CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
1520 West Adams St.
Phoenix, AZ 85007
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

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LAKE SHORE MINE - DIRECT REDUCTION IRON PLANT

DIRECT REDUCTION IRON PLANT

LOCATED IN ARIZONA, U.S.A.

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Spartan International, Inc. is offering for sale the Direct Reduction Iron (DRI) Plant located in Arizona, U.S.A., at the Lakeshore Copper Mine operated by Noranda Lakeshore Mines, Inc. The Noranda DRI Plant has the capacity to produce 250 tons per day (75,000 tons per year) of direct reduced iron.

The Noranda DRI Plant uses the SL/RN process for the production of direct reduced iron; the SL/RN process was developed by LURGI Chemie und Huttentechnik GmbH of Frankfurt, Germany. Primary design of the plant was done by LURGI in close cooperation with the Parsons Jurden Division of Ralph M. Parsons Company. The plant was erected under the supervision of both Parsons and LURGI.

The Noranda DRI Plant complex was built in 1973 and operated for about two years; the plant operated well and with good results. The DRI Plant complex was part of a copper mining operation at the Lakeshore Mine where the

direct reduced iron produced was used to recover copper from acid solutions; this process, also called "Cementation", was used by Hecla Mining Company, the previous owner of the Lakeshore Mine, until 1976 when the copper operations were shut down due to low copper prices. Noranda Lakeshore Mines, Inc., the present owner of the copper mining complex, re-opened the copper operations and decided to eliminate the DRI Plant complex from the copper operations. Noranda now recovers copper from acid solutions using a solvent extraction/electrowinning process.

The Noranda DRI Plant complex was partially disassembled during 1980 to provide space for the construction of the solvent extraction plant. The portion of the plant which was disassembled was properly match-marked and carefully disassembled to permit the erection of the plant at a new site; the disassembled portion of the plant is stored at the Lakeshore Mine. The equipment and buildings of the Noranda DRI Plant complex are complete and in near new condition.

The DRI Plant complex at Noranda Lakeshore Mines, Inc. was designed originally to produce metallic iron pellets which were then used in the copper operations to precipitate

metallic copper from copper containing acid solutions. Raw material for the DRI Plant complex was a red mud leach residue produced from the copper operations; this leach residue was basically an iron oxide (Fe_2O_3). Coal was used in the rotary kiln for the direct reduction of the iron oxide to metallic iron.

At the Noranda DRI Plant complex the mud containing the iron oxide went through the following processes:

1. Drying; in a rotary dryer.
2. Pelletizing; using a pelletizing disc.
3. Induration of the oxide pellets; in a traveling grate.
4. Direct reduction of exide pellets; in a rotary kiln.
5. Cooling of metallized pellets; in a rotary cooler.
6. Magnetic separation of the metallized pellets from the excess coal; using a hammermill and a magnetic drum separator.

The major equipment specifications are:

1. HARDINGE

   Leach residue rotary dryer, 8'8" dia x 55' long, 4.2 rpm, 316 L SS shell, 75 HP motor.

2. DRAVO

   Balling disc, 16'5" dia x 20" deep, mild steel pan,

adjustable 40° to 60° from horizontal, speeds of 6.0, 6.5, 7.0 and 7.5 rpm achieved by sheave change.

3. LURGI

   Traveling grate induration machine, 1 M wide and 28 M long with effective grate area of 28 sq. M and 14 windboxes, 6 updraft and 8 downdraft.

4. KENNEDY VAN SAUN

   Rotary reduction kiln built under specifications of LURGI, 3.14 M inside dia x 50 M long. Kiln shell 11'9-3/4" I.D. x 164'1" long (3.6 M x 50 M). Rotary kiln lined with 9" thick refractory (3.14 M inside diameter), with 6 air tubes and blowers, 7 shell thermocouples, 5 sampling ports, and lubricated positive seals at each end; speed variable from 0.4 to 1.2 rpm main drive and 0.05 rpm on emergency drive, slope 2.5 percent, 220 HP D.C. main drive motor; 15 HP emergency drive motor.

5. Reduction kiln afterburner, 10'11" dia x 36'2½" high burner chamber with combustion air and high pressure cooling water introduced at 2 levels; overall height including emergency stack and cap 104'5".

6. PEABODY ENGINEERING

   Afterburner Venturi Scrubber, inlet cap. 154,440 ACFM at 1,562°F, (850°C), maximum inlet temp

1,742°F (950°C). Pressure drop 23 inches W.G., gpm req. 690.

7. ROBINSON INDUSTRIES

   Afterburner Venturi Scrubber I.D. Fan, size 81" x 13-5/16", 90,000 ACFM at 178°F, 30 inches W.G. SP, 605 BHP, 316 L SS.

8. HARDINGE

   Rotary cooler, horizontal partially submerged, mild steel, 10' dia x 100' long, speed 4.3 rpm main drive and 0.21 rpm on emergency drive.

Colorado Minerals is marketing the Noranda plant in the following two ways:

1. As a Standard DRI Plant, which includes the Reduction Plant and the Plant for cooling and handling the metallized product as shown in the flowsheet, Figure 1, or
2. As a DRI Plant Complex including the Drying, Pelletizing and Indurating Plants shown in the flowsheet, Figure 2, in addition to the plants which make up the Standard DRI Plant.

Figure 3 is a drawing showing the general arrangement of the Noranda DRI Plant Complex; the Noranda DRI Plant is the area enclosed within the red lines. The de-

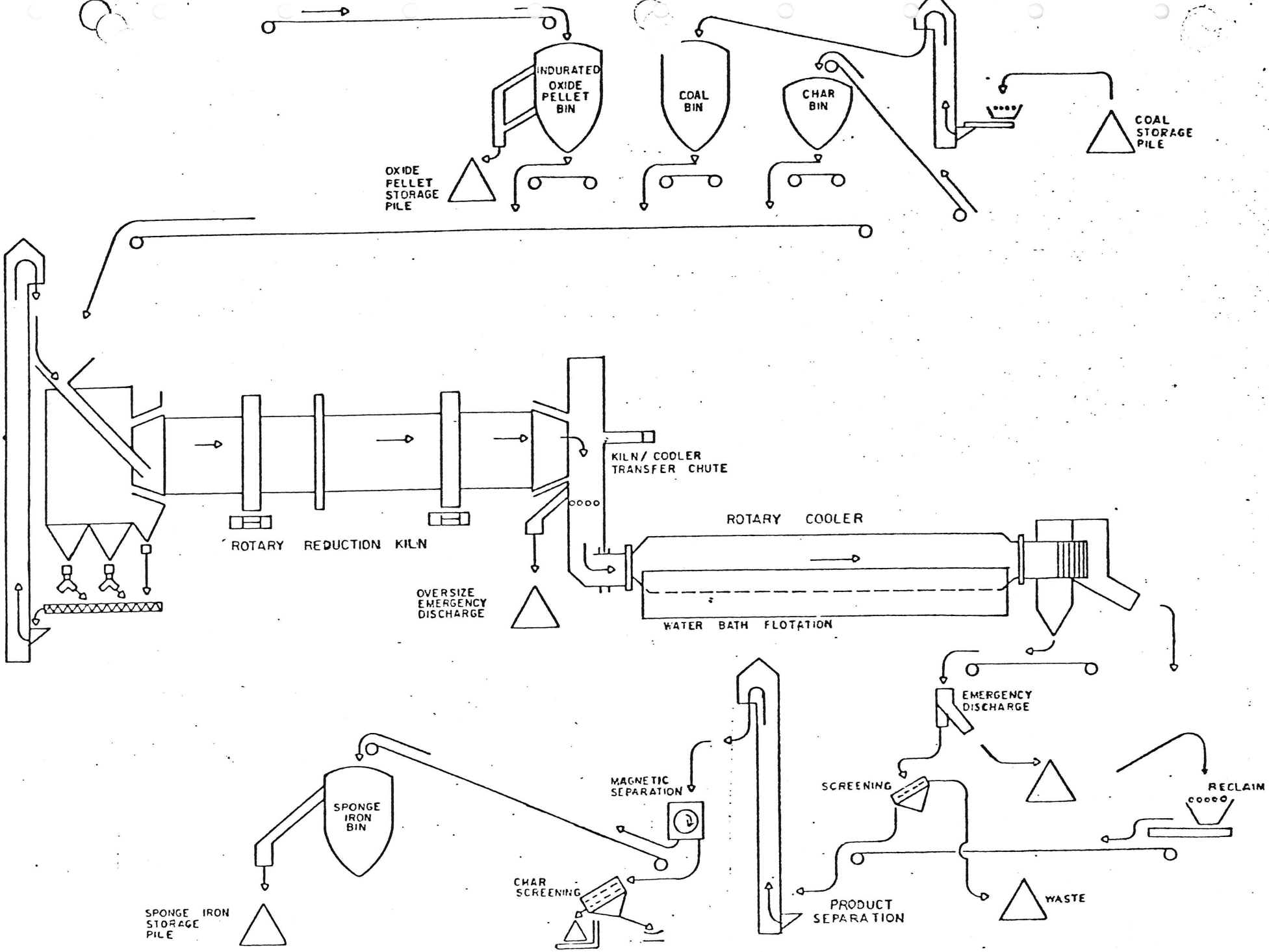


Figure 1. FLOWSHEET OF NORANDA DIRECT REDUCTION IRON PLANT

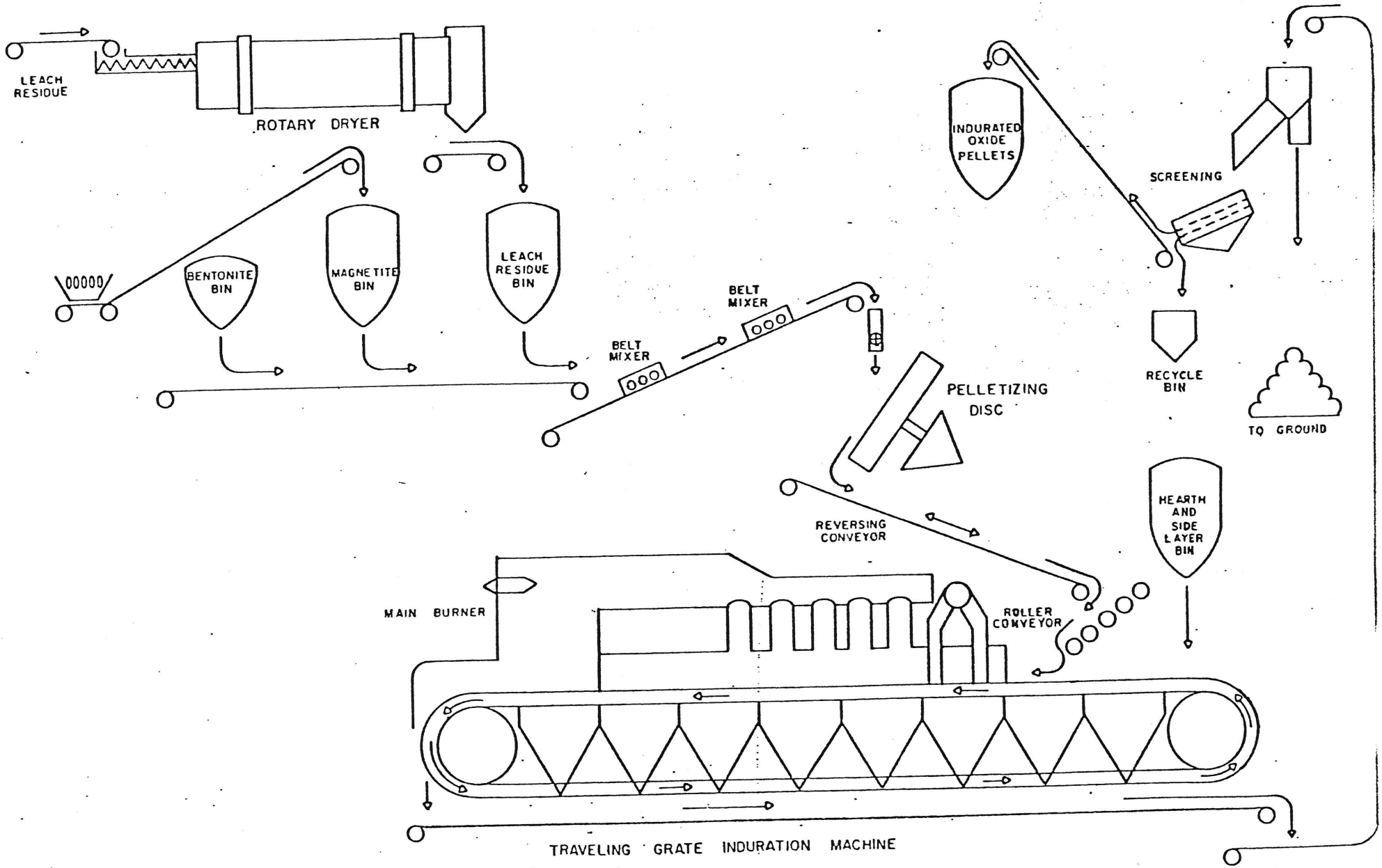


Figure 2. FLOWSHEET OF NORANDA PELLETIZING PLANT

scription of the Noranda plant has been separated into the Noranda DRI Plant and the Noranda DRI Plant Complex.

DESCRIPTION OF THE NORANDA DRI PLANT

A flowsheet of the Noranda DRI Plant is shown in Figure 4. Indurated iron ore pellets are weigh-fed with a predetermined ratio of coal and char---the carbonaceous residue derived from the coal and recycled. Coal is reclaimed from stockpile by front-end loader and the coal bin is filled by means of a hopper, vibrating feeder and bucket elevator system. Variable speed belt feeders in the case of pellets and coal, and a variable speed weight feeder in the case of the char, followed by a weighing conveyor in each case automatically control the feed rate of each constituent. The above materials are conveyed to the rotary kiln feed spout by conveyor belts. The feed tube is pressure compensated by a small auxiliary blower.

The function of the 3.6 M diameter by 50 M long kiln is to heat the magnetite pellets to 950°C to 1050°C in a strongly reducing environment. To accomplish the above the kiln is fitted with an oil burner at the discharge end of the kiln, six heat resistant air inlet tubes spaced along the kiln and extending to its center line, six air fans

with dampers fitted to the air inlet tubes and a lubricated, positive slip seal at each end of the kiln. The central burner is used to preheat the kiln and help control the temperature profile. By controlling the flow of air to each inlet tube, the combustion of coal and consequently the temperature profile along the kiln can be controlled.

The charge movement through the kiln is controlled by varying the rotational speed, normally at 0.5 rpm; the kiln slope is 2.5 percent. Total contact time in the kiln is in the range of 6 hours. Coal volatiles are consumed in the front end of the kiln and preheat the charge. In the first half of the kiln the volatile matter is given off by the coal and partially consumed by air from the air tubes. The residue of carbon and ash remaining from the coal (called char) is burned in a limited and controlled quantity of air to form carbon monoxide gas which reduces the iron in the oxide pellets to metallized iron. The rate at which the reduction takes place is aided by the porous nature of the pellets.

The kiln burner located at the discharge end of the kiln is used for heating up during start-up and for main-

taining a reducing atmosphere at the discharge end for preventing re-oxidation of the reduced pellets.

Hot gases leaving the feed end of the kiln are burned in an afterburner by the addition of fresh air. Draft in the kiln system is automatically controlled by dampers on a 600-HP induced draft blower. The excess waste gases are drawn into a wet scrubber system for particulate removal before being discharged into the atmosphere.

The hot reduced pellets leave the kiln and enter a 10-ft. diameter by 100-ft. long rotary cooler floating in a tank of cooled water. The transfer chute between the kiln and cooler is equipped with four water cooled grizzly bars set at a 35° slope. A unique dump-door system is used to remove chunks too large to enter the cooler throat.

Direct reduced iron pellets, ash and char discharge from the rotary cooler into a holding hopper that serves as an air lock, preventing fresh air from entering the system. The level is automatically controlled by a vibrating feeder varied by a nuclear level gauge.

Cooled direct reduced iron pellets are screened to minus 2 inches before being magnetically separated into a direct

reduced iron product. The non-magnetic portion is screened to separate the minus 1/4 inch plus 16 mesh fraction which is re-used in the kiln to replace some of the coal.

DESCRIPTION OF THE NORANDA DRI PLANT COMPLEX

The purpose of the Noranda DRI Plant Complex was to produce metallic iron to be used to precipitate copper from acid solutions. Production of reduced iron is accomplished in two metallurgical process steps:

1 - Agglomeration; wherein a fine iron oxide by-product is formed into small balls and indurated to produce a high quality iron-oxide pellet.

2 - Reduction; by the SL/RN process wherein the iron oxide pellets are transferred into direct reduced iron pellets.

The Reduction Process portion of the Noranda plant is included in the DRI Plant Complex and has already been described as the Noranda DRI Plant; thus, we will now describe only the Agglomeration Process in the Noranda DRI Plant Complex.

AGGLOMERATION

A flowsheet of the agglomeration plant is shown in Figure 5. Leach residue filter cake (the iron oxide residue

from the roasting and acid leaching of sulfide copper concentrates) is conveyed to a small hopper with screw conveyor which feeds the parallel flow type stainless steel rotary dryer, 8-ft 8-in diameter by 55 ft long, whose function is to reduce the moisture content of the leach residue to 16 to 20 percent. Hot drying gases are diverted from the waste gases from the reduction kiln into the dryer or are generated in an oil-fired burner located at the feed end of the dryer. A metal detector on the conveyor between the dryer and the magnetite bin protects subsequent equipment from plug-up or damage.

Bentonite is received in palletized 50-lb bags. Pellets are hoisted to the working platform at the top of the bin and bags are dumped by hand. The leach residue filter cake bin is designed to produce mass flow. Leach residue is fed and apportioned by means of variable speed belt feeders followed by weighing conveyors. Bentonite is fed and controlled by a variable speed rotary vane feeder followed by a weighing conveyor. The feed rates of leach residue and bentonite are weighed for best balling mixtures.

Raw materials are mixed at two stations by rotary belt mixers and the option is available to add water to the mix just before entering the second mixer. Additional mixing as well as lump breaking and aeration are performed on the mix as it falls through a rotary fluffer to the 16-ft 5-in diameter balling disc. Final moisture adjustment is made by water sprays on the disc.

The conveyor immediately following the disc may be reversed to reject green balls of poor quality or may be run forward to discharge green balls over a spreader roll to the grate roller feeder. Unwanted fines (minus 1/4 in.) fall through the gaps between the rollers and are recycled to the system. The bias of the roller feeder (rollers become progressively shorter across the grate) produces an even distribution of green pellets on the grate machine while feeding at an angle of 90^{o} to the direction of grate movement.

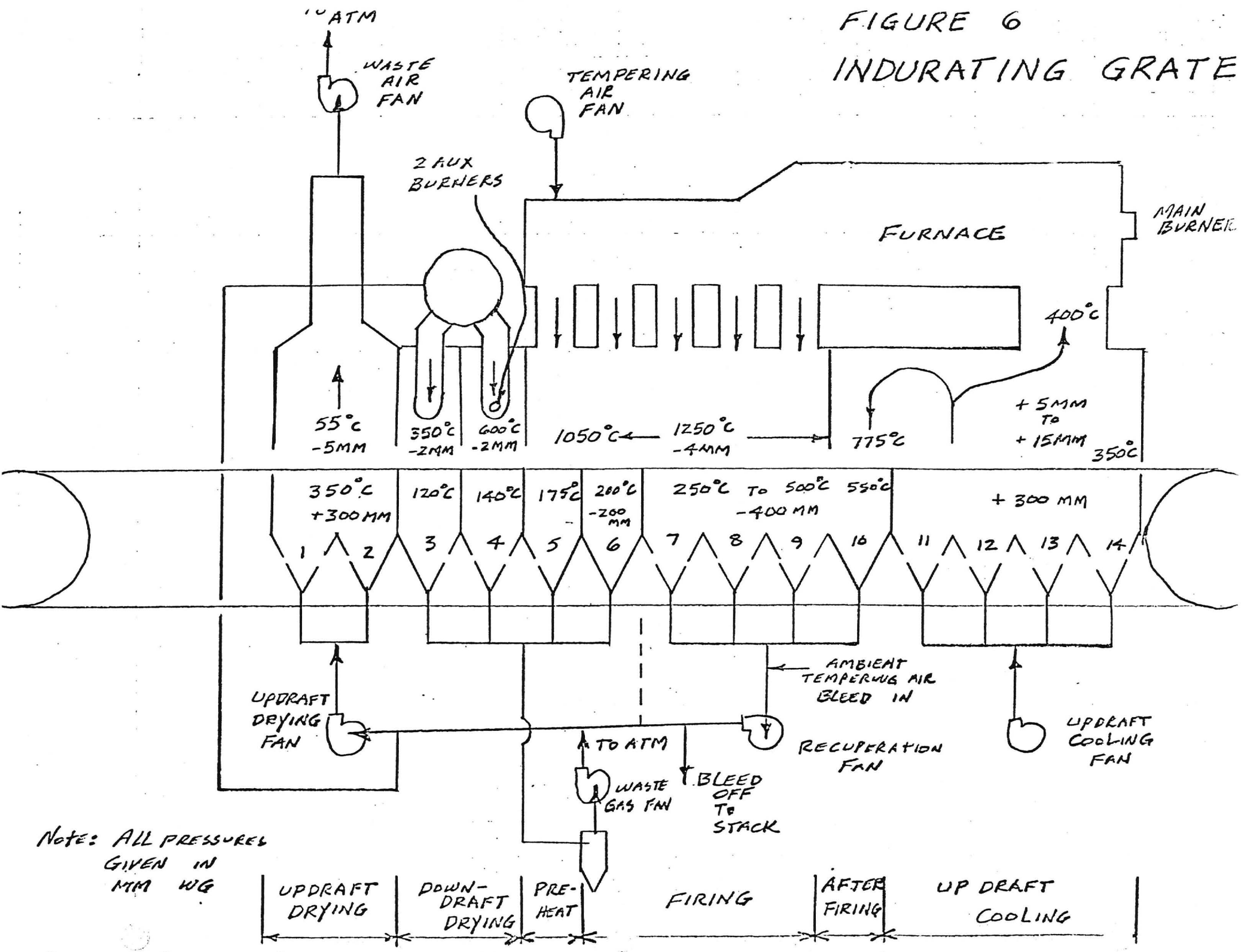
The traveling grate indurating machine is 1 meter wide and 28 meters long. For protection of grate bars and pallets a 10-cm hearth layer of previously indurated pellets is

placed on the grate prior to the 30-cm layer of green balls, and a sidewall layer is fed concurrently with the feeding of the green balls.

The purpose of the moving grate machine is to heat the green balls to a temperature of 1000°C to 1200°C and then cool them to ambient temperature with a minimum consumption of energy -- fuel oil and electric power in this case. Near the temperature of incipient fusion of the constituent materials grain growth takes place among adjacent grains and new compounds are formed by chemical combination of the contained silica, alumina, and iron. Upon cooling, the balls become hard and strong, yet porous, and are able to withstand forces of degradation even at a temperature of 1050°C while undergoing reduction.

Energy is conserved in the LURGI method of indurating iron oxide balls by heat treatment by recycling heat to the process by means of upward and downward flowing gases, Figure 6. As the bed of green balls containing about 22 percent moisture moves over the first two windboxes, it is subjected to an upward flow of hot (350°C) gases recuperated from the firing zone to dry the bed. Drying is completed by

FIGURE 6
INDURATING GRATE



downdraft flow of the same hot recuperated gases at windboxes #3 and #4. Auxiliary oil burners in the downcomers are used to raise the temperature of the gases in the hood over windbox #4 and additional burners can be installed in downcomers over windbox #3 if required in the future; however, the application of heat, and therefore the rate of drying, is limited by the tendency of balls to decrepitate if water vapor is formed too rapidly.

Hot gases from the furnace, tempered to about 1000°C, flow downdraft at windbox #5 to preheat the bed. At windbox #6 through windbox #9, the firing zone, the bed above the hearth is heated by untempered gases from the furnace to 1250°C to 1300°C and is held at this temperature through the afterfiring zone, windbox #10, to allow the indurating mechanisms to proceed. Air to windbox #10 is short-circuited from the updraft cooling air which provides preheated direct recuperated secondary air to the furnace.

Cooled pellets are fed from the grate discharge hopper by a vibrating feeder screen which rejects plus 1-1/2 inch material to a waste pile. As it passes under and traverses the entire length of the indurating machine, the grate pro-

duct belt conveyor receives all windbox dust fed through double dump valves as well as grate drippings. The material from the above conveyor is elevated in internal discharge type bucket elevators to feed a vibrating screen with a 3/4-in. opening top deck and a 1/4-in. opening bottom deck. The plus 3/4-in. fraction and the minus 1/4-in. fraction are diverted to the indurated pellet recycle bin. A variable speed belt feeder delivers the recycle material to a hammermill and the crushed hammermill product is returned to the circuit via raw material belt conveyor #1.

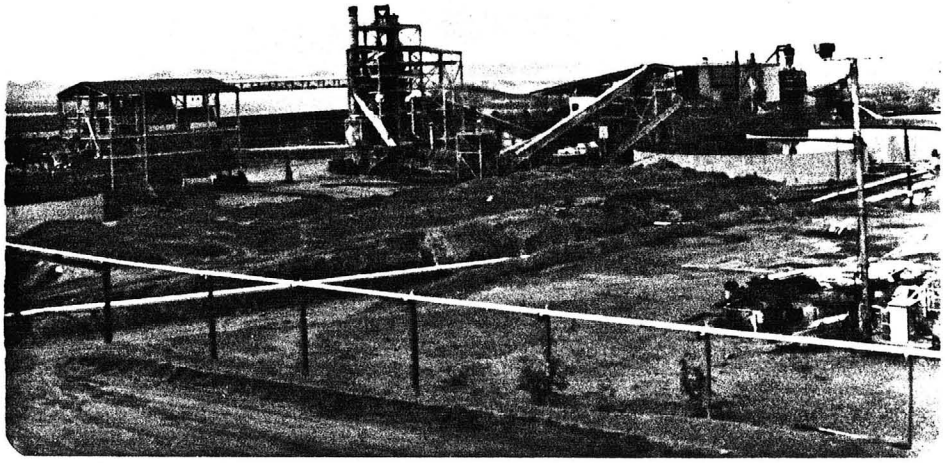
The minus 3/4-in. plus 1/4-in. fraction from the indurated pellet screen is conveyed to a wye or pant-leg chute which splits the product between the hearth layer bin and the indurated pellet bin. Load cells supporting the hearth layer bin sense the need for more or less material and automatically stop, speed up or slow down the hearth layer belt feeder which takes what it needs from the pant-leg splitter while the remainder overflows to the chute leg feeding the indurated pellet product belt conveyor.

EQUIPMENT SPECIFICATION DETAILS

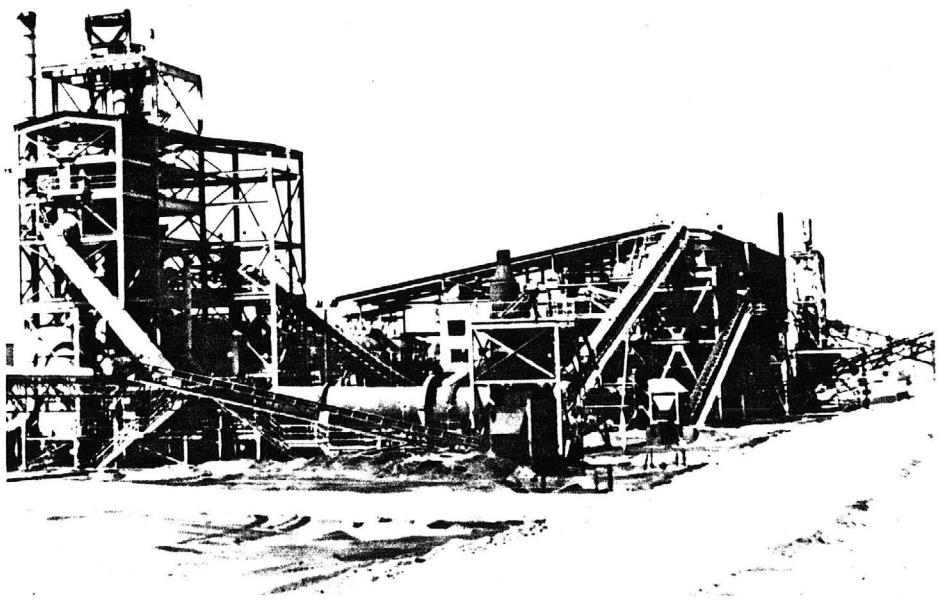
AND

DETAIL TECHNICAL DATA

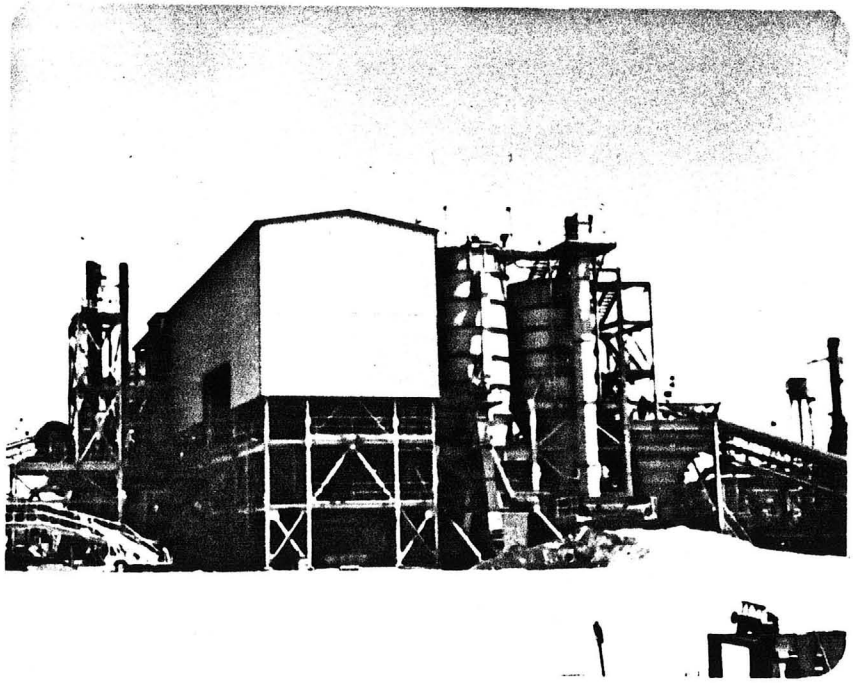
PLANT PHOTOGRAPHS



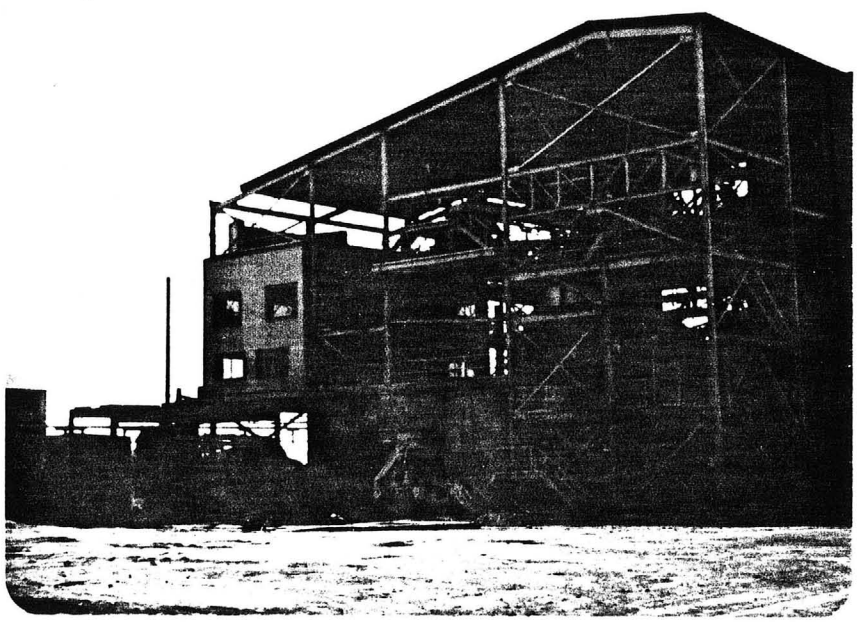
Photograph No. 1: Photo taken prior to partially dismantling the plant. Shows overall view of Noranda DRI Plant Complex. Reduction Rotary Kiln, Rotary Dryer and Afterburner Tower are at the center. The Induration Plant building is in the background on the right.



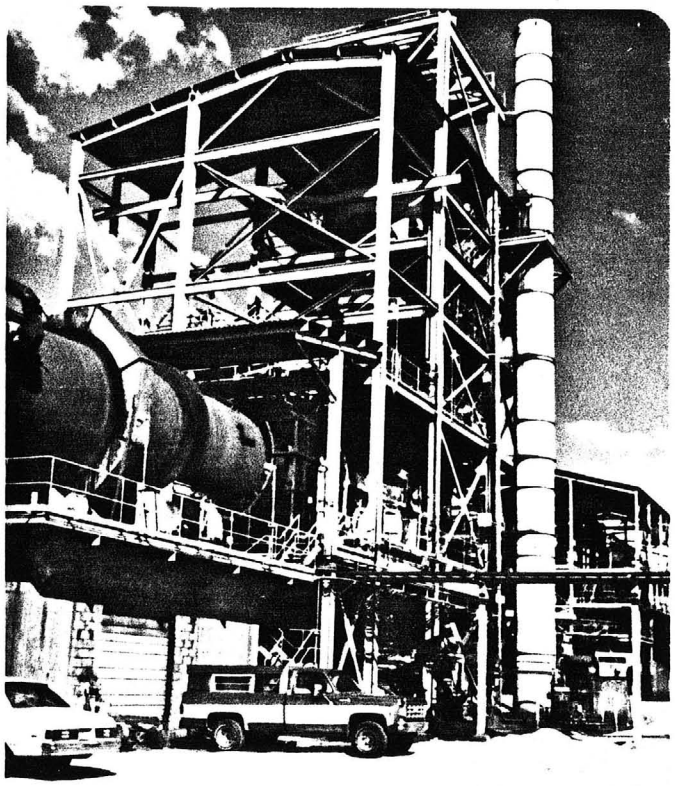
Photograph No. 2: Photo taken prior to partially disassembling the plant. In the foreground is the Rotary Dryer. The Afterburner Tower is shown on the left. The Reduction Rotary Kiln is in the background at the center. Induration Plant building is in the background on the right.



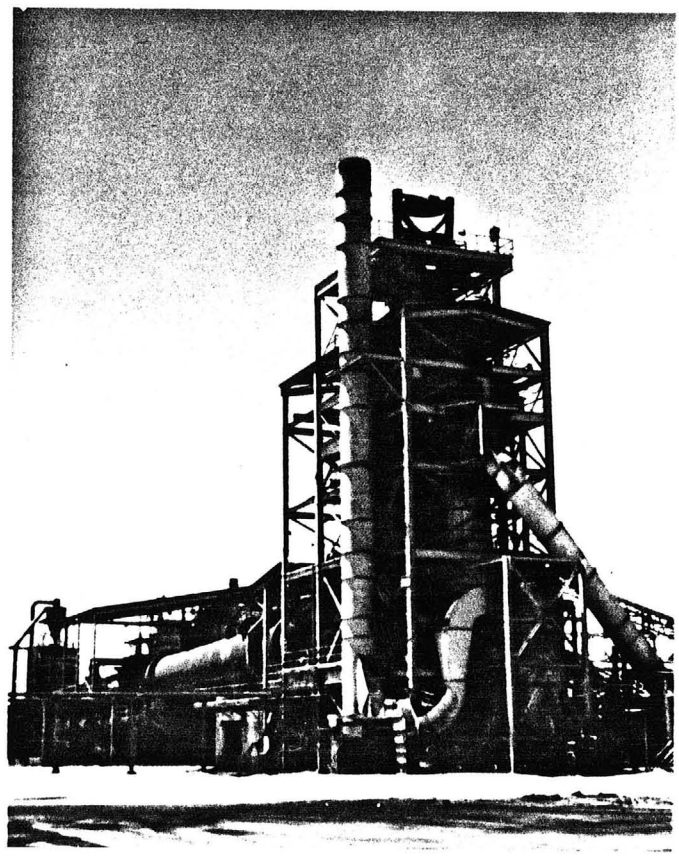
Photograph No. 3: Photo taken prior to partially dismantling the plant. Indurating Plant building at the center. Storage bins and materials handling equipment are on the right. Wet scrubber for dust control is to the left of the Induration Plant building.



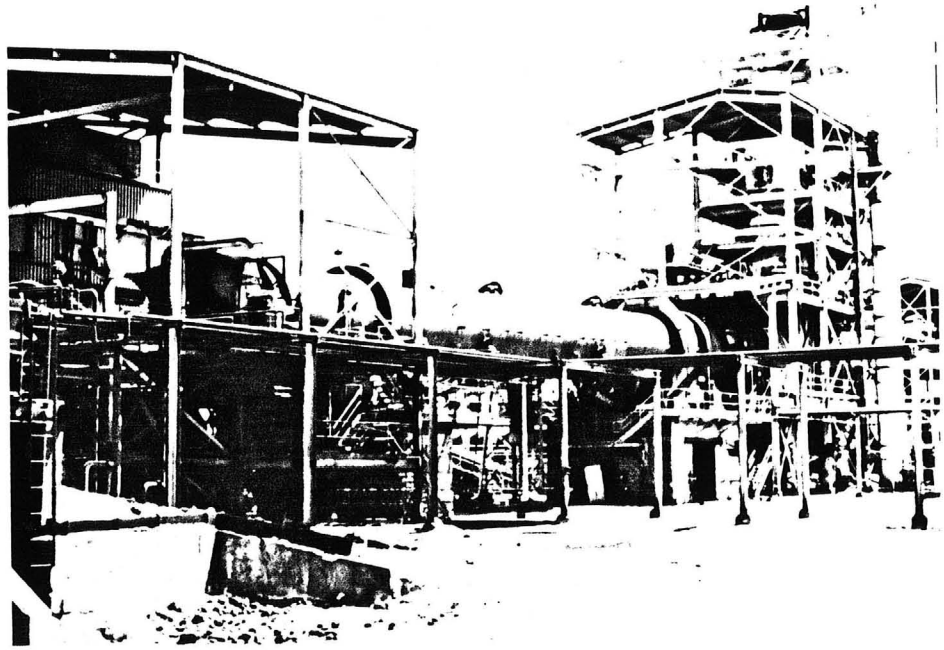
Photograph No. 4: Photo taken after completion of partially dismantling the plant. Indurating Plant building with Plant Office and Control Room shown to the left.



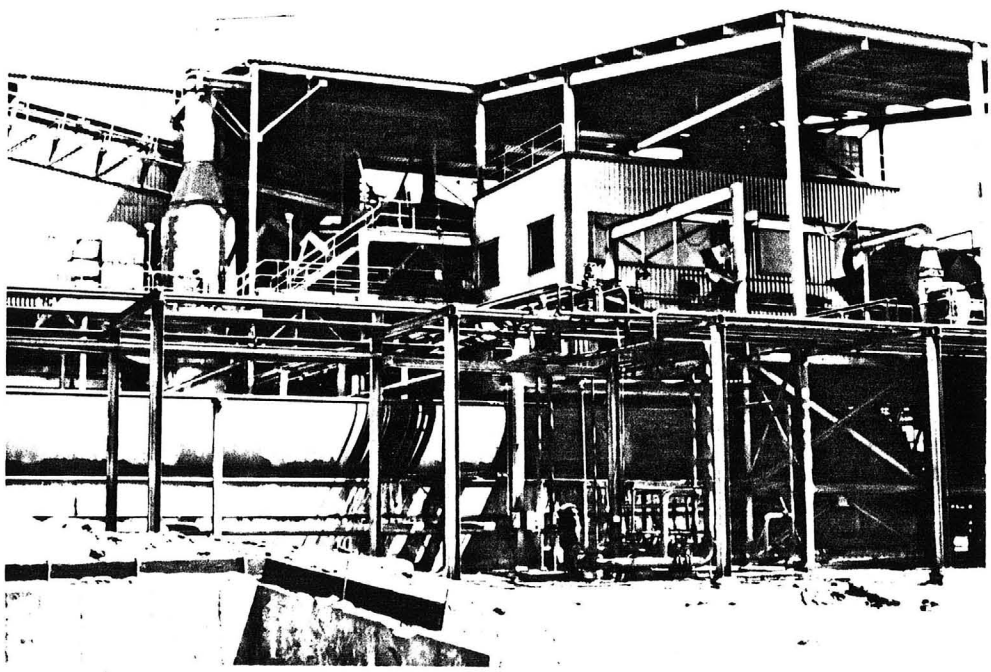
Photograph No. 5: Photo taken prior to partially dismantling the plant. A portion of the Reduction Rotary Kiln is shown on the left. The Afterburner Tower is at the center; the Venturi Scrubber smokestack is shown on the left.



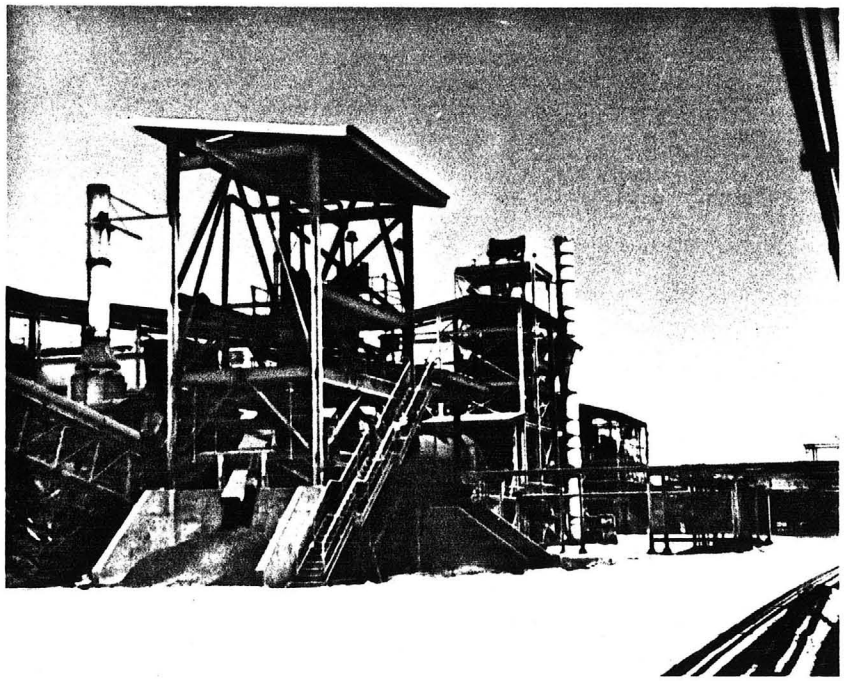
Photograph No. 6: Photo taken prior to partially dismantling the plant. In foreground are the After-burner and the Stack. A portion of the Reduction Rotary Kiln is shown on the left.



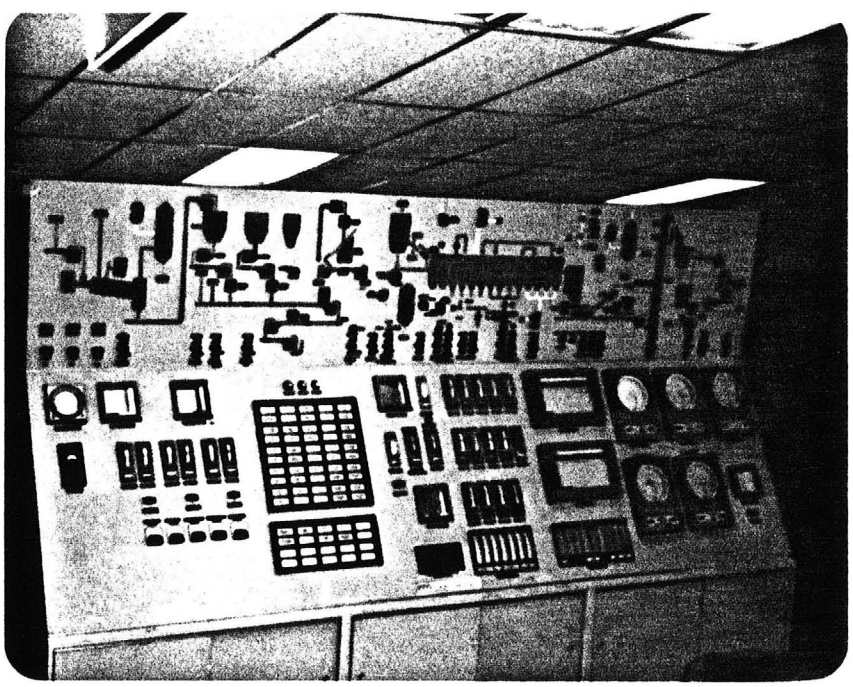
Photograph No. 7: Photo taken prior to partially dismantling the plant. The Reduction Rotary Kiln is at the center. The Control Room is shown to the left of the kiln; the Afterburner Tower is on the right.



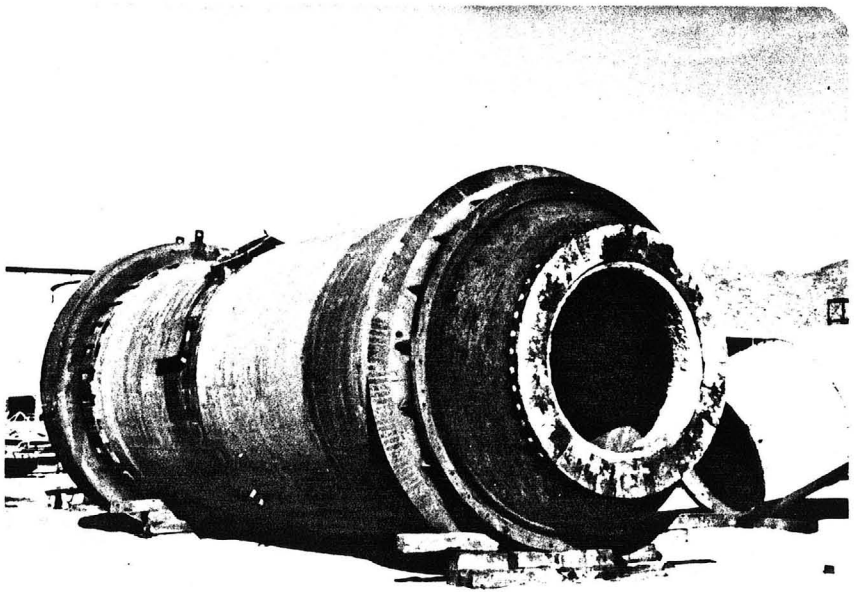
Photograph No. 8: Photo taken prior to partially dismantling the plant. The Rotary Cooler is shown in the foreground. The Office and Control Room and the Indurating Plant building are shown in the background.



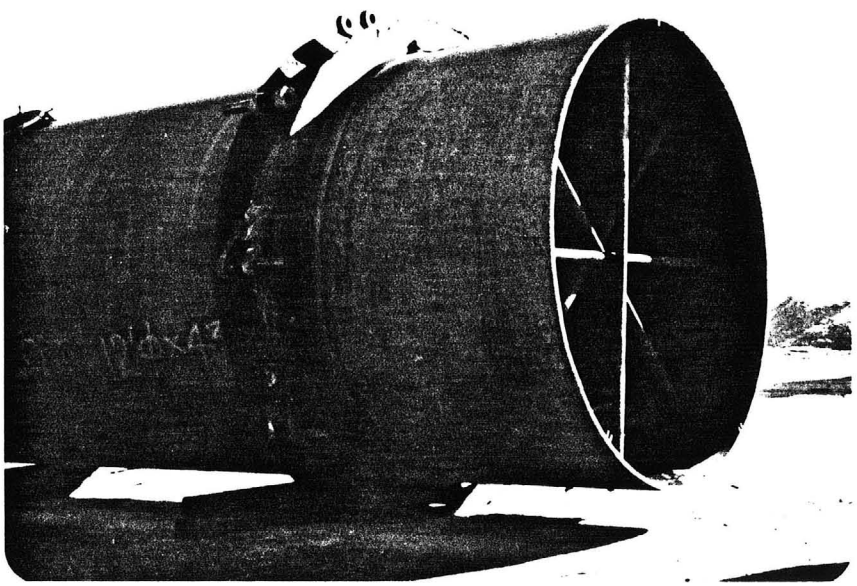
Photograph No. 9: Photo taken prior to partially dismantling the plant. In the foreground is the Plant for handling the cooled DRI pellets. A portion of the Rotary Kiln shows in the background at the center; the After-burner is at the end of the kiln.



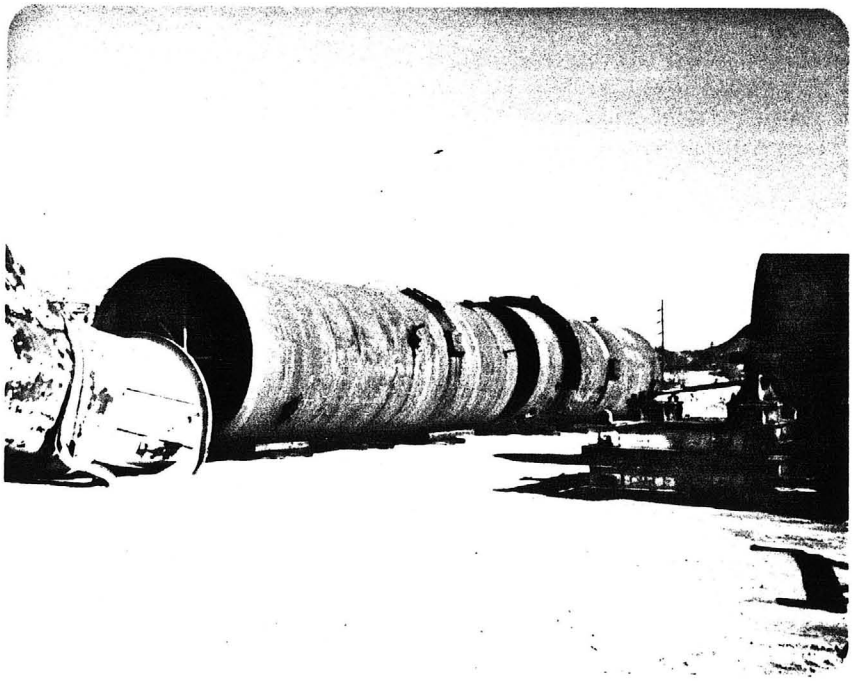
Photograph No. 10: The Instrument Control Panel inside the Control Room.



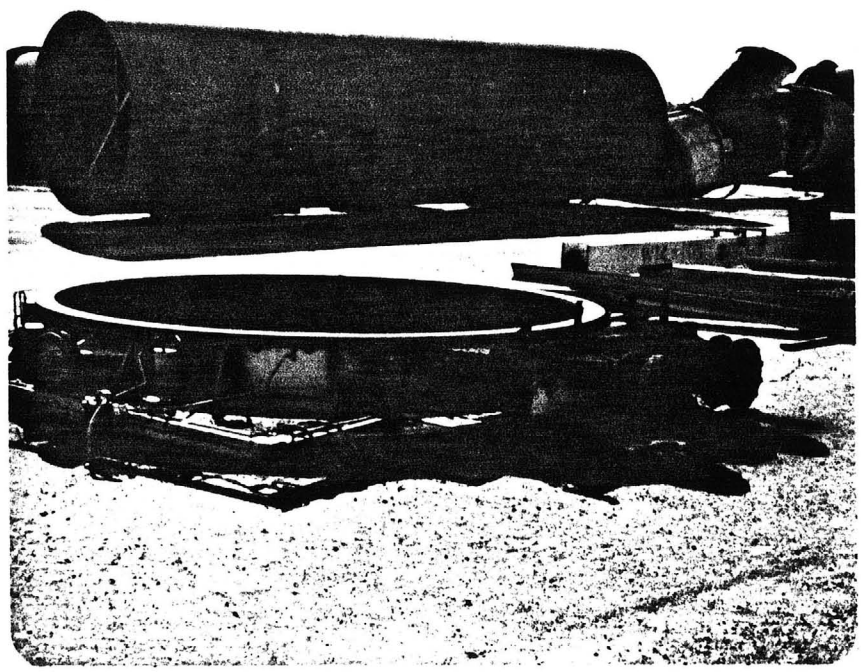
Photograph No. 11: Discharge end section of the Reduction Rotary Kiln.



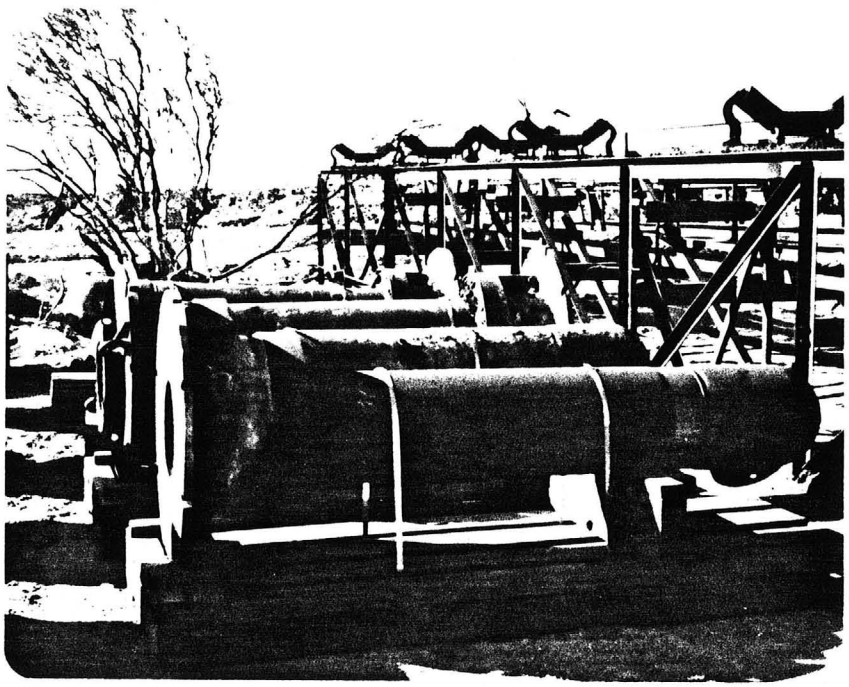
Photograph No. 12: One of two center sections of the Reduction Rotary Kiln.



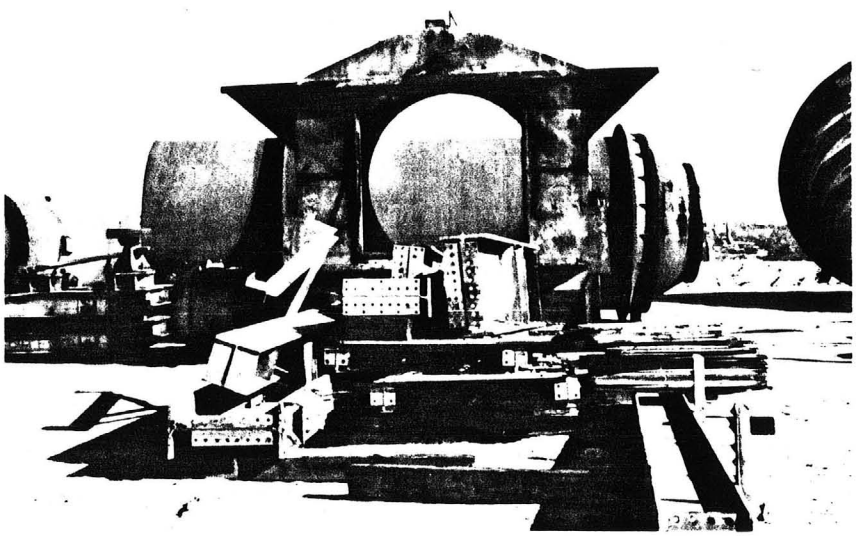
Photograph No. 13: Two center sections of the Rotary Reduction Kiln.



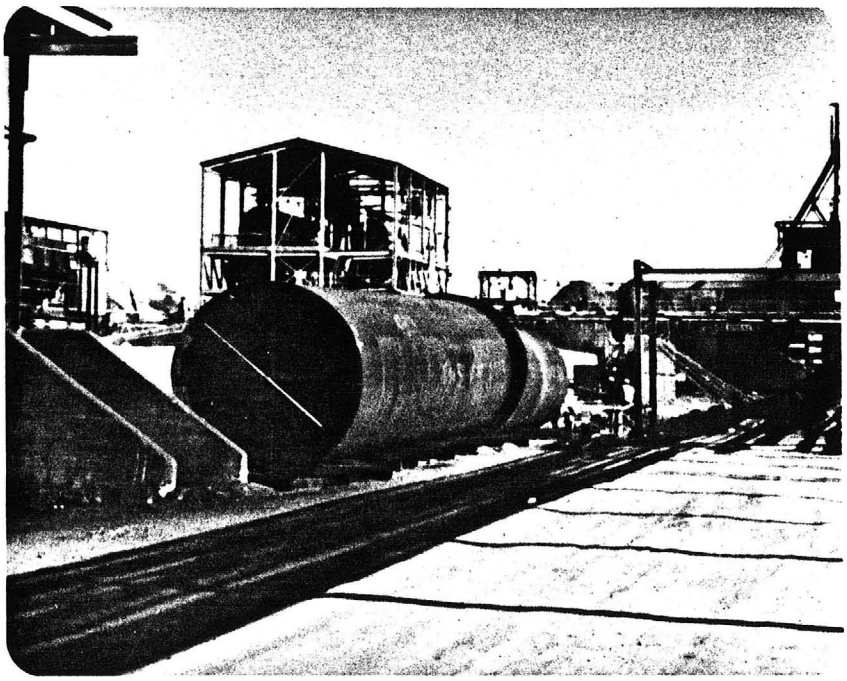
Photograph No. 14: One of the two seals for the Reduction Rotary Kiln is shown at the center.



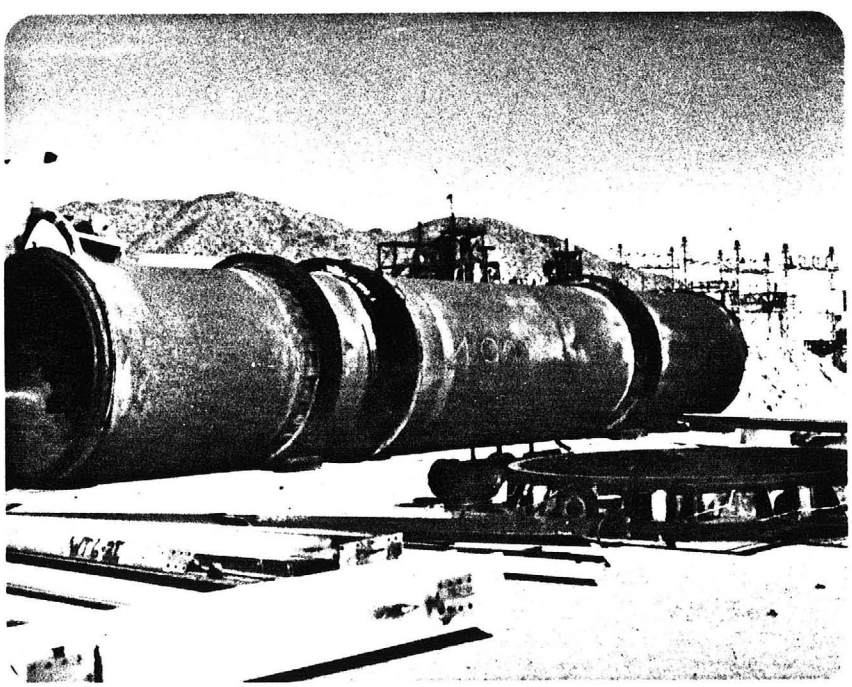
Photograph No. 15: LURGI air injection tubes for the Reduction Rotary Kiln.



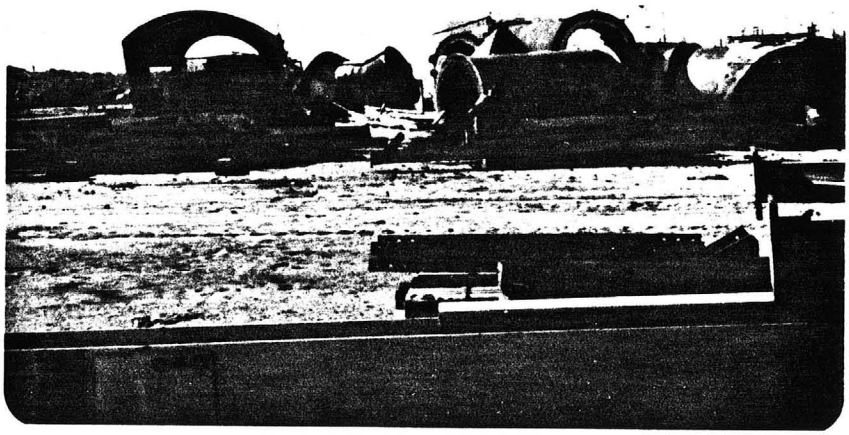
Photograph No. 16: Firing hood for the Reduction Rotary Kiln shown without the doors.



Photograph No. 17: Two sections of the Rotary Cooler.



Photograph No. 18: Stainless Steel Rotary Dryer.



Photograph No. 19: Sections of the Afterburner are shown in the background.

Photograph No. 20: Crated small parts of the partially dismantled plant.

EQUIPMENT SPECIFICATION DETAILS

AND

DETAIL TECHNICAL DATA

EQUIPMENT SPECIFICATIONS

MAJOR EQUIPMENT SPECIFICATIONS

TAG NUMBER	EQUIPMENT
610-4901-01	Hardinge leach residue rotary dryer, 8-ft 8-in. dia x 55-ft 0-in. long, 4.2 rpm, 316 L SS shell, 75 HP motor.
610-2803-01	Dravo balling disc, 16-ft 5-in. dia x 20-in. deep, mild steel pan, adjustable 40° to 60° from horizontal, speeds of 6.0, 6.5, 7.0 and 7.5 rpm achieved by sheave change.
610-4902-01	LURGI traveling grate induration machine, 1 M wide and 28 M long with effective grate area of 28 sq M and 14 windboxes, 6 updraft and 8 downdraft.
610-4904-01	Kennedy Van Saun rotary reduction kiln, built under specifications of LURGI, 3.14 M inside dia x 50 M long. Kiln shell 11-ft 9-3/4-in. I.D. x 164-ft 1-in. long (3.6M x 50 M). Rotary kiln lined with 9-in. thick refractory (3.14 M inside diameter). With 6 air tubes and blowers, 7 shell thermocouples, 5 sampling ports, and lubricated positive seals at each end; speed variable from 0.4 to 1.2 rpm main drive and 0.05 rpm on emergency drive, slope 2.5 percent, 220 HP D.C. main drive motor; 15 HP emergency drive motor.
610-4905-01	Reduction kiln afterburner, 10-ft 11-in. dia x 36-ft 2¼-in. high burner chamber with combustion air and high pressure cooling water introduced at 2 levels, overall height including emergency stack and cap 104-ft 5-in.
610-4706-01	Peabody Engineering, afterburner Venturi scrubber, inlet cap. 154,440 ACFM at 1,562°F (850°C), maximum inlet temp. 1,742°F (950°C). Press. drop 23 inches W.G., gpm req. 690.
610-1813-01	Robinson Industries, afterburner Venturi scrubber I.D. Fan, size 81-in.x 13-5/16-in., 90,000 ACFM at 178°F, 30 inches W.G. SP, 605 BHP, 316 L SS.
610-4903-01	Hardinge rotary cooler, horizontal partially submerged, mild steel, 10-ft dia x 100-ft long, speed 4.3 rpm main drive and 0.2 rpm on emergency drive.

Tag 610-1501-01/02	Afterburner Spray Water Pump (2 required)
Specification	SP-1514
Vendor	Sundstrand Fluid Handling 1436 Goodrich Boulevard Los Angeles, California 90022
Service	130 gpm max. (varies between 60 & 130 gpm) afterburner spray water. S. G. = 1.0 Temp. = 120°F max. 1163 ft. TDH @130 gpm 1,220 ft. @60 gpm
Description	Sundyne Pump Model LMV-311 Vertical Centrifugal Pump, C. S. casing, 316 S.S. impeller. Crane mechanical seal 9 AB, 316 S.S., with inducer. 100 HP - 3,600 RPM motor - direct drive through gearbox - 3,550 RPM input, 9,000 RPM output Total weight each: Pump & Gearbox = 760 lb. Motor = 1,580 lb. 2,340 lb.

Tag 610-1502-01	Spare 2 1/2" Sump Pump (1 required)
Specification	SP-1506
Vendor	Galigher Company 440 West Eighth South Salt Lake City, Utah 84110
Service	Originally intended for 62 gpm slurry, 4.4% solids (80% minus 40 microns) neutral pH, S. g. = 1.03, Amb. Temp., 74 ft. TDH
Description	Galigher Model 2.5 SR - 300 x 48" Vertical Centrifugal Sump Pump. Rubber lined and covered, 10 HP, 1,800 RPM motor with V-belt drive No. 2B57-6.4 - 6.4. Belt guard float and float switch furnished Total weight each: 1,035 pounds

Tag 610-1504-01	Char Fines Slurry Pump (1 required)
Specification	SP-1507
Vendor	Galigher Company 440 West Eighth Sough Salt Lake City, Utah 84110
Service	46 gpm Char Fines Slurry, 5 percent and solids, neutral pH, Amb. Temp., S.G. = 1.03, 38 ft. TDH
Description	Galigher Model 1 1/2" X 2" - 1.5 VRC 100 horizontal centrifugal pump, rubber lined and covered, semi-open impeller. 5 hp 1,800 RPM motor. T.B. Woods 2A drives. Drive sheave 5.6; driven sheave 7.0; speed ratio 1.25. Belt guard furnished Total weight each: 330 pounds pump only 495 pounds entire assembly

Tag 610-1505-01	Grate Discharge Dust Scrubber Pump (1 required)
Specification	SP-1515
Vendor	Barrett - Haentjens & Co. P.O. Box 15147 Phoenix, Arizona 85018
Service	160 GPM Grate Discharge Dust Scrubber Underflow, 3% solids (80% minus 40 micron), acidic, S.G. = 1.05, temp. AMB., 157 feet TDH.
Description	Barrett-Haentjens Hazleton 2 1/2" FN type VN Vertical Centrifugal Pump, Alloy and stainless steel. 20 hp - 1800 RPM motor, with guard float and float switch furnished.

Tag 610-1506-01	Waste Gas Scrubber Pump (1 required)
Specification	SP-1515
Vendor	Galigher Company 440 West Eighth South Salt Lake City, Utah 84110
Service	120 gpm Waste Gas Scrubber underflow, 0.6% solids (80% minus .5 mm) acidic solution, S.G. = 1.003 Temp. Amb. 95 ft. TDH
Description	Galigher Model 3.5 SR 2100 x 48" Vertical Centrifugal Sump Pump, rubber lined and covered. 25 HP - 1,800 RPM motor with V-belt drive No. 4B-6.0/7.4 - 9.4. Belt guard float and float switch furnished Total weight each: 1,275 pounds

Tag 610-1507-01	Product Separation Area Scrubber Pump (1 required)
Specification	SP-1506
Vendor	Galigher Company 440 West Eight South Salt Lake City, Utah 84110
Service	62 gpm dust scrubber underflow, 4.4% solids (80% minus 40 microns) neutral Ph, SG = 1.03, ambient temperature, 111 feet TDH
Description	Galigher model 3.5SR2100 x 48" vertical centrifugal sump pump, 55F natural rubber-lined and covered. 30 hp, 1800 rpm motor with "V" belt drive 4B71-8.6-11.0. Belt guard, float and float switch furnished Total weight each: 1,275 pounds less motor

Tag 610-1509-01/02	Afterburner Venturi Scrubber Pump (2 required)
Specification	SP-1515
Vendor	Barrett-Haentjens and Company P. O. Box 15147 Phoenix, Arizona 85018
Service	700 GPM Afterburner Gas Venturi Scrubber, underflow, 0.5% solids (80% minus 0.5 mm) pH = 2.5, S.G. = 1.003, Temp. Amb. 111 ft. TDH
Description	Barrett-Haentjens Hazleton 5" N type VN Vertical Centrifugal Pump, alloy and stainless steel. 30 HP 1,800 RPM motor, direct drive. Guard, float and float switch furnished

Tag 610-1510-01	Dryer Scrubber Pump (1 required)
Specification	SP-1515
Vendor	Galigher Company 440 West Eighth South Salt Lake City, Utah 84110
Service	51 gpm Dryer Scrubber, underflow 5.8% solids (80% minus 40 micron) acidic solution, S.G. = 1.03, Temp. Amb.
Description	Galigher Model 3.5 SR-2100 X 48" Vertical Centrifugal Sump Pump, rubber lined and covered. 20 HP - 1,800 RPM motor with V-belt drive No. 4B - 4.0/5.4-7.4. Belt Guard, float and float switch furnished Total weight each: 1,275 pounds

Tag 610-1512-01 & 02	Cooler Water Return Pump (2 required)
Specification	SP-1513-01/02
Vendor	Worthington Sales Company 1060 South Vail Avenue Montebello, California
Service	970 gpm (max) cooling water. S.G. - 1.0 Temp. 130°F max 100 ft. TDH
Description	Model 12-H-110 two-stage vertical turbine pump. C. I. Casing, bronze impeller, bronze stainless steel fitted. 40 HP - 1,800 RPM motor - Direct Drive Total weight each: 650 pounds w/o motor

Tag 610-1516-01/04	Floor Sump Pumps (4 required)
Specification	SP-1506
Vendor	Galigher Company 440 West Eighth South Salt Lake City, Utah 84110
Service	100 gpm floor drainage water, 4% solids, neutral Ph, S.G. = 1.08, ambient temperature, 65 feet TDH
Description	Galigher model 2.5 SR300 x 48" vertical centrifugal sump pump, rubber-lined and covered. 10 hp, 1800 rpm motor with "V"-belt drive No. 2B57-6.4-6.6. Belt guard, float and float switch furnished Total weight each 1,035 pounds

Tag 610-1801-01	Dryer Combustion Air Blower (1 required) (purchased with Tag 610-4901-01)
Specification	SP-4901
Vendor	Koppers/Hardinge/Process Combustion Corporation Robinson Industries
Service	Dryer Combustion air blower
Description	Type AHIE, size 26-1/8" x 7-3/4", SISW, arrangement 4, CW rotation, TH discharge, 5600 CFM, 1765 rpm, 10" W.G. SP, 12.75 bph at 70°F, 15 hp, 1800 rpm motor, frame 254T, Robinson Dwg. E-E-48

Tag 610-1801-01	Dryer Combustion Air Blower
Specification	SP - 4901
Vendor	Koppers Company, Inc. P.O. Box 312 York, PA. 17405
Service	Provide combustion air to natural gas fired burner on Leach Residue Dryer
Description	Part of combustion equipment furnished to Kippers by Process Combustion Corp. Blower rated at 5,600 SCFM @ 8" W.C. complete with 10 hp TEFC motor.

Tag 610-1802-01	Dryer Scrubber I.D. Fan (1 required) (Purchased with Tags 610-4701-01/610-4901-01
Specification	SP-4901
Vendor	Koppers/Hardinge/Ducon
Service	Dryer scrubber I.D. fan
Description	See Tag No. 610-4701-01 for description and details

Tag 610-1803-01	Grate Windbox Recoup Fan (1 required) (purchased with Tag. 610-4902-01)
Specification	SP - Lurgi/Dravo
Vendor	Lurgi/Dravo/Sheldons
Service	Grate windbox recoup fan
Description	Type Ph, size 6225, SWSI, Arr. 3, CCW, rotation TH disch. with inlet box. 37,800 SCFM, 83,190 ACFM at 572°F, 20" WG SP 1180 rpm, 380 hp, complete with scroll liners and parti. side plate liners. Turning gear with 7-1/2 hp motor, serial No. 741240-1. Sheldons Dwg. No. C-17351, for lube system see Sheldons Dwg. No. C-17345, for shaft seal blower see Sheldons Dwg. No. B-34742, Tag. No. 610-1823-01

Tag 610-1806-01	Grate Cooling Air Fan (1 required) (purchased with Tag 610-4902-01
Specification	SP - Lurgi/Dravo
Vendor	Lurgi/Dravo/Sheldons
Service	Grate cooling air fan
Description	Type A2211, size 402, SWSI, arrangement No. 1, class 4, CW rotation, 45° TAU discharge, 34,300 SCFM, 37,409 ACFM at 77°F. 18" WG SP, 1770 rpm, 132 bhp with variable inlet vanes. Serial No. 741239-1, Sheldons Dwg. No. C-17326
	Total weight each 2,700 pounds

Tag 610-1807-01	Grate Waste Gas Scrubber I.D. Fan (1 required) (Purchased with Tag 610-4702-01)
Specification	SP-4708
Vendor	Ducon
Service	Grate waste gas scrubber I.D. fan
Description	See Tag No. 610-4702 for description and details

Tag 610-1809-01	Grate Discharge Dust Scrubber I.D. Fan (1 required)
Specification	SP-4708
Vendor	Ducon
Service	Grate Discharge Dust Scrubber I.D. Fan
Description	See Tag No. 610-4707-01 for description and details
Tag 610-1810-01	Kiln Feed Tube Seal Blower (1 required) (Purchased with Tag No. 610-4904-01)
Specification	SP-Lurgi
Vendor	Lurgi/Cincinnati Fan and Ventilator Company
Service	Kiln feed tube seal blower
Description	Type PB, size 8, SWSI, arrangement 4, CCW rotation. DB discharge. 112 ACFM at 70°F, 2 inches WG SP. 3,450 rpm, .22 bhp, 1/3 hp motor, .1-115/230-60 Hertz 3,450 rpm, Cincinnati Dwg. PB4-971-00
Tag 610-1811-01/07	Kiln Air Blower (7required) Purchased with 610-4904-01
Specification	SP-Lurgi
Vendor	Lurgi/PIA Industries
Service	Kiln air blower
Description	Std. Industrial fan, size 11, SWSI, arrangement 4, CCW rotation, TH Discharge, 3,362 ACFM, 15.75" WG SP., 3,500 rpm, 13.4 bhp, type AH wheel with inlet venturi, inlet screen and outlet damper. 20 hp motor, 3,600 rpm TEFC frame 256T. PIA Dwg. P31574 Total Weight Each: 650 lbs. w/motor & damper

Tag 610-1812-01	Kiln Afterburner Air Blower (1 required)
Specification	SP-4705
Vendor	Robinson Industries
Service	Kiln Afterburner Air Blower
Description	Type AHIE, size 36-1/2 x 8-11/16", SWSI, arrangement No. 1, CCW rotation, UB discharge, 10,000 ACFM at 120°F, 20" WG SP , 1,815 rpm, 46 bhp, Woods "V"-belt drive with SVS 112 C4 motor sheave, 10" PD fan sheave, 4-C112 "V"-belts, 40.8" centers. Robinson Dwg. E-H-35
	Total weight each 1,700 pounds

Tag 610-1813-01	Afterburner Venturi Scrubber I.D. Fan (1 required)
Specification	SP-4705
Vendor	Robinson Industries
Service	Afterburner venturi scrubber I.D. fan
Description	Type RBE 1 size 81" x 13-5/16", SWSI, arrangement No. 1, CW rotation, BAU 45° discharge, 90,000 ACFM at 178°F, 30" WG SP, 1,180 rpm, 605 bhp, 316L SS, wheel, 316L SS shaft sleeve, carbon steel casing lined with Caskote SA abrasion resistant 3/16" rubber. Robinson Dwg. No. DA-81RBE-103
	Total weight each 11,970 pounds

Tag 610-1814-01	Kiln Combustion Air Blower (1 required) (Purchased with Tag 610-4904-01)
Specification	SP - Lurgi
Vendor	Lurgi/PIA Industries
Service	Kiln combustion air blower
Description	Industrial fan size 23, arrangement 8, standard duty, SISW, CCW rotation, UB discharge, 7,000 SCFM, 8015 ACFM at 1,770 rpm, 25" WG SP, 47.4 bhp, type AH wheel 50% width, two speed motor, 1800/900 rpm, 50 hp, frame 364T. PIA Industries Dwg. No. 74F0410-1 Total weight each - 2,800 pounds with motor and damper

Tag 610-1815-01	Product Separation Area Scrubber I.D. Fan (1 required) Purchased with 610-4708-01
Specification	SP-4708
Vendor	Ducon
Service	Product separation area scrubber I.D. fan
Description	See tag No. 610-4708-01 for description and details

Tag 610-1816-01	Grate Combustion Air Fan (1 required) (purchased with Tag No. 610-4902-01)
Specification	Sp - Lurgi/Dravo
Vendor	Lurgi Dravo/Buffalo Forge Company
Service	Grate combustion air fan
Description	Size 41, type CB design 2, SISI, CW rotation, DB discharge, arrangement 4, 1,500 SCFM, 1,770 ACFM, 65" WG SP, 3,550 rpm, 32.5 bhp at 120°F, 36.6 bhp at 20°F. 40 hp 3,600 rpm, motor with tapered shaft frame 324T. Buffalo Forge Company Dwg. No. 7W-86300
Total weight each	1,170 pounds plus motor

Tag 610-1817-01	Kiln Outlet Seal Air Blower (1 required) (purchased with Tag No. 610-4904-01)
Specification	Lurgi
Vendor	Lurgi/PIA Industries
Service	Kiln outlet seal air blower
Description	Size 15[illegible]I, SWSI, arrangement 8, CCS rotation, bh discharge, 4,060 ACFM at ambient temperature, 7.87" WG SP, 3,500 rpm, 7.42 bhp, serial No. 74F0408 or 74F0409, PIA Dwg. C120-0004
Total weight each	600 pounds with motor

Tag 610-1819-01	Kiln Inlet Seal Air Blower (1 required) (Purchased with Tag 610-4904-01)
Specification	Lurgi
Vendor	Lurgi/PIA Industries
Service	Kiln inlet seal air blower
Description	Same as Tag No. 610-1817-01
Tag 610-1820-01	Kiln Feed End Scrubber I.D. Fan (1 required) (Purchased with Tag 610-4711-01)
Specification	SP-4708
Vendor	Ducon
Service	Kiln feed end scrubber I.D. fan
Description	See Tag No. 610-4711-01 for description and details Total weight each
Tag 610-1821-01	Grate Tempering Air Fan (1 required) (purchased with Tag 610-4902-01)
Specification	Lurgi/Dravo
Vendor	Lurgi/Dravo/Buffalo Forge Co.

Service	Grate Tempering air fan
Description	Type "E", size 4-1/2, SWSI, arrangement 4, 11-3/4" Ø wheel, cw rotation, TAD 45° discharge, 550 SCFM, 650 ACFM at 120°F, 6" WG SP, 3,550 rpm, 1.19 bph, 1.43 bhp, at 20°F, Buffalo Dwg. 4W-55188
	Total weight each 125 pounds plus motor

Tag 610-1822-01	Grate Hood Seal Fan (1 required) (purchased with Tag 610-4902-01)
Specification	Lurgi/Dravo
Vendor	Lurgi/Dravo/Buffalo Forge Company
Service	Grate hood seal fan
Description	Reversible industrial exhauster, size 35, SWSI, arrangement 4, CCW rotation, UB discharge, 4,220 SCFM, 5,080 ACFM at 120°F, 6.7" WG SP, 1,752 rpm, 9.11 bhp, 11.4 bhp at 20°F Buffalo Dwg. 4W-70096. Total weight each 495 pounds plus motor

Tag 610-1823-01	Grate Fans (1 required) Purchased with 610-4902-01
Specification	Lurgi/Dravo
Vendor	Lurgi/Dravo/Sheldons
Service	Grate fans, bearing seal air blower
Description	Type PH, size 1301B, SWSI, arrangement 4, CW rotation, UB discharge, 150 CFM at ambient temperature, 16" WG SP, 3,500 rpm, .81 bhp. Serial No. 741241-2, Sheldons Dwg. B-34742

Tag 610-1824-01	Kiln Drive Motor Cooling Air Fan (1 required)
Specification	SP-4705
Vendor	Robinson Industries
Service	Kiln drive motor cooling air fan
Description	Type AHIE, size 15-5/8" x 4-5/8" SWSI, Arrangement 9, CCW rotation, bh discharge, 1,383 ACFM at ambient temperature, 3.5" WG SP, 1,993 rpm, 1.22 bhp, Robinson Dwg. E-B-46
	Total weight each 222 pounds

Tag 610-2013-01	Bentonite Rotary Feeder (1 required)
Specification	SP-3401-7
Vendor	Wallace and Tiernan c/o Luzan and Company 23228 Hawthorne Blvd. Torrance, California 90505
Service	Feed weighfeeders 146 normal, 161 maximum, lbs. per hour bentonite, 60 lbs/3 dry bulk density, 5% moisture content by weight, 100% minus 10 microns
Description	8" x 7-5/8" rotary inlet opening. DC drive/SCR control from weighfeeder
	Purchased with bentonite weigh feeder tag No. 610-3403-01

Tag 610-1804-01	Grate Waste Air Fan (1 required) (Purchased with Tag. 610-4902-01)
Specification	SP - Lurgi/Dravo
Vendor	Lurgi/Dravo/Sheldons
Service	Grate waste air fan
Description	Type RB26, size 542, SWSI, arrangement 3, CCW rotation, UB discharge; 35,000 SCFM, 44,903 ACFM at 165°F, 4.0" W.G. S.P., 705 rpm, 52 bhp, 316L S.S., casing with scroll liners, 316L S.S. wheel with wearplates, 316L shaft sleeve. Serial No. 741242-1; Sheldons Dwg. No. C-17327
	Total weight each 5800 pounds

Tag 610-1805-01	Traveling Grate Induration Machine (1 required) (Purchased with Tag. 610-4902-01)
Specification	SP-Lurgi/Dravo
Vendor	Lurgi/Dravo/Sheldons
Service	Grate updraft drying fan
Description	Type PH, size 6012, SWSI, arrangement 3, CW rotation, UB discharge, 90°F horizontal right inlet box. 26,000 SCFM, 54,495 ACFM at 572°F, 17"WG SP, 1180 rpm, 215 bph, w/scroll liners and partial casing sideplate liners. Serial No. 741241-1; Sheldons Dwg. No. C-17344; turning gear with 5 hp motor;for lube system see Sheldons Dwg. C-17345, for shaft seal blower see Sheldons Dwg. B-34742, Tag No. 610-1823-01
	Total weight each 10,800 pounds

Tag 610-2016-01	Indurated Pellet Bucket Elevator (1 required)
Specification	SP-2014
Vendor	FMC Link Belt 12631 East Imperial Highway Box 2246, Santa Fe Springs, Ca. 90670
Service	Convey 25.73 TPH max. of 100% minus 1-1/2", 95% minus 3/4" indurated pellets, 53'-0" centers, vertically. Maximum temperature 300°F, normal temperature 150°F.
Description	FMC model 1310 chain type bucket elevator, 10 - 5" buckets. 5 hp, 1,800 rpm motor with shaft-mounted speed reducer, 21 rpm output. 2A "V"-belts, 5.2 driving sheave, 18 driven sheave, speed 80 fpm. Total weight each 8,100 pounds

Tag 610-2024-01	Coal Bucket Eelvator (1 required)
Specification	SP-2012
Vendor	FMC Link Belt 12631 East Imperial Highway Box 2246, Santa Fe Springs, Ca. 90670
Service	Convey 46.5 TPH maximum of 100% minus 3" coal, occasional slabs up to 5" in length, 62'-0" centers, vertically
Description	FMC model 152 CD belt type bucket elevator. 18" belt, Goodyear Plylon 3150 w/3/16" x 1/16" thick R.C. punched for 89 14 x 16 x 8 style AA buckets every 18". 10 hp, 1,800 rpm motor with shaft-mounted speed reducer, 38 rpm output. 2B "V" belts, 6.4 driving sheave, 12,4 driven sheave. Speed 298 FPM. Total weight each 12,600 pounds

Tag 610-2025-01	Coal Vibrating Feeder (1 required)
Specification	SP-2007
Vendor	FMC Corporation Parts and Material Handling Division 404 El Segundo Blvd. Los Angeles, California 90061
Service	Flow rate: 6.1 min. to 10.0 max. TPH coal from bin and discharged to weigh belt conveyor
Description	Syntron model F440, 30"W x 60"L. Vibrating feeder with RSDC-2 control. Feeder rate is controlled by weigh belt downstream of feeder. 7" deep trough with 1/8" 304 SS liners

Tag 610-2027-01	Indurated Pellet Vibrating Feeder Screen (1 required)
Specification	SP-2016
Vendor	Rexnard c/o Lugon and Company 23228 Hawthorne Blvd., Suite 10 Torrance, California 90505
Service	Feed rate: 13.2 normal, 14.6 max. TPH indurated pellets, 100% minus 3/4" plus 1/4". Screen to remove minus 1/4" broken pellets
Description	Carrier vibrating screening feeder model FS-241205 with 4'-0" load plate and 3'-0" screen section complete with 2 hp motor and SCR control. 12" vertical side height, 24" width, 1/4" screen opening

Tag 610-2032-01	Kiln Backflow Bucket Elevator (1 required)
Specification	SP-2013
Vendor	FMC Link Belt 12631 East Imperial Highway Box 2246, Santa Fe Springs, Ca. 90670
Service	Convey 1.1 STPH normal, 3.5 STPH max. reduction kiln backflow material 49'-0" vertically.
Description	Link Belt model 767 continuous elevator-chain type. 125 fpm belt speed. Gravity takeup. 156 8 x 5 x 12 ga. stl. buckets. 3 hp, 1,800 rpm motor with shaft-mounted speed reducer, 20-1/2 rpm output. 2A "V"-belts, 4.2 driving sheave, 15.3 driven sheave. Speed 125 fpm. Total weight each 8,300 pounds

Tag 610-2033-01	Kiln Backflow Screw Conveyor No. 2 (1 required)
Specification	SP-2011
Vendor	Pacific Conveyor Company 13162 Grant Avenue Downey, California 90242
Service	1.6 max. tons per hour reduction kiln dust, char, pellets, and coal. Max. temperature 200°C
Description	Screw conveyor - 18" diameter screw 1/4" thick, 17'-0" long, inclined 24°-30'. 1,750 rpm, 5 hp motor, with B-60 "V"-belt drive 4.6/9.4 and Dorris reducer. Screw = 34 rpm. Carbon steel construction Total weight each 1,500 pounds

Tag 610-2034-01	Kiln Dust Screw Conveyor No. 1 (1 required)
Specification	SP-2011
Vendor	Pacific Conveyor Company 13162 Grant Avenue Downey, California 90242
Service	0.29 max tons per hour, reduction kiln dust.. Max. temperature 200°C.
Description	Screw conveyor - 9" diameter screw 3/16" thick, 17'-2" long, inclined 9°-54'. 1,750 rpm, 2 hp motor, with A-42, "V" belt drive 3.2/6.4 and Dorris reducer. Screw = 35 rpm. Carbon steel construction. Total weight each 500 pounds

Tag 610-2035-01	Cooler Discharge Vibrating Feeder (1 required)
Specification	SP-2007
Vendor	FMC Corporation Parts and Material Handling Division 404 West El Segundo Blvd. Los Angeles, California 90061
Service	Flow rate: 10.4 min. to 14.4 max. STPH reduced sponge iron pellets, from rotary cooler discharge hopper, to conveyor.
Description	Syntron model RF 40 24" W x 48" L vibrating feeder, with 1/2 hp variable speed motor and "V" belt drive controlled from a level probe. 8" deep trough with 3/16" ARS liners.

Tag 610-2037-01	Indurated Pellet Reclaim Vibrating Feeder (1 required)
Specification	SP-2007
Vendor	FMC Corporation Parts and Material Handling Division 404 West El Segundo Blvd. Los Angeles, California 90061
Service to belt conveyor	Flow rate: 25.5 STPH max. indurated pellet oversize from hopper fed by front end loader. Feeder discharges to belt conveyor.
Description	Syntron model RF-40 18" W x 60" L vibrating feeder, with 1/2-hp 1,800-rpm motor and "V"-belt drive. 4-to-1 turndown ratio for capacity adjustment. 8"-deep trough with 3/16" ARS liners.

Tag 610-2039-01 & 02	Reduced Pellet Bucket Elevator (2 required)
Specification	SP-2014
Vendor	FMC Link Belt 12631 East Imperial Highway Box 2246, Santa Fe Springs, Ca. 90670
Service	Convey 14.1 TPH max of 100% minus 1-1/2" cooler discharge reduced pellets, 31'-0" centers, vertically. Maximum temperature 300°F, normal temperature 150°F
Description	FMC model 1310 chain type bucket elevator, 10 - 5" buckets. 2-hp, 1,800-rpm motor with shaft-mounted speed reducer, 21-rpm output. 1A "V"-belt, 4.2 driving sheave, 15.0 driven sheave. Speed 80 fpm Total weight each 6,500 pounds

Tag 610-2043-01	Kiln Backflow Screw Conveyor No. 1 (1 required)
Specification	SP-2011
Vendor	Pacific Conveyor Company 13162 Grant Avenue Downey, California 90242
Service	1.3 max. tons per hour char pellets, and coal. Maximum temperature 200°C.
Description	Screw conveyor - 18" diameter screw 1/4" thick, 18'-6" long, inclined 22°-4'. 1,750-rpm, 5-hp motor, with B-60 "V"-belt drive 4.6/9.4 and Dorris reducer. Screw = 34 rpm Carbon steel construction Total weight each 1,500 pounds

Tag 610-2044-01	Kiln Dust Screw Conveyor No. 2 (1 required)
Specification	SP-2011
Vendor	Pacific Conveyor Company 13162 Grant Avenue Downey, California 90242
Service	1.0 max. tons per hour reduction kiln dust. Maximum temperature 200°C.
Description	Screw conveyor - 9" diameter screw 3/16" thick, 17'-6" long, inclined 20°-44'. 1,750-rpm, 2-hp motor, with A-42 "V" belt drive 3.2/6.4 and Dorris reducer. Screw = 35 rpm. Carbon steel construction Total weight each 500 pounds

Tag 610-2051-01	Reduced Pellet Reclaim Vibrating Feeder (1 required)
Specification	SP-2007
Venuor	FMC Corporation Parts and Material Handling Division 404 West El Segundo Blvd. Los Angeles, California 90061
Service	Flow rate: 12.7 normal to 1.41 maximum STPH reduced sponge iron pellets oversize, from reclaim hopper to belt conveyor
Description	Syntron model RF-40, 18" W x 60" L vibrating feeder with 1/2-hp, 1,800-rpm motor and "V"-belt drive. 4-to-1 turndown ratio for capacity adjustment. 8" deep trough with 3/16" ARS liners

Tag 610-2054-01	Coal Reclaim Vibrating Feeder (1 required)
Specification	SP-2007
Vendor	FMC Corporation Parts and Material Handling Division 404 West El Segundo Blvd. Los Angeles, California 90061
Service	Flow rate: 42 normal to 47 maximum TPH coal from hopper fed by front end loader, and discharged to bucket elevator
Description	Syntron model RF 40 24" W x 48" L vibrating feeder with 1/2-hp, 1,800-rpm motor and "V"-belt drive. 4-to-1 turn-down ratio for capacity adjustment. 8"-deep trough

Tag 610-2055-01	5-Ton Bridge Crane (1 required)
Specification	SP-2018
Vendor	Crane Hoist Engineering Corporation 12140 Bellflower Blvd. Downey, California 90241
Service	Maintenance - grate building
Description	5-ton capacity, underhung, single girder, motorized bridge crane. 27'-2" span. Hook to floor line 62'-0" available. Wheelbase 6'-0", runway rail 20" I,, 85 lbs. Total weight each 7,250 pounds

Tag 610-2056-01	3-Ton Electric Hoist (1 required)
Specification	
Vendor	Crane Hoist Engineering Corporation 12140 Bellflower Blvd. Downey, California 90241
Service	Grate pellet handling and general maintenance
Description	Wright model WLICA6M, with 24' lift at 20 fpm. 4 hp hoist motor, 1/2 hp motor driven trolley

Tag 610-2057-01	2-Ton Electric Hoist (1 required)
Specification	--
Vendor	Crane Hoist Engineering Corporation 12140 Bellflower Blvd. Downey, California 90241
Service	For grate waste air fan rotor and general maintenance
Description	Wright model WEL2ZP4M, with 66.75-foot lift at 22 fpm. 3-hp hoist motor, 1/2-hp motor-driven trolley

Tag 610-2058-01	1-Ton Electric Hoist (1 required)
Specification	--
Vendor	Crane Hoist Engineering Corporation 12140 Bellflower Blvd. Downey, California 90241
Service	Bentonite bag pallet handling
Description	Yale model KEWI-26G3052 with hand-geared trolley. 3-hp hoist motor for 26-foot lift at 30 fpm.

Tag 610-2101-01	Indurated Pellet Recycle Hammermill (1 required)
Specification	Existing equipment furnished by Hecla
Vendor	
Service	.87 dstph (max.) feed rate consisting of .59 dstph (max.) plus 3/4" and .32 dstph (max.) minus 1/4" indurated pellets
Description	--

Tag 610-2201-01	Reduced Pellet Magnetic Separator (1 required)
Specification	SP-2205
Vendor	Dings Company c/o Priority Systems Inc. 544 Rue Royale, Suite N Covina, California 91722
Service	15.5 dstph feed sponge iron and char, 75% magnetic, 25% nonmagnetic, 100% minus 1", 95% minus 3/4", 30% minus 1/4", 14% minus 16 mesh
Description	24" x 24" FC Perma-Drum model with replaceable 14-gauge stainless steel wear cover Total weight each 1,850 pounds

Tag 610-2402-01	Raw Material Belt Mixer No. 1 (1 required)
Specification	SP-2402
Vendor	Pekay Machine and Engineering Co., Inc. 2520 West Lake Street Chicago, Ill. 60612
Service	**Blend materials as follows:** (max. dstph) leach residue 12.09; magnetite 3.23; bentonite 0.081; indurate indurated pellet fines 0.47; green pellets 1.21. Maximum rate final mix 17.08 dstph, 21% moisture, bulk density 81.5 lbs./ft.^{3}
Description	Pekay Mixer Model TA-360-6-18, 5 hp, 1,200-hp motor. Mixer modified to handle material width of 8-1/2". Belt speed 61 fpm. Belt width 18", material height 2" Total weight each 3,500 pounds

Tag 610-2403-01	Raw Material Belt Mixer No. 2 (1 required)
Specification	SP-2402
Vendor	Pekay Machine and Engineering Company, Inc. 2520 West Lake Street Chicago, Ill. 60612
Service	Blend max. 17.08 dstph mixture of leach residue, magnetite, bentonite, indurated pellet fines, and green pellets at 21% moisture, with 2 gpm added water. This continues blending of product of raw material belt mixer No. 1 Total weight each 2,500 pounds

Tag 610-2701-01	Grate Roller Conveyor (1 required)
Specification	--
Vendor	Dravo (Lurgi)
Service	Flow rate: 16.2 normal, 17.9 max. dstph Pellets feed to traveling grate induration machine.
Description	39-1/2" (max.) length rollers, reducing to approx. 5-1/2", 25 total 4" OD rollers, @ 4-1/8" spaces. Each roller powered by one 25-hp motor. Furnished with traveling grate induration machine.

Tag 610-2702-01	Grate Discharge Vibrating Feeder Screen (1 required)
Specification	SP-2016
Vendor	Rexnord c/o Luzon and Company 23228 Hawthorne Blvd., Suite 10 Torrance, California 90505
Service	Feed rate: 23.5 normal, 26.0 maximum tph Indurated pellets, 100% minus 1-1/2" (occasional pieces minus 4" plus 1-1/2")
Description	Carrier vibrating screening feeder model FS241605 with 4'-0" load plate and 4'-0" screen section, complete with 5-hp motor and SCR control. 15" vertical side height, 30" width, 1-1/2" screen opening

Tag 610-2703-01	Indurated Pellet Vibrating Screen (1 required)
Specification	SP-2701
Vendor	W.S. Tyler, Inc. Screening Division 8200 Tyler Blvd. Mentor, Ohio 44060
Service	Feed rate: 23.1 normal, 25.5 maximum stph Indurated pellets, 97% minus 3/4". Ambient temperature material
Description	3' x 8' Tyler-type 110-R-Ty-Speed 2 bearing screen. Top deck 3/4" sq. opening. Bottom deck 1/4" sq. opening. 3-hp, 3,600-rpm motor with "V"-belt drive

Tag 610-2704-01	Reduced Pellet Vibrating Screen (1 required)
Specification	SP-2701
Vendor	W.S. Tyler, Inc. Screening Division 8200 Tyler Blvd. Mentor, Ohio 44060
Service	Feed rate: 9.66 average, 14.38 maximum stph. Reduced pellets from cooler discharge 99.9% minus 2" (occasional 8" to 10" pieces). Material temperature 200°F
Description	3' x 6' Tyler-type 110-R-Ty-Speed 2-bearing screen 2" square opening. 3-hp, 3,600-rpm motor with "V"-belt drive

Tag 610-2705-01	Char Ash Vibrating Screen (1 required)
Specification	SP-2701
Vendor	W.S. Tyler, Inc. Screening Division 8200 Tyler Blvd. Mentor, Ohio 44060
Service	Feed rate: 3.2 normal, 3.9 maximum stph. Nonmagnetic char, 12% minus 2" plus 1/4", 63% minus 1/4" plus 16 mesh, 25% minus 16 mesh. Ambient temperature material
Description	3' x 8' Tyler-type 110-R-Ty-Speed screen. Top deck 1/4" square opening, bottom deck 16 mesh square opening, stainless steel. 3-hp, 3,600-rpm motor with "V"-belt drive

Tag 610-2802-01	Disc Feed Fluffer (1 required)
Specification	--
Vendor	Lurgi
Service	To fluff magnetite, leach residue and bentonite mixture prior to the feed to pelletizing discs
Description	19" wide fluffing disc with eight 2" blades. Disc driven by 5-hp motor and "V"-belt drive

Tag 610-2803-01	Pelletizing Disc (1 required)
Specification	--
Vendor	Dravo (Lurgi)
Service	To pelletize 16.2 normal, 17.9 maximum dstph mixture of leach residue, magnetite and bentonite, to 1/4" to 5/8" diameter pellets for feed to traveling grate induration machine
Description	16'-5" inside diameter pelletizing disc. Operating angle variable between 40° and 60°; disc speeds adjustable 6.0, 6.5, 7.0 and 7.5 rpm. 75-hp, 1,800-rpm drive motor
	Total weight each 51,300 pounds dead weight 29,000 pounds approx. live load

Tag 610-3401-01	Magnetite Weighing Conveyor (1 required)
Specification	SP-3401-6
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 3.3 normal, 3.6 maximum (wet) tph (10% moisture by weight) magnetite, 132 lbs/ft^3 bulk density. 80% minus 270 mesh
Description	Ramsey model 1051-18 weighing conveyor. 18" wide x 15'-6" pulley centers. 10 fpm belt speed, capacity 4 tph maximum, 1-hp motor
	Controller signal to control speed on belt feeder upstream of this conveyor
	Total weight each 3,500 pounds

Tag 610-3402-01	Dried Leach Residue Weighing Conveyor (1 required)
Specification	SP-3401-6
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 10.93 normal, 12.09 maximum (dry) tph. Leach residue - 15% moisture by weight. 60 lb/ft^3 bulk density. 99% minus 65 mesh
Description	Ramsey model 1051-24 weighing conveyor. 24" wide x 15'-6" pulley centers. 40 fpm belt speed, capacity 15 tph maximum, 1-1/2-hp motor. Controller signal to control speed on belt feeder upstream of this conveyor Total weight each 3,500 pounds

Tag 610-3403-01	Bentonite Weigh Feeder (1 required)
Specification	SP-3401-7
Vendor	Wallace and Tiernan c/o Luzan and Company 23228 Hawthorne Blvd. Torrance, California 90505
Service	Flow rate: 146 normal, 161 maximum lbs. per hour bentonite. 60 lbs/ft^3 dry bulk density. Moisture content 5% by weight, 100% minus 10 microns
Description	Wallace and Tiernan 9" bentonite weighbelt feeder model 31-175RS-09G, with SCR control rotary feeder - see tag 610-2013-01. Weighfeeder drive 1/4-hp, 1,800-rpm motor

Tag 610-3405-01	Indurated Pellet Product Belt Scale (1 required)
Specification	SP-3401-4
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 13.1 normal, 14.5 maximum tph indurated iron oxide pellets. 87 lbs/ft^3 bulk density (dry), 100% minus 3/4" plus 1/4"
Description	Ramsey Vey-R-Weigh belt scale model 10-11, 18" belt width, 50 fpm belt speed Total weight each 400 pounds

Tag 610-3407-01	Char Weighfeeder (1 required)
Specification	SP-3401-5
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 2.7 normal, 2.9 maximum tph char. 33 lb/ft^3 bulk density (dry), size: plus 1.0 mm
Description	Ramsey model 10-95, 24" wide x 8'-0" pulley centers, 12.5 FPM belt speed, capacity: Approx. 0.15 min., 3.0 max. tph. 1-hp motor Total weight each 3,500 pounds

Tag 610-3408-01	Coal Weighing Conveyor (1 required)
Specification	SP-3401-6
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 7.0 normal, 10.0 maximum (wet) tph coal. 13% moisture by weight. 50 lb/ft^3 bulk density. Minus 3" x 0", occasional slabs 8" long
Description	Ramsey model 1051-24 weighing conveyor. 24" wide x 17'-0" pulley centers. 25 fpm belt speed, capacity 10 tph max. 1-hp motor Controller signal to control speed on vibrating feeder upstream of this conveyor Total weight each 3,500 lbs.

Tag 610-3409-01	Indurated Pellet Weighing Conveyor (1 required)
Specification	SP-3401-6
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 13.2 normal, 14.6 maximum tph indurated pellets. 87 lbs/ft^3 bulk density, size: minus 3/4" plus 1/4"
Description	Ramsey model 1051-18 weighing conveyor. 18" wide x 17'-0" pulley centers. 50 fpm belt speed. Capacity 15 tph maximum. 1-1/2-hp motor. Controller signal to control speed on vibrating feeder screen upstream of the conveyor Total weight each 3,500 pounds

Tag 610-3411-01	Sponge Iron Weighing Conveyor (1 required)
Specification	SP-3401-6
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	**Flow rate: 9.5 normal, 10.5 maximum (dry)** sponge iron pellets. 86 lb/ft^3 bulk density, size: minus 1"
Description	Ramsey Vey-R-Weigh Model 1050-18 weigh conveyor system. 18" wide x 15'-6" pulley center, 10 fpm belt speed, capacity 11 tph maximum, 1-hp motor Total weight each 3,500 pounds

Tag 610-3414-01	Green Pellet Belt Conveyor Weigh Scale (1 required)
Specification	SP-3401-4
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 20.1 normal, 22.2 maximum (wet) tph green iron oxide pellets. 85 lb/ft^3 bulk density, 23% moisture content by weight
Description	Ramsey Vey-R-Weigh conveyor scale system, model 10-11. 24" belt width, 43 fpm belt speed Total weight each 400 pounds

Tag 610-3415-01	Metal Detector (1 required)
Specification	--
Vendor	Oretronics 1045-C Shary Court Concord, California 94518
Service	To detect tramp metal in dried leach residue conveyed on belt. Normal flow rate 11.9 dstpm, max. rate 13.1 dstph. 60 lb/ft^3 bulk density with 15% moisture by weight. Dry contact operation shall be activated upon detection of tramp metal
Description	Oretronics model 3301 metal detector with special detector coils for temperature variations and NEMA padlocking latch handle For use with 18"-wide belt, 56 fpm belt speed

Tag 610-3416-01	Reduced Pellet Conveyor Scale System (1 required)
Specification	SP-3401-4
Vendor	Ramsey Engineering Company 770 Welch Road Palo Alto, California 94304
Service	Flow rate: 12.8 normal, 14.1 maximum tph reduced pellets, 76 lb/ft^3 bulk density
Description	Ramsey model Vey-R-Weigh conveyor scale system, model 10-11. 18" belt width, 100 fpm belt speed Total weight each 400 pounds

Tag 610-4401-01	Sponge Iron Sampler (1 required)
Specification	SP-4402
Vendor	Joy Manufacturing Company Denver Equipment Division 600 Broadway, P.O. Box 5268 Denver, Colorado 80217
Service	Sample reduced iron pellets. Sample required 8-12 lb. per 2 hours. Sample taken every 15 minutes normally, range of 2 to 60 minutes desired. Feed screen size: minus 1"
Description	24" model S2S Denver Automatic Sampler. Type C cutter 10" long x 2" wide. 24" cutter travel, cutter speed 7.5 inches per second, 1.554 lbs. per cut. Roller chain drive with 1/4-hp motor Total weight each 410 pounds

Tag 610-4402-01	Magnetite Sampler (1 required)
Specification	SP-4402
Vendor	Joy Manufacturing Company Denver Equipment Division 600 Broadway, P.O. Box 5268 Denver, Colorado 80217
Service	Sample magnetite. Sample required 6 - 8 lbs. per hour. Sample taken every 10 minutes normally. Range of 2 to 60 minutes desired. Material sampled: 2% plus 65 mesh, 40% minus 65 mesh, plus 400 mesh, 58% minus 400 mesh
Description	48" model H2S Denver Automatic Sampler, with swing bottom dump cutter 12" long x 1.13" wide. 48" cutter travel, cutter speed 12 inches per second, 0.167 lbs. per cut. Roller chain drive with 1/2-hp motor Total weight each 755 pounds

Tag 610-4403-01	Leach Residue Sampler (1 required)
Specification	SP-4402
Vendor	Joy Manufacturing Company Denver Equipment Division 600 Broadway, P.O. Box 5268 Denver, Colorado 80217
Service	Sample leach residue. Sample required: 8 - 10 pounds per hour. Material sampled: 1% plus 65 mesh, 34% minus 65 mesh plus 270 mesh, 65% minus 270 mesh. Sample taken every 11 minutes normally, range of 2 to 60 minutes desired
Description	48" model H2S 316SS Denver Automatic Sampler, with swing bottom dump cutter, 12" long x 2.45" wide. 48" cutter travel, cutter speed 12" per second, 0.149 pounds per cut. Roller chain drive with 1/2-hp motor Total weight each 755 pounds

Tag 610-4701-01 Purchased with Tag 610-4901-01	(1 required)
Specification	SP-4901
Vendor	Koppers/Hardinge/Ducon
Service	Dryer wet dust scrubber
Description	Type UW-4, model III, size 72 inlet cap, 15,600 acfm at 220°F outlet cap, 14,995 acfm at 184°F inlet S.P. 10" W.G., gpm reg. 44 fan 1,250-rpm, 125-hp motor, 1,800 rpm. Stainless steel construction, Ducon Dwg. K-74-048-1 Total weight - each scrubber - 6,700 pounds motor, base & drive - 2,000 pounds

Tag 610-4702-01
Includes 610-1802-01 (1 required)

Specification	SP-4708
Vendor	Ducon
Service	Grate waste gas scrubber
Description	Type DW-4, model III size 102 inlet cap. 37,475 acfm at 383°F, outlet cap. 29,000 acfm at 142°F, inlet S.P. 15.8" W.G. gpm reg. 87 fan 982 rpm, high speed wheel 250 hp motor, 1200 rpm, frame #5009U, 4160V, 316L SS construction with 3/16"-thick SS inlet wear liner Ducon Dwg. K74-063-1
Total weight each	See Ducon Dwg. K74-063-1

Tag 610-4703-01 (1 required)

Specification	Hecla
Vendor	Solar
Service	Grate Waste gas cleaning system expansion joint
Description	Nominal 42" diameter, expansion joint, axial comp. 3/4" angular movement 1°, pressure minus 16" W.G., temperature 385°F, 316L SS construction, Solar Dwg. - Data Sheet No. 1 - Job No. N3-5005

Tag 610-4704-Q1 Includes 610-1809-01	(1 required)
Specification	SP-4708
Vendor	Ducon
Service	Grate discharge dust scrubber
Description	Type UW-4, model III, size 102, inlet cap, 31,250 acfm at 195°F outlet cap. 27,220 acfm at 90°F inlet S.P. 7" W.G. gpm reg. 87, fan 678 rpm, 125-hp motor, 1800-rpm 460V, Ducon Dwg. K74-063-2, frame No. 444T
	Total weight each See Ducon Dwg. K74-063-2

Tag 610-4706-01	(1 required)
Specification	SP-4707
Vendor	Peabody Engineering
Service	Afterburner Venturi Scrubber
Description	Model/size VS 13, inlet cap. 154,440 acfm at 1,562°F (850°C) maximum inlet temp. 1,742°F (950°C), outlet cap. 81,510 acfm at 178°F (81°C) inlet S.P. -2.75 inches W.G. Press. drop 23 inches W.G., gpm reg. 690, Peabody Dwgs. A-76520, B-76521, B-76522, B-76526 and B-76870
	Total weight each 30,000 pounds

Tag 610-4708-01 includes 610-1815-01	(1 required)
Specification	SP-4708
Vendor	Ducon
Service	Product separation area scrubber
Description	Type UW-4, model III, size 78, inlet cap. 17,025 acfm at 70°F, outlet cap. 16,930 acfm at 66°F, inlet S.P. 6-1/2" W.G., gpm reg. 51, fan 972-rpm, 75-hp motor, 1,800 rpm, 460V, Ducon Dwg. K74-063-3
Total weight each	See Ducon Dwg. K74-063-3

Tag 610-4711-01 includes 610-1820-01	(1 required)
Specification	SP-4708
Vendor	Ducon
Service	Kiln feed end scrubber
Description	Type UW-4, model III, size 30, inlet cap. 2,400 acfm at 70°F, outlet cap. 2,385 acfm at 66°F, inlet S.P. 4-1/2" W.G., gpm reg. 7.5, fan 2,727 rpm, 15-hp motor, 1,800-rpm, 460V, Ducon Dwg. K74-063-4

Tag 610-4901-01	Leach Residue Rotary Dryer
Specification	SP-4901
Vendor	Koppers Company, Inc. Hardinge Operation P.O. Box 312 York, PA. 17405
Service	To dry 220 DST/D normal, 262.3 DST/D maximum, wet hydrated iron oxides. Feed moisture = 38.7%, bulk density 110#/cu. ft. Product moisture = 15.0%. Gas inlet temperature = 1700°F normal, 2000°F maximum from Kiln afterburner. Fuel oil auxiliary fuel. Total heat required = 17 million BTU/hr. maximum.
Description	104" diameter X 55' long shell, operating in partial water bath. Dryer rotation = 4.2 rpm Dryer shell plates = 1/2" shell with 3/4" bands, under tires. 1/2" shell with 1" bands, under gear. Other shell plates = 1/2". Shell plates 316 LSS with carbon steel reinforcing plates. 12" face X 28" dia rollers; 2-12" face X 7" tires. 75 HP, 1750 rpm motor. Total Weight Each 81,200 lbs. with chains

Tag 610-4902-01	Traveling Grate Induration Machine (1 required)
Specification	--
Vendor	
Service	To harden 23.5 normal, 26.0 maximum DSTPH sponge iron pellets
Description	1 meter wide induration machine, 2-hp, 1,800-rpm, motor with speed reducer to 0.159 rpm. 115'-8-1/4" c. to c. sprockets

Tag 610-4903-01	Rotary Cooler (1 required)
Specification	SP-4902
Vendor	Koppers Company, Inc. Hardinge Operation P.O. Box 312 York, Pa. 17405
Service	To cool hot reduced sponge iron pellets from 2,000°F input temperature to 150°F discharge temperature, max. 14.4 stph feed rate, in nonoxidizing atmosphere. 100% minus 1-1/2"; 84.4% plus 16 mesh with occasional lumps and bricks
Description	Hardinge 10' dia. x 100' long, carbon steel, partially submerged rotary cooler. 75-hp motor main drive, 5-hp emergency drive. Cooler is partially submerged in Purchaser's concrete basin. 3/8" shell thickness. 250 gpm primary cooling water requirement plus 20 gpm for each of two bearings Total weight each 160,000 pounds

Tag 610-4904-01 — Rotary Reduction Kiln (1 required)

Specification

Vendor	KVS (Lurgi)
Service	Flow rate: 22.8 dstph (+0.9 tph H_2O) normal 25.3 dstph (+ 1.0 tph H_2O) maximum Indurated pellets, coal and char. Inlet chamber operating at approximately 1,000°C
Description	11'-9-3/4" I.D. shell x 164'-1" long (3.6 M x 50 M long) reduction kiln. Shell rpm 0.4 to 1.3 max. 220 hp dc main drive motor. 15 hp emergency drive motor. 9" thick refractory lined. Kiln is oil fired, requiring 7,100,000 Btu/hr for normal operation. 7 kiln air blower shell fans provided. Kiln feed from leach residue conveyor is through a 55° inclined chute integral with afterburner structure

Tag 610-4905-01 — Reduction Kiln Afterburner (1 required)

Specification

Vendor	
Service	To burn off unburned carbon from reduction kiln combustion process and furnish hot gas flow to leach residue dryer: 9,400 scfm normal, 10,400 scfm maximum at 850°C
Description	13'-3-3/4" OD, 14" refractory lined afterburner chamber with 8'-2-3/4" OD, 9" refractory lined emergency stack. Afterburner structure, including stack and dust chamber approximately 94' high. Afterburner chamber is equipped with high pressure water sprays for temperature control and an emergency stack cap. Hot gas from afterburner is carried by 5' diameter duct to leach residue dryer

EQUIPMENT SPECIFICATION DETAILS

AND

DETAIL TECHNICAL DATA

SPARE PARTS/SUPPLIES

WAREHOUSE INVENTORY*

Warehouse Code	Item	Quantity
17-6120-0101	Roll, 5IN steel-20 DEG Trough Idler	3
17-6120-0102	Roll, 5IN steel-20 DEG Trough Idler	5
17-6120-0104	Roll, 5IN steel-flat Belt Return	1
17-6120-0105	Roll, 6IN Rubber Cushion Live Shaft	1
17-6120-0106	Roll, 6IN Rubber Cushion Live Shaft	3
17-6120-0107	Roll, 5IN Steel-Return Training Positive Action	1
17-6120-0108	Roll, 5IN Steel	1
17-6120-0109	Roll, 5IN Steel-Return Training Positive Action	2
17-6120-0112	Tread, Idler, 6 IN Rubber	4
17-6120-0114	Roll, 5IN Steel-Return Idler	3
17-6120-0115	Tread, 6IN Rubber-Return Training Positive Action	1
17-6120-0116	Tread, 6IN Rubber-Return	1
17-6120-0503	Idler, Rubber Disc Return	1
17-6120-1601	Sprocket, Steel-Bore 2-7/16 IN	2
17-6120-2402	Bucket	10
17-6120-3201	Bushing, Half	2
17-6120-3202	Bucket	7
17-6120-3203	Chain, 10 ft.	1
25-6120-2501	Card, Circuit Control Assy.	1
25-6120-2502	Card, Circuit Amplifier Assy.	2

Warehouse Code	Item	Quantity
25-6120-3501	Card, Circuit Control	1
25-6120-3502	Rectifier, Silicone Control	1
25-6120-5001	Board, Circuit	1
25-6120-5002	Timer, MC 2 Plugging	1
25-6120-0201	Card, Circuit SCR Logic	1
25-6149-0202	Card, Circuit SCR Control	1
25-6149-0203	Module, SCR Thyristor Power	1
25-6149-0406	Card, Circuit Power Supply	1
25-6149-0407	Card, Circuit SC	1
25-6149-0408	Card, Circuit CC	1
25-6149-0409	Card, Circuit VS	1
25-6149-0410	Card, Circuit Current Sensor	1
25-6149-0411	Card, Circuit Cal	1
25-6149-0412	Card, Circuit RL	1
25-6149-0413	Card, Circuit CPG	1
25-6149-0414	Card, Circuit VC	2
25-6149-0415	Pulsing, Unit 7 Contacts	1
25-6149-0416	Pulsing, Unit 7 Contacts	1
25-6149-0417	Transformer	2
25-6149-0418	Suppressor, Surge	1
25-6149-0419	Relay, 24 Volt DC	1
25-6149-0428	Card, Resister 1RP	1
25-6149-0429	Transformer	1
27-6149-0101	Plug, Spark 1-101	1
27-6149-0102	Solenoid, Repair Kit	1
27-6149-0103	Solenoid, Repair Kit	2

Warehouse Code	Item	Quantity
27-6149-0104	Solenoid, Repair Kit	1
27-6149-0105	Element, Thermocouple Type	1
27-6149-0106	Tube, 18 IN Resistant	4
27-6149-0107	Element, Thermocouple	2
27-6149-0108	Tube, Sillramic Protection	1
27-6149-0109	Tube, Silicon Carbide Protection	2
27-6149-0202	Transformer, 110/120 Volt	2
27-6149-0205	Operator, Push Button	2
27-6149-0206	Switch, Selector	1
27-6149-0207	Block, Contact Normally Open	2
27-6149-0208	Block, Contact Normally Closed	2
27-6149-0210	Relay, Plug in Type 1 Coil	3
27-6149-0211	Socket, Relay	2
27-6149-0212	Socket, Relay	2
27-6149-0213	Relay, Time Delay 8 Pin	2
27-6149-0214	Relay, Time Delay 8 Pin	2
27-6149-0215	Relay, Time Delay 8 Pin	1
27-6149-0216	Regulator, Pilot	1
27-6149-0217	Regulator, Type 7345H-01	1
27-6149-0218	Diaphragm, Balancing	1
27-6149-0219	Diaphragm, Gas	1
27-6149-0220	Diaphragm	1
27-6149-0221	Diaphragm, Oil Set of 5	10
27-6149-0222	Diaphragm, Air	2
27-6149-0223	Coil, Solenoid	2
27-6149-0224	Coil, Solenoid	3

Warehouse Code	Item	Quantity
27-6149-0225	Coil, Solenoid	1
27-6149-0401	Tip	2
27-6149-0402	Plug, Tip	2
27-6149-0403	Cap, Tip	2
27-6149-0404	Glass, Peephole	1
27-6149-0405	Tip, 6-144-70	1
27-6149-0406	Plug, Tip 6-116	1
27-6149-0407	Powerpac, Input	1
27-6149-0408	Rod, Heater Element	1
27-6149-0409	Tip, 6-067-70	1
27-6149-0410	Plug, Tip 4-067	1
27-6149-0418	Coil	1
27-6149-0419	Solenoid, Repair Kit	1
27-6149-0420	Coil	1
27-6149-0421	Solenoid, Repair Kit	1
27-6149-0423	Tip, Well	3
27-6149-0501	Tube, Thermocouple Protection	12
27-6149-0502	Tube, Thermocouple Protection	6
27-6149-0503	Tube, Thermocouple Protection	2
69-6118-0201	Fan Wheel, Ducon 71 IN Dia	1
69-6118-0301	Liner Set, 1/4 IN Thick	1
69-6118-0302	Thermocouple Element	2
69-6118-0304	Seal, Clamp	4
69-6118-0305	Plate, Thrust	3
69-6118-0306	Ring, Oil	4
69-6118-0307	O-Ring	2

Warehouse Code	Item	Quantity
69-6118-0309	Seal, Dust	2
69-6118-0310	Spring, Seal	2
69-6118-0311	Ring, Oil	2
69-6118-0501	Liner Set, 1/4 IN Thick	1
69-6118-1101	Fan, Industrial	2
69-6118-1301	Wheel & Shaft Assy	1
69-6118-1302	Shaft, Fan	1
69-6120-0701	Bearing	2
69-6120-0702	Bearing	1
69-6120-0703	Bearing	2
69-6120-0704	Bearing	1
69-6120-0705	Bearing	2
69-6120-0706	Seal	1
69-6120-0707	Seal	2
69-6120-0708	Seal	2
69-6120-0709	Gasket Set	1
69-6120-0710	Gasket Set	1
69-6120-2701	Screen, Wire	2
69-6120-3301	Screw	1
69-6120-3302	Screw	1
69-6120-3303	Screw	1
69-6120-3304	Conveyors Tag 610-2033	4
69-6120-3305	Bearing	10
69-6120-3306	Clamp	2
69-6120-3307	Bolt	2

Warehouse Code	Item	Quantity
69-6120-3308	Hanger	2
69-6120-3401	Screw	2
69-6120-3402	Screw	1
69-6120-3403	Bolt, Coupling with Nut	4
69-6120-3404	Bearing	12
69-6120-3405	Clamp	2
69-6120-3406	Screw	2
69-6120-3407	Hanger	2
69-6122-0101	Shell, Non-magnetic Stainless Steel	1
69-6124-0201	Wheel, Cutter	4
69-6124-0202	Shaft, 1-3/4 IN Dia	2
69-6124-0203	Roll, Idler	5
69-6124-0204	Roll, Idler	4
69-6124-0205	Curtain, Rubber	2
69-6124-0206	Curtain, Rubber	2
69-6124-0207	Lining, Rubber	2
69-6124-0208	Curtain, Rubber	1
69-6124-0209	Lining, Rubber	1
69-6127-0101	Motor, Gear	2
69-6127-0201	Brick, Rubber	8
69-6127-0251	Screen, Wire	2
69-6127-0301	Cloth	2
69-6127-0302	Cloth	6
69-6127-0304	Housing, Bearing	1
69-6127-0305	Housing, Seal	1
69-6127-0306	Ring, Snap	2

Warehouse Code	Item	Quantity
69-6127-0307	O-Ring	2
69-6127-0308	O-Ring	2
69-6127-0309	Ring, Seal	1
69-6127-0310	Seal, Oil	2
69-6127-0311	Sleeve, Seal	1
69-6127-0401	Cloth	4
69-6128-0302	Pinion, Bull Gear	1
69-6147-0201	Nozzles, SS 316	1
69-6147-0202	Nozzles, SS 316	1
69-6147-0203	Nozzles, SS 303	1
69-6147-0204	Nozzles, SS 303	2
69-6147-0601	Nozzle, Flooding 316 SS	8
69-6147-0602	Nozzle, 3/4 IN Flooding	6
69-6147-0603	Nozzle, 3/4 IN Monofan	3
69-6149-0200	Casting, Pallet Assy	5
69-6149-0201	Plate, Keeper	35
69-6149-0202	Bar, Drop	2
69-6149-0203	Bar, Drop	1
69-6149-0204	Bar, Drop	1
69-6149-0205	Bar, Spring Seal	3
69-6149-0206	Pin, Seal Bar	30
69-6149-0207	Spring, Seal Bar	31
69-6149-0208	Liner, Set of 6	1
69-6149-0209	Insert, Oil	2
69-6149-0210	Nozzle, Oil	2
69-6149-0211	Nozzle, Air	2

Warehouse Code	Item	Quantity
69-6149-0212	Pilot Assy	2
69-6149-0213	Tip, Pilot	2
69-6149-0214	Electrode, Pilot	2
69-6149-0215	Spider, Pilot Ceramic	4
69-6149-0216	Insert, Oil	1
69-6149-0217	Nozzle, Oil	1
69-6149-0218	Nozzle, Air	1
69-6149-0219	Pilot Assy	1
69-6149-0220	Tip, Pilot	3
69-6149-0222	Spacer, Pilot	10
69-6149-0223	Thermocouple Element	1
69-6149-0224	Thermocouple Element	1
69-6149-0228	Wall, Lower Side	24
69-6149-0230	Bar, Drop	2
69-6149-0231	Bar, Drop	400
69-6149-0232	Bar, Drop	2
69-6149-0233	Bar, Drop	1
69-6149-0234	Bar, Drop	1
69-6149-0235	Ring, Seal	3
69-6149-0236	Pack, Shim	60
69-6149-0237	Roller	1
69-6149-0239	Cap, End	4
69-6149-0240	Ring	6
69-6149-0241	Axle	4
69-6149-0242	Seal	7
69-6149-0243	Angle, Seal	2

Warehouse Code	Item	Quantity
69-6149-0401	Swirler	8
69-6149-0402	Anchor, Refactory	2
69-6149-0405	Thermocouple Element	4
69-6149-0408	Guide, Thermocouple	3
69-6149-0503	Nozzle, Spray	6
69-6149-0504	Nozzle, Spray	1
69-6149-0505	Swirler	8
69-6149-0506	Orifice	8
69-6149-0507	Swirle	8
69-6149-0508	Orifice	8
69-6149-0509	Swirler	4
69-6149-0510	Orifice	4
69-6149-0511	Washer, Seating	14
69-6149-0512	Adapter, Interchangeable	14
69-6149-0513	Washer, Adapter	20
69-6149-0514	Housing Spray Nozzle	8
71-6123-0501	Impeller	1
71-6123-0502	Nut, Impeller Lock	1
71-6123-0503	Nut, Impeller Jam	1
71-6123-0504	Sleeve, Shaft	1
71-6123-0509	Bearing	1
71-6129-0901	Impeller	1
71-6129-0902	Nut, Impeller Lock	1
71-6129-0903	Sleeve, Shaft	1
71-6129-0904	Nut, Impeller Jam	1
71-6179-0101	Seal, Mechanical (Lower)	2

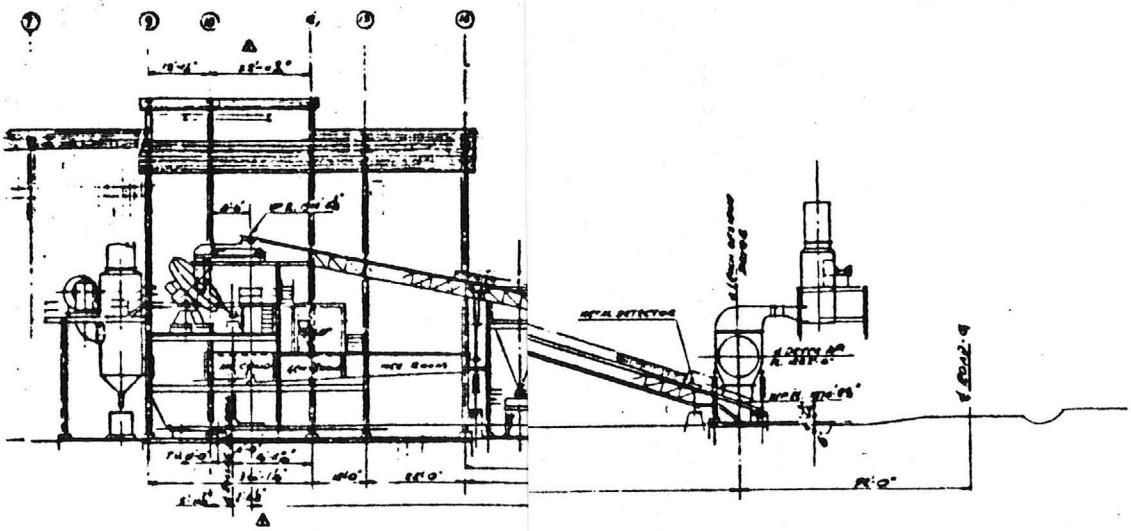
Warehouse Code	Item	Quantity
71-6179-0102	Kit, Repair	1
71-6179-0103	Seal, Rotating Face	1
71-6179-0104	Sleeve, Shaft (Single Seal)	1
71-6179-0105	Stud, Inducer	1
71-6179-0106	Washer, Impeller Tab	1
71-6179-0107	O-Ring (Diffuser Upper)	1
71-6179-0108	O-Ring (Diffuser Lower)	1
71-6179-0109	Seal, Mechanical	2
71-6179-0110	Kit, Repair	1
71-6179-0111	Seal, Rotating Face	1
71-6179-0112	O-Ring	2
71-6179-0113	Seal, Shaft	1
71-6179-0115	Lubricant, for Slined Shaft	2
71-6179-0116	O-Ring, Kit Repair	5
71-6179-0117	Bushing, Throttle	1
71-6179-0118	Impeller	1
71-6179-0119	Inducer	1

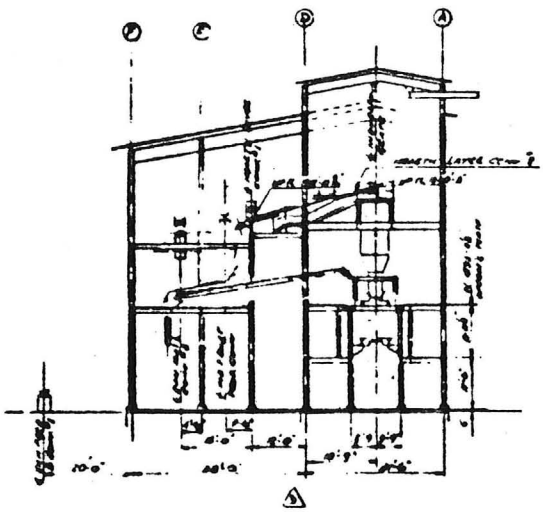
*More completely described in computer printout sheets that will be available from Noranda upon request

PLANT ENGINEERING

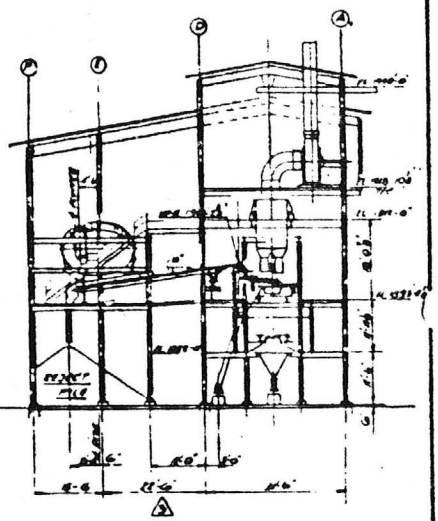
AND

CONSTRUCTION DRAWINGS

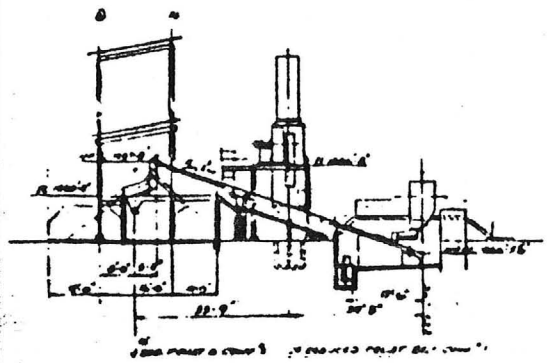




SECTION F-F



SECTION G-G



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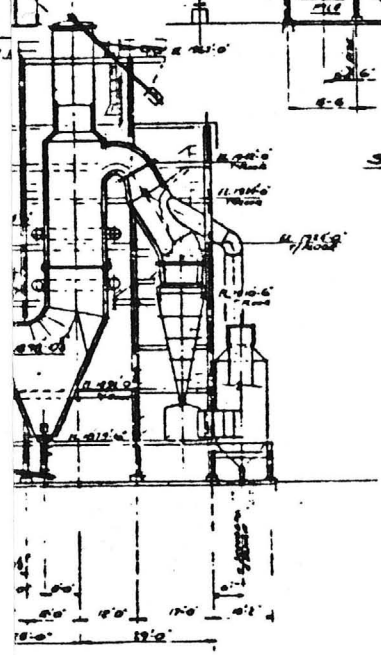


BILL OF MATERIAL

SPONGE IRON PLANT
COMPOSITE
GENERAL ARRANGEMENT
SECTIONS SHEET 8

610-D-1001

COMPANY

TECHNICAL REPORTS ON THE DRI PLANT

AT THE LAKESHORE MINE

THE SPONGE IRON PLANT OF THE LAKESHORE MINE

The purpose of the sponge iron plant in the complex mining-metallurgical facility that constitutes the Lakeshore Mine of the Hecla Mining Company at Casa Grande, Arizona is to produce metallic iron that can be used to precipitate copper from solutions derived from the sulfuric acid leaching of oxide copper ores. Production of iron is accomplished in two metallurgical process steps: 1. Agglomeration wherin a fine iron oxide by-product is formed into small balls and indurated by heat to produce pellets which will withstand the rigors of 2. reduction by the SL/RN process wherin the iron oxide pellets are transformed into sponge iron pellets.

RAW MATERIALS

The raw materials consumed in the agglomeration plant consist of leach residue filter cake (the iron oxide residue from the roasting and acid leaching of sulfide copper concentrates) , magnetite concentrates from the sulfide ore concentrator and purchased bentonite which acts as a binder in the production of pellets. No. 2 fuel oil is used for both agglomeration and reduction (No. 6 may also be used.) Coal of subbituminous rank and nominal minus 3-in. size is the primary fuel in the reduction step. Typical sieve and chemical analyses of raw materials are given in Table 1.

TABLE 1. PROPERTIES OF RAW MATERIALS

CHEMICAL ANALYSES, PERCENT BY WEIGHT, DRY BASIS

MATERIAL	LEACH RESIDUE	MAGNETITE CONCENTRATES	COAL
Fe (total)	47.3	55.1	---
Fe (divalent)	1.1	16.6	---
S	1.1	0.5	---
SiO_2	16.2	10.2	---
CaO	1.9	---	---
MgO	5.6	---	---
Cu	3.2	---	---
L.O.I.	4.8	---	---
Fixed C	---	---	41.7
Ash	---	---	21.2
Vols.	---	---	38.7
Water	25-35	10.0	4.9

TABLE 1. - continued

SIEVE ANALYSES, CUMULATIVE PERCENT RETAINED

MATERIAL	LEACH RESIDUE	MAGNETITE CONCENTRATES	COAL
1 in.	---	---	26.5
½ in.	---	---	42.2
¼ in.	---	---	58.2
16 mesh	---	---	85.6
65 mesh	---	2.0	---
115 mesh	1.0	8.8	---
170 mesh	3.0	16.0	---
250 mesh	8.3	30.0	---
325 mesh	15.9	48.0	---
400 mesh	25.2	70.0	---

AGGLOMERATION

A flowsheet of the agglomeration plant is shown in Fig. 1a, and specifications for major equipment are listed in the Appendix. Leach residue filter cake containing 25 to 35 percent water is conveyed from the filters to a small hopper with screw conveyor which feeds the parallel flow type rotary dryer whose function is to reduce the moisture content of the leach residue to 16 to 20 percent. Hot drying gases are diverted from the afterburner to the dryer or are generated in an oil-fired burner located at the feed end of the dryer. A metal detector on the conveyor between the dryer and the leach residue bin protects subsequent equipment from plug-up or damage.

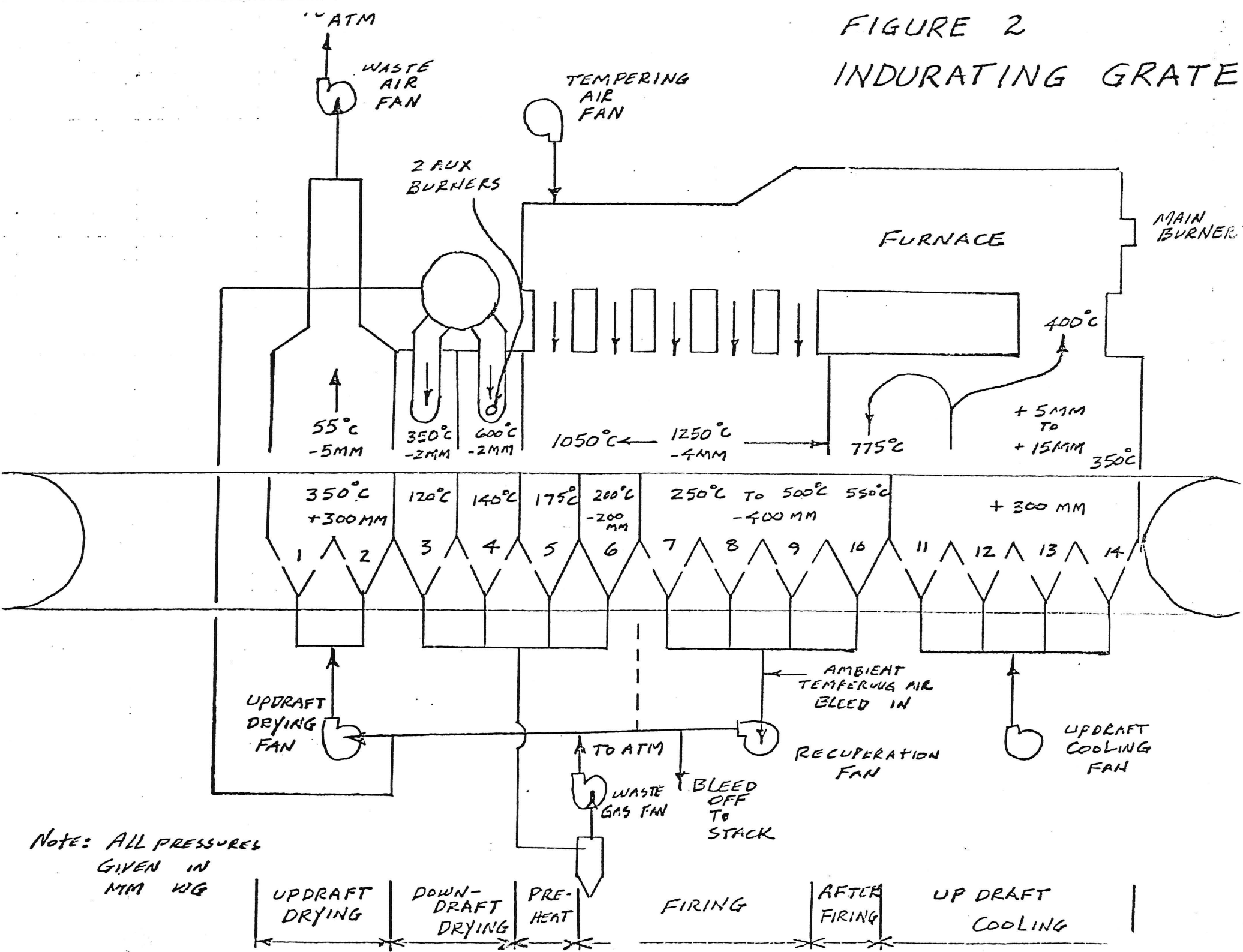
Magnetite is hauled from the concentrator by front-end loader and the magnetite bin is filled via a hopper, belt feeder and conveyor system.

Bentonite is received in palletized 50-lb bags. Pallets are hoisted to the working platform at the top of the bin and bags are dumped by hand.

Both the magnetite bin and the stainless steel leach residue bin are designed to produce mass flow. Magnetite and leach residue are fed and apportioned by means of variable speed belt feeders followed by weighing conveyors. Bentonite is fed and controlled by a variable speed rotary vane feeder followed by a weighing conveyor. The feed rates of magnetite and bentonite are paced by the feed rate of leach residue.

Raw materials are mixed at two stations by rotary belt mixers and the option is available to add water to the mix just before entering the second mixer. Additional mixing as well as lump breaking and aeration are performed on the mix as it falls through a rotary fluffer to the balling disc. Final moisture adjustment is made by water sprays on the disc. An expanded metal lining on the surface of the disc causes feed material to build up; then ceramic tipped scrapers cut the accretions to form a smooth surface of feed material to encourage the formation of balls. The balling disc is an "autosizing" device, and slope and speed of rotation can be changed (the latter requires a sheave change) to achieve optimum conditions.

FIGURE 2
INDURATING GRATE



Note: ALL PRESSURES GIVEN IN MM WG

The minus 3/4-in. plus ¼-in. fraction from the indurated pellet screen , conveyed to a wye or pant-leg chute which splits the product between the hearth layer bin and the indurated pellet bin. Load cells supporting the hearth layer bin sense the need for more or less material and automatically stop, speed up or slow down the hearth layer belt feeder which takes what it needs from the pant-leg splitter while the remainder overflows to the chute leg feeding the indurated pellet product belt conveyor.

REDUCTION

A flowsheet of the SL/RN plant is shown in Fig. 1b. The reduction step in the production of sponge iron begins with the feeding and apportioning of indurated iron oxide pellets, coal, and char - the carbonaceous residue derived from the coal and recycled to conserve energy. Coal is reclaimed from stockpile by front-end loader and the coal bin is filled by means of a hopper, vibrating feeder and bucket elevator system. Variable speed vibrating feeders in the case of pellets and coal and a variable speed belt feeder in the case of char followed by a weighing conveyor in each case automatically control the feed rate of each constituent to the desired set point. The above materials are delivered to the rotary kiln feed spout by kiln feed conveyors.

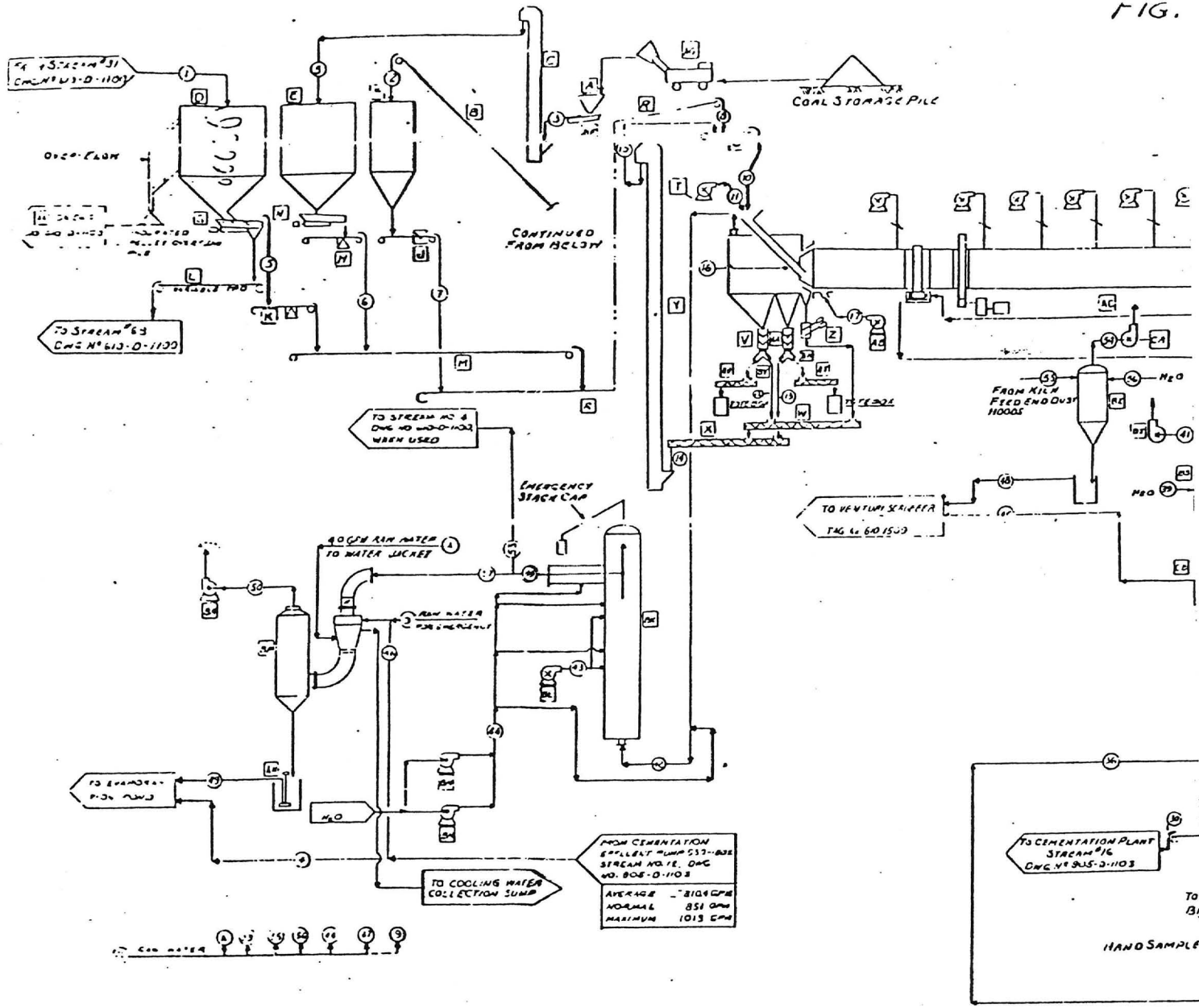
The function of the kiln is to heat the oxide pellets to 950° C to 1050° C in a strongly reducing environment. To accomplish the above the kiln is fitted with an oil burner at the discharge end of the kiln, six heat resistant air inlet tubes spaced along the kiln and extending to its center line, six air fans with dampers fitted to the air inlet tubes (see Fig. 3) and a lubricated, positive slip seal at each end of the kiln. The central burner is used to preheat the kiln and help control the temperature profile. By controlling the flow of air to each inlet tube, the combustion of coal and consequently the temperature profile along the kiln can be controlled.

Material is caused to move through the kiln by its rotation and slope of 2½ percent. Inorder to attain maximum retention time for heating and reduction at any feed rate, the rotational speed is adjusted so that a small amount of backflow is emitted from the feed end of the kiln. As the charge moves down the kiln, it is heated by the hot gases from the central burner and the burning coal. In the first half of the kiln the volatile matter is given off by the coal and partially consumed by air from the air tubes. The residue of carbon and ash remaining from the coal (called char) is burned in a limited and controlled quantity of air to form carbon monoxide gas which reduces the iron oxide pellets to metallic iron in the last half of the kiln according to the equation: $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$.

The rate at which the reduction reaction takes place is aided by the porous nature of the pellets. The pore network allows the reducing gases to penetrate the innermost passageways of the pellets and the gaseous products of the reduction reaction to find their way out.

Gases flowing from the kiln contain inert N_2, products of combustion - H_2O and CO_2 , combustible hydrocarbons and CO, and fine particulate matter derived from the coal and pellet feed. Combustible materials are consumed

FIG.


COAL STORAGE PILE
CONTINUED FROM BELOW
TO STREAM #63
TO STREAM NO. 6
EMERGENCY STACK CAP
40 GPM RAW WATER TO WATER JACKET
RAW WATER FOR EMERGENCY
TO VENTURI SCRUBBER
FROM KILN FEED END DUST
TO CEMENTATION PLANT STREAM #16
TO CHAR BIN
HAND SAMPLE
TO COOLING WATER COLLECTION SUMP
AVERAGE 8104 GPM
NORMAL 851 GPM
MAXIMUM 1013 GPM

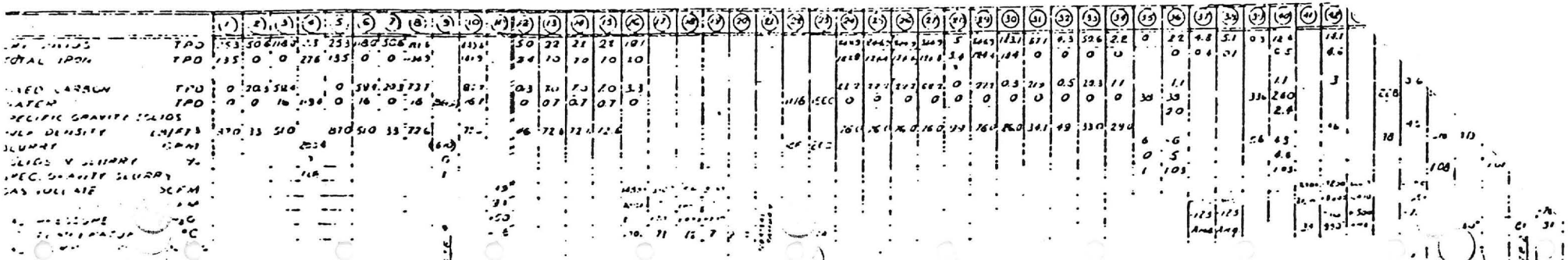
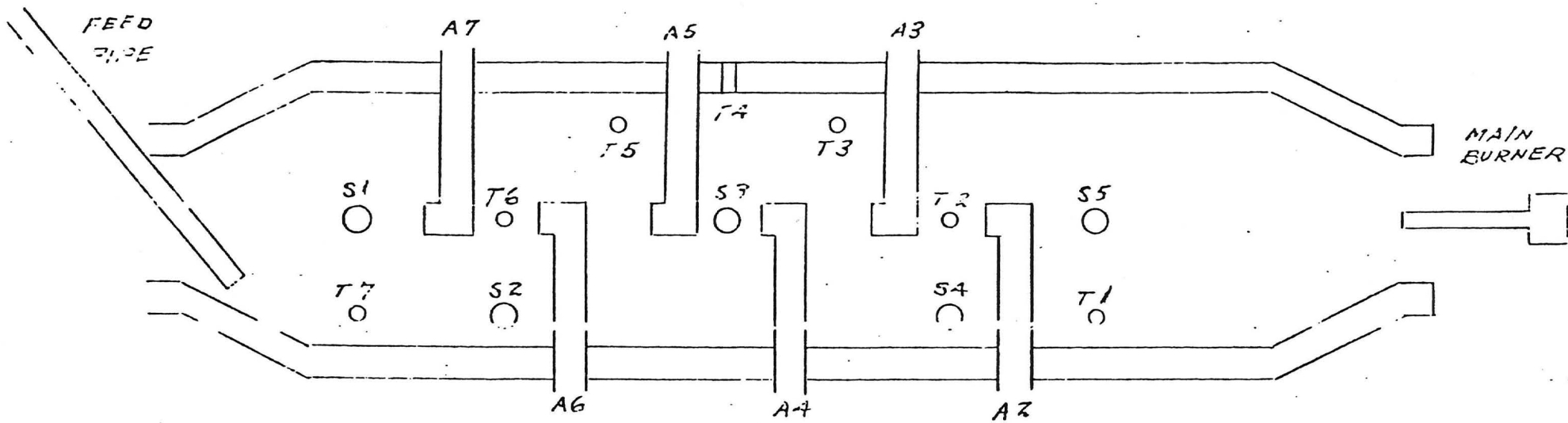


FIGURE 3

ARRANGEMENT OF AIR TUBES, THERMOCOUPLES AND SAMPLING PORTS IN ROTARY KILN



A - AIR TUBES
S - SAMPLING PORTS
T - THERMOCOUPLES

in a verticle cylindrical chamber called the afterburner by combustion air introduced into the afterburner at two levels. Water under very high pressure is sprayed into the afterburner immediately after the air in order to control the temperature . Additional temperature control water sprays are located at the kiln dust hood and at the afterburner outlet.

A portion of the hot gases from the afterburner are diverted to the leach residue rotary dryer as required. The remainder of the gases pass through a stainless steel scrubber for removal of particulate pollutants then through a damper and fan to stack. The scrubber is equipped with an adjustable venturi which automatically maintains a constant pressure drop, and therefore a reasonably constant collection efficiency, with a varying gas flow rate. The fan damper after the scrubber maintains the kiln hood pressure at the set point - normally slightly above atmospheric pressure - to prevent leakage of air which may cause reoxidation of the sponge iron. The rubber anti-corrosion lining of the scrubber fan scroll is protected from high temperature destruction by automatic shut down of the fan when the temperature of the gases exceed 80° C. When the fan shuts down, the afterburner emergency stack cap opens and kiln outlet gases are expelled directly to the atmosphere until the scrubber fan is restarted.

A water-cooled grizzly with 8-in. openings is installed in the kiln-cooler transfer chute to prevent plugging of the 18-in. dia cooler feed pipe by dislodged kiln accretions, tramp material, etc.

In the cooler the hot kiln product is cooled to a safe handling temperature, about 65° C, without reoxidation of the sponge iron. The above is accomplished in a horizontal rotary cylindrical vessel partially submerged in water. Heat is transferred from the load through the steel shell to the cooling water. Additional cooling of the shell is derived from water sprays at the hot feed end. Baffles within the cooler cause the load to be propelled forward as the cooler turns. A radiation type bin level measuring device and vibrating feeder unit are designed to maintain a minimum level in the cooler discharge hopper to prevent entry of air which would reoxidize the sponge iron. The belt conveyor which receives the cooler product is protected from inadvertently produced hot material by water sprays which are automatically turned on if the temperature in the cooler discharge hopper exceeds the set point, normally 150° C. In addition a flop gate simultaneously diverts all product to an emergency holding bin.

In the product separation area the entire cooler product is screened at 2-in. to remove large tramp material and accretions and is then elevated in internal discharge type bucket elevators and fed by means of a vibrating feeder to a drum type magnetic separator in which the magnetic sponge iron is separated from the non-magnetic unreduced iron oxide, char, and ash. The non-magnetic fraction drops to a double deck vibrating screen provided with a ¼-in. square mesh opening top deck and a 1 mm square mesh opening bottom deck. The plus ¼-in. oversize - consisting of tramp material, accretions, and unreduced pellets - is diverted to the waste pile. The minus ¼-in. plus 1 mm fraction, consisting mainly of char, is conveyed to the char bin for recycle to the kiln. The minus 1 mm fraction - consisting of fine char, ash, and fine unreduced iron oxide - is normally mixed with water and pumped as a slurry to the tailings pond but can be recycled via the char bin.

The sponge iron from the magnetic separator is weighed, sampled , and conveyed directly to the sponge iron pellet storage bin in the cementation plant. Typical chemical analyses of the char and sponge iron are given in Table II. In general 90 to 93 percent of the available iron can be reduced to metallic iron with a carbon to iron ratio of at least 0.1 in the product.

TABLE II CHEMICAL QUALITY OF PRODUCTS

CHEMICAL ANALYSES, PERCENT BY WEIGHT, DRY BASIS

MATERIAL	SPONGE IRON	CHAR
Fe (total)	66.7	5.4
Fe (metallic)	60.6	---
C	0.54	40.2
S	0.20	0.27

The production of iron from what would normally be considered a waste material, namely leach residue, for the purpose of precipitating copper from solution is considered to be unique in the industry. Certainly the decision to follow this path was influenced by the fortuitous circumstance in which the noble metals, gold and silver, in the sulfide ore follow the flotation concentrates to the leach residue to the sponge iron to the cement copper.

R.E.Hagen

Metallurgist-Sponge Iron

January 15, 1976

SL/RN SPONGE IRON PLANT AT HECLA MINING COMPANY LAKESHORE MINE

Norman G. Bishop
Superintendent Sponge Iron Plant
Robert Hagen
Metallurgist Sponge Iron Plant
Hecla Mining Company - Lakeshore Mine
Casa Grande, Arizona

ABSTRACT

This paper describes a 65,000 ton per year SL/RN plant designed to produce sponge iron from iron oxide leach residue which remains after roasting and leaching of chalcopyrite concentrates. The sponge iron is used to precipitate copper from solutions derived from acid leaching of oxide copper ores.

INTRODUCTION

The Lakeshore Mine of Hecla Mining Company is located on the Papago Indian Reservation in Pinal County, Arizona. Development of the underground mine, which produces both sulfide and oxide copper ores, was started in 1970 and production of ore began in late 1975. Construction of the metallurgical plant started in 1972 and went into production in January 1976.

The Lakeshore Mine is designed to produce 9000 tons per day of sulfide ore and 6450 tons per day of oxide ore. Both ore bodies are mined by continuous panel-caving. The sulfide ore is crushed in an underground primary crusher and transported to the surface on a 42-inch by 7200-foot belt conveyor. The oxide ore is hoisted to the surface through a 14-foot circular vertical shaft and crushed to size for bedding and leaching with sulfuric acid in 6450 ton vats. The resulting copper sulfate solution is treated with powdered sponge iron to precipitate the copper. The copper precipitate is vacuum filtered and pelletized for shipment to smelters for further refining.

The sulfide ore is processed through a 9000 ton per day flotation concentrator to produce 400 tons per day of copper sulfide concentrate. The sulfide concentrate is roasted and the resulting calcines are leached to produce a pregnant liquor which yields 30,000 tons per year of high purity cathode copper when treated by electrolysis. Two hundred tons per day of by-product sulfuric acid are produced from the SO_2 generated in the roasting operation. This acid is used to leach copper from the oxide ore. Another by-product of the roast/leach operation, about 250 tons per day of iron bearing leach residue, is converted to sponge iron via the SL/RN direct reduction process.

SELECTION OF METALLURGICAL PROCESSES

Extensive pilot plant work was carried out between 1969 and 1972, to determine the most beneficial way to extract the valuable metals from the ores. The following criteria guided the process selection: (1)

1. The process must meet the pollution control standards proposed at the time by Federal and State Environmental Protection Agencies and must have a reasonable capability of adapting to more stringent standards should they be imposed in the future.

2. The process should take advantage of the fact that the ore body consisted of both oxidized and sulfide mineral portions that could be mined concurrently. Practically, this meant it must incorporate conversion of the sulfur in sulfide flotation concentrate to sulfuric acid for use in the treatment of the oxidized ore.

3. The process should produce standard marketable copper shapes.

4. The process should be adaptable to relatively small scale operations with minimum loss of efficiency.

5. The process must have been reduced to successful commercial use.

PILOT PLANT WORK

Research work conducted by Hecla process engineers determined a flowsheet that could meet all selection criteria. A roast/leach/electrowinning (RLE) process was selected and a pilot plant was designed, built, and operated by Hecla personnel at the mine site. The pilot plant operated from September, 1971 until February, 1973.

Sponge Iron Test Work

Leach residue produced by the RLE process contains about 50% iron, 2% copper, 0.1 oz/ton gold, and 5 oz/ton silver. Conversion of this material to sponge iron for copper precipitation not only provides the source of iron but also results in the recovery of significant amounts of copper, gold, and silver which report in the cement product.

To test the feasibility of direct reduction of the roast-leach residue, samples were sent to representatives of three different processes for laboratory examination. In each case the preliminary tests indicated that the material was readily reducible.

Studies by the Hecla process development staff indicated that coal, rather than natural gas, would be the preferred reductant due to the outlook of gas shortages at the time the studies were made (early 1973). Lurgi Chemie und Hüttentechnik GMBH of Frankfurt Germany, representing the SL/RN Process, was selected to conduct more extensive work in their Frankfurt laboratories with full participation of Hecla engineers.

SL/RN Pilot Plant Project

Following successful completion of the laboratory work, continuous pelletizing and reduction tests were carried out in the Lurgi pilot plant. Raw materials consumed in the pilot testing included:

1. Three hundred fifty tons of leach residue produced in Hecla's RLE pilot plant.

2. Twenty tons of magnetite concentrate produced in Hecla's pilot concentrator.

3. Three hundred tons of Gallup, New Mexico sub-bituminous coal.

4. Two tons of Wyoming bentonite.

The data collected in the pilot project served as the basis for design of the Lakeshore sponge iron plant. Two significant design decisions resulting from the pilot project were: 1) Pellets should be fully indurated before entering the kiln. This was felt to be necessary because pellets made from the leach residue are relatively weak compared to conventional oxide pellets. Laboratory studies had demonstrated that the minimum compressive strength reached during reduction was directly proportional to the pellet strength prior to reduction. 2) For efficient operational control, pelletizing and reduction plants should operate completely independent of one another.

Design and Construction

Primary design of the sponge iron plant was done by Lurgi in close cooperation with the Parsons Jurden Division of Ralph M. Parsons Company and Hecla engineers. The pelletizing grate was supplied by Dravo Corporation, Lurgi's North American representative.

The plant was erected by Hecla with on site supervision by Parsons and Lurgi engineers. The sponge iron plant is operated under a licensing agreement with the SL/RN partners.

DESCRIPTION OF PELLET PLANT EQUIPMENT AND PROCESS

An artificial hematite (leach residue) produced by roasting and leaching of sulfide concentrates is filtered by two 8-foot by 16-foot drum type filters. Leach residue filter cake is conveyed from the filters directly to a rotary dryer or is stockpiled to be reclaimed later. Fresh filter cake normally runs between 28% to 32% moisture and filter cake reclaimed from stock normally runs between 18% to 22% moisture.

Drying

Filter cake drying is done in a Koppers rotary dryer (9 feet by 55 feet), to which hot gases for the drying process are supplied by either a 17 million Btu/hr fuel oil burner or by hot gas off the afterburner of the SL/RN reduction kiln (Figure 1).

Due to the corrosive nature of the leach residue, the rotary dryer is constructed of stainless steel with lifters and chains to help break up the wet filter cake and encourage heat transfer as the material passes through the dryer. Hot gases are pulled through the dryer concurrently with the flow of material. A Ducon stainless steel wet scrubber is used to clean the off-gas and induce the draft.

Balling

After drying, the leach residue containing 4% to 8% moisture is conveyed directly to a 250 ton capacity stainless steel mass-flow type bin. Leach residue is metered from the bin to a collecting belt where it is blended with about 0% - 30% magnetite and 0.5% bentonite by two Pekay belt mixers. Water may be added to the material (as needed) ahead of the second belt mixer. Final water additions are made directly on the balling disc (Figure 1).

Balling is done on a 16-foot diameter rotating disc designed by Dravo. The desired green ball size range is between 1/4 and 3/4 inch. Green balls from the disc are conveyed to the induration grate by a reversible conveyor belt and passed over a roller screen conveyor set at a right angle to the traveling grate. The roller screen removes the undersize (minus 1/4 inch) green balls which recycle back through the belt mixers to the disc. See Tables No. I and No. II for chemical and physical analysis of leach residue and magnetite.

Table I - Chemical Composition of Leach Residue and Magnetite

Constituent	Leach Residue %	Magnetite %
Fe	47.3	50.2
Fe^{++}	1.1	16.6
SiO_2	16.2	10.2
Al_2O_3	0.02	----
CaO	1.9	----
MgO	5.6	----
S	1.11	0.51
Cu	3.0	0.22
Au	0.05	----
Ag	3.69	----

Table II - Screen Analyses of Leach Residue and Magnetite

Screen Size	Wt. %	Cum. %	Wt. %	Cum. %
65	3.87	3.87	9.04	9.04
80	2.39	6.26	12.78	21.83
200	10.52	16.78	39.86	61.69
270	6.16	22.94	16.26	77.95
325	2.45	25.39	6.58	84.53
400	0.70	26.10	2.92	87.45
-400	73.90	100.00	12.55	100.00

Induration

The Dravo design traveling grate induration machine is one meter wide by twenty-eight meters long and has a maximum capacity of 350 tons per day. Heat for the induration process is supplied by one 32 million Btu/hr central burner and two 2-million Btu/hr auxiliary burners located over windbox No. 4. High temperature by induced draft (1250°C) induration gases from the central combustion chamber flow downward through a manifold hood to windboxes No. 5 through No. 10.

Hot gases recuperated from windboxes No. 7 through No. 10 are tempered to 300°C by fresh air and split to supply drying gases for windboxes No. 1, 2, 3, and 4. Gases are induced to flow downward to windboxes No. 3 and No. 4, and oppositely placed side burners supplement heat requirements in the hood over windbox No. 4. The first stage of green ball drying is done by updraft gases at 300°C through windboxes No. 1 and No. 2.

Hot pellets passing out of the high temperature firing zone of the furnace are cooled to less than 80°C by updraft fresh air through windboxes No. 11, 12, 13 and 14. The temperature of the cooling air is raised to approximately 650°C as the air passes up through the hot pellets and supplies preheated excess combustion air for the central burner.

Cooled indurated oxide pellets are screened to desired size (plus 1/4 inch by minus 3/4 inch) for the reduction process and conveyed directly to a 500-ton holding bin. The oxide pellets contain about 48% to 50% Fe; 20% to 25% insol; and 1.5% to 2.00% Cu. See Table III-A for average chemical and physical analysis of oxide pellets.

Table III - Reduction Kiln Feed Material

A. Hecla Oxide Pellets

Chemical		Physical		
Const.	Percent	Screen Size	Wt. %	Cum. %
Fe$_{T}$	49.50	3/4	0.21	0.21
Fe^{++}	0.27			
SiO_2	16.7	3/8	48.87	84.30
Al_2O_3	0.02	6m	14.75	99.05
CaO	2.0	-6m	0.95	100.00
MgO	5.8			
S	0.028			
Cu	<2.00			
Ag	2.99 oz/ton			
Au	0.03 oz/ton			

B. Gallup Coal

Chemical		Physical		
Const.	Percent	Screen Size	Wt. %	Cum. %
H_2O	7.79	1	32.84	32.84
F.C.	42.06	1/2	19.08	51.97
V.M.	39.98	1/4	16.75	68.67
Ash	18.00	16m	19.11	87.78
S	0.80	-16m	12.22	100.00

Gross caloric value Btu/lb. 10,000 - 11,695

Reducing Atmosphere:

	F°	C°
Softening Point	2174	1190
Melting Point	2300	1260
Flow Point	2525	1385

DESCRIPTION OF REDUCTION PLANT EQUIPMENT AND PROCESS

The indurated oxide pellets are reduced with coal by the SL/RN Process in a 12-foot by 164-foot rotary kiln. The reduction system is designed to produce 250 tons of sponge iron per day at 91% metallization.

Feed Material

Oxide pellets are metered from a 500-ton holding bin by a vibrating feeder screen (to remove minus 1/4 inch fines) to a weighing conveyor (Figure 2). Minus 3-inch Gallup coal is metered unscreened from a 250-ton holding bin to a weighing conveyor. The coal as received at the Lakeshore Mine contains between 40% to 45% fixed carbon and 15% to 20% ash (Table III-B).

Char, a by-product of the reduction process, is screened to remove excess ash and the minus 1/4 inch by 16 mesh fraction is recycled with the kiln feed via a 40-ton holding bin and belt feeder system. Char in the recycle size range averages 53.69% fixed carbon and 42.9% ash (Table V).

Reduction Process

The kiln feed is collected on a common conveyor belt and transported to the feed end of the kiln. The mixed feed material passes into the kiln through a feed tube that is pressure compensated by a kiln seal blower. As the feed material passes through the kiln the temperature in the bed is carefully controlled by the addition of combustion air through six air tubes located along the length of the kiln (Figure 2). Hot reducing gases pass through the kiln counter-current to the flow of feed material.

Afterburner

Hot combustible gases passing out of the kiln are burned by the addition of fresh air (through burner tubes located in the afterburner) to reduce the free carbon and carbon monoxide to acceptable environmental levels. The afterburner temperature is controlled by high pressure spray water. A portion of the hot gas is taken off the afterburner and used to dry leach residue in the rotary dryer previously described (Figure 1). A 600 hp induced draft fan pulls the excess afterburner gas through a wet venturi scrubber to remove the particulate material.

Cooler

Hot sponge iron and char pass out of the reduction kiln through a transfer chute and into a 10-foot by 100-foot Koppers rotary cooler. The transfer chute between the kiln and cooler contains four water cooled grizzly bars set on a 35° slope and spaced nine inches apart to divert oversize material to a discharge chute.

The cooler is horizontal and rotates at 4.1 rpm in a water filled concrete tank. Additional shell cooling is provided by external water sprays along the first 35 feet of the feed end. Material is moved through the cooler by angled steel flights and removed from the cooler by steel lifters.

Production Separation

Sponge iron and char discharge from the rotary cooler into a holding hopper that serves as an air lock to prevent fresh air from entering the cooler. A nuclear level gauge and a variable speed vibrating feeder act to maintain the air lock by holding a relatively constant material level in the hopper.

Cooled sponge iron (normally 50 to 75°C) mixed with char and other non-magnetics pass across a 2-inch screen to remove oversize material and then through a magnetic separator to separate the sponge iron from the non-magnetic material. The sponge iron is weighed and conveyed to a 500-ton capacity closed storage bin. Table IV shows the average chemical analysis for sponge iron. The non-magnetics are screened to remove the minus 1/4-inch by 16-inch mesh char for possible recycle as previously described. See Table V for chemical and screen analyses of char.

Table IV - Chemical Composition of Sponge Iron

Constituent	%
Fe_T	59.87
Fe_M	54.48
SiO_2	19.70
Al_2O_3	0.02
CaO	2.40
MgO	6.80
S	0.12
Cu	3.31
Ag	3.82 oz/ton
Au	0.04 oz/ton
Metallization	91.00

Table V - Chemical Composition and Size Analyses of Non-Magnetics

Constituent	-1/4" X 16m(%)
F.C.	53.69
V.M.	2.84
Ash	42.96

Screen	Weight %	Cumulative %
1	0.22	0.22
1/2	8.29	8.51
3/8	9.25	17.76
1/4	6.28	24.04
16m	60.50	84.54
32m	8.50	93.04
-32m	6.96	100.00

HISTORY OF OPERATIONS

Start-Up Training

One month prior to completion of sponge iron plant construction both hourly and supervisory personnel were selected to participate in the pre-start-up training program. Supervisory personnel were sent to the Acos Finos Piratini-SL/RN Plant near Porta Alegre, Brazil for two weeks of on-the-job training. Hourly operating personnel attended classroom and field training sessions conducted by both Lurgi process engineers and Hecla supervisors. Final check-out and run-in of plant equipment was integrated as part of the training program.

Operations

A total of six reduction campaigns were made between the initial start-up date, September 30, 1975, and the end of 1976. Due to start-up schedules in the mine in late 1975, the production of oxide copper ore created a need for sponge iron before sufficient leach residue (from sulfide copper ore) was available for sponge iron production. In order to meet the metallurgical plant iron requirements the first reduction campaign was made with five thousand tons of blast furnace quality iron oxide pellets purchased from the Eagle Mountain Pellet Plant of Kaiser Steel Company.

Reduction Campaign I

Reduction Campaign I, started on September 30, 1975, was brought to a successful conclusion on October 16, 1975 when the supply of purchased pellets was depleted. A total of eight hours downtime was recorded during the sixteen day campaign, thus plant availability was 98.1%. Most of the downtime recorded was due to the usual start-up problems with material handling equipment and bugs in the electrical/instrumentation systems.

On the basis of iron (Fe) throughput, the reduction plant achieved 91.6% of capacity and averaged 93.8% metallization for the campaign (Table VI). Sufficient sponge iron was produced during the short campaign to supply the copper precipitation requirements through April, 1976. Sponge iron was stockpiled on the ground with no cover from mid-October, 1975 to mid-April, 1976 with only one to two and a half percent loss in metallization during the storage period. It should be noted however, that the Lakeshore Plant is located in an area that receives only six to eight inches rainfall per year.

Reduction Campaign II

During the first quarter of 1976, the oxide mine production continued to run ahead of the sulfide mine causing the need for sponge iron to exceed the supply of leach residue. A second purchase of iron oxide pellets (2500 tons) was made from Kaiser Steel Company, and Campaign II started on April 16, 1976.

The operating plan for Campaign II was to consume the purchased pellets during the first eight to nine days and then switch to domestic (Hecla) pellets for the remainder of the campaign. The purchased pellets were depleted in eight days and the kiln feed switched to Hecla pellets. Due to start-up delays in the pellet plant, an insufficient stockpile of Hecla pellets was available to support the reduction plant feed requirements. After only two days on Hecla pellets it became necessary to place the kiln on "hold" to allow the pellet plant to catch up. It was thought at the time the hold on the kiln would last only two to three days.

Starting up the pellet plant had its own set of problems and delays and the kiln hold lasted ten days. With a small reserve of Hecla pellets on hand, pellet feed to the reduction kiln was resumed on May 6. Almost immediately large accretions that had formed during the hold period started coming out of the kiln. The water-cooled grizzly bars in the kiln/cooler transfer chute withstood the pounding of the accretions for two days before one of the grizzly bars bent and allowed large "chunks" to pass through and plug the throat of the transfer chute. Efforts to clear the blockage were unsuccessful and Campaign II was ended on May 9, 1976.

Reduction Campaign III

The kiln was cleaned of all accretions and ring material from Campaign II and made ready for Campaign III in fourteen days. Due to the blockage in the throat the chute was full of material that sintered during the cool down period and it took five days (of the fourteen) to clear the transfer chute.

New and larger water cooled grizzly bars were installed and Campaign III started on May 25, 1976. The larger grizzly bar has since proven to be adequate for the job.

Campaign III was the first campaign made on 100% Hecla indurated pellet feed. Production of Hecla indurated pellets was slowed by operator inexperience with drying leach residue and balling feed material that constantly changed in moisture content. The small stockpile of indurated pellets was exhausted after only fourteen operating days, and it was decided to terminate the campaign rather than place the kiln on hold again as in Campaign II. Campaign III ended on June 9, 1976.

From an operational and technical point of view, Reduction Campaign III was a success. The average sponge iron metallization for the campaign was 92.0% and plant availability was 100% as no downtime was experienced (Table VI).

Reduction Campaign IV

Campaign IV started on July 1, 1976, and ended August 22, 1976. Again 5000 tons of Kaiser pellets were purchased to supplement the iron requirements. Leach residue production during this period supplied only about half the iron requirements.

The operating plan for Campaign IV was to start the campaign with Hecla pellets then switch to purchased pellets until they were depleted and then switch back to Hecla

pellets to complete the campaign.

As planned, Hecla pellets were fed to the kiln for the first 23 days, then purchased pellets for 20 days, then finally Hecla pellets were used during the last nine days of the campaign. The campaign lasted 52 days and is the most successful campaign to date. Plant availability during the campaign averaged 97.5%. Sponge iron metallization averaged 89.2%, and the guaranteed carbon (new coal) to iron ratio was achieved while using Hecla pellets (Table VI).

Campaign IV ended August 22, 1976, and the kiln was cleaned out and made ready for the next campaign. Sufficient sponge iron was produced and stockpiled to supply the metallurgical needs through mid-September.

Reduction Campaign V

Campaign V started September 16, 1976 and ended October 24, 1976. This campaign was made with 100% Hecla oxide pellet feed. The campaign was plagued early with a series of electrical outages and a partial ring formed in the area between number three and four air tubes during the first week of the operation.

Unusually heavy rainfall in September added to the problems by wetting the coal stockpile and wet coal plugged bins, feeders, and belt transfer points throughout the system. Numerous short term coal outages were experienced during the second and third week of the campaign.

On the 21st day of the campaign a zero speed switch failure caused the kiln feed belt to burn and all kiln feed was stopped for ten hours while repairs were made. Electrical problems caused temporary outages of No. 6 shell fan several times during the campaign.

Due to numerous feed outages during the campaign, metallization was very difficult to control and local overheating in various areas of the kiln was common. Ring formations in the area between number three and four air tubes increased to such proportions that abnormal backflow of kiln feed was first noted on the thirty-fourth day of the campaign. The rate of backflow continued to increase over the next five days and the campaign was terminated on October 24, 1976.

The relatively soft ring formations were removed and the kiln was made ready for the next campaign in fifteen days.

Campaign V lasted 38 days and plant availability dropped to 88.2%. The campaign metallization averaged only 87.0%, due to the problems described above.

Reduction Campaign VI

Campaign VI started on November 9, 1976 and ended December 15, 1976. The campaign was again cut short due to lack of pellet feed. The pellet plant was shut down early in December to repair refractories in the combustion hood and the pellet inventory was depleted before the plant could get back into production. Since the sponge iron inventory at the time was sufficient to last through January, it was decided to terminate Campaign VI rather than place the kiln on hold for one or two days while the pellet plant got back into production.

Campaign VI recorded a very good 99.3% plant availability and metallization averaged 89.0% (Table VI).

SUMMARY

The SL/RN direct reduction kiln at the Hecla Mining Company, Lakeshore Mine started up in September, 1975, using pellets purchased from Kaiser Steel Company. Construction of the induration pellet plant was completed in March, 1976 and the plant started producing iron oxide pellets in April, 1976. Purchased pellets were used in part or whole during three of the first four reduction compaigns.

In six reduction campaigns during the first year of operations the average availability of the reduction plant was 96.5% and the sponge iron produced was adequate to meet the requirements for copper precipitation. The early successful achievement of operating and production goals was brought about by the total commitment of Hecla Management and the SL/RN group (represented by Lurgi Chemie und Hüttentechnik GMBH) to make the plant work; by pre-training an interested work force recruited from the versatile, readily adaptable construction workers who built the plant; and by the individual efforts of dedicated front line supervisors.

References

1. Griffith, W. A.; Day, H. E.; Jordan, T. S.; Nyman, V. C.; "Development of the Roast-Leach-Electrowinning Process for Lakeshore", Journal of Metals, pp 17 - 25, February, 1975.

Table VI - Reduction Campaign Data

CAMPAIGN	I	II		III	IV		V	VI	Design Rates
Pellet Type.....	P	P	H	H	P	H	H	H	H
Operating Days....	17	8.33	7.66	14.2	22	30	38	35	
Downtime Hours....	8	19	21	0	20	11	59	6	
% Operating Time..	98.1	90.5	88.6	100	96.22	98.5	88.25	99.3	
KILN FEED RATE									
Pellets TPH.....	10.54	10.51	9.27	9.9	99.0	10.3	9.9	9.8	14.6
% Fe_T.....	63.40	63.86	50.01	49.36	63.80	48.90	47.60	48.30	53.4
Coal TPH.....	8.71	8.82	6.87	8.20	7.30	6.50	5.90	6.00	7.6
% Fixed Carbon....	41.70	41.01	40.25	40.40	43.20	43.80	41.30	42.63	50.0
F.C./Fe Ratio.....	.574	.540	.597	.678	.690	.502	.517	.540	0.502
PRODUCTION									
Sponge Iron TPD...	187	200	147	173	136	173	175	171	250
% Metallization...	93.80	88.20	86.10	92.00	89.22	89.11	87.00	89.00	91
Start.....	9/30/75	4/16/76		5/25/76	7/1/76		9/16/76	11/9/76	
End.....	10/16/75	5/9/76		6/9/76	8/22/76		10/24/76	12/15/76	

H = Hecla Pellets

P = Purchased Pellets

$$\%\ \text{Plant Availability} = \frac{\text{Actual Oper. Hrs.}}{\text{Ideal Oper. Hrs.}}$$

$$= \frac{(\text{Ideal Oper. Hrs} - \text{Downtime})}{\text{Ideal Oper. Hrs.}} \times 100$$

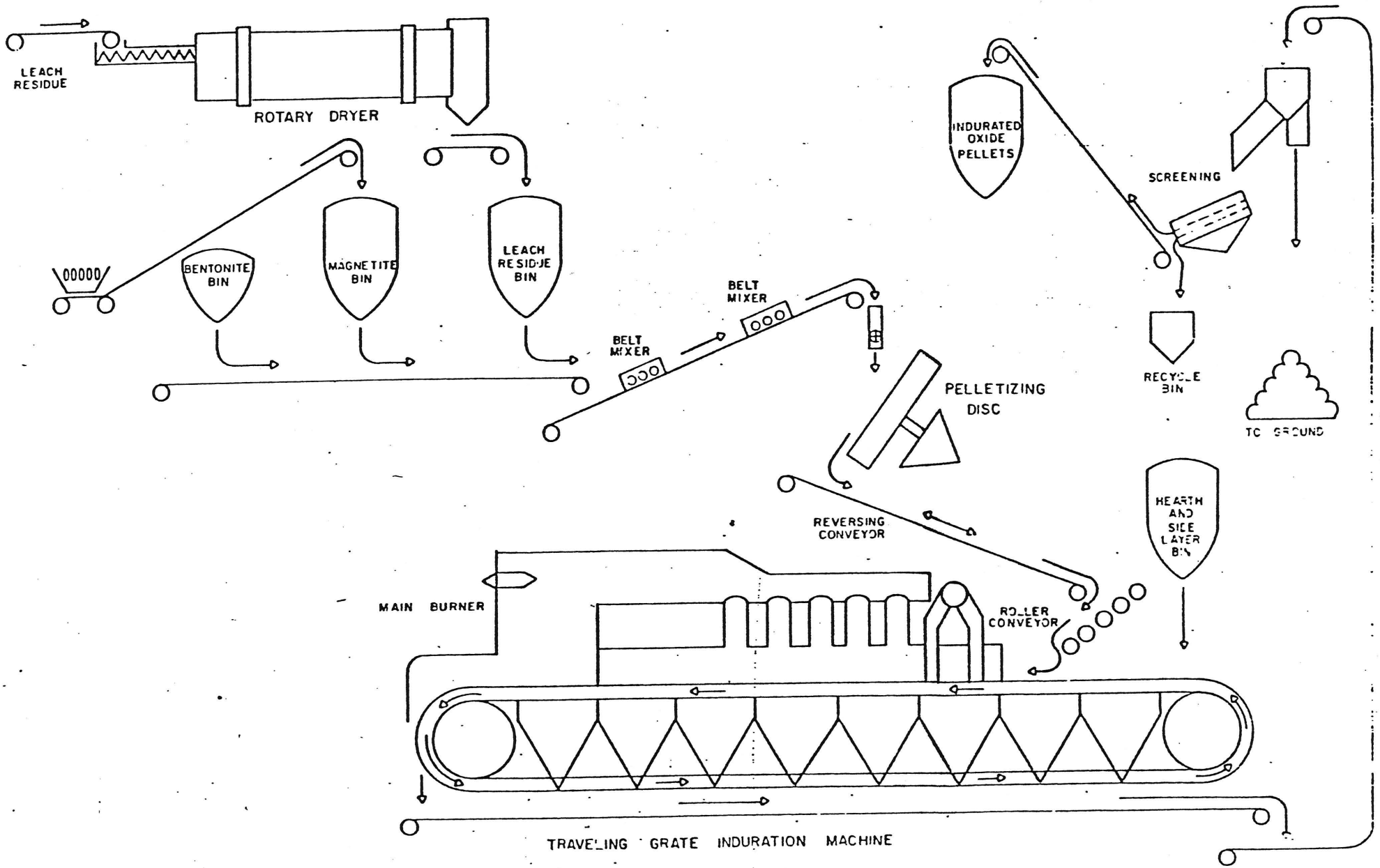


FIGURE 1. FLOWSHEET OF LAKESHORE PELLETIZING PLANT

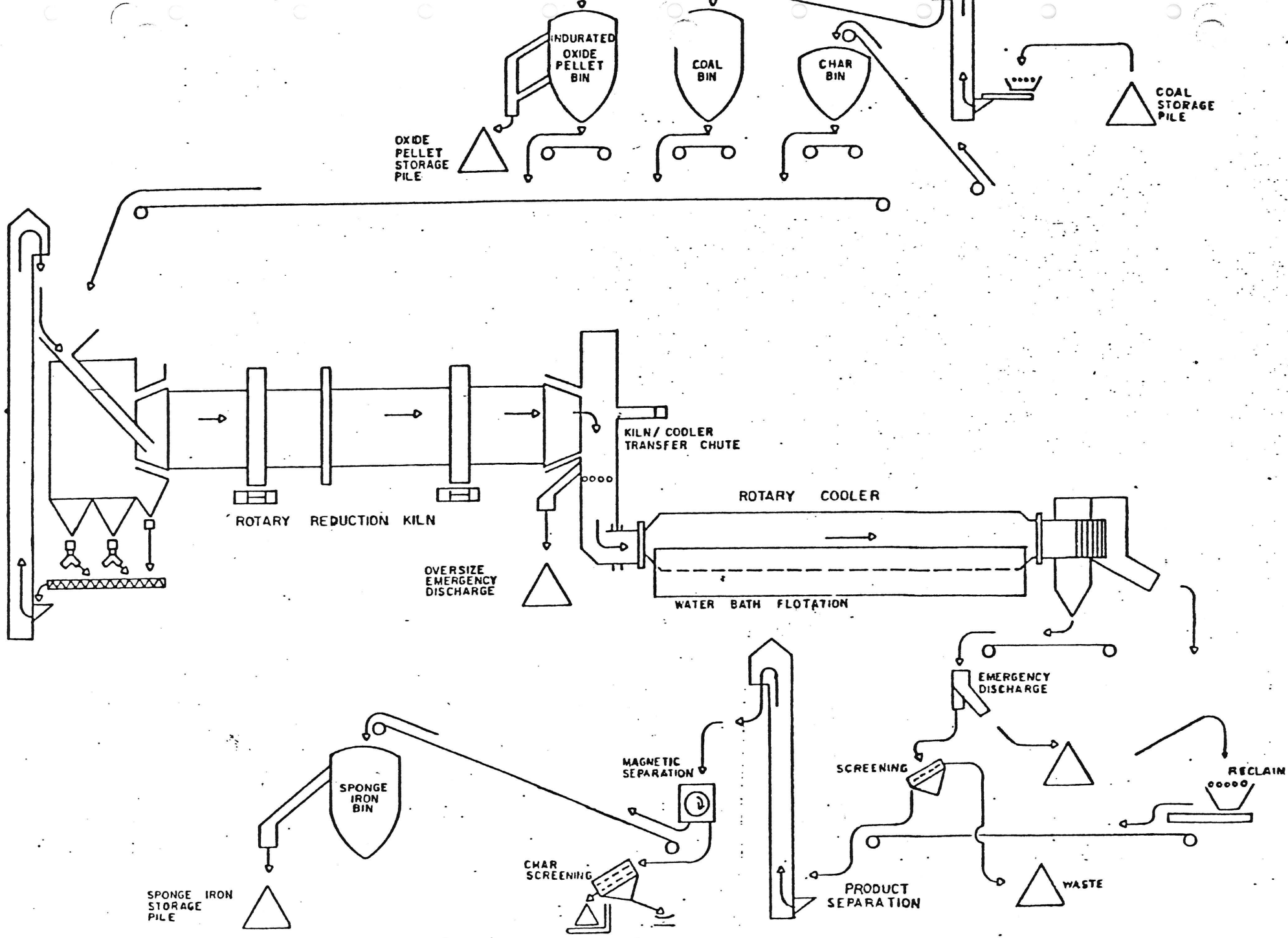


Figure 2. FLOWSHEET OF NORANDA DIRECT REDUCTION IRON PLANT

The conveyor immediately following the disc may be reversed to reject green balls of poor quality or may be run forward to discharge green balls over a spreader roll to the grate roller feeder. Unwanted fines (minus ¼-in.) fall through the gaps between the rollers and are recycled to the system. The bias of the roller feeder (rollers become progressively shorter across the grate) produces an even distribution of green pellets on the grate machine while feeding at an angle of 90° to the direction of grate movement.

For protection of grate bars and pallets a 10-cm hearth layer of previously indurated pellets is placed on the grate prior to the 30-cm layer of green balls, and a sidewall layer is fed concurrently with the feeding of the green balls.

The purpose of the moving grate machine is to heat the iron oxide balls to a temperature of 1250° C - 1300° C and then cool them to ambient temperature with a minimum consumption of energy - fuel oil and electric power in this case. Near the temperature of incipient fusion of the constituent materials the atoms that make up the balls become mobile, grain growth takes place among adjacent grains and new compounds are formed by chemical combination of the contained silica, alumina, calcia, magnesia, and iron oxide. Upon cooling, the balls become hard and strong, yet porous, and are able to withstand forces of degradation even at a temperature of 1050° C while undergoing reduction.

The Lurgi method of indurating iron oxide balls by heat treatment is illustrated in Fig. 2. Energy is conserved by recycling heat to the process by means of upward and downward flowing gases. As the bed of green balls containing about 22 percent moisture moves over the first two windboxes, it is subjected to an upward flow of hot (350° C) gases recuperated from the firing zone to dry the bed. Drying is completed by downdraft flow of the same hot recuperated gases at windboxes #3 & #4. Auxiliary oil burners in the downcomers are used to raise the temperature of the gases in the hood over windbox #4 and additional burners can be installed in downcomers over windbox #3 if required in the future; however, the application of heat, and therefore the rate of drying, is limited by the tendency of balls to decrepitate if water vapor is formed too rapidly.

Hot gases from the furnace, tempered to about 1000° C , flow downdraft at windbox #5 to preheat the bed. At windbox #6 through windbox #9, the firing zone, the bed above the hearth is heated by untempered gases from the furnace to 1250° C - 1300° C and is held at this temperature through the afterfiring zone, windbox #10, to allow the indurating mechanisms to proceed. Air to windbox #10 is short-circuited from the updraft cooling air which provides preheated direct recuperated secondary air to the furnace.

Cooled pellets are fed from the grate discharge hopper by a vibrating feeder screen which rejects plus 1½-in. material to the waste pile. As it passes under and traverses the entire length of the indurating machine, the grate product belt conveyor receives all windbox dust fed through double dump valves as well as grate drippings. The material from the above conveyor is elevated in internal discharge type bucket elevators to feed a vibrating screen with a 3/4-in. opening top deck and a ¼-in. opening bottom deck. The plus 3/4-in. fraction and the minus ¼-in. fraction are diverted to the indurated pellet recycle bin. A variable speed belt feeder delivers the recycle material to a hammermill and the crushed hammermill product is returned to the curcuit via raw material belt conveyor # 1.

TECHNICAL REPORTS ON THE OPERATION OF THE LAKESHORE MINE