Guidelines for the Medical Surveillance of Lead Workers

SECOND EDITION

The Department of Labour has made every effort to ensure that the information contained in this publication is reliable, but makes no guarantee of its accuracy or completeness and does not accept any liability for any errors. The Department may change the contents of this publication at any time without notice.

© Crown Copyright 2011

This material is Crown copyright unless otherwise stated and may be reproduced free of change without requiring specific permission. This is subject to it being reproduced accurately and not being used in a derogatory manner or in a misleading context. The source and copyright status must be acknowledged. The permission to reproduce Crown copyright-protected material does not extend to any material in this report that is identified as being the copyright of a third party.

Published by the Department of Labour
PO Box 3705
Wellington 6011
New Zealand
Website www.dol.govt.nz

Issued March 1994

Revised: August 2011
ISBN: 978-0-478-36026-4
# TABLE OF CONTENTS

## INTRODUCTION

How to use this guideline ................................................................. 6

## SECTION 1: INFORMATION FOR THE WORKPLACE

1.1 Why is lead exposure monitoring needed? ........................................ 8
1.2 Responsibilities for employers ....................................................... 8
1.3 Rights and responsibilities for employees ....................................... 8
1.4 Industries where exposure to lead may occur ................................... 9
1.5 Health effects of lead ...................................................................... 9
1.6 Symptoms of lead poisoning ........................................................... 10
1.7 Objective of lead health monitoring ................................................. 10
1.8 Medical surveillance ...................................................................... 11
1.9 Informed consent and the rights of workers ...................................... 12
1.10 Notification of high blood lead levels ............................................. 15
1.11 Suspension from work .................................................................. 15
1.12 Distribution of blood lead results .................................................. 16
1.13 Recording blood lead levels ............................................................ 16

## SECTION 2: INFORMATION FOR MEDICAL PROFESSIONALS

2.1 Estimating lead exposure ................................................................. 20
2.2 Blood lead tests – collection, analysis and quality assurance ............ 20
2.3 Units for reporting blood lead results .............................................. 21
2.4 Medical evaluations ...................................................................... 22
2.5 Adverse effects of lead exposure (detailed) ....................................... 22

## APPENDIX 1

GLOSSARY OF TERMS ......................................................................... 26

## APPENDIX 2

RELATED RESOURCES ......................................................................... 29

## APPENDIX 3

REFERENCES ......................................................................................... 30
INTRODUCTION

The second edition of this guideline has been developed by the Department of Labour. It updates and replaces the first edition and has been prompted by the Department of Labour's revised lead in blood suspension level which came into effect in September 2010.

Some facts about lead

Lead (chemical symbol Pb, atomic number 82) is a dense, soft bluish-white metal. It is resistant to corrosion, but it does not conduct electricity efficiently. It has been used for thousands of years, and was mined commercially in ancient Roman times, where it was used to manufacture water pipes.

Today, the use of lead is widespread, including in some industrial processes that were not available centuries ago. One of the major sources of lead exposure in the 20th century came from leaded petrol, which caused environmental contamination from inorganic lead compounds in motor vehicle exhausts.

However, advances in science and technology have eliminated the need for lead to be present in this vital fuel. The use of leaded solder in tin food cans, another significant source of lead absorption, is also a thing of the past.

As useful as lead is, it is a toxic substance, and capable of seriously harming the body’s central nervous system. Back in the days of the Roman Empire, an organic lead compound (lead (II) acetate) was used to sweeten wine. It is now considered by some historians to have been the main cause of dementia in several Roman Emperors1.

With our increased knowledge of the hazards of lead exposure comes increased responsibility for identifying hazardous lead processes, and taking all practicable steps to eliminate, isolate or minimise these hazards.

Why was the suspension level for lead changed?

The suspension level for lead was lowered in 2010 because current research shows that adverse health effects from lead can occur at concentrations lower than previously thought.

Legal requirements

Section 10 of the Health and Safety in Employment Act 1992 (the Act), requires employers to minimise exposure to significant hazards in workplaces. For employees working with lead, any minimisation of hazardous substances should include reducing exposure through:

• extraction ventilation,
• providing protective equipment where necessary, and
• monitoring employees’ exposure to lead hazards.

How to use this guideline

This guideline provides information for employers and occupational physicians about health monitoring, or medical surveillance, of lead workers as required by sections 10 and 11 of the Act.

These guidelines have been designed to provide information for a range of people with responsibilities in workplace monitoring for lead.

Section 1: for employers, employees, unions and other people in the workplace.

This section will cover:
• employer responsibilities surrounding the medical surveillance of lead;
• employee rights and responsibilities;
• lead-process industries;
• lead poisoning symptoms;
• objective of health monitoring;
• medical surveillance;
• informed consent and workers’ rights;
• blood result notification;
• suspension from work; and
• distributing test results.

Section 2: for occupational physicians and other occupational health personnel.

This section will cover:
• estimating blood exposure;
• blood lead assays;
• units for reporting results;
• medical evaluations; and
• detailed information on the adverse effects of lead exposure.

Note: this guideline does not provide information about the occupational health and safety aspects of working in lead processes or with lead-containing products.
Section 1: Information for the Workplace
SECTION 1: INFORMATION FOR THE WORKPLACE

1.1 Why is lead exposure monitoring needed?

Historically, the medical surveillance of lead workers was a legal requirement under the Lead Process Regulations 1950.

Today, medical surveillance is considered to be a “practicable step” under the Health and Safety in Employment Act 1992 (the Act), because the effect that certain workplace contaminants like lead has on exposed workers can only be accurately identified through medical examination or testing. Section 1.6 shows that many of the physical symptoms of lead poisoning can look like other ailments that may not be as serious, such as experiencing headaches or feeling sick.

1.2 Responsibilities for employers

Employers are required under the Act to take all practicable steps to provide a safe workplace. One of the ways this is done is to ensure that all significant workplace hazards are identified, assessed, and controlled (eliminated or isolated) so that they do not harm workers.

If that is not practicable, employees should put measures in place to minimise the harm that could occur to workers who may be exposed to the hazard.

If a hazard like lead is minimised, the Act also requires employers to monitor employees’ exposure to lead, and with their informed consent, to monitor their health.

If an employee’s blood lead levels record 2.4 µmol/litre and the employee is suspended from work, the employer is required to notify the Department of Labour of an occurrence of serious harm. See section 1.10 for further information.

1.3 Rights and responsibilities for employees

Employees are required to take all practicable steps to ensure their safety and that of others in the workplace. This includes both the things they do and the things they omit to do (such as not using protective clothing or equipment).

Employers should make clear to employees their responsibilities to use the provided safety equipment and to wear protective clothing. The expected level of an individual employee’s responsibility will usually increase with knowledge and seniority, but the employer’s overall responsibility to ensure a safe workplace remains.

Employees’ health and safety rights

Employees are entitled to:
- receive, for no charge, the necessary protective clothing and equipment necessary to safely do their job;
- wear their own suitable protective clothing if they wish to provide it;
• receive the results of any monitoring conducted by the employer relevant to them or their workplace; and
• receive reasonable opportunities to participate in workplace health and safety.

1.4 Industries where exposure to lead may occur

The following industries are likely to have lead processes that could generate elevated blood levels:
• lead–acid battery manufacture
• lead smelting
• non-ferrous smelting and casting (e.g. brass)
• steel scrap smelting
• scrap lead metal handling
• cutting/welding steel scrap
• machining or polishing lead-containing alloys
• plastic production (where lead compounds are used as stabilisers)
• demolition
• lead soldering
• plastic recycling
• panel beating
• paint removal
• sandblasting
• leadlight window manufacture
• lead casting, e.g. fishing weights, toy soldiers
• radiator repair, car exhaust repair and engine reconditioning (for older makes and models of vehicles)
• jewellery (silver) production
• shooting ranges (bullets).

1.5 Health effects of lead

Lead is known as a cumulative poison. This means that it builds up in the body, and it takes some time for the substance to be excreted.

Absorbed lead is distributed to almost all regions of the body; therefore it is a substance that is capable of causing different types of harm. The brain is the most sensitive to lead poisoning, while approximately 90% of absorbed lead is stored in bone tissue.

1.5.1 How is lead absorbed into the body?

Lead is mainly absorbed in two ways:
• inhalation (for example, breathing in lead dust or fumes); or by
• ingestion (for example, eating products containing lead, or eating food, smoking cigarettes or biting fingernails after working with lead).

While it is important to control airborne lead dust and fumes, it is also important to make sure that people working with lead have good personal hygiene habits. Even very small amounts of lead accidentally ingested with food or drink, smoking cigarettes or biting fingernails can increase a person’s lead uptake.
1.6 Symptoms of lead poisoning

Symptoms of lead poisoning can include:

A person’s health can also influence the severity of the action lead has on the body. Absorbed lead may be accumulated during health upsets such as infections, the flu or excessive alcohol consumption.

1.7 Objective of lead health monitoring

Health monitoring for lead is needed to make sure that the blood lead levels of all lead-exposed workers are kept below 1.5µmol/litre whole blood (micromoles of lead per litre of whole blood).
All employees working in lead processes where their blood levels could exceed 1.93µmol/litre whole blood must be regularly monitored until their lead blood levels drop below this figure.

Workers with blood lead levels at 2.4µmol/litre whole blood or above will be suspended from work. When their blood lead levels reach 1.93µmol/litre, they can return to work.

1.7.2 What is a safe level of lead exposure?

Lead has a number of effects on the body. These effects take place over a range of absorbed lead levels. People also react differently to varying amounts of lead intake, which is why it is difficult to set a “safe” level of exposure.

Years ago, the “maximum” set level of lead exposure was designed to prevent workers from getting colic or other similar health problems. Today, doctors accept that the neurological effects of lead can occur at lower exposure levels. This is especially the case for foetuses, which is why it is important to have appropriate exposure levels for women of child-bearing age, particularly women who are pregnant, lactating or breastfeeding. See Section 1.8.4 for further information.

For adults in general, maximum blood lead levels of 1.5µmol/litre whole blood are necessary to make sure that workers are not susceptible to lead-related neurological harm.

1.5µmol/litre whole blood is about the same as an average lead-in-air workplace exposure, over a 40-hour work week, of approximately 0.05mg/m³.

1.8 Medical surveillance

1.8.1 Departmental medical practitioners

Sections 36 and 37 of the Act give powers to Department of Labour medical practitioners (DMPs), including requiring an employee to be examined and, if necessary, to suspend an employee from work.

1.8.2 Employers’ responsibilities

Employers must ensure that medical surveillance is provided to all workers involved in lead work. This is normally provided by a health service provider such as an occupational health nurse or a general practitioner with a qualification in occupational medicine, usually employed by or contracted to the employer.

1.8.3 Health service providers

The health service providing the medical surveillance should work closely with the employer, employees, health and safety representatives and union (if applicable) to ensure that lead exposure in the workplace is controlled to the maximum extent possible.
The extent of the health service provider’s input will depend on the severity of exposure. If measures taken to control lead exposure are successful, i.e. where employee blood lead levels are not excessive and clinical symptoms of lead poisoning are absent, less frequent surveillance and blood lead testing may be suitable.

1.8.4 Suggested testing framework

Professional judgement is required to set up a testing procedure that can be applied in all work situations. However, as a general guide, the following testing framework is suggested:

**New employees**

Before a new employee begins lead-process work for an employer, the employee should have a medical examination, and have a baseline blood lead level taken. Follow-up blood tests should be set for new employees at intervals that allow the early detection of high lead absorption, so that action can be quickly taken to reduce exposure.

If the new worker’s risk of exposure to lead is high, blood lead tests should be repeated monthly until a stable blood lead level has been reached. If the stabilised blood lead level is below 1.5µmol/litre whole blood, and lead uptake is unlikely to change, blood lead monitoring at this frequency may not be necessary. However, this does not remove the employer’s responsibility to still take steps to minimise the employee’s exposure to lead.

**Existing employees**

The number of medical examinations and blood lead testing for existing employees should be designed to ensure that employee lead uptake is reduced as must as possible.

If there is a possibility of an increase in lead uptake, blood tests should be conducted monthly until the blood lead has stabilised to below 1.5µmol/litre whole blood.

**Female workers of child-bearing age**

These workers should be exposed to as little lead as possible. 1.5µmol/litre whole blood is not low enough for pregnant women or those planning to become pregnant, because a developing foetus is extremely susceptible to this substance. Ideally, these women should have no occupational exposure to lead at all.

Built-up lead can also be released from the mother’s bones during times of calcium stress such as pregnancy and lactation. Ideally, breastfeeding mothers should also avoid exposure to lead.

1.9 Informed consent and the rights of workers

Section 10(2)(d) of the Act requires the employer to take all practicable steps to obtain employee consent to monitor their health in relation to a significant hazard.
Where obtained, employee consent should ideally be informed consent.

1.9.1 What is informed consent?

Informed consent is:

- effective communication between the parties involved (employer, employees, union (where applicable), and medical service provider);
- providing the necessary information to the employees and union (where applicable); and
- the employee freely giving their consent to undergo the health monitoring.

This means that the employees must receive, as a minimum, the following information:

- how their health can be affected by exposure to lead (including risks for women who are or are planning to become pregnant, or breastfeeding);
- which work processes cause exposure to lead;
- why the tests are needed;
- frequency of testing;
- what the tests consist of;
- who will undertake the tests;
- who will pay for the tests;
- where will the test results go for analysis;
- what the test results are (for individual employees);
- who will have access to the test results;
- what will be done with the test results;
- what actions could occur if a test reveals a high blood lead result;
- what alternatives there are to blood testing (if applicable); and
- what the consequences are or could be if an employee does not consent to health monitoring.

It is recommended that an employee’s informed consent is obtained in writing.

Information about informed consent can be found in the Code of Health and Disability Services’ Consumers Rights, available from the Health and Disability Commissioner.

1.9.2 Issues surrounding “medical treatment”

Employees have the right to refuse medical treatment. This is outlined in the New Zealand Bill of Rights Act 1990. Whether blood lead level testing is “medical treatment” is subject to debate, because it is not defined under this Act.

However, in the workplace, if an employee involved in a lead process is considering the refusal of blood tests, they should be informed of the potential consequences before they make their final decision.

The consequences are likely to be different for every workplace, but could range from:

- removal from the process or processes where lead exposure is significant
• reduction of working hours;
• undertaking different forms of testing (note: these tests may not provide high-quality results);
• having tests conducted by the employee’s own doctor at their expense; or
• in extreme cases, if the employer cannot move a lead worker to a lead-free part of the workplace, suspension from work or eventual termination of employment.

These situations are known under the Employment Relations Act 2000 as an “employment relationship problem” that exists between the employer and the employee.

It is important that the correct procedure is followed when trying to resolve an employment relationship problem. For further information, visit the “Problem Solving” section of the Department of Labour’s website: http://www.ers.dol.govt.nz/problem, or seek independent advice.

1.9.3 Are there valid reasons for refusing blood tests?

The employer should consider that there may be reasons why employees might not want their blood to be tested. These could be for cultural or religious reasons, pre-existing medical conditions relating to their blood that requires special treatment, or even a phobia of blood or needles.

However, this does not mean that these employees should work in high-risk lead process areas without undertaking health monitoring. If there are no other ways to determine a lead-process worker’s health without a blood test, this might mean that the worker may not be able to work in lead-process occupations.
1.10 Notification of high blood lead levels

The employer should notify all blood lead results of 2.4µmol/litre whole blood or above to the Department of Labour. The information can be documented on a Notifiable Occupational Disease System (NODS) form, which is available from http://www.osh.dol.govt.nz/services/notification/nods.shtml.

Completed forms should be sent to the Department of Labour’s Head Office.

Alternatively, a high blood lead level resulting in an employee’s suspension from work can be notified as a serious harm occurrence.

The Department of Labour should be contacted as soon as possible after the event becomes known to the employer by phoning 0800 20 90 20.

The serious harm notification form should be completed and sent to the nearest regional office of the Department within seven days of initial notification. The form is available from http://www.osh.dol.govt.nz/services/notification/accident.shtml.

1.11 Suspension from work

DMPs will suspend a worker, or require them to be transferred to a job with little lead exposure if a single blood lead result is 2.4µmol/litre whole blood or greater.

If suspension is necessary, the DMP will take the history of the worker’s exposure to lead into account, along with clinical signs and symptoms.

If a worker is suspended, the frequency of retesting will depend on the history of the worker’s exposure to lead, but as a rule it is not recommended that blood samples be taken more often than every two weeks.

The suspended worker can return to work when follow-up tests indicate that the blood lead level has reduced to 1.93µmol/litre.

Ideally, worker blood tests should aim for results at 1.5µmol/litre whole blood or less.

2 In practice, the medical professional is likely to conduct the official notification, but the employer is responsible for ensuring that this is done.
1.12 Distribution of blood lead results

Personal blood lead results must be given to the employee concerned. Employees can also see other workplace monitoring results, as long as identifying information about other employees is removed.3

1.12.1 Informed consent for the release of medical information

To help manage the control of lead hazards in the workplace, the employer must have access to all monitoring results. To ensure employee permission, consent must be obtained for the information to be released to the employer.

It is recommended that informed consent for the release of biological test results is gained from the employee at the time the sample is taken, or at the time of employment.

1.13 Recording blood lead levels

The employer is required to monitor employees’ exposure to lead, where minimisation strategies are used to manage that hazard4. Assuming that consent has been obtained for the release of blood lead results (refer to section 1.12) it charts can be used to plot blood lead results for each employee. This allows for whole-of-workforce and/or individual worker trends to be easily recognised, and timely intervention made.

Plotting the averages of the blood lead results in each section of the workplace may assist in recognising trends or problems relating to a specific work area.

---

3 Required by section 11 of the Health and Safety in Employment Act 1992
4 Required by section 10(2)(c) of the Health and Safety in Employment Act 1992
1.13.1 Examples of lead result charts

Figure 2 is an example of a chart of an individual’s test results taken over 19 months. This graph should only be viewed by the employer, the employee and the health service provider.

![Example chart showing the trend in blood lead levels for an individual worker.](image-url)
Figure 3 is an example of a chart showing test results for a group of employees. There is no information identifying specific employees on this graph, which means that all relevant people can view it.

Figure 3: Example chart showing blood lead levels for five workers.
Section 2: Information for Medical Professionals
SECTION 2: INFORMATION FOR MEDICAL PROFESSIONALS

2.1 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 there is constant ongoing occupational exposure to lead.

In times of changing intensity of exposure, the relationship of lead in the blood to recent exposure is less quantifiable. 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 is a useful measure in assessing the likely effects on health. It also provides a more direct measure of an individual’s bodily uptake than measured air levels can.

Complete reliance should not be placed on biological monitoring, and it should be noted that:

- workers should also have regular health assessments; and
- lead-in-air determinations should also be used as a means of evaluating airborne lead exposure in the workplace at sources where lead is present.

Other biological tests such as zinc protoporphyrin (ZPP) or free erythrocyte protoporphyrin (FEP) estimations may be used to assess lead uptake. ZPP was previously considered to be the best test for screening asymptomatic children. However, it is not sufficiently sensitive at lower blood lead levels and therefore is not as useful a screening test for lead exposure as previously thought.

2.2 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 that the procedures specified by the analysing laboratory are adhered to.

Blood lead determinations should be performed by competent persons using suitable collection and analytical methods. It is recommended that laboratories that have the 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 AS4090:1993 – 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, provided that they have equivalent accuracy and precision.
2.3 Units for reporting blood lead results

Laboratory tests are carried out on a whole blood sample, but virtually all of the lead present in blood is found in red blood cells. Therefore, if a haematocrit (packed cell volume) measurement is taken on the blood, that measurement can be used to convert the whole blood result to a red cell result.

Most adverse effects of lead are described in relation to its whole blood level. The very small plasma lead component represents the most immediately mobilisable lead, although this cannot be reliably measured.

The Department of Labour recommends that the following be recorded:
- whole blood level
- packed cell volume

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

This allows for the results to be converted into 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 level result is 3.3µmol/litre and the packed cell volume is 45%:

   \[
   \text{Whole blood level} = \frac{3.3 \times \frac{45}{100}}{100} = 1.5\mu\text{mol/litre whole blood (rounded up from 1.485).}
   \]

2. **To convert from µmol/litre to µg/100ml:**

   The atomic weight of lead (of 207.2) is used.

   This indicates that for lead, 1 µmol/litre = 207.2 µg/litre (L).

   If the result is 1.5µmol/litre (whole blood), the level in µg/litre is given by:

   \[
   1.5 \times 207.2 \mu\text{g/L whole blood}
   = 311 \mu\text{g/L (whole blood) (rounded up from 310.8)}
   \]

   Divide result by 10

   \[
   = 31.1 \mu\text{g/100ml} \text{ (or } \sim 31 \mu\text{g/dL}; \text{ as one decilitre, dL = 100mL = 0.1L).}
   \]

   Therefore, in converting from µmol/L to µg/dL, a factor of (207.2/10) or \~20.7, is used.
2.4 Medical evaluations

Medical evaluations should consist of a full physical examination, a clinical history and an occupational history.

Physical examination should include attention to the following organ systems:
- neurological
- gastrointestinal (including mouth and gums)
- haematologic
- renal
- cardiovascular (especially blood pressure)
- respiratory.

Clinical history taking should take specific regard of potential 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.

2.5 Adverse effects of lead exposure (detailed)

2.5.1 Summary

The symptoms of lead exposure are often non-specific and the diagnosis may not be clear-cut. A key feature is the presence of multisystemic symptoms and signs. Chronic toxicity is more common, but acute symptoms can arise from high exposure to airborne lead, or ingestion.

Most lead exposures involve a mix of routes rather than inhalation alone. High airborne levels of small particulate such as fume can cause acute or sub-acute systemic poisoning with effects including:
- abdominal colic
- anaemia
- encephalopathy with headaches, tremors
- intractable seizures and coma (in severe cases).

Inadvertent ingestion due to poor hygiene with hand-to-mouth contact may contribute.

Metal fume fever has been described but appears uncommon with lead fume alone. Lead is not known to have any specific localised adverse effects on the respiratory tract. Dyspnoea may occur but respiratory function tests are typically normal.

2.5.2 Acute effects

Acute effects can occur after high respiratory exposures or ingestion of rapidly absorbable lead compounds. Effects can include:
- anorexia
- vomiting
- malaise
- headache and other symptoms of encephalopathy
- severe gastro-intestinal upset
- renal insufficiency.
Acute lead toxicity from short-term exposures is less common than symptoms from chronic exposure and presentation may be different.

Acute onset poisoning can occur in chronic exposures if exposure levels increase, or with de novo factors increasing lead absorption or mobilisation from bone.

2.5.3 Chronic effects

Symptoms can be non-specific. Lead toxicity may masquerade as a subtle neurasthenic condition. However, a key diagnostic feature is often the presence of multi-systemic signs and symptoms, albeit subtle. There can be dose-related dysfunction of the nervous, haematopoietic, gastro-intestinal, renal, endocrine and musculoskeletal systems. Gastro-intestinal and neurological effects are often less marked than with acute poisoning.

No symptom is invariable, but the most usual effects in adults include:
- abdominal pain
- fatigue
- arthralgia
- decreased libido
- headache
- irritability
- impotence
- depression
- anorexia
- muscle pain and/or weakness
- change in bowel habits
- weight loss
- paresthesia

Blood lead levels are an important, but not the sole, diagnostic consideration, given individual differences in susceptibility at any given blood level.

Neurological Effects

In adults, impaired performance in tests of short term memory, concentration, reaction time, mood, verbal concept formation and visuospatial functions may appear at blood levels at or over 40µg/dL to 50µg/dL, or between 30 to 60 µg/dL.

Irritability, sleep disturbance, fatigue, depression, loss of libido and headache may occur when levels generally exceed 40µg/dL. Tremor and vertigo may develop.

Peripheral neuropathy, characterised by muscle weakness with minimal sensory loss, is rare with blood leads below 60µg/dL, but subclinical abnormalities can occur with blood levels of 40 to 70µg/dL, or even down to 30µg/dL.

With heavy exposures, acute encephalopathy with vomiting, drowsiness, stupor, coma, and sometimes intractable seizures can develop rapidly. The onset and
course can be unpredictable, but severe encephalopathy is rare with blood levels under 100µg/dL.

With ALAD deficiency resulting in plumboporphyria (A rare disorder of porphyrin metabolism), clinical neurological effects may be seen at levels under 40µg/dL\(^\text{11}\). Minor hearing impairment has been reported when blood lead exceeds 70µg/dL\(^\text{12}\).

**Haematological Effects**

Anaemia may arise from inhibition of haeme synthesis in addition to shortened red cell life-span\(^\text{13}\). Biochemical indicators of decreased haeme synthesis occur before declines in haemoglobin level (which in turn commence at lead levels below those associated with frank anaemia\(^\text{14}\)), due to the high reserve capacity for haemoglobin production.

**Gastro-intestinal effects**

Symptoms include anorexia, abdominal pain (often crampy), nausea, vomiting, a change in bowel habits and weight loss. Symptoms may occasionally occur at blood levels as low as 40 to 60µg/dL\(^\text{15,16}\). A purple-blue “lead line” may occur in the gum margins due to an accumulation of lead sulphide\(^\text{17}\). There may be a metallic taste in the mouth\(^\text{18}\).

**Renal effects**

Depending on the extent of exposure, lead may induce glomerular impairment, tubular dysfunction, and, at a late stage, interstitial nephritis and fibrosis\(^\text{19}\). Long term exposure, especially when causing blood leads above 80µg/dL, presents an increased risk of chronic renal insufficiency, which sometimes progresses to renal failure, arising from interstitial and peritubular fibrosis\(^\text{20}\). Renal insufficiency can include decreased clearance of uric acid, with increased risk of gouty arthritis\(^\text{21,22}\) (“saturnine gout”) with similar features to primary gout.

**Cardiovascular effects**

Increases in individual blood pressure (and heart rate) have been linked to occupational lead exposure at peak blood lead levels of 48µg/dL and above\(^\text{23,24}\). Various cardiac rhythm abnormalities have been described, with acute (or chronic) poisoning. Congestive cardiomyopathy has also occasionally been described\(^\text{25}\).

**Fertility: Male Effects**

Decreased sperm counts and/or abnormal sperm morphology and motility have been variously noted at blood levels down to 40µg/dL\(^\text{26}\).

There is little data clarifying whether, and if so, to what extent such reductions in sperm quantity and quality adversely affect fertility.

There is inconsistent evidence regarding male-mediated foetal effects\(^\text{27}\). Some studies have reported increased risks of spontaneous abortion\(^\text{28}\) or reduced birth rates\(^\text{29}\) in wives of exposed lead workers, but others have not\(^\text{30}\).
**Fertility: Female effects**

Decreased female fertility has been noted, mainly in the context of relatively high, historical exposures\(^31\). A three-fold greater prevalence of sterility has been suggested\(^32\).

**Foetotoxicity**

Significant associations have been made between lead exposure and preterm birth, lower birth weight, reduced postnatal growth, increased incidence of minor congenital abnormalities and early deficits in postnatal neurological or neurobehavioural status\(^33\).

An increase in spontaneous abortion has been noted in both female lead workers\(^34\) and the partners of male lead workers, with most evidence related to heavy historic exposures.

There is no evidence that lead, particularly at relatively low levels, is associated with major congenital malformations\(^35\), although an association with minor anomalies has been asserted\(^36\).

**Endocrine effects**

Significantly depressed thyroid function incidences were found in groups of exposed workers with maximum blood levels almost entirely over 60µg/dL\(^37\), but not in a group with median levels of 51µg/dL\(^38\). Lack of rise in thyroid stimulating hormone (TSH) in those with low serum thyroxine levels suggests an effect on the hypothalamo-pituitary axis.

**Musculoskeletal effects**

Arthalgia and myalgia may occur at levels about 40-50µg/dL. Muscle weakness and low back pain are described\(^39\). “Saturnine gout” may develop, due to renal insufficiency with impaired uric acid clearance\(^40,41\).

**Metabolic effects**

Hyperuricaemia may develop\(^42\). Decreased concentrations of 1,25-dihydroxy vitamin D occur at even comparatively low blood lead levels\(^43\).
**APPENDIX 1  GLOSSARY OF TERMS**

**All Practicable Steps**  
**In summary:** Doing what is reasonably able to be done to control hazards, taking into account a number of factors including the likelihood and severity of any harm that might occur, and the availability and cost of ways to prevent harm.

**Baseline blood lead level**  
A blood test that determines what an employee’s existing lead levels in blood are before they are occupationally exposed to lead.

**Body burden**  
The total amount of a toxic substance in the body.

**Haemoglobin forming system**  
The series of enzymes required to form the haeme in haemoglobin (in red blood cells), which is required to carry sufficient oxygen in the blood stream. (Lead inhibits these enzymes).

**Blood lead assay**  
An analysis conducted to determine the concentration (level) of lead in the blood.

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

**Cumulative poison**  
A poison that has the ability to accumulate, or build up, in the body.

**Departmental Medical Practitioner**  
A person for the time being appointed under section 34(1) of the Health and Safety in Employment Act 1992.

**Health monitoring**  
Health monitoring generally refers to a programme of health-related interventions that may or may not necessarily be medical in nature. A health monitoring programme can include employee health self-assessments, questionnaires, information awareness and medical examination/testing.

**Haematocrit**  
The proportion of whole blood volume occupied by the red blood cells it contains.
Guidelines for the Medical Surveillance of Lead Workers (2nd edition)

Medical Surveillance

Medical surveillance generally consists of a series of medical examinations or invasive tests designed to detect and monitor a particular health effect. Medical surveillance is usually part of an overall health monitoring programme.

Notification

Blood lead results 2.4µmol/litre whole blood or above should be notified to the Department of Labour. For further information, refer to the Department of Labour’s website at http://www.osh.dol.govt.nz/services/notification/accident.shtml.

Units

In referring to blood levels, the expression micromoles/litre of whole blood (abbreviated to µmol/litre or µmol/L 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.

Serious Harm

Means death, or harm of a kind that is described in Schedule 1 of the Health and Safety in Employment Act 1992:

1. Any of the following conditions that amounts to or results in permanent loss of bodily function, or temporary severe loss of bodily function: respiratory disease, noise-induced hearing loss, neurological disease, cancer, dermatological disease, communicable disease, musculoskeletal disease, illness caused by exposure to infected material, decompression sickness, poisoning, vision impairment, chemical or hot-metal burn of eye, penetrating wound of eye, bone fracture, laceration, crushing.

2. Amputation of body part.

3. Burins requiring referral to a specialist registered medical practitioner or specialist outpatient clinic.

4. Loss of consciousness from lack of oxygen.

5. Loss of consciousness, or acute illness requiring treatment by a registered medical practitioner, from absorption, inhalation or ingestion of any substance.

6. Any harm that causes the person harmed to be hospitalised for a period of 48 hours or more commencing within 7 days of the harm’s occurrence.

Suspension levels

A suspension level is used to suspend employees with high blood lead levels from working with lead until the lead in their bodies reduces to an acceptable level.

A worker will be suspended by the departmental medical practitioner when a single blood lead result is 2.4µmol/litre
whole blood or greater.

The worker can return to work when the blood lead level reaches 1.93μmol/litre whole blood or less.
**APPENDIX 2 RELATED RESOURCES**


**Code of Health and Disability Services’ Consumers Rights** - available from the Health and Disability Services Commissioner:
Freephone 0800 11 22 33
Email: hdc@hdc.org.nz
Website: [www.hdc.org.nz](http://www.hdc.org.nz).
Appendix 3  References


Van Assen FJJ. *A Case of Lead Poisoning as the Cause of Congenital Anomalies in the Offspring* [Dutch]. Ned Tijdschr Verloskd Gynaecol 1958; 58:258-63.


More information

www.dol.govt.nz
0800 20 90 20

Information, examples and answers to your questions about the topics covered here can be found on our website www.dol.govt.nz or by calling us free on 0800 20 90 20.