Lead Exposure

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Introduction

Lead is a soft, malleable bluish-grey metal. This naturally occurring toxic metal is found in the earth's crust and in the environment. Estimates are that half of the world's annual lead production of more than 5.5 million tons is dispersed into the environment. Approximately 50% of the lead entering commerce is derived from recycled material.

Due to the toxicity of lead, it has been removed from products like fuel and paint, resulting in a decrease in the population lead levels in countries like the United States of America (USA). The reference range for non-exposed people has therefore been changed to < 4.9 µg/dL in the USA.

Lead exposure in South African Industry is regulated. The relevant legislation can be found in the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993) Lead regulations, 2001.

Where is lead found?

Lead used to be added as an “anti-knock” agent to petrol, and it also has excellent anti-corrosive properties. It has been used in paint, as solder in food cans, in water pipes and in the automobile industry in radiators. It is also used in leaded glass crystal and metal alloys. Much of this has changed, as lead is no longer used in petrol, domestic paint, food cans and other applications. However, leaded paint has been found in imported toys, and lead paint may still be found in old houses. As lead has been extensively used over a long period of time, it can still be found in unexpected places due to its stability. When patients are found to have clinical signs suggestive of lead poisoning, the possible source must always be investigated.

Industrial exposures and potentially risky occupations include (but are not limited to) the following:

- Battery manufacturing and recycling
- Lead smelting and refinery workers
- Brass, copper, or lead foundries
- Removing old leaded paint by welding or thermal stripping
- Bridge maintenance
- Soldering
- Scrap metal handling
- Stained glass makers
- Cable makers/splicers

Non-industrial exposures include:

- Pottery, glazing or making lead windows
- Renovating old houses
- Soldering or welding without personal protection
- Environmental exposure

Organic vs inorganic lead

Organic lead is formed when a hydrogen or carbon atom is bound to the lead atom. Examples include tetraethyl lead and tetramethyl lead, which can be found in fuel additives. Some absorption of organic lead occurs through the skin.

Inorganic lead is elemental lead and lead combined with oxygen or chloride, and is the form most often found in the environment.

Toxicokinetics of inorganic lead

Inorganic lead is absorbed through inhalation and ingestion. About half (but occasionally up to 80%) of inhaled lead is absorbed. Less than 10% of ingested lead is absorbed. The particle size, concentration of lead and its solubility can affect its absorption. Factors that enhance lead absorption from the intestinal tract include:

1. Age – children absorb lead better.
2. Iron stores – iron deficient individuals absorb lead better.
3. Fasting state – people with diets that are deficient in calcium, phosphate, iron, zinc and selenium absorb lead better.

Once absorbed, inorganic lead is distributed into three compartments: bone, blood and soft tissue. Bone contains about 90% of the total lead content in the body. Bone consists of two compartments, trabecular bone and cortical bone. The trabecular bone accounts for 20% of the total bone-bound lead, which has a biological half-life of < 10 years. The cortical bone accounts for the remaining 80% of the bone-bound lead; the biological half-life of lead in this compartment exceeds 10 – 15 years. Lead in bone may be released into the blood, re-exposing other organs long after the original encounter. The blood compartment has three subunits: the red blood cell pool, the protein-bound pool and the free lead diffusible pool. The blood fraction has a biological half-life of about 35 days. Ninety percent of lead in the blood is bound to red blood cells. The fraction of inorganic lead in the soft tissue compartment has a biological half-life of about 40 days.

Lead can affect all organ systems. Some of the effects are:

- Haematopoietic system: Lead affects several enzymes in the haematopoietic system. It has a strong affinity for sulfhydryl groups, which results in a decrease in the activity of delta aminolevulinic acid dehydratase (DALA) and ferrochelatase enzymes. Because the haemopoietic system has a large reserve capacity, anaemia is rarely seen with blood lead levels below 80 µg/dL.
- Renal effects: Proximal tubular nephropathy, glomerular sclerosis, and interstitial fibrosis can occur.
- Neurological effects: There is a wide range of neurological manifestations, ranging from cognitive difficulties to peripheral neuropathies. Clinically, patients exposed to lead can appear to have no symptoms despite having high blood lead levels. However, on repeat and careful interview, subtle neurological signs can be detected. This is true for both occupational and non-occupational exposure. Although the precise mechanisms are unclear, neuropathology is thought to be due to the altered release of neurotransmitters, and to increased levels of delta aminolevulinic acid.
- Fertility effects: A decrease in sperm count has been described. There are also several reports of increased numbers of early miscarriages.
- Carcinogenic effects: There is no conclusive evidence that lead causes cancer. However, the International Agency for Research on Cancer (IARC) states that inorganic lead is probably carcinogenic (Group 2B).

Clinical features of lead poisoning

There is a difference in presentation between adults and children. Children may display neurological symptoms, e.g. developmental delay, poor feeding and irritability.

Adults can present with joint and muscle pain, headache, irritability, mood disorders and abdominal pain. Because lead affects all organs, the clinical presentation may be related to any organ dysfunction. Severe dysfunction, however, may only be evident at blood lead levels > 80 µg/dL. The type and duration of exposure may influence the range and severity of clinical manifestations.

Excretion

Lead is excreted primarily in the urine and faeces, but can also be excreted in sweat, saliva, breast milk, hair, and nails to a minor degree.

Monitoring

It is compulsory to monitor environmental lead levels in the workplace. This helps to assess the need for engineering controls and the use of personal protective equipment (PPE). However, as environmental monitoring only gives an indication of the inhaled fraction, biological monitoring must be undertaken to assess an individual's total lead exposure and its effects. Blood lead levels are done for biological monitoring. Tests to assess biological effects include a full blood count, renal and liver function tests, as well as a clinical assessment of the central and peripheral nervous system.

A number of annexures to the South African lead regulations illustrate the actions required at different concentrations of lead. (See annexures A, B, C, and D below.) Annexure A shows the maximum intervals for re-assessment of blood lead measurements, whereas Annexure B shows the maximum intervals for re-assessment of urine lead measurements. Annexure C indicates that as of June 2005, if an individual has a blood lead levels of ≥ 60 µg/dL, he/she must be removed from a lead exposed work area. Annexure D shows that workers may return to work once the blood lead level is ≤ 50 µg/dL.

ANNEXURE A [Regulation 8(2)(b)(i)]

Blood lead (µg/dL)	Maximum intervals between blood lead measurements
Under 20	12 months
20 - 39	6 months
40 - 59	3 months
60 and over	At the discretion of the occupational medicine practitioner

ANNEXURE B [Regulation 8(2)(b)(ii)]

Urinary lead (µg/L)	Maximum intervals between urinary lead measurements
Under 120	6 weeks
120 – 149	1 week
150 and over	At the discretion of the occupational medicine practitioner

ANNEXURE C [Regulation 8(d)]

Blood lead level (µg/dL) Removal level	Date effected
75	30 June 2002
70	30 June 2003
65	30 June 2004
60	30 June 2005

ANNEXURE D [Regulation 8(3)(b)]

Blood lead level (µg/dL) Return level	Date effected
65	30 June 2002
60	30 June 2003
55	30 June 2004
50	30 June 2005

Closing remarks

If a person is exposed to lead at work, his/her employer should inform him/her that he/she is exposed to lead, which may be associated with potential adverse health effects. All workers should be educated regarding the correct workplace instructions to minimise potential exposure. This includes the use of PPE. The employer should understand the regulations and have a copy of the lead regulations at hand.

The South African regulations were last updated in 2001, displaying the proposed changes to be introduced in 2005, as shown in the annexures above. However, these levels no longer conform to international best practice guidelines. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that exposed individuals be removed from the work environment when the blood lead level is ≥ 30 µg/dL; the BAT (German) recommended removal blood level is ≥ 40 µg/dL for men, and ≥ 10 µg/dL for women younger than 45 years.

The removal level for women is based on the effect that lead has on the developing foetus. Lead crosses the placenta during pregnancy, and above a blood level of 10 µg/dL, has an influence on the developing foetus. Consequently, in Germany 10 µg/dL has been set as the removal level for women of childbearing age (< 45 years). There is much debate around this point. Other countries (including South Africa) have not adopted this cut-off. The South African lead regulations state that women of childbearing age must have blood lead determinations every 3 months (paragraph 8(2)(b)(i)), the removal level is 40 µg/dL as stated in paragraph 8(4)(a) and (b).

Iron deficiency increases lead absorption. Thus, women and children absorb lead to a greater degree, as they are more prone to have a chronic, subclinical iron deficiency. Lead dust often settles on surfaces including the floor. Small children are at risk for greater exposure due to their stature and normal behaviour of exploring the floor and putting objects into their mouth.

PPE and hygiene plays a very important role in the control of lead exposure. Lead is transferred from surfaces and clothes to hands and food, increasing the chance of ingestion in the workplace and at home. For this reason, work clothes should be kept in a separate locker from street clothes, and laundered at work separate from other clothing. All workers should wash their hands before eating and refrain from smoking at work, as smoking not only increases absorption of lead but also facilitates transfer of lead from hand to mouth. Workers should preferably shower before going home.

NOTE: This document is a guideline only and should be read in conjunction with the South African Lead Regulations.

References

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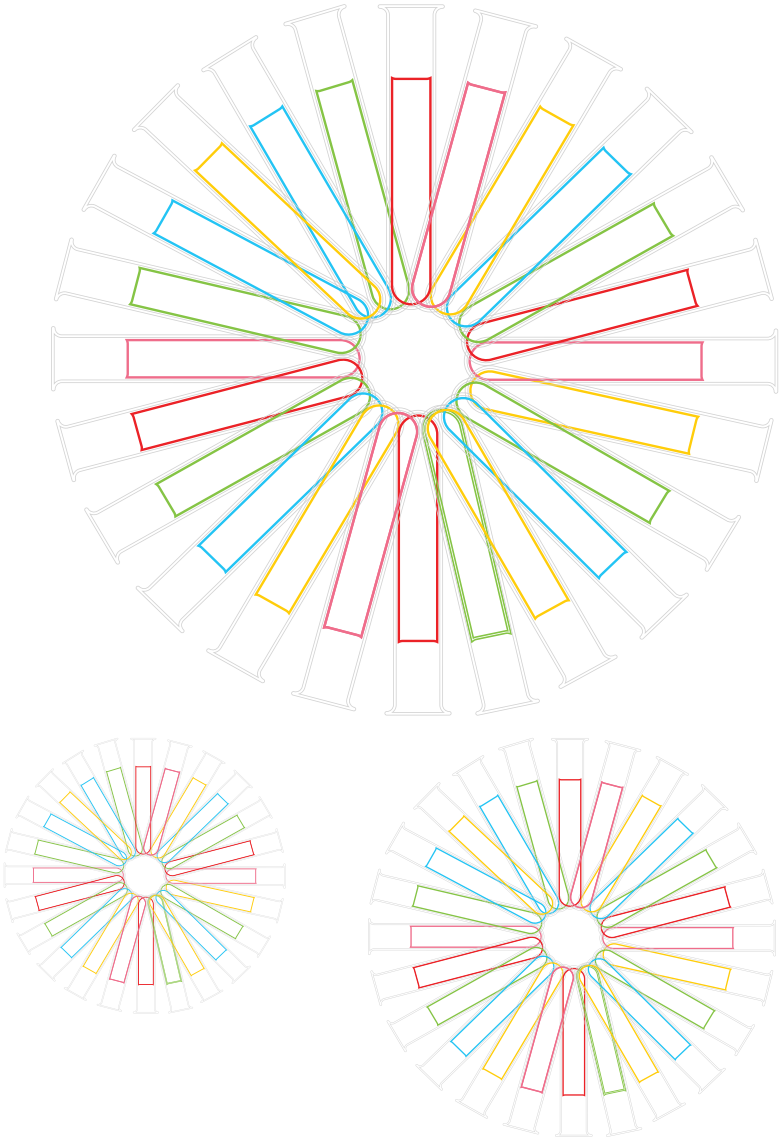

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