THE HEALTH OF LEAD WORKERS IN NEW ZEALAND — AN OVERVIEW OF MANAGEMENT

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Historical

Lead occurs in the earth's crust throughout the world and has been used by man since early Roman times when, because of its malleability and ease of working, it was adopted for pipework, guttering, and cladding It was used to line aqueducts and, more importantly, it was fashioned into eating and drinking utensils. Water, food, and drink, therefore, were in contact with, and to a greater or lesser degree contaminated by, lead before being ingested This, in part, no doubt accounts for the far shorter lifespan of those days.

Lead continued to be used throughout the centuries but it was not until the industrial revolution in the mid-1800s that vast quantities of lead were required for the manufacture of new machines and engineering projects such as bridges and large factories and buildings. The use of lead-based paints increased enormously, as the preservation quality of the metal was well known. The working conditions throughout industry were appalling with little or no regard to safety or health. The plight of the lead worker mattered little and lead absorption and poisoning amongst this group was the accepted norm.

By the turn of the nineteenth century, industrial reform was well under way, and regulations governing the control of the use of lead and, consequently, the health of the work force were implemented, and these have continued to be improved up to the present day. It was fortunate that the health hazards of lead were well recognised before the advent of lead/acid battery manufacture which rapidly expanded in the 1920s and 1930s and has continued to grow until it now consumes the major part of all lead usage. It is therefore towards the health management of the battery manufacturing work force that this paper is primarily directed

Clinical and sub-clinical effects of lead absorption

What are the signs and symptoms of excessive lead absorption and what are the clinical and sub-clinical effects that are likely to occur ?

The signs and symptoms are all non-specific and comprise the following - fatigue, lassitude, weight loss, lack of appetite, headaches, abdominal pain,

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stiffness of joints, nausea and diarrhoea or constipation Any of these signs and symptoms could, however, indicate excessive lead absorption and should be carefully considered when they appear in lead workers

The symptoms may indicate that lead absorption has begun to interfere with both the blood-making and nervous systems The biological effects which may result from the increased absorption of lead and consequent interference with haem synthesis and disturbance of haemoglobin formation at different blood lead levels include the following

- decreased activity of ALA dehydratase (ALA-D),
- increased ALA in blood and urine,
- increased erythrocyte protoporphyrin (EP) and zinc protoporphyrin (ZPP),
- decreased content of haemoglobin in blood,
- increased number of reticulocytes,
- decreased number and shortened life-span of erythrocytes,
- increased number of erythrocytes showing punctate basophilia

A fall in haemoglobin is common at levels of excessive lead absorption, but hypochromic anaemia is now rarely seen except where high blood/lead levels apply Blood changes result from interference with haem synthesis, reduction of the life-span of red cells and possibly haemolysis

Current and future standards

The clinical and sub-clinical effects occur at various different levels of lead absorption What has presented the most difficult problem to health and medical authorities throughout the world is the setting of a practical attainable standard that will protect the health of lead workers There are many schools of thought on what a safe level should be Obviously, the lower the better, but we could reach a ridiculous situation akin to driving at 20 km h^{-1} in a 50 km h^{-1} zone — probably safer, but consuming far greater quantities of petrol and time, both expensive commodities we can ill afford to waste

The standards set by the U S Occupational Health and Safety Agency (OSHA), for example, would be extremely costly to implement and in some cases virtually impossible to attain with our current technology The practicality and cost of these standards to the U S economy has been recognised by the Reagan Administration whose stated intention is to relax their stringency to a sensible, attainable level

Symptoms and signs of lead absorption rarely appear until the blood/lead level exceeds 80 µg/100 ml whole blood or 160 µg/100 ml red blood cells (RBC) Whilst this could be considered to be a "safe" level, really and truly it is on the *very top limit* and, in fact, a few employees could show clinical signs of lead absorption at this level This level used to be the mandatory suspension level in New Zealand, but in March 1986 it was reduced to 145 RBC in cognizance of the foregoing to prevent the possibility of the susceptible top 10% of the workforce displaying overt symptoms

The trend worldwide is to reduce the suspension level to what is considered to be universally acceptable to safeguard all individuals, regardless of each person's susceptibility to lead absorption What is more important though is the introduction of an "action" level where a worker's condition is evaluated to prevent further absorption (see later in New Zealand context)

The other standard that is of importance is the lead-in-air threshold limit value This has been set to ensure a safe working environment for an employee, and is generally internationally recognised as being 0 15 mg m^{-3} of air based on 40 h per week exposure time This level was reduced in New Zealand in March 1986 to 0 1 mg m^{-3} to coincide with the reduction in the lead/blood suspension level. It is difficult to draw conclusions from employees blood/lead levels to the lead-in-air concentrations to which they have been exposed, but it is an effective management tool that is used to determine various zones in the workplace which need extraction upgrading or change of work methods to produce a safe working environment. It is invaluable in determining the type of personal protective equipment that has to be used by the worker in various areas known to contain lead hazards to a greater or lesser degree. Once again the international trend is towards lowering the threshold limit value. However, in the authors' opinion, the resulting massive capital outlay and greatly increased running costs, which of course are ultimately passed on to the customer, cannot be justified for the very marginal improvement which would be likely to be achieved

Lead absorption and its prevention

So far, this paper has covered the historical background of lead in industry, the symptoms of excessive lead absorption, and the standards being used for its control Now, two most important questions must be addressed. (i) how is lead absorbed into the body, and (ii) how is its absorption prevented ?

Inorganic lead is absorbed into the body in only two ways· either by inhalation or by ingestion. Lead that is inhaled is in the form of lead fume or particles of lead dust of aerosol size or perhaps a little larger. Larger particles of lead dust on being inhaled are probably trapped in the nasal passages and mouth and in all likelihood are swallowed and end up in the digestive tract. The fume- and aerosol-sized dusts, however, find their way into the lungs where at least 40% are dissolved and absorbed directly into the bloodstream or into the lymphatic system. The pH factor of the lungs' fluids is conducive to dissolving lead and lead compounds once they are inhaled. Fortunately, because of the very small size of the particles that do get into the lungs, the actual amount of lead absorbed in this way is probably small — unfortunately it only requires a small amount before the body burden of lead begins to increase faster than it can be excreted.

Smoking must be considered as a significant contributing factor to lead inhalation. The temperature of a burning cigarette is sufficient to cause lead fume. Therefore, any particles of lead dust that may have been transferred from contaminated hands or clothing to the cigarette are transformed into fume and, of course, inhaled directly into the lungs and straight into the bloodstream.

Lead that is ingested comes either from larger particles of dust that have been trapped in the mouth or nasal passages and are eventually swallowed, or from eating foodstuffs or drinking liquids that have been contaminated with lead dust, probably from dirty hands or clothing. Lead which has got into the digestive tract is likely to consist of much larger particles than those that get into the lungs and there are likely to be considerably more of them. Fortunately, the fluid in the digestive tract is not very efficient at dissolving lead and its compounds and only about 10% of total input is absorbed into the body. Unfortunately, it is 10% of a large number of large lumps and probably accounts for the majority of the body burden of lead.

How is the absorption of lead prevented? Very easily — it is either removed, or a barrier is imposed between the metal and the nose and the mouth. A very simple answer to give, but an extremely difficult situation to achieve. The best method of preventing lead contamination is to enclose it completely or have it in a form that is unlikely to give rise to dust. Enclosure is an accepted and widely used method, as is the wetting of floors to prevent dust, but these procedures can only be used during certain stages of manufacture, and certain assembly stages can only be done when the lead is in a dry and dusty form. The handling of this material therefore has to take place under extraction. The normal method is partly to enclose the work bench and then exhaust the air either downwards or sideways from the working area. This causes an air flow around the worker and his/her hands, it is generally accepted that the air flow speed should not be less than 1 m s^{-1}.

Extraction prevents lead dust from entering the general working environment, but it does not prevent the workers' hands and clothing from being contaminated, and it is the easiest thing in the world for lead dust to be transferred to the hair, the mouth and the nose by the unthinking worker automatically touching parts of the face, etc. As soon as that happens, the dust is in the system — either the lungs or the digestive tract. To prevent this, the worker is protected by providing disposable toxic masks and hair coverings. The masks, of course, not only filter out any lead that may be present in the atmosphere, but masks and lead caps also act as a physical barrier between lead-contaminated hands or clothes and the mouth, nose or hair.

To recapitulate: the battery worker is in the workplace, the workplace is made as lead-free as possible by following accepted practices and by extracting dust if, and where, it is likely to arise, the worker is further protected by a mask and clothing that impose a physical barrier between the lead and the mouth or the nose. But what happens when the worker leaves the workplace ? Firstly, the mask and contaminated clothing have to be removed, and then lead dusts from the body Normally, the latter is only likely to be on hands and arms so a thorough scrub with hot soapy water and a nail brush is sufficient for tea and meal breaks, whilst a shower is mandatory at the end of the day — emphasis being placed on thoroughly washing the hair

Thorough washing is the hardest of all to discipline. Because it doesn't physically hurt, the toxic dangers of lead dust have to be continually hammered home to the workforce. The necessity for the highest standards of personal hygiene has to be continually stressed, and what is more, regular policing by chargehands or supervisors must be carried out to ensure that individual workers are washing and showering as required. No programme of lead-absorption prevention will ever be successful without training, counselling, and the strict enforcement of the standards of personal hygiene

There remains but one other thing to safeguard a worker's health. That is, of course, biological monitoring to ascertain the degree of lead absorption, so that corrective action can be taken if this becomes excessive This is done by measuring the lead in the red blood cells (RBC) and can be expressed as μmol per litre RBC or μg per 100 ml RBC. Workers in the authors' factory are tested each month and their blood/leads recorded. If the latter are beginning to approach the danger level, then the frequency of tests is increased to weekly and, of course, corrective action such as counselling and job placement to a less hazardous area is instigated.

Lucas Industries (NZ) Ltd have recently completed a programme designed to protect not only the worker but also his/her family. This was formulated by the Company Doctor with the full backing of management and unions, and carried out by the Company Occupational Health Nurse The programme included measurement of the blood/lead levels of each worker's spouse and children Of course, permission was obtained from the worker and priority was given to those families where the husband had had high blood/lead levels, but was subsequently extended to the total workforce. This certainly emphasised the importance of being scrupulously clean and therefore not contaminating the family.

What about the costs involved in health programmes? The capital expenditure to provide extraction and dust collecting equipment, the running costs to power these, provide protective clothing and masks, to launder them, to wet floors, to achieve a satisfactory standard of environmental cleanlinesss, to train the workforce and supervise personal hygiene, and last, but not least, to provide medical and laboratory facilities and personnel to carry out biological and environmental monitoring becomes massive — not only in monetary terms, but also in time and labour. Nevertheless, it is of paramount importance that the dangers of lead are continually brought to the attention of both the management and the worker