POLLUTION PREVENTION AT RAND REFINERY, LIMITED

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Rand Refinery, Limited, Germiston is a subsidiary of the Chamber of Mines of South Africa. It has been operating for some 55 years and over this period there has been an ever-increasing degree of pollution control. From being practically non-existent there now exists highly sophisticated pollution control measures in the form of a complex consisting of electrostatic precipitators, a bag plant and water purification equipment.

The major pollution problems facing the Refinery are associated with:-

air pollution, that is, the discharge of dust particles and noxious gases in excessive concentrations;

water pollution resulting from the toxic nature of the plant effluents; and

environmental pollution arising from the disposal of solid waste products.

The plant at the Refinery may be roughly divided into two sections:

(i) the Gold Refining section, which deals with the refining of all the newly-mined gold in the Republic of South Africa; and

(ii) the By-Products plant, which treats by-products produced at the Refinery and low-value gold-and silver-bearing materials deposited at the Refinery by mines and processors of precious metals.

Each of these sections has its own pollution problems which are dealt with in a specific manner. Of these two major divisions, the By-Products plant, from the point of view of pollution control, is the more important, and is therefore dealt with first.

BY-PRODUCTS PLANT

This consists of a blast furnace and ancillary equipment which uses a lead-reduction smelting process to recover precious metals, copper and lead for subsequent treatment.

The two main pollution problems in this plant are:

(a) Prevention of atmospheric pollution caused by the off-gases from the furnaces; and

(b) Prevention of environmental pollution caused by the disposal of waste residues.

(a) Prevention of Atmospheric Pollution

Associated with the lead blastfurnace plant is a small Dwight-Lloyd type sinter plant capable of producing ± 30 tons of sinter per day, and a cupel furnace for the cupellation of the blast furnace lead. The fumes from these furnaces are extracted via a common flue system and feed the electrostatic precipitators which are of the tube-and-wire type, with discharge electrodes of 1,6 mm diameter titanium wires suspended in 4,6 m long and 280 mm diameter steel tubes. Each unit has 116 tubes and a capacity of 280 m^3/min, giving a linear velocity of 0,65 m/sec through the tubes. The electrodes carry up to 1,0 mA each at a maximum potential of 65 000 V, supplied by means of high-voltage transformers and silicon rectifiers.

The air-borne material produced by the furnaces is composed mainly of oxides of the heavy metals and, being non-ionic by nature, is difficult to precipitate.

The total dust load is of the order of 15 kg/hour per precipitator, with a size grading of ± 50% less than 5 microns. With this type of material between 70% and 80% collection efficiency is achieved. The higher efficiencies are achieved when the concentration of SO_2 in the gas stream is of the order of 0,5% to 1,0%.

A typical analysis of dust collected is:

Gold	40/100 g/t	Copper	1/3%
Silver	3 000/4 000 g/t	Arsenic	1/8%
Lead	40/50%	Sulphur	3/10%
Iron	5/10%	Chloride	2/12%
Zinc	2/5%	Silica	2/8%

After treatment in the electrostatic precipitators, the gases are passed to a bag filter plant, which is also used to filter air from potentially dusty areas in the sinter plant. The bag filter plant has a capacity of 1 700 m^3/min, and uses 468 needle-felt polyester bags (measuring 3,2 m x 0,2 m), capable of withstanding temperatures of up to 135°C. The air-to-fabric ratio is 1,8 m^3/per min/m^2 of fabric.

The efficiency of collection is of the order of 99,6% to 99,8%, with a final discharge of 0,4 - 2,0 mg/m^3 passing up the 61 m high stack (diameter 1,675 m).

The following table shows a typical analysis of the off-gases from the dust-collecting systems:

Main Volume Discharged	$\pm$ 28 m^3/sec
Duct Density	0,96 kg/m^3
Duct Temperature	37°C to 40°C
Concentration Total Dust	1,13 mg/m^3
SO_2	0,12%
SO_3	0,01%
Other Acids	0,01% to 0,02%

(b) Environmental Pollution

As a result of the plant operations a very complex iron-lime-silica slag, low in precious metals, is generated in a granulated form.
A typical analysis of this material is as follows:

SiO_2	25 - 28%
FeO	30 - 36%
CuO	12 - 15%
Al_2O_3	3 - 7%
ZnO	3 - 6%
Pb	1 - 1,5%

Also present in the slag are small quantities of B_2O_3, and traces of certain metals such as copper, zinc and manganese.

This material is friable and is not suitable for road-making or land-filling. However, it has applications in the glass industry and as a medium for sand-blasting.

The monthly production of $\pm$ 400 tons is dumped on a selcted site where precautions are taken to prevent erosion into natural water-courses.
Despite the inert nature of the slag it is a very good medium for the propogation of vegetation, and natural grasses soon cover dormant areas of the dumping site.

GOLD REFINING SECTION

All the newly-mined gold produced in the Republic is processed in the gold refining section. This amounts to between 2 500 kg and 3 500 kg per working day.

The process is divided into 3 phases which can be further subdivided.

Phase I : Melting and Sampling

This operation commences on the receipt of the bullion in bar form and consists of the melting and sampling of the bullion deposits, and the casting of the sampled metal into suitably-sized ingots. The object is to obtain representative samples while causing as little change as possible to the metal composition of the deposited bars.

The small amount of oxide fume generated in this operation is collected via hoods and directed to the electrostatic precipitators.

Phase II : Refining and Bar Casting

The bullion as received assays, on average, 88 - 90% gold and 7 - 12% silver and base metals, (mainly copper, lead, zinc and iron). Bullion of this type is readily refined to a fineness of 9 950 + parts per ten thousand by a process devised by F.B. Miller in Australia in 1867. The process consists of injecting chlorine gas at 1,5 kg/cm^3 into the molten bullion which is contained in a suitable crucible.

A separation is effected between the gold on the one hand and the alloying elements on the other hand, the latter being converted to their respective chlorides in either the vapour or liquid phase at the refining temperature of $\pm$ 1 150°C.

During this operation considerable fuming occurs. The fume is extracted through specially-designed fixed and movable hoods. The fume and ventilation air is collected and fed to the electrostatic precipitators which are of similar design to those previously described.

The dust loading to this plant is relatively low at ± 65 mg/m^3.

A typical analysis of the feed to the precipitators is:

Concentration:	Gold	5,5%
	Silver	51,5%
	Base Metals & Non-Metals	43,0%

Size Analysis (Microns):

-	44	=	77,5%
-	20	=	50,4%
-	10	=	32,6%
-	5	=	14,0%
-	2	=	5,4%

This material lends itself to collection in electrostatic precipitators, and efficiencies in excess of 99% have been measured.

The base metal chlorides in the collected dust cause problems, as they are both hygroscopic and very corrosive. Because of its hygroscopic nature, the dust is difficult to remove from the precipitators, yet, if allowed to remain in these units, causes corrosion problems. The dust collected in this manner is treated in the By-Products Plant for the recovery of precious metals.

It may be of interest to add that each year about R750 000 worth of precious metals are recovered from the dust collectors, obviously a good case for air pollution prevention.

On completion of the refining, the gold is transferred to a holding furnace and is then manually cast into bars.

The gold in bar form is sold to the South African Reserve Bank on behalf of the mines.

The silver and base metal chlorides produced in the refining stage are treated for the recovery of silver. The process consists of a pyro-metallurgical stage for the recovery of traces of gold, followed by quenching in acidified water.

During the quenching stage some 90% of the soluble metal salts are removed. The suspension is filtered and the solids washed in conical tanks until free of soluble copper and lead salts. The clean silver chloride is reduced to metal using metallic zinc dust as the reductant. This silver is further refined by an electrolytic process to give silver crystals assaying 99,9+% silver which is melted and cast into the 35,5 kg bars of commerce. This process gives rise to a solution with a high metal content.
A typical analysis of the solution is:

Zinc	5 g/l
Copper	5 g/l
Lead	0,8 g/l
Iron	0,03 g/l
Silver	4 ppm
Nickel	4 ppm

These metals are all in solution as chlorides.

At present the solutions are passed through large vats, containing scrap iron. The copper is precipitated along with silver and some lead with an equivalent amount of iron going into solution.

This solution is treated with lime and the pH adjusted to 5,2. At this pH the iron and zinc salts are precipitated as hydroxides. This suspension, high in chlorides, is pumped to a rubber-lined sump.
Disposal is at present effected via the Municipal toxic effluent disposal system.

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