Arizona Geological Survey
125 Years
1888–2013

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

PRINTED: 06/24/2002

ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES AZMILS DATA

PRIMARY NAME: SAN MANUEL SMELTER

ALTERNATE NAMES:
MAGMA METALS COMPANY

PINAL COUNTY MILS NUMBER: 721A

LOCATION: TOWNSHIP 9 S RANGE 17 E SECTION 29 QUARTER SE
LATITUDE: N 32DEG 36MIN 58SEC LONGITUDE: W 110DEG 37MIN 18SEC
TOPO MAP NAME: PEPPERSAUCE WASH - 7.5 MIN

CURRENT STATUS: PRODUCER

COMMODITY:
MILL CU SMELTER

BIBLIOGRAPHY:

ADMMR SAN MANUEL SMELTER FILE
1973 CAP:200000 TONS TPY
EMJ M&M DIRECTORY

San Manuel Smelter

T H E   M A G M A   S M E L T E R   M O D E R N I Z A T I O N

By: Ken Driggs, Smelter Superintendent

May 6, 1989

Presented at the AIME Spring
Technical Session

Magma Copper Company
P.O. Box "M"
San Manuel, AZ 85631

The Magma Smelter Modernization

The Magma, San Manuel smelter is located 40 miles northeast of Tucson, Arizona. It was originally commissioned in 1955 with one reverberatory furnace, three Pierce Smith converters, two anode vessels, one casting wheel and expanded in the late 60's and early 70's to a three reverberatory, six converter operation with four anode vessels and two casting wheels. In 1974, a two train acid plant was commissioned to treat the SO_2 gas from the converters.

In 1984 a team of Magma and Newmont Mining (then our parent company) engineers evaluated various smelting processes that would comply with E.P.A. regulations and be compatible with the existing facilities. The results of the investigation led to the initiation of the Magma Smelter Project in October 1985. The project consisted of engineering, procurement and construction to retrofit a state-of-the-art smelting operation, to the Magma smelter. The cornerstone of the retrofit would be Outokumpu flash smelting technology.

The timetable for the project was established by a consent decree entered into by Magma, the U.S. District Court, the Environmental Protection Agency and the State of Arizona.

We agreed to retrofit our smelter prior to November 1, 1988. See attachment I.

The project included preparation facilities, concentrate handling modifications, drying installations and flash smelting with the associated offgas and slag treatment equipment. The converters were retrofitted with new primary and secondary gas handling systems. The primary system featured state-of-the-art Lurgi wet scrubbing. An anode casting wheel was modified and the acid plant converted to double contact. An oxygen plant was built to supply the flash furnace and converters.

On October 10, 1985 Davy McKee was awarded the smelter project engineering and construction management contract. Newmont Mining was contracted to continue project management through project completion. With the award of the design engineering contract to Outokumpu for the flash furnace and ancillary equipment, capacity and option studies were completed. The capacity was set at 3000 stpd of concentrate by arrangement with Cyprus Minerals to accommodate this concentrate.

The following descriptions, by plant areas, detail the project scope. Each is followed by design and major equipment specifications, where appropriate.

FLUX PREPARATION

Detailed engineering and construction management was by Davy McKee.

Coarse silica is delivered to an existing dump hopper, discharged by an apron feeder and conveyed to the existing jaw crusher. A dust suppression system was added to the dump hopper and jaw crusher. Existing conveyor belts transport the jaw crusher discharge to the four existing 450 ton storage bins. Apron feeders transport flux from the bins to a system of belts and gates which are controlled to accommodate either silica flux or limestone sized to specifications for its use.

A new diverter gate was installed at the discharge of an existing belt to feed a new vibrating screen or bypass the screen directly to an existing conveyor belt. The vibrating screen oversize product is conveyed via conveyor belts to the two existing 700 ton converter flux bins when crushing converter flux. Existing belt feeders followed by conveyors and a new tripper conveyor delivers flux to the existing 300 ton bins over the converters. The screen undersize during converter flux crushing is conveyed by a new belt through a diverter gate to one of two new 200 ton fine flash furnace flux bins.

When crushing furnace flux the new screen oversize is conveyed by conveyor through a diverter gate to a new crusher feed hopper, a feeder belt and 225 stph rotopactor crusher. The crusher discharge is conveyed by existing conveyors back to the new screen. The screen undersize product is then carried by existing conveyors to either of two 200 ton furnace flux bins. From these bins, existing belt feeders and conveyors deliver the furnace flux to a 250 ton bin.

Flux preparation concrete work began in July of 1987. The first equipment was set in January 1988 with equipment placement completed in April 1988. Plant testing and debugging took place in May. We began operation of the flux preparation plant in June 1988 making the construction duration 12 months.

CONCENTRATE HANDLING

Detailed engineering and construction management was by Davy McKee.

The existing San Manuel 3000 ton concentrate bin and six feeder belts were modified with variable speeds. These feeders discharge onto existing belts and into a series of new belts to a tripper belt into one of three 460 ton wet charge bins.

The existing custom concentrate receiving system was modified with two partition walls being added creating three 1000 ton bins. The existing system consists of dump hoppers and belt feeders to feed a tripper conveyor which discharges into the bins. Belt feeders convey concentrate from the bins to the belt system that follows the San Manuel concentrate path to the wet charge bins.

Construction in the existing concentrate handling area began in April 1988. Operational requirements necessitated a two hour shutdown every six hours to complete the demolition, modification and installation of new equipment. Commissioning began and was completed in June. The concentrate handling system was operational on July 1, 1988.

Additional truck and rail concentrate receiving was installed utilizing an abandoned coal receiving station. Concentrate is delivered from modified dump hoppers to the existing conveyor belts and new tripper conveyor to either of two new 1000 ton storage bins or ground storage. Each of the bins is equipped with a belt feeder, feeding existing conveyor belts and new belts and tripper. The tripper feeds the three 460 ton wet charge bins.

In November 1987 field fabrication of the two new custom concentrate storage bins began in this area. Commissioning started in June with the release to operations on July 6, 1988.

FLASH SMELTING

Detailed engineering for the furnace was by Outokumpu, the waste heat boiler by Ahlstrom and other areas by Davy McKee who also managed the construction.

The following equipment is new construction unless noted.

Stored concentrates are transferred by belt feeders out of the wet charge bins onto a transfer conveyor where it is joined with furnace flux feed from the adjacent charge bin being fed by a belt feeder with a weight scale. The wet charge passes to a belt conveyor with a belt scale providing a total charge weight to the dryer. The belt discharges onto a reversible shuttle conveyor. Wet charge can be fed by belt to the dryer or retracted and reversed to feed charge to the ground.

The dryer is fired by natural gas or fuel oil and uses nitrogen from the oxygen plant to replace secondary air. The dry charge furnace feed exits the dryer discharge housing and is transferred through a drag conveyor to the pneumatic lift tank.

The furnace feed carried out of the dryer in the exhaust gases are collected in an electrostatic precipitator and conveyed by drag conveyors to another drag conveyor to rejoin the charge stream. The cleaned dryer exhaust gases are then vented to atmosphere. The pneumatic conveyor transports the dry charge to an expansion tank where the material drops out and is fed to the dry charge bin. A cyclone removes the suspended material from the transport air as it leaves the expansion tank. From here the transport air is carried by the concentrate return air fan to the dryer discharge housing where the air can be further cleaned in the dryer electrostatic precipitator before discharge to the atmosphere. The charge collected in the cyclone is fed to the dry charge bin by rotary feeder.

Dry charge is withdrawn from the dry charge bin and metered to the concentrate burner by two drag feeders. The flash furnace is located on the foundation of the number three reverberatory furnace. This places the furnace in a position perpendicular to the converter aisle with the charge end (reaction shaft) nearest the aisle. The concentrate burner mixes the dry charge with oxygen enriched air and injects the mixture into the top of the furnace reaction shaft. Heat generated by the oxidation process melts the charge during passage from the burner to the base of the shaft. The melted charge drops into the settler while the dust laden gases pass into the furnace uptake shaft. On leaving the uptake shaft the dusty gases are introduced into a waste heat boiler located perpendicular to the central axis of the flash furnace. The dusty hot gases are cooled in the boiler and dust is collected in its hoppers. After being cooled in the boiler the gases are ducted into two electrostatic precipitators, each capable of handling 70% of FSF capacity, where the remaining dust is removed.

Waste heat boiler dust is transported by drag chain to a roll crusher where oversize material is crushed before being dropped into the flue dust feed pump. Dust from the electrostatic precipitator is also delivered to the flue dust feed pump via drag chains and a rotary feeder. The pump introduces the dust to the dust pneumatic conveyor duct for transport to the flue dust primary and secondary cyclone. The collected dust is fed via rotary feeders to the flue dust bin. Drag feeders feed dust from the bin to transfer drag feeder which drops dust onto the furnace dry charge feeders. The dust transport air is blown by the return air fan to the inlet of the waste heat boiler.

The cleaned gases are drawn from the electrostatic precipitators by one of two induced draft fans and ducted to the acid plant for further processing. Fugitive gases are collected from above the launders and tap holes and ducted to fans. The fugitive gases from the flash smelting furnace area are cleaned by an existing electrostatic precipitator and vented out of the old reverberatory stack.

Molten matte produced in the flash furnace is removed through tapholes and directed by launders to existing ladle cars north, south and east of the furnace. Molten slag is removed from the flash furnace through tapholes and directed by launders to Kress carrier slag pots at the west end or north side of the furnace.

The demolition of no. 3 reverb furnace, which was to be the location of the flash furnace, began in December 1986. Demolition was completed in April, 1987 and the integration of the old reverb foundation into the flash foundation began. Also in April rotary dryer foundation excavations activities commenced and by the end of May the first concrete foundations were in place. By the end of June the erection of the 83 foot long, 42 foot high and 27 foot wide furnace began. June also saw the start of concrete placement for the waste heat boiler. In September erection of the 120 foot long, 12 foot diameter rotary dryer began. Refractory installation for the flash furnace began in November.

In January 1988, mechanical work on the furnace was complete. The refractory was completed in March, as was the boiler tube screen walls and tube banks. Hydrostatic testing of the boiler and furnace water jackets was completed in May. Also in May the rotary dryer burner and mechanical electrical testing was completed. In June the furnace ancillary equipment commissioning began. On June 13, 1988 the furnace burners were ignited and furnace and boiler heatup began. Power was applied to the electrostatic precipitators in June. On July 7, 1988 flash furnace smelting operations commenced.

CONVERTER FACILITIES

Lurgi designed a new gas cooling and cleaning system for no. 3-6 converters to treat converter primary offgases. Davy McKee did detailed designs for the Lurgi conceptual designs on the converter fugitive systems for the new converter primary hood cooling system and the construction management.

The Lurgi offgas system utilizes a variable flow radial scrubber, 16 feet in diameter and 75 feet high, to contact the gas stream with water, resulting in the cooling and cleaning of the stream. This gas stream is drawn through the scrubbers and demisters by induced draft fans and passed to the acid plant for further treatment. The liquid stream is recirculated and a bleed passed to a settler where solids are concentrated to a slurry. This slurry stream, which is slightly acidic, is thickened. The decanted overflow returns to the scrubber and the underflow is recycled to the existing concentrate thickener. The system is designed to handle 87,000 scfm of gas per converter. Each converter has a dedicated cooling and cleaning system. The slurry collection system is common to all four converter systems.

The converter primary hood cooling system was changed from a natural convection system to a forced cooling water system. New water circulating and supply bring Powerhouse cooling tower water to the hoods. The existing hood water jackets continue to be used but piping was rerouted to direct the flow into a parallel circulation configuration.

To capture converter fugitive gases when the converter is out of the stack, a secondary hood system was installed. The hoods enclose the converter mouth carrying gases to a collection duct, through an induced draft fan and existing electrostatic precipitator, relocated from the former converter primary gas system. The fugitive gases are used for dilution air in the Acid Plant or routed up the existing converter stack.

In general, the converter retrofits were scheduled around the converter repair campaigns. Construction work commenced on no. 5 converter in January 1987 with the startup of the new systems ready with the startup from campaign repairs in June

1987. No. 6 converter went down in late June and was on line in early August. No. 3 was down from the end of October to mid December and no. 4 converter went down February 10 and went on stream April 11, 1988.

ANODE PLANT

Magma did all engineering and construction in the Anode Plant. This consists of modifying the no. 2 casting wheel to incorporate a double pour - double take-off system for anodes. The new casting system pours, via an automatic weighing system, and removes anodes in pairs. No. 1 casting wheel having 28 molds has the capacity to cast 70 tph while #2 wheel's capacity is 50 tph, having only 20 molds.

ACID PLANT

The conversion of the existing single absorption two train acid plant to double absorption was required to meet sulfur dioxide emission standards. To make this conversion, two new heat exchangers per train, one new final absorption tower per train, two new strong acid circulating pumps per train, additional catalyst, modification to the 98 percent acid pump tank and new ducting were required. The existing Karbate coolers were replaced with three new plate heat exchangers.

New conditions also required modifications to the gas conditioning circuit. This upgrading required the addition of two mist precipitators in parallel with the existing six units and one weak acid cooler. Controls at each air dilution valve were also required. For ease of maintenance, isolation valves were required at each pair of mist precipitators and at each plate heat exchanger. A new product acid line was installed to the acid storage area.

Detailed design and construction was by Monsanto Envirochem. Construction activity began in late 1986 and was under full swing by March 1987. The acid plant was shut down on October 16, 1987 for tieing in of new equipment. Train no. 1 was operational on October 21 and train no. 2 on November 3. All construction activity was completed by the end of 1987.

OXYGEN PLANT

The design engineering and construction was by Liquid Air who provided a turnkey installation. The plant consists of a 12,200 horsepower motor driven compressor, purification through molecular sieve absorption, cold box with heat exchangers and expansion turbines, two oxygen product compressors and after coolers, twelve hour liquid storage and control building.

Construction of the plant began in September, 1987. Mechanical completion was reached in May of 1988. Testing and commissioning had started in April and ran through mid-June. On June 29, 1988 the plant produced its first oxygen.

POWERHOUSE

Davy McKee did the design and construction management.

The new boiler feedwater and steam return conditions necessitated changes in the powerhouse. A superheater was required to raise the flash furnace waste heat boiler saturated steam temperature and lower the pressure to match existing plant steam conditions. The higher flash boiler operating pressure required new boiler feedwater pumps. To meet the greater demand on treated water a new ion exchange water treatment plant was built.

In October 1987 civil work commenced for the superheater foundation. In June 1988 the superheater was commissioned along with the boiler feedwater pumps. The water treatment plant construction began in March 1988 and was producing water in May.

SLAG HANDLING

Davy McKee did the detailed design and construction management with the exception of the modifications required in the concentrator to mill and float slag. Magma did this modification.

The flash furnace slag and converter slag are transported by the rubber-tired Kress slag pot carriers to the slag cooling area. The molten slag is poured from the pots into prepared pits for cooling. After eight hours of air cooling the solidified slag is further cooled by water sprays and then allowed to dry. The slag is cool enough for processing after approximately three days.

The slag from the pits is loaded by front end loader into a 50 ton truck. The slag is hauled to a dump hopper which feeds a mobile crusher. After being crushed to minus eight inches, the slag is screened into two fractions: minus two inch material which is used for pit bedding and minus eight inches plus two inches material which is loaded by front end loader onto rail cars which are moved by locomotive to the existing ore receiving dump station at the existing concentrator. The slag is dumped at a designated location and conveyed and processed by existing feeders, conveyors, secondary crushing and screening and tertiary crushing and screening. The final product is stored in the grinding mill feed bins.

In January, 1988 surveying operations were initiated relative to construction of 168 flash furnace slag pits (25 feet long by 14 feed wide) as well as 72 converter slag pits (25 feed long by 11 feet wide). Construction was completed in June 1988 and the pits received slag when flash furnace operation began.

GENERAL FACILITIES

Design engineering and construction management was by Davy McKee.

This area covered all the minor and some major utilities and construction work to tie the outer areas together. The major work was installation of larger transformers by Arizona Public Service to accommodate the increased loads placed on the existing substation.

Initial yard work began in October 1986 with testing and commissioning of piping, electrical equipment and buildings completed in June 1988.

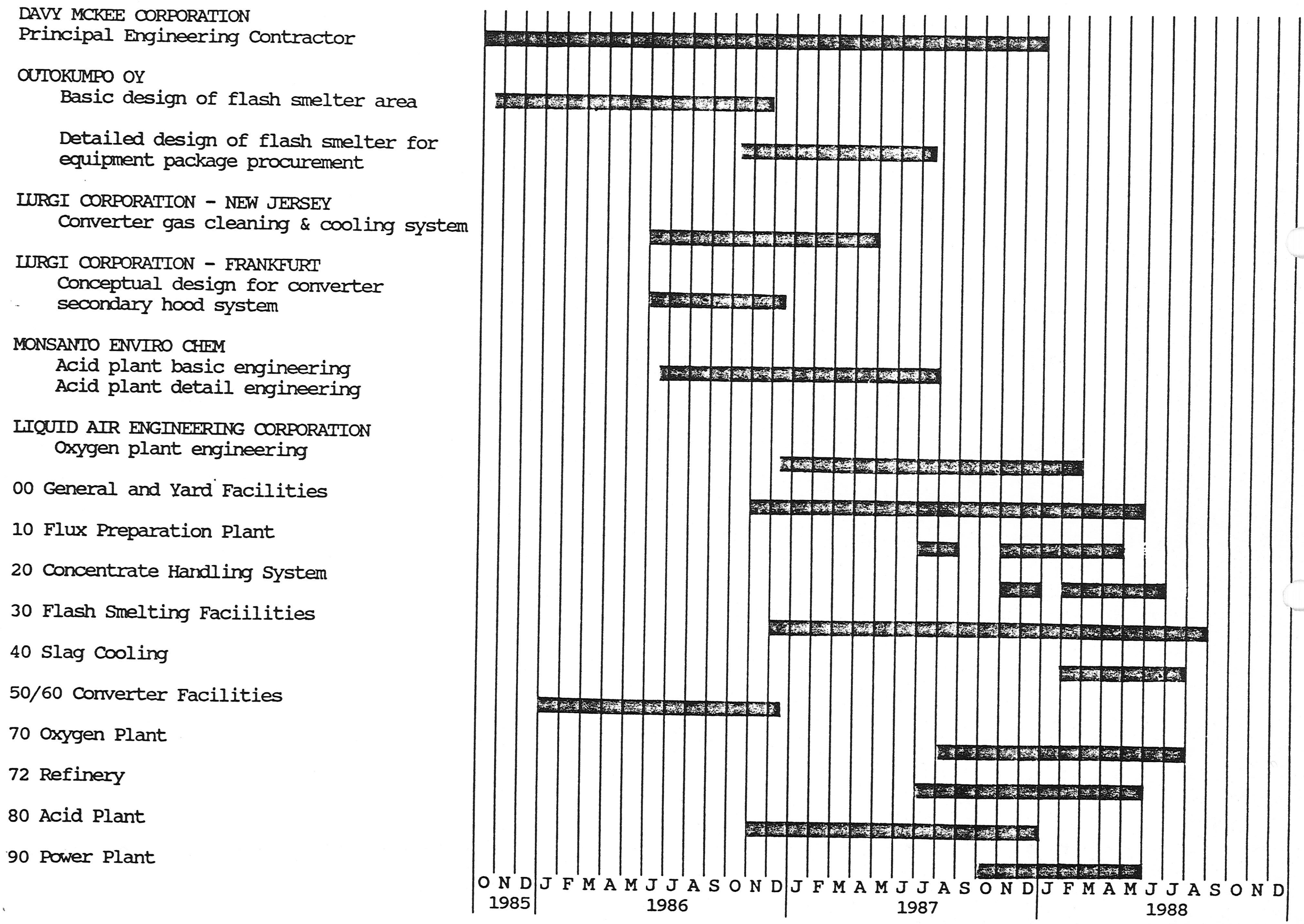
The flash smelting furnace was completed 24 days ahead of schedule, the Acid Plant 28 days ahead of schedule and the Converters completed seven months ahead of schedule. The project was completed under budget.

ATTACHMENTS

1.	Schedule of Engineering and Construction	
2.	Site Photos	
3.	<u>Drawing Numbers</u>	<u>Process Flow Diagram</u>
	609-9-5-102	Magma Smelter Project - Overall Plot Plan
4.	609-0-0-052	Flux Prep. & Material Handling
5.	609-0-0-061	Custom Concentrate Handling
6.	609-0-0-053	Dryer & FSF Charge
7.	609-0-0-054	Flash Smelting Furnace
8.	609-0-0-055	FSF Off-Gas Handling
9.	609-0-0-056	Converter Area
10.	609-0-0-057	Converter Off-Gas Handling
11.	321-152	Acid Plant Material Flow Diagram
12.	609-0-0-060	Custom Concentrate Handling

ATTACHMENT I

MAGMA SMELTER PROJECT SUMMARY
ENGINGEERING & CONTRACTOR SCHEDULE



San Manuel Smelter

C O N F I N E D   S P A C E   E N T R Y

By: George Price, Acid Plant Foreman

May 6, 1989

Presented at the AIME Spring
Technical Session

Magma Copper Company
P.O. Box "M"
San Manuel, AZ 85631

CONFINED SPACE ENTRIES

Good afternoon, my topic today will be the evolution and practice of confined space entries at the San Manuel smelter. Over the last decade, industry as a whole, and Magma in particular has begun to understand the special hazards of confined space environments, and develop methods to work in them safely. I'm here to share our experience, and perhaps learn from yours.

First, perhaps a definition of confined space entry would be in order. This would be any enclosed space which:

1. Has limited means of ingress and egress.
2. Has the potential for containing an atmosphere which is either hazardous in itself, or is capable of becoming hazardous.

Bins, flues, boilers, chemical towers and storage tanks, all are considered confined spaces.

Historically, the general industrial response in the United States to the hazards confined space entries has been to either ignore the special hazards they present or to remove the element of confinement by physically changing the space to be entered, removing the top of a bin, for example. Both of these methods have been found to suffer from severe drawbacks. In the first case, ignoring hazards, from both a legal and a moral standpoint, is simply unacceptable at Magma. We have a firm policy of reducing employee risk to the minimum achievable level. As for the latter policy, we can all testify, I'm sure, that modern process equipment savagely resists ad hoc re-engineering.

Our methodology is composed of five major components:

1. SIZE UP AND PREPARE THE JOB.

   The extreme complexity and danger of most confined space entries is not something that you want to confront "on the fly." Even after you have isolated and blanked all lines and ducts going into the vessel in question you will have to consider:

   A. Hazardous atmospheres that may exist or be created inside the space. We test each area for flammability, toxic gases, irritant or corrosive gases, and either an oxygen deficient or oxygen enriched atmosphere. If there is any chance that the working atmosphere may be either displaced by a toxic atmosphere, for example if a vent fan were to start pumping sulphur dioxide contaminated air into a compartment; or if the work in progress might consume the oxygen available or create hazardous fumes, as might be created by cutting or burning inside a vessel, then our testing becomes a continuous process. If there is any question about the work environment after testing, or if an adequate work environment is unattainable, then all work is performed using self-contained breathing apparatus.

B. Physical hazards existing within the vessel. It would be great if all confined space entries were performed in clean, empty storage spaces, but such is not the case. In modern equipment, hazards abound. Both physical hazards such as falling hazards, heat and cold stress, chemical residues, equipment located within the enclosed space, and the psychological hazards of having to work in an atmosphere which is strange and confining serve to make tasks very stressful for the confined space worker. Each interior hazard must be recognized and prepared for prior to entry. At the San Manuel smelter we weigh the level of personal protective equipment very carefully so that the worker is stressed as little as possible by both the environment and their equipment while still enjoying (if that word could possible be applied to this work) more than adequate protection from hazards inside the confined area. The investment of a few hours cool down with an air conditioner, for example, will lead to much greater employee productivity in an otherwise hot, confined, environment.

An interesting footnote to our physical hazard protection program was our discovery that many techniques and most of the equipment used by rock climbers and cave explorers were ideal for service in our confined spaces. While the image of laborers in a precipitator clearing out dust buildups with ice axes may be a bit unsettling to the traditionalist, our motto is "Whatever works best, we use."

2. SET UP YOUR RESCUE FIRST.

Each confined space entrant must be accompanied by a trained standby rescuer equipped for the worst possible environment which could be encountered at the work site. This person's sole responsibility is to enter the work space if his charge is in trouble and support that person until sufficient trained rescuers are present to extricate the victim. In the simple case of a heat stress victim in a sulfuric acid tank, the rescuer may be able to effect the rescue himself, but if this victim is inside the top of an acid gas absorbing tower is may take additional people to perform the rescue. As it is impractical to have large teams of people sitting around the scene of an entry waiting for a disaster (not to mention depressing to the crew that will be working) the designated rescuer bears a heavy burden in our rescue scenario. This person is solely responsible for the entrant prior to the arrival of the San Manuel Fire Department whom we have trained and equipped for perform extrications. The rescuer must evaluate the accident scene, ameliorate the hazard environment, and support the patient until the fire department can be summoned to take over the scene. While doing all this, he does not have time for is off site communication. Therefore, at each work site, a separate individual is designated as the man door watcher and radioman. The sole duty of this person during the entry is the maintenance of a clear communication chain with the entry party and with one of our radio base stations, who will summon the fire department if there is a need. While the line of communication with the entry party may take several forms, from the traditional tag line to personal radios, the method of communication with the base station is always by radio. As the San Manuel Fire Department's radios are rigged to "come up" on our smelter frequency,important information can be exchanged en route, shortening the time of the rescue. The chain of communication needs to be forged prior to its need.

The San Manuel Fire Department, the final ingredient in our rescue scenario, has been characterized fairly as a small town fire department with a world class rescue capability. Extensive financial resources and time have been devoted to making this group mission capable for the most demanding rescues. (If any of you would like to contribute by the way, just buy a soft drink from one of the machines you find around the property.

The revenue from the sales of on-plant candy and soft drinks handle almost all of their budget requirements. Now that's creative financing!) But I digress.

Industrial confined space rescue is in most ways similar in its demands to mine rescue. The major difference is that the confined space rescuer can prepare for the rescue of his entry party before the fact. The engineering and set up of the rescue will have the greatest impact on whether the incident which prompts the rescue will be survivable. Victims of asphyxiating gases or insufficient oxygen in their environment will have a maximum of six to eight minutes before their problem is fatal. Victims of traumatic incidents may have less or more time, depending on the extent of their injuries. RESCUE IN CONFINED SPACE IS A VERY SLOW PROCESS. Every effort must be made to shorten the amount of time that it takes to get your victim to where appropriate intervention can be applied to reduce his injuries to a manageable level. Removing an injured victim is far from an easy task, as his injuries may require medical support which will significantly complicate your task.

Now around this time some of you may be longing for the good old days, when you just got in and got the job done, without this long logistical tail. Unfortunately, in statistical studies of confined space crises, it has been shown that confined space incidents are less survivable than almost any other form of industrial injury. In one study, out of 196 incidents which were severe enough to report to N.I.O.S.H. there were 116 fatalities. Over 60% of the total fatalities were suffered by would be, unprepared rescuers. The lesson is clear, if you do not adequately prepare your entry, you will create victims. If you do not adequately prepare your rescue you will add the rescuers to the list of victims. It is for this reason that we treat each confined space entrant as a victim to be, and lay our plans accordingly. The training of our entry and rescue assets is, and must be continuous.

3. DOCUMENT EACH AND EVERY ENTRY.

One obviously can't learn from your mistakes and improve without adequate documentation. A confined space entry form, signed by both the supervisor of the crew and a representative of the Plant Safety Department is filled out prior to the entry and kept on file after the entry. In addition, a report is made on the entry itself after the work is completed. Our entry procedures and work methods are studied both before and after each entry to see if they are adequate or need revision.

4. TRAIN AND MAINTAIN DEDICATED ENTRY CREWS.

Our fourth point is that we, insofar as consistent with the work demands, train and maintain a dedicated crew for confined space entries. This is very hard to accomplish, as each department has its own needs. However, the lion's share of confined space entries are made by the Gas Handling Department and the Smelter Maintenance Group, so this is where our trained crews are based. On an as needed basis, they are available to other departments to either perform confined space work, augment crews within the department, or train crews in confined space entry practices. Of course, this takes a group of employees with a very high degree of professionalism and competence. The development of these crews and the maintenance of their standards occupies a very high priority in the San Manuel Smelter Division.

5. CONTINUOUSLY RESEARCH.

Finally, we've found that we must continuously work to improve working conditions and equipment used in confined space entry. A dedicated research effort has been and is needed to find better ways to improve worker safety and productivity in this most challenging area. The history of confined space entry has literally been written in blood. Hopefully, we'll use ink to record the future.

San Manuel Smelter

DISTRIBUTIVE CONTROL SYSTEM AT THE SAN MANUEL SMELTER

By: Tom Gonzales, Senior Smelter Engineer
Rick Seater, Asst. Plant Maint. Supt.

May 6, 1989

Presented at the AIME Spring
Technical Session

Magma Copper Company
P.O. Box "M"
San Manuel, AZ 85631

DISTRIBUTIVE CONTROL AT THE
SAN MANUEL SMELTER

In conjunction with the retrofit program, a Bailey Network 90 distributive control system was installed at the San Manuel Smelter. The system provides control, monitoring, and reporting functions for the flash furnace area, the converter aisle, concentrate and flux handling equipment, oxygen plant operations, water treatment plant operations, and for some of the new equipment installed in the powerhouse.

Engineering and equipment selection was done by Davy McKee Corporation, with project management provided by Newmont Mining. Magma employees were involved in final vendor selection and instrument specification.

The Network 90 control system uses control consoles consisting of color CRT screens and keyboards to control the process. These consoles communicate via a plant loop with multifunction controllers (MFC's) which perform the actual control operation. In the event of a control console failure or a plant loop failure the MFC will continue to control the process to the parameters last specified by the operator.

Two types of consoles in use at San Manuel are Management Command System (MCS) consoles and Operator Interface Units (OIU's). MCS consoles offer a touch screen, improved graphics control capability, improved trending and greater control flexibility compared to the OIU consoles.

The control system at San Manuel consists of six MCS consoles, two in the converter control room and four in the flash furnace control room as well as five OIU's, two in the powerhouse, two in the oxygen plant control room and one in the flash furnace control room. Operators use these consoles to monitor and control over 2000 control points and over 1000 PID loops. The OIU in the flash furnace control room is primarily used for configuration purposes. These consoles are linked to each other and to the rest of the Network 90 system via a dual redundant plant loop. Seven process control units (PCU's) are located strategically throughout the plant. These PCU's are connected to the plant loop and contain the MFC's and their associated analog and digital slave and master modules which actually control the process. The PCU's are located near the process areas they serve. Two are located adjacent to the flash furnace control room, two are located at the north end of the converter aisle, one is located below the concentrate dryer, there is one at the oxygen plant and one at the lime and flux plant.

Each PCU is provided with an uninterruptible power supply (UPS) which provides thirty minutes of backup power in the event of a power failure. The UPS units in the flash furnace, converter and oxygen plant PCU's also provide emergency power to the control consoles in those areas. A separate UPS supports the consoles in the powerhouse.

Each control console and PCU is connected to the plant loop via two Loop Interface Modules (LIM's). LIM's are redundant. If the primary fails, the backup will take over and an error message will be generated. Within each PCU are two Bus Interface Modules (BIM's). The BIM's are also redundant. Each MFC is also provided with a redundant backup. This extensive use of redundant backup equipment results in a very reliable control system. The entire distributed control system has only 25 analog backup units to allow operator control of critical loops in the event of a control system failure.

This is not to say that the system is perfect. Magma has experienced several instances of communications with both plant loops failing simultaneously and one instance of an MFC and its backup going into "configuration mode" simultaneously. While in configuration an MFC takes no control action. The problems with the plant loop have been addressed with software changes and appear to be solved. The MFC problem has not recurred and is, as yet, unexplained.

The distributed control system is also equipped with a Data Acquisition System (DAS). The DAS is a PDP-11 connected to the plant loop. This system gathers production data and provides long term trending as well as various reports required by smelter management.

From the very beginning Magma was concerned about support for the DCS. The availability of local vendor support was a critical item in the vendor selection process. Also, supervisors and technical employees were sent to various Network 90 classes. Prior to and during startup on site classes were given to instrument employees by Magma staff and by Bailey Controls instructors. This training effort is a continuing project, with additional training scheduled through 1989.

OPERATIONAL USE OF THE DISTRIBUTIVE CONTROL SYSTEM

Converter Department

The introduction of the Bailey Network 90 distributed control system began in the converter department. The Bailey DCS was functional with the modification of the last of four converters.

Training for the converter controller on the DCS was for the most part "hands on". However, each controller attended a two day training session on Lurgi scrubber operation. This training provided the controller with a working understanding of the process that he was monitoring on the screens.

The controller uses the DCS to monitor the operation of the scrubbers, hood cooling water system, fugitive system and production data entry. The DCS does not control the converter operation, but monitors and trends desired parameters that in our judgement measures the productivity of the converter.

The DCS provides the converter controller with a wealth of information that maximizes the use of newly installed equipment and minimizes the release of SO_2 to the ambient air.

FSF Department

The most important factor in operating a DCS system is not merely the manipulation of graphic displays, but in the understanding of the flash smelting process. With this point in mind, the first step in familiarizing the flash furnace operators in the development of a training program that would provide the background necessary to successfully operate the new furnace.

Operators attended a week long training program that included the following subjects:

1. Metallurgical Flash Smelting Furnace theory was thoroughly covered.

2. Each separate piece of equipment was covered with respect to its function, theory of operation, design operating parameters and a review of other plants known problems or anticipated problems with the equipment.

3. Each control loop for each piece of equipment was thoroughly reviewed. Again, its function and control logic were discussed.

4. After each session, the FSF operators trained in the field and physically located each control loop's instrumentation.

5. The final step in the training included actual manipulation of DCS screens and association of screen displays with instrumentation in the field.

Initially, control room operators were designated smelter engineers. These engineers were responsible for operating the control room during the start up and were on shift for four months. During this time the engineers trained the assigned control room operators under a "hands on" program. At the end of the four months, the control room operators were skilled enough to solo on the controls.

This approach to train operations employees proved to be very successful and has contributed significantly to our start up.

San Manuel Smelter

L U R G I   R A D I A L   F L O W   S C R U B B E R S

By: Jackson Jenkins, Converter Department Head
James R. Hawke, Smelter Engineer

May 6, 1989

Presented at the AIME Spring
Technical Session

Magma Copper Company
P.O. Box "M"
San Manuel, AZ 85631

LURGI RADIAL FLOW SCRUBBING SYSTEM
AT MAGMA SMELTER

Jackson G. Jenkins
Converter Department Head

James R. Hawke
Smelter Engineer
Magma Copper Company
San Manuel, Arizona

Magma's old reverberatory furnace smelting process was outdated, inefficient, high cost and environmentally poor. The retrofit applied to all areas of the smelter, including the converter section, which were fitted with four Lurgi radial flow scrubbers to cool and clean the converter gas stream. This paper outlines the process description, plant, construction and commissioning highlights.

Presented at AIME Spring Meeting
May 6, 1989
San Manuel, Arizona

INTRODUCTION

During the summer of 1987, Magma Copper Company began a program to modernize its converter gas handling and particulates cleaning system at its San Manuel division smelter. The program encompassed replacement of the conventional converter hoods, installation of a forced hood water cooling system, and Lurgi radial flow scrubber systems. The new facilities are monitored with a Bailey Network 90 distributed control system.

Beginning late 1979 Magma studied several alternatives to minimize fugitive emissions in the converting process. The alternatives investigated were: repair the existing high velocity flue system (HVF); redesign and replace the HVF system; install water sprays in the stub flue; install air to gas heater exchangers; implement waste heat boiler; and the Lurgi wet scrubbing system. Based on cost and feasibility, a decision was reached to install the Lurgi radial flow wet scrubbing system.

GENERAL PROCESS DESCRIPTION

In the converter gas cooling and cleaning system the offgas from the four copper converters is cooled and cleaned by wet scrubbing in four separate, independently operated lines of equipment. Each line is provided with a separate I.D. fan to enable individual control. The gas streams are then combined into a single stream inside a common gas mixing chamber for further processing in the sulfuric acid plant.

Dust captured by the recirculating scrubbing liquor is removed via a 200 GPM bleed stream through the splitter box. The purge stream bled from each scrubbing system is combined and stripped in equipment which is commonly shared. The stripped slurry is then collected in an agitated basin and pumped to an existing plant thickener at the mill.

With the converter "in stack", the combined offgas and the normal infiltration air to the converter mouth are withdrawn via the primary hooding and stub flue and directed to the Radial Flow Scrubber. The duct connecting the stub flue to the scrubber is in the shape of an A-frame (commonly referred to as the grasshopper legs) to minimize the build-up of dust in the ductwork.

The gas entering the radial flow scrubber at 1100^{o}F is sprayed with recirculating solution of dilute sulfuric acid and cooled adiabatically to 150^{o}F by evaporation of water from the scrubbing liquor in a brick lined venturi section. After quenching, the gas enters the adjustable scrubbing zone.

This zone is limited by two rings arranged above one another. The gas and an additional quantity of recirculating scrubbing solution, admitted by means of a nozzle, passes through the gap between these rings in a radial direction towards the outer casing of the scrubber.

The relative velocity between the gas and the scrubbing solution is decisive for the scrubbing efficiency. The lower ring can be raised or lowered mechanically so as to change the cross section and thereby the velocity of the gas.

The actuator is connected to a differential pressure controller so that the pressure drop and thus the efficiency of the scrubber can be maintained at a constant value, even at fluctuating gas throughput. At the outlet of the scrubbing zone, the gas is deflected by vanes and the resulting centrifugal forces separate the scrubbing solution from the gas.

After leaving the scrubber, the gas is directed to a mist eliminator to remove fine droplets of solution and then enters the I.D. fan. The gas discharging the fan is transferred to a mixing chamber and combined with scrubbed gas from the other lines.

Scrubbing solution from the integral pump tank is pumped to the various spray nozzles of the radial flow scrubber. In addition, a portion of the scrubbing solution is injected as a film along the walls of the cones so that the hot gas does not contact any unwetted surface. Two pumps are in service with the third acting as a common installed spare.

The dust content of the recirculating scrubbing solution is controlled by taking a portion of the overflow from the venturi stage and directing it to a settling cone. Thickened underflow is pumped from the settling cone to the stripping column while the clarified overflow is directed by gravity to the integral pump tank at the bottom of the scrubber.

Make-up for evaporation of water from the scrubbing medium and other losses is obtained by addition of fresh water to the integral pump tank.

Air for stripping the thickened slurry is drawn by a blower from the hooded vapor space above the stripped slurry basin. The carrier gas plus the SO_2 stripped from the solution are directed into the mixing chamber. Stripped slurry flows by gravity from the column into the basin. Two columns have been provided, one in service, the other an installed spare. The slurry collected in the basin is transferred to one of the mill plant thickeners.

Construction

On October 10, 1985 Magma contracted the Davy McKee organization for the engineering of the smelter modification as well as the converter off gas handling and fugitive gas collection system. This contract specified that Magma would retain the Newmont Mining Corporation in a project management function through the project completion.

The New Jersey based Lurgi corporation engineered the radial flow scrubbers. Their counterpart, the Frankfurt Germany Lurgi corporation engineered the converter secondary gas collection system.

The following sub-contractors we used:

1. Stebbins Engineering and Manufacturing Co. to install the converter gas scrubber refractory lining.
2. CDK Contracting Co. for mechanical, piping, electrical, instrument and structural services.
3. James & Luther Inc. for architectural/HVAC service

CONSTRUCTION HIGHLIGHTS

Apr. 6, 1987	Converter #5 shutdown and turned over for retrofit.
June 18, 1987	Commissioned Converter #5 gas cooling, cleaning and fugitive collection.
June 29, 1987	Converter #6 shutdown and turned over for retrofit.
Aug. 26, 1987	Commissioned Converter #6 gas cooling, cleaning and fugitive collection.
Oct. 26, 1987	Converter #3 shutdown and turned over for retrofit.
Oct. 29, 1987	The DCS for the converter was checked out at Bailey's factory.
Dec. 12, 1987	Commissioned Converter #3 gas cooling, cleaning and fugitive collection.
Jan. 22, 1988	Converter #5 was placed in full service with the DCS controls.

CONSTRUCTION HIGHLIGHTS

Feb. 9, 1988	Converter #4 shutdown and turned over for retrofit.
Feb. 26, 1988	Converter #6 was placed in full service with the DCS controls.
Mar. 18, 1988	Converter #3 was placed in full service with the DCS controls.
Apr. 11, 1988	Commissioned Converter #4 gas cooling, cleaning and fugitive collection system.
Apr. 25, 1988	Converter #4 was placed in full service with the DCS controls.

Converter modifications were completed 7 months ahead of schedule.

COMMISSIONING TROUBLES

The start-up of the Lurgi scrubbing system was relatively trouble free. The Lurgi representatives, the Magma staff, and the Davy McKee personnel combined in a team effort to resolve problems which arose during the start-up. The major problems encountered were:

Scrubber Bellows

The scrubber bellows shrouds the variable speed throat mechanism. The original design material was Hypalon, which after several inspections began showing serious signs of deterioration. It was determined that the bellows suffered from mechanical wear. A chloro-butyl rubber material is currently used in the bellows of #3, 5 and 6 scrubbers. A soft PVC material is presently used in the bellows of #4 scrubber. Both materials are currently performing well.

Scrubber Spray Distribution

The upper spray nozzles (B) that distribute recirculating liquor into the offgas experienced heat distortion. The swirl discs inside the nozzles were losing their integrity and/or falling out. The design material was UHMW-PE/PVDF. The first attempt was to reinforce the whirl discs with UHMW pins. The swirl discs were then reinforced with Hastelloy C welding rod pins. Both of these modifications were short term. Tests were also conducted using Hastelloy C 904L tips, silicon carbide tips, and alumina tips. Silicon carbide nozzles are currently being used and appear to be working well.

The emergency spray nozzles (D) which back up the recirculating liquor flow also experienced heat failure. The design Hastelloy B nozzles were changed to Hastelloy C 904L. The heat failure problem now appears to be resolved.

Recirculating Flow Switches

The paddle wheel flow switches which monitor flow to the cooling sprays (B) frequently plugged up. Once these switches would fail the emergency sprays would become activated. The existing flow switches were modified with a flush water system to prevent the solids from plugging the paddles. Since this modification no pluggage has occurred.

Hood Cooling Water Supply Filters

The cartridge filters are designed to remove particulates from the supply cooling water to the hood cooling panels. The cartridge filters frequently plugged up. It was concluded that the filters were too fine. The cartridges were replaced with 1/8" screens and are performing satisfactorily.

#5 Evase

The evase is the transition outlet duct between the I.D. fan and the fiberglass ductwork of the mixing chamber. After several months into the campaign the #5 evase began to show severe signs of corrosion. It was determined the material was not 317L, which was the specified design material. The 316 stainless was replaced with 317L and no further corrosion problems occurred.

Integral Tank

Soon after the start-up of each scrubber the screens which removed debris from the liquor, which feeds the recirculation pumps, became plugged. Bolts, welding rod, strips of rubber, brick chips and nozzles whirl discs where discovered on the screens. This restriction also contributed to the collection of solids in the tank. The debris which was found in the screen was material that was not visible during an inspection prior to start-up and was not cleared out during a system flushing. It is common practice that after any major work the integral tank screens are inspected for trash and accumulation of solids. It is important that the screen remain clear so that the possibility of debris passing the screen and plugging the gas cooling sprays (B nozzles) be eliminated.

Recycled Liquor and Slurry Balance

Soon after the start-up of the first scrubber it was found that not enough solids where being transferred to the settling tank. This caused a high dust recirculating load in the integral tank. An investigation was made to determine if the liquor and the slurry systems were in balance, and whether a homogeneous sample was being taken. It was determined that a splitter box was needed to correct this situation. Since the installation of the box no heavy recirculating integral tank solids have occurred.

H Drain Screen

In addition to the problems with the liquor and slurry balance, a pluggage problem was encountered with the scrubber particulates drain (referred to as the H drain). The H drain had a screen which was causing solids to accumulate. The screen was removed and no further problem was experienced.

Recirculating Pump Seal Water Solenoid Valves

The recirculating pumps have seal water solenoid valves which open and close whenever the pump is activated. Problems began occurring with the recirculating pumps shutting down. This was due to the solenoid valves closing and shutting the seal water off. An interlock with the system caused the pump to shut down. It was decided that the seal water would remain on at all times and that the solenoid valves would be removed.

Slurry Level Probe

The original level indicator in the slurry collection tank was a capacitance type. The indicator was constantly out of calibration due to the variations in the slurry density. The problem was solved by the use of a sonic level detector.

Kurz Flow Sensors

At the outlet of each I.D. fan a Kurz flow sensor was installed to monitor the flow of offgases to the acid plant. This flow data was used to calculate the volume of offgases to the acid plant to prevent the possibility of over pressurization of the humidifying tower. It was determined that the flow sensors were not reliable enough to use in this application. Currently the offgas flow to the acid plant is determined from the I.D. fan motor current.

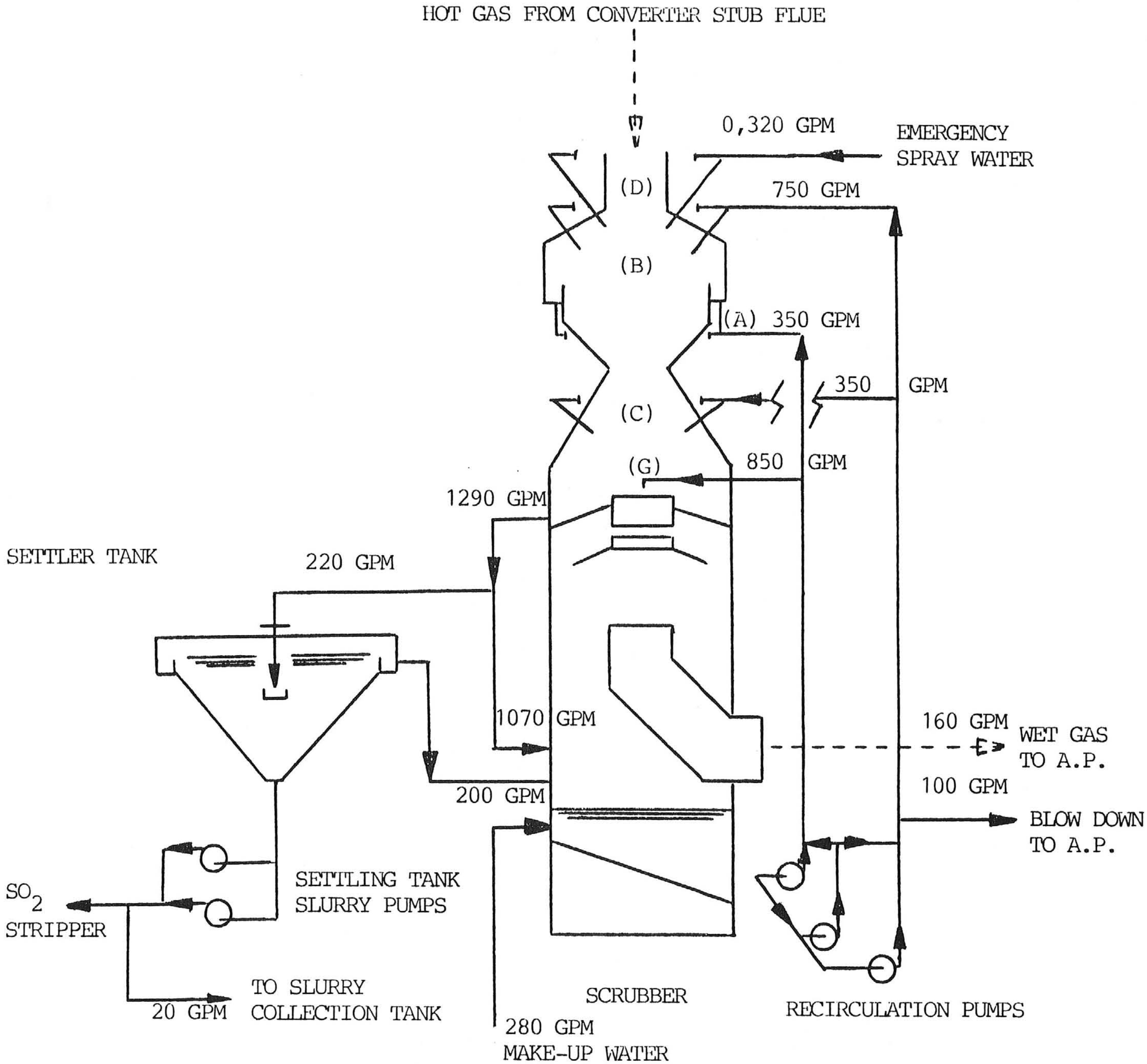
I.D. Fan Vibration Switches

During the interim period when the converters were processing low grade matte, many problems with I.D. fan vibrations were experienced. It was found that the I.D. fans could not handle the heavy dust load from the low grade matte. A standard procedure was established to sand blast the fan impeller blades after each converter campaign and whenever high vibrations occurred. This procedure, along with the absence of low grade matte, has eliminated the problem.

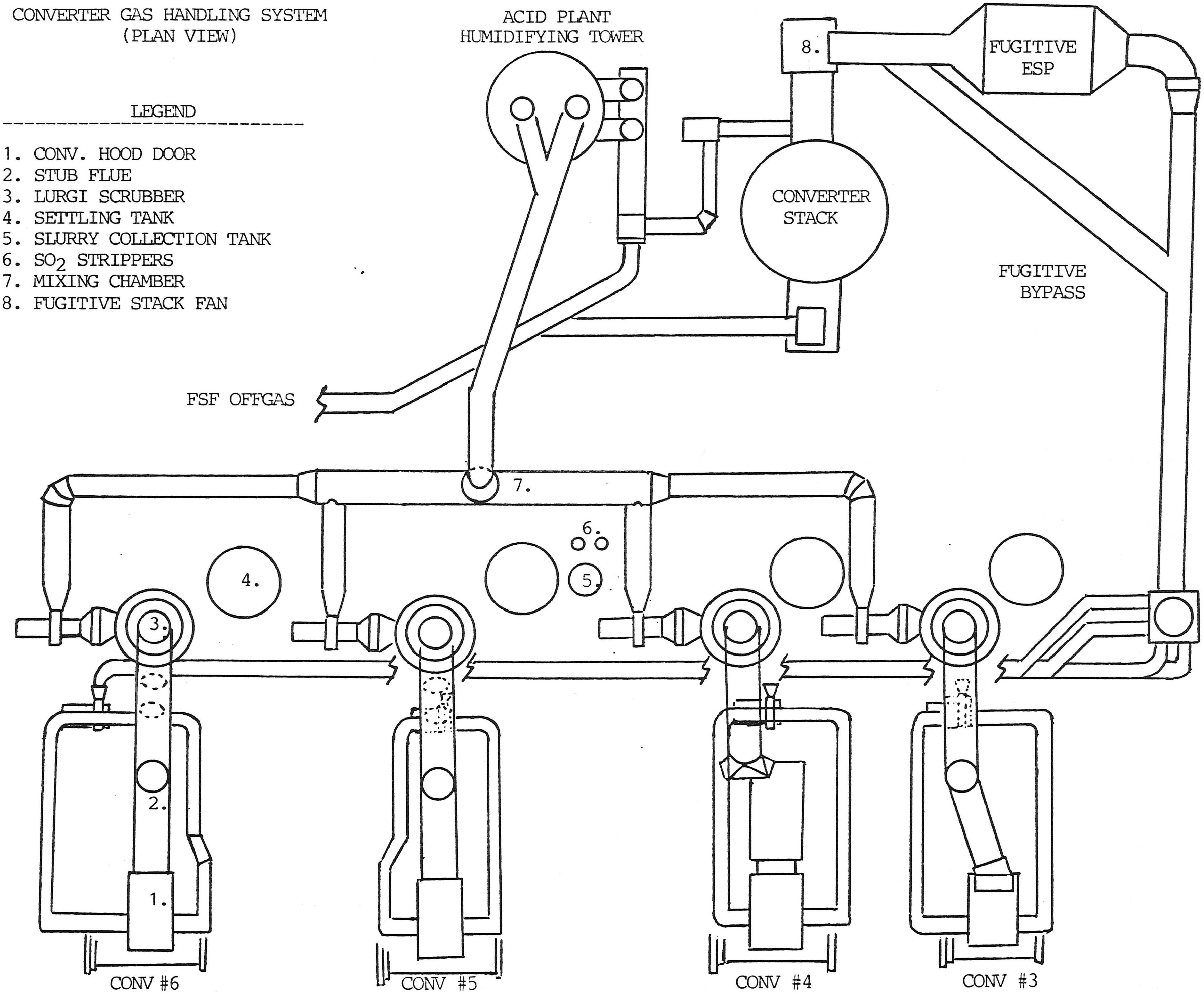
Scrubber Recirculation Pumps

The scrubber recirculation pump suction nozzles and expansion joints experienced abnormal wear. The casing and impellers were fabricated from CD-4MCU alloy steel. Preliminary test showed that corrosion was the major contributor. Currently, one of the three pumps installed on each scrubber is a Denver rubber line pump. This pump is used intermittently with the others. These pumps are still under investigation.

SCRUBBER LIQUOR BALANCE (COPPER BLOW)



CONVERTER GAS HANDLING SYSTEM
(PLAN VIEW)



GENERAL PLANT DESCRIPTION

FORCED WATER HOOD COOLING SYSTEM

The converter hood water system is a forced circulated water system. The circulation pumps send the cooling water to the head tank where the water then flows by gravity to each of the two inlet headers one on each side of the panels. The cooling water then passes through the jackets where heat is picked up from offgases and the heated water then discharges into the panel discharge header. The hot water from the north and south discharge headers meet at the pumps common header. The converter hood cooling system continuously circulates the cooling water whether the converter is blowing or on stand-by.

Each converter hood cooling system consists of one hood cooling water head tank, two hood cooling circulation pumps (one operating and one on stand-by), and 54 water jackets.

The converter hood cooling water system is a closed loop system under normal operating conditions. If the loop becomes open,that is, if a large hood water leak develops then the DCS system will sound an alarm. If the pump discharge water pressure goes below a set point, the control system sends a signal to start the stand-by pump automatically.

Water addition to the tank is based on temperature control. If the tank inlet water temperature rises, then the cooled water line automatic valve opens wider allowing more cooled water to come in. Taking water away from the tank, however, is based on the tank level control. If the tank water level rises, then the hot water line automatic valve opens wider allowing more hot water to be discharged.

PRIMARY OFF-GAS HANDLING SYSTEM

This system consists of a scrubbing tower, the spray loop system, the offgas handling equipment, and the dust collection equipment for each respective converter.

(Scrubber Tower)
The tower is 75′ 8" high and 16′ 5" (I.D. at base) and is fabricated of stainless steel. The tower is shaped like a bottle where the inside is actually divided into two main sections. The top section or the venturi section and the bottom section or the scrubbing and cleaning section. In the venturi part above the neck, there is a set of six nozzle sprays referred to as the "B" nozzles. Next to the "B" nozzles are a set of nozzles referred to as emergency water nozzles or "D" nozzles. Below this set of nozzles is the weir system. The venturi part below the neck is equipped with four nozzles referred to as the "C" nozzles. This part is also equipped with three thermocouples. At the bottom lies the venturi floor. The tower walls have two courses of brick with the second one being of carbon brick facing.

The scrubbing and cleaning section of the tower consists of the scrubbing zone, dust and mist eliminator zone, and integral pump tank. The throat opening of the scrubbing zone is adjusted by a gear jack driven by a torque motor and has a hand wheel provided for manual use. The dust and mist eliminator zone has a number of guide vanes designed to direct the flow toward the wall. At the bottom of the tower lies the integral tank which holds approximately 9,000 gallons of liquor. The bottom of the tank is sloped towards the pump inlet to prevent solids from building up in the tank.

(Spray Loop)
The spray loop system consists of the scrubber pumps, spray nozzles, and the integral tank. The scrubber pumps consists of a set of three horizontal centrifugal type, 100 HP motor with constant speed drives. Normally, two pumps are operating with the third one on standby which can substitute for either operating pump. Each pump is capable of delivering 1,200 gpm of spray liquor. One pump supplies the spray liquor to the "B" and "C" nozzles and the other supplies the "G" nozzle and weir. The integral tank supplies feed to the pumps. The emergency water sprays ("D" nozzles) are supplied with fresh water. A fresh raw water line supplies water to the integral tank as makeup water for evaporation losses.

(Offgas Moving & Handling Equipment)
The offgas moving and handling equipment consists of a demister, an induced draft (I.D.) fan, and I.D. fan inlet and discharge dampers, a wet gas duct, and a mixing chamber. The demister is a Chevron horizontal flow mist eliminator. It is made of fiberglass reinforced plastic. Each I.D. fan (also called Garden City Fan) has variable speed drives (1,200 rpm maximum). The fan has an 800 hp motor and a capacity of 167,000 scfm. The fan's housing and wheel are made of 317L stainless steel and the blades are Inconnel 625. The inlet damper is a vane type damper. The discharge damper or shut off valve is a butterfly valve with a pneumatic operated actuator and a manual override. The damper's body and blade are made of fiberglass reinforced plastic, while the shaft is stainless steel encapsulated with fiberglass reinforced plastic. The wet gas duct is fabricated of fiberglass with expansion joints being made of rubber lined with hypalon, and it carries the wet gas to the mixing chamber. The mixing chamber is a vertical vessel which combines the scrubbed gases from all four converters.

(Dust Collection System)
The dust collection system of the scrubber consists of a settling tank and settling tank slurry pumps, SO_2 stripper columns and SO_2 stripper blower, and a slurry collection tank along with slurry pumps.

The settling tank is a conical shaped tank that has no moving parts and used as a thickener. The settling tank slurry pumps are horizontal centrifugal, two pumps per line, one operating and one on standby. Each has a constant speed motor drive and a capacity of 35 gpm.

The SO_2 stripper columns are vertical filled with packing material (polypropylene). There are two columns, sized 17'-8" x 5' diameter each. The SO_2 stripper blower is a centrifugal fan with a constant speed motor drive.

The slurry collection tank is a vertical cylindrical stainless steel tank (10' x 10' diameter), has a 5,000 gallon capacity and is equipped with an agitator to keep the solids in suspension. There are two slurry pumps, one operating and on standby. The pumps are horizontal centrifugal and have variable speed drives. The pumps average pumping rate is 75-90 gpm, 150 gpm maximum.

(Scrubber Sump)
The scrubber sump receives drain discharge from all pump seal water, demister, scrubber I.D. fan, and integral tank overflow. The sump is equipped with a sump pump for returning the drained liquor to the integral tank.

FUGITIVE GAS COLLECTION SYSTEM

(General)
The fugitive gas collection system consists of four converter individual gas collection systems and a common gas cleaning and disposal system. There is also a bypass system to acid plant for air dilution. Each individual systems consists of: fugitive gas intake ducting, converter hood door system, fugitive gas exhaust fan, and ducting and dampers.

The common section of the gas collection system consists of: mixing vessel, electrostatic precipitator, fugitive gas collection fan, and fugitive gas bypass fan.

(Fugitive Gas Intake Ducting)
The fugitive gas intake ducting includes: converter hood, side walls, and suction funnels one on each side of the converter hood door. The hood sidewalls and suction funnels direct the fugitive gas toward the two exhaust ducts. Each duct is equipped with a manually operated damper.

(Converter Hood Door System)
The converter hood door system consists of a converter hood door, hood door frame, and hood door winch. The system is designed such that the hood door slides up and down on the hood door frame by means of a winch mechanism. The hood door winch mechanism has a dual motor drive to move the door at a high speed or to move it at a low speed. The mechanism includes a clutch and dual cables to the door.

(Fugitive Gas Exhaust Fan)
Each converter's fugitive gas collection system has its own variable speed 600 hp motor fugitive gas exhaust fan. The inlet duct to the fan is equipped with an exhaust fan inlet damper consisting of pneumatically actuated louvers and is mounted on the fan's inlet. The fugitive gas exhaust fan discharge duct is equipped with a fugitive gas control damper which is equipped with a 3/4 hp motor and is located at the mixing vessel inlet.

(Mixing Vessel)
The mixing vessel is designed to receive fugitive gas from all four converter fugitive gas systems and direct the combined gases toward the electrostatic precipitator.

(Electrostatic Precipitator)
The electrostatic precipitator is designed to remove dust particulates from the fugitive gas. It is equipped with a screw conveyor to remove the dust from the precipitator hopper to a dust truck. The precipitator inlet and outlet ducts are equipped with inlet and discharge dampers manually used to isolate the

precipitator during down time. A bypass duct is provided to divert the gas away from the precipitator during scheduled maintenance. The bypass duct is equipped with a manually operated damper.

(Fugitive Gas Collection Fan)
The fugitive gas collection fan located between the electrostatic precipitator and stack plenum provides the necessary draft to pull the combined gases from the mixing vessel through the electrostatic precipitator. The fan is a variable speed drive and has an 800 hp motor. The fan is equipped with two parallel dampers, one on each inlet. The dampers are automatically controlled by the pressure controller and are operated by a pneumatic actuator.

(Fugitive Gas Bypass Fan)
The fugitive gas bypass fan receives its feed from the stack plenum which is located between the stack and the fugitive gas collection fan. The fugitive gas bypass fan suction and discharge ducts are each equipped with an automatic control damper. The inlet damper is a pneumatically actuated louver type and is used to control the pressure on the discharge side when the fan is operating at its minimum speed. The discharge damper is a motorized type and is controlled from an SO_2 analyzer in the acid plant. The fan has a 125 hp motor with a variable speed drive.

CONCLUSION

Magma's implementation of the Lurgi scrubbing system is the first application of this kind in the copper industry. The Lurgi radial flow scrubbers have proven to be an useful method to handle converter offgases. To date there has not been any significant production losses resulting from a breakdown in the scrubbing system. The smelter is well satisfied with its performance and would readily recommend this system. A process such as this can only be effective with a successful maintenance and operating program.

OPERATING DATA

SETTLING TANK UNDERFLOW (SCRUBBER SLURRY)

G/L ACID	G/L SOLIDS	Mg/L * CL	Mg/L * F	%Cu	%Fe	%SiO2	SCREEN SIZE % -65 MESH	SPECIFIC GRAVITY LBS/CU FT
5.72	2.89	85.76	79.55	31.59	17.5	28.9	87.43	5.57

* Impurities maintained to <100 Mg/L

SCRUBBER OFFGAS

% MOISTURE	AVG VELOCITY (FT/SEC)	DRY (STD)	WET (STD)	PARTICULATE (GRAIN LOAD)
25.83	32.87	54,137	61,042	0.254

San Manuel Smelter

S T A R T U P   A N D   O P E R A T I O N   O F   M A G M A ' S
O U T O K U M P U   F L A S H   F U R N A C E

By: David Arana, FSF Department Head
David Jones, Smelter Engineer

May 6, 1989

Presented at the AIME Spring
Technical Session

Magma Copper Company
P.O. Box "M"
San Manuel, AZ 85631

Startup and Operation of Magma's Outokumpu Flash Furnace

David Arana - Flash Furnace Department Head
David M. Jones - Smelter Engineer
Magma Copper Company
Smelter Division
P.O. Box M
San Manuel, AZ 85631

Abstract

This paper describes the startup and operation of Magma Copper Company's new Outokumpu Flash Furnace. The furnace incorporates the latest Outokumpu technology and has a design capacity of 1,000,000 st/year of copper concentrate. Construction of the flash furnace and its peripheral equipment began in October 1986. The furnace was commissioned in June and early July of 1988. The furnace, which was constructed in record time, is the first Outokumpu retrofit of an existing smelter. Furnace on line time averaged 80.75% during the first five months of operation. The ability to raise the smelting rate of the furnace to design levels over extended periods of time has been hampered by several problems, including: fluidization of concentrate from the dry charge bin through the drag conveyors; buildup of accretions in the furnace waste heat boiler; and poor performance of the concentrate burner, especially at low feedrates. Recent modifications to the existing equipment, coupled with the concerted efforts of the smelter staff, has resulted in improved furnace availability and performance.

Presented at the Arizona AIME Spring Meeting
May 6, 1989
San Manuel, AZ

Introduction

Previous papers have described the pyrometallurgical facilities that serve the copper orebody located 45 miles northeast of Tucson, Arizona (1,2). For convenience a brief review of the mid-1988 smelter status is presented.

The smelter was originally commissioned in 1956 and later expanded in the mid 1960's and again in the early 1970's. The final expansion raised the smelter capacity to 1,000,000 stpy of copper concentrate. The smelter, prior to startup of the new flash furnace, consisted of: 3 fuel fired reverberatory furnaces; 6 Pierce-Smith converters; 4 anode refining vessels; and a single contact two train acid plant. Converter offgas, containing 3-5% sulphur dioxide, was treated in the acid plant for the manufacture of sulphuric acid. Reverberatory furnace offgas, containing less than 1% sulphur dioxide, was vented to the atmosphere through the 515 ft. high western stack. Due to the legal requirements of the 1977 Clean Air Act the smelter was required to operate under an NSO (Nonferrous Smelter Order). The provisions of the NSO required the smelter to operate under a Supplementary Control System (SCS). Compliance with the requirements of the SCS program required frequent curtailments in smelter operation. In 1987, Magma was issued a federal consent decree with a deadline of November 1, 1988 to comply with the requirements of the clean air act.

A project team was assembled in 1984 to study the various smelting processes, with compliance of the clean air act being the prime consideration. The smelting processes studied included: The INCO flash smelting process; The Mitsubishi Continuous Smelting Process; The Outokumpu Flash Smelting Process; and the Noranda process. Although each of the various processes studied is capable of producing an offgas that is amenable to sulphuric acid production, the Outokumpu flash smelting process was selected because of its reliability, flexibility and experience. Following site preparation, construction began in October 1986 and proceeded through 1987 and most of 1988.

Plant Description

The flash furnace department can be divided into three distinct areas: 1) Feed preparation; 2) Flash Furnace; and 3) Offgas handling.

Feed Preparation

Concentrate storage facilities are located in separate areas of the plant. Twelve existing 500 ton bins are utilized, as are two new 1000 ton bins. The feed, usually 4-5 different concentrates, is withdrawn and blended in controlled amounts and transported to three 464 ton capacity wet charge bins located above the rotary dryer. Flash furnace flux, containing 80-90%

SiO2, is reduced to 100% -10 mesh using a barmac crusher. The flux is then transported to a 250 ton capacity fine flux bin located next to the wet charge bins. The concentrate and flux are then blended in controlled amounts and fed to the rotary dryer.

The flux feed rate is measured directly by a nuclear belt scale. The concentrate feed rate is calculated by measuring the total wet charge feedrate to the dryer, using a belt weightometer, and then subtracting the flux.

The rotary dryer has a design capacity to dry 185 stph of feed from a moisture content of 8.7% down to a product which has less than .2% moisture. The combustion chamber is an L-shaped cylindrical structure 11 feet 6 inches in diameter and 14 feet 6 inches long. The chamber is of mild steel construction and it is lined with alumina firebrick. The burner, which normally uses natural gas, has a thermal rating of 20.8 million BTU's/hr. The combustion air fan is rated at 15,000 scfm. The Magma dryer is unique in that waste nitrogen from the oxygen plant is used in place of secondary air to reduce the risk of fire in the dryer or its electrostatic precipitator(ESP). The inlet temperature of the combustion chamber is normally maintained at 1000-1200 degrees F. and the outlet temperature of the dryer is maintained at 190-210 degrees F. The dryer shell is a steel cylinder 12 feet 5 inches in diameter and 131 feet long, sloped at an angle of 2.5 degrees. The shell, for the first third of its length, and the lifters are constructed of stainless steel to minimize sticking of wet concentrate. The dryer offgases discharge into one Flakt electrostatic precipitator. The dryer ESP, which has a gas handling capacity of 66,000 scfm, has a design dust loading of 31.4 stph. The dry charge passes through a double screen trommel and into the dryer discharge drag conveyor The drag conveyor transfers the dry product to a pneumatic feed tank. A pneumatic lift system then conveys the dry concentrate and flux to a 600 ton capacity dry charge bin located above the flash furnace.

Flash Furnace

The flash furnace has an operating design capacity of 3000 stpd of new concentrate, making it the highest capacity nonferrous smelting unit in the world. Furnace dimensions are:

Reaction shaft:	21' 3" O.D.
	19' 7" I.D.
	21'11" Height
Settler:	82 9" Length
	27' 5" Width
	11' 1" Height
Uptake shaft:	13' 4" I.D.
	30' 2" Height

The reaction shaft is lined with high quality Cr2O3-MgO refractory bricks. Jacket and spray water cooling systems are employed to protect areas of high wear inside the furnace. The jacket water system is a forced circulation closed loop system that provides 2500 gpm of cooling water to 325 elements. The spray water system is a forced circulation loop which supplies 1000 gpm of cooling water to the outside shell of the reaction shaft. There are six operating matte tapholes and four operating slag tapholes. The furnace is equipped with a fugitive gas system that collects gas from all tapholes and launders. The fugitive gas is cleaned in an existing electrostatic precipitator before being vented to the reverberatory furnace stack. The dry charge is withdrawn from the storage bin by two drag conveyors. The drag conveyors feed one Outokumpu Central Jet Distribution type burner, located directly in the center of the reaction shaft. The purpose of the burner is to introduce the dry concentrate/flux mixture as a dispersed suspension, with oxygen enriched air, over the entire area of the reaction shaft. To do this the burner utilizes a central atomizing air pipe with a flared tip at the end. Compressed air is then used to radially expand the dry charge over the entire reaction shaft. The distribution air is normally maintained at 650-1200 scfm, depending on furnace feedrate and burner performance. Three 600 hp process air fans are used to provide combustion air to the concentrate burner and auxiliary gas burners. A 743 stpd oxygen plant, designed by Liquid Air, supplies industrial oxygen to the flash furnace.

The dry furnace feed, consisting primarily of chalcopyrite and silica, rapidly combusts with oxygen in the upper part of the reaction shaft. These oxidation reactions are exothermic, that is, they give off heat. When the process air is sufficiently enriched with oxygen, the furnace is autogenous. An enrichment level in excess of 40% oxygen is sufficient to supply all of the heat necessary to operate the furnace. The design mass and heat balance for the furnace is given in Table 1. Two or three auxiliary burners are utilized in the settler to compensate for the endothermic slag forming reactions that occur.

Basic Outokumpu flash furnace control strategy is to set the desired feedrate and base all other parameters on this feedrate. The feedrate is controlled by adjusting the speed of the drag conveyors. The furnace has three primary control parameters: A) matte grade; B) silica content of the slag; and C) product temperature (matte and slag). Physically, matte grade is controlled by adjusting the ratio of total oxygen per ton of charge. This is accomplished by adjustment of the air and oxygen control valves. The matte grade has been maintained at 60-62% since startup. A matte grade of 60% is sufficiently low to allow for the consumption of reverts in the converters. Silica content in the slag is controlled by adjusting the ratio of flux/wet concentrate entering the dryer. Furnace product temperature is controlled by adjusting the degree of oxygen enrichment in the process air, while simultaneously maintaining constant the ratio of total oxygen/ton of charge. Furnace draft is controlled by the adjustment of a single damper located just after the waste heat boiler electrostatic precipitators.

The flash furnace and its auxiliary equipment are controlled by the plant distributed control system(DCS). The DCS that was chosen for the Magma smelter is the Bailey Controls Network 90. The Network 90 is a microprocessor based, modular control system capable of programmable and distributed control. A variety of intelligent, configurable control modules permit both modulating

Table 1 - FSF Mass and Heat Balance

Input	Temp. F.	MMBTU/st, (scf)	STPH, (SCFM)	MBTU/hr
Concentrate	77	0	125.0	0
Slag Conc.	77	0	7.2	0
Converter Dust	77	0	0.4	0
Silica Flux	77	0	13.7	0
Sulfatized dust	77	0	11.8	0
Process air	77	0	(24300)	0
Combustion air	77	0	(2400)	0
Oxygen(95%O2)	77	0	(10500)	0
Natural Gas	77	(920)	(240)	13200
Air leakage	77	0	(620)	0
Heat of Reaction				282700
				295900

Output	Temp. F.	MMBTU/st, (scf)	STPH, (SCFM)	MBTU/hr
FSF Matte	2190	0.74	58.9	43800
FSF Slag	2370	1.37	67.0	91600
Oxidized Dust	2460	1.00	10.4	10400
Gases	2460	(59.20)	(34800)	123600
Heat Losses				26500
				295900

Pivotal Concentrate Composition:

%Cu	%Fe	%S	%SiO2	%Al2O3	%CaO	%Others
28.35	28.46	33.61	5.96	1.42	.28	1.55

Design Matte Grade: 63%
Design %SiO2 in Slag: 27%

and sequential control. These modules are located in cabinets distributed in various areas of the plant. The control room operators interface with the DCS through four color CRT consoles.

Offgas Handling

Hot (2460 F) SO2 rich offgases exit the uptake shaft of the flash furnace and enter the waste heat boiler. The boiler is of typical Ahlstrom design. The boiler is designed to handle a maximum of 45,000 scfm of flash furnace offgas. Normal design flow of FSF offgas is 37,800 scfm. Design steam production is 120,000 lbs/hour at 875 psig. The total surface area of the radiation section is 19,752 square feet and the convection section is 17,976 square feet. The dust collection system utilizes rappers only. There are 63 rappers in the radiation section and 27 rappers in the convection section. The rapper sequence is 2 minutes on, 2 minutes off. Dust collected in the radiation and convection sections is transported by drag conveyor to a roll crusher, where any lumps that exist are crushed prior to being pneumatically conveyed to the flue dust bin. The dust is then blended with the FSF feed in measured amounts. A typical dust composition is given in Table 2.

Table 2 - FSF Dust Composition

%Cu	Total %Fe	%S	%SiO2	%Fe3O4	%Al2O3	%CaO
25.63	20.87	9.77	5.13	13.17	0.61	0.52

Waste heat boiler offgas exits the convection section and is distributed equally between two Flakt electrostatic precipitators. The precipitators are each designed to handle 30,000 scfm of boiler offgas. The maximum allowable dust load in the ESP discharge is .125 grains/scf. The electrodes are the rigid frame type and the insulators are a high alumina ceramic. Furnace gases are drawn through the precipitators by two 600 hp induced draft fans. Each fan is designed to handle 55,000 scfm of 600 F ESP offgas.

Operator Training and Startup

In January, 1988 smelter personnel began intensive training in preparation for the startup and operation of the flash furnace. A key group of 28 engineers, supervisors, and operators was selected to participate in the training. The two sites selected for the training were the Rio Tinto Minera flash smelter in Huelva, Spain and the original Outokumpu flash smelter in Harjavalta, Finland. 5280 manhours were expended on classroom instruction and in the field training. Additional on site training was conducted in April at San Manuel to familiarize smelter personnel with the new system.

Heatup of the flash furnace began on June 13. While the furnace heatup was in progress the auxiliary equipment was commissioned. The oxygen plant, rotary dryer, and waste heat boiler were all commissioned in late June. Flash smelting commenced on July 7th after a 24 day warmup period. The first month of furnace operation was plagued by the usual electrical and instrumentation problems common to most startups. The most serious operations problem was the control of the rotary dryer. Magma personnel had no previous experience in operation of a rotary dryer. The entire system was frequently shut down due to wet pluggage in the dryer discharge drag conveyor and pneumatic lift system caused by improper operation of the dryer. Problems with the dryer were overcome by late July and the furnace operation began to stabilize. By early August sufficient confidence was gained with the new furnace to allow the shutdown of both existing reverberatory furnaces. Table 3 gives the production figures for the flash furnace to date.

Table 3 - FSF Production Figures

Month	% FSF on Line Time	Avg. TPD Conc. Smelted	Total Tons New Conc. Smelted
July	53.8	844	21,110
August	83.5	2448	75,901
September	79.2	1859	55,770
October	86.9	1953	60,534
November	95.1	2526	75,769
December	54.5	2132	38,376
January	96.3	2103	63,100
February	97.1	2524	68,141
March	95.2	2724	72,163

Major problems experienced with the new system to date include:

A) Fluidization of dry charge from the dry charge bin through the drag conveyors.
B) Poor concentrate burner performance, especially at low furnace feedrates.
C) Buildup of accretions in the furnace waste heat boiler.
D) Production of FSF flue dust with undesirable characteristics.
E) Mechanical problems with the FSF drag conveyors.

A. The fluidization of dry charge into the flash furnace has been the single, worst problem encountered since startup. Numerous design modifications were made in the months following startup to alleviate this problem, with little or no success. Design modifications included:

A) Installation of anti-fluidization flappers on the return end of the drag conveyors.
B) Installation of a larger return air fan on the pneumatic lift system to relieve system pressure.
C) Installation of plates in the discharge of the dry charge bin.
D) Installation of extra vents on the dry charge bin to reduce bin pressure.
E) Improved monitoring of fluidization: the dry charge bin rate of change and the FSF drag conveyor amperages were added to the DCS.

Operators were instructed to maintain a high dry charge bin level and to keep the dryer product moisture above .1% in an attempt to combat the fluidization. These combined efforts, however, have had little or no effect on the problem. The latest attempt to solve the problem was made in early March when a slotted dry charge bin discharge outlet was installed at the recommendation of Jenike & Johanson, a material handling consulting firm. It is believed that this modification will result in mass flow type bin characteristics, instead of undesirable funnel flow (3).

B. The second major problem encountered with the new system has been the performance of the concentrate burner. It has never operated satisfactorily at design feedrates. The performance of the burner at low feedrates, however, has been even worse. Feedrate reductions of 40-60 tph have led to a number of problems, including: A) unsmelted concentrate in the bath; B) furnace bottom buildup; and C) burner and system pulsation. The burner was designed to operate at a feedrate of 125 tph of concentrate with an enrichment level of 40-43%. These parameters would result in a total process air flow of 35,000 scfm and a burner velocity of 200 ft/second. A feedrate of 80 tph and an enrichment level of 65%, however, would result in a total process air flow of 14,000 scfm and a burner velocity of only 79 ft/second. It is believed that a correlation exists between the process air velocity and the burner performance. Experience at other smelters that employ the Outokumpu flash smelting process would seem to support this belief (4,5). The burner throat was accordingly redesigned by Outokumpu and the modification was made in March. The new design increased the burner velocity 42%, but did not solve the basic problem since the process air velocity is not adjustable. Another contributing factor to the poor performance of the burner is the distribution of enriched air in the process air duct. Traverses taken of the duct have repeatedly shown that the air flow is not distributed uniformly. Efforts are continuing in an attempt to solve this problem. Pulsation of the burner at low feedrates is believed to be caused by uneven feed to the concentrate burner. During the March shutdown fluidization pads were added to the concentrate chutes underneath the drag conveyors. The purpose of the pads is to "fluff" the concentrate to prevent the pulsation phenomena.

C. The waste heat boiler was originally designed with a 16′ high water cooled baffle located 45 feet from the inlet of the radiation section. The purpose of the baffle was to prevent backmixing and to promote an upward flow of gas through the radiation section screen tubes. The baffle, however, acted as a dust collector in the boiler gas stream. In early December the boiler was shut down to repair a tube leak. Upon entering the boiler a large buildup was discovered behind the baffle. Smelter operations were suspended 13 days to remove the estimated 1000 tons of buildup. During the shutdown the baffle was removed and more access doors were added to facilitate cleaning and inspection. Subsequent boiler inspections have revealed only a slight, manageable buildup occurring in the boiler inlet.

D. Soon after startup the waste heat boiler electrostatic precipitators began to experience severe buildup problems due to the nature of the flash furnace dust. Chemical analysis revealed that a portion of the dust occurred in the sulfide state. Normally flash furnace dust is converted to a sulphate form in the furnace offgas handling system (6). An air line was installed in the radiation section of the boiler in September in an effort to sulphatize the dust. The resulting change in the dust composition was quite noticeable. The dust changed in appearance from a dark black to a reddish brown. The sulphate to sulfur ratio (SO_4/S) changed from 2.16 before the modification to 2.8 afterwards. Problems associated with the sticky dust have not recurred since.

E. A number of mechanical problems were experienced with the flash furnace drag conveyors after startup. The most serious problem was the tendency of the conveyors to ride up on the intermediate plate of the conveyor housing. This resulted in varying bed depths on the drag conveyors. The problem was solved by installing skis on both of the conveyors during the March shutdown.

Acknowledgements

The authors wish to thank the staff and employees of the smelter who made the successfull startup and operation of the furnace a reality.

Bibliography

1) McCain J.D., and Rana I.A.,"New Techniques and New Efficiencies at the San Manuel Smelter", Advances in Sulfide Smelting, Volume 2, (1983), pp. 709-725.
2) McCain J.D., and Rana I.A., "Computer Aided Copper Converter Scheduling at Magma", Journal of Metals, 35(1), (1983), pp. 61-66.
3) Johanson J.R., "Selection and Application Factors for Storage Bins for Bulk Solids", Plant Engineering, July 8, 1976, pp. 87-90.
4) Kemori N.,Shibata Y.,and Fukushima K.,"Thermodynamic Consideration for Oxygen Pressure in a Copper Flash Smelting Furnace at Toyo Smelter", Journal of Metals, 37(5), (1985), pp. 24-29.
5) Kemori N.,Shibata Y., and Tomono M.,"Measurement of Oxygen Pressure in a Copper Flash Smelting Furnace by an EMF Method", Metallurgical Transactions B, Vol. 17B, March 1986, pp. 111-117.
6) Davenport W.G.,and Partelpoeg E.H.,Flash Smelting - Analysis, Control and Optimization, Pergamon Press, 1987, p.133.

San Manuel Smelter (file)

FOR IMMEDIATE RELEASE
July 6, 1989

MAGMA PURCHASES MEXICAN CONCENTRATES

SAN MANUEL, ARIZONA -- Magma Copper Company (AMEX-MCU) has entered into a contract with Compania Minera de Cananea, S.A., Mexico City, for the purchase of approximately 154,000 tons of copper concentrates in the first year of a multi-year arrangement.

The concentrates will be smelted at Magma's San Manuel, Arizona smelter which contains the world's newest and largest flash smelting furnace.

Magma Vice President of Marketing John Champagne said Magma is pleased to have a new contract with Cananea, which operates a large open pit mine at Cananea, Sonora and smelters at Cananea and Santa Rosalita.

The contract provides Magma with copper concentrates from a large orebody within 200 miles of San Manuel with excellent highway and rail connections.

Magma is a leading producer of premium quality refined copper from its operations at San Manuel and Miami, Arizona and Chicago, Illinois.

# # #

NEWS FROM MAGMA
MAGMA COPPER COMPANY
P. O. Box M, San Manuel, Arizona 85631
Public Relations Officer—Frank Harris (602) 385-3256/385-2153

San Manuel Smelter (f)

K

RECEIVED
AUG 16 1988
DEPT. OF MINES & MINERAL RES.

FOR IMMEDIATE RELEASE
AUGUST 12, 1988

MAGMA SHUTS DOWN REVERBERATORY FURNACES
11 WEEKS AHEAD OF DEADLINE

SAN MANUEL ARIZONA, August 12, 1988 - Acting eleven weeks ahead of the deadline imposed by its consent decree with the federal Environmental and Protection Agency and the Arizona Department of Health Services, Magma Copper Company today shut down the last of the three reverberatory furnaces at its San Manuel, Arizona, copper smelter.

The three reverbs have been replaced by a single state-of-the-art flash furnace which is computer controlled and uses oxygen to ignite sulfur in the copper concentrate feed to provide heat for the smelting reaction.

The resulting high concentrations of sulfur dioxide are converted to commercial grade sulfuric acid in an adjacent plant which has also been upgraded to meet EPA standards.

Built at a cost of $133 million for the new smelting system and sulfuric acid plant plus $17 million for the oxygen plant, the retrofitted San Manuel smelter will meet all clean air standards and regulations.

more ----

NEWS FROM MAGMA
MAGMA COPPER COMPANY
P. O. Box M, San Manuel, Arizona 85631
Public Relations Officer—Frank Harris (602) 385-3256/385-2153

In addition to the flash furnace the smelter includes, a concentrate dryer, new electrostatic precipitators, a waste heat boiler and individual gas scrubbing units for each of the four production converters.

The furnace which went into operation July 7 was designed and engineered by Outokumpu Oy, Helsinki, Finland, and will process approximately one million tons of copper concentrate per year making it the largest copper smelting furnace in the world.

Magma will produce approximately 890 tons of new copper per day in the smelter and expects to achieve lower smelting costs from the conservation of energy and higher efficiencies of the flash furnace.

The flash furnace start-up process will be fully completed by November when it will be at sustained full production.

On February 23, 1987, the Federal District Court, in a consent decree, gave Magma an additional period to comply with new emission control regulations and imposed strict operating procedures during the smelter retrofit construction.

more ----

At that time Magma paid fines of $600,000 for alleged past violations of air standards and posted a $20 million letter of credit which would have been forfeited had the reverberatory furnaces not been shut down by a November 1 deadline.

Magma has paid an additional $25,000 fine to the State of Arizona for a violation on April 4 of an interim short-term peak sulfur dioxide standard and will pay $50,000 more for a similar violation on July 2.

The shutdown of the reverberatory furnaces at San Manuel marks the last of the traditional reverb furnaces in Arizona.

In 1920 there were 11 Arizona smelters processing 8,462,000 tons of ore and concentrate per year.

Today there are only three copper smelters processing approximately 2,000,000 tons of concentrate per year.

# # #

SAN MANUEL S[illegible]TER (F)

STATE MINE INSPECTOR

FEB 29 1988

FOR OFFICE USE ONLY

START-UP NUMBER 84004048

STATE NUMBER 10167100

MSHA NUMBER

Taylor

NOTICE TO ARIZONA STATE MINE INSPECTOR

In compliance with Arizona Revised Statute Section 27-303, we are submitting this written notice to the Arizona State Mine Inspector of our intent to start ___ stop ___ move ___ (please check one) a mining operation.

If this is a move, please show last location: ___
If you have not operated a mine previously in Arizona, please check here: ___ If you want the Education & Training Division to assist with your mine safety training, please check here: ___ If this operation will use Cyanide for leaching, please check here: ___

COMPANY NAME: TECHNICAL METALS INC. DALY McKEE SUBCONTRACTOR

DIVISION:

MINE OR PLANT NAME: MAGMA SMELTER TELEPHONE: (602) 385-3474

CHIEF OFFICER:

COMPANY ADDRESS: (HOME OFFICE) 4828 S PEORIA #204 { P.O. BOX 635 SAN MANUEL, AZ. 85631

CITY: TULSA STATE: OK ZIP CODE: 74105

MINE OR PLANT LOCATION: (Include county and nearest town, as well as directions for locating property by vehicle) Pima County, SAN MANUEL AZ.

MAGMA SMELTER PLANT.

TYPE OF OPERATION: Insulation Contr. PRINCIPAL PRODUCT:

STARTING DATE: 2-9-88 CLOSING DATE: 6-30-88 DURATION: 5 months

PERSON COMPLETING NOTICE: KEITH MATHESON TITLE: PROJECT MANAGER

DATE NOTICE MAILED TO STATE MINE INSPECTOR: 2-20-88

FORM 101-106 REV. 10/85

MAR [illegible] 1988

San Manuel Smelter
COPY

C O N F I N E D   S P A C E   E N T R Y

By: George Price, Acid Plant Foreman

May 6, 1989

Presented at the AIME Spring
Technical Session

Magma Copper Company
P.O. Box "M"
San Manuel, AZ 85631

CONFINED SPACE ENTRIES

Good afternoon, my topic today will be the evolution and practice of confined space entries at the San Manuel smelter. Over the last decade, industry as a whole, and Magma in particular has begun to understand the special hazards of confined space environments, and develop methods to work in them safely. I'm here to share our experience, and perhaps learn from yours.

First, perhaps a definition of confined space entry would be in order. This would be any enclosed space which:

1. Has limited means of ingress and egress.
2. Has the potential for containing an atmosphere which is either hazardous in itself, or is capable of becoming hazardous.

Bins, flues, boilers, chemical towers and storage tanks, all are considered confined spaces.

Historically, the general industrial response in the United States to the hazards confined space entries has been to either ignore the special hazards they present or to remove the element of confinement by physically changing the space to be entered, removing the top of a bin, for example. Both of these methods have been found to suffer from severe drawbacks. In the first case, ignoring hazards, from both a legal and a moral standpoint, is simply unacceptable at Magma. We have a firm policy of reducing employee risk to the minimum achievable level. As for the latter policy, we can all testify, I'm sure, that modern process equipment savagely resists ad hoc re-engineering.

Our methodology is composed of five major components:

1. SIZE UP AND PREPARE THE JOB.

   The extreme complexity and danger of most confined space entries is not something that you want to confront "on the fly." Even after you have isolated and blanked all lines and ducts going into the vessel in question you will have to consider:

   A. Hazardous atmospheres that may exist or be created inside the space. We test each area for flammability, toxic gases, irritant or corrosive gases, and either an oxygen deficient or oxygen enriched atmosphere. If there is any chance that the working atmosphere may be either displaced by a toxic atmosphere, for example if a vent fan were to start pumping sulphur dioxide contaminated air into a compartment; or if the work in progress might consume the oxygen available or create hazardous fumes, as might be created by cutting or burning inside a vessel, then our testing becomes a continuous process. If there is any question about the work environment after testing, or if an adequate work environment is unattainable, then all work is performed using self-contained breathing apparatus.

B. Physical hazards existing within the vessel. It would be great if all confined space entries were performed in clean, empty storage spaces, but such is not the case. In modern equipment, hazards abound. Both physical hazards such as falling hazards, heat and cold stress, chemical residues, equipment located within the enclosed space, and the psychological hazards of having to work in an atmosphere which is strange and confining serve to make tasks very stressful for the confined space worker. Each interior hazard must be recognized and prepared for prior to entry. At the San Manuel smelter we weigh the level of personal protective equipment very carefully so that the worker is stressed as little as possible by both the environment and their equipment while still enjoying (if that word could possible be applied to this work) more than adequate protection from hazards inside the confined area. The investment of a few hours cool down with an air conditioner, for example, will lead to much greater employee productivity in an otherwise hot, confined, environment.

An interesting footnote to our physical hazard protection program was our discovery that many techniques and most of the equipment used by rock climbers and cave explorers were ideal for service in our confined spaces. While the image of laborers in a precipitator clearing out dust buildups with ice axes may be a bit unsettling to the traditionalist, our motto is "Whatever works best, we use."

2. SET UP YOUR RESCUE FIRST.

Each confined space entrant must be accompanied by a trained standby rescuer equipped for the worst possible environment which could be encountered at the work site. This person's sole responsibility is to enter the work space if his charge is in trouble and support that person until sufficient trained rescuers are present to extricate the victim. In the simple case of a heat stress victim in a sulfuric acid tank, the rescuer may be able to effect the rescue himself, but if this victim is inside the top of an acid gas absorbing tower is may take additional people to perform the rescue. As it is impractical to have large teams of people sitting around the scene of an entry waiting for a disaster (not to mention depressing to the crew that will be working) the designated rescuer bears a heavy burden in our rescue scenario. This person is solely responsible for the entrant prior to the arrival of the San Manuel Fire Department whom we have trained and equipped for perform extrications. The rescuer must evaluate the accident scene, ameliorate the hazard environment, and support the patient until the fire department can be summoned to take over the scene. While doing all this, he does not have time for is off site communication. Therefore, at each work site, a separate individual is designated as the man door watcher and radioman. The sole duty of this person during the entry is the maintenance of a clear communication chain with the entry party and with one of our radio base stations, who will summon the fire department if there is a need. While the line of communication with the entry party may take several forms, from the traditional tag line to personal radios, the method of communication with the base station is always by radio. As the San Manuel Fire Department's radios are rigged to "come up" on our smelter frequency,important information can be exchanged en route, shortening the time of the rescue. The chain of communication needs to be forged prior to its need.

The San Manuel Fire Department, the final ingredient in our rescue scenario, has been characterized fairly as a small town fire department with a world class rescue capability. Extensive financial resources and time have been devoted to making this group mission capable for the most demanding rescues. (If any of you would like to contribute by the way, just buy a soft drink from one of the machines you find around the property.

The revenue from the sales of on-plant candy and soft drinks handle almost all of their budget requirements. Now that's creative financing!) But I digress.

Industrial confined space rescue is in most ways similar in its demands to mine rescue. The major difference is that the confined space rescuer can prepare for the rescue of his entry party before the fact. The engineering and set up of the rescue will have the greatest impact on whether the incident which prompts the rescue will be survivable. Victims of asphyxiating gases or insufficient oxygen in their environment will have a maximum of six to eight minutes before their problem is fatal. Victims of traumatic incidents may have less or more time, depending on the extent of their injuries. RESCUE IN CONFINED SPACE IS A VERY SLOW PROCESS. Every effort must be made to shorten the amount of time that it takes to get your victim to where appropriate intervention can be applied to reduce his injuries to a manageable level. Removing an injured victim is far from an easy task, as his injuries may require medical support which will significantly complicate your task.

Now around this time some of you may be longing for the good old days, when you just got in and got the job done, without this long logistical tail. Unfortunately, in statistical studies of confined space crises, it has been shown that confined space incidents are less survivable than almost any other form of industrial injury. In one study, out of 196 incidents which were severe enough to report to N.I.O.S.H. there were 116 fatalities. Over 60% of the total fatalities were suffered by would be, unprepared rescuers. The lesson is clear, if you do not adequately prepare your entry, you will create victims. If you do not adequately prepare your rescue you will add the rescuers to the list of victims. It is for this reason that we treat each confined space entrant as a victim to be, and lay our plans accordingly. The training of our entry and rescue assets is, and must be continuous.

3. DOCUMENT EACH AND EVERY ENTRY.

One obviously can't learn from your mistakes and improve without adequate documentation. A confined space entry form, signed by both the supervisor of the crew and a representative of the Plant Safety Department is filled out prior to the entry and kept on file after the entry. In addition, a report is made on the entry itself after the work is completed. Our entry procedures and work methods are studied both before and after each entry to see if they are adequate or need revision.

4. TRAIN AND MAINTAIN DEDICATED ENTRY CREWS.

Our fourth point is that we, insofar as consistent with the work demands, train and maintain a dedicated crew for confined space entries. This is very hard to accomplish, as each department has its own needs. However, the lion's share of confined space entries are made by the Gas Handling Department and the Smelter Maintenance Group, so this is where our trained crews are based. On an as needed basis, they are available to other departments to either perform confined space work, augment crews within the department, or train crews in confined space entry practices. Of course, this takes a group of employees with a very high degree of professionalism and competence. The development of these crews and the maintenance of their standards occupies a very high priority in the San Manuel Smelter Division.

5. CONTINUOUSLY RESEARCH.

Finally, we've found that we must continuously work to improve working conditions and equipment used in confined space entry. A dedicated research effort has been and is needed to find better ways to improve worker safety and productivity in this most challenging area. The history of confined space entry has literally been written in blood. Hopefully, we'll use ink to record the future.