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Reed, A. K., EPA Contract No. 68-02-1323

Battelle Columbus Laboratories

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Notice

This document is a preliminary draft. It has not been formally released by the U.S. Environmental Protection Agency and should not at this stage be construed to represent Agency policy. It is being circulated for comments on its technical merit and policy implications.

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STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT

reference 2

for

THE IRON ORE BENEFICIATION INDUSTRY

December, 1976

by

A. K. Reed

Battelle
Columbus Laboratories
Columbus, Ohio 43201

under

Contract No. 68-02-1323
Task No. 34

Gilbert Wood
Project Officer

Emission Standards and Engineering Division
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

CONTENTS

CONTENTS

TABLES

TABLES

TABLES

FIGURES

FIGURES

2. INTRODUCTION

> This document is a preliminary draft. It has not been formally released by the U.S. Environmental Protection Agency and should not at this stage be construed to represent Agency policy. It is being circulated for comments on its technical merit and policy implications.

This draft document presents information on the iron ore beneficiation industry. The report describes the various mining, concentrating, agglomerating, and handling processes; their emissions; and some of the various systems available for controlling emissions of sulfur oxides and particulate matter from these processes. This information <u>may</u> be subsequently used as part of the data base for consideration of standards of performance for new sources (Section 111 of the Clean Air Act, as amended June 1974) or emissions standards for hazardous air pollutants (Section 112). Either, both, or neither of these types of standards may be actually developed after determination of the presence or absence of need for controls.

3. THE IRON ORE BENEFICIATION INDUSTRY

3.1 GENERAL

Iron ore beneficiation pertains to the mining, crushing, grinding, concentrating, and agglomerating of iron containing ores. The iron ore industry presently mines over 6.4 Mg/s (200 million long tons per year) of crude to produce over 66,000,000 Mg (65 million long tons) of industrial iron ore pellets. The iron ore industry presently is projected to increase 30 percent by 1978. Geographically the major tonnages are produced in the Great Lakes region with Minnesota and Michigan being the largest producers.

3.1.1 Number, Production, and Distribution of Iron Ore Mines

Iron ore is presently mined at 41 mines ranging from 2 kg/s (180 long tons per day) to 1.3 Mg/s (110,000 long tons per day) production of iron ore. There are presently 19 pelletizing plants operating with a rated capacity of 2.1 Mg/s (65.75 million long tons per year) of pellets. Table 3.1 lists the mines in operation in 1974 and their rated ore production. Table 3.2 gives the pellet plants operating in 1974 along with their rated capacity of pellets.

The iron ore industry presently has expansions under way that will total 0.76 Mg/s (23.6 million long tons per year) of pellets. The locations of the expansions and their rated capacity are shown in Table 3.3. As shown there, the major expansions are occurring in Minnesota.

Crude iron ore production has increased from 5.79 Mg/s (179,851,000 long tons per year) in 1966 to 6.97 Mg/s (216,620,000 long tons per year) in 1975. The total production of crude along with tonnages for the four major

TABLE 3.1 IRON ORE MINES

Operation/Location	Start-Up Year	1974 Ore Mined kg/s	1974 Ore Mined ltpd	Mine Type
Arcturus Mine Marble, Minn.	NA	NA	NA	Open pit
Black River Falls Mine Black River Falls, Wisc.	1969	106	9,000	Open pit
Butler Taconite Nashwauk, Minn.	1967	268	22,800	Open pit
Canisteo Mine Coleraine, Minn.	1933	346	29,450	Open pit
Cedar City Mine Cedar City, Utah	1946	64	5,400	Open pit
Comstock Mine Cedar City, Utah	1953	49	4,200	Open pit
Eagle Mountain Mine Eagle Mountain, Calif.	1948	352	30,000	Open pit
Empire Iron Mining Co. Ishpeming, Mich.	1964	529	45,000	Open pit
Erie Mining Co. Hoyt Lakes, Minn.	1957	1,058	90,000	Open pit
Eveleth Taconite Co. Eveleth, Minn.	1965	200	17,000	Open pit
Grace Mine Morgantown, Pa.	1958	83	7,025	Underground
Gross-Nelson Mine Eveleth, Minn.	1966	71	6,000	Open pit
Groveland Mine Randville, Mich.	1959	168	14,250	Open pit
Hill Annex Mine Calumet, Minn.	1917	235	20,000	Open pit
Hull-Rust Mine Hibbing, Minn.	1965	47	4,000	Open pit
Jackson County Iron Co. Black River Falls, Wisc.	1969	88	7,500	Open pit
Lind-Greenway Mine Grand Rapids, Minn.	1953	235	20,000	Open pit
Lone Star Steel Co. Lone Star, Tex.	1947	188	16,000	Open pit

TABLE 3.1 IRON ORE MINES (Cont)

Operation/Location	Start-Up Year	1974 Ore Mined kg/s	1974 Ore Mined ltpd	Mine Type
Luck Mining Co. Silver City, N.M.	1938	2	180	Open pit
MacIntyre Development Tahawus, N.Y.	1942	59	5,000	Open pit
Mather Mine Ishpeming, Mich.	1943	86	7,300	Underground
McKinley Mine McKinley, Minn.	1968	200	17,000	Open pit
Meramec Mining Co. Sullivan, Mo.	1961	100	8,500	Underground
Minntac Plant Mt. Iron, Minn.	1967	1,294	110,000	Open pit
National Steel Pellet Plant Keewatin, Minn.	1967	282	24,000	Open pit
Nevada-Barth Corp. Carlin, Nev.	1960	14	1,200	Open pit
Pilot Knob Pellet Co. Ironton, Mo.	1968	70	5,979	Underground
Republic Mine Ishpeming, Mich.	1956	285	24,200	Open pit
Neville Mine Chisholm, Minn.	1974	102	8,650	Open pit
New York Division Star Lake, N.Y.	1944	113	9,600	Open pit
Rana Mine Kinney, Minn.	1974	42	3,600	Open pit
Reserve Mining Co. Silver Bay, Minn.	1955	1,000	85,000	Open pit
Rouchleau group Virginia, Minn.	1943	NA	NA	Open pit
Sherman Mine Chisholm, Minn.	1948	NA	NA	Open pit
Sherwood Mine Iron River, Mich.	1940	19	1.600	Underground
Stephens Mine Aurora, Minn.	1957	NA	NA	Open pit

TABLE 3.1 IRON ORE MINES (Cont)

Operation/Location	Start-Up Year	1974 Ore Mined kg/s	1974 Ore Mined ltpd	Mine Type
Sunrise Mine Sunrise, Wyo.	1900	NA	NA	Underground
Tilden Mining Co. Ishpeming, Mich.	1974	433	36,800	Open pit
U.S. Pipe & Foundry Co. Russellville, Ala.	1954	8	700	Open pit
Whitney Mine Hibbing, Minn.	1973	239	20,300	Open pit
Wyoming Mine Virginia, Minn.	1960	38	3,200	Open pit

Source: Reference 1.

TABLE 3.2 PELLET PLANTS

Company	Location	Start-Up Year	Pellet System	Rated Capacity Mg/s	Rated Capacity million ltpy
Erie Mining Co.	Minn.	1957/1960	Shaft furnace	0.332	10.3
Reserve Mining Co.	Minn.	1956/1962	Straight grate	0.348	10.8
U.S. Steel - Minntac	Minn.	1967/1972	Grate - kiln	0.386	12.0
Butler Taconite	Minn.	1967	Grate - kiln	0.084	2.6
National Steel Pellet Plant	Minn.	1969	Grate - kiln	0.090	2.8
Eveleth Taconite Co.	Minn.	1965	Grate - kiln	0.077	2.4
Hanna Mining Co. - Groveland	Mich.	1963	Straight grate	0.068	2.1
Marquette Iron Mining Co. - Republic	Mich.	1962	Grate - kiln	0.080	2.5
Humbolt Mining Co.	Mich.	1960	Grate - kiln	0.029	0.9
Pioneer Pellet Plant	Mich.	1965	Grate - kiln	0.052	1.6
Empire Iron Mining Co.	Mich.	1963/1967	Grate - kiln	0.113	3.5
Tilden Mining Co.	Mich.	1975	Grate - kiln	0.129	4.0
Meramec Mining Co.	Mo.	1964	Shaft furnace	0.058	1.8
Pilot Knob Mining Co.	Mo.	1968	Straight grate	0.032	1.0
Jackson County Iron Co.	Wis.	1969	Straight grate	0.024	0.75
Bethlehem Steel Corp. - Grace	Pa.	1961	Shaft furnace	0.048	1.5
Cities Service Co.	Tenn.	1972	Grate - kiln	0.029	0.9
Kaiser Steel Corp.	Cal.	1965	Straight grate	0.090	2.8
U.S. Steel Corp. - Atlantic City	Wy.	1962	Straight grate	0.048	1.5

Source: Reference 1.

TABLE 3.3 PELLET PLANT EXPANSIONS

Company	Location	Pellet System	Start-Up Year	Rated Capacity	
				Mg/s	million ltpy
Empire Mining Co.	Mich.	Grate-kiln	1975	0.058	1.8
Eveleth Taconite Co.	Minn.	State-kiln	1976	0.116	3.6
Hibbing Taconite Co.	Minn.	Straight grate	1976	0.174	5.4
National Steel Pellet Plant	Minn.	Grate-kiln	1977	0.135	4.2
Inland Steel Co. - Minorca	Minn.	Straight grate	1978	0.084	2.6
U.S. Steel Corp. - Minntac	Minn.	Grate-kiln	1978	0.193	6.0

Source: Reference 1.

producing areas are given in Table 3.4. The percentages of total crude mined in the four regional areas are given in Table 3.5. Table 3.6 gives the production of ore and total shipments for the regional areas in 1975.

3.1.2 Ore Types and Distribution

Iron oxides are the most significant mineral component of iron ores; however, other forms of iron minerals are mined for their iron content. Iron ore deposits are generally categorized according to their genesis, structure, geologic features, or amenability to metallurgical uses. There are in general three types of deposits--bedded, massive, and residual. The bedded deposits are sedimentary layers that have accumulated in bodies of water. The massive-type deposits are veins or masses of iron minerals that have replaced preexisting minerals or filled voids or fissures in existing rock formations. The residual deposits are bodies of iron minerals that have been subjected to a leaching action whereby some of the nonferrous mineral constituents have been removed.

Iron ore deposits are known to occur in a large number of states in the United States. The general distribution of known iron deposits in the United States is illustrated by Figure 3.1. As can be noted from Figure 3.1, there are 20 states that have some known occurrence of iron ore.

The bedded iron formations constitute the largest iron formations presently being mined. These deposits are characterized by the Lake Superior ores. Typically these ores consist of interbanded chert or quartz and iron minerals with prominent granular or oolitic texture. They are generally associated with chert, slate, shales, and dolomite. The deposits are generally well-defined and have broad regional extent and are developed

TABLE 3.4 PRODUCTION OF CRUDE ORE

Year	Regional Production, thousands of tons				
Year	Lake Superior	Southeastern States	Northeastern States	Western States	Total U.S.[(a)]
1966	142,819	7,042	11,365	18,625	179,851
1967	144,754	7,461	10,329	18,479	181,023
1968	156,832	7,621	10,075	19,360	193,889
1969	166,654	8,992	9,575	18,966	204,187
1970	170,071	10,376	9,029	19,666	209,142
1971	159,390	9,265	7,651	18,132	194,438
1972	155,685	9,186	6,615	13,137	184,623
1973	183,681	8,493	6,806	17,795	216,775
1974	183,600	7,030	6,365	17,183	214,178
1975	185,170	7,250	5,150	15,050	212,620

(a) Includes some by-product ore.
Source: Reference 2.

TABLE 3.5 PERCENTAGE OF TOTAL CRUDE PRODUCTION BY REGION

Year	Lake Superior	Southeastern States	Northeastern States	Western States
1966	79.4	3.9	6.3	10.4
1967	80.0	4.1	5.7	10.2
1968	80.9	3.9	5.2	10.0
1969	81.6	4.4	4.7	9.3
1970	81.3	5.0	4.3	9.4
1971	82.0	4.8	3.9	9.3
1972	84.3	5.0	3.6	7.1
1973	84.7	3.9	3.2	8.2
1974	85.7	3.3	3.0	8.0
1975	87.1	3.4	2.4	7.1

Source: Reference 2.

TABLE 3.6 IRON ORE MINE PRODUCTION AND TOTAL SHIPMENTS IN 1975

	Regional Production, Mg (long tons)				
	Lake Superior	Southeastern States[a]	Northeastern States[a]	Western States	Total U.S.[a]
Production (Crude Ore)	188,132,464 (185,169,748)	7,365,960 (7,249,961)	5,232,827 (5,150,420)	15,290,468 (15,049,673)	216,021,719 (212,619,802)
Run of Mine	113,005 (111,225)	114,404 (112,602)	— —	1,105,500 (1,088,091)	1,332,909 (1,311,918)
Coarse	4,902,726 (4,825,518)	—[b]	—[b] (—)[b]	1,030,682 (1,014,451)	6,354,602 (6,254,530)
Fines	6,246,587 (6,148,216)	101,864 (100,260)	585,028 (575,815)	898,889 (884,733)	7,832,368 (7,709,024)
Pellets	53,938,444 (53,089,020)	—[b] (—)[b]	—[b] (—)[b]	3,465,893 (3,411,312)	60,823,010 (59,865,167)
Sinter	— (—)	—[b] (—)[b]	—[b] (—)[b]	— (—)	550,822 (542,148)
Other	— (—)	— (—)	— (—)	— (—)	— (—)
Total Shipments	65,200,763[c] (64,173,979)[c]	3,373,712[d] (3,222,157)[d]	1,918,273 (1,888,064)	6,500,964 (6,398,587)	76,893,712[c,d] (75,682,787)[c,d]

(a) Includes by-product ore.
(b) Shipment not shown to avoid use of individual company data.
(c) Includes shipments of 98,881 Mg (97,324 long ton) containing 5 percent or more manganese.
(d) Includes shipments of 45,335 Mg (44,621 long ton) containing 5 percent or more manganese.

Source: Reference 2.

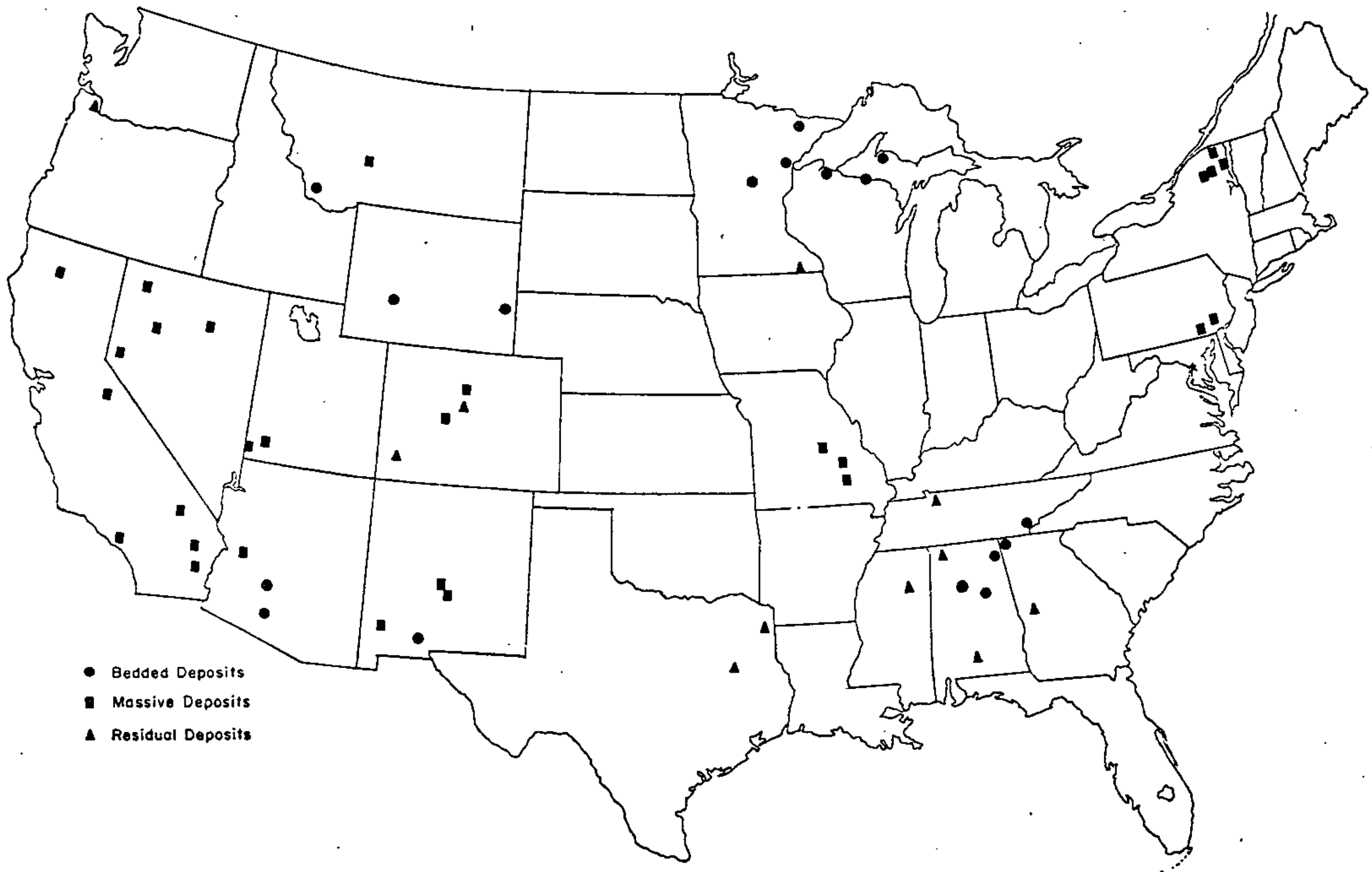

FIGURE 3.1. LOCATION OF IRON ORE RESERVES IN THE U.S.

in the pre-Cambrian rock groups. These deposits are often highly metamorphosed. This type of deposit is generally referred to as taconite, metataconite, jaspilite, and iron-quartzite and is typical of the Mesabi Range deposits. Other bedded type deposits in the U.S. are in the "red" ores or "Clinton" deposits found in Alabama. These deposits consist of hematite, chamosite, and siderite interbedded with carbonaceous shale, sandstones, and carbonate rocks.

The massive iron deposits are divided into four different types, two of which are being exploited in the U.S. One type referred to as the Kiruna type is typical of the Pea Ridge deposit in Missouri. This deposit is a massive magnetite deposit that appears as an intrusion into granitoid and syenite rocks. These deposits are typically high in magnetite with an appreciable amount of apatite present. The other type found in the U.S. is referred to as a contact-metasomatic type. The deposit at Cornwall, Pennsylvania, is an example. These types of deposits are massive and vein-like containing mostly magnetite and hematite but sometimes also carbonate and pyrite, often associated with skarn minerals. These deposits occur primarily in limestone, volcanic-sedimentary basic rocks, and amphibolites.

The residual deposits are of lesser importance presently. However, one typical deposit is being exploited in Texas and consists mainly of glauconitic sand, quartz, clay, and siderite.

3.1.3 Projected Growth

The iron ore industry in the U.S. is projected to have an annual growth from 1.3 to 2.3 percent from 1968 to the year 2000. The expansion plans already announced and under construction show an increase of 0.76 Mg/s (23.6 million ltpy) of pellets from 1975 rated capacity to 1978 rated capacity.[2] This growth would result in a total production of pellets in 1978 of 2.876 Mg/s (89.35 million ltpy). However, this expanded growth in three years is not expected to continue but probably will drop back to the 1.3 to 2.3 percent projected growth rate over the long-range period to the year 2000.

3.2 PROCESSES AND THEIR EMISSIONS

The first stage in the processing of iron ores is mining which includes drilling, blasting, and removing the rock. The second stage in the processing reduces the rock size by crushing and grinding to liberate the iron minerals from the gangue minerals. The ground material is then treated in a beneficiation plant designed to increase the iron content of the material. This processing can include a variety of steps such as washing, various gravity separation techniques, magnetic separation, flotation, thickening, and filtering. The filtered material is then mixed with a binder (usually bentonite) and agglomerated using balling drums, balling cones, or pelletizing discs. The agglomerated balls [pellets approximately 1.0 cm (3/8 inch) in diameter] are fired in a furnace to produce a hard relatively nondusting pellet which is ideal for blast furnace operation. The fired pellets are cooled, sized by screening, stored, and shipped to the steel mills.

The potential sources of particulate emissions from the iron ore operation are the mining, crushing, and conveying of the ore, the furnace firing and cooling gases, and the pellet handling, screening, storage, and loading operations. All plants have some variety or combinations of particulate control devices on most of the various sources of air emissions.

3.2.1 Mining Operations

3.2.1.1 Process Description. The mining of iron ore consists of two general mining methods, underground and open pit. The largest tonnages of iron ore produced come from the open pit operations. In general, this mining operation consists of three steps; drilling-blasting, loading, and hauling.

The underground mining of iron ores in the United States is presently practiced at six different locations. In general, underground mining requires a higher grade of iron ore than needed for open pit mining in order to achieve comparable unit costs. Underground mines usually are highly mechanized and the drilling, loading, and hauling operations generally are done with wet material. Two examples of underground mining of iron ore are the Meramec Mine and the Pilot Knob Mine in Missouri.

Open pit mining is the most attractive method of exploiting certain deposits because it can generally be adapted to most shapes of deposits. In addition, open pit mining can be adapted to large tonnage output with flexibility at the lowest cost.

Taconites in general are siliceous and hard to drill and fragment. Thus, in taconite mines, the bench height tends to be higher than in open pit mining of other ores; drilling and blasting are carefully engineered to assure good fragmentation.

The drilling and blasting operations in a taconite mine are carefully planned and executed because the costs are high and the fragmentation achieved affects the operating costs for all the subsequent steps. Three principal types of drills are used; jet piercers, rotary drills, and some down-the-hole percussion drills.

The jet piercing drill is preferred for the harder taconite-type rocks with the drilling action relying on the spalling characteristics of the rock. The jet piercing drilling actions depends on the decrepitation of the rock resulting from stresses caused by differential thermal expansion. This drill induces the thermal stress from a burner using fuel oil, oxygen, or air, and water which generates a flame temperature of 1922 to 2644 K (3000 to 4300 F). The drills generally operate at 0.085 to 0.381 cm/s (10 to 45 fph), consume from 42 to 79 cm^3/s (40 to 75 gph) of fuel oil, and produce a hole of 23 to 38 cm (9 to 15 inches) in diameter.

Rotary drills are generally used in those mines where the ore is relatively soft. Also they are used in drilling the over-burden which is usually less consolidated than the ore. However, with tungsten carbide bits now available, rotary drills are being used more extensively. The rotary drill relies on the cutting action of a rotating cone-shaped bit with the cuttings removed by air or sometimes an air-water mixture. The drilling rate depends on the rotational speed of the bit and the pressure applied to the bit. The drill bit life can vary from 72 to 720 ks (20 to 200 hours) depending on the characteristics of the ore and the operating conditions used in drilling. Dust suppression techniques are generally used with rotary drilling. They can include water additions to the air and water injection in the upward airflow from the bit. The injection of water in the air stream generally shortens bit life and results in somewhat increased bit cost.

The down-the-hole percussion drills are only used in some special circumstances and do not account for a large tonnage of ore; therefore, they are not considered important to this discussion.

The blasting in open pit mines varies considerably with the ore body, mine plan, equipment used, drill hole size, drill hole spacing, bench height, loading equipment, etc. In general a single blast will fragment from several 100,000 mg (hundred thousand tons) of ore to a 1,016,000 Mg (million tons) and will use from 0.27 to 0.45 kg (0.6 lb to over 1 lb) of explosives per 1 Mg (1 ton) of ore broken. Blasting in some of the large operations is scheduled to occur during favorable meteorological conditions to prevent the propagation of sound waves.

Loading practice in open pit operations usually involves the use of large shovels with 7- to 13-m^3 (9- to 15-cubic yard) buckets for the primary loading while large front-end loaders are used in secondary or cleanup operations.

Hauling operations include railroad haulage from the working faces to large trucks or some combination of trucks and rail haulage usually depending on the individual operation. The trucks used range in size from 51 to 356 Mg (50 to 350 tons) (the latter is a prototype unit in operation at Eagle Mountain, California). The ore transported by railroad usually is done by unit car trains such as at Reserve Mining Company where 160-car unit trains transport ore some 80 km (50 miles) to the crusher station.

3.2.1.2 Emissions From Mining. The principal mining operations include drilling, blasting, loading ore, and hauling of the ore, all of which can produce particulate emissions.

Some of the fugitive emission sources are controlled to some degree in the iron ore industry principally by using water sprays as in the case of drilling and mine road dust. Other sources of fugitive emissions such as blasting and the haulage loads are more difficult to handle; in addition, the severity of the emissions usually depends on the weather. There are presently no estimates available of fugitive emission quantities from the various mining operations. Only one plant of the 19 plants surveyed in this study reported on emissions in this category. In this case (Eveleth Taconite Company), the emissions from the truck dump and rail car loading and unloading pockets were estimated to be about 19 g/s (150 pounds per hour) while processing about 232 kg/s (825 tons per hour) of ore. These emissions sources were either uncontrolled or had dry cyclone collectors operating.

3.2.2 Beneficiation of Iron Ore

The present-day specifications for blast furnace feed are so stringent and the crude ore grades are in general so low that practically all of the crude ore has to be beneficiated before it can be marketed. The beneficiation steps and procedures required will vary from simply crushing and washing to various combinations of crushing, washing, gravity and magnetic separation, and flotation. The variations used in the overall processes beneficiating the crude ore are illustrated by the data included in Table 3.7. As can be noted, the majority of the ore is processed through a crushing, grinding, and a magnetic separation stage with flotation being applied in a few cases to make the final concentrate.

3.2.2.1 Crushing. Iron ore crushing is generally accomplished by utilizing gyratory-type crushers and vibrating screens to size the material. Figure 3.2 illustrates the gyratory-type crusher. Typically, the crushing circuit will consist of primary, secondary, and tertiary crushers combined with vibrating screens to separate the desired size fraction.

Several variations in material flow and number of crushers are used; however, in general, the ore will be crushed in a primary gyratory crusher to

TABLE 3.7. BENEFICIATION METHODS USED BY ACTIVE IRON ORE MINES

	Location	Grinding, primary/ secondary	Concentrating Method
Erie Mining Co.	Minn.	RM-BM	MS
Reserve Mining Co.	Minn.	RM-BM	MS
U.S. Steel Corp. (Minntac)	Minn.	RM-BM	MS
Butler Taconite	Minn.	DSAG-BM	MS
National Steel Pellet Plant	Minn.	DSAG-BM	MS
Eveleth Taconite Co.	Minn.	RM-BM	MS
Hanna Mining Co. - Groveland	Mich.	RM-BM	MS-Spi-Flot
Marquette Iron Mining Co. - Republic	Mich.	RM-BM	Flot
Humboldt Mining Co.	Mich.	--	--
Pioneer Pellet Plant	Mich.	RM-BM	W-HM-MS
Empire Iron Mining Co.	Mich.	WAG-BM	MS-Flot
Tilden Mining Co.	Mich.	WAG-BM	SFl-Flot
Meramec Mining Co.	Mo	RM-BM	MS-Flot
Pilot Knob Mining Co.	Mo.	WAG-BM	MS-Flot
Jackson County Iron Co.	Wis.	RM-BM	MS
Bethlehem Steel Corp. - Grace	Pa.	RM-BM	MS
Cities Service Co.	Tenn.	BM	Flot-R
Kaiser Steel Corp.	Cal.	RM-BM	HM-J-MS
U.S. Steel Corp. - Atlantic City	Wyo.	RM-BM	MS

Source: Reference 1.

Legend:

RM - Rod Mill
BM - Ball Mill
DSAG - Dry Semi-Autogenous
WAG - Wet Semi-Autogenous Grinding
MS - Magnetic Separation
Spi - Spiral
Flot - Flotation
HM - Heavy Media
W - Washing
R - Roasting
J - Jig
SFl - Selective Flocculation

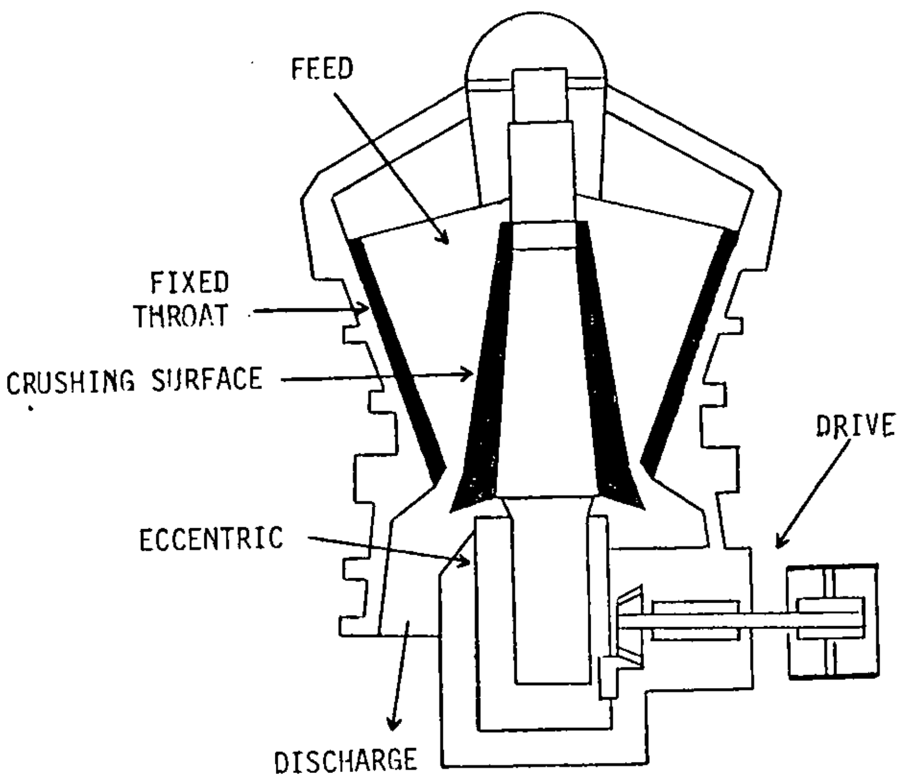

Figure 3.2 Gyratory crusher

approximately 18 cm (7 inches). The primary crushers are 137- to 152-cm (54- to 60-inch) gyratories with the product going to a stockpile or primary crusher bins. This material is then picked up by vibrating feeders and put on a conveyor belt which, in some instances, will be processed on vibrating screens. Some plants will send all of the primary crusher discharge directly to the secondary crusher or fine crushing plant.

The fine crushing plant will generally consist of secondary and tertiary crushers and, in some plants, there will be a fourth-stage crusher. These are generally cone crushers. Vibrating screens are usually incorporated into the flowsheet to remove the undersize material from the next crusher feed. This method of screening off the undersize allows the next crusher to handle a larger volume of material than it otherwise could. In general, the fine crushing plant will produce material that is primarily less than 0.64-cm (1/4-inch) size. The fine crusher discharge is conveyed to holding bins or silos to provide feed material for the grinding circuit. Typical crushing circuits are shown in Figures 3.3 and 3.4.

3.2.2.2 Grinding and Concentration. The grinding circuit will consist of rod mill-ball mill combinations or autogeneous mills. Generally water is added at this point and the material is handled as a slurry through the concentrator. In both cases the material will be subjected to size classification by screens or cyclones and concentration by magnetic separators, gravity separators, flotation, or some combination of these methods.

Typically the rod mill discharge will be pumped to magnetic separators referred to as cobbers. The nonmagnetic material will be discarded to the tailings. Some plants will classify this material to separate the coarse tailings from the fine tailings. These plants will generally use the coarse

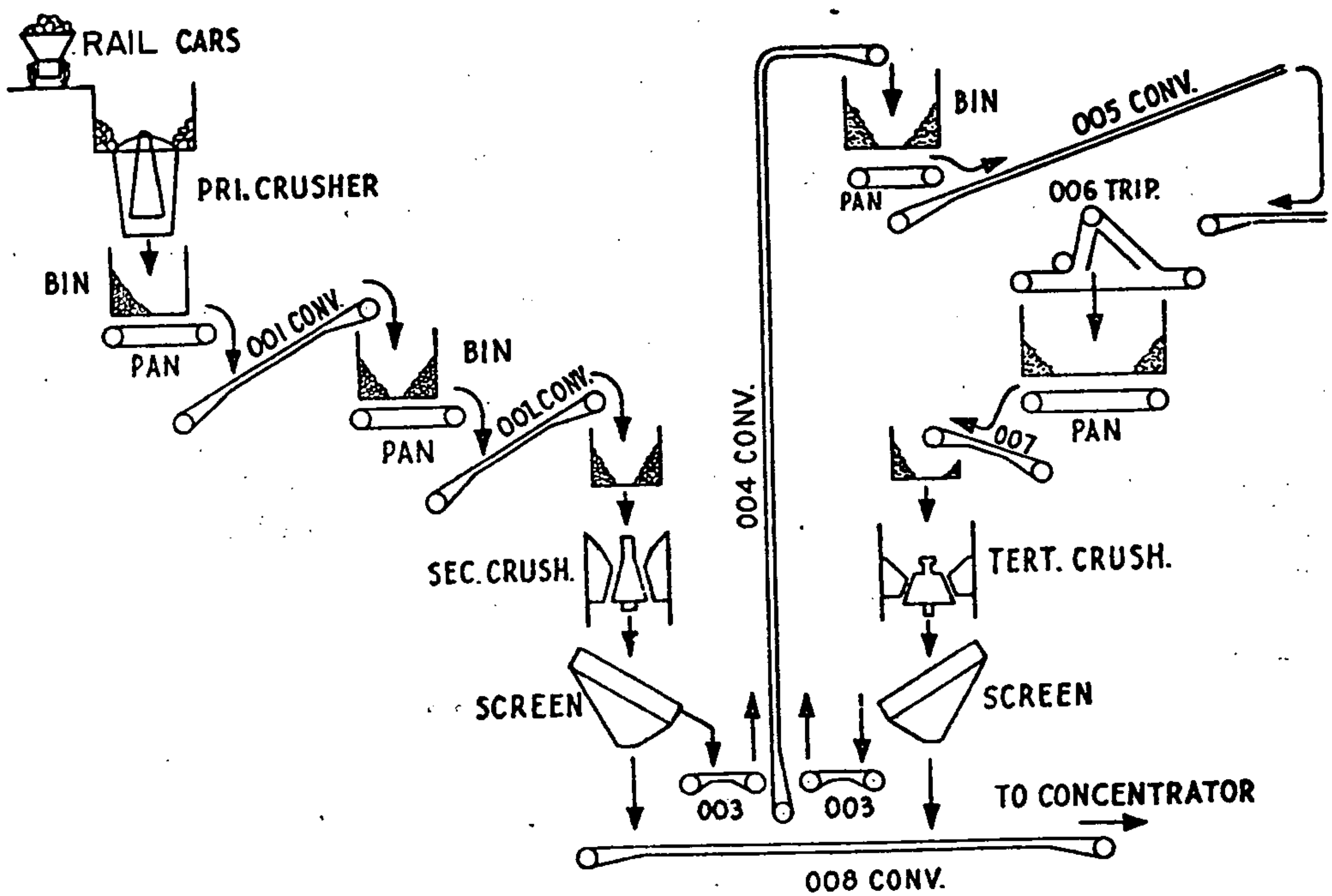

Figure 3.3 Crushing plant flowsheet (U.S. Steel - Minntac)

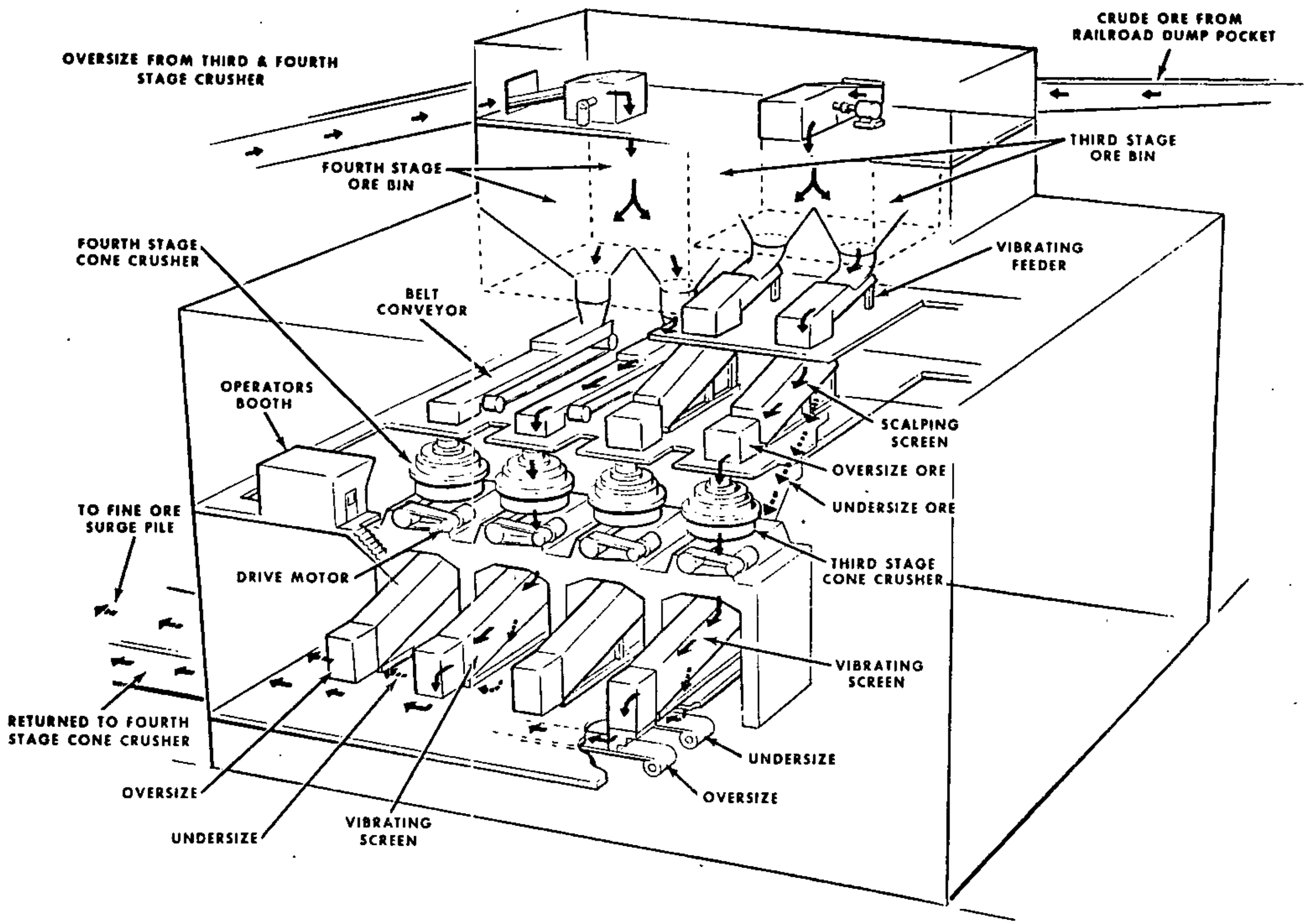

Figure 3.4 Fine crushing building (Eveleth Taconite Company).

tailings for dike construction or road building material whereas the fine material will be pumped directly to the tailings thickeners. The magnetic fraction will be pumped to primary ball mills and ground further; the ball mill discharge is then pumped to classifying cyclones with the coarse material (underflow) returning to the ball mill and the fine material (overflow) pumped to rougher magnetic separators. The rougher magnetic separators discard the nonmagnetics to the tailings and the magnetics are ground to a finer size in secondary ball mills. The secondary ball mills discharge to classifying cyclones with the coarse material returning to the rougher magnetic separators or secondary ball mills. The finer material is pumped to either a dewatering device such as hydroseparators, thickeners, siphonsizers, etc, or magnetic separators. In some plants there are cleaner and finisher magnetic separators. In essence, some plants use two stages of magnetic separation; others use three or four stages of magnetic separation.

In addition to the above flow schemes, some plants will use gravity separation devices such as jigs, spirals, heavy media separators, flotation, or various combinations of these techniques. Also some plants are using autogeneous grinding circuits instead of the conventional methods described above. In these plants the ore will be ground in the autogeneous mill and discharged to a double-deck screen which separates the 2.5- to 6.4-cm (1- to 2-1/2-inch) material which is used as grinding media in the pebble mills. The plus 6.4-cm (2-1/2-inch) material is returned to the autogeneous mill, the minus 2.5-cm (1-inch) material is passed over a 0.840-mm (20-mesh) DSM screen with the fines bypassing the pebble mill and going straight to the magnetic cobbers. The pebble mill then discharges to a classifying cyclone with the overflow going to the magnetic finishers and the underflow returning to the pebble mill.

In the newest plant using autogeneous grinding (Tilden Mine), no magnetic separation is used, the pebble mill discharges to a cyclone, then a desliming thickener, and then to the flotation section. The flowsheet of the Tilden Mine concentrator is shown in Figure 3.5. In the flotation section, a combination of chemical reagents is added to cause the gangue materials (silicates) to be selectively floated away from the iron materials.

Typically the slurry from the concentrator is then filtered utilizing disc-type vacuum filters which are illustrated in the photograph of Figure 3.6.

The final product from the beneficiation section is a filtered iron concentrate containing approximately 9 percent moisture, 60 percent iron, and 2 to 7 percent silica with a size ranging from 80 percent minus 0.0445 mm (325 mesh) to 90 percent minus 0.0127 mm (500 mesh). This material is transferred to large bins which feed the agglomeration section.

3.2.2.3 Emissions From Beneficiation Operations. The beneficiation operation thus consists of one or all of the following: crushing, screening, transporting, grinding, magnetic separation, flotation, thickening, and filtering. All operations in this section except for the crushing, screening, and transporting are done wet (as a slurry); therefore, particulate emissions are not a problem. In the case of crushing and transporting, the potential emissions are usually at the feed or discharge points of the crusher or at conveyor transfer points. Screens can be significant sources; thus, they are generally hooded with a control device attached.

Some particulate emission values were obtained in this study for a variety of beneficiation plants. These are averaged by category and listed in Table 3.8.

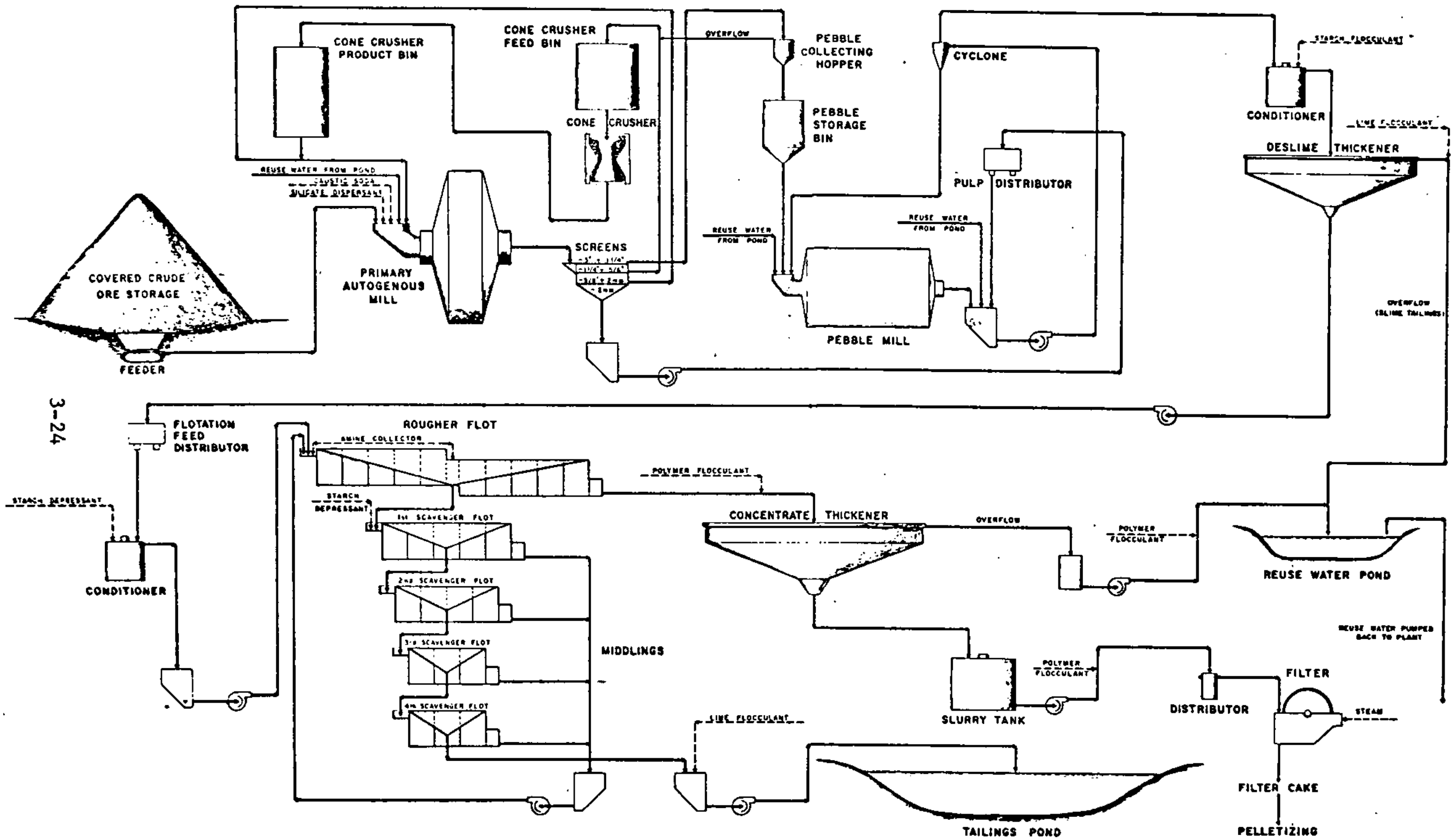

Figure 3.5 Iron ore concentrator flowsheet utilizing autogenous milling and flotation circuits - Tilden Mine.

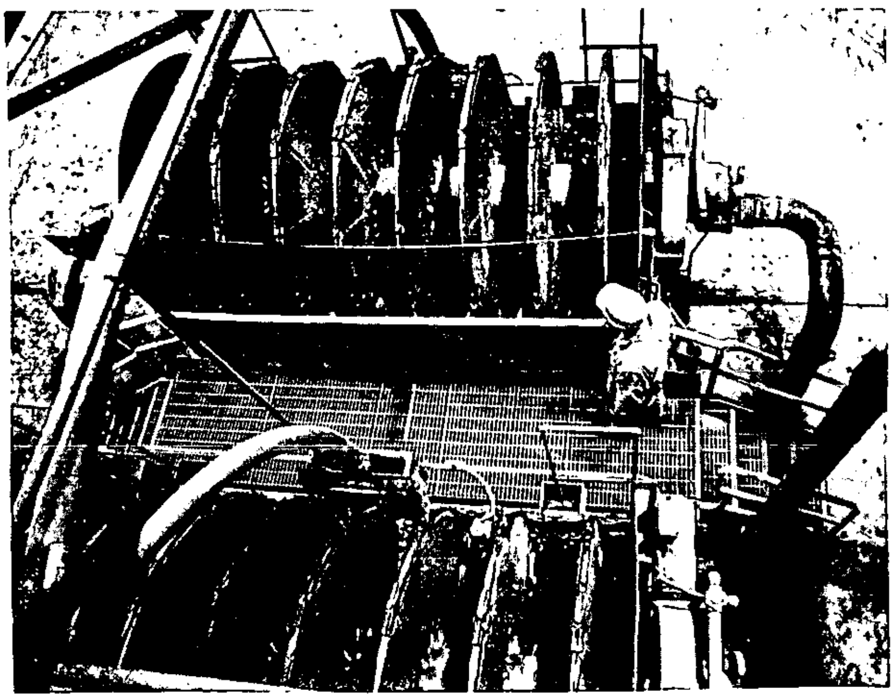

Figure 3.6 Disc-type vacuum filter

TABLE 3.8a SUMMARY OF EMISSIONS FROM BENEFICIATION OPERATIONS OF SEVERAL IRON ORE PLANTS (ENGLISH UNITS)

	Production Rate,	Gas Volume		Particulate Emissions	
	Long tons/hr	Scfm	Scfm/ton/hr	Lb/hr	Lb/ton
Conventional Plants					
Hanna Mining - Groveland	616	152,000	247	28.8	0.047
Erie Mining Company	3544	860,000	242	302.5	0.085
Eveleth Taconite Company	825	165,000	200	56.9	0.069
U.S. Steel - Minntac	4672	968,000	208	-	-
U.S. Steel - Atlantic City	579	235,000	405	-	-
		Avg.	260		0.067
Plants Using Dry Autogeneous Grinding					
Hanna Mining - National	962	502,000	522	172.6	0.18
Hanna Mining - Butler	923	444,000	480	195.8	0.21
		Avg.	500		0.20
New Plants With Wet Autogeneous Grinding					
Pickands Mather - Hibbing	2400	37,500	16	16.	0.007

TABLE 3.8b SUMMARY OF EMISSIONS FROM BENEFICIATION OPERATIONS OF SEVERAL IRON ORE PLANTS (METRIC UNITS)

	Production Rate,	Gas Volume		Particulate Emissions	
	kg/s	Std. m^3/s	per kg per s	g/s	g/Mg of ore
Conventional Plants					
Hanna Mining -- Groveland	174	72	0.41	3.6	21
Erie Mining Company	1,000	406	0.41	38.1	38
Eveleth Taconite Company	233	78	0.33	7.2	31
U.S. Steel - Minntac	1,319	457	0.35	-	-
U.S. Steel - Atlantic City	163	111	0.68	-	-
		Avg.	0.44		30
Plants Using Dry Autogeneous Grinding					
Hanna Mining - National	272	237	0.87	21.7	80
Hanna Mining - Butler	260	210	0.81	24.7	94
		Avg.	0.84		87
New Plants with Wet Autogeneous Grinding					
Pickands Mather - Hibbing	677	18	0.03	2.0	31

The data in Table 3.8 show a rather clear-cut difference in particulate emissions depending on the type of beneficiation plant considered. For example, assuming a typical plant will process about 1000 tons per hour of ore, the conventional crushing and grinding plant will emit about 8 g/s (65 pounds per hour) of particulates, and this is contained in about 106 standard m^3/s (225,000 scfm) of gas volume. The plants using dry *semiautogeneous grinding* will have up to 25 g/s (200 pounds per hour) of particulates and a gas volume about twice that of conventional plants. It should be noted that at least one of the two plants which currently utilize dry grinding is implementing a change to the wet autogeneous grinding method. This wet method apparently will result in greatly reduced emissions as projected by the Hibbing project which can have emissions as low as 0.78 g/s (7 pounds per hour) per 1000 Mg (1000 tons) of ore processed.

3.2.3 Agglomeration

The last decade has seen a significant increase in the use of agglomerated iron ores either in the form of sinter or pellets. The increased use of agglomerated ores results from the decrease in the availability of direct shipping ores and the improvement in blast furnace performance when using agglomerated ores. The blast furnace operation is not efficient for handling fines; therefore, a significant increase in the production of pellets and sinter can be anticipated in the next decade.

3.2.3.1 Sintering. The sintering process was developed because of the difficulties that arise in the handling of fine ores and concentrates. Fine materials create dust problems and are not as efficient in subsequent operations such as the blast furnace. Sintering overcomes these difficulties by causing the fine particles to bond together, or agglomerate, into porous pieces that are strong enough to hold their shapes in subsequent furnace operations and porous enough to permit good gas dispersion through the bed. Sintering is accomplished by mixing a finely divided solid fuel, such as coke breeze, with the fine ore, igniting the fuel and burning it with a forced draft through the mixture. This process is used primarily for fines generated at steel mills, although at least two sintering plants are at separate locations.

The sintering machine basically consists of a number of individual containers, termed pallets, for receiving and conveying the material. The pallets are simply rectangular troughs with walls on two sides, and grates to support the charge. The pallets successively pass under equipment which deposits and levels a bed of charge material [usually about 30.5 cm (12 inches) in depth] under a burner which ignites the upper surface of the charge. The pallets then pass a number of chambers referred to as wind boxes which are connected to the exhaust side of a fan to draw the hot air through the charge on the pallets. The rate of travel of the pallets is regulated so that they will arrive at the end of the wind box section when the charge has reached the desired temperature.

In this manner, mixtures of ores or concentrates containing fuel are ignited, and the initial combustion is propagated downward by the down draft through the wind box section. The flame front continues to the bottom of the charge. It should be noted that the firing is reversed in some cases and the wind boxes are operated in an updraft mode. The heat developed by the combustion of the fuel in the layer of charge produces the porous agglomerate called sinter. The sintering process also serves to decompose such undesirable constituents in the material as carbonates and sulfates.

3.2.3.2 Pelletizing. Pelletizing literally means the forming of little spherical agglomerates. This process has become increasingly important as the ores become lower in iron content and more finely disseminated thus causing the beneficiation processes to work with finer material. The finer material from minus 0.64 cm (minus 1/4 inch) to minus 0.0127 millimeter (0.0500 inch) in size could not be treated in the blast furnaces effectively, therefore the forming of balls, 0.95 to 1.27 cm (3/8 to 1/2 inch) in size, by pelletizing has become necessary.

The pelletizing or balling circuit starts with the concentrate storage bins which hold the concentrate produced in the beneficiation section. This material is taken out of the concentrate storage bins by variable-speed table feeders and deposited on a conveyor belt that passes under a feeder which adds bentonite at the rate of 4 to 9 kg/Mg (9 to 20 lb per long ton) of concentrate. Bentonite is a clay binder used to provide strength (strong enough to withstand handling before firing) to the pellets. The bentonite and concentrate are then thoroughly mixed and fed to balling drums or pelletizing discs. The majority of the iron ore plants use balling drums; however, a few plants use pelletizing discs or cones. The pelletizing disc is shaped like a large saucer which is tilted and rotated, thus forming balls which continue to grow in size until they finally reach the desired size 0.95 to 1.27 cm (3/8 to 1/2 inch) at which point they are discharged over the edge of the disc. Several variables control the operation of the disc such as moisture content, bentonite addition, degree of tilt, rotating speed, and particle size of the material being handled.

The balling drum circuit is similar in nature to the disc except the mechanism is a large rotating drum, 2.7 to 4.6 m (9 to 15 feet) in diameter and 9.1 to 12.2 m (30 to 40 feet) long. A typical balling drum circuit is shown in Figure 3.7. The pelletizing circuit consists of the concentrate being fed to the drum which is slightly inclined [approximately 0.12 to 0.16 rad (7 to 9 degrees)] and rotated [approximately 0.13 to 0.17 revolutions per second (8 to 10 rpm)]. As the material passes through the drum, the pellets grow in size and pass on to the screen. Cutter bars are used inside the drum to trim the material off the wall of the drum; usually the drum will have a 1.27- to 1.91-cm (1/2- to 3/4-inch) lining of concentrate. There are basically two types of cutter bars, oscillating and rotating. The oscillating cutter bar oscillates back and forth parallel to the center line of the drum and has tungsten carbide teeth which trim off the concentrate to the desired thickness. The rotating cutter operates parallel to the center line of the drum; however, the cutters now rotate in the opposite direction of the drum and in this manner trim the concentrate off the drum. The cutter bar is necessary to provide a smooth and regular surface lining on the drum to allow consistent pellet formation.

The pellets being discharged from the pelletizer are screened with the undersized material being recycled back to the feed end of the pelletizer. In newer plants, oversize pellets are broken and also recycled to the pelletizer. Pellets of correct size are then conveyed on to the induration furnaces.

The indurating or firing of the pellets is accomplished by several basic furnace configurations and combinations. The basic types presently being used are

- Shaft furnace
- Straight grate -

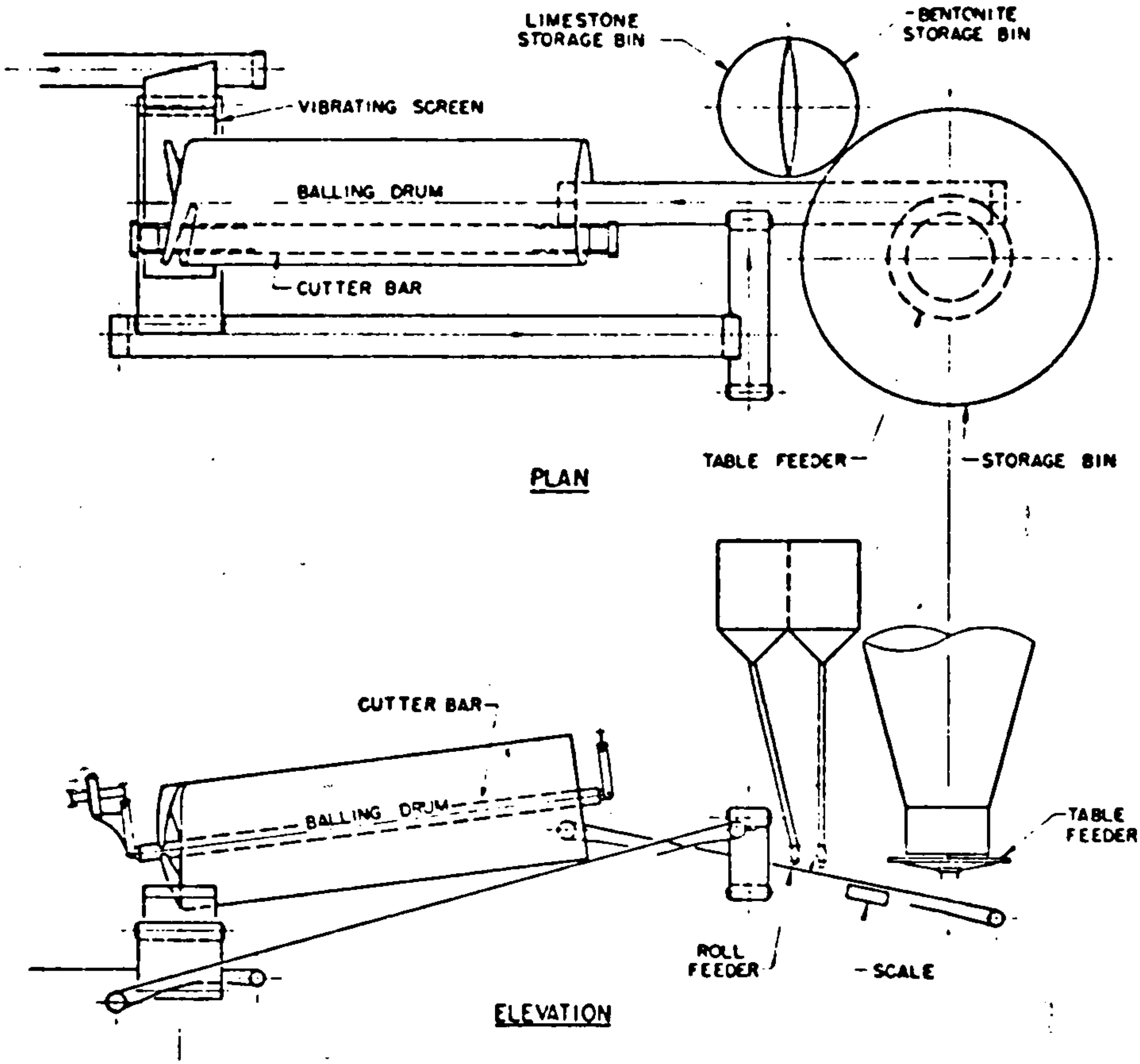

Figure 3.7 Typical balling drum circuit.

McKee type - no hearth layer

Dravo-Lurgi - hearth layer used

- Grate-kiln
- Circular grate.

Each of the above indurating systems has a drying zone, firing zone, and cooling zone. However, a number of things are different such as the off-gas flows, mechanical handling of pellets, mechanical wear, and thermal efficiency. Presently the largest tonnage of pellets is produced in the "grate-kiln" and the "straight grate" systems. The shaft furnace was one of the earliest systems, with the circular grate being the newest approach. Each system has its supporters and their reasons for using a certain configuration.

3.2.3.2.1 Shaft Furnace. The shaft furnace is quite simple in design and operation; basically, it consists of a large, vertical steel shell which is refractory lined and in which the green pellets are fed in the top and flow out the bottom with the gases flowing countercurrent to the pellets. A cross section of a shaft furnace is presented in Figure 3.8. Typically, a furnace will process 14 to 17 kg/s (50 to 60 tons per hour) of pellets and have approximate dimensions of 2.1 to 2.4 m (7 to 8 feet) wide at the stock-line and approximately 20 m (65 feet) high.

In the shaft furnace operation, green pellets are layered in the top of the furnace by indexing type feeders which evenly distribute the pellets across the furnace. The pellets then begin descending down the furnace to be dried and preheated by the upward flow of air and gases introduced at the bottom of the furnace. The pellets flow into the bustle zone where the firing occurs, then continue down the furnace to the cooling zone where air is being introduced. Thus, the cold air coming in at the bottom is heated by the

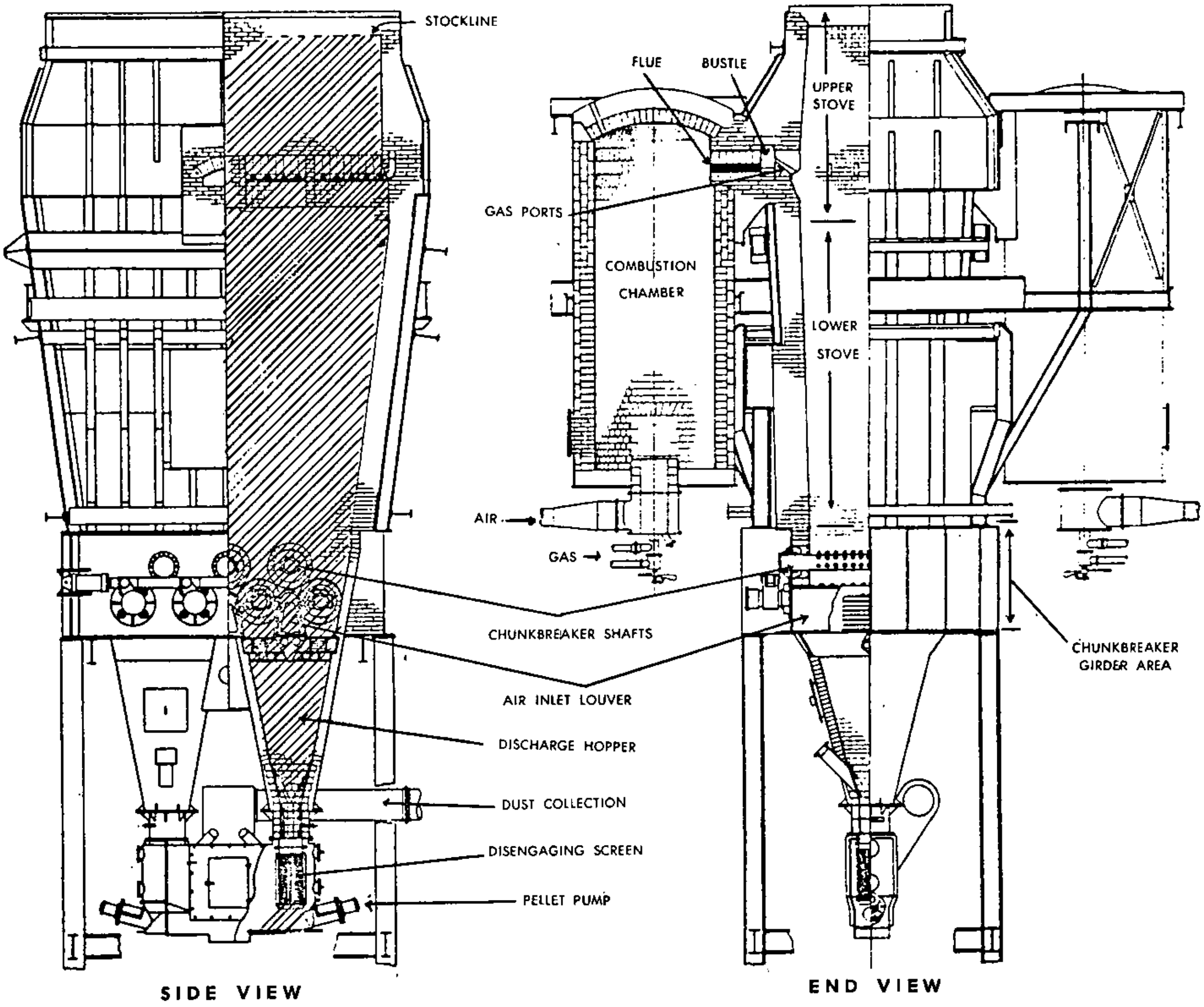

Figure 3.8 Cross-Section of Vertical Shaft Furnace

hot pellets descending down the furnace; this, therefore, provides fuel economies in the firing process. The average residence time for the pellets in the furnace is about 4 hours.

There are some rather severe limitations to the shaft furnace.(3) First, it is limited to magnetite ores. Induration is dependent upon the exothermic reaction of the magnetite. If the FeO content is below approximately 18 percent, induration cannot be sustained. Second, it is difficult to maintain even distribution of the gases through the shaft, resulting in adjacent hot and cold spots effecting fired pellet quality. Third, generally speaking, the quality of shaft furnace pellets is the poorest of all the pelletizing systems.

The pellets are discharged from the furnace by several means ranging from continuous discharge by vibrating units to intermittent discharge by hoppers and screens. The shaft furnaces can be fired with natural gas, fuel oil, or coal (using an external combustion chamber) and typically will require 644 to 966 MJ/Mg (400,000 to 600,000 Btu's per ton) of pellets. No new plants, however, are being constructed which employ shaft furnaces.

3.2.3.2.2 Straight Grate System. The straight grate or traveling grate furnace consists of a moving grate passing through several zones which include drying, preheating, firing, burning, and cooling. There are basically two types of straight grate machines; the McKee type and Dravo-Lurgi type. The primary difference in the two types is that the Dravo-Lurgi machine recycles fired pellets to be layered on the grate (referred to as a "hearth layer") before green (unfired) pellets are put on the grate. This straight grate system then requires fired pellet screening and recycle plus additional equipment to spread the fired pellets. With the fired pellet layer next to the grate [usually approximately 10 cm (4 inches)], the grate is not subjected to as high a temperature; therefore, it usually can be constructed out of less expensive materials and it provides longer life than the McKee type. However, the McKee type will allow a higher throughput for the same size grate. The two types of straight grate machines are shown in Figures 3.9 and 3.10. A number of control variables are associated with the straight grate such as air distribution, grate speed, distribution of pellets on the grate, temperatures maintained in the wind box hoods, gas volume, etc.

3.2.3.2.3 Grate-Kiln System. The grate-kiln indurating furnace consists of a combination traveling grate and rotary kiln. The traveling grate is used to dry and preheat the pellets prior to the actual firing which is accomplished in the rotary kiln. A typical grate-kiln system is illustrated in Figure 3.11.

The green pellets are fed by roll feeders, vibrating feeders, or vane-type feeders to the grate section. The initial grate section is used to dry the pellets at a temperature of 644 to 700 K (700 to 800 F). The drying zone gases come from the preheat zone of the grate and the pellets are dried by passing the gas through the pellet bed. Both updraft and downdraft drying can be utilized but most grate kilns utilize downdraft drying. These gases usually pass through a particulate control device and are then vented to the atmosphere. The continuous grate feeds the pellets to the preheat zone which is again operated in a downdraft mode with the source gas coming from the kiln. The preheat zone is usually maintained between 1311 and 1422 K (1900 and 2100 F). After the gases pass down through the pellet bed, they typically pass through a bank of cyclone collectors and then on to the drying zone. The pellets coming out of the preheat zone are now thoroughly dry of

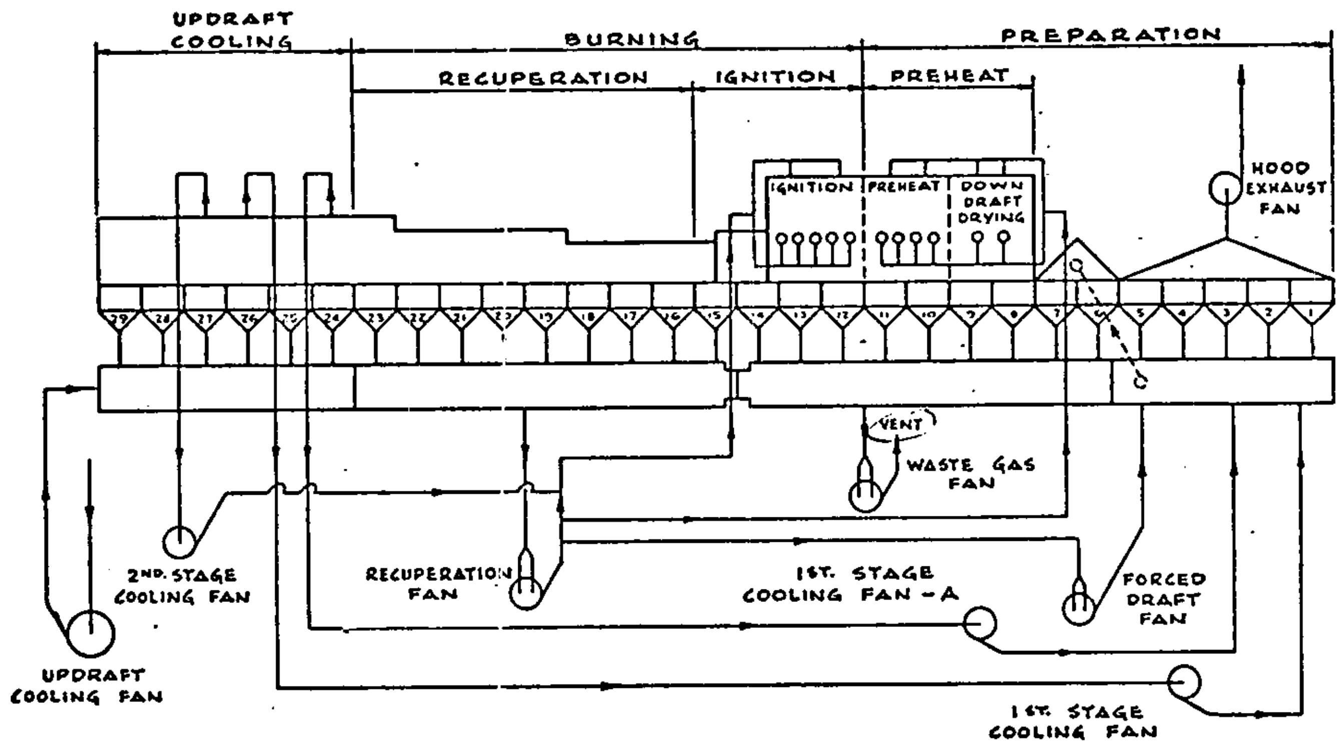

Figure 3.9 Straight grate induration system, McKee type.

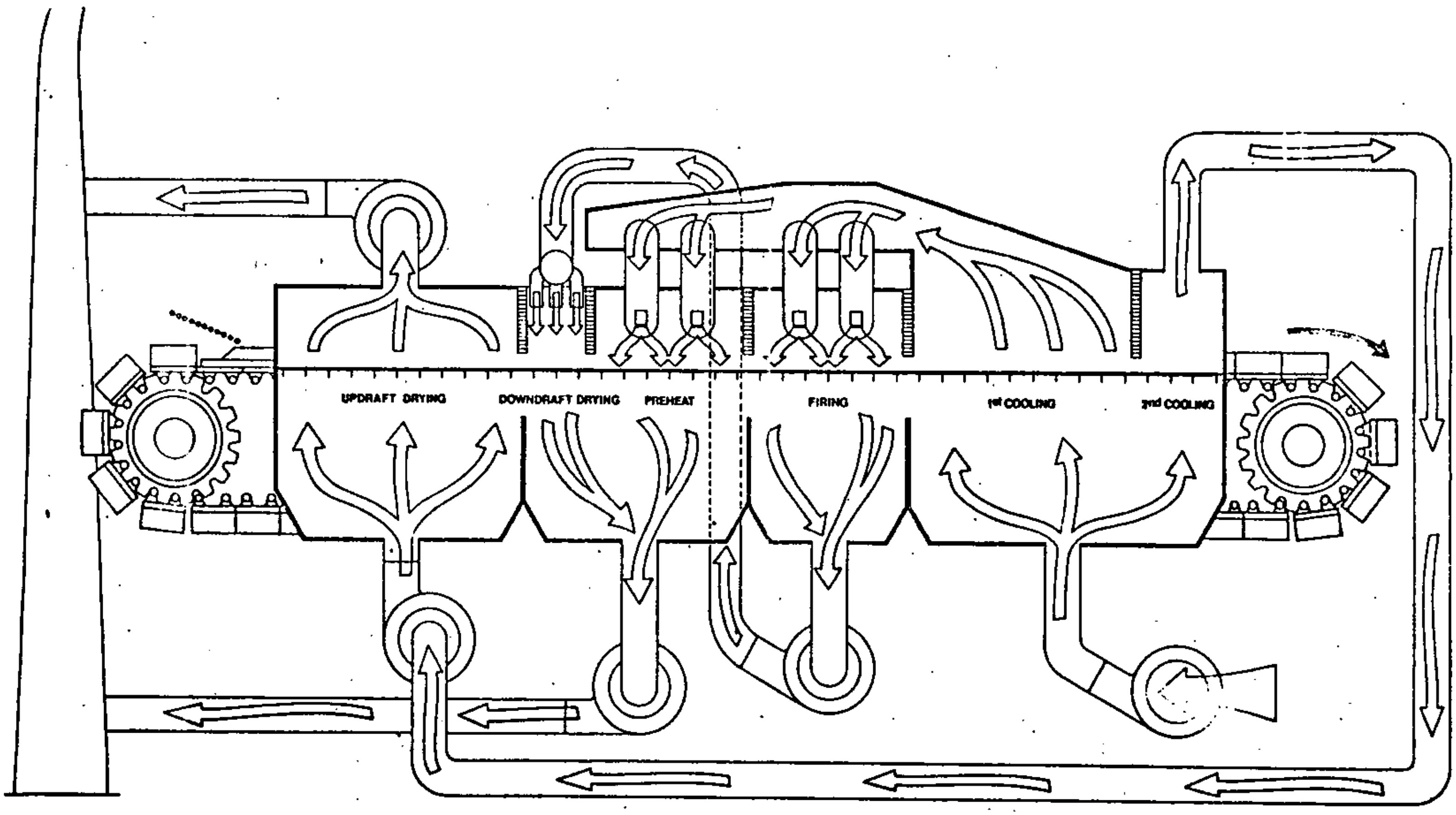

Figure 3.10 Straight grate induration system, Dravo-Lurgi type.

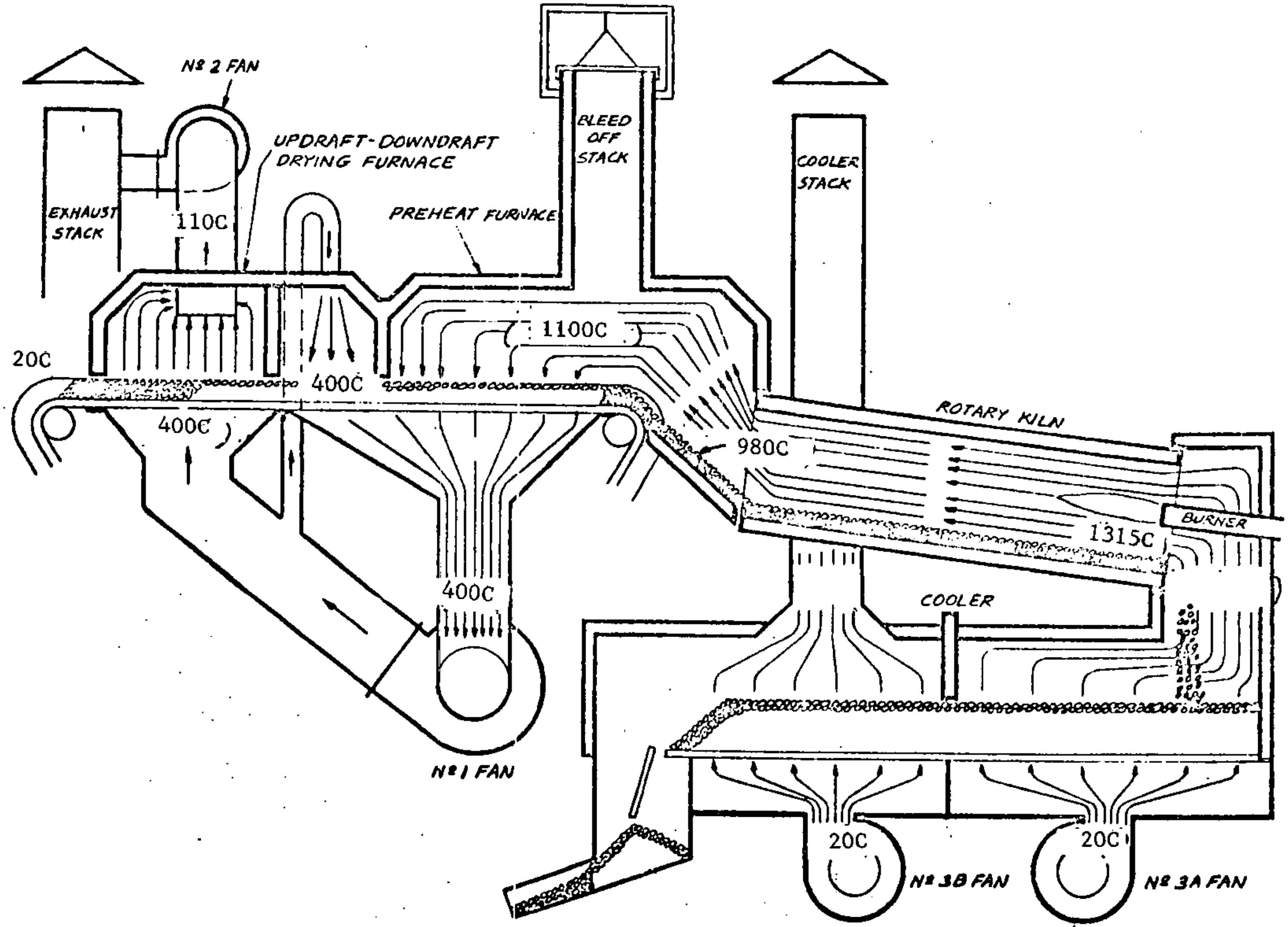

Figure 3.11 Grate-kiln induration system.

moisture and structurally strong. These pellets are now passed to the rotating kiln which is maintained between 1561 and 1589 K (2350 and 2400 F) for the final firing. The kiln is fired with natural gas, fuel oil, or coal and the hot gases are countercurrent to the material flow. The pellets passing out of the kiln drop into an annular cooler which can provide two or even three stages of cooling. The first stage cooling gases are approximately 1422 to 1478 K (2100 to 2200 F) and are used as a firing gas in the kiln. The second stage cooling gases typically are vented to atmosphere but can be recuperated. The cooled pellets are then conveyed to shipping or storage.

3.2.3.2.4 Circular Grate. The "circular grate" system is essentially the fourth generation furnace and reported to have incorporated all the advantages of the other furnaces. The circular grate furnace is operating only in one place, in Mexico. No U.S. installations are presently foreseen; however, newer installations in the future may consider this type of furnace.

The basics of the circular grate machine are illustrated in Figure 3.12. Operationally, it incorporates a hearth layer similar to that used in the Dravo-Lurgi system with the exception that the same fired pellets remain on the grate and are not removed with each pass. The gas handling system requires only one stack. This system and no return strand that has to be heated, reportedly results in lower fuel consumption. Additional improvements are reported to result from the over-bed seals which provide for a dust- and gas-free environment. However, operating data are only now being established and it is unknown what overall influence the system may have within the iron ore pelletizing industry.

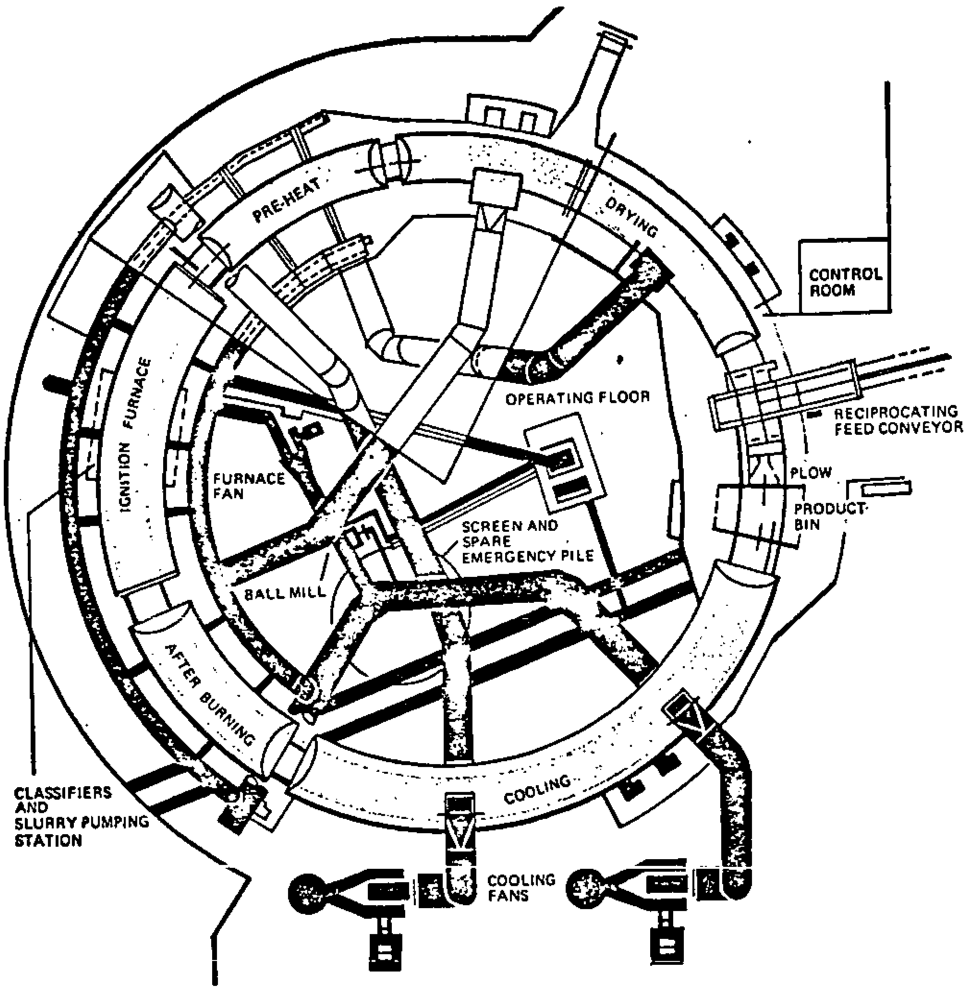

Figure 3.12 Plan view of circular grate machine.

3.2.3.3 Emissions From Agglomeration. The agglomeration operation as described consists of the balling drum or disc section and the induration furnace section. The pellets after being formed in the balling section are passed on to the induration furnace for drying and firing and because the pellet forming is done entirely with the concentrate being in a wet or damp stage, there is no real source of emissions in the balling section.

In the furnace section, there are two main sources of particulate emissions; the waste process gas exhausted from the furnace and the pellet handling equipment.

A significant amount of data were obtained in this program on the emissions from the induration furnaces and data are summarized in Table 3.9 and detailed in Appendix C. The data are arranged according to furnace type and in most cases are reported by the specific companies involved through field testing at their plants.

The levels of emissions, in general, show a marked dependence on the particular emission control devices used at the various plants. The bulk of the data is for multiclone installations and these plants, at best, have emissions of 446 g/Mg (1.0 pound per ton) of pellets produced. Those plants using ESP collectors have emissions averaging about 103 g/Mg (0.23 pound per ton) of pellets and those with scrubbers average about 201 g/Mg (0.45 pound per ton) of pellets. Also it is evident that the plants having no primary control device or simply drop-out boxes have the highest emissions.

There appears to be only small differences in gas volumes exhausted from the various furnace configurations. For example, grate-kiln and vertical shaft systems typically average about 2.48 m^3/s per kg per s (1500 scfm per ton per hour) of pellets. Straight grate systems generally have a somewhat

TABLE 3.9a. SUMMARY OF PARTICULATE EMISSION DATA ON PELLETIZATION SYSTEMS
(English Units)

	Production Rate, tons/hr	Gas Volume		Particulate Emissions		Primary Control Device
		scfm	scfm/ton/hr	lb/hr	lb/ton	
Plants Using the Grate-Kiln System						
Marquette Iron Mining Co. - Republic	342	367,000	1,070	48.1	0.14	ESP
Eveleth Taconite Co.	303	458,000	1,510	64.3	0.21	Venturi Scrubber
Empire Iron Mining Co.	606	691,000	1,140	131.2	0.22	ESP
Tilden Mining Co.	546	757,000	1,390	180	0.33	ESP
Pioneer Pellet Plant	208	525,000	2,520	142.6	0.69	Scrubber
National Steel Pellet Plant	291	502,500	1,730	295	1.0	Multiclone
Butler Taconite	282	422,000	1,500	472.7	1.7	Multiclone
U.S. Steel - Minntac	1818	2,440,000	1,340	4810	2.6	Multiclone-Drop-out Box
Humboldt Mining Co.	110	136,000	1,240	963	8.8	Multiclone
		Average:	1,500			
Plants Using the Straight Grate System						
Hanna Mining Co. - Groveland	259.1	390,000	1,500	184.9	0.70	Multiclone
Jackson County Iron Co.	125	250,000	2,000	110	0.88	Multiclone
Pilot Knob Mining Co.	112	305,000	2,720	125.4	1.1	Multiclone
Kaiser Steel Corp.	360	599,000	1,660	736.8	2.1	Multiclone
U.S. Steel - Atlantic City	217.5	628,000	2,890	641.5	3.0	None
Reserve Mining Co.	1221	2,580,000	2,110	3641.7	3.0	None
		Average:	2,100			
Plants Using the Vertical Shaft Furnace						
Erie Mining Co.	1176	1,560,000	1,330	1054.1	0.9	Multiclone
Bethlehem Steel Corp. - Grace	250	471,000	1,880	774.9	3.1	Multiclone
Meramec Mining Co.	229	290,000	1,270	1615.5	7.1	Multiclone
		Average:	1,500			

TABLE 3.9b. SUMMARY OF PARTICULATE EMISSION DATA ON PELLETIZING SYSTEMS

	Production Rate, kg/s	Gas Volume		Particulate Emissions		Primary Control Device
		Stdm^3/s	Std m^3/s per kg per s	g/s	g/Mg of ore	
Plants Using the Grate-Kiln System						
Marquette Iron Mining Co. - Republic	97	173	1.78	6.1	63	ESP
Eveleth Taconite Co.	86	216	2.51	8.1	94	Venturi Scrubber
Empire Iron Mining Co.	171	326	1.91	16.5	98	ESP
Tilden Mining Co.	154	357	2.32	22.7	147	ESP
Pioneer Pellet Plant	59	248	4.20	18.0	308	Scrubber
National Steel Pellet Plant	82	237	2.81	37.2	446	Multiclone
Butler Taconite	80	199	2.49	59.6	759	Multiclone
U.S. Steel-- Minntac	513	1,152	2.25	606.1	1,161	Multiclone-Drop-out Box
Humbolt Mining Co.	31	64	2.07	121.3	3,929	Multiclone
		Average:	2.48			
Plants Using the Straight Grate System						
Hanna Mining Co. - Groveland	73	184	2.52	23.3	313	Multiclone
Jackson County Iron Co.	35	118	3.37	13.9	393	Multiclone
Pilot Knob Mining Co.	32	144	4.50	15.8	491	Multiclone
Kaiser Steel Corp.	102	283	2.77	92.8	938	Multiclone
U.S. Steel - Atlantic City	61	296	4.85	80.8	1,339	None
Reserve Mining Co.	345	1,218	3.53	458.9	1,339	None
		Average:	3.59			
Plants Using the Vertical Shaft Furnace						
Erie Mining Co.	332	736	2.22	132.8	402	Multiclone
Bethlehem Steel Corp. - Grace	71	222	3.13	97.6	1,384	Multiclone
Meramec Mining Co.	65	137	2.11	203.6	3,170	Multiclone
		Average:	2.49			

higher gas volume as indicated by the average use of 3.59 m^3/s per kg per s (2100 scfm per ton per hour) of pellets.

It is believed that these data are consistent with actual conditions in the field and, in general, agree with other field test data taken by outside agencies.

3.2.3.4 Sulfur Emissions From Coal Firing. With the anticipated changeover to coal firing of indurating machines, significant quantities of sulfur oxide emissions are also expected from pelletizing systems. Current sulfur oxide emissions using natural gas are very low, typically averaging about 12 ppm SO_2 (source: Eveleth Taconite Company test data). This calculates to about 27 g of SO_2 per Mg (0.06 pounds of SO_2 per ton) of pellets produced, assuming a gas flow of 137 m^3/s (290,000 scfm).

With coal firing instead of natural gas, a significant increase in the SO_2 emissions can be expected. For example, it can be assumed that a ton of iron ore pellets will require about 528 MJ (500,000 Btu) for induration regardless of the type of induration machine employed. Thus, a 1.016 Mg (ton) of pellets will require about 15.9 kg (35 pounds) of coal for combustion (assuming a heating value of 33.3 kJ/g (14,300 Btu/lb) and this coal will provide about 0.64 kg (1.4 pounds) of SO_2 as potential emissions. This is based on using a low-sulfur Eastern Kentucky or West Virginia coal with a sulfur content of 2 percent.

Generally, from the above assumptions it can be stated that coal firing will increase SO_2 emissions by a factor of 23 times over natural gas firing, and will result in a waste gas which contains about 275 ppm SO_2.

3.2.4 Factors Affecting Emissions From Iron Ore Plants

In general the factors affecting emissions from iron ore plants include: moisture content of the ore and overburden, type of ore (taconite, hematite, etc), size of blast and amount of ore processed, type of equipment, and operating practices employed such as plant maintenance and general housekeeping. In addition, a variety of geographical and seasonal conditions affect the particulate emission, especially the fugitive-type emission. In most cases, these general factors combine to contribute to a plant's total emissions.

The type of ore has some affect on emissions, principally in the ore handling stages. This includes the inherent moisture content of the ore and overburden. The softer, more weathered ores (red and brown ores, hematite) have a greater potential for emissions than the harder ores (taconites).

The type of equipment and operating practice probably has the largest single effect on potential particulate emissions. The equipment selection is based on a variety of factors, some of which are not altogether quantified; but, in general are influenced by the plant age, type of ore processed, capacity of plant, and equipment configuration. In general, emissions from equipment are a function of equipment, configuration and auxiliary equipment, such as hoods, skirts, and general plant maintenance. The operating practices employed by a plant, such as pellet formation and control, furnace control, etc., influence the particulate emissions.

The most significant geographical factor affecting particulate emissions would be climate. Climate conditions, such as wind velocity and direction, relative humidity, and precipitation, can affect emissions. Other factors could be the general topography surrounding the plant and general amount of vegetation around the facility.

Seasonal variations have some effect on potential emissions. For example, the winters in Minnesota as opposed to the winters in California and other less severe seasonal changes.

REFERENCES FOR SECTION 3.

1. Engineering and Mining Journal, November, 1974.

2. Iron Ore - 1975, American Iron Ore Association.

3. The Development of Four Generations of Pelletizing, O. G. Gramp, paper presented at CIM Conference of Metallurgists, Quebec City, August 26-29, 1973.

4. EMISSION CONTROL TECHNIQUES

4.1 CONTROL DEVICE ALTERNATIVES

The diversity of the particulate emission sources, sizes, and quantities inherent in an iron ore plant has resulted in the utilization of a variety of control techniques and devices. In general, where applicable, dust suppression techniques such as water sprays will be used. However, other sources are not amenable to this control method and require hooding and the use of collection devices. The various sources of particulate emissions and the control alternatives currently in use, or proposed by the industry are listed in Table 4.1.

4.1.1 Control of Mining Operations

4.1.1.1 Drilling. In general the particulate emissions from drilling operations are handled by wetting the drill cuttings with water. This dampens the particulates and prevents them from becoming airborne. Other techniques could be used such as shrouding the drill hole and passing the air carrying the particulates through a collection device. Typically the particulate emissions from the drilling operation are effectively contained by water sprays or injection.

4.1.1.2 Blasting. Effective methods have not been demonstrated for controlling particulate emissions from blasting operations. However, most companies employ good blasting techniques and schedule their blasting to occur when the meterological conditions are the most favorable. Other factors also dictate a close control of the blasting operation and this helps to reduce dust emissions.

4.1.1.3 Loading and Hauling. The dust emissions from hauling

TABLE 4.1 EMISSION SOURCES AND CONTROL ALTERNATIVES

Operation or Source	Control Alternatives
Mining	
Drilling	No control Water injection Venting of gas to collection device
Blasting	No control
Loading and Hauling	No control Water sprays Water wetting of road surface Oil coating of road surface
Beneficiation	
Crushing	Water sprays Dry collectors Wet scrubbers Baghouse
Screening	Same as crushing
Conveying and Transfer	Same as crushing
Pellet Induration	
Main Process Gases	No control Dry collectors Wet scrubbers Electrostatic precipitator (ESP) Baghouse
Furnace Transfer Points	Same as process gases excluding ESP
Miscellaneous Sources	
Bentonite Facilities	Wet scrubbers Baghouse
Pellet Handling and Loadout	Water sprays Wet scrubbers Baghouse
Stockpiles	Water sprays
Tailings Ponds	Wetting Chemicals Vegetation

of ore and overburden on the road are proportional to the amount of traffic, speed, and road surface conditions. In general, dusty conditions are hard on the equipment; therefore, the mines try to maintain their road surfaces and control their traffic to minimize the dust emissions.

The road surface emissions can be controlled by water or oil coating of the surface or by using chemical additives and employing soil stabilization techniques. The most common method is water spraying which can be quite effective depending on the general conditions and weather. Road dust can also be controlled by periodic application of chemicals (such as $CaCl_2$) and soil stabilization additives (composed of synthetic or natural petroleum resins).

4.1.2 Control of Beneficiation Operations

Typically a beneficiating plant will consist of numerous sources of emissions associated primarily with the crushing plant and ore handling facilities (conveyors, feeders, screens, etc). In general, the rest of the plant (fine grinding, magnetic separation, and/or flotation) consists of handling slurries and, therefore, does not represent a dust emission problem. The crushing plant and ore handling facilities will typically have a multiplicity of dust-producing points. As such, effective emission control involves a combination of water wetting, hooding, and the use of dry or wet control devices.

4.1.2.1 Primary Crushing. Wet dust suppression usually begins at the primary crusher where water sprays are normally used around the periphery to spray the ore as it is dumped into the crusher. For plants using truck haulage, this can be an effective way of reducing emissions. The crusher is normally open at the top and receives ore from two sides, thus effective hooding and dust collection is difficult, although some plants have partially enclosed the crusher by a building.

In some cases, additional water sprays are located at the primary crusher discharge and in the area of the pan feeder and primary ore conveyor. In other cases, these emissions are hooded and directed to a control device. Many plants now use the dry centrifugal collector, such as is shown in Figure 4.1, for control of the primary crusher emissions. More recently, a few plants have installed baghouses at the primary crusher. A typical baghouse is illustrated in Figure 4.2.

4.1.2.2 Secondary Crushing and Screening. Typically, the secondary crushers and screens in an iron ore beneficiating plant are covered with a hood and exhausted to a control device. Screens are generally completely covered to control particulate emissions at the surface of the screen. In some plants the screen and crusher will be covered by the same hood. Typical arrangements are shown in Figures 4.3 through 4.5.

The control devices used in conjunction with the above hood arrangements are typically the wet mechanical-type scrubbers and/or separators. The most common systems used in the industry are the wet packed-bed scrubbers as shown in Figure 4.6 or the centrifugal separators as illustrated in Figure 4.7. Some plants may use up to 30 or 40 of these units in the beneficiating plant alone. They are compact, have reasonable cost, and are effective in controlling emissions from these sources.

4.1.2.3 Conveying and Transfer. Typically, the dust emissions from conveyor belts and transfer stations are controlled in much the same way as crushers and screens. In general, the conveyors are covered with a hood which attempts to limit the amount of air being swept over the belt, and this is generally done by using rubber skirting. Typical configurations are shown in Figures 4.8 and 4.9. The air sweep velocities vary widely depending on tightness of enclosure, material handled, distance to control

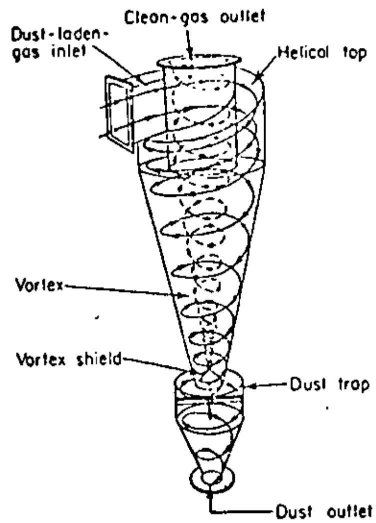

Figure 4.1 Typical high-efficiency involute cyclone. (Source: Reference 4)

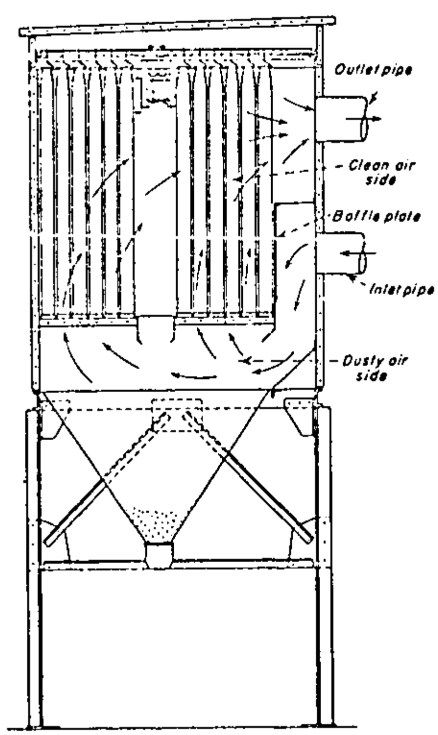

Figure 4.2 Typical baghouse collector. (Source: Reference 4)

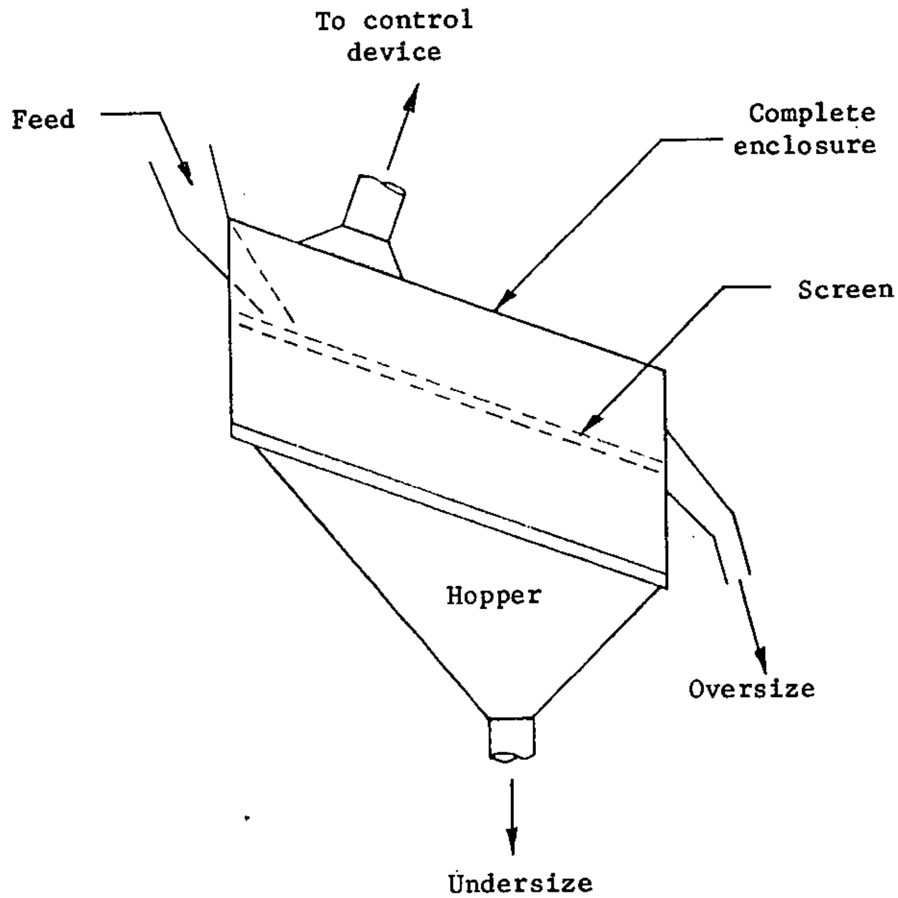

Figure 4.3 Hood configuration for vibrating screen.

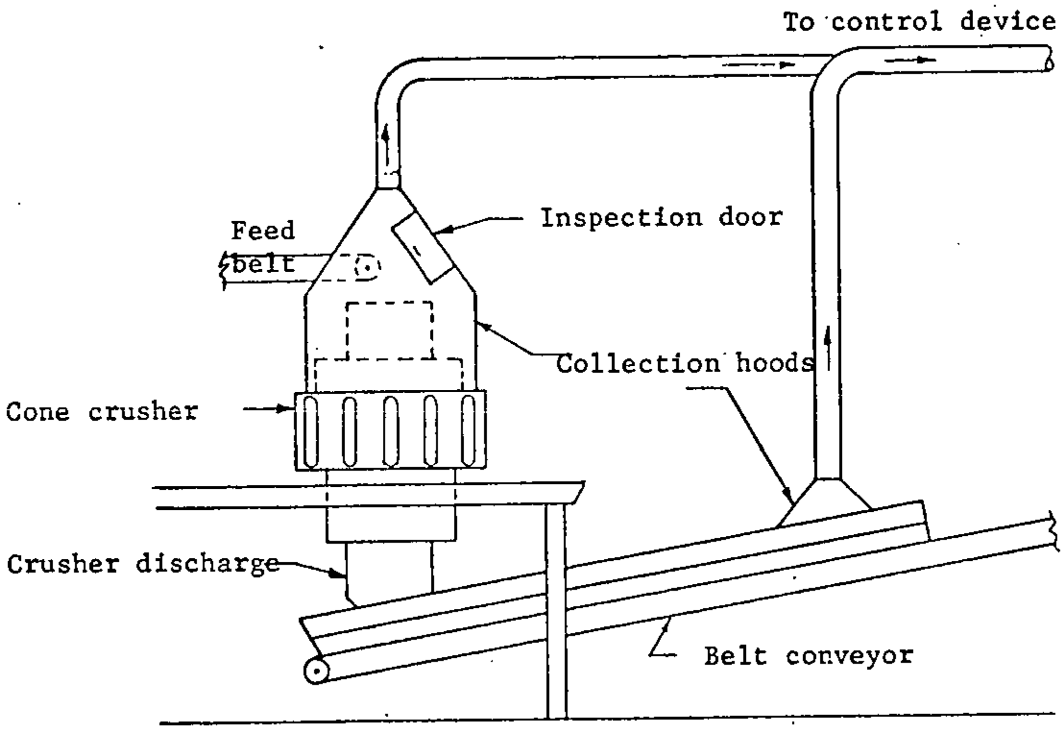

Figure 4.4. Hood configuration for secondary crusher.

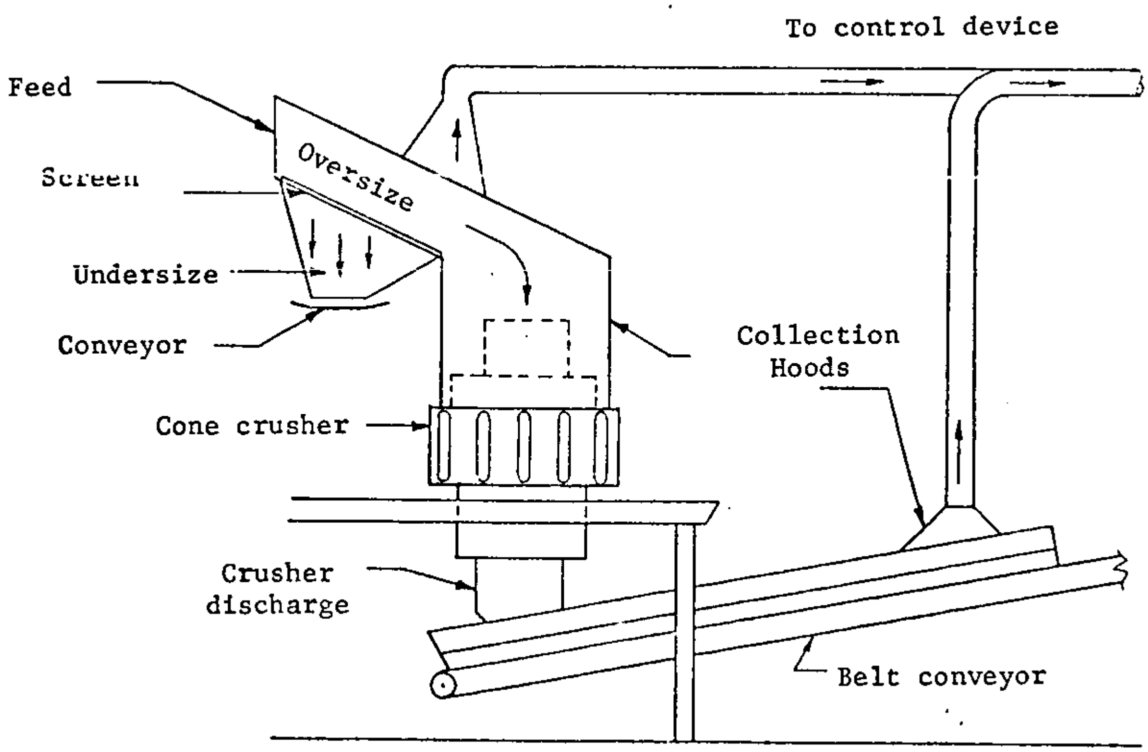

Figure 4.5 Hood configuration for crusher-screen combination.

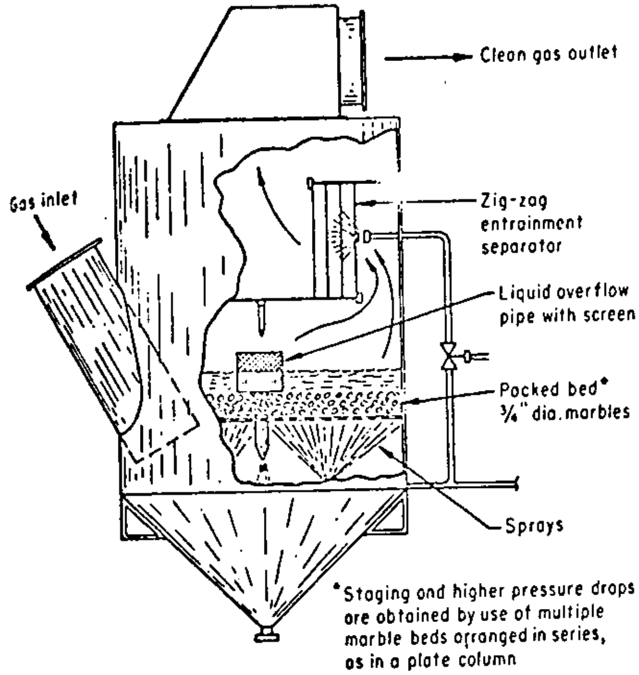

Figure 4.6 Packed-bed scrubber (National Dust Collector Corporation, hydrofilter)

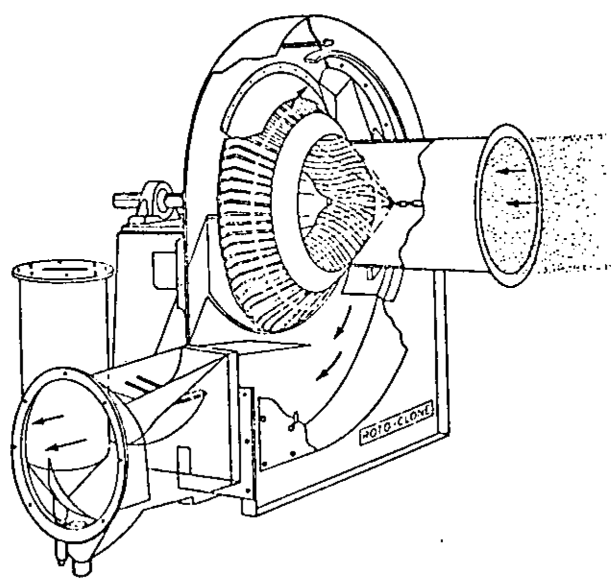

Figure 4.7 Centrifugal fan-type scrubber (American Air Filter Company, rotoclone)

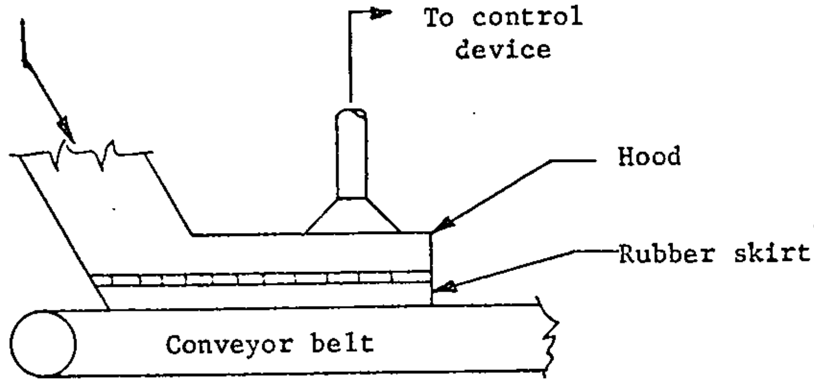

Figure 4.8 Hood configuration for ore chute transfer.

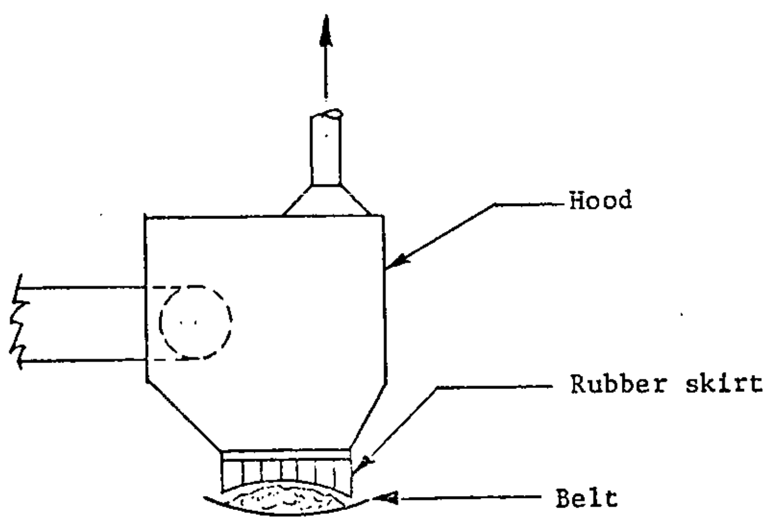

Figure 4.9 Hood configuration for conveyor belt transfer.

device, etc. These velocities will range from 100 to 400 cm/s (200 to 800 fpm) with conveying velocities being 2000 cm/s (3940 fpm) and up.

Again, the most common control devices used for conveyors and transfer points are those illustrated in Figures 4.6 and 4.7

4.1.3 <u>Control of Pelletization</u>

4.1.3.1 Main Process Gases. The pellet induration section is perhaps the primary source of particulate emissions associated with the complete iron ore plant complex. The airborne particulates generated in pelletization differ from those in the beneficiation operations in that the product material is ore concentrates and the waste gas streams generally are hot. Equally important is the fact that very large gas volumes are generated by the induration furnace and effective control of particulates involves both good hooding and collection, and efficient removal. The control techniques used by the industry are geared basically to the type of indurating furnace employed in each particular plant. Thus, the basic furnace configurations will be discussed separately.

4.1.3.1.1 Vertical Shaft Process. Currently, three plants employ the vertical shaft furnace for induration of their iron ore pellets. There are basically two main sources of emissions from the vertical-shaft furnace. The top gases or firing gases exit at the top of the furnace and are typically passed through multiclone collectors. The bottom gas which is used for pellet cooling is controlled by dry cyclones, multiclones, or wet scrubbers.

There are basic differences in control techniques associated with the vertical shaft process over the more conventional straight grate or grate-kiln systems. One factor is that a large number of individual units must be controlled (the Erie Mining Company plant has 27 vertical shaft lines) and another is that the gases are typically much hotter. Bottom gases, for example, can exit at 772 K (930 F); thus many plants use waste heat exchangers for recovery of this energy. The collection device must be adaptable to a large fluctuation in gas temperature and particulate loading.

4.1.3.1.2 Straight Grate Process. This process is basically one of two types -- Dravo-Lurgi system or the McKee system. However, from a particulate emissions standpoint, there are only subtle differences between the two systems. In both, there are two main waste gas streams generated as shown in Figures 4.10 and 4.11. One process gas stream (windbox exhaust) is pulled from the down-draft drying and preheat sections of the grate machine. These gases contain products of combustion which are recycled from the firing zone by the recuperation fan. Typically the firing gases go through a multiplicity of dry cyclone collectors on each side of the machine before entering the recuperation fan and this represents the first stage of emission control.

After passing through the downdraft drying zone, the most common practice in controlling emissions from this source is the use of a multiple tube, dry cyclone collector (multiclone). A typical multiclone configuration is illustrated in Figure 4.12. Some plants employ the multiclone preceded by a dropout box for coarse particulates and this reportedly is effective in reducing wear on the multiclone with improved performance. The three plants surveyed in this program which utilize the Dravo-Lurgi process all use multiclones for control of the windbox exhaust. The two plants utilizing the McKee process, however, have no control device on the windbox exhaust.

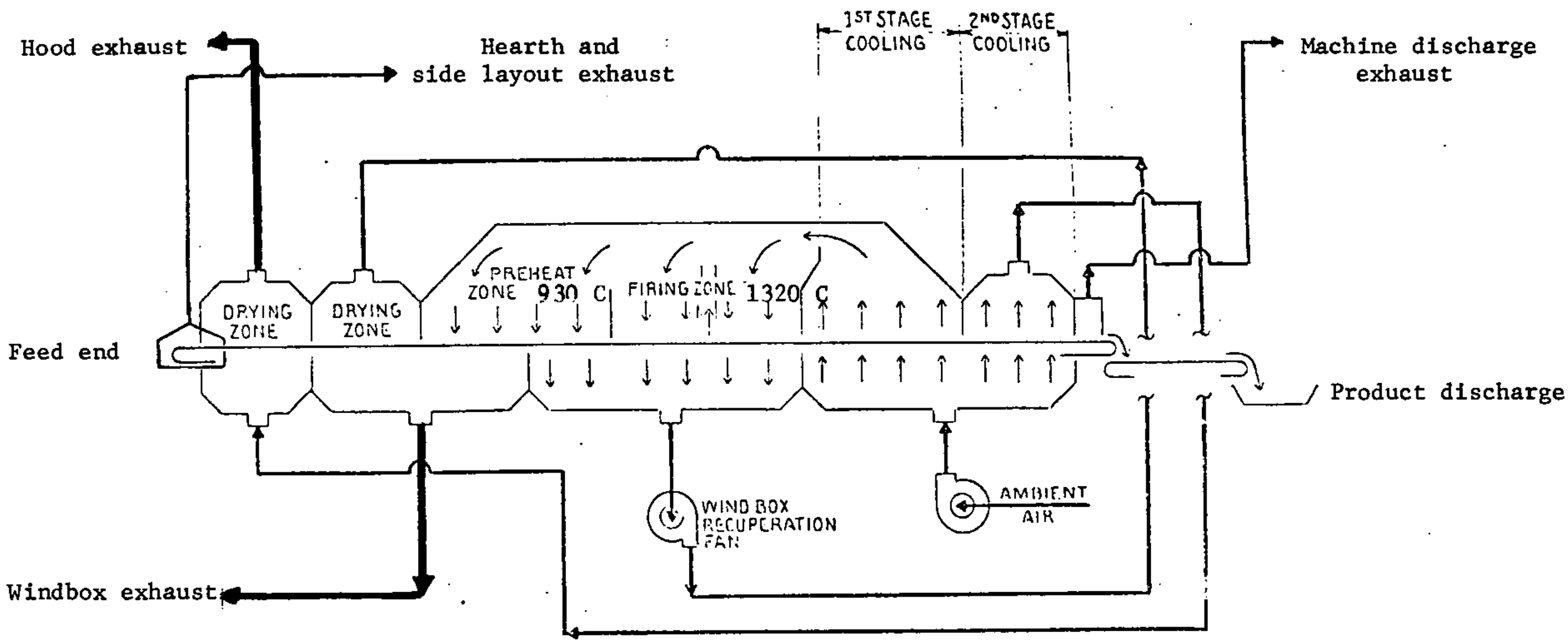

Figure 4.10 Air flow diagram-Dravo-Lurgi straight grate machine

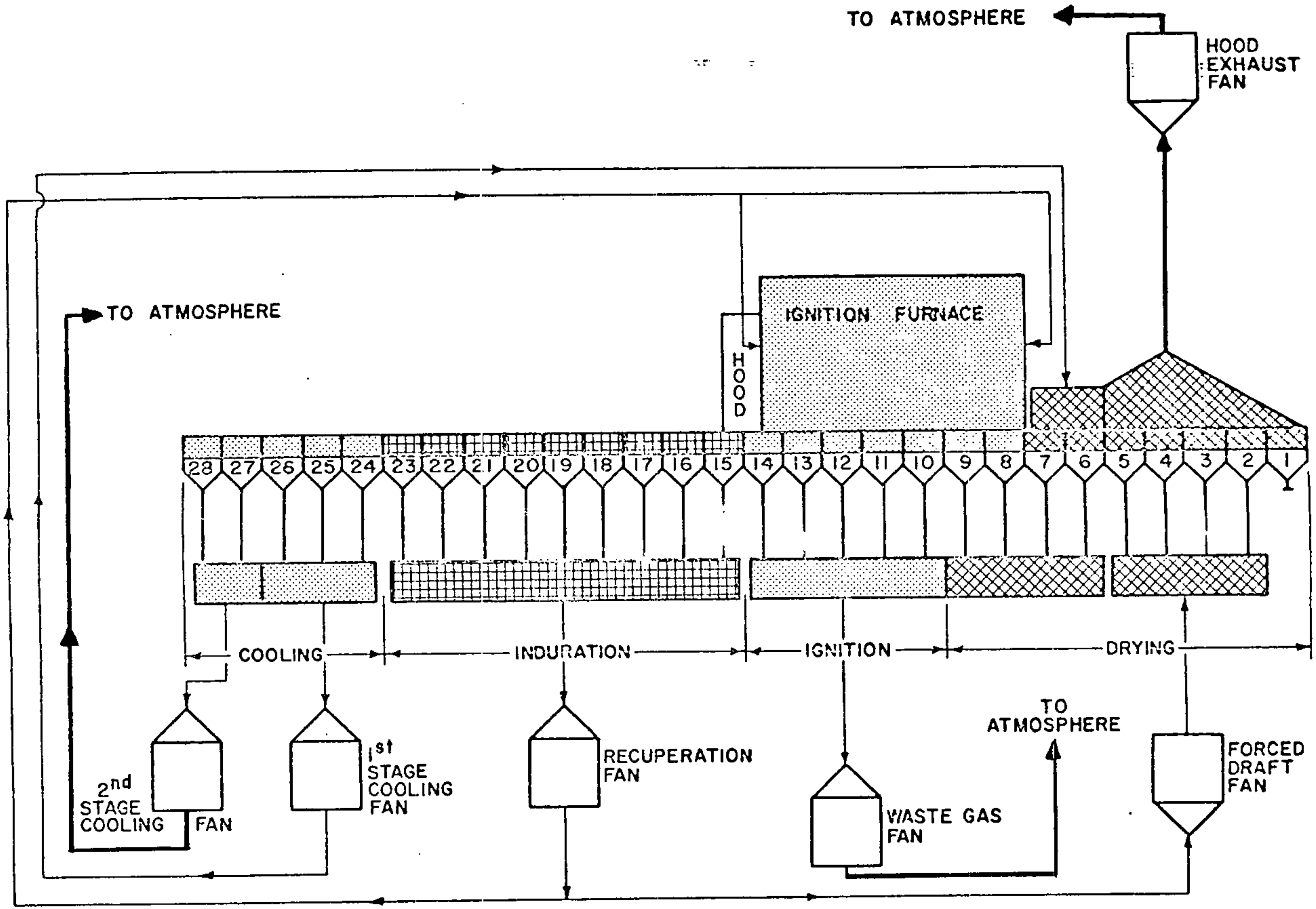

Figure 4.11 Air flow diagram-McKee straight grate machine.

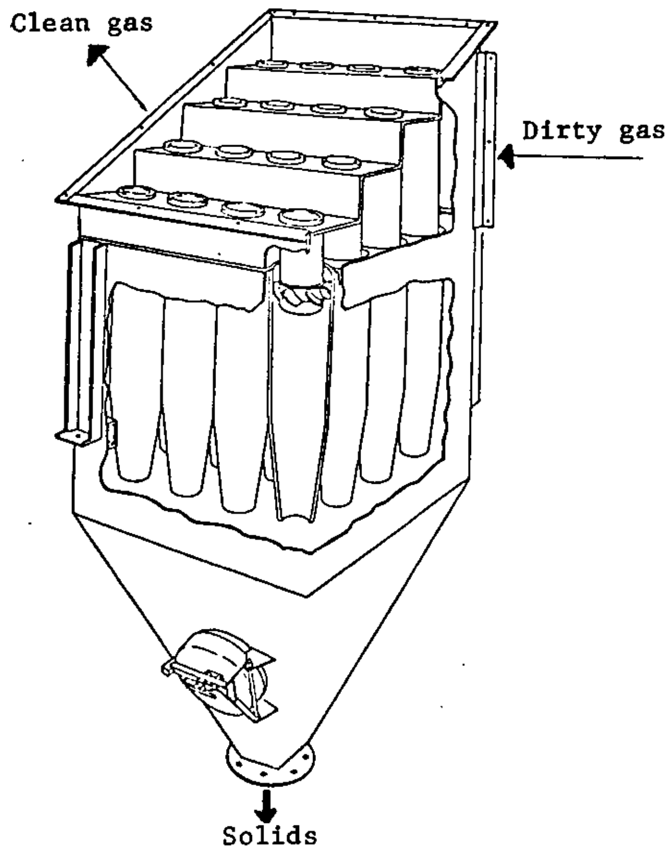

Figure 4.12. Multiple tube dry collector (multiclone).

The other main process gas from these machines is the hood exhaust which is used for initial drying of the green pellets. This gas has previously been used for the cooling sections of the machine to recover heat energy and reuse it for the drying step. Typically, emissions from this source are much lower than for the windbox exhaust because the damp pellet bed acts much like a filter for removing particulates and because only minor amounts of fines are generated in these sections. Most plants, do not employ a control device for the hood exhaust. The emissions, however, can be significant since a large quantity of gases are used even if a low particulate concentration results. One proposed new plant (Hibbing Taconite Company), will use a wet scrubber on the hood exhaust.

The only remaining waste process gas from straight-grate machines is that used for second-stage cooling of the fired pellets and this occurs in several of the early McKee machines. Modifications have been proposed, however, to eliminate this as a source of particulate emissions. The proposed changes will involve recycling of the gas for heat recuperation.

4.1.3.1.3 Grate-Kiln Process. As shown in Figure 4.13, the main waste gases from the grate-kiln system that are generated in firing, preheating, and drying, are combined into a single emission point. These gases are very similar to the windbox exhaust gases from the straight grate machines.

The plants surveyed in this study, which employ the grate-kiln system are using a number of different control devices for treatment of this waste gas effluent. Again the most common method is the dry multi-clone collector shown in Figure 4.12. Two plants under the Cleveland-Cliffs management are utilizing an electrostatic precipitator (ESP) for control of these gases. This device, illustrated in Figure 4.14, has shown very high

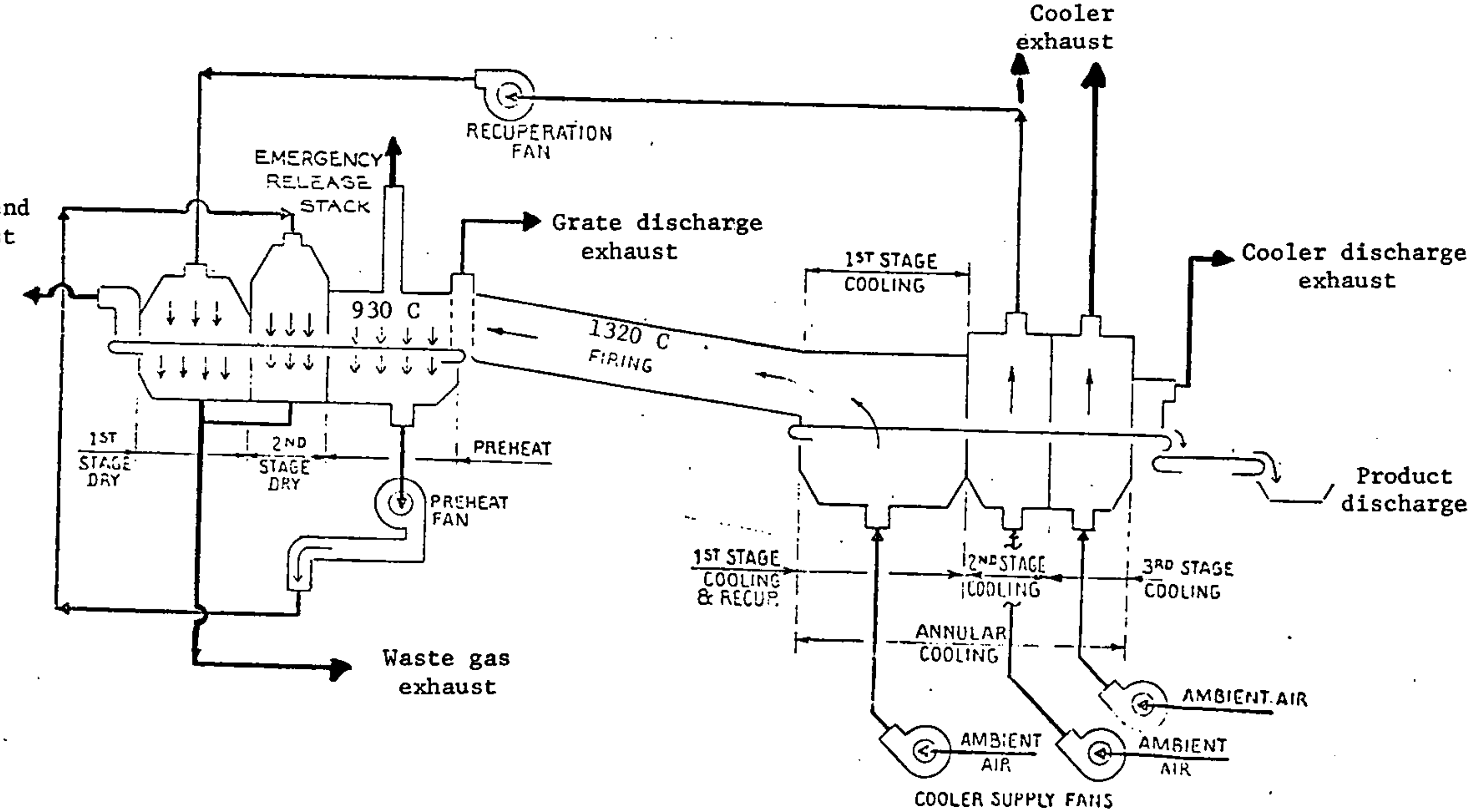

Figure 4.13 Air flow diagram-grate kiln process

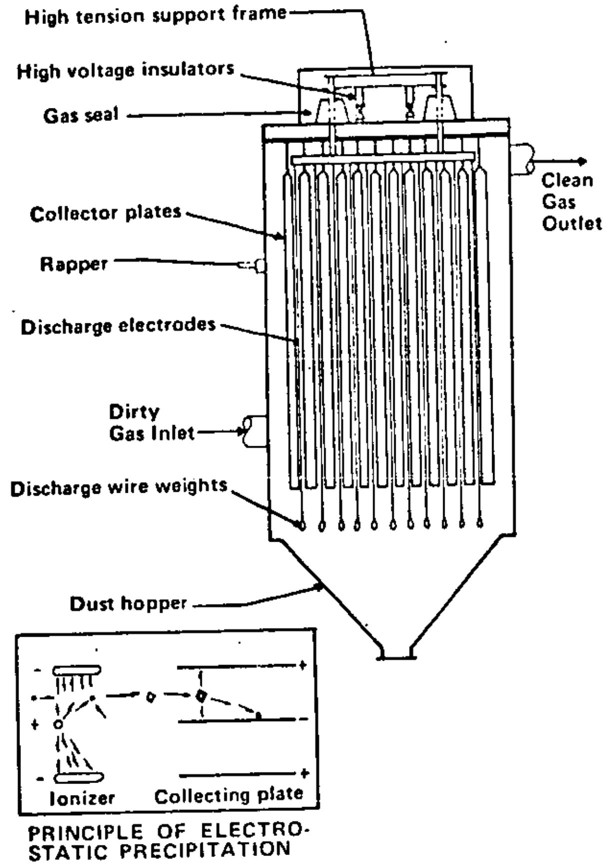

Figure 4.14 Electrostatic precipitator.

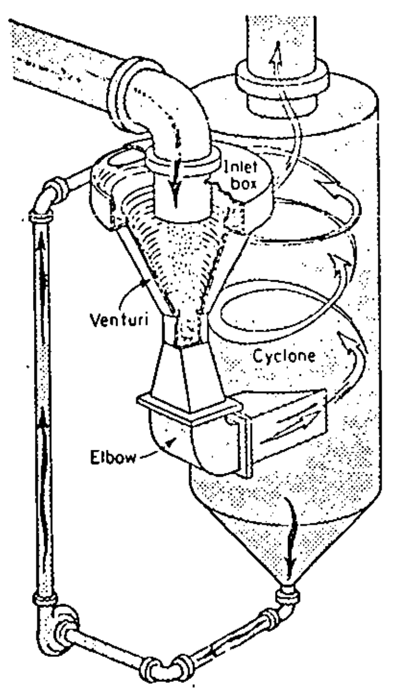

Figure 4.15 Venturi scrubber .

collection efficiencies and very few operating problems in the several years it has been in use in these plants.

In addition to the ESP, two plants have installed wet scrubbers for control of the waste gas stream. One unit is a spray-impingement-type scrubber designed for Cleveland-Cliff's Pioneer Pellet Plant. This unit has not been completely satisfactory according to past emission tests but, on occasion, can give very good collection efficiency. The other unit is a venturi-type scrubber employed by Eveleth Taconite Company which has a pressure drop of about 23 cm (9 inches) of water. The venturi principle illustrated in Figure 4.15 provides for very high collection efficiencies on the fine particulates generated in the grate-kiln process. The Eveleth plant is under expansion which will include a larger grate-kiln line and a venturi scrubber will be used here also.

The remaining process emission source for the grate-kiln system are those gases used for second or third-stage cooling of the fired pellets. This is identified as the cooler exhaust in Figure 4.13. Generally, most plants do not use a control device for this source because, typically, the gases are very low in particulate emissions. More recently, however, the newer or proposed plants will employ some type of collector on this source.

4.1.3.2 Furnace Transfer Points. In addition to the main process emissions described above, there are several other sources of particulate emissions generated in the pelletization process. Basically these are associated with the transfer of pellets from one section of the machine to another and the characteristics of the source are again dictated by the type of indurating machine employed. Table 4.2 summarizes the usual transfer point sources associated with each machine.

TABLE 4.2 SUMMARY OF TRANSFER POINT SOURCES VERSUS TYPE OF INDURATING MACHINE EMPLOYED

Dravo-Lurgi Straight Grate	McKee Straight Grate	Grate-Kiln Process	Vertical Shaft Process
Hearth and Side Layout	Grate Feed	Grate Feed	Pellet Recycle System
Grate Discharge	Grate Discharge	Grate Discharge	Product Screen and Transfer
Product Screen and Transfer	Product Screen and Transfer	Cooler Discharge	
		Product Screen and Transfer	

Typically, the particulate emissions generated at each of the pellet transfer points can be significant and most plants employ hooding and the use of a collection device to control these emissions. The control devices used will vary from plant to plant but in most cases some type of wet scrubber will be employed. Some plants utilize the "Rotoclone" or packed-bed scrubber previously illustrated in Figures 4.6 and 4.7. More recently, many plants have been installing the Ducon "dynamic scrubber" which is illustrated in Figure 4.16. This device is a combination three-stage collector and reportedly has collection efficiencies up to 99.5 percent in the 1 to 2 μm (40 to 79 micro-inch) range. It is being used extensively for pellet plant installations and also to some extent in many beneficiation plants for control of crushing, screening, and conveyor transfer.

4.1.4 Control of Other Sources

4.1.4.1 Bentonite Facilities. Almost all iron ore beneficiation plants make use of bentonite clays as a binder in their iron ore pellets, and dust emissions consisting of bentonite are often a problem. There are

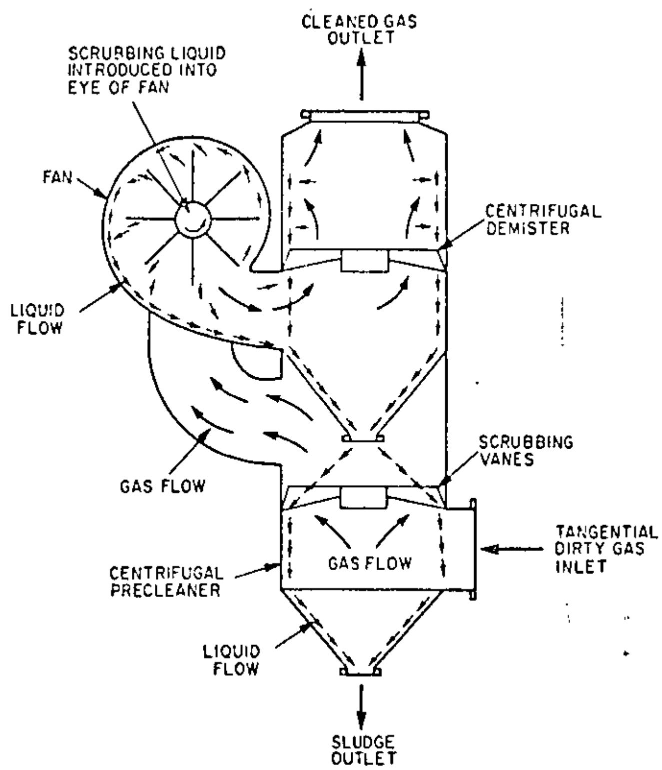

Figure 4.16 Combination wet scrubber (Source: The Ducon Company)

basically two sources of emissions; one is the bentonite unloading station where the bentonite is pneumatically conveyed from rail cars and into storage silos. The other source is the blending stations where the bentonite is mixed with the iron ore concentrates prior to the balling drums.

Most plants currently use a baghouse for control of the bentonite emissions and, depending on size, either multiple units or a single baghouse may be employed. Usually, the blending stations are all ducted to one collector. In a few plants, a high-efficiency wet scrubber is used instead of the baghouse.

Efficient local capture and containment of bentonite dust is mandatory for the iron ore plants to provide for worker safety. High efficiency collectors are routinely utilized because of the fine particle size of the bentonite material.

4.1.4.2 Pellet Load-Out. Most iron ore plants ship their pellets by rail cars which are either loaded directly from the indurating furnaces or from stockpiles. The loadout facilities and also screening stations for the final pellets constitute sources of particulate emissions. These sources are typically controlled by the use of wet scrubbers such as the "rotoclone" or Ducon units. A few plants have proposed the use of a baghouse for this purpose. However, some plants exercise no controls in this area.

4.1.4.3 Stockpiles. Particulate emissions from the conveying of final pellets to stockpiles are most generally controlled by direct water spraying of the material. The use of water sprays begins immediately as the pellets leave the furnace section of the plant. Stockpiles are typically placed in the open atmosphere and emissions have not been quantified.

4.1.4.4 Tailings Ponds. The tailings areas are potential sources of fugitive emissions. The industry usually tries to provide ground cover and vegetation to reduce wind lift and erosion of the tailings. In some plants this is quite effectively and extensively accomplished.

4.1.4.5 Sulfur Oxides. As pointed out in Chapter 3, the pelletization systems are also a potential source of sulfur oxide emissions if coal is used for firing of the macines. Generally these emissions will be restricted to the waste gas exhaust only (firing gases); the effluent gases as projected in Chapter 3 will contain about 275 ppm SO_2 for a typical grate-kiln system.

Because natural gas is the predominant fuel being used, control techniques for SO_2 are not currently used by the iron ore industry. However, this subject has received widespread development in other industries, particularly the power generation industry. Applications in related industries, such as sintering plants, also have been made in Japan.[1] Thus, the techniques used in these instances should be applicable to the U.S. iron ore industry.

Many techniques and process modifications have been investigated in recent years for the control of sulfur oxide emissions. These methods are described in detail in the literature and in recent symposia.[1,2,3] It seems fairly clear, however, that for iron ore pelletization application, one of the wet scrubbing techniques probably would be most applicable. This results from the fact that scrubbing systems are generally more effective on dilute gas streams (275 ppm SO_2) and considering that recovery of sulfur or other sulfur compounds probably is not warranted. The scrubbing systems believed to be most applicable are those using caustic, lime, or limestone scrubbing or the double alkali system. For the application under consideration, it is estimated that a 90 percent removal of SO_2 could be achieved.

4.1.4.5.1 Caustic Scrubbing. Several modifications of this process have been developed and are currently in use on an industrial scale. A notable example is the General Motors Chevrolet Assembly Plant at St. Louis, Missouri, which uses the process on two boilers fed with coal containing 3.2 percent sulfur and 10 percent ash.(3) The system utilizes cyclones and electrostatic precipitators to first remove fly ash from the flue gas stream. After particulate removal, the flows are combined and passed through a three-stage Peabody impingement scrubber with chevron demisters. The efficiency of SO_2 removal is believed to be greater than 90 percent. Sulfite is oxidized to sulfate.

The only major problem with this process is that the effluent, sodium sulfate solution, must be further treated or disposed of. At the GM plant, the solution is simply discharged to the Mississippi River. Apparently, this is being allowed as at least an interim measure due to the large dilution obtained.

A modification of this process, commonly called the Wellman-Lord process, has been used extensively in Japan for treatment of boiler flue gases.(1) Here the scrubbing medium is sodium bisulfite instead of sodium sulfite. The bisulfite is then disproportionated by heat treatment followed by recovery of SO_2 as sulfuric acid. Processes for sulfur recovery, however, are not believed applicable to the iron ore industry.

4.1.4.5.2 Lime-Limestone Scrubbing. The most successfully operating processes on boilers to date have generally employed lime as the scrubbing medium. The first major large-scale demonstration was the Chemico installation at the Mitsui Aluminum Company in Japan and more recently the installation at Louisville Gas and Electric's Paddy's Run Station.[3] These processes are both very similar to the simple sodium hydroxide scrubbing but the product is a calcium sulfate sludge which avoids the problems of soluble salt disposal. This, of course, brings up new problems of sludge disposal.

4.1.4.5.3 Double Alkali Process. Perhaps the most advanced scrubbing concept now being tested on a commercial scale is the double alkali process. In this process, soluble salts such as those of sodium or ammonia are used in the primary circuit, but lime or limestone is used in the secondary circuit.

Nippon Kokan, one of the largest steel producers in Japan, has developed an ammonia scrubbing process to combine ammonia in coke-oven gas with SO_2 in a waste gas from an iron-ore sintering plant.[1] A prototype plant with a capacity of 42 Std m^3/s (88,500 scfm) of waste gas has been operating at Keihin Works in the following two ways: (1) ammonium sulfite formed by the reaction is oxidized to produce ammonium sulfate; (2) ammonium sulfite is treated with lime to precipitate calcium sulfite, which is oxidized by air into gypsum, and to recover ammonia, which is returned to the absorbing system. Waste gas from the sintering plant typically contains 250 to 500 ppm SO_2 and about 95 percent removal can be achieved. The gases are first cleaned by an electrostatic precipitator prior to the scrubbing system.

One potential problem with this process as it might apply to the U.S. iron ore industry, is that a salable gypsum or ammonium sulfate fertilizer must be produced. Alternatively, however, a calcium sulfate sludge could be disposed of sililarly to the straight lime scrubbing systems.

4.2 PERFORMANCE OF TYPICAL CONTROL TECHNIQUES

4.2.1 General Aspects and Vendor Guarantees

There are numerous factors which influence the efficiency of collectors to remove particulates from gas streams. The selection of one of the four basic types of collectors depends on knowledge of the equipment giving off the gas as well as the gas itself. A general summary of factors which influence the type of equipment to be installed on the process as well as the factors which affect the device's operation follows:

- Volumetric Flow Rate of Gas - Range and frequency of variation
  - Continuous or discontinuous
- Gas Temperature - Pressure - Moisture Content - Range, frequency, and duration of variations
- Particulates Specific Gravity - Any significant variations between particulates
- Size Distribution of Particulates - Any variations
- Particulate Characteristic - Solid, liquid droplet, hydroscopic, electrical resistivity, reactivity, etc
- Particulate Concentration - Weight per unit volume and variations
- Chemical Composition of Gas - SO_2, hydrocarbons, organics, etc

The cyclone and multiclone dry collectors are sensitive to change in particle size and concentration, gas velocity, and volume. The installation of dropout boxes or enlarged zones generally increase the efficiency of the device. The presence of moisture or gases reaching the dewpoints may hinder the device's efficiency.

The wet mechanical collection devices, such as venturi scrubbers, packed-bed-type, and the centrifugal scrubbers, are usually very efficient and in general are sensitive to temperature changes or concentration within design limits. The chemistry of the gas can affect the scrubber due to the formation of acids which causes excessive wear. In general, large flow variations can be designed into wet scrubber applications.

The baghouse collector is one of the most efficient collectors; however, a number of factors particularly affect its operation. Some of these are as follows:

- Air-cloth ratio
- Particle size and size distribution
- Gas volume
- Temperature of gases
- Dewpoint of gas, the gas or device cannot drop below the dewpoint
- Mechanical aspects such as bag cleaning cycle time, wear on bags, etc.

Probably one of the most critical variables in a baghouse operation as related to iron ore plants is the gas temperature and dewpoint. Thus, for application to furnace exhaust gases, the baghouse option will require careful assessment of types of fabrics, configurations, etc.

The electrostatic precipitator (ESP) has a very high efficiency on fine particles and is fundamentally independent of the velocity of the gas stream flow. The ESP is less sensitive to particle size but is highly sensitive to gas density and electrical conductivity. Large variations in electrical conductivity (or resistivity) are a critical factor affecting the efficiency of an ESP.

Currently, the iron ore industry is utilizing all four of the basic types of collectors; namely, mechanical collectors, fabric filters, wet scrubbers, and electrostatic precipitators. Several basic characteristics of each of these control devices are shown in Table 4.3.

TABLE 4.3a. CHARACTERISTICS OF PARTICULATE CONTROL DEVICES (ENGLISH UNITS)

Control Equipment	Optimum[a] Size Particle, microns	Optimum Concentration, grains/cu ft	Temperature Limitations, F	Approximate Pressure Drop, in, w.g.	Efficiency, percent	Space[b] Requirements
Mechanical collectors:						
Settling chamber	>50	>5	700	<0.1	<50	L
Cyclone	5-25	>1	700	1-5	50-90	M
Dynamic precipitator	>10	>1	700	Fan	<80	M
Impingement separator	>10	>1	700	<4	<80	S
Bag filter	< 1	>0.1	500	>4	<99	L
Wet collectors:						
Spray tower	25	>1	40-700[c]	0.5	<80	L
Cyclonic	5	>1	40-700[c]	>2	<80	L
Impingement	5	>1	40-700[c]	>2	<80	L
Venturi	< 1	>0.1	40-700[c]	1-60	<99	S
Electrostatic precipitator	< 1	>0.1	1000	<1	95-99	L

(a) Minimum particle size collected at approximately 90 percent efficiency under usual operating conditions.

(b) Space requirements: S, small; M, moderate; L, large.

(c) Limited by materials of construction when sprays not in operation.

Source: Reference 4

TABLE 4.3b. CHARACTERISTICS OF PARTICULATE CONTROL DEVICES (METRIC UNITS)

Control Equipment	Optimum[a] Size Particle, μm	Optimum Concentration, g/m^3	Temperature Limitations, K	Approximate Pressure Drop, N/M^2	Efficiency, percent	Space[b] Requirements
Mechanical Collectors:						
Settling Chamber	>50	>11.4	644	<24.9	<50	L
Cyclone	5–25	> 2.3	644	249–1246	50–90	M
Dynamic Precipitator	>10	> 2.3	644	Fan	<80	M
Impingement Separator	>10	> 2.3	644	<996	>80	S
Bag Filter	< 1	> 0.2	533	>996	>99	L
Wet Collectors:						
Spray Tower	25	> 2.3	278–644[c]	125	<80	L
Cyclone	5	> 2.3	278–644[c]	>498	<80	L
Impingement	5	> 2.3	278–644[c]	>498	<80	L
Venturi	< 1	> 0.2	278–644[c]	249–14,946	<99	S
Electrostatic Precipitator	< 1	> 0.2	911	>249	95–99	L

(a) Minimum particle size collected at approximately 90 percent efficiency under usual operating conditions.
(b) Space requirements: S, small, M, moderate; L, large.
(c) Limited by materials of construction when sprays not in operation.

Source: Reference 4

Table 4.3 illustrates that only three types of devices can achieve high collection efficiency (approaching 99 percent) on very fine particulates; these are the bag filter, the wet venturi scrubber, and the ESP. The dry cyclone or multiclone can approach 90 percent efficiency but only on particulates in the 5 to 25 μm (197-984 micro-inch) range. The information contained in Table 4.3 also indicates that other types of wet scrubbers perform much poorer than the venturi scrubber, although it should be pointed out that combination scrubbers are not adequately covered by these data and probably have efficiencies in the 95 to 99 percent range on particulates of 1 to 5 μm (40 to 197 micro-inch).

Further information on collection efficiency can be ascertained from performance guarantees offered by many companies who manufacture these control devices. Vendor guarantees typically specify an outlet dust loading to be met based on assumed particle sizes and inlet dust concentrations. Several such guarantees are included in Table 4.4. It should be noted that this information was obtained from proposed modification or expansion projects of several iron ore companies and thus should be directly applicable to the control of iron oxide or bentonite dusts.

4.2.2 Field Test Data

In addition to the basic considerations presented in the previous section, significant data also are available through field testing of actual existing sources and control devices. These data are basically of two types. First, most iron ore plants were contacted and requested to submit any available emission source test data through Section 114 of the Clean Air Act. The bulk of these data are summarized and presented in Appendix C of this document. Secondly, three plants were selected for additional field testing under EPA contract associated with this program.

TABLE 4.4 TYPICAL PERFORMANCE GUARANTEES ON SOME CONTROL DEVICES USED BY THE IRON ORE INDUSTRY

Type of Collector	Vendor	Application	Inlet Dust Load, g/m^3 (gr/scf)	Guaranteed Performance: Outlet Dust Concentration, g/m^3 (gr/scf)	Guaranteed Performance: Collection Efficiency, percent
Multiclone	Barron/A.S.E. Inc.	Preheat furnace gases	2.3 - 22.9 (1-10)	-- (--)	90
Multiclone	Zurn Industries, Inc.	Grate waste gases	0.2 - 3.4 (0.1 - 1.5)	-- (--)	75
Bag filter	Fuller Company	Bentonite control	-- (--)	0.09 (0.04)	--
Packed-bed scrubber	National, hydrofilter	Bentonite blending	17.2 (7.5)	0.2[a] (0.1)[a]	98.7[b]
Combination wet scrubber	Ducon, Type UW-4[c]	Furnace trans. pts.	13.7 (6.0)	0.7 (0.03)	99.5[b]
Venturi scrubber	Ducon, Type VVO	Grate waste gases	3.0 (1.3)	0.07 (0.03)	97.7[b]
ESP	Research Cottrell	Grate waste gases	-- (--)	0.05 (0.02)	99.7

(a) Conditional on particles being no greater than 40 percent less than 2 microns.
(b) Calculated values based on assumed inlet dust loading and guaranteed outlet dust loading.
(c) The Ducon Company generally rates this collector at 99.5 percent efficiency in the 1 to 2 micron range.

This testing was done at the Hanna Mining Company, Groveland plant, the Eveleth Taconite Company, and at Cleveland Cliff's, Empire Mine.

Although much of the data relate to the total mass rate of emissions, source information also was obtained on collector efficiencies. For purposes of discussion, this will be categorized as major sources or minor sources.

4.2.2.1 Major Sources. Test data in this category are primarily from control devices operating on the main process gases from the pelletization machines. The most common collectors used for this purpose are the dry mechanical collectors, such as the multiclone or simply a drop-out chamber. A summary of the data available on these devices is contained in Table 4.5. These measured efficiency values, in general, substantiate the typical values discussed in the previous section. For example, a number of tests were obtained on large-diameter cyclones and the efficiency of these devices typically averaged about 80 percent. The range in operating efficiency was from 48 to 88 percent. On the other hand, a much greater variation in operating performance was noted with multiclone installations. These devices had operating efficiencies ranging from 7.5 up to 98.8 percent. This wide variation might be attributed to erosion and hole formation allowing some units to bypass much of the dust emissions. If the unit is well maintained, however, it appears that multiclone collectors can perform at 90 percent overall collection efficiency.

The remaining field test data on wet scrubbers and ESP units again point out that these collectors are much superior to the dry cyclonic devices. The ESP for instance showed 99.2 percent removal of filterable particulates with a 97.3 percent removal for total particulates. The wet venturi scrubber was very close to these performance figures in

TABLE 4.5 SUMMARY OF FIELD TEST DATA ON CONTROL DEVICES CURRENTLY USED IN IRON ORE PELLETIZATION

Emission Source Tested	Control Device Used	Measured Efficiency, percent Range	Measured Efficiency, percent Average	Source of Data
G.K. preheat gases	Multiple cyclones	--	80	Hanna Mining - Butler Plant tests [a]
G.K. preheat gases	Multiple cyclones	62-86	--	Hanna Mining - National Plant tests [a]
V.S. top gas	Dual cyclones	48-76	63	Bethlehem - Grace Mine [a]
V.S. bottom gas	Dual cyclones	67-88	79	Bethlehem - Grace Mine [a]
G.K. waste gas	Settling chamber	--	96	U.S. Steel - Minntac [a]
G.K. waste gas	Multiclone (vane type)	--	98.8	U.S. Steel - Minntac [a]
V.S. top gas	Multiclone	7.5-47.4	23.6	Bethlehem - Maremec Mine [a]
V.S. bottom gas	Multiclone	74.3-96.9	83.5	Bethlehem - Maremec Mine [a]
V.S. top gas	Multiclone	--	92	Erie Mine [a]
V.S. bottom gas	Multiclone	--	89.5	Erie Mine [a]
G.K. waste gas	Wet scrubber	84-96.6	--	Cleveland-Cliffs - Pioneer Pellet Plant [a]
G.K. waste gas	ESP	--	97.3 [b]	Cleveland-Cliffs - Empire [c]
G.K. waste gas	Venturi Scrubber	--	96.0 [b]	Eveleth Taconite Company [c]

(a) Data supplied by operating companies through Section 114 responses.
(b) Filterable particulate efficiencies were 99.2 percent for Empire and 96.1 percent for Eveleth.
(c) Data from EPA tests in November 1975.

total particulate removal but reportedly was not operating at its best during the test period.

4.2.2.2 Minor Sources. Only limited data were obtained in this study on the performance of smaller collection devices which are used for control of crushers, conveyors, transfer points, etc. The bulk of these data pertained primarily to three types of wet scrubbers as summarized in Table 4.6 Typically, the wet scrubbers tested all showed collection efficiencies greater than 99 percent during some period of testing. From these data, it would be difficult to assign better performance from one device over the other two that were tested.

TABLE 4.6 FIELD TEST DATA ON MINOR SOURCE WET SCRUBBERS USED BY THE IRON ORE INDUSTRY

Emission Source Identification	Type of Control Device	Measured Efficiency, percent	Source of Data
Screen House - Line 2	National "hydrofilter"	99.2	Hanna Mining - Butler Plant[a]
Screen House - Line 5	National "hydrofilter"	99.5	Hanna Mining - Butler Plant[a]
Primary crusher	American Air Filter "Rotoclone"	92	Erie Mining Company [a]
Pan feeder	Ditto	94	Ditto
Secondary screen	"	99.7	"
Load-out	"	97	"
Grate discharge	Ducon "combination scrubber"	99.7	Hanna Mining - Groveland[b]
Grate return area	Ducon "combination scrubber"	99.85	Eveleth Taconite Company[b]

(a) Data supplied by operating companies through Section 114 responses.
(b) Data from EPA tests in November 1975.

References for Chapter 4

1. SO_2 Abatement for Stationary Sources in Japan, EPA-600/2-76-013a, January, 1976.

2. "Sulfur Removal and Recovery", Symposium at the 167th Meeting of the American Chemical Society, Los Angeles, California, April 4-5, 1974.

3. "Sulfur Emission Control For Industrial Boilers", Proceedings of the American Power Conference, Volume 36, 1974.

4. R. D. Ross, "Air Pollution and Industry", 1972.

5. MODIFICATION AND RECONSTRUCTION

In accordance with section 111 of the Clean Air act, as amended in 1970 and 1974, standards of performance shall be established for new sources within a stationary source category which " ... may contribute significantly to air pollution ..." Standards apply to operations or apparatus (facilities) within a stationary source, selected as "affected facilities," that is facilities for which applicable standards of performance have been promulgated and the construction or modification of which commenced after the proposal of said standards.

It is important to note that an "existing facility" may become subject to standards of performance if deemed modified or reconstructed as defined in the general provisions of 40 CFR Part 60.

5.1 40 CFR PART 60 PROVISIONS FOR MODIFICATION AND RECONSTRUCTION

5.1.1 Modification.

Section 60.14 defines modification as follows:

> "Except as provided under paragraphs (d), (e), and (f) of this section, any physical or operational changes to an existing facility which result in an increase in the emission rate to the atmosphere of any pollutant to which a standard applies shall be considered a modification within the meaning of section 111 of the Act. Upon modification, an existing facility shall become an affected facility for each pollutant to which a standard applies and for which there is an increase in the emission rate to the atmosphere."

The exception in paragraph (d) allows for an existing facility to undergo a physical or operational change which results in an increase in the emission rate of any pollutant to which a standard applies, but not be deemed a modification, provided the owner or operator can demonstrate to the Administrator's satisfaction (by any of the procedures prescribed under paragraph [b] of this section) that the total emission rate of that pollutant from all facilities within the stationary source has not increased. This may be accomplished by decreasing the emission rate from other facilities within the stationary source, to which reference, equivalent or alternative methods of sampling and analysis can be applied, to compensate for emission rate increases resulting from physical or operational changes to an existing facility. The required emission reduction may be effected through the installation or improvement of control systems or through physical or operational changes, including reducing a facility's production rate. In addition, an owner or operator may completely and permanently close any facility within the stationary source to prevent an increase in the total emission rate from occuring regardless of whether reference, equivalent or alternative test methods can be applied, if it can be clearly demonstrated (by any of the procedures prescribed under paragraph [b] of this section) that the emission rate reduction resulting from such closure offsets any increase.

Paragraph (e) lists certain physical or operational changes which will not be considered as modifications, irrespective of any change in the emission rate. These changes include:

a. Routine maintenance, repair and replacement.

b. An increase in the production rate not requiring a capital expenditure as defined in section 60.2(bb).

c. An increase in the hours of operation.

d. Use of an alternative fuel or raw material if prior to the standard, the existing facility was designed to accommodate that alternate fuel or raw material.

e. The addition or use of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or replaced by a system considered to be less efficient.

f. The relocation or change in ownership of an existing facility.

Paragraph (b) clarifies what constitutes an increase in emissions in kilograms per hour and the procedures for determining the increase including the use of emission factors, material balances, continuous monitoring systems, and manual emission tests. Paragraph (c) affirms that the addition of an affected facility to a stationary source does not make any other facility within that source subject to standards of performance. Paragraph (f) simply provides for superseding any conflicting provisions.

5.1.2 Reconstruction.

Section 60.15 regarding reconstruction states:

> "An existing facility shall be considered an affected facility by the Administrator upon reconstruction through the replacement of a substantial majority of the existing facility's components irrespective of any change of emission rate. The owner or operator may request the Administrator to determine whether the proposed reconstruction involves replacement of a substantial portion of the existing facility's components based on the capital cost of all new construction and other technical and economic considerations."

The purpose of this provision is to ensure that an owner or operator does not perpetuate an existing facility by replacing all but vestigial components, support structures, frames, housings, etc., rather than totally replacing it in order to avoid subjugation to applicable standards of performance. As noted, upon request EPA will determine if the proposed replacement of an existing facility's components constitutes reconstruction.

5.2 APPLICABILITY TO THE IRON ORE BENEFICIATION INDUSTRY

The iron ore industry typically undergoes modification, reconstruction, or addition of capacity by the addition of new equipment integrated into the existing plant. The exceptions, of course, are the clearly new source plants that would be constructed to mine a new deposit. As such, the applicability of section 111 standards to the iron ore beneficiation industry would be twofold.

Firstly, new source plants clearly would be "affected facilities" if construction commenced after the date of proposal of these standards. Secondly, existing plants would also become "affected facilities" if the plant undergoes expansion by addition of capacity and the expansion commenced after the date of proposal of these standards. It should be noted, however, that the expansion facilities which, for the most part, are constructed as new and separate production lines, would be the only facilities termed "affected facilities". This means, of course, that the existing production lines, even if in the same physical location, would not be covered under the standards.

One additional consideration arises concerning the applicability of these standards and this is described in paragraph (e) concerning the use of alternative fuels. In all probability the iron ore industry will be affected by this aspect because of the anticipated change over to coal firing of induration systems instead of natural gas firing. An increase in emissions will result as pertaining to sulfur oxides from combustion of the coal. Currently, many plants are being redesigned to accomodate this alternative fuel and the applicability of the standard will be in question until such redesign is complete.

The major problem in the iron ore industry of implementing any standards pertaining to existing plants will be a problem of retrofitting the control device to the equipment used and within the physical limitations of the buildings. A typical example would be the retrofitting of a specific control device to each source of emission in a plant using shaft furnaces. A typical shaft furnace will exhaust some 12 m^3/s (25,000 cfm) of hot gases and handle approximately 15.5 kg/s (55 tons per hour) of pellets. If a baghouse is the control device [each 12 m^3/s (25,000 cfm) baghouse would require approximately 23 m^2 (250 ft^2)], then to retrofit to a typical situation, say 27 furnaces, the plant requires some 627 m^2 (6,750 ft^2) of area plus space for gas cooling and temperature control device. This poses a real problem to retrofit into existing plants. Additional problems are encountered in iron ore plants around the furnace area in that the furnace floor where the gases will be coming off are generally from 15 to 30 m (50 to 100 feet) off the ground, therefore, requiring support or suspension. Typically, the plants are designed with minimum available space within the covered structure, therefore, always posing a space requirement problem.

The retrofitting of dry cyclone and wet scrubbers would appear to pose the least problem of retrofit; whereas the baghouse would pose the largest problem and electrostatic precipitators an intermediate problem based primarily on space requirements.

6. MODEL EMISSION CONTROL SYSTEMS

The emission control system, as defined, consists of the combination of a process and control technique. This section therefore will outline several example emission control systems - the purpose being to provide options for the selection of a "best system of emission reduction". These selections then would be the basis for potential standards under Section 111 of the Act which apply to new and modified sources or for standards under Section 112 which, in addition aplly to existing sources.

This discussion of control systems is divided into various subsections corresponding to the separate process operations within an iron ore plant.

6.1 MINING, BLASTING, AND HAULING

There are few control system alternatives for the mining, blasting, and hauling of iron ores. The process operations involve primarily open pit mining but some underground mining is practiced. For the few underground operations, emissions have not been measured but are expected to be very low and therefore, no control devices are specified. For the open pit operations, the fugitive dust emissions are best controlled by the use of water and/or chemical sprays. Wetting of the haulage loads and haul roads should also be practiced to reduce fugitive emissions from these sources.

6.2 PRIMARY CRUSHING

All open pit iron ore plants utilize the gyratory-type crusher for primary crushing of the ore, underground mines use jaw crushers; thus, there are no process alternatives considered for this operation. The control system however, can have a number of variations as discussed below.

Case 1(a) - This control option would consist of the usual practice of employing water sprays at the crusher top where ore is dumped in from trucks. The crusher discharge (pan feeder and conveyor) would be hooded and exhausted to a dry cyclonic-type collector. Collected dusts would be recovered and used in subsequent processing. This control system is rated at about 80 percent efficiency and will result in emissions of about 8.9 kg/1000 Mg (20 pounds per 1000 tons) of ore processed. (See Tables C-1 and C-12).

Case I(b) - Essentially the same as Case I(a) except this alternative would incorporate a wet scrubber for control of the crusher discharge emissions. Water sprays again would be used at the crusher top.

Case I(c) - This control option would involve hood collection of both the top and bottom crusher emissions and the use of a baghouse collector for both sources. This control alternative would result in emissions of about 1.1 kg/1000 Mg (2.5 pounds per 1000 tons) of ore processed. (See Tables C-17 and C-19).

6.3 SECONDARY CRUSHING, SCREENING, CONVEYOR TRANSFER, AND ORE STORAGE

These process operations are conducted basically the same from plant to plant within the industry. A small segment of the industry, however, employs entirely different processing for fine grinding of the ore. One process variation is the use of the dry autogenous grinding and air classification system and this is utilized at two of the Hanna-operated plants. Reportedly, this process has no particular advantages and a change will be made to the wet grinding system. The two plants presently using the dry system have significantly higher emissions for the fine grinding operations as indicated in Appendix C.

The other main process variation is the use of wet autogenous grinding of ore feed from the primary crushers. This option, of course, would eliminate most of the particulate emission sources associated with the fine grinding steps. Currently only one plant in the industry is successfully using this approach.

Considering the above aspects, only three control system alternatives are selected as outlined below.

Case II(a) - This control option comprises the conventional secondary and tertiary crushing process with the use of hooding and wet scrubbers to control particulate emissions from all sources. The particular scrubber employed may be any one of the several discussed in Chapter 4, but must have collection efficiencies equal to or greater than 99 percent of entering particulates. This level of performance is considered available and demonstrated technology.

Case II(b) - Essentially the same as Case II(a) except baghouse collectors would be used in place of wet scrubbers. This option could involve combining some sources into one collector.

Case II(c) - This control option would involve the use of wet autogenous grinding mills as a process variation over conventional crushing equipment. Because particulate emissions would be essentially eliminated by this option, there is no need to specify a control device. Some minor dust emissions may be generated however around conveyors feeding the autogenous mills and these emissions are estimated at about 1.8 kg/1000 Mg (4 pounds per 1000 tons) of ore processed.

6.4 PELLET INDURATION

The control systems associated with pellet induration are perhaps the most complex part of the current study. Basically, there are three types of process variations currently in use by the industry, the straight grate, the grate-kiln, and the vertical shaft systems. There presently is a fourth furnace configuration referred to as the circular grate which is reported to incorporate all the best features of both the grate-kiln and straight-grate systems. For purposes of discussing control device alterations, only the grate-kiln and the straight-grate systems are discussed below, since these two systems process the majority of iron ore in the U.S.

6.4.1 Grate-Kiln System

The grate-kiln system, its emission points, and the various control system options are presented in Figure 6.1. Each control system alternative is characterized by selecting different combinations of control devices for each source of emissions. The sources shown are the main waste gas exhaust, the cooler process air exhaust, and the smaller emission points commonly called the grate feed, grate discharge, and cooler discharge.

Case III(a) - This control system option consists of the common practice of employing a dry multiclone collector for the main waste gases and wet scrubbers such as the Rotoclone or Ducon units for the minor emission points. No collector is utilized for the cooler exhaust. It is estimated that this alternative will result in emissions in the range of 446 to 892 kg/1000 Mg (1000 to 2000 pounds per 1000 tons) of pellets produced.*

Case III(b), (c), and (d) - These control system options are identical to Case III(a), except for the use of a different control device for the main waste gas emissions. In Case III(b), a wet Venturi scrubber is selected and emissions are estimated at about 89 kg/1000 Mg (200 pounds per 1000 tons)* of pellets produced. In Case III(c), an electrostatic precipitator is used with emissions as low as 63 kg/1000 Mg (140 pounds per 1000 tons)* of pellets and in Case III(d), a baghouse collector is selected. No full-scale tests of the baghouse have been made but it is expected to have emissions close to that of the ESP option.

Case III(e) - This control system option is considered to provide an alternative to the use of wet scrubbers for the minor point emissions of the indurating machine. A baghouse could be utilized for this purpose although no present plant is considering such a system. With a baghouse, emissions would be slightly reduced over that anticipated from wet scrubbers and the improvement would be in the finer particle sizes.

Case III(f) and (g) - These options are considered to provide alternatives for the control of the cooler exhaust emissions. Very little data is available on these emissions but they typically range from 13 to 63 kg/1000 Mg (30 to 140 pounds per 1000 tons) of pellets produced.

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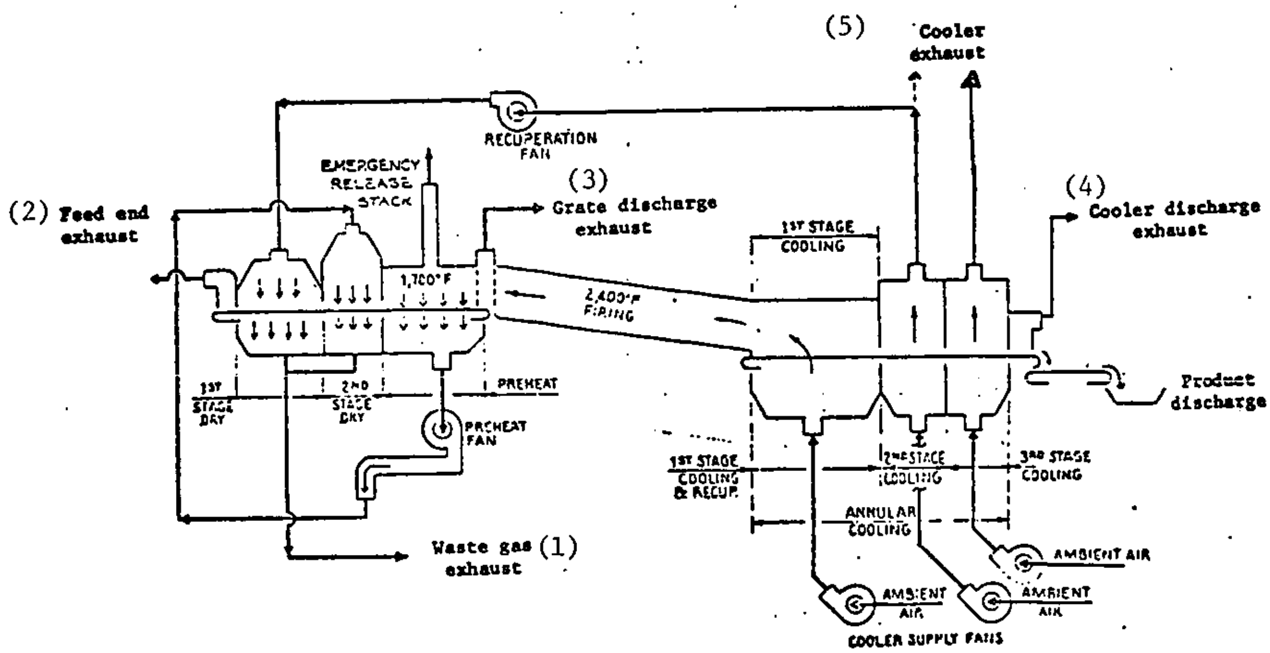
*For detailed emission data, see Table 3.9.



Case III[(a)]

1. Multiclone
2. Wet scrubber
3. Wet scrubber
4. Wet scrubber
5. None

Case III[(b)]

1. Venturi scrubber
2. Wet scrubber
3. Wet scrubber
4. Wet scrubber
5. None

Case III[(c)]

1. ESP
2. Wet scrubber
3. Wet scrubber
4. Wet scrubber
5. None

Case III[(d)]

1. Baghouse
2. Wet scrubber
3. Wet scrubber
4. Wet scrubber
5. None

Case III[(e)]

1. (a),(b),or (d)
2. Baghouse
3. Baghouse
4. Baghouse
5. None

Case III[(f)]

1. (a),(b),(c),or (d)
2. (a) or (e)
3. (a) or (e)
4. (a) or (e)
5. Multiclone

Case III[(g)]

1. (a), (b), (c), or (d)
2. (a) or (e)
3. (a) or (e)
4. (a) or (e)
5. Wet scrubber

Figure 6.1. Model Pellet Induration-Grate Kiln Options

6.4.2 Straight Grate System

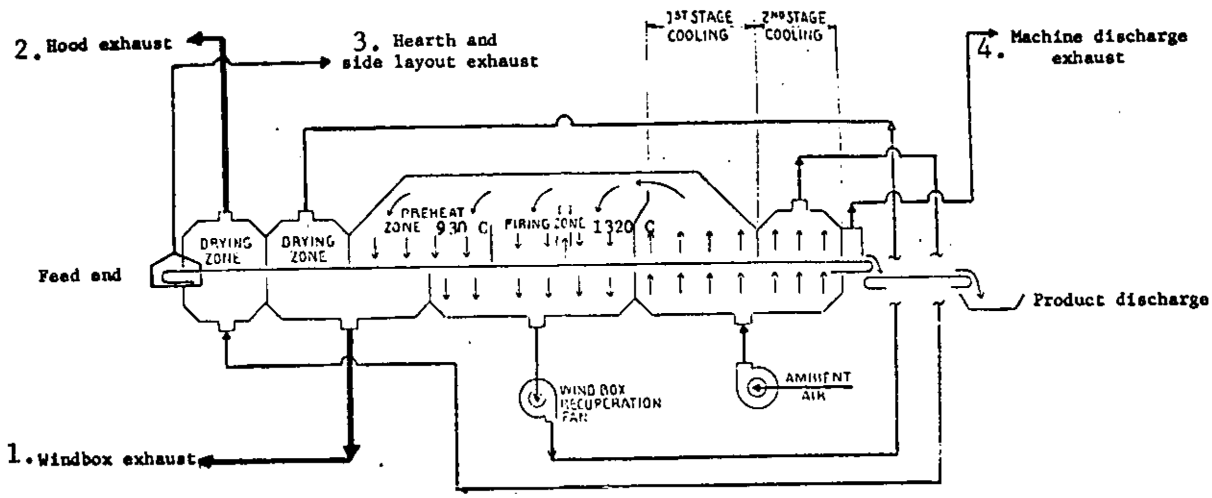
The straight grate system, its emission points, and the various control system options are presented in Figure 6.2. For reasons of simplification, only the Dravo-Lurgi configuration is considered; a similar diagram would also apply to the McKee type machine. The sources shown are the windbox exhaust, the hood exhaust, and the smaller emission points commonly called the machine discharge and the hearth-side layout exhaust.

Case IV(a) - This control system option consists of the usual practice of employing a dry multiclone collector for the windbox exhaust and wet scrubbers such as the Rotoclone or Ducon units for the minor emission points. No collector is utilized for the cooler exhaust. It is estimated that this alternative will result in emissions of about 536 kg/1000 Mg (1200 pounds per 1000 tons) of pellets produced.*

Case IV(b), (c), and (d) - These control system options are identical, except for the use of a different primary control device for the main emission points. In either case, the hood and windbox exhaust streams are fitted with a separate control device or combined into a single source of emissions. It should be noted however that sulfur oxides will appear predominately in the windbox exhaust and the combining of sources may not be practical from this standpoint. In Case IV(b), a wet venturi scrubber is utilized. No straight grate plants presently employ such a system but emissions most likely would be similar to Case III(b) or 89 kg/1000 Mg (200 pounds per 1000 tons) of pellets produced.* Case IV(c) with an electrostatic precipitator and Case IV(d) with a baghouse again would have emissions similar to the respective grate-kiln options.

Case IV(e) - This control system option is considered to provide an alternative to the use of wet scrubbers for the minor point emissions of the indurating machine. With a baghouse, overall emissions would be slightly reduced over that anticipated from wet scrubbers.

*For detailed emission data, see Table 3.9.



Control Device Legend

Case IV(a)

1. Multiclone
2. None
3. Wet Scrubber
4. Wet Scrubber

Case IV(b)

1., 2. {Venturi Scrubber}*
3. Wet Scrubber
4. Wet Scrubber

Case IV(c)

1., 2. {ESP}*
3. Wet Scrubber
4. Wet Scrubber

Case IV(d)

1., 2. {Baghouse}*
3. Wet Scrubber
4. Wet Scrubber

Case IV(e)

1., 2. { (a),(b),(c),or (d) }*
3. Baghouse
4. Baghouse

*These sources may be fitted with separate units or combined into a single source.

Figure 6.2. Model Pellet Induration - Straight Grate Options.

APPENDIX C

Iron Ore Plant
Emission Data

TABLE C-1a. IRON ORE PLANT EMISSION DATA

(Hanna Mining Company - Groveland Plant)

Source of Emissions	Point Source Characteristics[(a)] Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions,[(a)] lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Primary Crushing						
1. Crusher discharge	11,000	70	Dry cyclone	12		
Secondary and Tertiary Crushing						
1. Screens and belts	28,000	70	Rotoclone	3.0		
2. Screens and belts	28,000	70	Rotoclone	3.0		
3. Screens and belts	27,000	70	National	5.4		
Concentrator Ore Conveying and Storage						
1. Belt transfer	7,000	70	National	0.7		
2. Belt transfer	10,000	70	Ducon	1.3		
3. Belt transfer and silo	10,000	70	Wet scrubber	1.2		
4. Silos	7,000	70	National	0.2		
5. Belt transfer	8,000	70	Antipole	0.4		
6. Silo discharge (4 units)	4 x 4,000	70	Antipole	4 x 0.4		
Total Beneficiation:	152,000			28.8	616 (Ore)	0.05
Bentonite Facilities	2,000	70	Baghouse	0.5		
Pellet Induration						
1. Windbox exhaust	268,000	360 max	Multiclone	170		
2. Exhaust hood (leakage)	35,000	260 max	None	7		
3. Grate discharge	50,000	100	Ducon	3.7		
4. Hearth layer	15,000	80	Ducon	1.3		
5. Product screen and transfer	20,000	70	Ducon	2.4		
Total Pellet Plant:	390,000			184.9	245.2	0.7
		Total Plant Emissions:		213.7	245.2 (Pellets)	0.9

(a) Information supplied by Hanna on August 28, 1975.

TABLE C-1b. IRON ORE PLANT EMISSION DATA
(Hanna Mining Company - Groveland Plant)

Source of Emissions	Point Source Characteristics (a): Gas Flow Std. m3/s	Temp., K	Collector Used	Particulate Emissions (a) g/s	Production Rate, kg/s	Emission Factor g/Mg
Primary Crushing						
1. Crusher discharge	5.2	294	Dry cyclone	1.51	174	-
Secondary and Tertiary Crushing						
1. Screens and belts	13.2	294	Rotoclone	0.38	174	-
2. Screens and belts	13.2	294	Rotoclone	0.38	174	-
3. Screens and belts	12.7	294	National	0.68	174	-
Ore Conveying and Storage						
1. Belt transfer	3.3	294	National	0.09	174	-
2. Belt transfer	4.7	294	Ducon	0.16	174	-
3. Belt transfer and silo	4.7	294	Wet scrubber	0.15	174	-
4. Silo	3.3	294	National	0.03	174	-
5. Belt transfer	3.8	294	Antipole	0.05	174	-
6. Silo discharge (4 units)	4x1.9	294	Antipole	4x0.05	174	-
Total Beneficiation:	71.7			3.63	174	22
Bentonite Facilities	0.9	294	Baghouse	0.06	-	
Pellet Induration						
1. Wind box	126.5	456 max	Multiclone	21.42	73	-
2. Exhaust hood (leakage)	16.5	400 max	None	0.88	73	-
3. Grate discharge	23.6	311	Ducon	0.47	73	-
4. Hearth layer	7.1	300	Ducon	0.16	73	-
5. Product screen and transfer	9.4	294	Ducon	0.30	73	-
Total Pellet Plant:	184.1			23.30	73	313
			Total Plant Emissions:	26.93	69	402

(a) Information supplied by Hanna on August 28, 1975.

TABLE C-2a. IRON ORE PLANT EMISSION DATA

(Hanna Mining Company - Pilot Knob Plant)

Source of Emissions	Point Source Characteristics[a]: Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions[a], lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Bentonite Facilities	2,000	70	Dracco bag	0.1		
Limestone Facilities (2 units)	4,000	70	Dracco bag	0.6		
Pellet Induration						
1. Windbox exhaust	116,000	380 max	Multiclone	64.8		
2. Hood exhaust	123,000	300 max	None	52.2		
3. False windbox	2,000	400 max	None	3.2		
4. Grate discharge	37,000	95	Ducon	2.8		
5. Hearth layer	5,000	70	Ducon	0.5		
6. Product conveyors	5,000	70	National	0.5		
7. Product screen	11,000	70	Ducon	0.7		
Totals:	305,000			125.4	112 (pellets)	1.1

(a) Information supplied by Hanna on September 19, 1975.

Primary, secondary crushing, underground
Conc. plant wet autogenous grinding

TABLE C-2b. IRON ORE PLANT EMISSION DATA

(Hanna Mining Company - Pilot Knob Plant)

Source of Emissions	Point Source Characteristics[a]: Gas Flow, Std m^3/s	Temp., K	Collector Used	Particulate Emissions[a], g/s	Production Rate, kg/s	Emission Factor, g/Mg
Bentonite Facilities	0.9	294	Dracco bag	0.01		
Limestone Facilities (2 units)	1.9	294	Dracco bag	0.08		
Pellet Induration						
1. Windbox exhaust	54.8	467 max	Multiclone	8.16		
2. Hood exhaust	58.1	422 max	None	6.58		
3. False windbox	0.9	478 max	None	0.40		
4. Grate discharge	17.5	308	Ducon	0.35		
5. Hearth layer	2.4	294	Ducon	0.06		
6. Product conveyor	2.4	294	National	0.06		
7. Product screen	5.2	294	Ducon	0.09		
Totals:	144.0			15.80	32 (pellets)	491

(a) Information supplied by Hanna on September 19, 1975.

TABLE C-3a. IRON ORE PLANT EMISSION DATA

(Hanna Mining Company - National Steel Pellet Plant)

Source of Emissions	Point Source Characteristics[a]: Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions[a], lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Primary Crushing						
1. Crusher discharge	18,000		Multiclone	9.2		
2. Transfer house	10,000		Multiclone	1.4		
Grinding and Screening						
1. Coarse screening (6 units)	6 x 12,000		Ducon	6 x 4.5		
2. Process collectors (6 units)	6 x 41,000		Venturi	6 x 16.4		
3. Primary collectors (5 units)	5 x 22,000		Venturi	5 x 5.7		
4. Primary collector (1 unit)	31,000		Venturi	3.6		
5. Secondary collector	15,000		Ducon	4.5		
Total Beneficiation:	502,000			172.6	962 (ore)	0.2
Bentonite Facilities						
1. P.K. Mixer	3,500		Ducon	0.5		
2. Silo	1,500		Baghouse	0.1		
Pellet Induration						
1. Waste gas	270,000	235	Multiclone	276		
2. Cooler exhaust	149,000		None	16.4		
3. Grate feed	15,000		Ducon	0.3		
4. Grate discharge	14,000		Ducon	0.6		
5. Cooler discharge	25,000		Ducon	1.0		
6. Pellet conveyors	8,500		Rotoclone			
7. Pellet feeders	16,000		Rotoclone		(concentrate)	
Total Pellet Plant:	502,500			295	291	1.0
	Total Plant Emissions:			467.5	315 (pellets)	1.5

(a) Information supplied by Hanna on October 14, 1975.

TABLE C-3b. IRON ORE PLANT EMISSION DATA

(Hanna Mining Company - National Steel Pellet Plant)

Source of Emissions	Point Source Characteristics[a]: Gas Flow, Std m^3/s	Temp., K	Collector Used	Particulate Emissions[a], g/s	Production Rate, ks/s	Emission Factor, g/Mg
Primary Crushing						
1. Crusher discharge	8.5		Multiclone	1.16		
2. Transfer house	4.7		Multiclone	0.18		
Grinding and Screening						
1. Coarse screening (6 units)	6 x 5.7		Ducon	6 x 0.57		
2. Process collectors (6 units)	6 x 19.4		Venturi	6 x 2.07		
3. Primary collectors (5 units)	5 x 10.4		Venturi	5 x 0.72		
4. Primary collector (1 unit)	14.6		Venturi	0.45		
5. Secondary collector	7.1		Ducon	0.57	(ore)	
Total Beneficiation:	236.9			21.75	271	89
Bentonite Facilities						
1. P.K. Mixer	1.7		Ducon	0.06		
2. Silo	0.7		Baghouse	0.01		
Pellet Induration						
1. Waste gas	127.9	386	Multiclone	34.78		
2. Cooler exhaust	70.3		None	2.07		
3. Grate feed	7.1		Ducon	0.04		
4. Grate discharge	6.6		Ducon	0.08		
5. Cooler discharge	11.8		Ducon	0.13		
6. Pellet conveyors	4.0		Rotoclone			
7. Pellet feeders	7.6		Rotoclone		(concentrate)	
Total Pellet Plant:	237.2			37.17	82	446
		Total Plant Emissions:		58.91	89 (pellets)	670

(a) Information supplied by Hanna on October 14, 1975.

TABLE C-4a. IRON ORE PLANT EMISSION DATA

(Hanna Mining Company - Butler Taconite Plant)

Source of Emissions	Point Source Characteristics(a): Gas Flow, scfm	Point Source Characteristics(a): Temp, F	Point Source Characteristics(a): Collector Used	Particulate Emissions(a), lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Primary Crushing						
1. Crusher discharge	18,000		FAA Multiclone	12.2		
2. Transfer house	10,000		Buell Multiclone	3.9		
Grinding and Screening						
1. Coarse screening (5 units)	5 x 11,000		National	5 x 8.6		
2. Process collectors (5 units)	5 x 42,000		Venturi	5 x 19.5		
3. Primary collectors (4 units)	4 x 25,000		Venturi	4 x 5.3		
4. Primary collector (1 unit)	33,000		Venturi	8.6		
5. Secondary collector	18,000		National	9.4	(ore)	
Total Beneficiation:	444,000			195.8	~~923~~	~~0.2~~
Bentonite Facilities						
1. P.K. Mixer	3,000		National	0.2		
2. Silo				0.2		
Pellet Induration						
1. Waste gas	240,000	210	Multiclone	437.7		
2. Cooler exhaust	128,000		None	28.7		
3. Grate feed	12,000		National	5.2		
4. Grate discharge	13,000		Ducon	0.4		
5. Cooler discharge	15,000		Ducon	0.1		
6. Pellet conveyors	11,000		Ducon	0.2	(concentrate)	
Total Pellet Plant:	422,000			472.7	~~281.9~~	~~1.7~~
Total Plant Emissions:				668.5	~~284~~ (pellets)	~~2.4~~

(a) Information supplied by Hanna on October 14, 1975.

TABLE C-4b. IRON ORE PLANT EMISSION DATA

(Hanna Mining Company - Butler Taconite Plant)

Source of Emissions	Point Source Characteristics[a]: Gas Flow, Std m^3/s	Temp., K	Collector Used	Particulate Emissions[a], g/s	Production Rate, kg/s	Emission Factor, g/Mg
Primary Crushing						
1. Crusher discharge	8.5		FAA multiclone	1.54		
2. Transfer house	4.7		Buell multiclone	0.49		
Grinding and Screening						
1. Coarse screening (5 units)	5 x 5.2		National	5 x 1.08		
2. Process collectors (5 units)	5 x 19.8		Venturi	5 x 2.46		
3. Primary collectors (4 units)	4 x 11.8		Venturi	4 x 0.67		
4. Primary collector (1 unit)	15.6		Venturi	1.08		
5. Secondary collector	8.5		National	1.18	(ore)	
Total Beneficiation:	209.6			24.67	260	89
Bentonite Facilities						
1. P. K. Mixer	1.4		National	0.03		
2. Silo				0.03		
Pellet Induration						
1. Waste gas	113.3	372	Multiclone	55.15		
2. Cooler exhaust	60.4		None	3.62		
3. Grate feed	5.7		National	0.66		
4. Grate discharge	6.1		Ducon	0.05		
5. Cooler discharge	7.1		Ducon	0.01		
6. Pellet conveyors	5.2		Ducon	0.03	(concentrate)	
Total Pellet Plant:	199.2			59.56	80	759
			Total Plant Emissions:	84.23	80 (pellets)	1072

(a) Information supplied by Hanna on October 14, 1975.

TABLE C-5a. IRON ORE PLANT EMISSION DATA

(Pickands Mather and Company - Erie Mine)

	Point Source Characteristics[b]					
Source of Emissions	Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions, lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Coarse Crushing						
1. 60-in. gyrators (2 units)	2 x 97,200	--	Wheelabrator bag	2 x 25[a]		
2. 36-in. gyrators (4 units)	4 x 15,000	77	AAF Rotoclone	4 x 4.5[b]		
3. Pan feeders (2 units)	2 x 20,000	71	AAF Rotoclone	2 x 35.6[b]		
4. Drive house (2 units)	2 x 10,000	--	AAF Rotoclone	2 x 4.3[c]		
Fine Crushing						
1. Ore storage (2 units)	2 x 8,000	--	AAF Rotoclone	2 x 3.4[c]		
2. Ore storage (2 units)	2 x 9,600	--	Wheelabrator bag	2 x 2.5[a]		
3. Feeders, screens, and belts (7 units)	7 x 33,000	75	AAF Rotoclone	7 x 3.3[b]		
4. Feeders and belts (2 units)	2 x 20,000	--	AAF Rotoclone	2 x 8.6[c]		
Concentrator						
1. Fine ore storage (6 units)	6 x 12,000	--	AAF Rotoclone	6 x 5.1[c]		
2. Rod mill feeders (9 units)	9 x 16,800	--	AAF Rotoclone	9 x 7.2[c]		
3. Transfer points (2 units)	2 x 8,500	--	AAF Rotoclone	2 x 3.6[c]		
Total Beneficiation:	860,800			302.5	3544 (Ore)	0.085
Bentonite Facilities					132.6	
1. Silos and feeders (11 units)	11 x 1,500	--	Wheelabrator bag	11 x 0.1[d]		
2. Feeders (9 units)	9 x 2,000	--	Wheelabrator bag	9 x 0.2[b]		
3. Coal storage	15,200	--	Wheelabrator bag	1.3[d]		
4. Screw conveyor	300	--	Wheelabrator bag	--		
Pellet Plant (27 shaft furnaces)						
1. Top gas (24 units)	24 x 38,640	315	Am. Std. Multiclone	24 x 28.1[b]		
2. Top gas (2 units)	2 x 39,400	--	Am. Std. Multiclone	2 x 67.8[e]		
3. Top gas (1 unit)	57,960	--	Am. Std. Multiclone	67.8[e]		
4. Bottom gas (25 units)	25 x 12,000	375	AAF Rotoclone	25 x 0.6[b]		
5. Bottom gas (1 unit)	39,400	190	Am. Std. Multiclone	45.7[b]		
6. Pellet handling (2 units)	2 x 26,000	--	AAF Rotoclone	2 x 11.1[c]		
7. Elevators (2 units)	2 x 4,500	--	AAF Rotoclone	2 x 1.9[c]		
8. Chips circuit (3 units)	33,200	--	AAF Rotoclone	14.2[c]		
9. Loading pocket (4 units)	63,000	270	AAF Rotoclone	4 x 17.8[b]	30.5	
Total Pelletization	1,560,000			1054.1	1176	0.9
			Total Plant Emissions:	1356.6	1176 (Pellets)	1.15

(a) Emissions estimated at 0.03 g/scf.
(b) Information supplied by Pickands Mather and Company on September 26, 1975.
(c) Emissions estimated at 0.05 g/scf.
(d) Emissions estimated at 0.01 g/scf.
(e) Emissions based on MPCA tests at Erie.

TABLE C-5b. IRON ORE PLANT EMISSION DATA

(Pickands Mather and Company - Erie Mine)

Source of Emissions	Gas Flow, Std m^3/s	Temp., K	Collector Used	Particulate Emissions, g/s	Production Rate, kg/s	Emission Factor, g/Mg
Coarse Crushing						
1. 1.5-m gyrators (2 units)	2 x 45.9	--	Wheelaborator bag	2 x 7.06[a]		
2. 0.9-m gyrators (4 units)	4 x 7.1	298	AAF Rotoclone	4 x 1.27[b]		
3. Pan feeders (2 units)	2 x 9.4	295	AAF Rotoclone	2 x 10.05[b]		
4. Drive house (2 units)	2 x 4.7	--	AAF Rotoclone	2 x 1.21[c]		
Fine Crushing						
1. Ore storage (2 units)	2 x 3.8	--	AAF Rotoclone	2 x 0.96[c]		
2. Ore storage (2 units)	2 x 4.5	--	Wheelaborator bag	2 x 0.71[a]		
3. Feeders screens, belts (7 units)	7 x 15.6	297	AAF Rotoclone	7 x 0.93[b]		
4. Feeders, belts (2 units)	2 x 9.4	--	AAF Rotoclone	2 x 2.43[c]		
Concentrator						
1. Fine ore storage (6 units)	6 x 5.7	--	AAF Rotoclone	6 x 1.44[c]		
2. Rod mill feeders (9 units)	9 x 7.9	--	AAF Rotoclone	9 x 2.03[c]		
3. Transfer points (2 units)	2 x 4.0	--	AAF Rotoclone	2 x 1.02[c]		
Total Beneficiation:	406.3			85.37	1000	38
Bentonite Facilities						
1. Silos, feeders (11 units)	11 x 0.7	--	Wheelaborator bag	11 x 0.03[d]		
2. Feeders (9 units)	9 x 0.9	--	Wheelaborator bag	9 x 0.06[b]		
3. Coal storage	7.2	--	Wheelaborator bag	0.37[d]		
4. Screw conveyor	0.1	--	Wheelaborator bag	--		
Pellet Plant (27 shaft furnaces)						
1. Top gas (24 units)	24 x 18.2	431	Am. Std. Multiclone	24 x 7.93[b]		
2. Top gas (2 units)	2 x 18.5	--	Am. Std. Multiclone	2 x 19.1[e]		
3. Top gas (1 unit)	27.4	--	Am. Std. Multiclone	19.1[e]		
4. Bottom gas (25 units)	25 x 5.7	464	AAF Rotoclone	25 x 0.17[b]		
5. Bottom gas (1 unit)	18.6	361	Am. Std. Multiclone	12.90[b]		
6. Pellet handling (2 units)	2 x 12.3	--	AAF Rotoclone	2 x 3.13[c]		
7. Elevators (2 units)	2 x 2.1	--	AAF Rotoclone	2 x 0.54[c]		
8. Chips circuit (3 units)	3 x 15.7	--	AAF Rotoclone	3 x 4.01[c]		
9. Loading pocket (4 units)	4 x 29.7	406	AAF Rotoclone	4 x 5.02[b]		
Total Pelletization:	736.3			297.49	332	402
		Total Plant Emissions:		382.86	332	513

(a) Emissions estimated at 0.069 g/m^3.
(b) Information supplied by Pickands Mather and Company on September 26, 1975.
(c) Emissions estimated at 0.114 g/m^3.
(d) Emissions estimated at 0.023 g/m^3.
(e) Emissions based on MPCA tests at Erie.

TABLE C-6a. IRON ORE PLANT EMISSION DATA

(Reserve Mining Company)

Source of Emissions	Point Source Characteristics[a] Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions, lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Mining and Ore Transport Coarse Crushing						
1. Primary						
2. Secondary	"Operations at Babbitt Mine, no information on particulate emissions"					
3. Feeders, conveyors, and bins						
Fine Crushing						
1. Dump pocket	47,000	60	NI	NI		
2. Pan feeder	14,700	60	NI	NI		
3. Conveyor transfer	24,200	60	NI	NI		
4. Storage bin (2 units)	2 x 73,400	60	NI	NI		
5. Crusher feed (2 units)	2 x 75,000	70	NI	NI		
6. Conveyor transfer	62,800	70	NI	NI		
7. Conveyor discharge (2 units)	2 x 36,000	70	NI	NI		
Concentrator						
1. Transfer bin (2 units)	2 x 18,800	60	FAA Dry cyclone	NI		
2. Red Mill feeders (22 units)	22 x 30,000	60	FAA Dry cyclone	22 x 1.2[a]		
3. Lab pulverizer	3,500	60	None	NI		
Total Beneficiation:	1,220,000			NI	3436 (Ore)	--
Bentonite Facilities						
1. Storage (2 units)	2 x 1,300	70	Sly bag	NI		
2. Mixers (3 units)	3 x 4,800	70	Dracco bag	NI		
3. Mixers (4 units)	4 x 1,800	70	Sly bag	NI		
4. Mixers (3 units)	3 x 1,300	70	Sly bag	NI		
5. Unloading (1 unit)	4,900	70	AAF Bag	NI		
Pellet Plant (Eight Straight-Grate Lines)						
1. Windbox exhaust (6 units)	6 x 110,800	375	None	6 x 183[a,b]		
2. Hood exhaust (6 units)	6 x 88,500	215	None	6 x 50.6[a,b]		
3. Windbox exhaust (2 units)	2 x 115,000	460	None	2 x 376.6[a,c]		
4. Hood exhaust (2 units)	2 x 226,000	220	None	2 x 635.4[a,c]		
5. Grate feed (3 units)	3 x 25,000	170	AAF Rotoclone	3 x 5.1[a]		
6. Grate discharge (6 units)	6 x 32,000	150	AAF Rotoclone	6 x 22.6[a]		
7. Grate discharge (4 units)	4 x 32,000	150	AAF Rotoclone	4 x 16.3[a]		
8. Pellet test lab	5,500	60	Wheelabrator bag	NI		
9. Conveyor hoods (27 units)	27 x 10,000	70	None	NI		
10. Silo exhaust (10 units)	10 x 10,000	70	None	NI		
Total Pelletization	2,580,000			~~3641.7~~	1221 (Pellets)	3.0

(a) Emission data supplied by Reserve Mining Company.
(b) Based on Machine No. 6 which has roller feeder and second stage cooling recycled.
(c) Based on Machine No. 12.

TABLE C-6b. IRON ORE PLANT EMISSION DATA

(Reserve Mining Company)

Source of Emissions	Point Source Characteristics[(a)] Gas Flow, Std m^3/s	Temp., K	Collector Used	Particulate Emissions, g/s	Production Rate, kg/s	Emission Factor, g/Mg
Mining and Ore Transport Coarse Crushings						
1. Primary						
2. Secondary	"Operations at Babbitt Mine, no information on particulate emissions"					
3. Feeders, conveyors, bins						
Fine Crushing						
1. Dump pocket	22.2	289	NI	NI		
2. Pan feeder	69.4	289	NI	NI		
3. Conveyor transfer	11.4	289	NI	NI		
4. Storage bin (2 units)	2 x 34.6	289	NI	NI		
5. Crusher feed (2 units)	2 x 35.4	294	NI	NI		
6. Conveyor transfer	29.6	294	NI	NI		
7. Conveyor discharge (2 units)	2 x 17.0	294	NI	NI		
Concentrator						
1. Transfer bin (2 units)	2 x 8.9	289	FAA Dry Cyclone	NI		
2. Rod mill feeders (22 units)	22 x 14.2	289	FAA Dry Cyclone	22 x 0.15(a)		
3. Lab pulverizer	1.7	289	None	NI		
Total Beneficiation:	575.8			NI	970	--
Bentonite Facilities						
1. Storage (2 units)	2 x 0.6	294	Sly bag	NI		
2. Mixers (3 units)	3 x 2.3	294	Dracco bag	NI		
3. Mixers (4 units)	4 x 0.9	294	Sly bag	NI		
4. Mixers (3 units)	3 x 0.6	294	Sly bag	NI		
5. Unloading (1 unit)	2.3	294	AAF bag	NI		
Pellet Plant (8 Straight-Grate Lines)						
1. Windbox exhaust (6 units)	6 x 52.3	464	None	6 x 27.67(a,b)		
2. Hood exhaust (6 units)	6 x 41.8	375	None	6 x 6.38(a,b)		
3. Windbox exhaust (2 units)	2 x 54.3	511	None	2 x 47.45(a,c)		
4. Hood exhaust (2 units)	2 x 106.7	378	None	2 x 80.06(a,c)		
5. Grate feed (3 units)	3 x 11.8	350	AAF Rotoclone	3 x 0.64(a)		
6. Grate discharge (6 units)	6 x 15.1	339	AAF Rotoclone	6 x 2.85(a)		
7. Grate discharge (4 units)	4 x 15.1	339	AAF Rotoclone	4 x 2.05(a)		
8. Pellet test lab	2.6	289	Wheelaborator bag	NI		
9. Conveyor hoods (27 units)	27 x 4.7	294	None	NI		
10. Silo exhaust (10 units)	10 x 4.7	294	None	NI		
Total Pelletization:	1,217.8			459	345	1339

(a) Emission data supplied by Reserve Mining Company.
(b) Based on Machine No. 6 which has roller feeder and second stage cooling recycled.
(c) Based on Machine No. 12

TABLE C-7a. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Republic Mine)

Source of Emissions	Point Source Characteristics[a]			Particulate Emissions[a], lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
	Gas Flow, scfm	Temp, F	Collector Used			
Beneficiation Processes	"No information given"					
Bentonite Facilities	"No information given"					
Pellet Plant (Two Grate-Kiln Lines)						
1. Waste gas (Unit No. 1)	176,000	209	ESP	8.9		
2. Waste gas (Unit No. 2)	191,000	232	ESP	39.2		
3. Cooler exhaust	"No information given"					
4. Grate feed	"No information given"					
5. Grate discharge	"No information given"					
6. Cooler discharge	"No information given"					
7. Pellet loadout	"No information given"					
Total Pelletization				48.1	342	0.14

(a) Emission data supplied by Cleveland-Cliffs Iron Company on October 30, 1975.

TABLE C-7b. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Republic Mines)

	Point Source Characteristics[a]					
Source of Emissions	Gas Flow, Std. m^3/s	Temp., K	Collector Used	Particulate Emissions[a], g/s	Production Rate, kg/s	Emission Factor, g/Mg
Beneficiation Processes		"No information given"				
Bentonite Facilities		"No information given"				
Pellet Plant (Two Grate-Kiln Lines)						
1. Waste gas (Unit No. 1)	83.1	372	ESP	1.12		
2. Waste gas (Unit No. 2)	90.2	384	ESP	4.94		
3. Cooler exhaust						
4. Grate feed						
5. Grate discharge		"No information given"				
6. Cooler discharge						
7. Pellet loadout						
Total Pelletization:				6.06	97	63

(a) Emission data supplied by Cleveland-Cliffs Iron Company on October 30, 1975.

TABLE C-8a. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Humboldt Mine)

	Point Source Characteristics[a]					
Source of Emissions	Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions[a], lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Beneficiation Processes	"Plant receives ore concentrates from Republic Mine and therefore has no emissions associated with beneficiation."					
Bentonite Facilities	"No information given."					
Pellet Plant (Two Grate-Kiln Lines)						
1. Waste gas (Unit No. 1)	66,000	223	Multiclone	584		
2. Waste gas (Unit No. 2)	70,000	229	Multiclone	379		
3. Cooler exhaust	"No information given."					
4. Grate feed						
5. Grate discharge						
6. Cooler discharge						
7. Pellet loadout						
Total Pelletization				963	110	8.8

(a) Emission data supplied by Cleveland-Cliffs Iron Company on November 20, 1975.

TABLE C-8b. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Humbolt Mine)

Source of Emissions	Point Source Characteristics[a] Gas Flow, Std. m^3/s	Temp., K	Collector Used	Particulate Emissions[a], g/s	Production Rate, kg/s	Emission Factor, g/Mg
Beneficiation Processes	"Plant receives ore concentrates from Republic Mine and, therefore, has no emissions associated with beneficiation."					
Bentonite Facilities	"No information given"					
Pellet Plant (Two Grate-Kiln Lines)						
1. Waste gas (Unit No. 1)	31.2	379	Multiclone	73.58		
2. Waste gas (Unit No. 2)	33.0	383	Multiclone	47.75		
3. Cooler exhaust	"No information given"					
4. Grate feed						
5. Grate discharge						
6. Cooler discharge						
7. Pellet loadout						
Total Pelletization:				121.34	31	3929

(a) Emission data supplied by Cleveland-Cliffs Iron Company on November 20, 1975.

TABLE C-9a. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Pioneer Pellet Plant)

	Point Source Characteristics[a]					
Source of Emissions	Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions[a], lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Beneficiation Processes	"No information given"					
Bentonite Facilities	"No information given"					
Pellet Plant (One Grate Kiln)						
1. Waste gas	525,000		Wet scrubber	142.6	208	0.69
2. Other sources	"No information given"					

(a) Emission data supplied by Cleveland-Cliffs Iron Company on September 28, 1975.

TABLE C-9b. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Pioneer Pellet Plant)

	Point Source Characteristics[a]					
Source of Emissions	Gas Flow, Std m3/s	Temp, K	Collector Used	Particulate Emissions[a], g/s	Production Rate kg/s	Emission Factor, g/Mg
Beneficiation Processes			No information given			
Bentonite Facilities			No information given			
Pellet Plant (One Grate Kiln)						
1. Waste gas	247.8		Wet Scrubber	17.97	59	308
2. Other sources			No information given			

(a) Emission data supplied by Cleveland-Cliffs Iron Company on September 28, 1975.

TABLE C-10a. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Empire Mine)

Source of Emissions	Point Source Characteristics[a] Gas Flow scfm	Temp, F	Collector Used	Particulate Emissions[a], lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Beneficiation Processes			"No Information Given"			
Bentonite Facilities			"No Information Given"			
Pellet Plant (Three Grate-Kiln Lines)						
1. Waste Gas (Unit No. 1)	260,000	290 max	Buell ESP	100	200	
2. Waste Gas (Unit No. 2)	224,000	272 max	Buell ESP	17.9	197	
3. Waste Gas (Unit No. 3)	207,000	210	Buell ESP	13.3	209	
Total Pelletization:	691,000			131.2	606	0.22

(a) Information supplied by Cleveland-Cliffs on November 25, 1976.

TABLE C-10b. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Empire Mine)

Source of Emissions	Point Source Characteristics[a]			Particulate Emissions[a], g/s	Production Rate kg/s	Emission Factor, g/Mg
	Gas Flow, Std. m3/s	Temp, K	Collector Used			
Beneficiation Processes			No information given			
Bentonite Facilities			No information given			
Pellet Plant (Three Grate-Kiln Lines)						
1. Waste gas (Unit No. 1)	122.7	417 max	Buell ESP	12.60	56	
2. Waste gas (Unit No. 2)	105.7	407 max	Buell ESP	2.26	56	
3. Waste gas (Unit No. 3)	97.7	372	Buell ESP	1.68	59	
Total Pelletization:	326.2			16.53	171	98

(a) Information supplied by Cleveland-Cliffs on November 25, 1976.

TABLE C-11a. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Tilden Mine)

Source of Emissions	Point Source Characteristics[a] Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions[a], lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Beneficiation Processes			"No Information"			
Bentonite Facilities			"No Information"			
Pellet Plant (One Grate-Kiln System)						
1. Waste Gas (North Stack)	185,000	320	ESP	69		
2. Waste Gas (South Stack)	572,000	275	ESP	111		
Total Pelletization:	757,000			180	546	0.33

(a) Information supplied by Cleveland-Cliffs on December 30, 1975.

TABLE C-11b. IRON ORE PLANT EMISSION DATA

(Cleveland-Cliffs Iron Company - Tilden Mine)

Source of Emissions	Point Source Characteristics[a] Gas Flow, Std m3/s	Temp, K	Collector Used	Particulate Emissions[a], g/s	Production Rate kg/s	Emission Factor, g/Mg
Beneficiation Processes			No information			
Bentonite Facilities			No information			
Pellet Plant (One Grate-Kiln System)						
1. Waste gas (North Stack)	87.3	433	ESP	8.69		
2. Waste gas (South Stack)	270.0	408	ESP	13.99		
Total Pelletization:	357.3			22.68	154	147

(a) Information supplied by Cleveland-Cliffs on December 30, 1975.

TABLE C-12a. IRON ORE PLANT EMISSION DATA

(Eveleth Taconite Company)

Source of Emissions	Point Source Characteristics[(a)] Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions, lb/hr[(a)]	Production Rate, tons/hr[(a)]	Emission Factor, lb/ton
Mining and Ore Transport						
1. Truck Dump	61,000	--	FAA Cyclone	63.6		
2. Loading Pocket	34,000	--	"None"	47.5		
3. Ore Unloading	24,000	--	FAA Cyclone	42.2		
Total Mining and Ore Transport:	119,000			153.3		
Coarse Crushing						
1. Crusher Discharge	17,000	--	FAA Cyclone	17.9		
Fine Crushing						
1. Secondary (2 units)	2 x 24,000	--	AAF Scrubber	14.2		
2. Tertiary (3 units)	3 x 20,000	--	AAF Scrubber	15.5 est		
Concentrator						
1. Conveyor	12,000	--	AAF Scrubber	6.3		
2. Silo	4,000	--	FAA Cyclone	1.6		
3. Rod Mill Feeders (2 units)	2 x 12,000	--	AAF Scrubber	1.4		
Total Beneficiation:	165,000			56.9	825 (crude ore)	0.069
Bentonite Facilities						
1. Silo	9,000	--	Ducon Scrubber	0.3		
2. Transfer Stations	4,000	--	Buell Baghouse	0.03		
Pellet Plant (One Grate-Kiln Line)						
1. Waste Process Gas	260,000	--	Ducon Venturi	53.5		
2. Cooler Exhaust	119,000	--	"None"	9.2		
3. Grate Feed	19,000	--	Ducon Scrubber	0.2		
4. Grate Discharge	19,000	--	Ducon Scrubber	0.5		
5. Cooler Discharge	20,000	--	Ducon Scrubber	0.5		
6. Pellet Loadout	8,000	--	AAF Scrubber	0.1		
Total Pelletization:	458,000			64.3	303 (concentrate)	0.21
Total Plant Emissions:				274.5	288 (pellets)	0.95

(a) Information supplied by Eveleth Taconite Company on September 2, 1975.

TABLE C-12b. IRON ORE PLANT EMISSION DATA

(Eveleth Taconite Company)

Source of Emissions	Point Source Characteristics(a): Gas Flow, Std m^3/s	Temp., K	Collector Used	Particulate Emissions,(a) g/s	Production Rate, kg/s	Emission Factor, g/Mg
Mining and Ore Transport						
1. Truck dump	28.8	--	FAA Cyclone	8.01		
2. Loading pocket	16.1	--	None	5.99		
3. Ore unloading	11.3	--	FAA Cyclone	5.32		
Total Mining & Ore Transport	56.2			19.32		
Coarse Crushing						
1. Crusher discharge	8.0	--	FAA Cyclone	2.26		
Fine Crushing						
1. Secondary (2 units)	2 x 11.3	--	AAF Scrubber	1.79		
2. Tertiary (3 units)	3 x 9.4	--	AAF Scrubber	1.95 est.		
Concentrator						
1. Conveyor	5.7	--	AAF Scrubber	0.79		
2. Silo	1.9	--	FAA Cyclone	0.20		
3. Rod mill feeders (2 units)	2 x 5.7	--	AAF Scrubber	0.18		
Total Beneficiation:	77.9			7.17	233 (ore)	112
Bentonite Facilities						
1. Silo	4.3	--	Ducon scrubber	0.04		
2. Transfer stations	1.9	--	Buell baghouse	0.004		
Pellet Plant (One Grate-Kiln Line)						
1. Waste process gas	122.7	--	Ducon venturi	6.74		
2. Cooler exhaust	56.2	--	None	1.16		
3. Grate feed	9.0	--	Ducon scrubber	0.03		
4. Grate exhaust	9.0	--	Ducon scrubber	0.06		
5. Cooler discharge	9.4	--	Ducon scrubber	0.06		
6. Pellet loadout	3.8	--	AAF scrubber	0.01		
Total Pelletization:	216.2			8.10	86 (Concentrate)	94
	Total Plant Emissions:			34.59	81 (Pellets)	424

(a) Information supplied by Eveleth Taconite Company on September 2, 1975.

TABLE C-13a. IRON ORE PLANT EMISSION DATA

(Bethlehem Steel Corporation - Grace Mine)

Source of Emissions	Point Source Characteristics[a]: Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions, lb/hr[a]	Production Rate, tons/hr	Emission Factor, lb/ton
Bentonite Facilities	1,200	--	Baghouse	NI		
Pellet Plant (Six Shaft Furnaces)						
1. Top Gas (Unit No. 1)	42,000	310	(b)	34		
2. Top Gas (5 units)	5 x 51,000	315	Am. Std. Multiclone	5 x 82		
3. Bottom Gas (Unit No. 1)	21,000	490	(c)	29.4		
4. Bottom Gas (5 units)	5 x 23,000	615	Res. Cot. Multiclone	5 x 36.7		
5. Pellet Handling (3 units)	NI	--	AAF Rotoclone	NI		
6. Pellet Discharge	37,000	130	Am. Std. Multiclone	118		
Total Pelletization	471,000			774.9	250 (Pellets)	3.1

(a) Information supplied by Bethlehem on September 24, 1975.
(b) This collector is a combination Am. Std. multiclone followed by four Buell large-diameter cyclones.
(c) This collector is a combination Research Cottrell multiclone followed by two Ducon large-diameter cyclones.

Note: NI is no information or insufficient data supplied.

TABLE C-13b. IRON ORE PLANT EMISSION DATA

(Bethlehem Steel Corporation - Grace Mine)

Source of Emissions	Point Source Characteristics[a] Gas Flow, Std m^3/s	Temp., K	Collector Used	Particulate Emissions,[a] g/s	Production Rate, kg/s	Emission Factor, g/Mg
Bentonite Facilities	0.6	-	Baghouse	NI		
Pellet Plant (Six Shaft Furnaces)						
1. Top gas (Unit No. 1)	19.8	428	-(b)	4.28		
2. Top gas (5 units)	5 x 24.1	431	Am. Std. Multiclone	5 x 10.33		
3. Bottom gas (Unit No. 1)	9.9	528	-(e)	3.70		
4. Bottom gas (5 units)	5 x 10.9	597	Res. Cot. Multiclone	5 x 4.62		
5. Pellet handling (3 units)	NI	-	AAF Rotoclone	NI		
6. Building exhaust	17.5	328	Am. Std. Multiclone	14.87		
Total	222.3			97.64		
Pelletization:					71 (pellets)	1384

(a) Information supplied by Bethlehem on September 24, 1975.
(b) This collector is a combination Am. Std. multiclone followed by four Buell large-diameter cyclones.
(c) This collector is a combination Research Cottrell multiclone followed by two Ducon large-diameter cyclones.
Note: NI is no information or insufficient data supplied.

TABLE C-14a. IRON ORE PLANT EMISSION DATA

(Bethlehem Steel Corporation - Maremec Mine)

Source of Emissions	Point Source Characteristics: Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions, lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Fine Crushing	NI	--	Baghouse	NI		
Ore Transfer	NI	--	Baghouse	NI		
Bentonite Facilities	NI	--	Baghouse	NI		
Super Magnetite Circuit	NI	--	Baghouse	NI		
Pellet Plant (Five Shaft Furnaces)						
1. Top Gas (5 units)	5 x 35,800	400	Multiclone	5 x 295[a]		
2. Bottom Gas (5 units)	5 x 22,200	590	Dry Cyclones	5 x 28.1[b]		
3. Pellet Handling	NI	--	NI	NI		
4. Pellet Discharge	25,000	--	NI			
5. Screen House	8,600	--	Rotoclone	NI		
Total Pelletization:	323,000			1615.5	229	7.1

(a) Based on information supplied by Bethlehem for furnace No. 1.
(b) Based on information supplied by Bethlehem for cooler No. 2.

TABLE C-14b. IRON ORE PLANT EMISSION DATA

(Bethlehem Steel Corporation - Maremec Mine)

Source of Emissions	Point Source Characteristics: Gas Flow, Std m3/s	Temp, F	Collector Used	Particulate Emissions, g/s	Production Rate kg/s	Emission Factor, g/Mg
Fine Crushing	NI	-	Baghouse	NI		
Ore Transfer	NI	-	Baghouse	NI		
Bentonite Facilities	NI	-	Baghouse	NI		
Pellet Plant (Five Shaft Furnaces)						
1. Top gas (5 units)	5 x 16.9	478	Multicyclone	5 x 37.17[a]		
2. Bottom gas (5 units)	5 x 10.5	583	Dry Cyclones	5 x 3.54[b]		
3. Pellet handling	NI	-	NI	NI		
4. Plant dust	NI	-	NI	NI		
Total Pelletization:	136.9			203.55	65	3170

(a) Based on information supplied by Bethlehem for Furnace No. 1.
(b) Based on information supplied by Bethlehem for Cooler No. 2.

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TABLE C-15a. IRON ORE PLANT EMISSION DATA

(Kaiser Steel Corporation - Eagle Mountain Mine)

Source of Emissions	Point Source Characteristics(a) Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions(a), lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Primary Crusher	19,000		Tubulaire Scrubber	NI	1009 (ore)	
Fine Crusher						
1. Crushers, Bins, & Conveyors (3 units)	104,000		Ducon Scrubber	NI		
Bentonite Facilities						
1. Silo	5,000		Baghouse	NI		
2. Pekay Mixers	NI		Sly Baghouse	NI		
Pellet Plant (One Dravo-Lurgi Straight Grate System)						
1. Windbox Exhaust	180,000	350	FAA Multiclone	340.6		
2. Hood Exhaust	236,000	NI	"None"	341.0		
3. Bleed-Off	50,000	NI	"None"	55.2		
4. Grate Discharge	60,000	200	Ducon Scrubber	NI		
5. Hearth Layer	11,500	100	Ducon Scrubber	NI		
6. Product Screen	56,500	150	Ducon Scrubber	NI		
Total Pelletization:	599,000			736.8	360 (pellets)	2.05

(a) Information supplied by Kaiser Steel, on August 6 and September 8, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-15b. IRON ORE PLANT EMISSION DATA

(Kaiser Steel Corporation - Eagle Mountain Mine)

Source of Emissions	Point Source Characteristics(a) Gas Flow, Std m3/s	Temp, F	Collector Used	Particulate Emissions(a), g/s	Production Rate, kg/s	Emission Factor, g/Mg
Primary Crusher	9.0		Tubulaire Scrubber	NI	285 (ore)	
Fine Crusher						
1. Crushers, Bins, & Conveyors (3 units)	49.5		Ducon Scrubber	NI		
Bentonite Facitilies						
1. Silo	2.4		Baghouse	NI		
2. Pekay Mixers	NI		Sly Baghouse	NI		
Pellet Plant (One Dravo-Lurgi Straight-Grate System)						
1. Windbox exhaust	85.0	450	FAA Multiclone	42.92		
2. Hood exhaust	111.4	NI	None	42.97		
3. Bleed-off	23.6	NI	None	6.96		
4. Grate discharge	28.3	367	Ducon Scrubber	NI		
5. Hearth layer	5.4	311	Ducon Scrubber	NI		
6. Product screen	26.7	339	Ducon Scrubber	NI		
Total Pelletization:	282.7			92.84	102 (pellets)	915

(a) Information supplied by Kaiser Steel, on August 6 and September 8, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-16a. IRON ORE PLANT EMISSION DATA

(U.S. Steel Corporation - Atlantic City, Wyoming)

Source of Emissions	Point Source Characteristics(a): Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions,(a) lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Coarse Crushing						
1. Upper Cavity	60,000		Venturi	NI		
2. Pan Feeder	17,000		Venturi	NI		
Fine Crushing						
1. Screen House (2 units)	2 x 26,000		AAF Rotoclone	NI		
2. Transfer Point	8,000		AAF Rotoclone	NI		
3. Secondary (2 units)	2 x 5,000		AAF Rotoclone	2 x 1.0		
4. Tertiary (2 units)	2 x 5,000		AAF Rotoclone	2 x 0.9		
5. Feed Bins	6,000		AAF Rotoclone	NI		
Concentrator						
1. Tripper Transfer	4,000		Venturi	NI		
2. Silo Fans (2 units)	2 x 15,000		"None"	NI		
3. Rod Mill Feeders (3 units)	3 x 8,000		AAF Rotoclone	NI	(ore)	
Total Beneficiation:	221,000			NI	578.8	
Bentonite Facilities						
1. Silo	2,600		Sly Baghouse	NI		
Pellet Plant (Two McKee Straight Grate Lines)						
1. Windbox Exhaust (2 units)	2 x 95,000	NI	"None"	2 x 208.3		
2. Hood Exhaust (2 units)	2 x 130,000	NI	"None"	2 x 23.6		
3. Grate Feed (2 units)	2 x 33,000		"None"	177.7		
4. Grate Discharge (2 units)	2 x 50,000		AAF Rotoclone	NI		
5. Pellet Loadout	9,000		AAF Rotoclone	NI	(pellets)	
Total Pelletization:	627,600			641.5	217.5	2.95

(a) Information supplied by U.S. Steel, November 13, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-16b. IRON ORE PLANT EMISSION DATA

(U.S. Steel Corporation - Atlantic City, Wyoming)

Source of Emissions	Point Source Characteristics[a] Gas Flow, Std m3/s	Temp, F	Collector Used	Particulate Emissions,[a] g/s	Production Rate kg/s	Emission Factor, g/Mg
Coarse Crushing						
1. Upper cavity	34.5		Venturi	NI		
2. Pan feeder	8.5		Venturi	NI		
Fine Crushing						
1. Screen house (2 units)	2 x 12.3		AAF Rotoclone	NI		
2. Transfer point	3.8		AAF Rotoclone	NI		
3. Secondary (2 units)	2 x 2.4		AAF Rotoclone	2 x 0.03		
4. Tertiary (2 units)	2 x 2.4		AAF Rotoclone	2 x 0.02		
5. Feed bins	2.8			NI		
Concentrator						
1. Tripper transfer	1.9		Venturi	NI		
2. Silo fan (2 units)	2 x 7.1		None	NI		
3. Rod mill feeders (3 units)	3 x 3.8		AAF Rotoclone	NI	(ore)	
Total Beneficiation:	110.9			NI	163	
Bentonite Facilities						
1. Silo	1.2		Sly Baghouse	NI		
Pellet Plant (Two McKee Straight Grate Lines)						
1. Windbox exhaust (2 units)	2 x 44.8	NI	None	2 x 5.42		
2. Hood exhaust (2 units)	2 x 51.4	NI	None	2 x 0.61		
3. Grate feed (2 units)	2 x 15.6		None	4.62		
4. Grate discharge (2 units)	2 x 23.6		AAF Rotoclone	NI		
5. Pellet loadout	4.3		AAF Rotoclone	NI	(pellets)	
Total Pelletization:	296.2			16.68	61	1317

(a) Information supplied by U.S. Steel, November 13, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-17a. IRON ORE PLANT EMISSION DATA

(U. S. Steel - Minntac Plant)

Source of Emissions	Point Source Characteristics[(a)] Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions,[(a)] lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Primary Crushing						
1. Dry Collectors (2 units)	130,000		Baghouse	12.8		
2. Wet Collectors (3 units)	25,000		National Scrubber	3 x 0.4		
Fine Crushing						
1. Step I, Sec. and Ter. (14 units)	267,200		National Scrubber	14 x 0.2		
2. Step II, Secondary (7 units)	146,000		National Scrubber	7 x 0.2		
3. Step II, Tertiary (11 units)	209,700		National Scrubber	11 x 0.2		
Concentrator						
1. Rod Mill Feeders (8 units)	190,800		National Scrubber	8 x 0.1		
Total Beneficiation:	968,700			21.2	4672 (ore)	0.005
Bentonite Facilities						
1. Mixers (4 units)	4 x 10,000		Baghouse	4 x 0.1		
2. Day Bins (4 units)	7,400		Baghouse	4 x 0.1		
Pellet Plant (Five Grate-Kiln Lines)						
1. Waste Gas, Step I (3 units)	3 x 322,000		Drop-out Boxes	3 x 932	948	2.9
2. Waste Gas, Step II (2 units)	2 x 591,000		Multiclone	2 x 993	870	2.3
3. Cooler Exhaust (5 units)	NI		NI	NI	(pellets)	
4. Grate Feed, Step I (3 units)	3 x 15,000		Ducon	3 x 0.4		
5. Grate Feed, Step II (2 units)	2 x 14,000		Sly	2 x 0.4		
6. Grate Discharge, Step I (3 units)	3 x 15,000		Ducon	3 x 0.4		
7. Grate Discharge, Step II (2 units)	2 x 14,000		Sly	2 x 0.4		
8. Cooler Discharge, Step I (6 units)	6 x 15,000		Ducon	6 x 2.9		
9. Cooler Discharge, Step II (2 units)	2 x 28,000		Sly	2 x 2.9		
Total Pellet Plant:	2,440,000			4810.0	1818 (pellets)	2.6

(a) Information supplied by U.S. Steel, November 13, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-17b. IRON ORE PLANT EMISSION DATA

(U. S. Steel - Minntac Plant)

Source of Emissions	Point Source Characteristics[a] Gas Flow, Std m3/s	Temp, F	Collector Used	Particulate Emissions,[a] g/s	Production Rate kg/s	Emission Factor, g/Mg
Primary Crushing						
1. Dry Collectors (2 units)	61.4		Baghouse	1.61		
2. Wet Collectors (3 units)	11.8		Natl Scrubber	3 x 0.05		
Fine Crushing						
1. Step I, Sec. & Ter. (14 units)	126.1		Natl Scrubber	14 x 0.03		
2. Step II, Secondary (7 units)	68.9		Natl Scrubber	7 x 0.03		
3. Step II, Tertiary (11 units)	99.0		Natl Scrubber	11 x 0.03		
Concentrator						
1. Rod mill feeders (8 units)	90.1		Natl Scrubber	8 x 0.01		
Total Beneficiation:	457.2			2.67	1,319 (ore)	2
Bentonite Facilities						
1. Mixers (4 units)	4 x 4.7		Baghouse	4 x 0.01		
2. Day bins (4 units)	3.5		Baghouse	4 x 0.01		
Pellet Plant (Five Grate-Kiln Lines)						
1. Waste gas Step I (3 units)	3 x 152.0		Drop-out Boxes	3 x 117.43	268	1,295
2. Waste gas, Step II (2 units)	2 x 279.0		Multiclone	2 x 125.12	246 (pellets)	1,027
3. Cooler exhaust (5 units)	NI		NI	NI		
4. Grate feed, Step I (3 units)	3 x 7.1		Ducon	3 x 0.05		
5. Grate feed, Step II (2 units)	2 x 6.6		Sly	2 x 0.05		
6. Grate discharge, Step I (3 units)	3 x 7.1		Ducon	3 x 0.05		
7. Grate discharge, Step II (2 units)	2 x 6.6		Sly	2 x 0.05		
8. Cooler discharge, Step II (6 units)	6 x 7.1		Ducon	6 x 0.37		
9. Cooler discharge, Step I (2 units)	2 x 13.2		Sly	2 x 0.37		
Total Pellet Plant:	1,151.7			606.06	513 (pellets)	1,161

(a) Information supplied by U.S. Steel, November 13, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-18a. IRON ORE PLANT EMISSION DATA

(Inland Steel - Jackson County Iron Company)

Source of Emissions	Point Source Characteristics[a] Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions,[a] lb/hr	Production Rate, tons/hr	Emission Factor, lb/ton
Primary and Secondary Crushing						
1. Scrubber (2 units)	2 x 44,000		Ducon, Type L	NI		
Bentonite Facilities						
1. Day Bins (1 unit)	NI		Baghouse	NI		
Pellet Plant (One Straight Grate Line)						
1. Windbox Exhaust	132,500	350	FAA Multiclone	80		
2. Hood Exhaust	63,200	160	"None"	30		
3. Grate Discharge	36,000	120	Ducon, Type UW-4	NI		
4. Hearth Layer	4,800	100	Ducon, Type UW-4	NI		
5. Product Screen	13,500	100	Ducon, Type UW-4	NI	(pellets)	
Total Pelletization:	250,000			110	125	0.88

(a) Information supplied by Inland Steel on September 8, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-18b. IRON ORE PLANT EMISSION DATA

(Inland Steel - Jackson County Iron Company)

	Point Source Characteristics[a]					
Source of Emissions	Gas Flow, Std m3/s	Temp, K	Collector Used	Particulate Emissions,[a] g/s	Production Rate kg/s	Emission Factor, g/Mg
Primary and Secondary Crushing						
1. Scrubber (2 units)	2 x 20.8		Ducon, Type L	NI		
Bentonite Facilities						
1. Day bins (1 unit)	NI		Baghouse	NI		
Pellet Plant (One Straight-Grate Line)						
1. Windbox exhaust	62.5	450	FAA Multiclone	10.08		
2. Hood exhaust	29.8	344	None	3.78		
3. Grate discharge	17.0	322	Ducon, Type UN-4	NI		
4. Hearth layer	2.3	311	Ducon, Type UN-4	NI		
5. Product screen	6.4	311	Ducon, Type UN-4	NI	(pellets)	
Total Pelletization:	118.0			13.86	35	393

(a) Information supplied by Inland Steel on September 8, 1975.
Note: NI is insufficient data supplied at this time.

TABLE C-19a. IRON ORE PLANT EMISSION DATA

(Pickands Mather Proposed Hibbing Plant)

Source of Emissions	Point Source Characteristics(a) Gas Flow, scfm	Temp, F	Collector Used	Particulate Emissions, lb/hr(a)	Production Rate, tons/hr	Emission Factor, lb/ton
Coarse Crushing						
1. Crusher Discharge	13,500		Baghouse	5.8		
Fine Crushing	"Plant will use wet autogenous mills, therefore, no emissions for fine grinding"					
Concentrator						
1. Mill Feeders (6 units)	6 x 4,000		Wet Scrubber	6 x 1.7		
Total Beneficiation:	37,500			16	2400 (ore)	0.007
Bentonite Facilities						
1. Silo	4,000		Baghouse	0.3		
2. Day Bin System	4,000		Baghouse	0.3		
Pellet Plant (Option I: Two Grate-Kiln Lines)						
1. Waste Gas (2 units)	2 x 330,000	230	Wet Scrubber	2 x 82		
2. Cooler Exhaust (2 units)	2 x 143,000	240	Dry Cyclone	2 x 45		
3. Grate Feed (2 units)	2 x 20,000	150	Wet Scrubber	2 x 8.6		
4. Grate Discharge (2 units)	2 x 20,000	150	Wet Scrubber	2 x 8.6		
5. Cooler Discharge (2 units)	2 x 18,000	150	Wet Scrubber	2 x 7.7		
6. Pellet Transfer (1 unit)	7,000	150	Wet Scrubber	3		
7. Pellet Loadout		150	Baghouse			
Total Option I:	1,077,000			307.4	650 (pellets)	0.47
Pellet Plant (Option II: Two Straight Grate Lines)						
1. Windbox Exhaust (2 units)	2 x 218,000	330	Wet Scrubber	2 x 62		
2. Hood Exhaust (2 units)	2 x 354,000	180	Wet Scrubber	2 x 85		
3. Grate Discharge (2 units)	2 x 65,000	145	Wet Scrubber	2 x 28		
4. Hearth Layer (2 units)	2 x 14,000	145	Wet Scrubber	2 x 6		
5. Transfer Point	5,000	145	Wet Scrubber	2.2		
6. Pellet Loadout		150	Baghouse			
Total Option II:	1,315,000			364.8	650 (pellets)	0.56

(a) Information supplied by Pickands Mather Co. on October 28, 1975.

C-19b - IRON ORE PLANT EMISSION DATA

(Pickands Mather Proposed Hibbing Plant)

Source of Emissions	Point Source Characteristics[a] Gas Flow, Std m3/s	Temp, F	Collector Used	Particulate Emissions, g/s[a]	Production Rate kg/s	Emission Factor, g/Mg
Coarse Crushing	6.4			0.73		
1. Crusher discharge			Baghouse			
Fine Crushing	Plant will use wet autogenous mills; therefore, no emissions for fine grinding.					
Concentrator						
1. Mill feeders (6 units)	6 x 1.9		Wet Scrubber	6 x 0.21		
Total Beneficiation:	17.7			2.02	677 (ore)	3
Bentonite Facilities						
1. Silo	1.9		Baghouse	0.04		
2. Day bin system	1.9		Baghouse	0.04		
Pellet Plant (Option I: Two Grate-Kiln Lines)						
1. Waste gas (2 units)	2 x 155.8	383	Wet Scrubber	2 x 10.33		
2. Cooler exhaust (2 units)	2 x 67.5	389	Dry Cyclone	2 x 5.67		
3. Grate feed (2 units)	2 x 9.4	339	Wet Scrubber	2 x 1.08		
4. Grate discharge (2 units)	2 x 9.4	339	Wet Scrubber	2 x 1.08		
5. Cooler discharge (2 units)	2 x 8.5	339	Wet Scrubber	2 x 0.97		
6. Pellet transfer (1 unit)	3.3	339	Wet Scrubber	0.38		
7. Pellet loadout		339	Baghouse	-		
Total Option I:	508.3			38.73	183 (pellets)	210
Pellet Plant (Option II: Two Straight Grate Lines)						
1. Windbox exhaust (2 units)	2 x 102.9	439	Wet Scrubber	2 x 7.81		
2. Hood exhaust (2 units)	2 x 167.1	356	Wet Scrubber	2 x 10.71		
3. Grate discharge (2 units)	2 x 30.7	336	Wet Scrubber	2 x 3.53		
4. Hearth layer (2 units)	2 x 6.6	336	Wet Scrubber	2 x 0.76		
5. Transfer point	2.4	336	Wet Scrubber	0.28		
6. Pellet loadout		339	Baghouse	-		
Total Option II:	620.7			45.96	183 (pellets)	250

(a) Information supplied by Pickands Mather Co. on October 28, 1975.