11.23 Taconite Ore Processing

11.23.1 General[1]

The taconite ore processing industry produces usable concentrations of iron-bearing material by removing nonferrous rock (gangue) from low-grade ore. The six-digit Source Classification Code (SCC) for taconite ore processing is 3-03-023. Table 11.23-1 lists the SCCs for taconite ore processing.

Taconite is a hard, banded, low-grade ore, and is the predominant iron ore remaining in the United States. Ninety-nine percent of the crude iron ore produced in the United States is taconite. If magnetite is the principal iron mineral, the rock is called magnetic taconite; if hematite is the principal iron mineral, the rock is called hematic taconite.

About 98 percent of the demand for taconite comes from the iron and steel industry. The remaining 2 percent comes mostly from the cement industry but also from manufacturers of heavy-medium materials, pigments, ballast, agricultural products, and specialty chemicals. Ninety-seven percent of the processed ore shipped to the iron and steel industry is in the form of pellets. Other forms of processed ore include sinter and briquettes. The average iron content of pellets is 63 percent.

11.23.2 Process Description[2-5,41]

Processing of taconite consists of crushing and grinding the ore to liberate iron-bearing particles, concentrating the ore by separating the particles from the waste material (gangue), and pelletizing the iron ore concentrate. A simplified flow diagram of these processing steps is shown in Figure 11.23-1.

Liberation is the first step in processing crude taconite ore and consists mostly of crushing and grinding. The ore must be ground to a particle size sufficiently close to the grain size of the iron-bearing mineral to allow for a high degree of mineral liberation. Most of the taconite used today requires very fine grinding. Prior to grinding, the ore is dry-crushed in up to six stages, depending on the hardness of the ore. One or two stages of crushing may be performed at the mine prior to shipping the raw material to the processing facility. Gyratory crushers are generally used for primary crushing, and cone crushers are used for secondary and tertiary fine crushing. Intermediate vibrating screens remove undersize material from the feed to the next crusher and allow for closed-circuit operation of the fine crushers. After crushing, the size of the material is further reduced by wet grinding in rod mills or ball mills. The rod and ball mills are also in closed circuit with classification systems such as cyclones. An alternative to crushing is to feed some coarse ores directly to wet or dry semiautogenous or autogenous grinding mills (using larger pieces of the ore to grind/mill the smaller pieces), then to pebble or ball mills. Ideally, the liberated particles of iron minerals and barren gangue should be removed from the grinding circuits as soon as they are formed, with larger particles returned for further grinding.

Concentration is the second step in taconite ore processing. As the iron ore minerals are liberated by the crushing steps, the iron-bearing particles must be concentrated. Because only about 33 percent of the crude taconite becomes a shippable product for iron making, a large amount of gangue

Table 11.23-1. KEY FOR SOURCE CLASSIFICATION CODES FOR TACONITE ORE PROCESSING

Key[a]	Source	SCC
A	Ore storage	3-03-023-05
B	Ore transfer	3-03-023-04
C	Primary crusher	3-03-023-01
D	Primary crusher return conveyor transfer	3-03-023-25
E	Secondary crushing line	3-03-023-27
F	Secondary crusher return conveyor transfer	3-03-023-28
G	Tertiary crushing	3-03-023-02
H	Tertiary crushing line	3-03-023-30
I	Tertiary crushing line discharge conveyor	3-03-023-31
J	Screening	3-03-023-03
K	Grinder feed	3-03-023-34
L	Primary grinding	3-03-023-06
M	Classification	3-03-023-36
N	Magnetic separation	3-03-023-17
O	Secondary grinding	3-03-023-38
P	Conveyor transfer to concentrator	3-03-023-41
Q	Concentrate storage	3-03-023-44
R	Bentonite storage	3-03-023-07
S	Bentonite transfer to blending	3-03-023-45
T	Bentonite blending	3-03-023-08
U	Green pellet screening	3-03-023-47
V	Chip regrinding	3-03-023-11
W	Grate/kiln furnace feed	3-03-023-49
X	Straight grate furnace feed	3-03-023-79
Y	Vertical shaft furnace feed	3-03-023-69
Z	Hearth layer feed to furnace	3-03-023-48
AA	Grate/kiln, gas-fired, acid pellets	3-03-023-51
AB	Grate/kiln, gas-fired, flux pellets	3-03-023-52
AC	Grate/kiln, gas- and oil-fired, acid pellets	3-03-023-53
AD	Grate/kiln, gas- and oil-fired, flux pellets	3-03-023-54
AE	Grate/kiln, coke-fired, acid pellets	3-03-023-55
AF	Grate/kiln, coke-fired, flux pellets	3-03-023-56
AG	Grate/kiln, coke- and coal-fired, acid pellets	3-03-023-57
AH	Grate/kiln, coke- and coal-fired, flux pellets	3-03-023-58
AI	Grate/kiln, coal-fired, acid pellets	3-03-023-59
AJ	Grate/kiln, coal-fired, flux pellets	3-03-023-60
AK	Grate/kiln, coal- and oil-fired, acid pellets	3-03-023-61
AL	Grate/kiln, coal- and oil-fired, flux pellets	3-03-023-62
AM	Vertical shaft, gas-fired, top gas stack, acid pellets	3-03-023-71

Table 11.23-1. (cont.).

Key[a]	Source	SCC
AN	Vertical shaft, gas-fired, top gas stack, flux pellets	3-03-023-72
AO	Vertical shaft, gas-fired, bottom gas stack, acid pellets	3-03-023-73
AP	Vertical shaft, gas-fired, bottom gas stack, flux pellets	3-03-023-74
AQ	Straight grate, gas-fired, acid pellets	3-03-023-81
AR	Straight grate, gas-fired, flux pellets	3-03-023-82
AS	Straight grate, oil-fired, acid pellets	3-03-023-83
AT	Straight grate, oil-fired, flux pellets	3-03-023-84
AU	Straight grate, coke-fired, acid pellets	3-03-023-85
AV	Straight grate, coke-fired, flux pellets	3-03-023-86
AW	Straight grate, coke- and gas-fired, acid pellets	3-03-023-87
AX	Straight grate, coke- and gas-fired, flux pellets	3-03-023-88
AY	Grate/kiln furnace discharge	3-03-023-50
AZ	Vertical shaft furnace discharge	3-03-023-70
BA	Straight grate furnace discharge	3-03-023-80
BB	Hearth layer screen	3-03-023-93
BC	Pellet cooler	3-03-023-15
BD	Pellet screen	3-03-023-95
BE	Pellet transfer to storage	3-03-023-16
BF	Pellet storage bin loading	3-03-023-96
BG	Secondary storage bin loading	3-03-023-97
BH	Tertiary storage bin loading	3-03-023-98
b	Haul road, rock	3-03-023-21
b	Haul road, taconite	3-03-023-22
b	Nonmagnetic separation	3-03-023-18
b	Tailings basin	3-03-023-40
b	Other, not classified	3-03-023-99
c	Traveling grate feed	3-03-023-09
c	Traveling grate discharge	3-03-023-10
c	Indurating furnace: gas-fired	3-03-023-12
c	Indurating furnace: oil-fired	3-03-023-13
c	Indurating furnace: coal-fired	3-03-023-14
c	Kiln	3-03-023-19
c	Conveyors, transfer, and loading	3-03-023-20

[a]Refers to labels in Figure 11.23-1.
[b]Not shown in Figure 11.23-1.
[c]Inactive code.

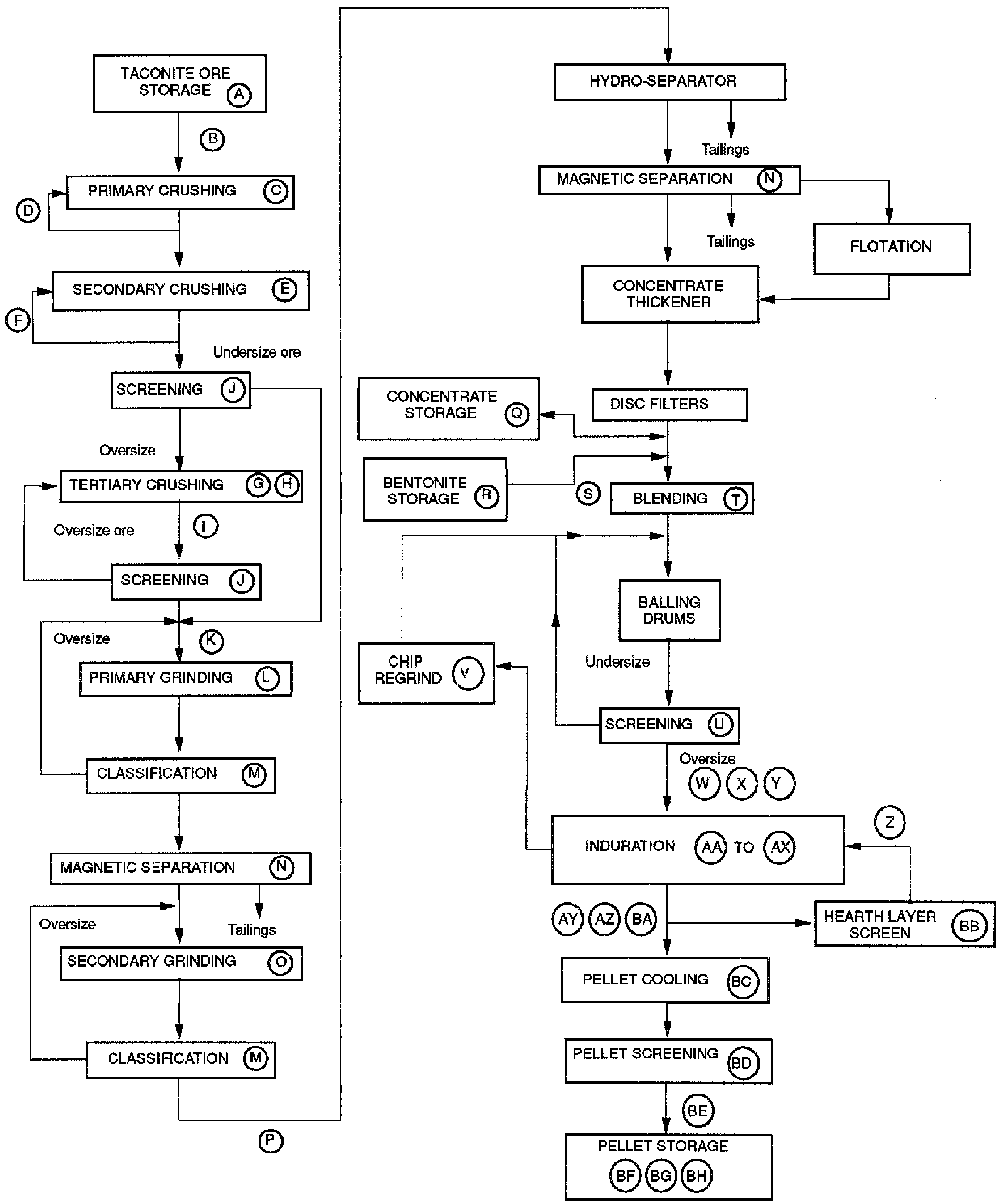

Figure 11.23-1. Process flow diagram for taconite ore processing.
(Refer to Table 11.23-1 for Source Classification Codes)

is generated. Magnetic separation and flotation are the most commonly used methods for concentrating taconite ore.

Crude ores in which most of the recoverable iron is magnetite (or, in rare cases, maghemite) are normally concentrated by magnetic separation. The crude ore may contain 30 to 35 percent total iron by assay, but theoretically only about 75 percent of this is recoverable magnetite. The remaining iron is discarded with the gangue.

Nonmagnetic taconite ores are concentrated by froth flotation or by a combination of selective flocculation and flotation. The method is determined by the differences in surface activity between the iron and gangue particles. Sharp separation is often difficult.

Various combinations of magnetic separation and flotation may be used to concentrate ores containing various iron minerals (magnetite and hematite, or maghemite) and wide ranges of mineral grain sizes. Flotation is also often used as a final polishing operation on magnetic concentrates.

Pelletization is the third major step in taconite ore processing. Iron ore concentrates must be coarser than about No. 10 mesh to be acceptable as blast furnace feed without further treatment. Finer concentrates are agglomerated into small "green" pellets, which are classified as either acid pellets or flux pellets. Acid pellets are produced from iron ore and a binder only, and flux pellets are produced by adding between 1 and 10 percent limestone to the ore and binder before pelletization. Pelletization generally is accomplished by tumbling moistened concentrate with a balling drum or balling disc. A binder, usually powdered bentonite, may be added to the concentrate to improve ball formation and the physical qualities of the "green" balls. The bentonite is mixed with the carefully moistened feed at 5 to 10 kilograms per megagram (kg/Mg) (10 to 20 pounds per ton [lb/ton]).

The pellets are hardened by a procedure called induration. The green balls are dried and heated in an oxidizing atmosphere at incipient fusion temperature of 1290° to 1400°C (2350° to 2550°F), depending on the composition of the balls, for several minutes and then cooled. The incipient fusion temperature for acid pellets falls in the lower region of this temperature range, and the fusion temperature for flux pellets falls in the higher region of this temperature range. The three general types of indurating apparatus currently used are the vertical shaft furnace, the straight grate, and the grate/kiln. Most large plants and new plants use the grate/kiln. Currently, natural gas is the most common fuel used for pellet induration, but heavy oil is used at a few plants, and coal and coke may also be used.

In the vertical shaft furnace, the wet green balls are distributed evenly over the top of the slowly descending bed of pellets. A stream of hot gas of controlled temperature and composition rises counter to the descending bed of pellets. Auxiliary fuel combustion chambers supply hot gases midway between the top and bottom of the furnace.

The straight grate furnace consists of a continuously moving grate, onto which a bed of green pellets is deposited. The grate passes through a firing zone of alternating up and down currents of heated gas. The fired pellets are cooled either on an extension of the grate or in a separate cooler. An important feature of the straight grate is the "hearth layer", which consists of a 10- to 15-centimeter (4- to 6-inch) thick layer of fired pellets that protects the grate. The hearth layer is formed by diverting a portion of the fired pellets exiting the firing zone of the furnace to a hearth layer screen, which removes the fines. These pellets then are conveyed back to the feed end of the straight grate and deposited on to the bare grate. The green pellets being fed to the furnace are deposited on the hearth layer prior to the burning zone of the furnace.

The grate/kiln apparatus consists of a continuous traveling grate followed by a rotary kiln. The grate/kiln product must be cooled in a separate cooler, usually an annular cooler with counter current airflow.

11.23.3 Emissions And Controls[2-7,41]

Particulate matter (PM) emission sources in taconite ore processing plants are indicated in Figure 11.23-1. Taconite ore is handled dry through the initial stages of crushing and screening. All crushers, size classification screens, and conveyor transfer points are major points of PM emissions. Crushed ore is normally wet ground in rod and ball mills. Because the ore remains wet, PM emissions are insignificant for the rest of the process until the drying stage of induration. A few plants use dry autogenous or semi-autogenous grinding and have higher emissions than do conventional plants.

Emissions from crushing and conveying operations are generally controlled by a hood-and-duct system that leads to a cyclone, rotoclone, multiclone, scrubber, or fabric filter. The inlet of the control device will often be fed by more than one duct. Water sprays are also used to control emissions.

The first source of emissions in the pelletizing process is the transfer and blending of bentonite. Additional emission points in the pelletizing process include the main waste gas stream from the indurating furnace, pellet handling, furnace transfer points (grate feed and discharge), and annular coolers for plants using the grate/kiln furnace.

Induration furnaces generate sulfur dioxide (SO_2). The SO_2 originates both from the fuel and the raw material (concentrate, binder, and limestone). Induration furnaces also emit combustion products such as nitrogen oxides (NO_x), and carbon monoxide (CO). Because of the additional heating requirements, emissions of NO_x and SO_2 generally are higher when flux pellets are produced than when acid pellets are produced.

The combination of multicyclones and wet scrubbers is a common configuration for controlling furnace waste gas. The purpose of the multicyclones is to recover material from the drying gases as they pass from the preheat stage to the drying stage. The wet scrubber reduces concentrations of SO_2 and PM in the furnace waste gas. Minor emission sources, such as grate feed and discharge, are usually controlled by small wet scrubbers.

Annular coolers normally operate in stages. The exhaust of the first-stage cooler is vented to the indurating furnace as preheated combustion gas. The second and third stages generally are uncontrolled.

Particulate matter emissions also arise from ore mining operations. The largest source of PM in taconite ore mines is traffic on unpaved haul roads. Other significant PM emission sources at taconite mines are tailing basins and wind erosion. Although blasting is a notable emission source of the various fractions of PM, it is a short-term event, and most of the material settles quickly.

Emissions from taconite ore processing facilities constructed or modified after August 24, 1982 are regulated under 40 CFR 60, subpart LL, Standards of Performance for Metallic Mineral Processing Plants. The affected emission sources include crushers, screens, conveyors, conveyor transfer points, storage bins, enclosed storage areas, product packaging stations, and truck and rail loading and unloading stations. The regulation limits PM stack emissions from these sources to 0.05 grams per dry standard cubic meter (0.022 grains per dry standard cubic foot). In addition, the opacity of stack emissions for these sources is limited to 7 percent unless the stack is equipped with a wet scrubber, and process fugitive emissions are limited to 10 percent. The standard does not affect emissions from indurating furnaces.

Table 11.23-2 presents the factors for PM emissions from taconite ore indurating furnaces. Factors for emissions of PM from taconite ore processing sources other than furnaces are presented in Table 11.23-3. Factors for emissions of SO_2, NO_x, CO, and CO_2 from taconite ore processing are presented in Tables 11.23-4 and 11.23-5 for acid pellet and flux pellet production, respectively. Table 11.23-6 presents emission factors for other pollutants emitted from taconite ore indurating furnaces. Emission factors for fugitive dust sources associated with taconite ore processing can be estimated using the predictive equations found in Section 13.2 of AP-42, which includes, for the parameters used in the equations, values based on measurements at taconite ore processing facilities.

Table 11.23-2. EMISSION FACTORS FOR TACONITE ORE INDURATING FURNACES[a]

Source	Filterable[b] PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Condensible[c]	EMISSION FACTOR RATING
Natural gas-fired grate/kiln (SCC 3-03-023-51,-52)	7.4[d]	D	0.63[e]	E	0.022[f]	D
Natural gas-fired grate/kiln, with multiclone (SCC 3-03-023-51,-52)	0.44[g]	D	0.13[h]	E	NA	
Natural gas-fired grate/kiln, with wet scrubber (SCC 3-03-023-51,-52)	0.082[j]	C	ND		0.0055[k]	D
Natural gas/oil-fired grate/kiln (SCC 3-03-023-53,-54)	ND		ND		0.040[m]	D
Natural gas/oil-fired grate/kiln, with ESP (SCC 3-03-023-53,-54)	0.017[m]	E	ND		ND	
Coal/oil-fired grate/kiln, with wet scrubber (SCC 3-03-023-61,-62)	0.19[n]	E	ND		ND	
Coke-fired grate/kiln, with wet scrubber (SCC 3-03-023-55,-56)	0.10[p]	E	ND		ND	
Coke/coal-fired grate/kiln, with wet scrubber (SCC 3-03-023-57,-58)	0.14[q]	D	ND		ND	
Gas-fired vertical shaft top gas stack (SCC 3-03-023-71,-72)	16[r]	D	ND		ND	
Gas-fired vertical shaft top gas stack, with multiclone (SCC 3-03-023-71,-72)	1.4[s]	D	ND		ND	
Gas-fired vertical shaft top gas stack, with wet scrubber (SCC 3-03-023-71,-72)	0.92[t]	E	ND		0.050[t]	E
Gas-fired vertical shaft top gas stack, with multiclone and wet scrubber (SCC 3-03-023-71,-72)	0.66[u]	D	ND		ND	
Gas-fired vertical shaft bottom gas stack, with rotoclone (SCC 3-03-023-73,-74)	0.031[t]	E	ND		0.0086[t]	E
Oil-fired straight grate (SCC 3-03-023-83,-84)	1.2[v]	E	ND		ND	
Coke/gas-fired straight grate, with wet scrubber (SCC 3-03-023-83,-84)	0.11[w]	D	ND		ND	

Table 11.23-2 (cont.).

[a] Applicable to both acid pellets and flux pellets. Emission factors in units of lb/ton of fired pellets produced. One lb/ton is equivalent to 0.5 kg/Mg. Factors represent uncontrolled emissions unless noted. SCC = Source Classification Code. ND = no data.
[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 sampling train or equivalent.
[c] Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d] References 4-5,40.
[e] Reference 40.
[f] References 4,36,39-40. Based on data presented in Reference 40, 84 percent of condensibles consists of inorganic material.
[g] References 32-36,39,42-43.
[h] Reference 39.
[j] References 20,27,37.
[k] References 4,37.
[m] Reference 5.
[n] Reference 18.
[p] Reference 29.
[q] References 26-27.
[r] References 12-14,24.
[s] References 12-13,24.
[t] Reference 45.
[u] Reference 14.
[v] Reference 6.
[w] References 30-31.

Table 11.23-3. EMISSION FACTORS FOR TACONITE ORE PROCESSING-- OTHER SOURCES[a]

Source	Filterable[b] PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Condensible[c]	EMISSION FACTOR RATING
Primary crusher, with cyclone (SCC 3-03-023-01)	0.25[d]	E	ND		ND	
Primary crusher, with cyclone and multiclone (SCC 3-03-023-01)	0.060[d]	E	ND		ND	
Primary crusher, with wet scrubber (SCC 3-03-023-01)	0.0012[e]	E	ND		ND	
Primary crusher, with fabric filter (SCC 3-03-023-01)	0.0019[f]	E	ND		ND	
Secondary crushing line, with wet scrubber (SCC 3-03-023-27)	0.0027[g]	E	ND		ND	
Tertiary crusher, with rotoclone (SCC 3-03-023-02)	0.0013[h]	E	ND		ND	
Tertiary crushing line, with wet scrubber (SCC 3-03-023-30)	0.0016[g]	D	ND		ND	
Grinder feed, with wet scrubber (SCC 3-03-023-34)	0.0011[j]	C	ND		ND	
Hearth layer feed, with wet scrubber (SCC 3-03-023-48)	0.017[k]	D	ND		ND	
Hearth layer screen, with wet scrubber (SCC 3-03-023-93)	0.038[m]	E	ND		ND	
Grate/kiln feed, with wet scrubber (SCC 3-03-023-49)	6.6×10^{-5} (g)	E	ND		ND	
Grate/kiln discharge (SCC 3-03-023-50)	0.82[n]	D	ND		0.00035[p] 9.0×10^{-5} (q)	E E
Grate/kiln discharge, with wet scrubber (SCC 3-03-023-50)	0.0019[r]	E	ND		0.00012[q]	E
Straight grate feed (SCC 3-03-023-79)	0.63[s]	E	ND		ND	
Straight grate discharge (SCC 3-03-023-80)	1.4[s]	E	ND		ND	
Straight grate discharge, with wet scrubber (SCC 3-03-023-80)	0.012[k]	D	ND		ND	
Pellet cooler (SCC 3-03-023-15)	0.12[t]	D	ND		ND	
Pellet screen (SCC 3-03-023-95)	10[u]	E	ND		ND	

Table 11.23-3 (cont.).

Source	Filterable[b] PM	EMISSION FACTOR RATING	PM-10	EMISSION FACTOR RATING	Condensible[c]	EMISSION FACTOR RATING
Pellet screen, with rotoclone (SCC 3-03-023-95)	0.037[u]	E	ND		ND	
Primary crusher return conveyor transfer, with wet scrubber (SCC 3-03-023-25)	0.00031[f]	E	ND		ND	
Pellet transfer to storage, with wet scrubber (SCC 3-03-023-16)	0.0036[m]	E	ND		ND	
Secondary crusher return conveyor transfer, with wet scrubber (SCC 3-03-023-28)	0.0057[v]	D	ND		ND	
Conveyor transfer to concentrator, with wet scrubber (SCC 3-03-023-41)	0.00028[g]	E	ND		ND	
Tertiary crushing line discharge conveyor, with wet scrubber (SCC 3-03-023-31)	0.0017[g]	E	ND		ND	
Bentonite storage bin loading, with wet scrubber (SCC 3-03-023-07)	2.4[m]	E	ND		ND	
Bentonite transfer (SCC 3-03-023-45)	3.2[s]	E	ND		ND	
Bentonite transfer, with wet scrubber (SCC 3-03-023-45)	0.11[s]	E	ND		ND	
Bentonite blending (SCC 3-03-023-08)	19[s]	E	ND		ND	
Bentonite blending, with wet scrubber (SCC 3-03-023-08)	0.25[s]	E	ND		ND	
Bentonite blending, with fabric filter (SCC 3-03-023-08)	0.11[s]	E	ND		ND	
Pellet storage bin loading (SCC 3-03-023-96)	3.7[u]	E	ND		ND	
Pellet storage bin loading, with rotoclone (SCC 3-03-023-96)	0.071[u]	E	ND		ND	
Secondary storage bin loading, with wet scrubber (SCC 3-03-023-97)	0.00019[g]	E	ND		ND	
Tertiary storage bin loading, with wet scrubber (SCC 3-03-023-98)	0.0018[g]	D	ND		ND	

Table 11.23-3 (cont.).

[a] Factors represent uncontrolled emissions unless noted. Emission factors for furnace feed, furnace discharge, coolers, and product handling are in units of lb/ton of pellets produced; emission factors for other sources are in units of lb/ton of material processed or handled. One lb/ton is equivalent to 0.5 kg/Mg. SCC = Source Classification Code. ND = no data available.
[b] Filterable PM is that PM collected on or prior to the filter of an EPA Method 5 (or equivalent) sampling train.
[c] Condensible PM is that PM collected in the impinger portion of a PM sampling train.
[d] References 10-11.
[e] Reference 22.
[f] Reference 27.
[g] Reference 28.
[h] Reference 6.
[j] References 7,9.
[k] References 8-9.
[m] Reference 8.
[n] References 4-5.
[p] Reference 5.
[q] Reference 4. Condensible inorganic PM fraction only.
[r] Reference 4.
[s] Reference 2.
[t] References 16-17,27.
[u] Reference 23.
[v] References 21,28.

Table 11.23-4. EMISSION FACTORS FOR TACONITE ORE INDURATING FURNACES--ACID PELLET PRODUCTION[a]

Source	SO_2[b]	EMISSION FACTOR RATING	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2[c]	EMISSION FACTOR RATING
Natural gas-fired grate/kiln (SCC 3-03-023-51)	0.29[d]	D	1.5[e]	D	0.014[f]	D	99[g]	C
Natural gas-fired grate/kiln, with wet scrubber (SCC 3-03-023-51)	0.053[h]	D	j		j		j	
Coke-fired grate/kiln (SCC 3-03-023-55)	1.9[k]	E	ND		ND		99[g]	C
Coal/coke-fired grate/kiln, (SCC 3-03-023-57)	2.3[m]	E	ND		ND		99[g]	C
Coal/coke-fired grate/kiln, with wet scrubber (SCC 3-03-023-57)	1.5[n]	D	ND		ND		j	
Gas-fired vertical shaft top gas stack (SCC 3-03-023-71)	ND		0.20[p]	E	0.077[p]	E	94[q]	C
Gas-fired vertical shaft top gas stack, with wet scrubber (SCC 3-03-023-71)	0.28[p]	E	j		j		j	
Gas-fired straight grate (SCC 3-03-023-81)	ND		ND		0.039[r]	E	ND	
Gas-fired straight grate, with wet scrubber (SCC 3-03-023-81)	0.10[r]	E	ND		j		ND	
Coke-fired straight grate, with multiclone and wet scrubber (SCC 3-03-023-85)	0.99[s]	D	ND		j		ND	
Coke/gas-fired straight-grate (SCC 3-03-023-87)	ND		0.44[r]	D	0.15[r]	E	62[s]	D

[a] Emission factors in units of lb/ton of fired pellets produced. One lb/ton is equivalent to 0.5 kg/Mg. Factors represent uncontrolled emissions unless noted. SCC = Source Classification Code. ND = no data.
[b] Mass balance of sulfur may yield a more representative emission factor for a specific facility than the SO_2 factors presented in this table.
[c] Mass balance on carbon may yield a more representative emission factor for a specific facility than the CO_2 factors represented in this table.
[d] References 4,39-40.
[e] References 19,27,39.
[f] Reference 39.
[g] References 5,18,29,32-34,39-40,42.
[h] Reference 4.
[j] See emission factor for uncontrolled emissions.
[k] Reference 29.
[m] Reference 15.
[n] References 15,25,29.
[p] Reference 44.
[q] References 12-14,24,44-45.
[r] Reference 31.
[s] References 30-31.

Table 11.23-5. EMISSION FACTORS FOR TACONITE ORE INDURATING FURNACES--FLUX PELLET PRODUCTION[a]

Source	SO_2[b]	EMISSION FACTOR RATING	NO_x	EMISSION FACTOR RATING	CO	EMISSION FACTOR RATING	CO_2[c]	EMISSION FACTOR RATING
Natural gas-fired grate/kiln, with wet scrubber (SCC 3-03-023-52)	0.14[d]	D	1.5[e]	D	0.10[f]		130[g]	C
Coal/coke-fired grate/kiln, with wet scrubber (SCC 3-03-023-58)	1.5[h]	D	ND		ND		130[g]	C
Gas-fired straight grate (SCC 3-03-023-82)	ND		2.5[j]	D	ND		ND	
Pellet cooler (SCC 3-03-023-15)	Neg.		ND		ND		6.4[f]	E

[a] Emission factors in units of lb/ton of fired pellets produced. One lb/ton is equivalent to 0.5 kg/Mg. Factors represent uncontrolled emissions unless noted. SCC = Source Classification Code. ND = no data. Neg. = negligible.
[b] Mass balance of sulfur may yield a more representative emission factor for a specific facility than the SO_2 factors presented in this table.
[c] Mass balance on carbon may yield a more representative emission factor for a specific facility than the CO_2 factors represented in this table.
[d] Reference 20.
[e] References 19,27,39.
[f] Reference 27.
[g] References 20,25-27,36-37.
[h] References 15,25,29.
[j] Reference 38.

Table 11.23-6. EMISSION FACTORS FOR TACONITE ORE PROCESSING--
OTHER POLLUTANTS[a]

EMISSION FACTOR RATING: E

Source	Pollutant	Emission factor, lb/ton	References
Gas-fired grate/kiln (SCC 3-03-023-51,-52)	VOC	0.0037[b] 0.075[c]	39 27
Gas-fired grate/kiln, with multiclone (SCC 3-03-023-51,-52)	Lead	0.00050	39
Coke-fired grate/kiln (SCC 3-03-023-55,-56)	H_2SO_4	0.17	29
Coke-fired grate/kiln, with wet scrubber (SCC 3-03-023-55,-56)	H_2SO_4	0.099	29
Gas-fired vertical shaft top gas stack (SCC 3-03-023-71,-72)	VOC	0.013[d]	44
Gas-fired vertical shaft bottom gas stack (SCC 3-03-023-73,-74)	VOC	0.046[d]	44
Gas-fired straight grate furnace, with multiclone and wet scrubber (SCC 3-03-023-81,-82)	Lead	6.8×10^{-5}	31
Gas-fired straight grate furnace, with multiclone and wet scrubber (SCC 3-03-023-85,-86)	Beryllium	2.2×10^{-7}	31
Coke/gas-fired straight grate furnace, with multiclone and wet scrubber (SCC 3-03-023-87,-88)	Lead	7.6×10^{-5}	31
Coke/gas-fired straight grate furnace, with multiclone and wet scrubber (SCC 3-03-023-87,-88)	Beryllium	2.9×10^{-7}	31

[a] Factors represent uncontrolled emissions unless noted. All emission factors for furnaces in lb/ton of fired pellets produced. One lb/ton is equivalent to 0.5 kg/Mg. SCC = Source Classification Code. ND = no data available.
[b] Based on Method 25A data. EMISSION FACTOR RATING: D.
[c] Based on Method 25 data.
[d] Based on Method 25A data.

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