 11.16-2 and 11.16-3.

The uncontrolled emission factors presented in Table 11.16-1 and 11.16-2 represent the process dust entering the emission control device. It is important to note that emission control devices are frequently needed to collect the product from some gypsum processes and, thus, are commonly thought of by the industry as process equipment and not as added control devices.

Emissions sources in gypsum plants are most often controlled with fabric filters. These sources include:

- rotary ore dryers (SCC 3-05-015-01)
- roller mills (SCC 3-05-015-02)
- impact mills (SCC 3-05-015-13)
- kettle calciners (SCC 3-05-015-11)
- flash calciners (SCC 3-05-015-12)
- board end sawing (SCC 3-05-015-21,-22)
- scoring and chamfering (SCC 3-05-015-__)
- plaster mixing and bagging (SCC 3-05-015-16,-17)
- conveying systems (SCC 3-05-015-04)
- storage bins (SCC 3-05-015-09,-10,-14)

Uncontrolled emissions from scoring and chamfering, plaster mixing and bagging, conveying systems, and storage bins are not well quantified.

Emissions from some gypsum sources are also controlled with electrostatic precipitators (ESP). These sources include rotary ore dryers, roller mills, kettle calciners, and conveying systems. Although rotary ore dryers may be controlled separately, emissions from roller mills and conveying systems are usually controlled jointly with kettle calciner emissions. Moisture in the kettle calciner exit gas improves the ESP performance by lowering the resistivity of the dust.

Table 11.16-1 (Metric Units). EMISSION FACTORS FOR GYPSUM PROCESSING^a

EMISSION FACTOR RATING: D

Process	Filterable PM ^b	PM-10	CO ₂ ^c
Crushers, screens, stockpiles, and roads (SCC 3-05-015-05,-06,-07,-08)	— ^d	— ^d	NA
Rotary ore dryers (SCC 3-05-015-01)	0.0042(FFF) ^{1.7e}	0.00034(FFF) ^{1.7}	12 ^f
Rotary ore dryers w/fabric filters (SCC 3-05-015-01)	0.020 ^g	0.0052	NA
Roller mills w/cyclones (SCC 3-05-015-02)	1.3 ^h	ND	NA
Roller mills w/fabric filters (SCC 3-05-015-02)	0.060 ^h	ND	NA
Roller mill and kettle calciner w/electrostatic precipitators (SCC 3-05-015-02,-11)	0.050 ^{h,j}	ND	ND
Continuous kettle calciners and hot pit (SCC 3-05-015-11)	21 ^k	13	ND
Continuous kettle calciners and hot pit w/fabric filters (SCC 3-05-015-11)	0.0030 ^k	ND	NA
Continuous kettle calciners w/cyclones and electrostatic precipitators (SCC 3-05-015-11)	0.050 ^k	ND	NA
Flash calciners (SCC 3-05-015-12)	19 ^m	7.2 ^m	55 ⁿ
Flash calciners w/fabric filters (SCC 3-05-015-12)	0.020 ^m	0.017 ^m	ND
Impact mills w/cyclones (SCC 3-05-015-13)	50 ^p	ND	NA
Impact mills w/fabric filters (SCC 3-05-015-13)	0.010 ^p	ND	NA
Board end sawing--2.4-m boards (SCC 3-05-015-21)	0.040 ^q	ND	NA
Board end sawing--3.7-m boards (SCC 3-05-015-22)	0.030 ^q	ND	NA
Board end sawing w/fabric filters--2.4-and 3.7-m boards (SCC 3-05-015-21,-22)	36 ^r	27 ^r	NA

^a Factors represent uncontrolled emissions unless otherwise specified. All emission factors are kg/Mg of output rate. SCC = Source Classification Code. NA = not applicable. ND = no data.

^b Filterable PM is that PM collected on or prior to an EPA Method 5 (or equivalent) sampling train.

Table 11.16-1 (cont.).

- ^c Typical pollution control devices generally have a negligible effect on CO₂ emissions.
- ^d Factors for these operations are in Sections 11.19 and 13.2.
- ^e References 3-4,8,11-12. Equation is for the emission rate upstream of any process cyclones and applies only to concurrent rotary ore dryers with flow rates of 7.5 cubic meters per second (m³/s) or less. FFF in the uncontrolled emission factor equation is "flow feed factor," the ratio of gas mass rate per unit dryer cross section area to the dry mass feed rate, in the following units: (kg/hr-m² of gas flow)/(Mg/hr dry feed). Measured uncontrolled emission factors for 4.2 and 5.7 m³/s range from 5 to 60 kg/Mg.
- ^f References 3-4.
- ^g References 3-4,8,11-12. Applies to rotary dryers with and without cyclones upstream of fabric filter.
- ^h References 11-14. Applies to both heated and unheated roller mills.
- ^j References 11-14. Factor is for combined emissions from roller mills and kettle calciners, based on the sum of the roller mill and kettle calciner output rates.
- ^k References 4-5,11,13-14. Emission factors based on the kettle and the hot pit do not apply to batch kettle calciners.
- ^m References 3,6,10.
- ⁿ References 3,6,9.
- ^p References 9,15. As used here, an impact mill is a process unit used to dry, grind, and calcine gypsum simultaneously.
- ^q References 4-5,16. Emission factor units = kg/m². Based on 13-mm board thickness and 1.2 m board width. For other thicknesses, multiply the appropriate emission factor by 0.079 times board thickness in mm.
- ^r References 4-5,16. Emission factor units = kg/10⁶ m².

Table 11.16-2 (English Units). EMISSION FACTORS FOR GYPSUM PROCESSING^a

EMISSION FACTOR RATING: D

Process	Filterable PM ^b	PM-10	CO ₂ ^c
Crushers, screens, stockpiles, and roads (SCC 3-05-015-05,-06,-07,-08)	— ^d	— ^d	NA
Rotary ore dryers (SCC 3-05-015-01)	0.16(FFF) ^{1.77e}	0.013(FFF) ^{1.7}	23 ^f
Rotary ore dryers w/fabric filters (SCC 3-05-015-01)	0.040 ^g	0.010	NA
Roller mills w/cyclones (SCC 3-05-015-02)	2.6 ^h	ND	NA
Roller mills w/fabric filters (SCC 3-05-015-02)	0.12 ^h	ND	NA
Roller mill and kettle calciner w/electrostatic precipitators (SCC 3-05-015-02,-11)	0.090 ^{h,j}	ND	ND
Continuous kettle calciners and hot pit (SCC 3-05-015-11)	41 ^k	26	ND
Continuous kettle calciners and hot pit w/fabric filters (SCC 3-05-015-11)	0.0060 ^k	ND	NA
Continuous kettle calciners w/cyclones and electrostatic precipitators (SCC 3-05-015-11)	0.090 ^k	ND	NA
Flash calciners (SCC 3-05-015-12)	37 ^m	14 ^m	110 ⁿ
Flash calciners w/fabric filters (SCC 3-05-015-12)	0.040 ^m	0.034 ^m	ND
Impact mills w/cyclones (SCC 3-05-015-13)	100 ^p	ND	NA
Impact mills w/fabric filters (SCC 3-05-015-13)	0.020 ^p	ND	NA
Board end sawing--8-ft boards (SCC 3-05-015-21)	0.80 ^q	ND	NA
Board end sawing--12-ft boards (SCC 3-05-015-22)	0.50 ^q	ND	NA
Board end sawing w/fabric filters-- 8- and 12-ft boards (SCC 3-05-015-21,-22)	7.5 ^r	5.7 ^r	NA

^a Factors represent uncontrolled emissions unless otherwise specified. All emission factors are lb/ton of output rate. SCC = Source Classification Codes. NA = not applicable. ND = no data.

Table 11.16-2 (cont.).

- ^b Filterable PM is that particulate collected on or prior to an EPA Method 5 (or equivalent) sampling train.
- ^c Typical pollution control devices generally have a negligible effect on CO₂ emissions.
- ^d Factors for these operations are in Sections 8.19 and 13.2.
- ^e References 3-4,8,11-12. Equation is for the emission rate upstream of any process cyclones and applies only to concurrent rotary ore dryers with flow rates of 16,000 actual cubic feet per minute (acfm) or less. FFF in the uncontrolled emission factor equation is "flow feed factor," the ratio of gas mass rate per unit dryer cross section area to the dry mass feed rate, in the following units: (lb/hr-ft² of gas flow)/(ton/hr dry feed). Measured uncontrolled emission factors for 9,000 and 12,000 acfm range from 10 to 120 lb/ton.
- ^f References 3-4.
- ^g References 3-4,8,11-12. Applies to rotary dryers with and without cyclones upstream of fabric filter.
- ^h References 11-14. Applies to both heated and unheated roller mills.
- ^j References 11-14. Factor is for combined emissions from roller mills and kettle calciners, based on the sum of the roller mill and kettle calciner output rates.
- ^k References 4-5,11,13-14. Emission factors based on the kettle and the hot pit do not apply to batch kettle calciners.
- ^m References 3,6,10.
- ⁿ References 3,6,9.
- ^p References 9,15. As used here, an impact mill is a process unit used to dry, grind, and calcine gypsum simultaneously.
- ^q References 4-5,16. Emission factor units = lb/100 ft². Based on 1/2-in. board thickness and 4-ft board width. For other thicknesses, multiply the appropriate emission factor by 2 times board thickness in inches.
- ^r References 4-5,16. Emission factor units = lb/10⁶ ft².

Table 11.16-3. SUMMARY OF PARTICLE SIZE DISTRIBUTION DATA FOR UNCONTROLLED PM EMISSIONS FROM GYPSUM PROCESSING^a

EMISSION FACTOR RATING: D

Diameter (µm)	Cumulative % Less Than Diameter			
	Rotary Ore Dryer ^b	Rotary Ore Dryer With Cyclone ^c	Continuous Kettle Calciner ^d	Flash Calciner ^e
2.0	1	12	17	10
10.0	8	45	63	38

- ^a Weight % given as filterable PM. Diameter is given as aerodynamic diameter, except for continuous kettle calciner, which is given as equivalent diameter, as determined by Bahco and Sedigraph analyses.
- ^b Reference 3.
- ^c Reference 4.
- ^d References 4-5.
- ^e References 3,6.

Table 11.16-4. SUMMARY OF PARTICLE SIZE DISTRIBUTION DATA FOR FABRIC FILTER-CONTROLLED PM EMISSIONS FROM GYPSUM MANUFACTURING^a

EMISSION FACTOR RATING: D

Diameter (µm)	Cumulative % Less Than Diameter		
	Rotary Ore Dryer ^b	Flash Calciner ^c	Board End Sawing ^c
2.0	9	52	49
10.0	26	84	76

^a Aerodynamic diameters, Andersen analysis.

^b Reference 3.

^c Reference 3,6.

Other sources of PM emissions in gypsum plants are primary and secondary crushers, screens, stockpiles, and roads. If quarrying is part of the mining operation, PM emissions may also result from drilling and blasting. Emission factors for some of these sources are presented in Sections 11.19 and 13.2. Gaseous emissions from gypsum processes result from fuel combustion and may include nitrogen oxides, sulfur oxides, carbon monoxide, and carbon dioxide (CO₂). Processes using fuel include rotary ore dryers, heated roller mills, impact mills, calciners, and board drying kilns. Although some plants use residual fuel oil, the majority of the industry uses clean fuels such as natural gas or distillate fuel oil. Emissions from fuel combustion may be estimated using emission factors presented in Sections 1.3 and 1.4 and fuel consumption data in addition to those emission factors presented in Table 11.16-1.

References For Section 11.16

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