General Industiral Series

Control and Monitoring of Atmospheric Emissions

1. Introduction

Monitoring and controlling air quality from smelting, refining and product application industries will regulate air quality and restrict emissions of pollutants from point sources to the atmosphere, thereby managing risks to human health and the environment.

2. Emission Control Principles

Following the mining of the lead ore, dust can be generated during the crushing operations prior to flotation.

Battery breaking in the secondary industry has the potential to generate a lead contaminated acid mist during the sawing or crushing of whole case batteries.

The prepared primary or secondary feedstock can generate lead dust during the transportation phase whether by mobile fleet vehicles or by conveyor.

Smelters operate more efficiently if the furnace charge can be prepared and blended prior to charging. Charge preparation beds or mix buildings will generate lead dust.

Sintering is part of the primary smelting circuit. During sintering the lead concentrate and sulfur are oxidized to produce lead oxides and sulfur dioxide gas. Lead emissions, as well as cadmium and arsenic, are released. They can leak from hooding, or in the crushing circuit or when mixing with the new feed.

The smelting operation in both primary and secondary lead smelting plants involves the reduction of lead bearing material into impure metallic lead in the furnace.

Lead emissions can occur during furnace charging, smelting and tapping, especially fugitive[1] emissions as the "red" hot molten metal is drained from a furnace.

Refining in both primary and secondary circuits can generate lead emissions.

Casting of final product can also generate a low level of lead emissions.

Where any employees are liable to receive significant exposure to lead, the lead in air concentration must be measured in accordance with an appropriate national or internationally recognized procedure at least every three months. Whenever possible employees should be advised of the likely levels of exposure in the workplace and the precautions necessary to minimize or even eliminate the risk of lead exposure.

3. Emission Control Principles

Material movement should be managed to minimize the amount of handling. Blending of wet sludges and dry materials may reduce dusting. Blending of dusty materials may be done in an enclosed building. Water may be needed to control dust. Some regulators require ventilated buildings.

[1] Fugitive emissions are caused by the high vapor pressure of lead and its compounds at about 1000ºC .

Some process modifications may be feasible to eliminate or reduce the generation of emissions. For example:

- Lower pot temperatures decrease the rate of dross formation and the surface generation of dust.
- Furnace metal can either be tapped into moulds/pots under a ventilated shroud or directly into a bath of covered and ventilated molten lead between 310 and 350 K to minimize fugitive emissions.
- Plant layout can also be modified to reduce the amount of materials handled.

Exposure can be reduced in some cases if machines are selected to perform high exposure tasks so its employees may be removed from the area. However, while screws, conveyors and hoist buckets solve some problems, robotics are seldom cost effective.

Efforts should be made to enclose the emission source to the extent that is feasible or provide local exhaust ventilation. Occasionally it is possible to enclose and isolate a specific emission source. Because enclosures are seldom air tight, a negative draft exhaust system is often applied to the enclosure. One of the most common ways to control emissions is to provide local exhaust ventilation at the point source of emission generation. Capturing emissions at their source reduces the potential for emissions to disperse into the air. It also prevents secondary employee exposure created by the re-entrainment of second contaminants. The capture velocity of an exhaust hood must be great enough to prevent fumes or dust from escaping the airflow into the hood. The airflow must have sufficient velocity to carry fume and dust particles into the hood and to overcome the disrupting effect of cross-drafts and other random air movements. The velocity required to accomplish this will vary from application to application, but in general 300-500 fpm is used.

Where engineering controls are provided to minimize or contain lead emissions, inspections and maintenance regimes must be established at service intervals that are either recommended by the manufacturer or comply with a statutory regulation. A record of all inspections and engineering maintenance work must be kept up to date.

4. Exposure Reduction

Efforts should be made to wash down areas with water and keep areas damp and keep the working surfaces damp. Operator training, prudent work practice and good housekeeping are key elements in minimizing lead emissions when operating mobile equipment.

Local exhaust ventilation and clean air stations provided with positive filtered air could be provided so that employees can retreat to the clean air station when they are not needed in the process.

Respiratory protection is also important and should be available for any employee involved in the processes. These can be of the mask type or the filtered air hood. If sulfur is present carbon filter combinations are useful.

Belt wipes on a tail pulley properly maintained on conveyors and skirting and curtains should be placed at the head of any belt drive system. It is also important to make efforts to contain the whole process in one enclosed building and to separate one operation from another so that there is no cross-contamination in the event of a rogue emission.

5. Dust Collectors

In electrostatic precipitators a high potential electric field is established between discharge and collecting electrodes of opposite electrical charge. The discharge electrode is a small cross-sectional area such as a wire or piece of flat stock and the collection electrode is large in surface areas such as a plate. The gas to be cleaned passes through an electric field that develops between the electrodes. At a critical voltage the gas molecules are separated into positive and negative ions this is called ionization and takes place at or near the surface of the discharge electrode. Ions having the same polarity as a discharge electrode attach themselves to neutral particles in the gas stream as they flow through the precipitator. These charge particles are then attracted to a collecting surface, dust particles lose their charge and they can then be easily removed by washing, vibration or gravity.

Fabric collectors remove particles by straining, diffusion, and electrostatic charge. The fabric may be constructed of any fiberous material either nature or manmade and may be spun into a yarn and woven or felted by needling impacting or bonding. The best modern bag is made of Teflon which will capture submicron particles but has high initial cost. Regardless of construction the fabric represents a porous mass through which the gas is passed unidirectional such that the dust particles are retained on the dirty side and the clean gas passes through. A non-woven or felted fabric is more efficient than a woven fabric of identical weight because the void areas or pores in the non-woven fabric are smaller. A specific type of fabric can be made more efficient by using smaller fiber diameters or a greater weight of fiber per unit area or by packing the fibers more tightly. For non-woven construction the use of finer needles for felting also improves efficiency.

6. Wet Collectors

Chamber or spray tower collectors consist of a round or rectangular chamber into which water is introduced by spray nozzles. The principal mechanism is impaction of dust particles on the liquid droplets created by the nozzles. These droplets are separated from the air stream by a centrifugal force or impingement on water eliminators. Wet centrifugal collectors comprise a large portion of the commercially available wet collector designs. This type utilizes centrifugal force to accelerate the dust particle and impinge it upon a wetted collector surface.

Wet dynamic precipitators are a combination fan and dust collector. Dust particles in the dirty air stream impinge upon rotating fan blades which are moistened with spray nozzles. The dust particles impinge into water droplets and are trapped along with the water by a metal cone while the cleaned air makes a turn of 180 degrees and escapes from the front of the specially shaped impeller blades. Dirty water from the water cone goes to the water and sludge outlet and the cleaned air goes to an outlet section containing a water elimination device.

The orifice type of wet collector design has the air flowing through the collector and in contact with a sheet of water in a restrictive passage. The venturi collector uses a venturi shaped constriction to establish throat velocities.

7. Dry Centrifugal Collectors

Dry collectors separate and train particulate from an air stream by the use or combination of centrifugal inertia and gravity. The gravity separators consist of a chamber or housing in which the velocity of the gas stream is made to drop rapidly so that the dust particles settle out by gravity. Inertial separators depend on the inability of dust to make a sharp turn because its inertia is much higher than that of a carrier gas stream. Blades or louvers in a variety of shapes are used to require abrupt turns of 120 degrees or more. The cyclone collector is commonly used for the removal of coarse dust from an air stream as a pre-cleaner to more efficient dust collectors and as a product separator in an air conveying system.

8. Primary Lead Production

Mining:

Open pit mining creates emissions in blasting, loading and ore hauling. Keeping road grades smooth and wet with water trucks minimize dust. Underground blasting and hauling sends emissions out of vent shafts.

Milling:

Either underground or surface primary crushing is followed by secondary and tertiary crushing which requires bag filtering to control emissions.

Storage, loading and transportation of concentrates are all potential blowing losses.

Storage buildings or organic binders hold storage losses down.

Covering loads on trucks must be a standard routine. Railcars are usually not a problem because of the low profile of a load, however, drain holes need plugging to avoid spillage and trucks need sift proof design.

Sintering process emissions are heavily laden with lead/cadmium/arsenic sulfides and oxides as well as 3-8% SO_2 gases. Strong SO_2 gases from the front end of the machine are filtered by an Electrostatic precipitator. The gas is scrubbed, cooled, passes through a mist electrostatic precipitator and is dried by passing through sulfuric acid. The clean dry gas is heated and converted to SO_3 by vanadium or cesium pentoxide catalyst and then absorbed to make high strength sulfuric acid.

Low strength SO_2 gas can be recirculated to the front of the machine or absorbed to make ammonium sulfate fertilizer. Alternatively, low strength gas can be passed through a fabric filter baghouse.

Crushing circuit dust should be filtered through a baghouse and recycled.

Some sinter buildings are now filtering exhaust building air or totally enclosing and filtering the air. The inside environment suffers, however, as a result and it may be necessary to provide operators working in such an environment with appropriate approved personal protective equipment (PPE) in case lead in air values rise unexpectedly.

9. Secondary Lead Production

Battery collection involves incentive systems and initiatives to encourage the return of used car batteries. Battery breakage and cracked cases are all to common amongst collected used lead acid batteries leading to acid leakage and either environmental contamination or personal injury to those involved in the collection process. Accordingly collectors of used lead acid batteries need to consider shrink wrapping the batteries prior to transportation and the use soda ash to neutralization acid spillage.

Barrels of drosses may have arsenic and stibine gas generation from alloy metals under moist conditions. Keeping aluminum scrap separated from lead bearing scrap avoids the risk of explosions in kettles and furnaces.

Battery drainage involves puncturing, shearing, sawing or hammermills. Hammermills require enclosure to reduce the noise and control acid mist. Storage of used lead acid batteries before or after draining may involve some acid mist. Batteries and other scrap materials should be kept wet to avoid dusting. Buildings do not necessarily need to be fully enclosed and ventilated, but some are where baghouse dust and dry drosses are handled and blended. Wet scrubbers are sometimes used on high volume battery hammermills and acid handling tanks.

To control SO_2 emissions from blast or reverberatory furnaces, some operations choose to desulfurize using sodium carbonate or sodium hydroxide. Sodium sulfate byproducts can be sold.

Smelting furnaces are usually controlled with baghouses. Some blast furnaces require afterburners to reduce volatile organic hydrocarbon. Electric furnaces and reverberatory furnaces destroy organics because of time and temperature. Blending reverberatory and blast furnace gases can sometimes destroy blast furnace organics as well.

10. Lead Oxide Production

Since the oxide mills, classifiers and storage hoppers are normally under negative pressure most airborne lead levels are due to system upsets resulting from air surges, plugged systems or leaking equipment. Sources of oxide spills or leaks include trunnion seals, bearing seals, conveying systems, transfer points and improper airflow resulting in puffing oxide at the mill inlet.. Vehicles used in loading operations will also generate emissions.

For battery production lead oxide is made by ball mills or "Barton" pots. Glass making oxide and red lead is made sequentially in multilevel roasters. The product is actually captpured in cyclones and baghouses.

Some designs include only discharging bleed air through a separate Hepa filter system.

Engineering controls typical in lead oxide production are as follows:

- Ventilation around agitator shafts and seals prevent puffs of lead oxide from escaping into the atmosphere.
- A duct may be placed over the air intake which will contain the volume of the puff and prevent it from entering the workplace.
- Ventilate or enclose the drum filling operations and wagon loading (or tent car) of lead oxide.
- Consideration should be given to the installation of a pressure relief valve to the screw conveyor to vent dust generated during the transfer operations.
- Enclose where ever possible conveying systems or ventilate them at trans fer points.
- Isolate by physical separation by walling off operations in one area of nega tive pressure from the rest of the plant. Some apply positive pressure to the control rooms for operators with television cameras to monitor the process.

11. Emission Testing & Analysis

Emission testing and analysis can take a number of forms, but essentially it is important to test for particulates, sulfur dioxide and visible emissions, that is the opacity.

Air samples of the workplace should be taken using calibrated sampling pumps with cassettes containing either mixed cellulose ester (MCE) or polyvinyl chloride (PVC) filters. There may be a number of country specific statutory sampling requirements, nonetheless the following guide will provide a comprehensive overview of the effectiveness of any control measures:

- Static perimeter samplers - located on the boundary limits of the operations.
- Static process samplers - located close to those operations most likely to fume of produce leaded dusts.
- Personal monitoring - the sampler is located on the operator and the test proceeds as he or she undertakes their duties. This test measures the level of occupational exposure at the place of work.
- Static urban/rural samplers - located outside of the plant and close to places that may be of concern to the public, or environmental groups. Typical loca tions would be a farm, local housing estates, hospital, school or nursery.

After any new installation or modification to the lead process it is recommended that a determination of the lead in air values is made as soon after commissioning as possible and that the sampling covers the lead exposure of a representative number of employees who are likely to be the most exposed to airborne lead.

Static samplers provide information on emission trends in, around and outside of the plant. Samplers positioned outside of the plant and close to local housing or amenities provide an essential guide to the lead levels in the community. If lead emissions are under control then the samplers will provide the community with assurance that they are not being contaminated and the company with the means to respond quickly if community lead levels start to rise for any reason.

Secondary operations require testing for hydrocarbons and dioxins in the furnace off gasses and the Engineering Maintenance Department should pay particular attention to any baghouse leaks using opacity tests or baghouse leak detectors. In-line organic or sulfur dioxide testing equipment is available, but will not function consistently unless installed downstream of the baghouse or dust collection control equipment.

12. Emission Source Standards

While it is essential to comply with government emission limits for any lead process industry, it is also important to set internal company standards and these should cover three sources:

- Process emissions.
- Fugitive sources of emissions.
- Fugitive dust sources.

Fugitive emissions and fugitive dusts can be measured with a personal monitor or hi-volume filter testing equipment when studying internal emission sources. However, working methods and personal practices are the most important factors that affect occupational lead exposure and all personnel involved in lead operations must be adequately trained in lead abatement strategies.

13. Summary - The Key Success Factors

Emission control programs to reduce dust, lead and heavy metals, sulfur dioxide, organics and acid mists are essential in order to manage risks both to workers, near-by communities and the environment.

However, they are expensive and the projects often need to be implemented sequentially because they interfere with operations and are complicated. It may be appropriate to plan a series of projects over several or more years beginning with the most effective and significant.

It is recommended that plans for or modifications to control and monitoring regimes are communicated to employees, municipal authorities and local community groups in order to gain their confidence in the effective management of lead risk and to gain their contribution and input to ensure that local monitoring stations are both welcome and positioned in places of likely concern.

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