Roaster Off Gas Cleaning Operations - Brief History

Gas cleaning was initiated at Giant in October of 1951 with the installation of a low temperature Cottrell electrostatic precipitator designed to collect the combined calcine dust and condensed arsenic trioxide from the exit gases of the Edwards type hearth roaster. With the installation of the first fluosolid roaster in 1952, a new 9 foot diameter, 150 foot high brick stack was added, together with a booster fan and an enlarged flue system ~~(Figure 6)~~. It was hoped that the new system would improve the electrostatic precipitator performance, through better control of draft and air tempering. However with the expanded roaster production the precipitator collection efficiency actually dropped 10%.

It appeared that the roasting of arsenopyrite under ideal conditions for gold extraction did not result in ideal conditions for precipitator operation. The first stage fluosolids reactor was operated under very close air control to maintain moderate reducing conditions. As a result the roaster exit gases contained a high concentration of SO_2 and essentially no SO_3. At the reduced precipitator temperature, ~~that~~ the dust particles including the non conductive arsenic, absorbed the SO_3 as a surface layer. This was sufficient to render the suspended dust conductive and thus recoverable. The SO_3 deficiency in the roaster exit gas allowed non conductive particles of condensed arsenic to pass through the electrostatic precipitator and out the stack.

In 1955 a second Cottrell unit was installed to operate as a high temperature electrostatic precipitator for the selective recovery of the gold bearing calcine dust prior to the collection of condensed arsenic in the original low temperature Cottrell unit. The tandem operation of the hot and cold precipitators resulted in improved dust collection efficiency, however the condensed arsenic particles were not sufficiently conductive to allow recovery in the cold unit. Efforts were made to increase the SO_3 content in the roaster off gas with limited success. Eventually the combined recovery of arsenic trioxide and calcine dust dropped to 60% making it necessary to operate both precipitators at a low temperature.

In 1957 a small fabric baghouse collector was piloted on a fraction of the roaster off gas. The unit indicated that arsenic collection efficiencies exceeding 99% were attainable with satisfactory bag life.

In 1958 an enlarged two stage fluosolids reactor was installed. At the same time an eight compartment model 30 Dracco type baghouse was put into operation. For a short period, the baghouse was used to collect both calcine dust and condensed arsenic trioxide from the tempered roaster off gas. Once the new fluosolid reactor was operating satisfactorily, one of the Cottrell units was put on stream as a high temperature electrostatic precipitator. From that time, the selective collection of gold bearing calcine dust and condensed arsenic trioxide has been practiced. In the spring of 1962 the original low temperature Cottrell unit was converted and now operated in parallel with the high temperature precipitator.

Gas Cleaning - Recovery of Calcine Dust

The combined roaster off gases leave the second stage reactor and pass through two Ducon dust cyclones positioned in series. Each cyclone discharges calcine dust into separated quench tanks. All of the quenched roaster products are pumped to the calcine washing circuit. The remaining calcine dust and gas exit the cyclones at 880° F and are air tempered to 700° F before entering the electrostatic precipitators.

The two precipitators are identical Type K rod curtain Cottrell units. Each precipitator consist of two units arranged in parallel with each unit split into two sections arranged in series. Each section is comprised of 882, 1/8 inch diameter (Schedule 40) collecting electrodes and 272, 3/16 inch square twisted discharge electrodes. The collecting electrodes are arranged to form 18 curtains, 8 feet long by 12 feet high with an 8 inch duct between curtains. The discharge electrodes form 17 curtains and sit in the 8 inch duct. The precipitator housing is of mild steel construction and is fully insulated.

Time controlled rapping hammers strike the collecting and discharge electrode frames to dislodge dust from the electrodes. The calcine dust falls into V-shaped hoppers and is then conveyed to quench tanks.

The distribution and gas flow through the precipitator units is controlled by multivane dampers located in the inlet and outlet of each unit. At present, only two of the four units are active while the remaining two are held in reserve. When severe electrical shorts or other difficulties arise in an on-stream unit, one of the reserve units is put in service until the required repairs are completed.

High voltage direct current is produced by a transformer stepping up low voltage 550 primary to a high voltage 50,000 secondary. The high potential AC current is converted to high voltage DC current through the use of mechanical rectifiers. Negatively charged discharge electrodes ionize the surrounding gas and impart a charge to the conductive calcine dust. The charged dust particles are attracted to and deposit on the electrically grounded collecting electrodes. The dust remains on the collecting electrodes until discharged by the action of the rapping hammers.

Maximum voltage without arcing produces the highest precipitator collection efficiency. Operating voltage is affected by gas composition, temperature, and dust concentration, all of which are a function of the roaster operating parameters.

The voltage and amperage on the primary side of the transformer are monitored to indicate the presence of a broken discharge or collection electrode, an electrical short caused by a build-up of dust between the curtains or a dirty insulator. To overcome minor problems which can plague an installation of this type, a lengthy check-list of items which must be attended to on a scheduled basis is adhered to. Seemingly unimportant items such as damaged flue and shell insulation give rise to cold spots which promote the formation of hard aggregates of antimony and calcine dust. These aggregates damage the hopper screw conveyors or cause electrical shorts. Air leakage around the access doors is sufficient to condense arsenic trioxide out of the gas and contaminate the collected calcine dust.

Collection effiency of the electrostatic precipitator averages 94.5% of the gold contained in the cyclone tail gas.

Table 1: Electrostatic Precipitator Operating Parameters

Inlet Temperature	700° F	~~371°C~~	600
Outlet Temperature	600° F	~~316°C~~	500
Primary Voltage	550 Volt		
Secondary Voltage	50,000 Volt		
Type K Rod Curtain Cottrell:	E.S.P.		

Typical Analysis of Electrostatic Precipitator Dust

Au	Fe	S	As	Sb	
1.43	18.00	2.75	2.29	~~0.30~~	1.00
ozs/ton	wt%	wt%	wt%	wt%	

Average Au Collection Efficiency in E.S.P.: 94.5%

Gas Cooling

Tail gas from the electrostatic precipitator is cooled to 220^0 F by the addition of tempering air drawn from outside the roaster building through a mixing fan. The arsenic trioxide contained in the vapour phase condenses into a fine grained dust in an expansion chamber located just downstream of the mixing fan. The temperature in the baghouse is maintained at 220^0 F through the use of a pneumatically controlled damper located in the tempering air inlet to the mixing fan. A thermocouple and temperature controller are used to automate the positioning of this damper.

500
The gas volume leaving the electrostatic precipitator is approximately 6500 s.c.f.m. at a temperature of ~~600~~^{0} F. This gas is air tempered to a volume of approximately 35,000 s.c.f.m. at a temperature of 220^0 F.

The condensed arsenic trioxide dust is recovered from the cooled roaster off gas in an eight compartment model 300 Dracco baghouse. Each compartment contains 300, five inch diameter by 10' 7" ~~10~~ foot long, * Draylon 32 bags. Rated capacity is 60,000 cfm at 230^0 F. The unit was designed for an air to cloth ratio of 1.9 cfm per square foot. Collection efficiency is at least 99.8%. The unit was originally supplied with a timed shaking device for dislodging the dust from the bags.

Each two compartments are equipped with a V-shaped hopper and screw conveyors for the collection and removal of the arsenic trioxide. A cross conveyor transfers the arsenic trioxide dust into a Fuller Kinyon pneumatic conveying pump.

~~In 1978 the Federal Government announced its intention to establish an emission standard of 15 mg/scm total arsenic for gold roaster stack emissions. During this period the baghouse collection efficiency at Giant was improve by modifying the basic baghouse operating parameters.~~

Baghouse Temperature

The operating temperature in the baghouse was reduced from 230 to 220^0 F to increase the percentage of arsenic trioxide condensed from the vapour to the solid phase. Further temperature reduction is felt impractical due to the constraint of maintaining the gas temperature above the SO_2 acid dew point.

Bag Shaking Cycle

The baghouse was originally supplied with a timed shaking device for dislodging the dust from the bags. At Giant the shaking cycle was activated every 45 minutes for a total of 32 cycles per day. A study indicated that the poorest collection efficiency occurred during the bag shaking cycle. It is believed that the action of shaking the bags caused some of the fine grained arsenic trioxide to pass through the pores in the filter media this increasing the emission of arsenic trioxide from the stack.

* ' HOMOPOLYMER ACRYLIC DRALON T

The baghouse design air to cloth ration of 1.9 cfm per square foot was felt to be fairly low, so the shaking cycle was converted from a timed cycle to a pressure drop cycle. The bag shaking mechanism is now activated when the pressure drop across the baghouse reaches 2 inches of water. As a direct result the frequency of shaking was reduced from 32 to 4 cycles per day. The arsenic trioxide dust now builds up on the dirty side of the bags acting as an additional filter media. This filtering action of the dust combined with the reduced frequency of shaking have contributed to an overall improvement in the baghouse collection efficiency.

Table 2: Baghouse Operating Parameters

Parameter	Prior to 1977	Present
Temperature	230° F 116°C	220° F 104°C
Bag Shaking Cycle	Timed Shaking Cycle Every 45 Minutes	Pressure Drop Shaking Cycle. When pressure drops across the baghouse reaches 2" of water.
Shaking Frequency	32 Cycles/day	4 Cycles/day
Filter Media	Orlon	Draylon 32 → Homopolymer Acrylic Dralon "T
Stack Emissions mg/scm of Arsenic	75-25- mg/scm AST	6-10 mg/scm AST
lbs/day of Arsenic	273 - 760 lbs/day	16 - 20 lbs/day

Average Baghouse Dust Grade

Au	Fe	S	As	Sb
65 - 72 wt%	85 - 95 wt%	1.0 - 2.5 wt%	0.3 - 07 wt%	0.10 - 0.15 ozs/ton

Average Collection Efficiency: 99.85%

Filter Media

The baghouse was originally supplied with Orion filter media, however after an extensive period of testing various manufacturer's filter bags, a switch was made to Porritts and Spencer's Draylon 32 filter media. These bags have ~~proven to be very reliable in this application.~~ become unavailable IN 1992, A SWITCH WAS MADE TO CROSIBLE, LTD ACRYLIC DRALON T FILTER MEDIA

A variable speed, hydraulic drive stack fan draws the "cleaned" baghouse tail gas to a 9 foot diameter by 150 foot acid brick stack. The stack gas typically analyzes: 1.25% SO_2, 78.50% N_2, and 0.10% CO_2 with a dry molecular weight of 29.4 lb/lb mole.

Disposal of Recovered Arsenic Trioxide

An average of 15 tons of material is recovered in the baghouse each operating day. The typical analysis of this baghouse dust is 85 to 95 wt% As_2O_3 to wt% Fe, 0.3 to 0.7 wt% Sb and 0.10 to 0.15 oz/ton of gold.

Baghouse dust is pneumatically conveyed into specially prepared underground stopes located in permafrost zones. These stopes are designed and excavated solely for the storage of arsenic trioxide dust. After excavation of a stope is complete, concrete bulkheads are installed to prevent the movement of any stored material from the stope. The permafrost is then allowed to permeate back into the area before any baghouse dust is placed in the stope. The pneumatic conveying air used to transport the baghouse dust underground is vented back into the baghouse inlet flue.