Occupational Safety and Health Information Series

GUIDELINES FOR THE MEDICAL SURVEILLANCE OF LEAD WORKERS

OSH
OCCUPATIONAL SAFETY & HEALTH SERVICE

DEPARTMENT OF LABOUR
TE TARI MAHI

Guidelines for the Medical Surveillance of Lead Workers was prepared by Errol Hodgkinson, Occupational Health Scientist and Professor Bill Glass, Occupational Physician.

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Summary and Glossary of Terms

Units: In referring to blood levels, the expression micromoles/litre of whole blood (abbreviated to µ mol/litre whole blood) is used throughout this document. The section headed "Units for Reporting Blood Lead Results" discusses the relationship between the various units that may be encountered.

Departmental medical practitioner: Means a person for the time being appointed under section 34 (1) of the Health and Safety in Employment Act 1992.

Blood protoporphyrin levels: Two biochemical tests that measure the effect of lead on the blood-forming system, zinc protoporphyrin (ZPP) and free erythrocyte protoporphyrin (FEP), may be used to indirectly estimate exposure to lead.

Notifcation: Blood lead results 2.6µmol/litre whole blood or above should be notified to the Occupational Safety and Health Service of the Department of Labour.

Scope: The overall objective is to ensure that the blood lead level of all workers is maintained below 1.5µmol/litre whole blood. All workers employed in a process where they may experience a blood lead level in excess of 1.5µmol/litre whole blood are to be under regular surveillance until it can be demonstrated that excessive exposure is unlikely to occur.

Suspension levels: A worker will normally be suspended by the departmental medical practitioner where:

a single blood lead result is 3.2pmol/litre whole blood or greater; or

three consecutive monthly estimations are 2.6µmol/litre whole blood or above.

Introduction

Section 10 of the Health and Safety in Employment Act 1992 places duties on employers to minimise exposure to significant hazards, provide protective equipment and to monitor the employees' exposure to hazard. These guidelines, prepared by the Occupational Safety and Health Service of the Department of Labour, provide parameters that can be used to evaluate exposure and the extent of the control required.

Health Effects

Lead can be absorbed into the body by inhalation (breathing) and ingestion (eating). Airborne lead dust and fumes must be controlled but it is also important to ensure that those working with lead observe good personal hygiene. Even very small amounts of lead inadvertently ingested with food, drink, cigarettes or from biting fingernails can increase the lead absorption.

Lead is a cumulative poison in that it is only slowly released from the body. Absorbed lead is distributed throughout the body. The central nervous system (brain) is the most sensitive critical organ, while the bone tissue is the storage organ where 90% of the body burden is found.

Symptoms of Lead Toxicity

Symptoms of lead poisoning involving the nervous system can include:

- Mood changes, such as depression or irritability;
- Memory impairment;
- Sleep disturbance;
- Concentration difficulties;
- Headaches;
- Tingling and numbness in fingers and hands
- Muscle weakness and wrist drop; and, very rarely
- Fits.

Symptoms of lead poisoning involving the stomach and intestine can include:

- Lack of appetite;
- Nausea;
- Diarrhoea;
- Constipation;
- Stomach pains; and
- Weight loss.

Other effects may include:

- Kidney damage and blood pressure;
- Decrease in numbers and quality of sperm; and
- A tendency to abortion.

The general state of a person's health may influence the severity of the action lead has on the body. Absorbed lead may be mobilised during health upsets such as infections, 'flu' or excessive alcohol consumption.

Estimating Lead Exposure

It is generally accepted that the level of lead in blood is a measure of the amount of lead recently absorbed and therefore an indicator of recent exposure. This is particularly true where occupational exposure is constant. In times of changing intensity of exposure it is less so. For example, in a situation where the body burden of lead is high and exposure is suddenly decreased, the body burden will have a greater influence on the blood lead value than the current exposure level.

Biological monitoring using blood lead estimations has become accepted as a useful measure in assessing the likely effects on health. It also provides an indirect measure of exposure. Complete reliance should not be placed on biological monitoring.

- Workers should also have regular health assessments.
- Lead in air determination should be used as the primary means of evaluating airborne lead exposure occurring in the workplace.

Other biological tests, such as zinc protoporphyrin (ZPP) or free erythrocyte protoporphyrin (FEP) estimations, may be used to assess lead uptake. These levels rise more slowly than blood lead levels and remain elevated longer. As blood protoporphyrin tests reflect the level of lead that has been absorbed in the last 3 to 4 months, they are a better indicator of body burden.

Scope

As discussed previously, lead may exert a number of effects on the body. These effects take place over a range of absorbed lead levels. This, and the fact that the response is not the same for all individuals, complicates the setting of a "safe" level of exposure. In the past, recommended maximum levels of exposure were designed to protect workers from overt outcomes such as colic. It has been accepted in recent years that neurological effects occur at relatively low exposure levels. A blood lead level less than 1.5µmol/litre whole blood is necessary to ensure that reasonable protection against neurological effects is maintained. This will not be protective against interference with the blood forming system.

It is noted that a blood lead level of 1.5µmol/litre whole blood is consistent with an average lead in air exposure over a 40-hour week of approximately 0.05µg/m^3.

Where a significant hazard has not been eliminated and isolation is not practicable, section 10(2)(c) of the Health and Safety in Employment Act requires employers to monitor employees' exposure to the hazard. Because we are all exposed to lead to some extent, it is necessary to define the level of lead exposure that is of health concern. As discussed above, it is desirable to avoid blood levels in excess of 1.5µmol/litre whole blood. This is the target level for all industries where exposure to lead may occur.

All workers employed in a process where they may experience a blood lead level in excess of 1.5µmol/litre whole blood are to be under regular surveillance until it can be demonstrated that excessive exposure is unlikely to occur.

Lead exposure resulting in elevated blood lead levels may occur in the following processes:

- Lead battery manufacture
- Lead smelting
- Nonferrous smelting and casting (e.g. brass)
- Radiator repair
- Car exhaust repair
- Smelting steel scrap
- Scrap metal handling
- Cutting/welding steel scrap
- Machining or polishing lead-containing alloys
- Engine reconditioning
- Plastic production (where lead compounds are used as stabilisers)
- Demolition
- Lead soldering
- Plastic recycling
- Panel beating
- Paint removal
- Leadlight window manufacture
- Lead casting, e.g. fishing weights, toy soldiers
- Shooting range.

Organic lead

Tetra alkyl leads are used as antiknock additives in petrol. Significant exposure to the compounds is unlikely to occur with exposure to petrol. In the combustion engine organic lead is transformed into inorganic lead and is the source of lead exposure among muffler welders and engine reconditioners.

Exposure to organic lead may be monitored with urinary lead tests as blood levels are not a reliable indicator of exposure.

Surveillance

Sections 36 and 37 of the Health and Safety in Employment Act give wide ranging powers allowing the departmental medical practitioner to require tests and to suspend workers. The minimum requirements for medical surveillance that follow do not limit these provisions.

Employers are to ensure that medical surveillance is extended to all workers involved in the above processes and other processes that may result in blood lead levels above 1.5pmol/litre whole blood. The surveillance would normally be provided by an occupational health nurse or a general practitioner with a qualification in occupational medicine, employed by or contracted to the employer.

The service providing the medical surveillance should work closely with the employer to ensure that lead exposure is minimised. The extent of input will vary with the severity of exposure that is actually occurring. In instances where it can be confirmed that the measures taken to limit lead exposure have been successful, i.e. where blood lead levels are not excessive and clinical symptoms of lead poisoning are absent, frequent blood lead testing may not be appropriate.

It is not sensible to prescribe a procedure to be applied in all situations as professional judgement is required. However, the following framework is suggested:

New Employees

Before a person begins work, a medical examination is to be performed and a baseline blood lead level taken. The frequency of further blood lead tests should be set to allow for the early detection of potentially harmful absorption and for action to be taken to reduce exposure. Where it is anticipated that the risk is high, blood lead tests should be repeated monthly until it is shown that a stable blood lead level has been reached. Where the stabilised blood lead level is considerably below 1.51lmol/litre whole blood, and uptake is unlikely to change, regular blood lead monitoring need not continue. This does not remove the responsibility of the employer to maintain steps to minimise employees' exposure to lead.

Existing Employees

The frequency of medical examination and blood lead testing should be designed to have the maximum impact in ensuring that lead uptake is reduced to the lowest practicable level. Where there is a likelihood of an increase in uptake, it is recommended that blood tests be conducted monthly until the blood lead has stabilised.

Female Workers

To safeguard the foetus from the harmful effects of lead, it is unwise for a female who could possibly become pregnant to work with lead. Harmful effects to the foetus may occur at very low blood lead levels and it is recommended that where a female does work in a job where excessive exposure is possible a blood lead level below 1.5pmol/litre whole blood be maintained.

Notification

The employer should ensure that all blood lead results 2.6,umol/litre whole blood or above are notified to the Occupational Safety and Health Service of the Department of Labour. The information outlined in the appendix should be addressed to the local branch office (see list of OSH branch offices at the end of these guidelines).

Suspension

Departmental medical practitioners will normally suspend a worker or require them to be transferred to a job with minimal lead exposure where:

(a) A single blood lead result is 3.2µmol/litre whole blood or greater; or

(b) Three consecutive blood lead results are 2.6µmol/litre whole blood or above.

In deciding if suspension is necessary, the departmental medical practitioner will consider the history of the worker's exposure to lead and clinical signs and symptoms.

Following suspension, the frequency of retesting that is appropriate also depends on the history of the worker's exposure to lead, but it is not recommended that blood samples be taken more often than every two weeks.

Blood Lead Tests—Collection, Analysis and Quality Assurance

The blood lead assay requires a venous blood sample collected in an evacuated tube suitable for trace metal analysis. To ensure that a reliable result is obtained, care must be taken to avoid contaminating the sample at collection and delays in storage and transport. It is important to see that the procedures specified by the analysing laboratory are adhered to.

Blood lead determinations are to be performed by competent persons using suitable collection and analytical methods. It is recommended that only laboratories that have TELARC registration for blood lead analyses be engaged. Laboratories conducting tests must be able to demonstrate adequate performance in a recognised quality assurance programme for blood lead assays.

For blood lead tests the methods detailed in the Australian Standards, AS 4090:1993 *Whole blood—Determination of lead content—Graphite furnace atomic absorption spectrometric method* or AS 2411:1993 *Venous blood—Determination of lead content—Flame atomic absorption method* are recommended. Other procedures are acceptable providing they have equivalent accuracy and precision.

Suitable external quality assurance programmes are provided by:

UKNEQAS for General Clinical Chemistry
Clinical Chemistry Department
Queen Elizabeth Hospital
Birmingham B152TH
UNITED KINGDOM
Fax: 021 414 1179

Robens Institute of Health and Safety
University of Surrey
Guildford GU 5XH
UNITED KINGDOM
Fax: 483 503517

Distribution of Blood Lead Results

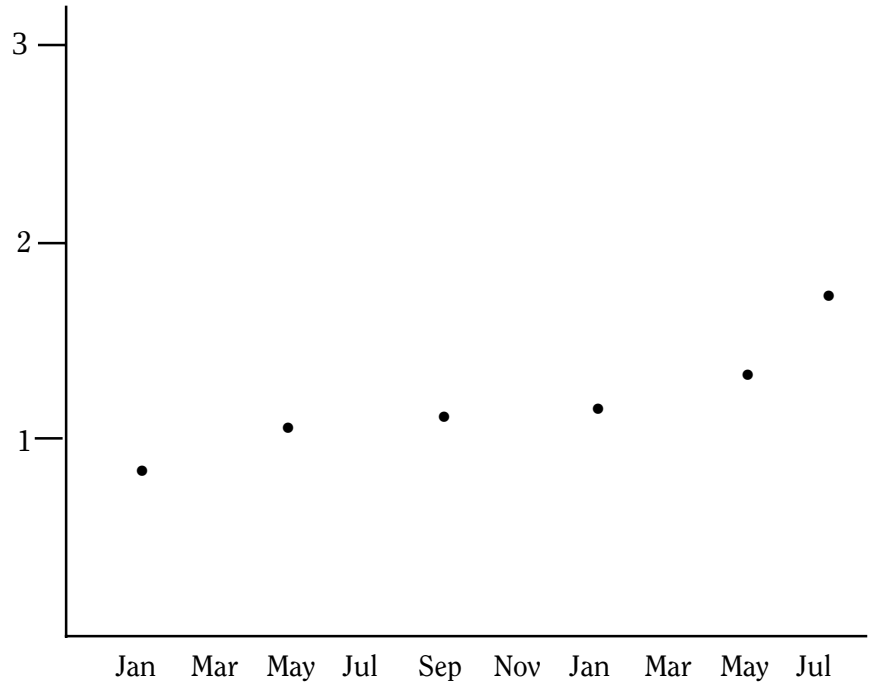
Personal blood lead results are to be given to the employee. Employees may also request other monitoring results relating to the workplace providing all information about other employees is omitted (section 11 of the Health and Safety in Employment Act 1992).

To effectively manage the control of lead in the workplace, the employer must have access to all monitoring results. It is strongly recommended that informed consent for release of biological sampling results be gained from the employee at the time the sample is taken or at the time of employment.

Recording Blood Lead Levels

Section 10(2)(c) of the Health and Safety in Employment Act 1992 requires the employer to monitor the employees' exposure to the hazard (lead). Assuming consent has been obtained for the release of blood lead results, it is recommended that charts are used to plot blood lead results for each employee. This allows for trends to be easily recognised and timely intervention made. Plotting the mean of the blood lead results in each section of the plant may assist in recognising trends.

An example of a plot of an individual's result is given in the following diagram:



Example showing the trend in blood lead levels for an individual worker

Units for Reporting Blood Lead Results

In New Zealand it has been the practice to report **blood lead results in the** units micromoles lead per litre red cells (µ mol/litre red cells). This contrasts with the approach that has generally been taken overseas, where blood lead results have been expressed as the amount of lead present in the whole bloo~ (either µmol/litre whole blood or µg/lOOml whole blood). Various arguments have been put forward in support of each of these approaches. Without looking in depth at either argument the following is of interest:

- Virtually all of the lead present in blood is found in the red cells.
- Laboratory tests are carried out on a whole blood sample.
- A haematocrit is taken on the blood that is used to convert the whole blood result to a red cell result.
- The plasma lead represents the mobile lead—this cannot be reliably measured.

Considering that there is no "correct" way to express the results, OSH recommends that the following be recorded:

- Whole blood level
- Packed cell volume

and that the units µ mol/litre be used to express the whole blood result.

This allows for the results to be converted to any other units, i.e:

1. To convert a red cell level to a whole blood level:

Whole blood level = red cell level x packed cell volume/100

If the red cell result is 3.3µmol/litre and the packed cell volume is 45%

$$\text{Whole blood level} = 3.3 \times \frac{45}{100}$$

= 1.5µmol/litre whole blood

2. To convert from µ mol/litre to µg/lOOml the atomic weight of lead (207.2 is used.

If the result was 1.5µmol/litre whole blood, the level in µ g is given by:

1.5 x 207.21 µ g/litre whole blood

=311

= 31 µg/lOOml whole blood

Medical Evaluations

Medical evaluations should consist of a full physical examination, a clinical history and an occupational history.
The physical examination should give attention to the following bodily systems:

- Cardiovascular, including blood pressure;
- Renal;
- Neurological;
- Gastrointestinal, including mouth and gums;
- Haematologic; and
- Respiratory.

The clinical history should take specific regard of lead-related symptoms. The occupational history should record in detail the worker's lead exposure with respect to both length of time and the level of exposure.

It is suggested that the following list be used in gathering the history of lead-related symptoms:

- Low energy
- Loss of appetite
- Stomach pains or cramps
- Constipation
- Metallic taste in mouth
- Depression or feeling low
- Irritability
- Trouble with concentrating
- Trouble with memory
- Personality change
- Headache
- Tingling or numbness in arms or legs
- Shakiness of the hands
- Weakness in arms or legs
- Muscle or joint pains
- Loss of interest in sex.

APPENDIX: Elevated Blood Lead Notification

Employer .....

Address .....
.....

Medical practitioner .....

Name of employee .....

Total hours worked per week .....

History of lead-related work over last 5 years .....
.....
.....
.....
.....
.....
.....
.....
.....
.....

Age .....

Description of process presently engaged in .....
.....
.....
.....

Recent blood lead results

Date __ /__/__

Result (µumol/litre whole blood)
.....
.....
.....

Other biological monitoring results (e.g. ZPP FEP)
Date __ /__/__ Result

Notified by .....
.....
.....

Signed ..... Date __ /__/__