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ARIZONA CONFERENCE, AIME

SMELTING DIVISION

1986 SPRING MEETING

JUNE 21, 1986

PHELPS DODGE CORPORATION

DOUGLAS REDUCTION WORKS

DOUGLAS, ARIZONA

T A B L E   O F   C O N T E N T S

A DESCRIPTION OF

PLANT AND OPERATION

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PHELPS DODGE CORPORATION

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DOUGLAS, ARIZONA

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JUNE, 1986

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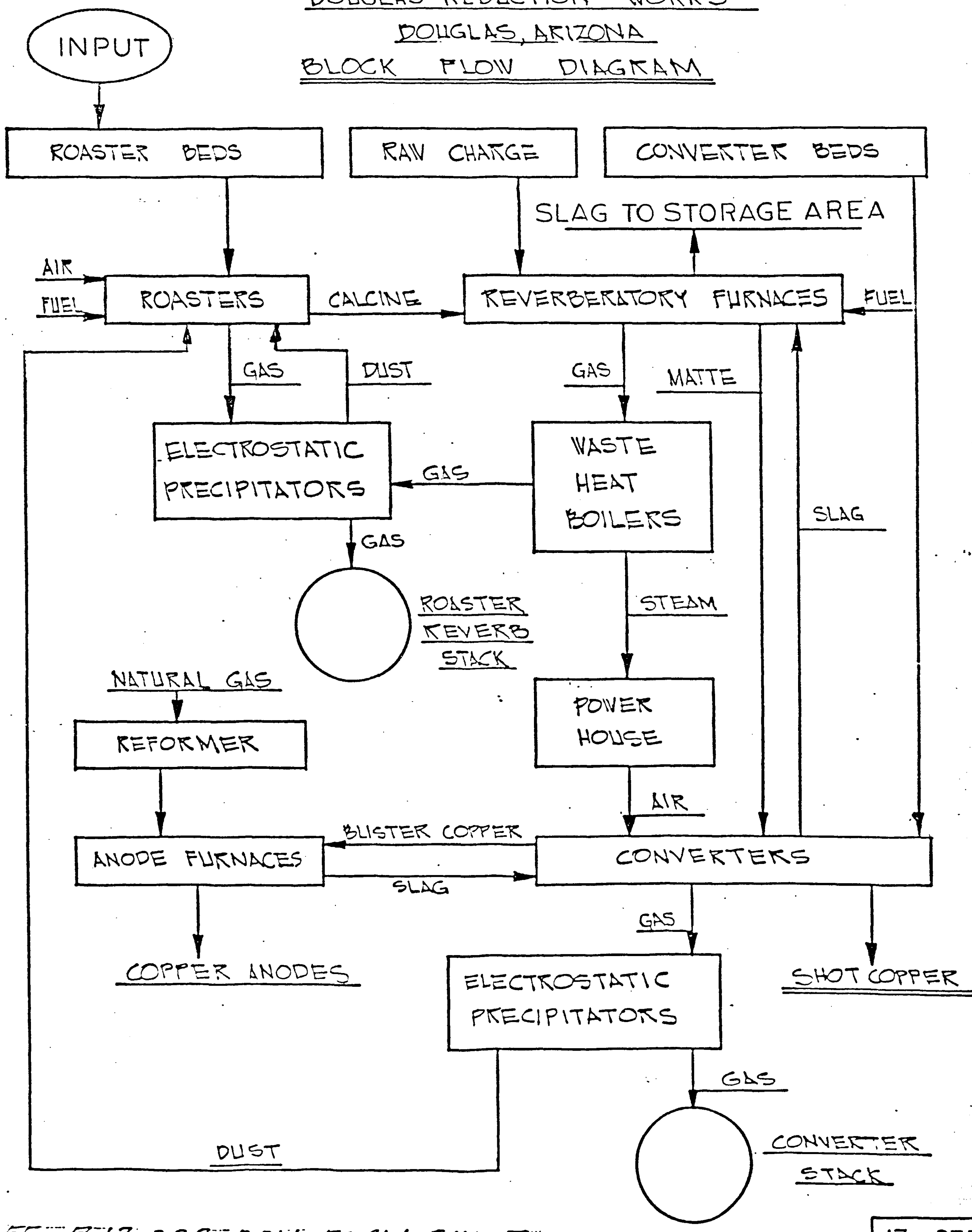
BLOCK FLOW DIAGRAM



REF. B17-222 DRW FLOW SHEET

A DESCRIPTION OF PLANT AND OPERATION

GENERAL

The Douglas Reduction Works consists of the Smelter and ancillary facilities required for the treatment of concentrates, ores, scrap copper, refinery slags, and copper precipitates. Anodes are shipped by rail to Phelps Dodge Refinery at El Paso, Texas.

Major units and operations included in this description are as follows:

1. Preparation Department
2. Scrap Brass Plant
3. Plant Metallurgy
4. Roaster Department
5. Reverberatory Department
6. Converter Department
7. Anode Plant
8. Power House
9. Precipitators
10. Miscellaneous
11. Supplementary Control Systems

PREPARATION DEPARTMENT

The Preparation Department is responsible for the receipt, unloading, sampling, preparation, bedding and reclaiming of ore, concentrate and flux. All operations are performed as required on day shift with the exception of reclaiming.

Receipt of Material

Most plant receipts are by rail with Rail Switching Services, Inc. crews handling yard movement. A 200-ton capacity railroad scale is installed for weighing rail shipments.

A truck receiving facility is available for handling barren silicious flux and some custom ores. Truck scales are available for custom receipts. Flux accounting is accomplished through the use of a belt scale.

Concentrate Handling

Concentrates are received in special bottom dump concentrate cars and are dumped directly into receiving bins from which they are transferred by belt conveyor directly to the bedding plant. Limerock may also be handled through this system.

Concentrates are removed from the receiving bins by automatic, timed belt feeders. A sample is cut from the belt by an automatic sampler during transit.

Crushing Plant

Mine-run ores, limerock, and silica flux are dumped into separate receiving bins from 100-ton bottom dump ore cars. The receiving bins are a continuous structure of sixteen separate bins with a total capacity of approximately 7,000 tons.

Crushing Plant - Continued

Ore is drawn from any one of the bins through ore gates onto a rail-mounted pan feeder from which it is transferred by a 36-inch conveyor belt to the primary crusher. Due to the large amount of tramp iron and wood, belt magnets and hand picking must be used to protect the crusher. The primary crusher, a 24 x 60 gyratory with hydroset mechanism, crushes the ore to minus 2-1/2 inches. The operator tends the crusher, picks wood from the belt, and monitors transfer of the ore to the screens by a system of probes, interlocks, and fail-safe devices interlocked to alarms and lights on a panel at the crusher. The product passes over a belt scale through an automatic sampler to the screening plant.

The screening plant consists of two surge bins and six rod deck screens. Two screens serve the primary ore screen bin and the remainder serve the secondary bins. Screening is to a nominal 1/4 inch. Undersize from all screens is transferred by a conveyor system to the bedding plant while screen oversize goes to the fine crushing plant. Two 78 x 24 inch rolls are used for fine crushing. Screen oversize from the two primary ore screens is crushed through one rolls crusher to minus 1 inch and sent to the secondary screen bins. Secondary screen oversize is placed in a closed circuit with the second rolls crusher which is at a closed setting.

Bedding Plant

The Bedding Plant consists of eight 10,000-ton mixing beds and seven 200-ton tanks. Five beds are normally used for roaster mixes, two are used for converter flux mixes, and one bed is used for raw charge mixes.

Bedding Plant - Continued

Materials from concentrate unloading and from the crushing plant can be handled independently on the eastern five roaster beds using separate parallel conveyor belt systems. Only one belt services the full eight beds. Belt scales weigh materials going to the system.

Each bed mix is made up using proportions of the various receipts as set by the Metallurgist. The materials are placed in layers over the full 270 ft. length of the bed. The normal roaster bed now averages 7,200 dry tons. Receipts are such that it is usually possible to maintain fairly uniform mixes.

Reclaiming

Bed reclaiming is accompanied by two reclaiming machines which are moved on a transfer car in a pit at one end of the beds. Roaster charge is transferred to the roaster plant twice each shift while barren silica for slurrying and reverb fluxing and converter flux are run once a shift. The use of interlocks, fail-safe devices and various controls enables a two-man crew to handle the reclaiming.

Sample Mill

Preparation of plant process and receipt samples is the responsibility of the sample crew. Sampling tasks not assigned as a part of the duties of operations crews are also performed. The automatic ore sampler is operated by the Sample Mill. Buckets on arms extending from a rotating shaft cut the ore stream. The sample passes through a 2-foot standard crusher where it is reduced to minus 1/2 inch. Crusher discharge is again

Sample Mill - Continued

cut by the sampler. The cut sample falls through a bank of splitters into pans and is further reduced by use of standard sample preparation devices such as rolls, grinders, and pulverizers.

Concentrates are automatically sampled at a belt transfer point as the material stream impinges on a rotating slotted disc. Sample material passes through the slot onto transfer belts to another slotted disc and falls into sample pans. It is still necessary to hand sample abnormally wet concentrates from the main belts.

SCRAP BRASS PLANT

Secondary copper-bearing material is handled through the Scrap Brass Plant where it is sampled, unloaded, and transferred by truck to the proper destination within the plant.

The scrap is sent directly to the Converter Aisle for smelting in the converters.

Scrap samples are taken during unloading. Normal treatment includes shredding or shearing to minus 2 inches, cone and quartering, matting the sample by melting with sulfur in a small furnace and then preparing assay pulps from the melts using standard ore sample preparation procedures. No. 2 copper samples are melted and a shot copper sample is taken for analysis.

The Scrap Brass Plant also handles copper precipitate receipts which are sampled with air-powered augers before unloading. Unloading is to a stockpile from which the material is transferred by truck to the bedding system.

PLANT METALLURGY

Roaster Charge

The roasters are charged from two types of beds. One bed is made up primarily with smelter foul slag and can be dried in two of the roasters for charging to the reverberatory furnaces during emission curtailments for the Supplementary Control System. Five beds are made up with smelter reverts, copper precipitates, concentrates, ores, scrap brass and refinery slag fines, and fluxes and are charged to the remaining roasters to make calcine for charging to the reverberatory furnaces during normal production. Materials to be placed on the roaster beds are determined by the Plant Metallurgist and are subject to material on hand and anticipated receipts. When possible, an effort is made to utilize all bed storage capacity so that variations between bed mixes can be minimized, and the actual composition of a bed can be known before the first reclaim from the bed.

Bed calculation requires that determination of all copper-bearing materials are assayed for SiO_2, Al_2O_3, Fe CaO, MgO, S, and metal values. The composition of all copper-bearing materials is calculated and summed, and the total SiO_2 requirement is determined based on the desired reverberatory slag composition which is established by observation of past smelter practice with slight modifications made for variations in composition of receipts.

Flux additions to the bed is not standard, however, and components of reverberatory slag from sources other than the roaster charge must be considered. The two primary sources of reverberatory slag components, other than roaster charge, are reverberatory hot patch slurry and converter slag.

Roaster Charge - Continued

The amount of slurry used in each sprung-arch reverberatory furnace varies little on a daily basis, and the amount of slurry used during the smelting of a bed can be determined by multiplying a daily slurry factor times the days smelting of the bed should require.

Converter slag additions to the reverberatory furnaces are dependent upon a number of factors. Amount of converter slag produced is dependent upon matte grade, secondaries additions, and flux additions. Composition of converter slag is dependent upon the composition of the materials placed into the converters with a slag containing approximately 26% SiO_2 and 26% Fe_3O_4 desired to achieve optimum smelting of secondaries with minimal magnetite input to the reverberatory furnaces. Converter flux beds are made up with silica flux diluted to 65% to 75% SiO_2 using ores and foul slags as diluents.

Matte grade is determined so that the available roasters can supply all the charge requirements of the reverberatory furnaces without producing more matte than the reverberatory furnaces can hold during curtailments or the converters can treat during normal production.

ROASTER DEPARTMENT

The Roaster Plant consists of twenty four, six-hearth roasters arranged in two parallel rows of twelve roasters. At full production, sixteen to twenty one roasters are in operation except when meteorological conditions limit operations to fewer than sixteen roasters.

Each roaster is fed from a separate 100-ton feed bin by two drum feeders. The feed rate is controlled by adjusting the tension on the feeder drive, and feed rate is varied to obtain the desired sulfur -- a higher feed rate will allow less sulfur to be removed from a fixed quantity of feed. From the feed bins, the charge falls onto a dry floor and is spread across the floor by blades on four arms rotating about a center column. From the dry floor, the charge drops to the outside of the floor of the first hearth and is raked inwards by rabbles, on two air-cooled arms that rotate about the center column. The charge is raked alternately in and out on the subsequent hearths and is turned over many times to allow exposure of sulfur to oxygen. Cold air is forced into the center column, passes through each of the arms to cool the arms and heat the air, and is discharged into the bottom hearth of the roaster. Supplemental heat is needed to initiate the exothermic reaction between sulfur and oxygen and is supplied by the combustion of natural gas or No. 6 Fuel Oil in the next to the bottom hearth. Calcine is discharged into hoppers from the bottom hearth.

The roaster shell is steel and is 21 feet 7 inches in diameter. Floors are cast with refractory material and sidewalls are fireclay brick. Rabble arms and rabbles on the lower three hearths are heat resistant cast steel.

REVERBERATORY DEPARTMENT

Two bath smelting furnaces and one side-charge furnace are used for smelting of roaster calcine. The furnaces are all 26 feet wide by 103 feet to 107 feet long inside. The bath furnaces have sprung silica arches maintained by hot patching with silica slurry, and the side-charge furnace is a flat suspended basic roof of panelized construction.

Charging

Calcine is hauled from the roasters in tanks moved by electric trolley. Each furnace is charged from two tanks, one on each side of a furnace, forty-five times each day. The bath furnaces are charged by gravity flow through Wagstaff feeders, two on each side of each furnace; and two enclosed drag chains convey charge to drop holes at 4-ft. intervals along the sides of the side-charge furnace. Charge smelts on the surface of the bath furnaces and on the sidewalls of the side-charge furnace.

Matte Tapping

Each furnace has four tap holes, two on each side of the furnace. Matte is tapped from the furnace on demand of the converters and flows through copper launders to ladles in the Converter Aisle. The launders are covered for collection of fumes.

The tap holes in the side-charge furnace are located beyond the charging area to prevent the charge from stopping the matte flow. The tap holes in the bath furnaces are located nearer the Converter Aisle as there is no danger of charge stopping the matte flow.

Converter Return Slag

Converter slag is poured into either of two fixed launders at the sides of the bridgewall of each furnace.

Skimming Reverberatory Slag

Slag is skimmed from the center of the endwall of each furnace into a short launder which is hooded for fume collection, and falls into slag pots. The slag pots are pushed to a slag-dumping area by diesel-electric locomotive, and the liquid slag is poured down the side of the dump. Slag containing matte is placed in pits to cool and is placed in the bedding system for retreatment.

The skim notches are maintained by water-cooled jackets, and adobe stoppers are used to plug the skim holes.

Firing

Natural gas is introduced to the bath furnaces at the rate of 130,000 CFH through six inspirating burners and to the side-charge furnace at the rate of 130,000 CFH through four inspirating burners.

No. 6 Fuel Oil can be substituted for natural gas during times of natural gas shortages.

Waste Heat Boilers

The No. 8, side-charge furnace, has a single four drum waste heat boiler rated at 2,568 BHP -- 85,000 pounds steam per hour which is superimposed over the end of the furnace. Waste heat passes directly from the furnace into the boiler with no by-pass provision. Passages are maintained by retractable, air motor-driven soot blowers and hand lancing.

The No. 9, bath furnace, has two 1,120 BHP boilers rated at 34,000 pounds steam per hour each. The twin boilers are connected by a crossover flue, and a damper can be placed in a crossover to divert hot gases into only one boiler and allow repairs to the isolated boiler while

Waste Heat Boilers - Continued

the furnace is in operation. Passages are maintained by air operated soot blowers.

The No. 10, bath furnace boiler system is similar to the No. 9 boiler system, but each boiler is rated at only 30,000 steam per hour.

Furnace Construction

The No. 8 furnace sidewalls and uptake walls are basic magnesite chrome brick, and the bottom is 2 feet 2 inches of poured slag.

The Nos. 9 and 10 furnaces have silica brick sidewalls, and the hearths are poured slag covered by an impervious layer of chrome ore and a six to seven inch layer of magnetite. Eighteen inches of tamped periclase lines the matte crucibles. The slag zone above the crucibles has a water cooled cast copper jacket, 20 inches high. Cooling water is circulated to the Power House heat exchangers.

CONVERTER DEPARTMENT

Matte from the reverberatory furnaces is converted to blister copper in five 13 feet by 30 feet converters. Four of the converters have riding rings placed within the shell and are limited to 42 tuyeres of 1-3/4 inch diameter black pipe spaced on 6-inch centers. The fifth converter has riding rings at the end of the shell and has 52 tuyeres of 1-3/4 inch diameter black pipe spaced on 6-inch centers.

Blowing air is supplied at approximately 15 psi and enough air can be produced to operate four converters simultaneously. Four converters are rarely operated simultaneously now due to the smaller volume of matte and shorter converting time for higher grade mattes.

The Converter Aisle is serviced by four air conditioned overhead cranes. The two center cranes have 60-ton capacity hoists, and the two outer cranes have 40-ton capacity hoists. Cranes are responsible for handling of hot metal ladles, secondaries boats, and clamshells. Dangerous floor work by men is not required due to the design of the materials handling equipment. Communications between foremen and crane operators is by low power FM radio with hand signals also used. An extendable boom digging machine and a crawler bucket loader are used for cleaning under converters and loading boats.

Shot copper for use at the Corporation refinery is also produced by the Converter Department.

ANODE DEPARTMENT

The Anode Department oxidizes the blister copper, produced by the converters, to remove the remaining sulfur and slag forming impurities. The oxidized copper is then reduced to less than 0.15 percent oxygen using reformed gas and cast as 750-pound anodes. Anodes average 99.7% copper.

The department has two 13 feet by 28 feet basic lined furnaces similar in design to the converters, a circular 22-mold casting wheel, and a natural gas reformer.

The oxidation and reducing steps are accomplished by introducing plant air or reformed gas into the bath through two 1-1/2 inch tuyers at a pressure of 15 to 20 psi. A 4-way valve is used to change from one gas to the other or to vent to atmosphere. Reformer operation is automatic. Two operating panels with stop/start buttons, equipment signal lights, and gas flow recorders are used to control reformer operation from the anode furnace floor. A pressure loss, fail-safe design will introduce natural gas into the tuyeres should there be a failure.

The use of reformed gas for the anode copper reduction step was developed at this plant in 1958. The present reformer has been in operation since early 1959 with no significant interruption in anode production due to reformer maintenance.

The finished anode copper is poured from the anode vessel into a spoon which in turn is tilted to fill the molds. Furnace movement, positioning of the reversible casting wheel, spoon operation, and mold washing are controlled by one man. Barite is used as the mold wash, and water sprays and air jets are used to cool the molds. The solidified copper anodes are broken from the mold and transferred by air operated hoist and hooks to a bosh tank for final cooling. Casting rate is approximately 33 tons per hour.

Anodes are removed from the bosh tank by use of an overhead crane. Following trimming and inspection, the anodes are loaded for shipment to the Corporation refinery in El Paso, Texas.

POWER PLANT

The Power Plant produces the power requirements of the smelter. Smelter requirements are AC and DC electricity and high and low pressure air.

The reverb waste heat boilers produce steam at 350 psi and 650°F which is used in power generation by three 6,250 KW turbo- generators with surface condensers, duplicate condensate pumps and air ejectors. The alternators are cooled with integral air coolers. Three pumps circulate condenser cooling water through a cooling pond with a surface of 200,000 square feet. A direct-fired boiler rated at 60,000 pounds steam per hour is located within the Power House for use in power generation when the waste heat boilers are unable to meet steam requirements.

Boiler feed water is obtained from a preparation unit consisting of multiple effect evaporators operated by high pressure steam. Distilled water from the evaporators is stored in two tanks. The feed water is de-aerated, conditioned, and heated prior to use.

At times, steam production is in excess of power requirements, and in such circumstances, excess steam is condensed and the water returned to the feed water system.

The plant DC requirements are generated by two 600 KW motor generator flywheel sets and two 300 KW motor generator sets.

Converter air is supplied by three 20,000 CFM electrically driven turbo-blowers and one 30,000 CFM steam driven turbo-blower. Constant converter air pressure is maintained by an automatic Westinghouse controller.

High pressure plant air is supplied by five electrically driven air compressors at the Power House.

Plant water supply is from three wells on the property.

Three 44,000 volt circuits are available for transmission of power to the Bisbee operation.

PRECIPITATORS

At full production, eleven electrostatic precipitator units are in operation at this plant -- four for the converters, three for the reverberatory furnaces, and four for the roasters.

The converter precipitator units are attached to a balloon flue, and gases from any converter may pass through any precipitator. Precipitator design efficiency is 96.5 percent. Dust is conveyed to tanks for removal. The cleaned gases pass through a short flue to a 564 feet tall smokestack.

The roaster precipitator units are connected to the roasters by a long flue, and gases from all roasters mix before entering the precipitators. Design efficiency is 99.6 percent. Dust is conveyed by screw, bucket elevator, and drag chains to the roasters' receiving tank and then into the roasters.

The reverberatory precipitator units are connected to the reverberatory furnaces by a long flue and gases from all furnaces mix before entering the precipitators. Design efficiency is 99 percent. Dust from the reverberatory precipitators is conveyed to a tank and pumped pneumatically to the same tank as roaster precipitator dust.

The roaster and reverberatory precipitators are adjacent to each other, and the roaster and reverberatory main flues are separated by a guillotine damper. Cleaned gases pass through flues to a 544 feet tall stack.

Flue temperatures are maintained with auxiliary burners to insure efficient precipitator operation.

MISCELLANEOUS

Shops

The smelter maintains carpenter, iron, boiler, pipe, electric and machine shops, and a general repair crew to handle smelter maintenance.

MISCELLANEOUS - CONTINUED

Assay Office

A modern fully equipped assay office performs all chemical analyses and determinations required by operations. Atomic absorption and other modern instrumental analytical procedures supplement the traditional wet chemical and fire assaying capabilities of the lab.

Test Department

The Test Department maintains all process instrumentation, obtains data from recording meters, and makes process checks not performed by other departments such as flue testing and combustion. It also performs a limited amount of experimentation and research.

Safety

The prevention of accidents is of primary importance in operations and employee participation is emphasized. Scheduled safety meetings are held in all work units. Codes of Safe Practice are issued covering all smelter work units.

SUPPLEMENTARY CONTROL SYSTEM

In order to comply with federally mandated ambient air standards, a system of supplementary controls was implemented on August 31, 1975. The system consists of a series of sulfur dioxide monitors distributed in the area affected by smelter emissions and meteorological monitoring equipment tied into a central computer system and monitored by a trained meteorological staff. When the control system indicates conditions which could cause a violation of federal standards, operations are curtailed.

PARTICULATE CONTROL AND DUST HANDLING EQUIPMENT

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PHELPS DODGE CORPORATION

DOUGLAS REDUCTION WORKS

DOUGLAS, ARIZONA

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JUNE, 1986

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PARTICULATE CONTROL AND DUST HANDLING EQUIPMENT

OVERVIEW

As a result of increasing costs and Clean Air regulations, the recovery and reclamation of airborne particulate matter in gas streams, which are being discharged into the atmosphere, has become an important side aspect of production. Some of the more popular methods for recovering solid particulates are fabric filtration or baghouses, scrubbers and electrostatic precipitators. At the Phelps Dodge, Douglas Reduction Works' smelter, the operation and maintenance of all air pollution or dust control equipment comes under the Dust Control Department.

Figure I is a simplified flow diagram showing the locations of pollution control equipment in the process. In the Preparation Department, dust pickup hoods are located over belt transfer points at the crusher, rolls, bins and screens, as well as on the screens themselves. This dust laden air is filtered through three baghouses. The major dust producer in this operation is silica rock.

During the roasting of the concentrate and flux, some of the calcine is carried off in the flue gas. In order to recover this material, the gases are passed through four electrostatic precipitators. The dust and fumes generated during the loading of the hot calcine into railroad cars for hauling to the reverberatory furnaces are drawn off by another fan and passed through a cyclone-baghouse combination. The off gases from the reverbs first pass through waste heat boilers, then through three electrostatic precipitators to remove material that did not go into the bath in the furnace, but rather, stayed airborne. The dust collected from the roaster and reverb precipitators is conveyed back to the roasters by a system of screw conveyors and drag chains. The roaster baghouse dust is conveyed by screw conveyor back to the roaster discharge hopper.

To eliminate smoke and fumes from around the reverb furnaces, hoods have been installed above the matte and slag launders, together with enclosures around the tap and skim holes. Three 45,000 CFM, 100 hp fans located above the converters draw off the fumes which are then exhausted.

The off gases from each of the five converters are ducted to a balloon flue and then ducted to four electrostatic precipitators before being discharged to the converter stack. This dust is also returned to the roasters by a conveying system.

EQUIPMENT DETAILS

The Nos. 1 and 2 baghouses are 8-compartment automatic continuous collectors, each containing 1,440 bags. Air is drawn through these units by two 200 hp, 45,000 CFM fans. The No. 3 baghouse is an intermittent collector, having one compartment containing 1,248 bags. The air mover is a 150 hp fan with a design volume of 40,000 CFM of air. The No. 4 baghouse is an 8-compartment unit preceded by a cyclone. Because of the large pressure drop through the ducting, cyclone and baghouse, the 40,000 CFM fan in this installation is driven by a 250 hp, 2300 volt motor.

Each roaster and reverb precipitator is one unit wide and four sections long in the direction of gas flow and has 29 ducts which are 9 inches wide by 30 feet high by 36 feet long. The ducts in each are formed by 30 vertical collecting plates 30 feet high by 9 feet long in the direction of the gas flow. The collecting plates are arranged in three banks of ten plates in each section. Each bank of plates is supported at its upper leading and trailing edge by individual anvil beams. Suspended vertically in the center of the ducts of each section are 348 discharge electrodes which are suspended from a single, high voltage, wire supporting frame. These electrodes are 0.109 inch diameter with a shroud and cap at the top and bottom. Each wire supports a 25-pound cast iron weight in plumb bob suspension except for four wires in each section which support the lower steadying frame. There are 1,392 discharge electrodes in one section. The high voltage for each section is supplied by 45 KV, 1000 ma average, transformer rectifier sets.

The converter precipitators are basically identical to the roaster/reverb precipitators in construction except for three things: There are only three sections instead of four, the lower steadying frame was supported by stiff electrodes, and each 1500 ma transformer rectifier is shared by two sections (one in each precipitator). Therefore, a shorted wire or overloaded section takes out two units instead of one.

The 22.6 ft. diameter roaster/reverb stack which is 544 ft. tall has a test station located at the 304 ft. level, while the 564 ft. tall, 19 ft. diameter converter stack has a test station at the 285 ft. level. The difference in height of the stacks is not apparent because of the different elevations of their bases. The converter stack handles about 14 million standard cubic feet per hour while the roaster/reverb discharges about 22 million standard cubic feet per hour.

SUMMARY

The dust control systems utilized by the Douglas Reduction Works to improve the quality of the air represent a large capital investment and are integrated with the entire operation of the smelter. It is hoped that this brief description will assist you in recognizing the various pieces of pollution control equipment as you make your tour of the smelter.

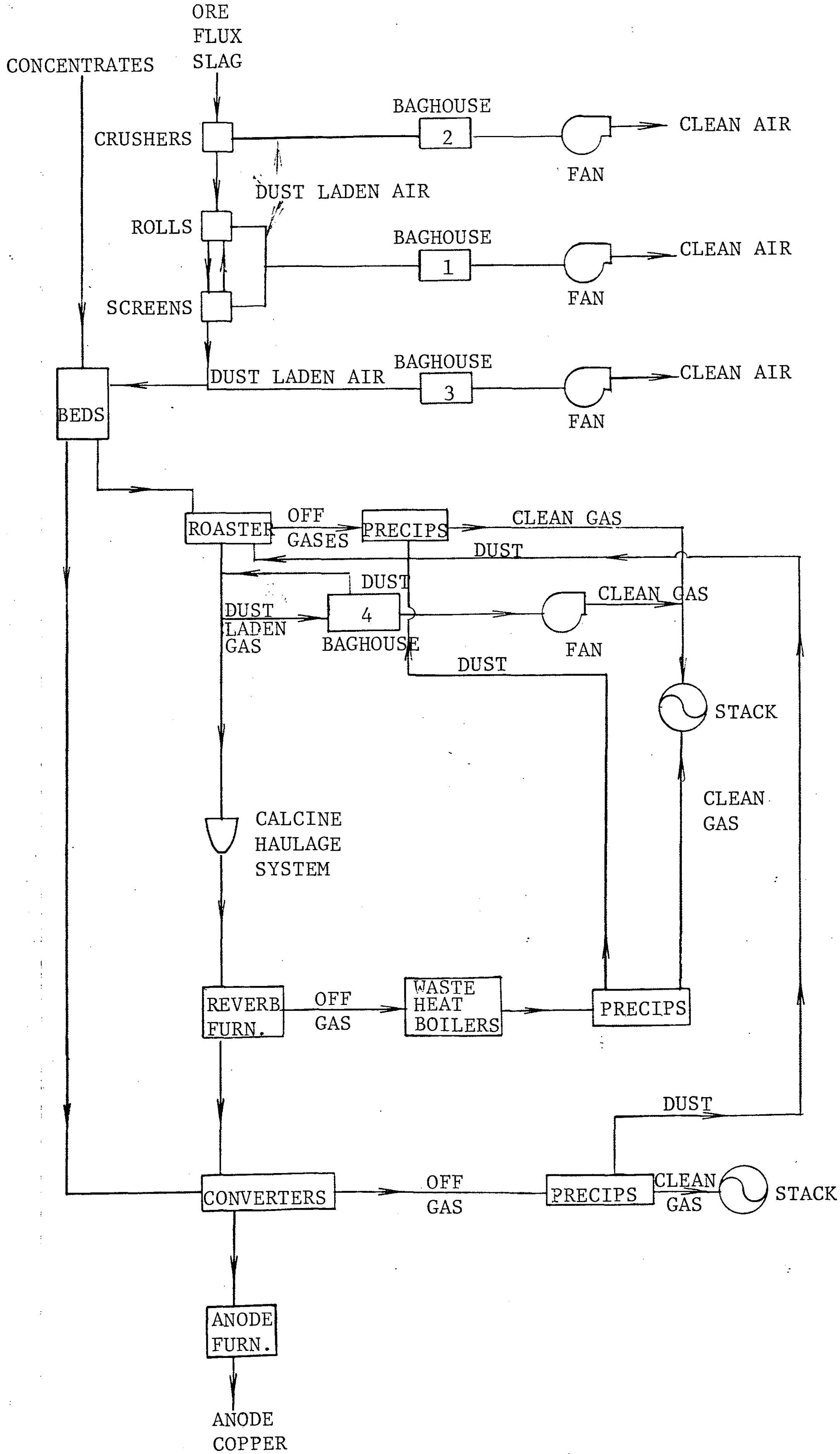

FIGURE NO. 1 FLOW SHEET

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SMELTER DUST COLLECTION
SYSTEM FLOW SHEET

SUPPLEMENTARY CONTROL

SYSTEM OPERATION

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PHELPS DODGE CORPORATION

DOUGLAS REDUCTION WORKS

DOUGLAS, ARIZONA

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JUNE, 1986

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SUPPLEMENTARY CONTROL SYSTEM OPERATION

INTRODUCTION

On August 31, 1975, the Supplementary Control System at the Douglas Reduction Works, Phelps Dodge Corporation, Douglas, Arizona went into operation on a real time basis. The primary purpose of the operation is to maintain Arizona Ambient Air Quality SO_2 Standards by curtailing emissions from the smelter during periods when meteorological conditions exist or are forecast to occur, which would cause these standards to be exceeded. After having now completed over ten years "on the line," the Supplementary Control System has proved itself to be not only a viable and economical means of maintaining SO_2 Air Quality Standards, but has provided the smelter with the capability to produce copper competitively.

THE SUPPLEMENTARY CONTROL SYSTEM (SCS)

The SCS physically is a data gathering and processing system. In order to operate effectively, three basic inputs are required: (1) real time knowledge of the quality of the ambient air in the area of responsibility, (2) real time knowledge of the meteorology of the area, and (3) knowledge of the emission rate of the smelter. Therefore, the SCS at Douglas is designed to provide this required data to a single location--the Central Station.

THE SUPPLEMENTARY CONTROL SYSTEM (SCS) - CONTINUED

Two other names are often used to describe such a system and when combined, describe it better. The Closed Loop infers no break in the system (See Attachment 1). This is essentially true in that each action triggers a reaction which causes another action, etc., until equilibrium or the desired condition is reached. Intermittent Control describes the type of control over emissions. It is not continuous in either time or percent of emission reduction and emissions are only reduced during the time and to the extent meteorological conditions dictate.

AIR QUALITY MONITORING

At Douglas, air quality is monitored at nine locations (See Attachment 2). Distances from the smelter vary from just less than one mile to over two miles. Eight of the SO_2 sensors are permanently located and one is in a mobile van. The mobile monitor is presently located about one mile west of the smelter. The mobile monitor, as well as the other eight are required by State regulations as an integral part of the SCS system. The mobile monitor's location and length of stay is at the direction of the Director, Arizona Department of Health Services. In siting, two primary criteria were used--population centers and climatology. While population centers were rather easy to determine, developing climatology of the area required considerable effort in data gathering, processing, and analysis. Both meteorological and SO_2 data were used for this purpose. Meteorological data was available from Phelps Dodge, the Federal Aviation Agency, the U.S. Army, and the National Weather Service. SO_2 data was obtained from Phelps Dodge, the Arizona Office of Air Quality Management, and the Environmental Protection Agency. Site selection was made only after all data had been analyzed, studies written, and extensive computer diffusion modeling undertaken. At all times, coordination was maintained with the Arizona Office of Air Quality Management. All efforts were expended for one reason--to locate the sensors at the most representative locations to insure the air quality standards deemed necessary by the State to protect public health and welfare were maintained by the Smelter.

METEOROLOGICAL MONITORING

At Douglas, there is a 110-meter tower erected specifically for obtaining local weather data. Information constantly available is the temperature at 10 and 110 meters and the difference (Delta T) and windspeeds and direction at 10 and 110 meters. A standard weather instrument shelter is located near the Central Station which, in addition to providing ambient temperature readings, also contains maximum/minimum thermometers. A rain gauge is located close by. Within the Central Station are a barometer and a 30-day barograph (continuous recorder of atmospheric pressure). Another important system in use at the Central Station provides the capability to measure the winds above Douglas. Each morning and at other times as needed, a Pilot Balloon (PIBAL) is released, and as it rises, its azimuth and elevation are measured, providing the means to calculate windspeeds and directions at about 350 feet intervals vertically to any desired altitude.

When the SCS originally became operational it was thought that the upper air data required could be supplied by the normal National Weather Service rawinsonde from Tucson, but it was soon found that significant differences often existed in the air mass over Douglas and a program was begun to acquire local soundings over Douglas and currently, each morning, the SCS receives temperature data from the aircraft flight to just over 10,000 feet above sea level.

In addition to the locally obtained meteorological data, the Douglas SCS also has access to national facsimile service provided by the National Weather Service.

EMISSION RATE MONITORING

The SCS at Douglas is monitoring smelter SO_2 emissions using two procedures. The emission rate is determined by a statistical procedure using the sulfur input to the smelter and is based on metallurgical analysis and operating units on line. It provides the SCS with a means of estimating hourly emissions within the accuracy required.

Stack emission concentrations are provided by SO_2 sensors located in the two main stacks.

DATA TRANSMISSION

All data transmission from sensors to the Central Station at present is by hardwire lines, except data transmission to and from the Mobile Monitor is by radio. This allows placement of this monitor at any directed location without regard to telephone facilities. All data is passed via computer. The analog signal is provided to a chart recorder at each site, providing a continuous recording of air quality data and a valuable backup to the system by increasing data recoverability.

DATA DISPLAYS AND READOUTS

All sensor signals arriving at the central station are fed into the computer. The computer operating program queries each monitor site sensor once each thirty seconds. Each remote site is equipped with a computer which after receiving three minutes of data, averages and transmits the data to the central computer which prints the 3-minute average on the high-speed line printer, the primary display unit. At the end of each thirty minutes, the computer provides a 30-minute average of all data and an hourly average on the hour.

MAINTENANCE

A full-time electronic technician is responsible for maintenance of the SO_2 sensors, meteorological acquisition system, and telemetry. The computer and its peripheral equipment are replaced by spares on hand, then returned to the factory for repair.

METEOROLOGISTS--THE DECISION MAKERS

Everything described so far is a system to provide information on a real time basis, to a single point and to a single person--the duty meteorologist. At Douglas, there are four meteorologists who man the Central Station seven days a week. All are experienced, are capable of decision making, and accepting the inherent responsibility of that decision. This is an important consideration because the meteorologist has been delegated control over the smelter's SO_2 emissions which is directly related to the copper producing units.

DECISION MAKING PROCESS

It is beyond the scope of this paper to discuss the meteorology involved, but is appropriate, at this time, to mention that the meteorology of the local area has a greater influence on ground-level concentrations than emission rates. Therefore, the meteorologist must be constantly aware of current and forecast weather conditions.

Essentially, the meteorologist's job is to evaluate all information available and determined the ability of the air mass around the smelter to diffuse the SO_2. If diffusion is good, little or no emission reduction may be needed. Under very limited mixing conditions, heavy curtailment can be and have been required.

COMMUNICATIONS

Two written forecasts are provided each day--a 24-hour planning forecast available about 9:00 each evening, and a 12-hour operational forecast issued prior to 7:30 each morning. These forecasts are made assuming a standard production schedule. Any deviation, actual or planned, is provided to Emission Control.

The primary means of communications is by radio. A list of designated operators listed in Call Priority has been provided and each one has the authority to initiate actions as directed by Emission Control. No curtailments are made based on the written forecasts. Each curtailment action is called to the operator by Emission Control and confirmed within thirty minutes of the execution time.

The curtailment is given in production units, and in essence, the meteorologist is controlling the emission rate by controlling the number of sulfur producing units in the stack. The operators, after receiving a curtailment notice, determine on the basis of the matte level in the reverberatory furnaces which units will continue to produce and which will be curtailed. To aid in this decision, a matrix has been developed which provides the operator predetermined options, under specified production unit and matte levels.

EFFECTIVENESS OF THE SCS

The SCS began operation with little precedence to follow and no real time testing. Even though the SCS operated in a training status for over a year, upon beginning real time operation it soon became apparent that many of the developed rules and procedures were not valid under real time conditions. These learning experiences occasionally resulted in non-compliance with the Arizona Ambient Air Standards, and therefore received intense post analysis and study to determine methods to prevent reoccurrence. These efforts are showing significant results. With continuing evaluation and review of the SCS operating procedures and additional real time experience, 100 percent compliance is the goal we strive to maintain.

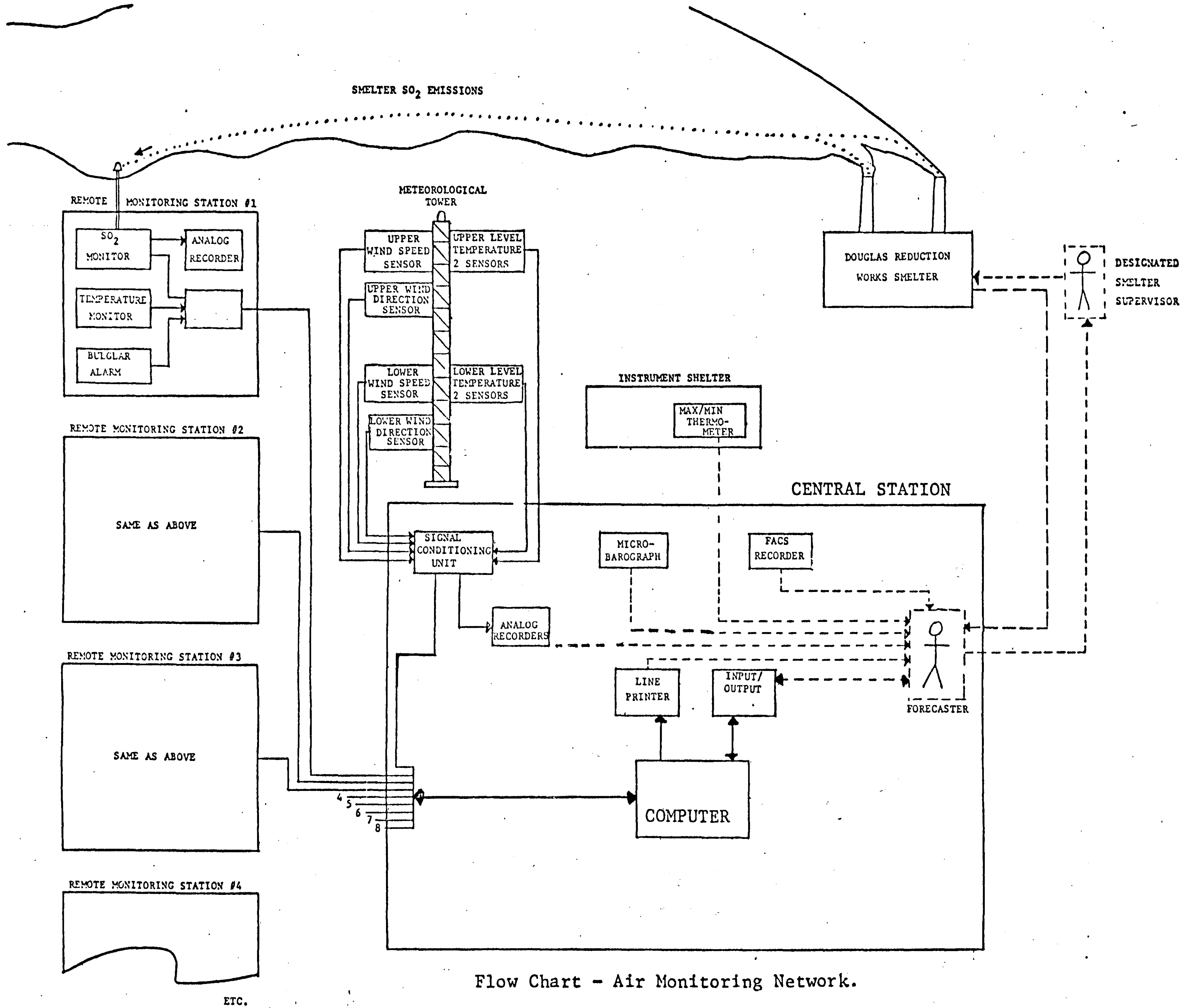
A NEW GENERATION FOR THE SCS

The Supplementary Control System has evolved into a meteorologist orientated subjective method of forecasting the weather parameters and applying this state of the art meteorology to maintaining air quality. One hundred percent compliance was achieved in July, 1985 when an entire year had passed without any exceedances on Phelps Dodge's SO_2 monitoring network. The same trend of no exceedances since July of 1985 has continued to this day.

With this record, changes were required to make the system auditable. An objective method of forecasting ambient SO_2 concentration that will leave a complete and identifiable trail for an auditor was developed based on the ten years operating experience. This is an interim objective method to be used until a completely objective method to maintain air quality using computer generated models together with the years of data collected at the SCS. This new generation of air quality tools for the SCS will be in place and operating by October 31, 1986.

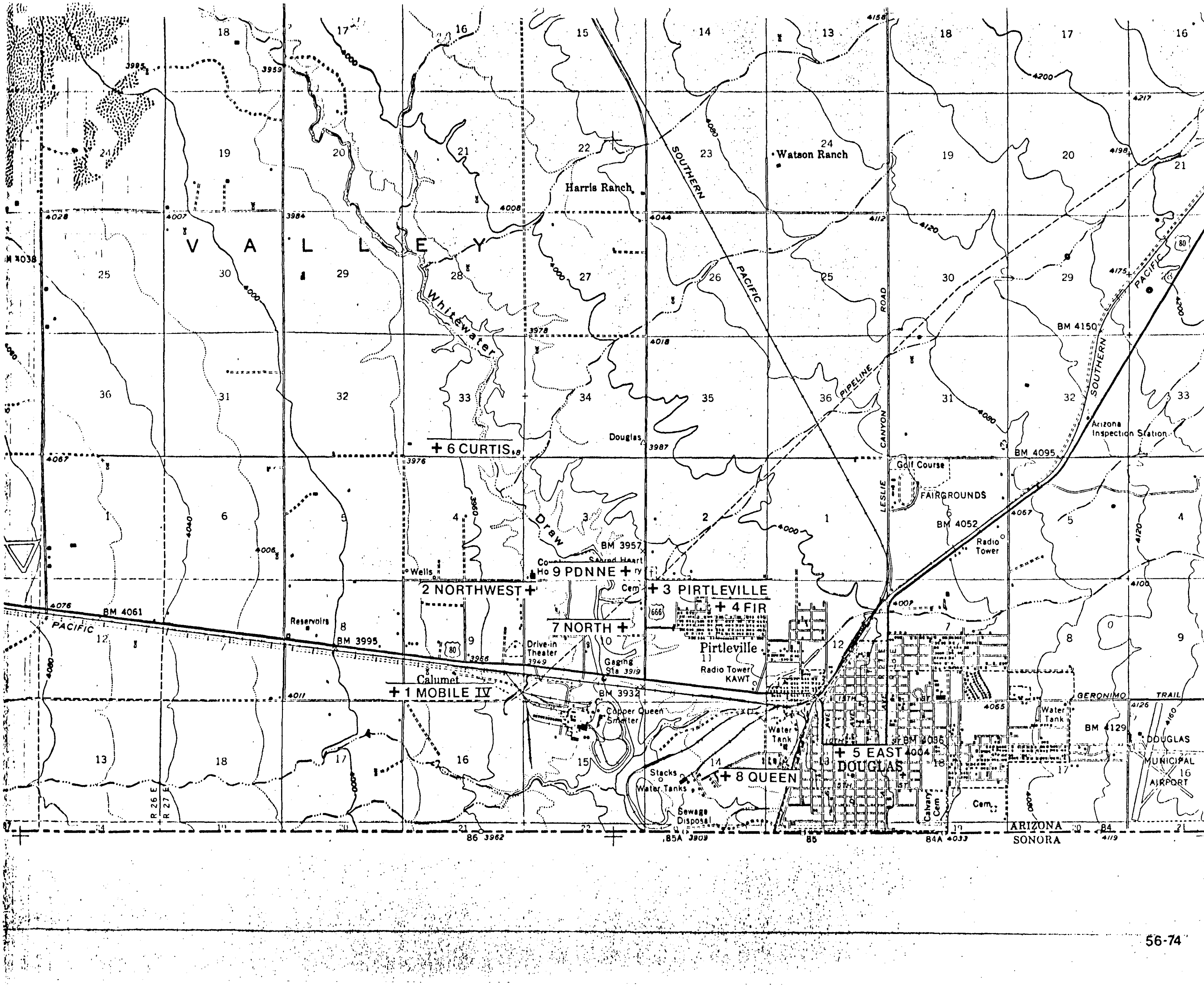
Attachment 1: Flow Chart - Air Monitoring Network

Attachment 2: Remote Monitoring Station Locations for Phelps Dodge Corporation, Douglas Reduction Works' Closed Loop System.



Flow Chart - Air Monitoring Network.

Attachment 1



ATTACHMENT 2

DOUGLAS SMELTER FILE.

SMELTING DIVISION OF ARIZONA SECTION, A. I. M. E.
SPRING MEETING

* * *

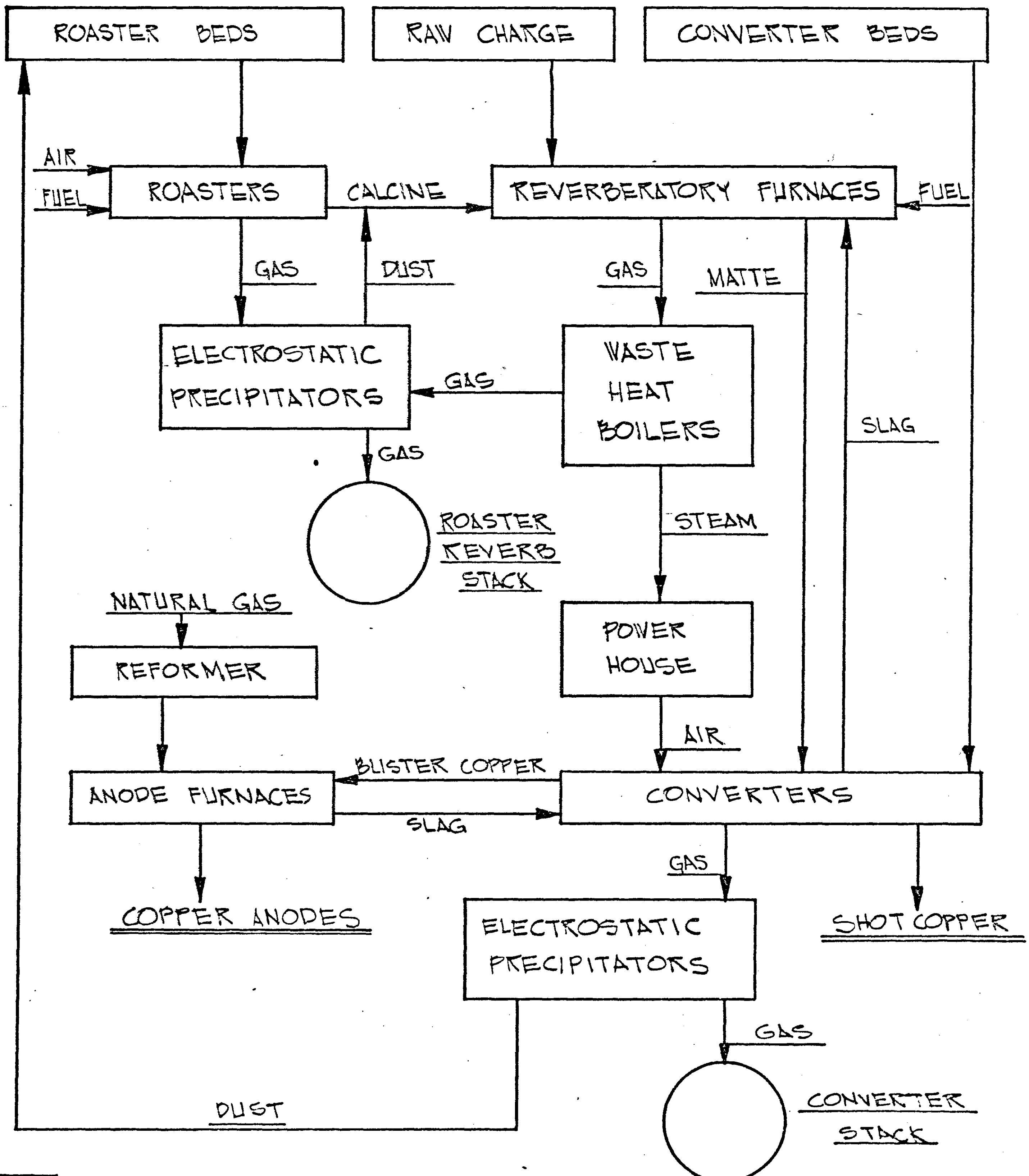
A DESCRIPTION OF PLANT AND OPERATION BY

R. C. HUISENGA, ASSISTANT METALLURGIST
PHELPS DODGE CORPORATION
DOUGLAS REDUCTION WORKS
DOUGLAS, ARIZONA

* * *

MAY 1, 1976

PHELPS DODGE CORPORATION
DOUGLAS REDUCTION WORKS
DOUGLAS, ARIZONA
BLOCK FLOW DIAGRAM



PHELPS DODGE CORPORATION DOUGLAS REDUCTION WORKS

A DESCRIPTION OF PLANT AND OPERATION

GENERAL

The Douglas Reduction Works consists of the Smelter and ancillary facilities required for the treatment of direct smelting underground ores and precipitates produced by the Copper Queen Branch of Phelps Dodge Corporation; and considerable tonnage of custom and toll materials which include concentrates, scrap brass, refinery slags and copper precipitates. Production is shipped by rail to Phelps Dodge Refineries at El Paso, Texas and Laurel Hill, New York.

Major units and operations included in this description are as follows:

1. Preparation Department
2. Scrap Brass Plant
3. Plant Metallurgy
4. Roaster Department
5. Reverberatory Department
6. Converter Department
7. Anode Plant
8. Power House
9. Precipitators
10. Miscellaneous
11. Supplementary Control Systems

PREPARATION DEPARTMENT

The Preparation Department is responsible for the receipt, unloading, sampling, preparation, bedding and reclaiming of ore, concentrate and flux. All operations are performed as required on day shift with the exception of reclaiming.

Receipt of Material

Most plant receipts are by rail with Southern Pacific Company crews handling yard movement. A 200-ton capacity railroad scale is installed for weighing rail shipments.

A truck receiving facility is available for handling barren silicious flux and some custom ores. Truck scales are available for custom receipts. Flux accounting is accomplished through the use of a belt scale.

Concentrate Handling

Concentrates are received in special bottom dump concentrate cars and are dumped directly into receiving bins from which they are transferred by belt conveyor directly to the bedding plant. Limerock may also be handled through this system.

Concentrates are removed from the receiving bins by automatic, timed belt feeders. A sample is cut from the belt by an automatic sampler during transit.

Crushing Plant

Mine run ores, limerock and silica flux are dumped into separate receiving bins from 100-ton bottom dump ore cars. The receiving bins are a continuous structure of sixteen separate bins

PREPARATION DEPARTMENT - CONTINUED

Crushing Plant - Continued

with a total capacity of approximately 7000 tons.

Ore is drawn from any one of the bins through ore gates onto a rail mounted pan feeder from which it is transferred by a 36-inch conveyor belt to the primary crusher. Due to the large amount of tramp iron and wood, belt magnets and hand picking must be used to protect the crusher. The primary crusher, a 24 x 60 gyratory with hydroset mechanism, crushes the ore to minus 2½ inch. The operator tends the crusher, picks wood from the belt and monitors transfer of the ore to the screens by a system of probes, interlocks and fail-safe devices tied in to alarms and lights on a panel at the crusher. The product passes over a belt scale through an automatic sampler to the screening plant.

The screening plant consists of two surge bins and six rod deck screens. Two screens serve the primary ore screen bin and the remainder serve the secondary bins. Screening is to a nominal 3/8 inch. Undersize from all screens is transferred by a conveyor system to the bedding plant while screen oversize goes to the fine crushing plant. Two 78 x 24 inch rolls are used for fine crushing. Screen oversize from the two primary ore screens is crushed through one rolls crusher to minus 1 inch and sent to the secondary screen bins. Secondary screen oversize is placed in closed circuit with the second rolls crusher which is at a closed setting.

Bedding Plant

The Bedding Plant consists of eight 10,000-ton mixing

PREPARATION DEPARTMENT - CONTINUED

Bedding Plant - Continued

beds and seven 200-ton tanks. Five beds are normally used for roaster mixes, two are used for converter flux mixes, and one bed is used for raw charge mixes.

Materials from concentrate unloading and from the crushing plant can be handled independently on the eastern five roaster beds using separate parallel conveyor belt systems. Only one belt services the full eight beds. Belt scales weigh materials going to the system.

Each bed mix is made up using proportions of the various receipts as set by the Metallurgist. The materials are placed in layers over the full 270 ft. length of the bed. The normal roaster bed now averages 7200 dry tons. Receipts are such that it is usually possible to maintain fairly uniform mixes.

Reclaiming

Bed reclaiming is accompanied by two reclaiming machines which are moved on a transfer car in a pit at one end of the beds. Roaster charge is transferred to the roaster plant twice each shift while barren silica for slurrying and reverb fluxing and converter flux are run once a shift. The use of interlocks, fail-safe devices and various controls enables a two-man crew to handle the reclaiming.

Sample Mill

Preparation of plant process and receipt samples is the responsibility of the sample crew. Sampling tasks not assigned as a part of the duties of operations crews are also performed. The

PREPARATION DEPARTMENT - CONTINUED

Sample Mill - Continued

automatic ore sampler is operated by the Sample Mill. Buckets on arms extending from a rotating shaft cut the ore stream. The sample passes through a 2-foot standard crusher where it is reduced to minus 1/2 inch. Crusher discharge is again cut by the sampler. The cut sample falls through a bank of splitters into pans and is further reduced by use of standard sample preparation devices such as rolls, grinders and pulverizers.

Concentrates are automatically sampled at a belt transfer point as the material stream impinges on a rotating slotted disc. Sample material passes through the slot onto transfer belts to another slotted disc and falls into sample pans. It is still necessary to hand sample abnormally wet concentrates from the main belts.

SCRAP BRASS PLANT

A considerable tonnage of secondary copper bearing material is handled through the Scrap Brass Plant where it is sampled, unloaded, and transferred by truck to the proper destination within the plant.

An extremely wide variation in scrap material is received principally from scrap dealers in the midwest and western states. The bulk of the scrap is sent directly to the Converter Aisle for smelting in the converters, but some scrap materials contain combustibles which are burned from the material in incinerators prior to transfer to the aisle. Screening facilities at the truck handling station permit the diversion of fine material to the bedding plant.

SCRAP BRASS PLANT - CONTINUED

Scrap samples are taken during unloading. Normal treatment includes shredding or shearing to minus 2 inches, cone and quartering, matting the sample by melting with sulfur in a small furnace and then preparing assay pulps from the melts using standard ore sample preparation procedures. No. 2 copper samples are melted and cast into a cake which is sawed for the assay sample.

The Scrap Brass Plant also handles copper precipitate receipts which are sampled with air powered augers before unloading. Unloading is to a stockpile from which the material is transferred by truck to the bedding system.

PLANT METALLURGY

Roaster Charge

The roasters are charged from two types of beds. One bed is made up primarily with smelter revert materials and new receipts which are low in sulfur and can be dried in two of the roasters for charging to the reverberatory furnaces during emission curtailments for the Supplementary Control System. Five beds are made up with smelter reverts that cannot be handled elsewhere, copper precipitates, concentrates, ores, scrap brass and refinery slag fines, and fluxes and are charged to the remaining roasters to make calcine for charging to the reverberatory furnaces during normal production. Materials to be placed on the roaster beds are determined by the Plant Metallurgist and are subject to material on hand and anticipated receipts. When possible, an effort is made to utilize all bed storage capacity so that variations between bed mixes can be minimized, and the actual composition of a bed can be known before the first reclaim from the bed. Bed mixing is be-

PLANT METALLURGY - CONTINUED

Roaster Charge - Continued

coming more dependent upon current receipts and estimated compositions as the transition is made from smelting of corporation materials to smelting of purchased materials.

Bed calculation requires the determination of all copper bearing materials on the bed and to be added to the bed. Samples of these materials are assayed for SiO_2, Al_2O_3, Fe, CaO, MgO, S, and metal values. The composition of all copper bearing materials are calculated and summed, and the total SiO_2 requirement is determined based on the desired reverberatory slag composition which is established by observation of past smelter practice with slight modifications made for variations in composition of receipts.

Flux additions to the bed is not standard, however, and components of reverberatory slag from sources other than the roaster charge must be considered. The two primary sources of reverberatory slag components, other than roaster charge, are reverberatory hot patch slurry and converter slag.

The amount of slurry used in each sprung arch reverberatory furnace varies little on a daily basis, and the amount of slurry used during the smelting of a bed can be determined by multiplying a daily slurry factor times the days smelting of the bed should require.

Converter slag additions to the reverberatory furnaces are dependent upon a number of factors. Amount of converter slag produced is dependent upon matte grade, secondaries additions and flux additions. Composition of converter slag is dependent upon the composition of the materials placed into the converters with a slag containing approximately 26% SiO_2 and 26% Fe_3O_4 desired to

PLANT METALLURGY - CONTINUED

Roaster Charge - Continued

achieve optimum smelting of secondaries with minimal magnetite input to the reverberatory furnaces. Converter flux beds are made up with silica flux diluted to 70-75% SiO_2 using ores and foul slags as diluents.

Matte grade is determined so that the available roasters can supply all the charge requirements of the reverberatory furnaces without producing more matte than the reverberatory furnaces can hold during curtailments or the converters can treat during normal production. The theoretical sulfur requirement for the desired matte grade is calculated, and a reverberatory sulfur oxidation correction factor based on an average of current actual to theoretical matte grade is calculated and multiplied times the theoretical sulfur requirement for the desired matte grade. The roaster operations are requested to obtain the calculated sulfur.

ROASTER DEPARTMENT

The Roaster Plant consists of twenty-four, six hearth roasters arranged in two parallel rows of twelve roasters. Sixteen to twenty-one roasters are in operation except when meteorological conditions limit operations to fewer than sixteen roasters.

Each roaster is fed from a separate 100-ton feed bin by two drum feeders. The feed rate is controlled by adjusting the tension on the feeder drive, and feed rate is varied to obtain the desired sulfur - a higher feed rate will allow less sulfur to be removed from a fixed quantity of feed. From the feed bins, the charge falls onto a dry floor and is spread across the floor by

ROASTER DEPARTMENT - CONTINUED

blades on four arms rotating about a center column. From the dry floor, the charge drops to the outside of the floor of the first hearth and is raked inwards by rabbles, on two air cooled arms that rotate about the center column. The charge is raked alternately in and out on the subsequent hearths and is turned over many times to allow exposure of sulfur to oxygen. Cold air is forced into the center column, passes through each of the arms to cool the arms and heat the air, and is discharged into the bottom hearth of the roaster. Supplemental heat is needed to initiate the exothermic reaction between sulfur and oxygen and is supplied by the combustion of natural gas or No. 6 Fuel Oil in the next to the bottom hearth. Calcine is discharged into hoppers from the bottom hearth.

The roaster shell is steel and is 21' - 7" in diameter. Floors are cast with refractory material and sidewalls are fireclay brick. Rabble arms and rabbles on the lower three hearths are heat resistant cast steel.

REVERBERATORY DEPARTMENT

Two bath smelting furnaces and one side-charge furnace are used for smelting of roaster calcine. The furnaces are all 26' wide by 103' to 107' long inside. The bath furnaces have sprung silica arches maintained by hot patching with silica slurry, and the side-charge furnace is a flat suspended basic roof of panelized construction.

Charging

Calcine is hauled from the roasters in tanks moved by

REVERBERATORY DEPARTMENT - CONTINUED

Charging - Continued

electric trolley. Each furnace is charged from two tanks, one on each side of a furnace, forty-five times each day. The bath furnaces are charged by gravity flow through Wagstaff feeders, two on each side of each furnace; and two enclosed drag chains convey charge to drop holes at four foot intervals along the sides of the side-charge furnace. Charge smelts on the surface of the bath furnaces and on the sidewalls of the side-charge furnace.

Matte Tapping

Each furnace has four tap holes, two on each side of the furnace. Matte is tapped from the furnace on demand of the converters and flows through copper launders to ladles in the Converter Aisle. The launders and ladles are covered for collection of fumes and ducts convey the fumes to electrostatic precipitators.

The tap holes in the side-charge furnace are located beyond the charging area to prevent the charge from stopping the matte flow. The tap holes in the bath furnaces are located nearer the Converter Aisle as there is no danger of charge stopping the matte flow.

Converter Return Slag

Converter slag is poured into either of two fixed launders at the sides of the bridgewall of each furnace.

Skimming Reverberatory Slag

Slag is skimmed from the center of the end wall of each furnace into a short launder which is hooded for fume collection,

REVERBERATORY DEPARTMENT - CONTINUED

Skimming Reverberatory Slag - Continued

and falls into slag pots. The slag pots are pushed to a slag dumping area by diesel-electric locomotive, and the liquid slag is poured down the side of the dump. Slag containing matte is placed in pits to cool and is placed in the bedding system for retreatment.

The skim notches are maintained by water cooled jackets, and adobe stoppers are used to plug the skim holes.

Firing

Natural gas is introduced to the bath furnaces at the rate of 126,000 CFH through six inspirating burners and to the side-charge furnace at the rate of 125,000 CFH through four inspirating burners.

The No. 6 Fuel Oil can provide energy equivalent to that of natural gas by using standby forced air burners.

Waste Heat Boilers

The No. 8, side-charge furnace, has a single four drum waste heat boiler rated at 2568 BHP - 85,000 pounds steam per hour which is super imposed over the end of the furnace. Waste heat passes directly from the furnace into the boiler with no by-pass provision. Passages are maintained by retractable, air motor driven soot-blowers and hand lancing.

The No. 9, bath furnace, has two 1120 BHP boilers rated at 34,000 pounds steam per hour each. The twin boilers are connected by a crossover flue, and a damper can be placed in a crossover to divert hot gases into only one boiler and allow repairs to the isolated boiler while the furnace is in operation. Passages

REVERBERATORY DEPARTMENT - CONTINUED

Waste Heat Boilers - Continued

are maintained by air operated soot blowers.

The No. 10, bath furnace boiler system is similar to the No. 9 boiler system, but each boiler is rated at only 30,000 steam per hour.

Furnace Construction

The No. 8 furnace sidewalls and uptake walls are basic magnesite-chrome brick, and the bottom is 2' - 2" of poured slag.

The Nos. 9 and 10 furnaces have silica brick sidewalls, and the hearths are poured slag covered by an impervious layer of chrome ore and a six to seven inch layer of magnetite. Eighteen inches of tamped periclase lines the matte crucibles. The slag zone above the crucibles has a water cooled, cast copper jacket, 20 inches high. Cooling water is circulated to the Powerhouse heat exchangers.

CONVERTER DEPARTMENT

Matte from the reverberatory furnaces is converted to blister copper in five 13' by 30' converters. Four of the converters have riding rings placed within the shell and are limited to 42 tuyeres of 1-3/4 inch diameter black pipe spaced on six inch centers. The fifth converter has riding rings at the end of the shell and has 52 tuyeres of 1-3/4 inch diameter black pipe spaced on six inch centers.

Blowing air is supplied at approximately 15 psi and enough air can be produced to operate four converters simultaneously. Four converters are rarely operated simultaneously now due to the

CONVERTER DEPARTMENT - CONTINUED

smaller volume of matte and shorter converting time for higher grade mattes. Oxygen enrichment is practiced on a limited scale to aid in the smelting of secondaries, but the oxygen system limits enrichment to one converter at a time.

The Converter Aisle is serviced by four air-conditioned overhead cranes. The two center cranes have 60-ton capacity hoists, and the two outer cranes have 40-ton capacity hoists. Cranes are responsible for handling of hot metal ladles, secondaries boats, and clamshells. Dangerous floor work by men is not required due to the design of the materials handling equipment. Communications between foremen and crane operators is by low power FM radio with hand signals also used. An extensible boom digging machine and a crawler bucket loader are used for cleaning under converters and loading boats.

Shot copper for use at the Corporation refineries is also produced by the Converter Department.

ANODE DEPARTMENT

The Anode Department oxidizes the blister copper, produced by the converters, to remove the remaining sulfur and slag forming impurities. The oxidized copper is then reduced to less than 0.15 percent oxygen using reformed gas and cast as 750 pound anodes. Anodes average 99.7% copper.

The department has two 13 ft. by 28 ft. basic lined furnaces similar in design to the converters, a circular 22-mold casting wheel, and a natural gas-air reformer.

The oxidation and reducing steps are accomplished by introducing plant air or reformed gas into the bath through two 1-1/2

ANODE DEPARTMENT - CONTINUED

inch tuyeres at a pressure of 15 to 20 psi. A four-way valve is used to change from one gas to the other or to vent to atmosphere. Reformer operation is automatic. Two operating panels with stop-start buttons, equipment signal lights and gas flow recorders are used to control reformer operation from the anode furnace floor. A pressure-loss, fail-safe design will introduce natural gas into the tuyeres should there be a failure.

The use of reformed gas for the anode copper reduction step was developed at this plant in 1958. The present reformer has been in operation since early 1959 with no significant interruption in anode production due to reformer maintenance.

The finished anode copper is poured from the anode vessel into a spoon which in turn is tilted to fill the molds. Furnace movement, positioning of the reversible casting wheel, spoon operation and mold washing are controlled by one man. Pulverized silica or zinc oxide is used as the mold wash, and water sprays and air jets are used to cool the molds. The solidified copper anodes are broken from the mold and transferred by air operated hoist and hooks to a bosh tank for final cooling. Casting rate is approximately 33 tons per hour.

Anodes are removed from the bosh tank by use of an overhead crane. Following trimming and inspection, the anodes are loaded for shipment to the Corporation refinery in El Paso, Texas.

POWER PLANT

The Power Plant produces the power requirements of the smelter. Smelter requirements are AC and DC electricity and high and low pressure air.

POWER PLANT - CONTINUED

The reverb waste heat boilers produce steam at 350 psi and 650°F which is used in power generation by three 5000 KW turbo-generators with surface condensers, duplicate condensate pumps and air ejectors. The alternators are cooled with integral air coolers. Three pumps circulate condenser cooling water through a cooling pond with a surface of 200,000 square feet. A direct fired boiler rated at 60,000 pounds steam per hour is located within the Powerhouse for use in power generation when the waste heat boilers are unable to meet steam requirements.

Boiler feed water is obtained from a preparation unit consisting of multiple effect evaporators operated by high pressure steam. Distilled water from the evaporators is stored in two tanks. The feed water is de-aerated, conditioned and heated prior to use.

At times, steam production is in excess of power requirements, and in such circumstances, excess steam is condensed and the water returned to the feed water system.

The plant DC requirements are generated by two 600 KW motor generator flywheel sets and two 300 KW motor generator sets.

Converter air is supplied by three 20,000 CFM electrically driven turbo-blowers and one 30,000 CFM steam driven turbo-blower. Constant converter air pressure is maintained by an automatic Askania controller.

With the exception of small compressors at the gas reformers, 100 psi high pressure plant air is supplied by five electrically driven air compressors at the Powerhouse.

Plant water supply is from three wells on the property.

Three 44,000 volt circuits are available for transmission of power to the Bisbee operation.

PRECIPITATORS

Eleven electrostatic precipitator units are in operation at this plant - four for the converters, three for the reverberatory furnaces and four for the roasters.

The converter precipitator units are attached to a balloon flue, and gases from any converter may pass through any precipitator. Precipitator design efficiency is 96.5 percent. Dust is conveyed to tanks for removal. The cleaned gases pass through a short flue to a 564' tall smokestack.

The roaster precipitator units are connected to the roasters by a long flue, and gases from all roasters mix before entering the precipitators. Design efficiency is 99.6 percent. Dust is conveyed to a tank and pumped pneumatically to a larger tank above the calcine trolley tracks from which it is placed in calcine tanks for feeding to the reverberatory furnaces.

The reverberatory precipitator units are connected to the reverberatory furnaces by a long flue and gases from all furnaces mix before entering the precipitators. Design efficiency is 99 percent. Dust from the reverberatory precipitators is conveyed to a tank and pumped pneumatically to the same tank as roaster precipitator dust.

The roaster and reverberatory precipitators are adjacent to each other and the roaster and reverberatory main flues are separated by a guillotine damper. Cleaned gases pass through flues to a 544' tall stack.

Flue temperatures are maintained with auxiliary burners to insure efficient precipitator operation.

MISCELLANEOUS

As a result of the separation of this smelter from the mines, the mechanical and outside overhead other than smelting operations is larger than would be expected.

Shops

The smelter maintains carpenter, tin, boiler, blacksmith, pipe, electric and machine shops and a general repair crew to handle smelter maintenance.

Assay Office

A modern fully-equipped assay office performs all chemical analyses and determinations required by operations. Emission spectrography, atomic absorption and other modern instrumental analytical procedures supplement the traditional wet chemical and fire assaying capabilities of the lab.

Test Department

The Test Department maintains all process instrumentation, obtains data from recording meters, and makes process checks not performed by other departments such as flue testing, dust counting and combustion. It also performs a limited amount of experimentation and research.

Safety

The prevention of accidents is of primary importance in operations and employee participation is emphasized. Scheduled safety meetings are held in all work units. Codes of Safe Practice are issued covering all smelter work units.

SUPPLEMENTARY CONTROL SYSTEM

In order to comply with federally mandated ambient air standards, a system of supplementary controls was implemented on August 31, 1975. The system consists of a series of sulfur dioxide monitors distributed in the area affected by smelter emissions and meteorological monitoring equipment tied into a central computer system and monitored by a trained meteorological staff. When the control system indicates conditions which could cause a violation of federal standards, operations are curtailed.

RCH:jc

March 23, 1976

A DESCRIPTION

OF

PLANT AND OPERATION

* * *

PHELPS DODGE CORPORATION

D O U G L A S   R E D U C T I O N   W O R K S

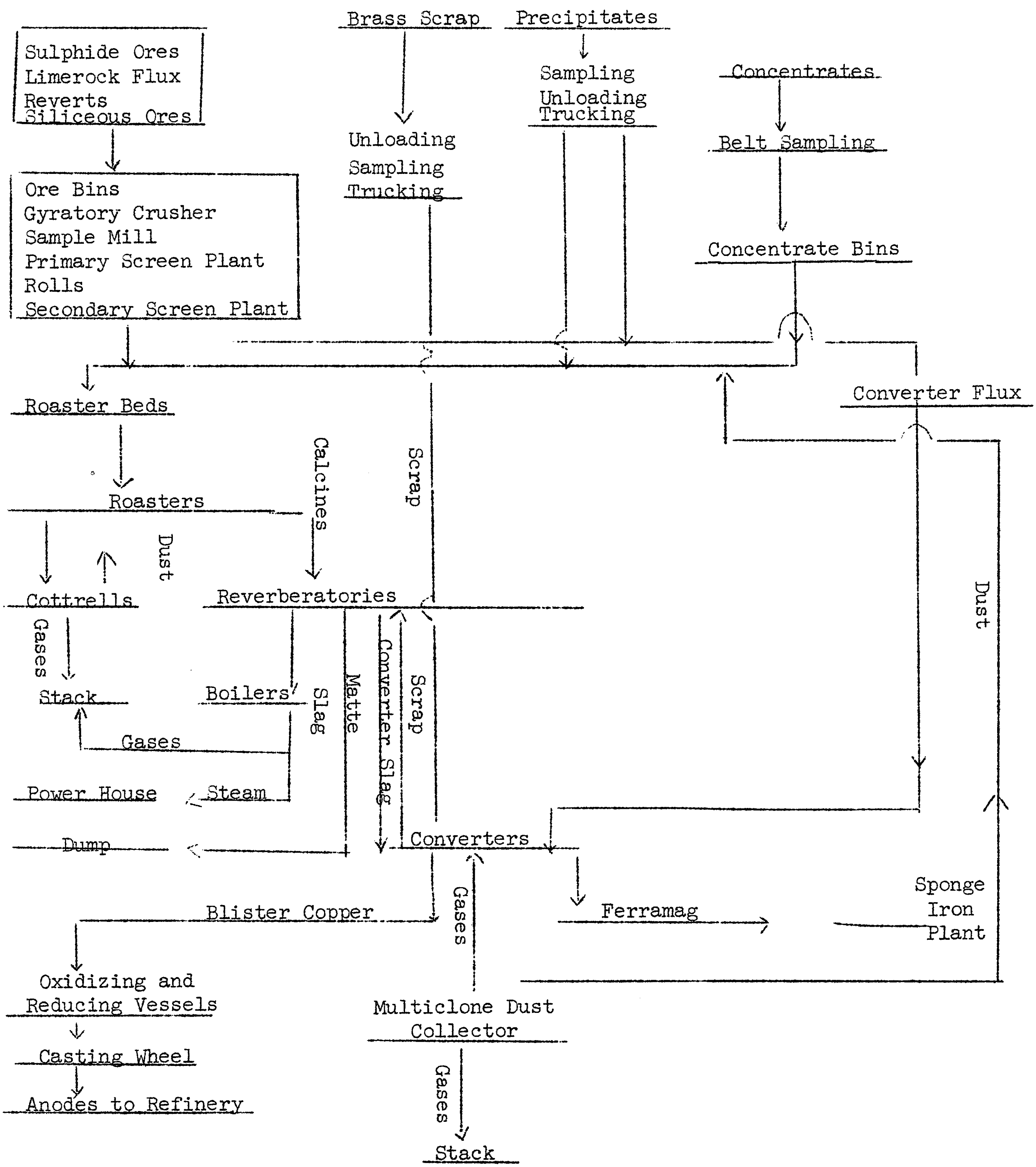
DOUGLAS, ARIZONA

* * *

April 15, 1964

FLOW SHEET

DOUGLAS REDUCTION WORKS



PHELPS DODGE CORPORATION
D O U G L A S   R E D U C T I O N   W O R K S
DOUGLAS, ARIZONA

A DESCRIPTION OF PLANT AND OPERATION

GENERAL

The Douglas Reduction Works consists of the smelter and allied facilities required for the treatment of the direct smelting underground ores, concentrates, and precipitates produced by the Copper Queen Branch of Phelps Dodge Corporation. In addition to these materials, the smelter treats a considerable tonnage of custom materials from Arizona and Mexico plus scrap brass, refinery slags and copper precipitates, the latter on a toll basis for Phelps Dodge Refining Corporation. Production is shipped by rail to Corporation refineries at El Paso, Texas and Laurel Hill, New York.

The NMBM receipts are in general quite low grade and have a considerable excess of sulfur over that required for efficient reverberatory and converter operation. For this reason it is necessary for this smelter to roast the greater part of NMBM receipts.

Major units and operations included in this description are as follows:

1. Preparation Department.
2. Scrap Brass Plant.
3. Plant Metallurgy.
4. Roaster and Cottrell Plant.
5. Reverberatory Department.
6. Converter Department.
7. Sponge Iron Plant.
8. Anode Plant.
9. Power House.

PREPARATION DEPARTMENT

The Preparation Department is responsible for the receipt, unloading, sampling, preparation, bedding and reclaiming of ore, concentrate and flux receipts. With the exception of reclaiming, all operations are done on one eight hour shift.

Receipt of Material

Except for a small amount of scrap brass, all plant receipts are by rail. Southern Pacific Company yard crews handle rail movement for the plant.

Receipts are weighed over a 200-ton capacity Howe railroad scale.

Concentrate Handling

Lavender Pit concentrates and minus 1/2-in. Paul limerock are received in bottom dump TCG cars or modified SP ballast cars. These fine materials are dumped into receiving bins and transferred by belt conveyor directly to the bedding plant.

The S. P. Crew places an average twelve car spot above the bins which will accommodate four cars at a time. Car doors are opened and the concentrates blown from the cars using air lances. Movement of cars over the bins is accomplished using a small smelter crew-operated electric locomotive.

Concentrates are removed from the receiving bins by automatic, timed belt feeders for transfer to the bedding plant. A sample is cut from the belt during transit.

Crushing Plant

Mine run ores and silica flux are dumped into separate receiving bins from the railroad cars. Principal cars in use are Southern Pacific ballast cars (80T) and the new Southern Pacific 100 ton bottom dump ore cars recently placed in service.

The receiving bins are a continuous structure of 16 separate bins with a total capacity of approximately 7000 tons.

Ore is drawn from any one of the bins through ore gates onto a rail mounted pan feeder from which it is transferred by a 36-in. conveyor belt to the primary crusher. Due to the large amount of tramp iron and wood, belt magnets and hand picking must be used to protect the crusher. The primary crusher, an Allis Chalmers 24 x 60 superior gyratory with hydroset mechanism, crushes the ore to minus 2-1/2 in. The operator tends the crusher, picks wood from the belt and monitors transfer of the ore to the screens by a system of probes, interlocks and fail-safe devices tied in to alarms and lights on a panel at the crusher. The product passes through an automatic sampler and over a belt scale to the screening plant.

The screening plant consists of two surge bins and six Allis-Chalmers Riple-Flow rod deck screens. Two screens serve the primary ore screen bin and the remainder the secondary bin. Screening is to a nominal 3/8-in. Undersize from all screens is transferred by a conveyor system to the bedding plant while screen oversize goes to the fine crushing plant. Two 78 x 24 in. Traylor rolls are used for fine crushing. Screen oversize from the two primary ore screens is crushed through one rolls crusher to minus 1-in. and sent to the secondary screen bins. Secondary screen oversize is placed in a closed circuit with the second rolls crusher which is at a close setting.

Bedding Plant

The Bedding Plant consists of eight 10,000 ton Messiter system mixing beds and eight 200 ton tanks. Five beds are normally used for roaster mixes and three for converter flux.

Materials from the concentrate unloading and from the crushing plant can be handled independently on the eastern five roaster beds using separate parallel conveyor belt systems. Only one belt services the full eight beds. Merrick Weightometers are available for weighing materials going to the system.

Each bed mix is made up using proportions of the various receipts set by the metallurgist. The materials are placed in layers over the full 270 ft. length of the bed. The normal roaster bed now averages 7200 dry tons. Receipts are such that it is usually possible to maintain fairly standard mixes.

Reclaiming

Two old Robbins reclaiming machines, whose movement is accomplished by a transfer car in a pit at the end of the beds, service the bedding plant. Roaster charge is transferred to the roaster plant twice each shift while barren silica for slurrying and reverb fluxing and converter flux are run once a shift. The use of interlocks, fail-safe devices and various controls enables a two man crew to handle the reclaiming.

Sample Mill

Preparation of plant process and receipt samples is the responsibility of the sample crew which also performs sampling tasks not assigned as a part of the duties of operations crews.

The automatic ore sampler is operated by the sample mill. Buckets on arms extending from a revolving shaft cut the ore stream. The sample passes through a 2-ft. standard Symons crusher where it is reduced to minus 1/2 in. Crusher discharge is again cut by the sampler. The cut sample falls through a bank of splitters into pans and is further reduced by use of standard sample preparation devices such as rolls, grinders and pulverizers.

SCRAP BRASS PLANT

A considerable tonnage of secondary material containing copper is handled through the Scrap Brass Plant where it is sampled, unloaded, and transferred by truck to the proper destination within the plant.

An extremely wide variation in scrap material is received, principally from scrap dealers in the midwest and western states. The bulk of the scrap is sent directly to the converter aisle for smelting in the converters, but some scrap materials contain combustibles which are burned from the material prior to transfer to the aisle. A minor amount of fines is handled through the bedding plant.

Scrap samples are taken by hand during the unloading. Normal treatment includes shearing to minus 2-in., cone and quartering, matting the sample by melting with sulfur in a small furnace and then preparing assay pulps from the melts using standard ore sample preparation procedures.

The Scrap Brass Plant also handles copper precipitate receipts which are sampled in the cars in the railyard using motor driven augers. Unloading is to a stockpile from which the material is transferred by truck to the bedding system.

PLANT METALLURGY

Roaster Charge

A single calcine charge, whose makeup is primarily dependent upon inventory balances of smelter receipts, is used for all the reverberatory furnaces. It is fortunate that variations are usually gradual and surge capacity is such that a fairly standard mix can be maintained over long periods of time.

All materials bedded are assayed for SiO_2, Al_2O_3, Fe, CaO, MgO, S and metal values, and a mineralogical assay is made based on the chemical analysis. Bedding of the various materials follows the current standard mix. Barren silica and limerock are used for fluxing.

The amount of sulfur to be left in the calcine following roasting is dependent upon the grade of copper in the bed mix and converter smelting requirements. With the large amount of scrap materials and secondaries presently being smelted, it is desirable to maintain a matte balance which will keep the converters operating at near capacity. The metallurgist calculates a sulfur for the calcine which will give the required matte plus the excess required for reduction of magnetite in the reverberatory furnaces.

The fluxing of each bed mix is dependent upon the calcine sulfur to be obtained and upon the plant metallurgical balance. Silica and lime are placed on the roaster beds to produce a final reverberatory slag with a silicate degree of 1.45 to 1.50 when the charge is roasted to the correct sulfur. Fluxing is adjusted to maintain certain mineralogical ratios or factors found to give the best results in smelting of the charge.

Converter Charge

At the present time a converter flux containing over 75% SiO_2 is being used, which has been giving satisfactory fluxing with a maximum use of secondaries and reasonable refractory life. Converter slag currently averages 24.9% SiO_2 with 25.9% Fe_3O_4. The flux mix is made up to use the maximum permissible amount of the Bisbee oxide ores.

Magnetite Control

Magnetite control is quite important at this smelter due to the long furnace operating periods between major repairs. Until the new No. 10 furnace was built last year, no spare units were available to permit shutting a furnace down for digging the bottom. Both roasting and converting produce large amounts of magnetite, so these operations are pointed toward minimizing the magnetite produced and sent to the reverbs. Magnetite buildup in the reverberatory furnaces is controlled through adjustment of calcine sulfur, charge fluxing and furnace heat.

Typical Analyses

Following are typical analyses for the various major smelter input materials, fluxes and plant metallurgical products:

Material	SiO_2	Al_2O_3	Fe	CaO	S	Cu
NMBM						
A-B Division Ore	20.7	5.6	28.0	2.5	29.3	5.00
Cole A Ore	20.7	4.2	31.1	1.1	28.7	4.80
Cole B Ore	20.1	4.9	28.6	1.9	30.7	5.80
Cole C Ore	22.8	5.8	27.7	3.5	18.0	6.10
L. P. Concentrates	8.0	3.1	33.0	-	40.3	12.90
L. P. Precipitates	6.3	2.7	10.3	-	-	60.30
Scrap Residue & Brass	-	-	28.4	-	-	40.30
Refinery Slags	-	-	10.4	-	-	46.50
Custom Precipitates	1.5	4.5	5.7	-	-	74.40
Big Hole Ore	38.9	15.2	13.5	-	6.7	7.70
Miscellaneous Ores	77.9	6.2	4.4	1.2	0.1	0.93

Total NMBM contained only 12.4% copper in 1963.

Material	SiO_2	Al_2O_3	Fe	CaO	S	Cu
FLUX						
Limerock	2.7	0.9	0.7	53.0		
Silica	92.7	2.6	1.9	0.2		
METALLURGICAL ASSAYS						
Roaster Charge	22.6	3.5	24.6	5.5	25.6	8.75
Roaster Calcine	24.0	3.7	26.1	5.9	14.3	9.20
Reverb Matte	-	-	39.6	-	25.8	29.30
Reverb Slag	39.7	5.3	33.5	7.3	0.8	0.37
Converter Charge	15.1	1.2	32.2	0.4	19.4	25.00
Converter Slag	23.5	1.9	50.7	0.6	0.8	6.90
Anode Copper						99.6

ROASTER DEPARTMENT

Roaster Plant

The Roaster Plant consists of twenty-four, seven-hearth Herreschoff roasters arranged in two parallel rows of twelve roasters.

Each roaster is fed from a separate 100-ton feed bin by two vaned drum feeders and feed rate is controlled by a variable speed adjustment on the feeder drive. The feed bins are equipped with air vibrators which automatically rap the bins on a timed sequence to aid in feeding.

The roasters are standard Herreschoff whose shell diameter is 21' 7". The seven roaster hearths are standard - a dry floor and six inside hearths. Natural gas is introduced on the fifth, or next to bottom, hearth for supplemental heat in roasting and column air is discharged into the roaster on the bottom or sixth hearth. Calcine discharge from each roaster is into a single holding hopper over the calcine haulage tracks.

Sixteen to twenty roasters are usually in operation. Charge averages 180 to 200 dry tons per roaster day at a fuel ratio of 0.40 to 0.50 million BTU per ton.

Present practice is to use castable refractories in making hearth replacements. Sidewalls remain fire-clay brick. The rabble arms and rabbles on the lower three hearths are heat resistant cast steel.

Calcine produced in the roaster plant is transferred to the reverberatory furnace by rail. Two trains of two and four 15-ton calcine cars are used to pull the calcine hoppers fifteen times a shift, weigh the calcine on track scales and spot the cars for unloading at the reverberatory furnaces.

Cottrell Plant

Gas from the twenty-four roasters is drawn into a brick and tile lined flue running the length of the building and discharging into the Cottrell plant header flue. Initial dust collection is made in the series of dust hoppers forming the flue bottom.

The Cottrell plant has six separate precipitator units of four sections each, all of which are used in normal operation. The five older units have corrugated iron collector plates while the newest unit has pipe curtains. Twisted 3/8 inch rods are used for the negative electrodes. Two mechanical rectifiers supply each unit with the required high voltage DC current. Cottrell gas discharge is into a flue leading to the roaster-reverb stack.

Approximately 90% of the dust entering the units is recovered and conveyed by screw feeders back to the roaster plant where it is charged either onto the fifth hearth of six of the roasters or into a dust hopper from which it can be pulled directly into the calcine trains.

REVERBERATORY DEPARTMENT

General

Four reverberatory furnaces are currently available - two side-charge and two bath smelting furnaces, but only three furnaces are in operation at any one time. The construction of a second bath smelting furnace in 1963 has permitted a program of repairing and renovating the older three furnaces. At the present time the No. 9 bath furnace is being rebuilt and extensive repairs are being made to its waste heat boilers.

All furnaces have the nominal inside dimensions of 26 x 107 feet and are of sprung silica arch construction.

Side Charge Furnaces - No. 7 and No. 8

Construction

The sprung silica arch for these furnaces has the same configuration the length of the furnace resulting in no restriction to gas flow before the boiler outlet. Silica brick is the principal furnace refractory with a magnesite facing at the bridgewall and other exposed wear points. Bottoms are 2' 2" of poured slag.

A single Babcock-Wilcox four drum Sterling waste heat boiler is superimposed over the end of the furnace. The furnace opens directly into the boiler with no provision for bypassing the boiler. Each of the side charge boilers is rated at 2568 BHP - 85,000 pounds steam per hour. Hand operated soot-blowers and hand lancing are used to maintain the boiler passages.

Charging Calcine

The side-charge charging system consists of two enclosed drag-chain conveyors at the sides of the furnace running 60 feet from the brdigewall. Distribution of calcine is through gate valves and charge pipes spaced at four foot intervals between the buckstays the length of the drag box. Both sides are charged at the same time on a 32 minute cycle.

Matte Tapping

Matte is tapped through the sidewalls beyond the charge zone into launders which carry it to ladles in the converter aisle. Tapping is alternated among four tap holes, two to a furnace side.

Converter Slag

Converter slag is charged through two fixed launders at the sides of the bridgewall.

Furnace Slag

Furnace slag is skimmed through the center of the end wall under the boiler into a short launder leading to the slag car. Water cooled jackets are used to maintain the notch.

Firing

The side charge furnaces are fired with natural gas through the bridgewall using four high pressure 10-in. inspirator burners at a rate of 125,000 to 135,000 CFH. Smaller supplemental burners are used in the sidewalls to maintain bath temperature at the boiler end. An emergency fuel oil system can be used in place of the natural gas.

Bath Smelting Furnaces - No. 9 and No. 10

Construction

Sidewalls and arch are of silica brick with the arch drooping down as it approaches the boiler uptake.

The furnace hearth consists of a fused impervious layer of chrome ore and magnetite approximately six to seven inches thick placed on top of a poured slag subjacent hearth.

The matte retaining crucible consists of an 18-inch thick tamped periclase lining backed by silica brick supported by the buckstays.

The slag zone above the crucible falls within a water jacketed wall. Jackets are cast copper, 20 inches high, with cooling coils embedded in them. The cooling water is circulated in a closed system between the furnace and power house heat exchangers and pumps.

Two separate 1120 BHP waste heat boilers rated at 34,000 pounds per hour steam are used for waste heat recovery from the No. 9 furnace, while the No. 10 boilers are rated at 30,000 pounds steam. Gases pass from the furnace uptake through short cross-over flues into each boiler which can be isolated from the furnace by use of dampers. The older No. 9 boilers use hand operated soot-blowers and require hand lancing, but the No. 10 boilers have air driven retractable soot-blowers.

Charging Calcine

The bath smelting furnaces are each equipped with four Wagstaff feeders located two on each sidewall of the furnace near the bridgewall. Charging ports are covered with air-operated, cast-refractory doors when not in use. Charging is rotated among the guns on 16 minute cycles.

Matte Tapping

Matte is tapped through the sidewalls near the burner end of the furnace. Each furnace has four tap holes among which tapping is alternated. The No. 10 furnace has heated, covered launders of tamped periclase.

Converter Slag

Converter slag is charged through two launders at the sides of the bridgewall. Launders are fixed on the No. 9 furnace, but the No. 10 furnace has retractable slag launders operating through ports similar to the charge ports.

Furnace Slag

Slag skimming is similar to the side-charge furnaces, the principal difference being that the No. 10 furnace has a fume exhaust system.

Firing

Firing is with natural gas at a rate of 135,000 CFH through six high-pressure 8-in. inspirator burners located in the bridgewall augmented by side-wall burners. A standby oil burner system can be used in place of natural gas.

Operation of Furnaces

All three operating furnaces receive the same charge, the calcine trains being rotated through the operating roasters to minimize charge variation. Charging rates are currently:

	Tons Calcine/Furnace Day	Mil. BTU/Ton
Side Charge	950-980	3.52
Bath Smelting	1000	3.53

Furnace combustion is controlled to maintain 0.4 to 0.5% O_2 at a point within the furnace approximately 10 feet from the uptake. All furnaces have automatic draft controllers operating dampers on the boiler outlets. Side charge furnace pressure is maintained at 0.005 inches of water draft, the bath furnace at 0.015 draft.

Slag disposal is a major problem due to the low grade of plant input. An average of close to 180 pots of slag a day must be skimmed from the furnaces or smelting is curtailed. Slag haulage is done by two 25-ton diesel-electric locomotives operating in tandem working with six 225 cu. ft. slag pots. The locomotives push a loaded train of three pots to the dump each trip and leave three empty pots under the furnace slag launders for filling. The track layout is such that the slag train reverses itself on the return trip so that the locomotives can pick up the now loaded pots and leave the emptied pots.

Furnace gases pass through a flue system to the roaster-reverb stack which is 572 feet high with a 22'-7" diameter discharge.

Maintenance of Furnace Refractories

The silica arches and sidewalls of the furnaces are maintained by hot patching with a silica slurry, a method developed at the former United Verde Branch.

At this smelter, the barren 90 to 93% silica rock used as flux is used for hot patching. The crushed rock is ground in a ball mill to 86 to 90% minus 200 M to produce a slurry containing 53 to 60% solids.

The slurry is stored in a 10,000 gallon tank containing an agitator from which it is removed by a Denver 5 x 4 SRL pump into a 4-in. rubber lined distribution loop over the top of the furnaces. Distribution to the work areas is through down-comers located at the furnace sides and rubber hoses.

The slurry is sprayed through pipe nozzles onto the brickwork by the use of plant air at the nozzle.

Arch campaigns have been extended considerably. The No. 7 furnace operated from September 1955 to October 1961 at which time eight feet of arch had to be replaced at the uptake. A section in the charge zone subsequently failed in December 1962 and part of the arch was replaced during renovation of the furnace in 1963. The No. 8 operated from February 1953 to February 1962. The No. 9 operated from January 1950 to December 1962. The arch was removed this past winter for the renovation and rebuilding now being done.

CONVERTER DEPARTMENT

Matte from the reverberatory furnaces is converted to medium blister copper in five 13 x 30 ft. Peirce-Smith converters. Normally full operation of three converters is obtained by rotating service among four hot converters. Air at 14 psi enters the converters through 1.5-in. tuyeres spaced at 6-in. centers. The blowing rate is 20,000 to 25,000 CFM. The No. 1 through 4 converters have 42 tuyeres while the No. 5 has 52 due to differences in riding ring location. Some 2-in. tuyeres are used near the ends to even wear.

The Converter Department is serviced by three overhead cranes - two of

40 ton and one of 60 ton capacity. The No. 1 crane has been recently renovated and an air conditioned cab installed. The use of tail chains has been virtually eliminated through the use of an oversized clevis on the ladles.

Silica flux is charged to the converters through the mouth from an inclined chute fed by a belt feeder under the flux bins. Flux charging is controlled by the skimmer.

The gas from the converters passes through a balloon flue and eight multiclone units to the separate converter stack which is 18 feet inside diameter at the top of its 572 ft. height. Balloon flue dust is returned to the converters while multiclone dust is returned to the bedding plant.

Cleanup in the aisle is aided by the use of an extensible boom type machine.

The Converter Department makes a minor amount of shot copper for use in Corporation refineries.

SPONGE IRON PLANT

A 25 TPD Sponge Iron Plant is in operation at this smelter. It will be doubled in capacity during 1964 and new slag granulating facilities constructed.

Ferramag, a mixture of iron oxides, is produced by blowing a converter charge of matte without adding silica flux. The ferramag is granulated by pouring into a water stream with the resultant product serving as the feed to the Sponge Iron Plant.

The Sponge Iron Plant converts the ferramag to plus 64% metallic iron by reducing with air reformed natural gas in a reducing furnace. The sponge iron is used in the Copper Queen Branch precipitation plant at Bisbee.

Plant equipment includes:

1. A 40-foot long, four foot diameter kiln for drying and preheating ferramag.

2. A vertical reducing furnace.
3. A natural gas-air reformer.
4. Auxiliary materials handling equipment.

ANODE DEPARTMENT

The Anode Department oxidizes the blister copper to remove the remaining sulfur and slag forming impurities. The oxidized copper is then reduced using reformed gas to less than 0.10 per cent oxygen and cast as 725 pound anodes for shipment to the Corporation refineries at El Paso, Texas and Laurel Hill, New York. Anodes average 99.6% copper.

The department has two 13 x 20 ft. basic lined furnaces similar in design to the Peirce-Smith converters, a circular 22-mold casting wheel and a natural gas-air reformer.

Normally two charges are poured each day on a variable schedule. One furnace is receiving converter copper and starting the processing cycle while the other is finishing the oxidizing, reducing and casting cycle. Anode slag is return to the converters.

The oxidation and reducing steps are accomplished by introducing plant air or reformed gas into the bath through two 1-1/2 in. tuyeres at a pressure of 15 to 20 pounds. A four-way valve is used to change from one gas to the other or to vent to atmosphere. Reformer operation is automatic. Two operating panels with start-stop buttons, equipment signal lights and gas flow recorders are used to control reformer operation from the anode furnace floor. A pressure-loss, fail-safe design will introduce natural gas into the tuyeres should there be a failure. Approximately 0.204 mil. BTU are required per ton anode copper.

The use of reformed gas for the anode copper reduction step was developed at this plant in 1958. The present plant has been in operation since early 1959 with no significant interruption in anode production due to reformer maintenance.

The finished anode copper is poured from the anode vessel into a tilting spoon which in turn is tilted to fill the molds. Furnace movement, positioning of the reversible casting wheel, spoon operation and mold washing are controlled by one man. Pulverized silica or zinc oxide is used as the mold wash and water sprays and air jets are used to cool the molds. The solidified copper anodes are broken from the mold and transferred to a bosh tank for final cooling using air operated hoist and hooks. Casting rate is approximately 30 tons per hour.

Anodes are removed from the bosh tank by use of an overhead crane. Following trimming and inspection, the anodes are loaded for shipment.

POWER PLANT

The Power Plant produces the power requirements of the smelter and a good share of the power requirements of the Bisbee operations. Smelter requirements are AC and DC electricity and high and low pressure air.

The waste heat boilers produce steam at 350 psi and 660°F. which is used in power generation by three 5000 KW turbo-generators with surface condensers, duplicate condensate pumps and air ejectors. The alternators are cooled with integral air coolers. Three pumps circulate condenser cooling water through a cooling pond with a surface of 200,000 square feet. A direct fired Erie boiler rated at 60,000 pounds steam per hour is located within the power house for use in power generation when the waste heat boilers are unable to meet steam requirements.

Boiler feed water is obtained from a preparation unit consisting of multiple effect evaporators operated by high pressure steam. Distilled water from the evaporators is stored in two tanks. The feed water is de-aerated, conditioned and heated prior to use.

At times steam production is in excess of power requirements, and in such circumstances, excess steam is condensed and the water returned to the feed water system.

The plant DC requirements are generated by two 600 KW motor generator flywheel sets and two 300 KW motor generator sets.

Converter air is supplied by three 20,000 CFM electrically driven turbo-blowers and one 30,000 CFM steam driven turbo-blower. Constant converter air pressure is maintained by an automatic Askania controller.

With the exception of small compressors at the gas reformers, 100 psi high pressure plant air is supplied by four electrically driven air compressors at the power house.

Plant water supply is from three wells on the property.

Three 44,000 volt circuits are available for transmission of power to the Bisbee operation.

MISCELLANEOUS

As a result of the separation of this smelter from the mines, the many and varied operations, and the custodial requirements of a separate hospital and the Corporation General Western Offices, the mechanical and outside overhead other than smelting operations is larger than would be expected.

SHOPS

The smelter maintains carpenter, tin, boiler, blacksmith, pipe, electric and machine shops and a general repair crew to handle smelter maintenance.

ASSAY OFFICE

A fully equipped assay office performs all chemical analyses and determinations required by operations.

TEST DEPARTMENT

The Test Department maintains all process instrumentation, obtains data from recording meters, and makes process checks not performed by other departments such as flue testing, dust counting and combustion. It also performs a limited amount of experimentation and research.

SAFETY PROGRAM

The prevention of accidents is of primary importance in operations and employee participation is emphasized. Scheduled safety meetings are held in all work units. Codes of Safe Practice are issued covering all smelter work units.

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