PRACTICAL ASPECTS OF AIR POLLUTION CONTROL IN THE LEAD INDUSTRY

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SYNOPSIS:

The control of air-borne emissions is an integral part of the operation of modern lead smelters and refiners. The different types of furnaces are discussed with particular emphasis on exhaust systems, hygiene ventilation and dust collecting plants.

OPSOMMING:

Die beheer van lugbesoedeling is 'n belangrike afdeling in die werksproses van 'n moderne Lood Smeltery en Raffinadery. Verskillende oonde word bespreek met klem veral op uitlaatstelsels, higiëniese ventilasie en stofbeheer stelsels.

At present in South Africa the production of lead and lead alloys is confined to smelters and refiners of secondary material. Two major and two minor plants are located at the coast and a major one on the Reef. Total production is about 40 000 metric tons per year. The metal is used to make a range of goods which are of great economic and strategic importance to the country.

The secondary lead industry clearly conserves the mineral resources and conserves foreign exchange. In general, health and pollution hazards are associated with smelting operations and the recycling of metallic scrap makes a worthwhile reduction in the overall problem. The industries served are as diverse as those that make storage batteries, lead compounds, cable sheathing, chemical plant, etc. to jewellery alloys.

This paper is primarily concerned with the recovery of lead from residues and scrap, but there is obviously common ground between the production of lead and the use of the metal and compounds.

Dust or fume emitted by any industry is a nuisance which can interfere with the quality of life of everyone in the neighbourhood, but in the lead business special care has to be taken because such emissions are toxic.

Superficial investigation of the processes which are used to produce lead would indicate that comparatively simple plant is used and the methods used to prevent pollution of the environment are those reflecting good common sense. Recent experience indicates that in the industry at least one-third of production management and supervisory time is devoted to air pollution and hygiene control. Capital expenditure on dust arresting equipment is frequently two and three times the amount spent on the smelter or refinery unit that is served. It must be stressed that economic necessity dictates that lead, tin and antimony cannot be dissipated in clouds of dust or plumes of smoke –

In May 1979:	Tin price	R13 510,00 per metric ton
	Lead price	R 1 153,00 per metric ton
	Antimony price	R 4 116,00 per metric ton

Consideration of the ways to combat pollution of the air by lead and lead compounds can be summarised under the following headings:

(1) Handling of Raw Material.
(2) Smelting.
(3) Refining.
(4) Stack Emissions.

HANDLING

The traditional method of preventing the release of dust during loading or tipping operations is to keep the material well damped and to stow in bunkers which prevent drying out. Water sprinkler systems can be used to keep the contents moist.

The load-carrying sections of trucks, etc. should be covered when carrying leady residues and in South Africa traffic regulations require that, on public roads, all loads be safely contained on, or in, the vehicle. In the wider context this clearly prohibits loss of any material in transit. For limited in-plant movement, it is usually sufficient to see that all skips are not filled beyond 150 mm from the top.

The disadvantages of using water to prevent dusting are worth noting:

(1) The water has to be driven off during the smelting operation with a consequent reduction in thermal efficiency.

(2) Some molten lead compounds, for example, mixtures of lead and iron sulphides, react violently with water and at best the steam released in the furnace bath causes severe splashing.

(3) Water evaporated from the charge can condense in the dust collector and on the filter sleeves. This aspect is discussed later.

(4) At least 75% of raw material received by a secondary smelter is of known composition, for example, scrap battery plates from motor vehicle starter batteries, but when these are damped to prevent dusting the allowance for water content has to be determined for every lot. A moisture content of about 6% inhibits dusting in most lead-containing raw materials.

The movement of raw material from the storage area can be carried out mechanically in two ways:

1. Wheeled loaders or dumpers.
2. Overhead cranes with grab buckets.

(1) Wheeled transport has a major defect because the moist material adheres to the wheels and is spread along the roadway from the storage area to the charging hopper. It is usual practice in overseas plants nowadays to automatically wash the wheels of all heavy vehicles which have been exposed to contamination by lead dust or mud before they travel on public roads. Clearly the smelter roads have to be paved and washed down regularly. In South Africa, water has to be conserved and preferred practice is to keep the roadways clean using a dry mechanical sweeper fitted with an extraction fan and dust collector.

(2) Overhead transport is not sufficiently flexible for most applications and spillage is a problem.

In this paper, practical aspects are considered, but the elegant solution to the handling problem could be as shown in the illustration – (fig. 1).

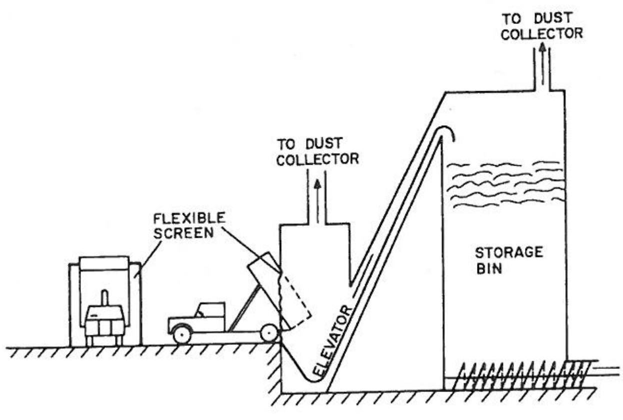

FIG 1 *Hygienic Mechanised Handling*

A Tip into ventilated hopper.
B Deliver to ventilated silo.
C Retrieve from silo.
D Charge to furnace.

A, B and D present no difficulty, other than expense.

C Retrieval is always a problem because the density and other physical properties of lead residues cause severe compacting and bridging in the bin.

There is a real need for a reliable, safe and hygienic method of carrying out this operation.

SMELTING FURNACES

The different types of furnaces are:

Blast Furnace	Smelting Temperature	1500°C
Rotary Furnace	–do–	900–1100°C
Reverberatory Furnace	–do–	1000°C

The control of furnace atmosphere and temperature is as important in the lead industry as in any other. The air/fuel ratio is set for the conditions required, taking into consideration whether secondary air is introduced into the furnace or not.

For hygiene reasons it is preferable to operate smelting units under negative pressure, but energy conservation is usually best served by maintaining a minimum draught and a positive pressure. The compromise is usually met by enclosing all furnace openings with hygiene ventilation covers.

Various methods can be used to prevent the emission of dust during furnace charging and are illustrated:

Blast Furnace –Double door system.
Open top – low level exhaust.
(fig. 2)

Reverberatory Furnace
–Negative furnace pressure.
Through the roof using pressurisation of charging chute.
Ventilation above charging door.
(fig. 3)

Rotary Furnace –Negative pressure and ventilation.
(fig. 3)

Blast and Reverberatory Furnaces operate continuously and charge is added at regular intervals. Rotary Furnaces operate on a batch system, the usual cycle is 6–8 hours.

The reactions which take place in these furnaces are simple:

$$PbO + C = Pb + CO$$
$$PbSO_4 + 2C = PbS + 2O_2$$
$$PbSO_4 + PbS = 2Pb + 2SO_2$$

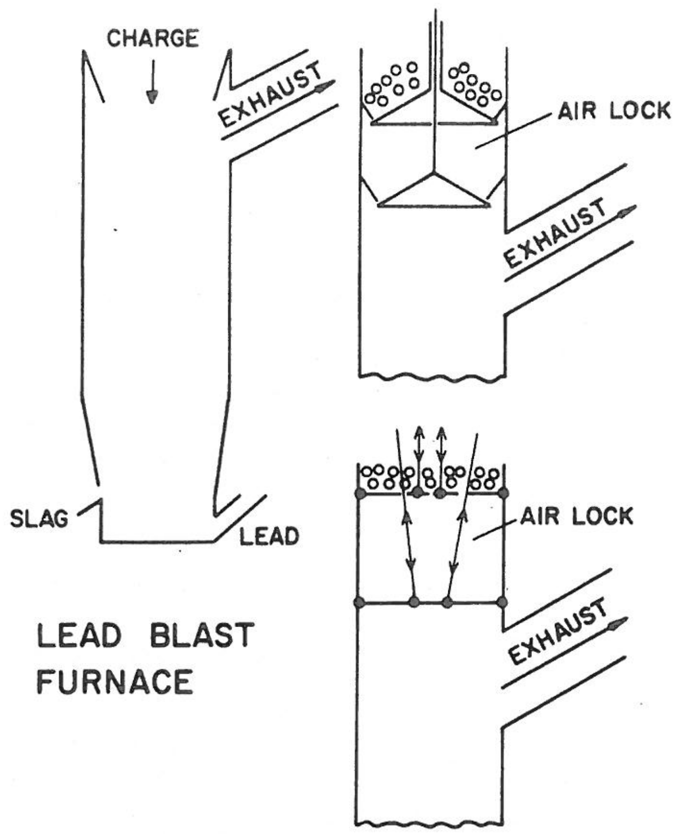

FIG 2 *Lead Blast Furnace*

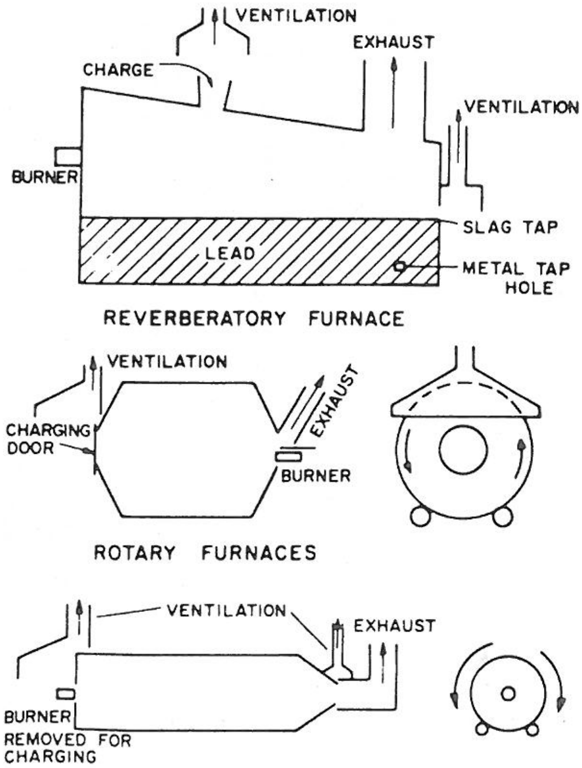

FIG 3

The combination of these reactions is complex and all smelting requires that fluxes be added to produce a fusible slag, for example, iron oxide, limestone, iron borings, soda ash, etc.

Dust and fume are released during smelting. Dust is carried by the movement of gases in the furnace and the lead compounds are volatilised at the furnace temperature to produce fume.

The mixture of the dust and condensed fume when it is collected is known in the trade as flue-dust and contains many different compounds, with different physical properties. A short list shows:

	M.P.
Pb	327°C
PbO	890°C
$PbSiO_3$	766°C
$PbSO_4$	1 170°C
PbS	1 120°C
$PbCl_2$	501°C
Na_2CO_3	851°C
Fe_3O_4	1 538°C Decomposes
$FeSiO_3$	1 550°C
$CaSiO_3$	1 540°C

The quantities of flue-dust to be handled for the various types of furnaces are shown:

Blast Furnace	16–22% of lead-containing feed.
Rotary Furnace	8–12% of lead-containing feed.
Reverberatory Furnace	14–18% of lead-containing feed.

Clearly the nature of the charge material and furnace operation can modify this expectation.

Transport velocity for lead dust in ducts is usually quoted as 25m/sec. at sea level and designs for general ventilation based on this figure are successful.

Handling hot lead furnace exhaust gases is more complicated and it is necessary to note that if a furnace is operating successfully, the following applies:

Lead dust will be deposited in the flue generally at a change of direction, particularly when condensation and solidification of the fume compounds take place. The ideal flue would be vertical, water-cooled or lined with 50 mm of refractory so that heat is readily dissipated. As the height would have to be between 60 – 100 m, the usual compromise is typically as shown. (fig. 4)

Ideally the dust should be removed mechanically and continuously, but flue-dust produced in the Blast Furnace is usually pyrophoric and burns spontaneously to produce a hard and abrasive sinter which sooner or later damages screw conveyors or other extraction systems.

The temperatures of the Reverberatory and Rotary Furnace exhaust gases are 900°C and 700°C respectively and lead compounds are present as solids, liquids and gases. For energy and furnace atmosphere reasons it is usual to keep the volume and, therefore, the velocity of the exhaust gases

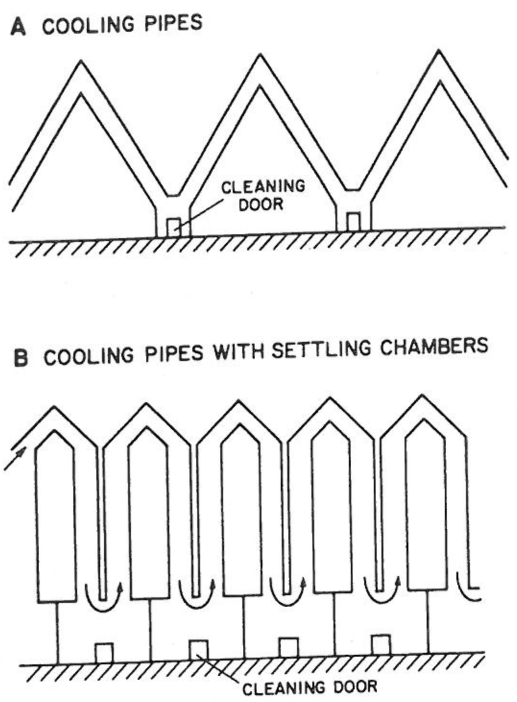

FIG 4

to a minimum and this complicates the need to keep the flue-dust in suspension so that drop out in the flues can be eliminated. To maintain the necessary gas velocities, cooling air is entrained at the furnace exhaust, but clearly this increases the size of the filter plant and fan. The dust in these cases is oxidised and not usually pyrophoric, but the temperature of the gases can inhibit the use of mechanised dust removal. Refractory or water-jacketed flues are used to handle exhaust gases above 550°C, but at temperatures below this mild steel performs satisfactorily, particularly on the South African highveld where the air is dry. Corrosion at the coast is a problem at the high temperature zone because protective coatings are damaged and the steel rusts.

Fabric filters using various configurations of sleeves and dust releasing methods are the most favoured in the industry. Terylene, either woven or felt, is the most widely used cloth. The temperature of the gases entering the unit should be between 80°C – 120°C. If it is too low, water vapour will condense on the sleeves, which will become "blinded" by the damp dust which may not be readily released by shaking or compressed air cleaning systems. If the temperature is too high, the material is degraded and there is the very real risk of burning the cloth by the spontaneous combustion of the dust.

Electrostatic and wet scrubber units are also used and it is not the intension to discuss the relative merits of any particular system, but the following should be noted:

(1) The handling of fabric or machinery contaminated with lead dust is a hazard to health. This applies equally whether a sleeve or pad is changed inside or outside the collector. In many cases there is less overall hazard if the filter element is changed inside a compartment which is under slight negative pressure.

(2) Dust from smelting units contains a greater or lesser quantity of coal, tar, oil, finely divided carbon, etc., and is not readily washed off. Only the best protective clothing and equipment should be used and this must be cleaned and serviced regularly. The servicing of filters in the lead industry has to be regarded as a "dirty job" and the correct motivation and supervision of the operators is one of management's important duties.

(3) Because the gas velocities in a filter are low, lead dust will build up on any horizontal surface and hopper sides should be as steep as possible, compatible with a reasonable filter height. All dust should be removed from the unit continuously or, when light dust loading applies, at least once a day. Rapping with a heavy rubber hammer prevents compacting of the dust in the hoppers, particularly if the dust is damp from the water introduced to prevent dusting at the charging of the furnace which is served by the dust collecting unit.

(4) Fabric filter life is limited – about nine months for arduous duties, i.e. about 400 g/m^3 flue dust per hour, to at least three years for general ventilation units. A hole 4 mm in diameter produces a visible plume at the stack and enlargement of the original opening is rapid to produce an emission which requires attention and replacement of the element concerned. To maintain adequate draught at a furnace when a dust collector is serviced, it is important that the filter be divided into compartments which can be individually isolated. The minimum number should be four so that the filtration capacity never falls below 75% of the total.

(5) Flue dust is discharged continuously by screw conveyors or intermittently into custom-made lines. The dust is netted and ideally is returned immediately to the smelting unit. At certain works the dust is fused with fluxes to produce a sintered material which can be readily smelted. Hydrometallurgical techniques are used to eliminate troublesome volatile compounds which may be present.

It would be appropriate to issue a word of warning about the possibility of damaging explosions in the closed furnaces and flue systems that good industrial hygiene requires.

In the Blast Furnace, in the event of unscheduled shutdown of exhaust, mixtures of carbon monoxide and air can explode and it is essential that pressure release doors are fitted.

In the Reverberatory and Rotary Furnaces, explosions usually occur if the incorrect gas or oil burner lighting procedures are followed. In the latter, excessively wet or dry charges can extinguish the flame if the furnace is rotated prematurely. Similarly, finely divided reducing agents, such as anthracite, can make an explosive mixture.

Although the probability of explosion in the dust collector is remote, the spontaneous firing of the dust is often possible. It should be noted that the greater the profusion of dust collecting systems to protect the populace from pollution by airborne lead dust the greater the number of workers who are required to service the plants, and it is in their own health interest to be part of a lead absorption monitoring scheme. Similarly, close attention has to be paid to protective equipment and clothing. Separate lockers in separate change-rooms are essential to prevent the contamination of personal clothing by work-place overalls, etc. Nowadays, it is usual to wash and clean protective clothing on an in-plant basis and laundry facilities are part of the welfare block.

REFINING

Temperatures are between 200° – 600° Celsius in cast iron or steel pots – capacity 25 – 100 metric tons, although specials go up to 200 metric tons. Dusty drosses are produced as well as volatile lead compound fumes.

Prevention of air pollution and protection of the health of the worker requires that the refining process dust and fume be ventilated to dust collection units – usually fabric filters.

To provide a cover to contain dust and fume produced during refining is comparatively simple, but allowance has to be made for:

(1) The charging of the pot, probably using metal blocks or dumps from the smelter.

(2) The removal of the drosses at different stages of refining. (fig. 5)

Fortunately, very little dust or fume is produced during the melting operation as this takes place below 420°C, but there is a problem when scrap cable strippings, or similar material, contaminated with tar or oil are used, and this is best overcome by pre-melting in a specially constructed pot. The gases from this are passed through an after-burner before ducting to the dust collection unit.

The rate of dust and fume evolution varies during refining and the draught on the pot is changed from a minimum when heating up to a maximum when cooling is required or the access doors on the cover are open.

The removal of drosses from the metal surface is usually carried out with a perforated ladle and good practice re-

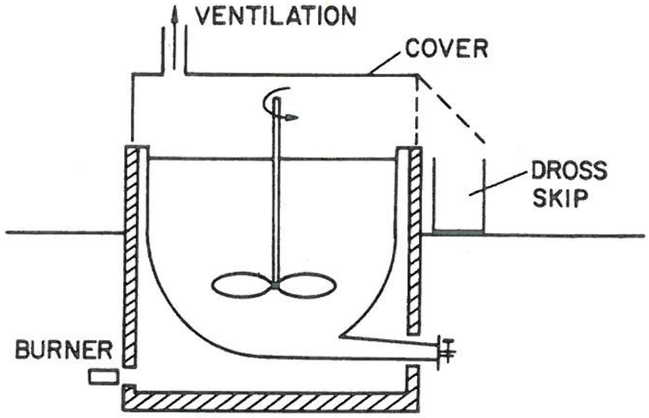

FIG 5 Spouted Refining Pot

quires that the operation be carried out under adequate ventilation.

The handling of by-products of the refining process requires the same care as discussed under the handling of raw materials. The preferred method is wetting, either by immersing the skip contents in water for a day or two, or standing under a sprinkler for the same time. The process is complete when the refined metal is cast into market ingots, using either a bottom pouring pot or an ingot casting machine fed by a pump. The casting temperature is usually between 400°C – 450°Celsius and the volatility of lead and alloys under these conditions is extremely low and is not a hazard to health.

Similarly, the re-melting of lead does not produce fume, but care must be exercised when the small quantity of lead oxide produced on the surface is to be removed, that is, there must be adequate ventilation to a dust filter. The dross should be left in a closed container for return to the smelter.

STACK EMISSION

The height of chimneys discharging gases is prescribed by the Air Pollution Authority and to a large extent is proportionate to the SO_2 content. The quantity of this gas is usually too small or too erratic to warrant an acid recovery plant.

All stacks should be monitored with respect to lead content and the recording type of instrument is the most useful for supervisory management purposes. In many overseas countries the results have to be forwarded to the statutory controlling inspectorate. Most types of instruments make provision for a warning system to draw the attention of the operators to a leak in one of the filter sleeves or elements.

CONCLUSION

The lead industry in South Africa has come a long way in the recent years to operate efficiently to meet the needs of a modern community. At the same time considerable effort and very large sums of money have been spent to ensure that the expansion programmes have been designed to reduce the risk of air pollution by the industry to a very low and safe level.

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