Occupational Health Report Series Number 5: 2000

A Small Industry Study:

Lead Exposure in Vehicle Service Industries

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with an introduction and discussion by Glass W I

OCCUPATIONAL SAFETY & HEALTH SERVICE

DEPARTMENT OF LABOUR TE TARI MAHI

Published by the Occupational Safety and Health Service
Department of Labour
Wellington
New Zealand

First published, July 2000

ISBN 0-477-03632-5

Contents

Foreword

It is with pleasure I write the foreword to this report with its particular relevance to the OSH Business Plan for 1999/2000.

The report brings together two traditional New Zealand occupational health issues, the first, health hazards in small workplaces, the second, lead as an identified hazard in the vehicle service industries such as radiator repair, engine reconditioning and muffler repair.

Two studies are incorporated in the report. The first, a 1984 study on *Lead Exposure and Absorption in Automotive Engine Reconditioning* by Mr Keith Briggs and the second, a 1994 study, part of an OSH National Project compiled by Mr Errol Hodgkinson.

R.J.M. Hill

R J M Hill
General Manager
Occupational Safety and Health Service

July 2000

Introduction

Health and safety for those employed in small scale enterprises (SSE) remains an unsolved problem in both developed and underdeveloped countries. In a conference to review this situation (Thailand 1993) (1) Professor Rantanan of Sweden made the following points:

- Worldwide there are 1 billion workers employed in small scale enterprises including agriculture.
- Employment is intensive.
- Production systems are flexible and can thus respond to economic requirements.
- Creative solutions are developed but tend to remain within the enterprise.
- Small-scale enterprises are often at the edge of survival.
- Resources are small and limit development.
- Hours of work are long.
- Working environmental conditions are inferior.

Professor Rantanan further noted that, although there were over 300 database references on SSEs, there was little well quantified data. As resources of the SSEs are small they need external support for improving their occupational health and safety activities with Government interventions, advice and help. Information and training for managers and workers is an urgent necessity, together with an inspection system to ensure minimum requirements of occupational health and safety are met. A range of models to assess in organising healthcare for workers in small industry have been recommended and tried. Two that had significant success were the Slough experiment in England (2) and the Industrial Health Clinic in New Zealand (3, 4) 1949-1979.

In 1981, a meeting of the Scientific Committee on Occupational Health in Developing Countries was held in Colombo, Sri Lanka. Part of the agenda of this meeting was to consider the role of the primary healthcare worker generally in health service provision and, in particular, in relation to workers in small-scale enterprises. The Colombo Statement on Occupational Health in Developing Countries (5) also offered important guidelines to countries wishing to tackle the question of health and safety in small-scale enterprises.

We come now to the questions of lead exposure in the vehicle service industries.

In a letter to the New Zealand Medical Journal in 1986 (6), Hinton et al analysed industrial lead exposure in the South Island over the period 1984-86. Abstracting those occupations associated with the vehicle service industry the following results were recorded:

Occupation	Numbers Tested	Mean PbB	Range PbB
Garage mechanic	31	1.30	1.20-2.50
Engine reconditioner	25	1.45	1.40-3.40
Radiator repairer	38	1.60	0.48-3.00
Muffler repairer	21	2.05	1.10-3.10

These results updated an earlier report by Hinton (7) and confirmed the picture for the vehicle service industries.

In another New Zealand study (8) radiator repairers were placed in a high risk category. The hazard relating to the high temperature soldering (2000 degrees) and the extent of lead-contaminated dust (up to 30%) produced by cleaning the radiator parts with electric rotary brushes. Further, as radiator repair work is usually carried out without any special ventilation, the potential for high exposure remains significant.

The New Zealand experience is confirmed by that overseas with the publication of a number of articles (9-13). Another study of interest concerns lead exposure to the children of radiator repair workers, where it was shown that several children had levels associated with subclinical toxicity and in excess of revised Centre for Disease Control guidelines of 10 micrograms per 100 ml of whole blood.

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Lead Exposure and Absorption in Automotive Engine Reconditioning 1984

(W/2 84)

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Acknowledgements

The author would like to express his appreciation to many people, without whose assistance this study would not have been possible:

To the following companies for their willingness to participate in the study:

V B Giles Ltd, Wellington

Engine Rebuilders Ltd, Palmerston North

Watsons Peining Services, Palmerston North

Motor Machinists Ltd, Palmerston North

Metalock NI Ltd, Palmerston North

Williams and Adams Ltd, Wellington

Kerry Lindsey Engine Reconditioners, Petone

S C Cummings Ltd, Lower Hutt

Engine Reconditioners (1958) Ltd, Wellington

M G Flighty, Porirua

Motor Rebores (1962) Ltd, Wellington

Automotive Reconditioners (1979) Ltd

To the Medical Officers of Health of Wellington, Hutt, and Palmerston North for the assistance of their staff in workplace monitoring.

To Mel Tyson and the staff of the Environmental Chemistry and Dust Laboratories, National Health Institute, Wellington, for analysis of samples and moral support, and to Anne Jorgensen for typing services rendered.

J K Briggs (Scientist)
October 1984

Abstract

Seventy-nine workers employed in 12 separate automotive engine reconditioning workshops in the lower half of the North Island were investigated to evaluate the risk to workers' health arising from exposure to lead at work.

The median blood lead level (PbB) of the workforce sampled was 3.4 µmol/l RBC [35.4 µg/dl].

Twenty-six of the workers (35%) had a PbB >3.8 µmol/l RBC [>39.5 µg/dl], indicating a significant occupational exposure to lead. Three workers (4%) were found to have a PbB >5.7 µmol/l RBC [>59.3 µg/dl]. (The New Zealand intervention level.)

Five out of the 36 static air samples (14%) and 6 out of the 35 personal air samples (17%) taken during the working day exceeded the current New Zealand recommended TLV (TWA) for inorganic lead in air (PbA) of 0.15 mg/m^3. One personal air sample exceeded the current recommended TLV (STEL) of 0.45 mg/m^3.

The results indicate that inorganic lead is present in automotive engine reconditioning workshops at levels equivalent to other recognised lead processes.

Recommendations are made for the:

1. Monitoring of workers' health.
2. Control of lead in the workplace.
3. Improved construction and layout of the workshops.
4. Adoption of improved hygiene practices.
5. Recognition of automotive engine reconditioning as a lead process.

Contents

Tables

Figures

Introduction

The adverse health effects arising from the absorption of inorganic lead have been well described (1) and much has been done to reduce worker exposure in those industries where lead has been shown to be present. Many countries have enacted legislation and published guidelines to ensure the protection of exposed workers. In New Zealand the Lead Process Regulations 1950 and the *Control of Lead at Work,* Occupational Health Guidelines (2) have been enacted to protect workers exposed to lead.

Most industries where a significant lead risk is present have already been identified, e.g. battery manufacturers, lead smelters, radiator repairers and ceramic makers. However, occasionally, as a result of a particular local situation, a lead risk can be shown to exist in an industry not previously considered to present a significant hazard.

A survey of industries in the Auckland area (3) carried out in 1980 identified those industries where lead and/or its compounds were used, or were present as a result of industrial activity. Determinations of atmospheric lead (PbA) and blood lead levels (PbB) were made as part of the investigation.

This study was extended by a further investigation of the motor service and repair industry (4). This included a group of engine reconditioners and the blood lead levels of this group were found to conform to a range expected for the non-occupationally exposed, i.e. 0 to 2 µmol/l RBC [0 to 20 µg/dl] (5) indicating little accumulation from the reconditioning process.

However, a limited investigation of one automotive engine reconditioner in 1982 (6) recorded higher blood lead levels. One worker had a level of 5.7 µmol/l RBC [59.3 µg/dl] suggesting significant occupational exposure.

The Central Occupational Health Unit was therefore directed to carry out a broader based study to quantify the risk to worker health from lead present in reconditioning workshops.

A total of 12 workshops employing some 79 workers in the Wellington, Hutt, and Palmerston North health districts were investigated between January and March 1984.

The Reconditioning Process

It has been stated that the life expectancy of New Zealand motor vehicles is often in excess of 20 years, approximately twice that of similar vehicles in most western nations.

Considerable re-engineering is therefore necessary, to ensure the adequate performance of vehicles.

The process of reconditioning a petrol- or diesel-powered motor includes a number of distinct stages:

1. External cleaning
2. Dismantling
3. Cleaning of internal parts
4. Replacement or refurbishment of parts, and
5. Final reassembly of reconditioned motor.

On arrival at a recondition workshop, motors normally have a considerable coating of dirt and oil. The first stage in the process is to remove these deposits by one or more of the following methods:

- Immersion in a tank of solvent
- Spraying with a solvent
- Steam cleaning

The motor is then dismantled and the internal parts similarly cleaned as necessary. Considerable carbonaceous deposits build up internally within a motor on parts exposed to the combustion process, e.g. pistons, cylinder heads, and valves, and these must also be removed. Normal cleaning as described above is not sufficient to remove these deposits and physical abrasion of the deposits is necessary. This is accomplished with an electrically-powered rotating wire brush, or by blasting a stream of small glass spheres onto the deposits with a device called a bead blaster.

With prolonged use, many motor parts are subject to considerable wear and this must be corrected during reconditioning. Some parts, e.g. crankshafts, valves and cylinders, can be machined and then re-used, unless damaged. Other parts, e.g. pistons and bearings, needed to be replaced.

Method

Environmental and biological monitoring was carried out in 12 workshops investigated. Each of the 79 employees was asked to complete a self-administered personal questionnaire (Appendix 1), extra data being added to this by the personnel carrying out the biological sampling. Data was also obtained on layout, facilities and hygiene standards of each workshop.

Blood Lead Determination

Blood samples were collected from 75 (those willing to give blood) of the 79 workers investigated, by the District Health Office medical and nursing staff. The samples were collected in standard heparinised tubes and returned to the National Health Institute, Wellington, for analysis. The blood lead levels were determined by flame atomic absorption spectrophotometry after chelation and extraction into methyl isobutyl ketone (7). The National Health Institute takes part in the international collaborative quality control testing programme for blood lead analysis and results are quoted as accurate to + 5%.

> *Note: All blood lead levels are given first in micromoles per litre of packed red blood cells (µmol/l RBC) with an approximate conversion to microgram per decilitre [µg/dl] whole blood following in brackets. The approximate conversion rate between the two units, assuming a haemocrit of 50% is:*
>
> *Concentration in µg/dl whole blood = 10.4 x Concentration in µmol/l RBC.*

Lead in Air Determination

Static and personal air sampling was carried out for one working day in each workshop. Both types of sampling used essentially the same equipment. The sampling train consisted of a battery-operated pump sampling at a rate of approximately 1.5 litres per minute through a ‘Millipore’ cellulose ester filter of maximum pore size 0.8 µm, mounted in a 25 mm ‘Glasrock’ sampling head.

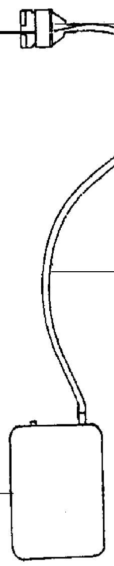

Figure 1. Air Sampling Apparatus

The filterheads on each set of equipment were changed during the lunch break, approximately halfway through the working day. Pump flow rates were calibrated before, during and after sampling.

Personal Sampling

Personal air samplers were attached to a number of workers within each workshop for the duration of one working day. The filterheads were attached horizontally within the breathing zone of the worker.

Static Sampling

Three static air samples were obtained in each workshop. The filterheads were again placed horizontally at approximately 1 metre above the floor level. The location within the workshop and the proximity of adjacent equipment were noted.

Lead in Dust Determination

Certain aspects of the reconditioning process produce considerable amounts of dust which tends to build up at various locations around a workshop. Samples of deposited dust were collected in lead-free containers, from recorded locations within each workshop.

All filters and dust samples were submitted to the National Health Institute for analysis. Lead was determined by flame atomic absorption spectrophotometry after digestion of the sample in concentrated nitric acid.

Results

Workforce Characteristics

All of the 79 reconditioners interviewed were males. Figure 2 gives the distribution of age groups within the workforce and table 1 gives the breakdown of the workforce based on years experience as a reconditioner. The majority of the workforce (66%) had been employed in the industry for less than 10 years.

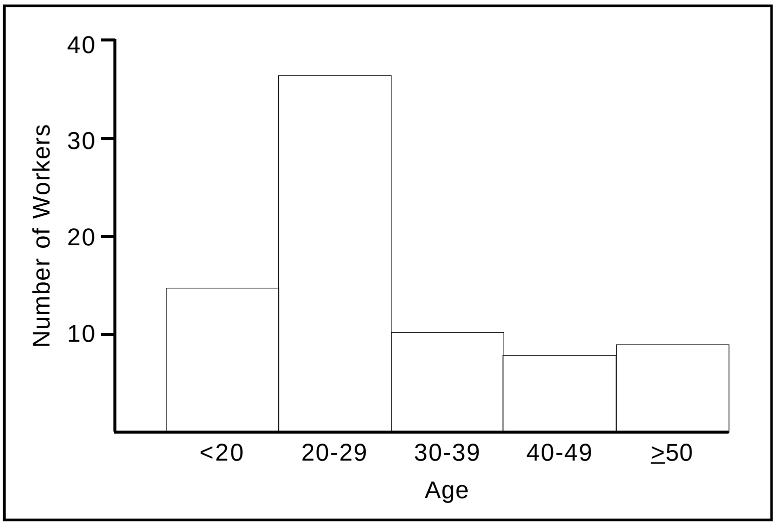

Figure 2. Age Distribution of Workforce

Years Worked as Reconditioner	No. of Reconditioners	Percentage of Study Workforce
0 - 5	36	45.6
6 - 10	16	20.3
11 - 15	10	12.6
16 - 20	4	5.1
21 - 25	4	5.1
26 - 30	4	5.1
31 - 35	4	5.1
36 - 40	1	1.3
	79	100%

Table 1. Years Experience in Engine Reconditioning

Distribution of Blood Lead Levels in the Workforce

Blood lead levels were determined for 75 out of the 79 workers interviewed. The lowest recorded level was 0.9 µmol/l RBC (PbB) from a worker who worked solely on lathes and who had only worked in the industry for 4 months. The highest figure recorded was 6.2 µmol/l RBC (PbB) from an apprentice who had been employed in a workshop for 12 months and who, at the time of investigation, was involved largely in engine cleaning.

A summary of these results is given in table 2. A complete tabulation of all the results is given in Appendix 2.

PbB (µmol/l RBC)	**n**	**%**
0 - <1	1	1.33
1 - <2	11	14.67
2 - <3	22	29.33
3 - <4	18	24.00
4 - <5	14	18.67
5 - <6	7	9.33
6 - <7	2	2.67
7 - <8	0	0
Total	**75**	**(100%)**
Median = 3.4 µmol/l RBC		

Table 2. The Distribution of PbB Levels Within the Studied Workshops

Distribution of Blood Lead Levels with Workplace

Table 2 gives the overall distribution of blood lead levels for the 75 workers sampled. Considerable variation of PbB range and median value was evident between the different workshops and these results are presented in table 3.

Workshop	a	b	c	d	e	f	g	h	i	j	k	l
Size of Workforce	6	7	3	17	4	7	5	9	4	6	5	6
Number of PbB Samples Taken	6	7	2	16	4	7	5	8	4	5	5	6
PbB Median Value (µmol/l RBC)	4.35	2.50	3.85	2.05	3.00	4.50	5.60	2.40	4.25	4.00	2.90	3.70
PbB Range (µmol/l RBC)	2.4 / 5.1	1.2 / 3.5	3.8 / 3.9	0.9 / 3.4	1.2 / 3.4	3.0 / 5.6	4.0 / 6.2	1.8 / 6.1	2.9 / 5.0	2.8 / 5.0	2.5 / 3.5	2.9 / 4.7

Table 3. PbB Distribution Between Workshops

Personal Lead in Air Sampling

Table 4 lists the inorganic lead in air (PbA) obtained from the personal air monitors, three sampling sets were used in each workshop.

Each worker's mean PbA level is listed along with the corresponding PbB level.

Premises	PbB (µmol/l RBC)	PbA (mg/m³)	Premises	PbB (µmol/l RBC)	PbA (mg/m³)
a	4.5	.08	g	5.6	.58
	4.7	.04		6.2	.27
	5.1	.05		4.0	.16
b	3.4	.04	h	6.1	.08
	2.9	.01		3.2	.14
	3.5	.18		1.8	.06
c	3.9	.01	i	5.01	.07
	3.8	.01		2.9	.03
d	3.4	.24		4.6	.10
	2.6	.03	j	4.3	.03
	2.9	.01		4.7	.11
e	3.4	.02		5.0	.07
	3.1	.01	k	2.5	.02
	2.9	.02		2.9	.03
f	3.1	.06		2.5	.02
	4.3	.01	l	2.9	.04
	4.5	.07		2.5	.05

Table 4. The Relationship Between PbB and Personal PbA Levels

Static Lead in Air Monitoring

Sets of static air monitoring equipment were operated at three sites within each of the twelve workshops studied. The location of sampling sites varying between workshops. The filter within each sampling set was changed approximately half way through the working day.

The results obtained are shown in table 5 and include an indication of the machinery closest to the sampling point. The figures given in each of the columns (e.g. 0.15 mg/m³ (PbB) for workshop 'd' adjacent to the buffing wheel) is the mean of the results from the 2 filters used over the sample period. The figure 'n' at the base of the table includes the total number of filters exposed.

	M			e ³)			a				n
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T a b l e

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Blood Lead Levels and Personal Habits

Comparison of the blood lead data and smoking and/or nail-biting revealed a trend of increasing mean blood lead level with smoking and/or nail-biting (table 6).

Habits		n	x PbB µmol/l RBC	(µg/dl)	Median µmol/l RBC
non-smokers	non-nail-biters	28	3.14	[32.7]	3.10
all non-nail-biters		52	3.18	[33.1]	3.00
smokers	non-nail-biters	24	3.24	[33.7]	2.90
all	non-smokers	45	3.28	[34.1]	3.40
all workers		75	3.33	[34.6]	3.40
all smokers		30	3.39	[35.2]	3.45
non-smokers	nail-biters	17	3.53	[36.7]	3.45
all nail-biters		23	3.65	[38.0]	3.50
smokers	nail-biters	6	3.98	[41.4]	4.60

Table 6. Changes in Mean PbB With Habits

Blood Lead Level and Work Type

For the purposes of the study, the reconditioning process was regarded as comprising four main functions identified on the questionnaire as cleaning; disassembly; grinding/honing/planing; and reassembly. Workers were asked to identify whether each of these components formed a major, a minor, or no part of their current daily work pattern (table 7).

	Mean PbB (µmol/l RBC)		
Job Function	**Major Part**	**Minor Part**	**No Part**
1. Cleaning	3.94	3.16	2.53
2. Disassembly	3.84	3.19	2.73
3. Grinding / Honing / Planing	3.52	3.06	2.50
4. Reassembly	3.69	2.99	3.15

Table 7. Variations in Mean PbB with Work Type

Blood Lead and Subject Symptom Assessment

Workers were asked if they believed that they suffered unduly from any of the clinical symptoms listed in table 8 and known to be associated with increased lead absorption.

Of the 75 workers completing a questionnaire and supplying a blood specimen, 38 (50.7%) reported suffering from 1 or more symptoms.

Table 8 gives the breakdown of reported symptoms and the median PbB value of workers reporting the symptoms.

	Number Experiencing Symptoms	Percentage of Workforce	Median PbB µmol/l RBC	[µg/dl]
No Symptoms	37	49.3	2.90	[30]
Symptoms				
a. Tiredness	30	40.0	3.45	[36]
b. Muscle weakness	5	6.7	4.00	[42]
c. Sleeplessness	24	32.0	3.90	[41]
d. Headache	13	17.3	3.90	[41]
e. Constipation	3	4.0	3.10	[32]
f. Diarrhoea	2	2.7	4.50	[47]
g. Stomach pains	10	13.3	3.80	[39]
h. Irritability	19	25.3	3.90	[41]

Table 8. Workers' Symptoms Reported and Median PbB Values

Blood Lead Levels and the Siting of Rest Areas

The siting of worker rest and canteen facilities varied considerably between workshops, but can be divided into 2 main categories:

1. Those workshops where the rest/canteen area was within the environs of the workshop.
2. Those workshops where the area was separate from the main workshop.

Comparing worker blood lead levels (PbB) on the basis of this division, a statistically significant difference was demonstrated ($t = 3.8$ $p < 0.001$). In premises where these facilities were within the main workshop, the employees had higher PbB.

It was disturbing to note that the dust sample collected from one rest area situated within a workshop c had a lead content as high as 28%!

Canteen/Rest Area Location	Mean PbB (µmol/l RBC)	n	S.D.
Within Workshop	4.45	13	1.08
Separate from Workshop	3.09	62	1.18

Table 9. Variation of PbB with Rest Area Siting

Blood Lead Level and Length of Service

Comparison of the blood lead levels with length of service in the industry (table 1) produced a significant negative correlation ($r = -0.22$, $\gamma = 73$, $p<0.05$), suggesting that the less time spent as a reconditioner, the higher the blood level. One explanation of this phenomenon is in the areas of work undertaken by different groups within a workshop. Those workers that have been longest in the industry have usually acquired greater degrees of skill and therefore are employed on the more critical work areas such as crankshaft grinding. These skilled areas of work also happen to be relatively clean operations in comparison with other parts of the reconditioning process. Conversely, the younger and less skilled employees are employed on the simpler, dirtier jobs where the exposure to lead is greatest, such as engine cleaning.

Another possible explanation of the negative correlation between work experience and mean PbB, is that the more experienced workers tend to be more aware of the need for cleanliness and are therefore more careful to ensure an adequate standard of personal hygiene. No data was collected that would allow for a clarification of this phenomenon.

The Distribution of Worker Blood Lead Levels

The significance of the worker blood lead levels data is seen in perspective when compared in table 10 with previously obtained New Zealand data for workers in other known industries where lead is present (3).

Industry	PbB Range	Mean PbB	Sample Size (n)
Battery Repair	2.2-4.0	2.9	6
Solder Manufacture	1.9-5.5	3.3	24
Plastic Formulation	1.9-4.3	3.1	23
Motor Vehicle Assembly	1.4-5.6	4.6	8
Radiator Repair	1.8-7.6	4.3	66
Soldering	1.8-4.6	3.0	46
Printing	1.7-5.4	3.2	22
Pottery	2.2-6.3	3.6	11
Engine Reconditioning	0.9-6.2	3.3	79

Table 10. Comparison of PbB Range in Reconditioners with Other Lead Processes

From these results it can be seen that the PbB range observed in the study sample corresponds to the ranges observed for many other recognised lead processes.

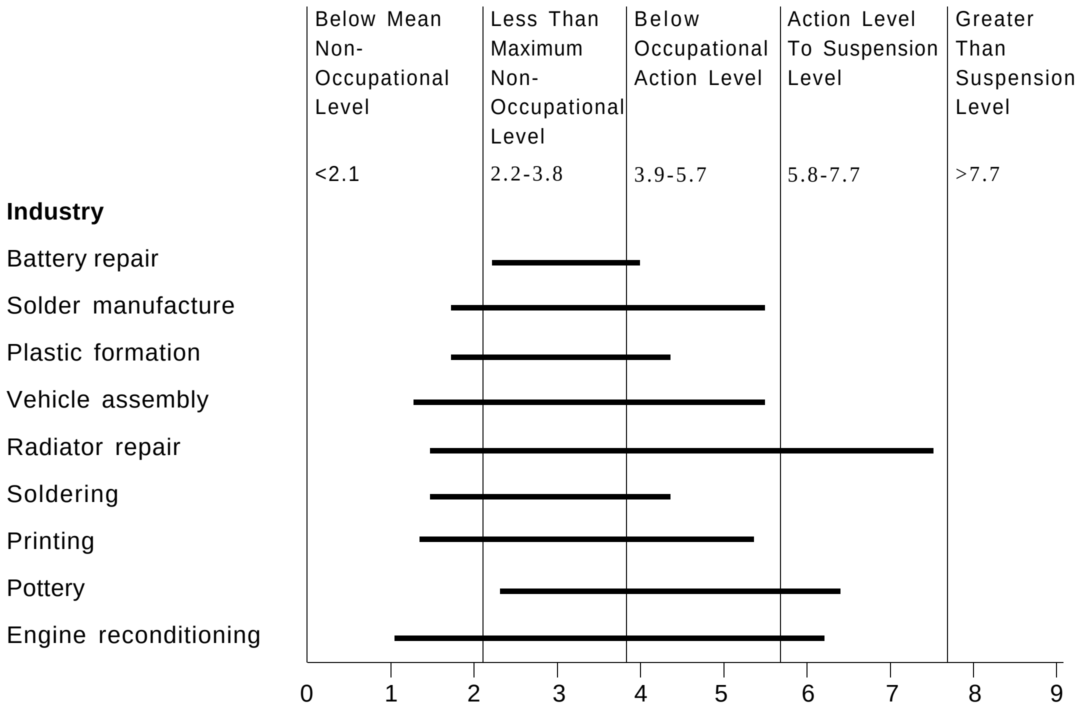

Figure 3. PbB Classification Giving Ranges Found in Some NZ. Industries.

Figure 3 compares the ranges in blood lead level for the different industries, with a classification of degree of exposure.

Personal Air Sampling

When the results from the personal air samplers for lead in air (PbA) were compared to the blood lead levels of those workers involved, a statistically significant correlation was observed ($r = 0.40$, $\gamma = 32$, $p<0.02$). Studies of PbB/PbA levels in other industries where lead is present have produced conflicting results. Williams et al (8) carried out a study of 39 battery workers in England and obtained a similarly high degree of PbB/PbA correlation (r = 0.9, p,0.05). Bierre and Winchester (9), in a shorter study of radiator repairers in Auckland, found a similarly significant correlation coefficient (r = 0.9, p,0.05). Conversely, results obtained by Døssing and Paulev (10) from a study of welders employed in a lead/zinc smelter in Greenland found no PbB/PbA correlation.

The value of the observed correlation is limited by the sampling methods used. Personal air monitoring was only carried out on one day whereas PbB levels are a reflection of long-term lead exposure patterns. However, the fact that a correlation was observed between PbB/PbA with the personal samplers does suggest that inhaled airborne lead is an important mode of exposure.

Of the 36 personal air samples obtained, 5 (13%) exceed the present recommended TLV (TWA) for inorganic lead dust and fume of 0.15mg/m^3 of which one with a level of 0.58 mg/m^3 exceeds the present recommended TLV (STEL) of 0.45 mg/m^3 (11). The TLV for inorganic lead dust and fume are at present under review. It is proposed to reduce the TLV (TWA) to 0.1 mg/m^3 and the TLV (STEL) to 0.3 mg/m^3. If adopted, this would mean that 7 samples (20%) would exceed the TLV (TWA).

Static Air Sampling

As the location of static air samples was varied from one workshop to the next (table 5), it was not surprising to discover that no correlation could be found between the mean PbA results obtained from the static samples and the mean PbB for the corresponding workshop.

It was noted that the PbA levels at static sampling sites close to buffing wheels were consistently higher than all other sites. This difference was statistically significant ($p<0.05$) compared with the PbA levels for all sites other than the static samplers placed adjacent to a bead blaster.

In 5 out of the 19 workshops (56%) where static samplers were placed adjacent to buffing wheels, the mean PbA for the exposure period exceeded the current recommended TLV. In workshop (g) the concentration of lead recorded in the air near to the buffing wheel exceeded the 0.3 mg/m^3 (STEL) at present under consideration by the New Zealand Government.

Blood Lead Levels and Personal Habits

Examining the survey data for blood lead levels and comparing them to personal habits as reported in the questionnaire (table 8), a trend of increasing PbB with indulgence in various habits is demonstrated. Non-smoking non-nailbiters had the lowest mean group PbB, and smoking nailbiters the highest.

Although a trend is apparent in the data, the only significant statistical difference obtained ($p<0.06$) was in the comparison of nailbiters with non-nailbiters. The results for nailbiting indicate that it contributes more to lead uptake than does smoking which has been shown in other studies to be associated with increased lead uptake (12).

Blood Lead and Work Type

The questionnaire recorded details of those aspects of the reconditioning process carried out by each worker at the time of investigation. Work types were divided into four categories: engine cleaning; disassembly; grinding/honing/planing, and reassembly (table 7).

The mean PbB level of workers carrying out these work types as a major function were compared with the mean PbB of those carrying out the job or a minor, or no, part of the work. Workers carrying out the following 3 functions were found to have a significantly high mean PbB than where the position was a minor, or no part of work.

Engine cleaning	($p<0.001$)
Disassembly	($p<0.001$)
Reassembly	($p<0.001$)

No such difference was found with grinding/honing/planing.

These results would indicate that engine cleaning, disassembly and reassembly all expose workers to lead, whereas grinding/honing/planing exposes workers to much lower levels. However, no significant difference was found between the mean PbB of workers carrying out the 4 work classifications.

Blood Lead and Subjective Symptom Assessment

Inorganic lead is present throughout the environment and measurable amounts can be found in all adults. Apart from exposure to lead in the workplace, other common sources are food, drink and airborne dusts. For those people not exposed to lead at work these other sources would be expected to give rise to a blood lead level within a range 0 to 2 μmol/l RBC [0-20 μg/dl] (13, 14).

Working with lead exposes workers to greater amounts than would normally be encountered. In engine reconditioning, the major source of lead would appear to be in dust produced in the mechanical cleaning of carbon deposits from engine parts. These dust particles enter the body via two main routes, ingestion and inhalation. Once inside the body a proportion of the lead content of the dust is absorbed into the bloodstream and circulated around the body. Certain organs, e.g. bone, kidney, and the nervous system, preferentially re-absorb lead from the circulatory system.

The body is able to excrete absorbed lead at a slow rate. The biological half-life within the human body is approximately 36 days. Repeated exposure can therefore result in an increasing body burden of lead. The biological response to this lead accumulation can vary. For many years it has been known that workers exhibiting elevated lead levels can suffer from a variety of physical symptoms (12, 13, 14, 16, 17) affecting, for example, the skeletal system, the musculature, the nervous system (both central and peripheral), the digestive system, the renal system, and haemopoietic system.

For a more detailed account of the biological effects of lead, readers are referred to the above references.

In answering the questionnaire, workers were asked to indicate if they believed they suffered unduly from one of the symptoms listed, which are known to be associated with lead absorption (table 8). Just over 50% reported that they suffered unduly from one or more of the symptoms listed. Comparing the mean PbB for workers reporting each symptom with those reporting no symptoms, the mean PbB was significantly higher in workers who reported suffering from sleeplessness ($t = 2.1$ $p<0.05$) and irritability ($t = 2.1$ $p<0.05$).

Several studies (12, 15) have reported on the frequency with which other lead workers have reported suffering physical symptoms. The frequency observed in this study is similar to that found by Neri et al (12).

Blood Lead Level and Blood Pressure

Several studies have reported a connection between PbB and high blood pressure (13).

The blood pressure was obtained from all workers having blood samples taken for lead analysis, see Appendix II. Clousen and Rastogi (13) carried out a study of lead absorption in 216 individuals working in groups in Denmark. Highest blood levels were found amongst mechanics and it was noted that 37% of this group had high blood pressure over 160/95. The results of this study indicate that only 8% of the workers tested (6 out of 75) exhibited similar high blood pressure patterns to that recorded in the Danish study.

Sources of Lead in the Workplace

The lead content of the dust samples obtained adequately demonstrates the high amounts of lead present in the workshops studied. The highest lead content was 33% in a dust sample taken from the carbon deposits removed from motors by a buffing wheel.

Tetra-alkyl lead is added to petrol as an “antiknock” agent and to boost the fuel’s octane rating. In New Zealand, petrol contains about 0.84 g/l tetra-alkyl lead, twice as much as most European countries and the USA presently permit. This higher level is to some degree offset by the number of vehicles operated on lead-free fuels, i.e. CNG, LPG and diesel. It is planned to reduce the amount of tetra-alkyl lead added to petrol within the next few years (18). (N.B. No organic lead compounds are now added to New Zealand fuel.)

These lead additives are converted to particular bromochlorides in the combustion process and are then either emitted with the exhaust gases, or deposited within the motor and exhaust systems (19).

The rebuilding of motors can also involve the use of lead. In older motors, where ready-made bearings are not available, replacement bearings are formed from molten lead alloys. As the temperature of the lead used is only enough to bring it to a molten state, little fume is produced and the amount of dust produced is also small. Little risk of lead inhalation exists (4). This process is now rarely carried out and then only in a few workshops. It is concluded that this process contributes little to the overall lead levels present in the workshop environment.

Lead is also present within certain special lubricants used in motor vehicles, particularly diesels, to increase resistance to high pressures. The main compound is lead naphthenate in concentrations up to 7%. Whilst the engine oils used in petrol vehicles do not usually contain significant amounts of lead (<10 ppm), over a period of time this level can rise dramatically as the oil scavenges lead from the fuel and bearings as they wear.

Levels of up to 3500 ppm have been found in old motor oil that has been used over a distance of 4500 km (13). The skin absorption of lead from old engine oil has been implicated as a prime cause of blood-lead elevation in studies on motor mechanics, the rate of absorption being accelerated by handcleaning with solvent-based cleansing agents.

The two most probable sources of lead within a reconditioning workshop are, therefore, from the carbonaceous engine deposits, or used engine oil.

As the lead content of the engine deposits is approximately 100 times that of the used engine oil and many engines are drained of oil prior to entering the workshops, the contaminated engine deposits probably constitute the major source of lead.

Lead in the Workplace and the Law

In keeping with many other countries, New Zealand has adopted legislation to protect the health of workers in industries that involve the use or presence of lead. In New Zealand, the Lead Process Regulations 1950 and amendments, include under the definition of a lead process "c) The repair or assembly, or breaking up of any appliance which contains any lead or lead product".

As automotive engine reconditioning involves the repair of motors which contain lead contamination residues, it clearly falls within the scope of a lead process as defined above, and unless specifically exempted under Regulation 3A, all automotive engine reconditioning operations should presumably comply with legislative requirements. These requirements cover such areas as :

- Cleaning — Regulation 14
- Amenities — 15, 16, 17, 18
- Protective Clothing — 20
- Hygiene — 22
- Medical examinations — 24

It must be stressed that these requirements are thought to be the minimum necessary to adequately protect the health of employees exposed to lead in the workplace.

Further advice on methods of controlling lead exposure are to be found in guidelines published by the Department of Health, under the title *The Control of Lead at Work* (2).

Conclusions

1. Workers employed in engine reconditioning workshops exhibit higher average blood lead levels than do workers not exposed to lead. The range of blood lead levels recorded in this survey was similar to the ranges known to occur amongst other occupationally-exposed lead process workers.

   At present, motor reconditioning is not recognised as being a process that involves workers in exposure to high lead levels.

2. The amount by which the average motor reconditioner has his blood lead level elevated is accentuated by a number of factors. Three principal factors would be:

   - Personal habits - smoking or nailbiting in the workshop.
   - Involvement in engine cleaning and buffing operations.
   - The siting of the workers' rest/canteen area within the workshop.

3. Two symptoms–sleeplessness and irritability–may be related to blood lead levels within the ranges observed in this study.

4. The major probable source of lead in reconditioning workshops was found to come from the carbonaceous deposits that form within the motor and are removed in the reconditioning process. The fine dust produced by their removal contained up to 33% lead (weight/weight).

5. The layout of equipment within most workshops has not been planned with a view to isolating the lead producing aspects of the process or to prevent the movement of lead containing dusts into 'cleaner' areas.

6. The washing, sanitary and changing facilities within most workshops were rudimentary. Only one of the twelve surveyed satisfied the requirements of the Lead Process Regulations for the protection of workers.

Recommendations

1. That automotive engine reconditioning should be recognised to be a lead process within the meaning of the Lead Process Regulations and that the industry should take the appropriate steps to meet the requirements so that workers' health can be adequately safeguarded.

   The progress of workshops toward meeting these requirements should be monitored by district offices and advice given as appropriate.

   (It is recognised that the presence of lead within the workplace results from the amount of organic lead compounds added to petrol. Any reduction of lead in fuel will lead in time to a corresponding reduction of lead deposited in motors and therefore a reduction of lead in the workplace).

2. That the following action be taken to minimise worker exposure to lead:

   a) Workers should be informed of the risk of increased lead uptake associated with smoking and nailbiting and the hazard this presents to good health.

   b) Workers involved in 'dirty' operations should wear adequate protective clothing. Those involved in buffing operations should wear a suitable dust mask or respirator.

   c) Workers should not be permitted to eat or drink whilst in the workshop.

3. That the attention of district offices be drawn to the need to recognise automotive engine reconditioning as a lead process and that health education and workplace monitoring be carried out as appropriate.

4. Where practicable, the removal of carbon deposits from engine parts should be carried out within a bead blaster, properly maintained to collect all dust produced and prevent leakage into the workshop environment. When the use of such equipment is not feasible and cleaning is carried out on buffing wheels, the siting of these should be such as to minimise the amount of dust affecting other areas of the workshop. It is recommended that suitable local exhaust ventilation be provided at the buffing wheel, this should be designed to draw the dust-laden air away from the direction of the operator's face. Dust that accumulates on the floor, walls, or equipment must be removed at frequent intervals.

5. The improvements be made to the washing, sanitary and changing facilities provided for workers in accordance with the Department's Occupational Health Guidelines *The Control of Lead at Work*.

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Lead National Project

Summary of Results from an Audit of Lead Exposures in Vehicle Service Industries 1994

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December 1994

Contents

Summary

A wide range of lead exposures were found in the vehicle service industries over the period 1988 - 1993. The radiator repairers in particular were elevated in comparison with the current standards. The trends in blood lead levels suggest that maintaining levels below 1.5 μmol/litre in the engine reconditioning and radiator repair industries is a feasible goal.

The Health and Safety in Employment Act 1992 clearly places the onus on the employer to monitor the worker's exposure to potentially hazardous substances like lead. It is suggested that OSH maintains an audit role in these and other lead industries and, in particular, ensures that the employer arranges health surveillance for all workers potentially exposed to excessive amounts of lead.

Introduction

Of all of the substances that may be encountered in the workplace lead is arguably the most studied. Unfortunately the knowledge that has been gained has not necessarily been all that useful in ensuring the problem of excessive uptake of lead is a thing of the past.

As part of the OSH National Chemical Project in 1992-1993, lead exposure associated with the vehicle service industries (radiator repair, muffler repair and engine reconditioning) was investigated. The aim of the study was to gain an overview of the blood lead levels among the workers in the industries and to look at some of the issues in relation to managing the risk associated with lead exposure.

Exposure to lead does occur in other vehicle related industries, eg petrol pump operators, mechanics and other groups such as parking building attendants that may be exposed to exhaust fumes. Exposure among these groups is considerably lower with the elevation of blood lead levels being below the level of concern(1).

Occupational health surveillance is an established tool in managing the hazard presented by exposure to substances encountered in the workplace. For many substances it is debatable just how effective surveillance is - especially if it is unlikely to result in meaningful interventions. For instance, while medical surveillance of asbestos workers may help us obtain more accurate statistics, early detection of the disease will not change the prognosis for the persons affected nor is it now likely to enable timely interventions in the workplace. Lead is one substance that can employ medical surveillance usefully. By monitoring early signs and symptoms of lead poisoning and the blood lead level of an individual it is possible to effectively intervene ,avoiding continued exposure and possible health damage.

Background

Over the last 20 years there has been a slow and erratic devolution of the responsibility for surveillance of lead workers from the government authority to the employer. Up until approximately 1980 the Department of Health offered a free occupational health service to all industries. This was indeed a ‘service’ and included the laboratory assay of blood lead and environmental lead samples and the field input from occupational health nurses and environmental health officers. During this period some of the larger industries contracted a ‘factory doctor’ but the major input for occupational hygiene was provided by the Government. As the demand for the services grew the first change in policy was to remove the routine assay of blood lead from the free list for those industries that were deemed to be able to pay for the work. Of all the industries that were known to have a significant lead exposure risk, it was only the battery manufacturers that, as a group, responded to this policy shift. As the principle of cost recovery was adopted by government departments in the mid 1980s, generally a charge was made for analysing lead in blood (where the monitoring was routine) but the remainder of the occupational health input continued to be provided as a free service by the occupational health nurses employed by the Department of Health and later by Area Health Boards. One factor complicating a tidy and equitable transfer to a user-pays system for blood lead assays was (and still is to some extent) the variation in the way that the laboratories and the organisation collecting the samples charged out the work. In some areas true commercial rates applied while in others the user enjoyed full or partial subsidy.

The Health and Safety in Employment Act clearly places the onus on the employer to monitor the worker’s exposure to potentially hazardous substances like lead. In the OSH publication, *Guidelines for the Medical Surveillance of Lead Workers*[2], the scope of this responsibility is defined.

Results

In total, 292 firms were represented in the data gathered, made up of 103 radiator repairers, 98 engine reconditioners, 79 muffler repairers and 12 garages that carried out a mixture of the tasks. A further 54 firms were identified as carrying out one of the industries targeted in the audit but had not had the workers tested for blood lead levels. In a number of these cases it had been noted that the employer had been approached in the past and had elected not to co-operate.

The distribution of the number of firms within the various industries targeted in the audit is summarised in table 1:

Industry	**Number with accessible blood lead data**	**Number without a history of blood lead monitoring**	**Totals**
Radiator Repair	103	10	113
Engine Reconditioning	98	23	121
Muffler Repair	79	21	100
Garages	12	-	12

Table 1. Number of Industries in Audit

Within the firms that did have accessible information available there was a wide range in the depth of monitoring data. In some instances, it would appear that regular monitoring had been performed on the workers at risk while in other cases only one or two tests had been carried out over the years from 1988 to 1993.

In the vast majority of cases the result for the concentration of lead in the red blood cells was the only figure available, as during the period covered by the audit, that was all the analysing laboratories were reporting. To allow a comparison with the units that are now used (µmol/litre whole blood) a conversion was made assuming that the packed cell volume was 50%. i.e.:

the whole blood result = red cell result x 50/100.

This is a convenient conversion, as it gives rounded figures, but it exaggerates the results slightly as the average packed cell volume for this group has been estimated at 48% [(3)]. If in the future the figures in this report are to be used in making comment on blood lead level trends, allowance should be made for the conversions that have been used.

Figure 1 looks at the experience of the workers within the different industry groups. The number of years worked in the respective industries is plotted as a frequency diagram.

In order to present a snapshot of the blood lead status within the industries at the time of the audit, the last blood lead result for each worker was noted. This was usually a 1992 or 1993 result but in some instances, because either the worker had left employment or the surveillance programme had ceased, it was necessary to use an earlier figure. Results from office and ancillary staff not directly involved in the process were excluded from the analysis (where it was possible to identify them).

In Figure 2, the distribution of the blood lead results is plotted for each industry group. As noted previously, all results have been converted to the units µmol/litre whole blood.

The trend in blood lead levels over time was examined by plotting the average level for each industry group by year (see Figure 3). To arrive at the average figure the following

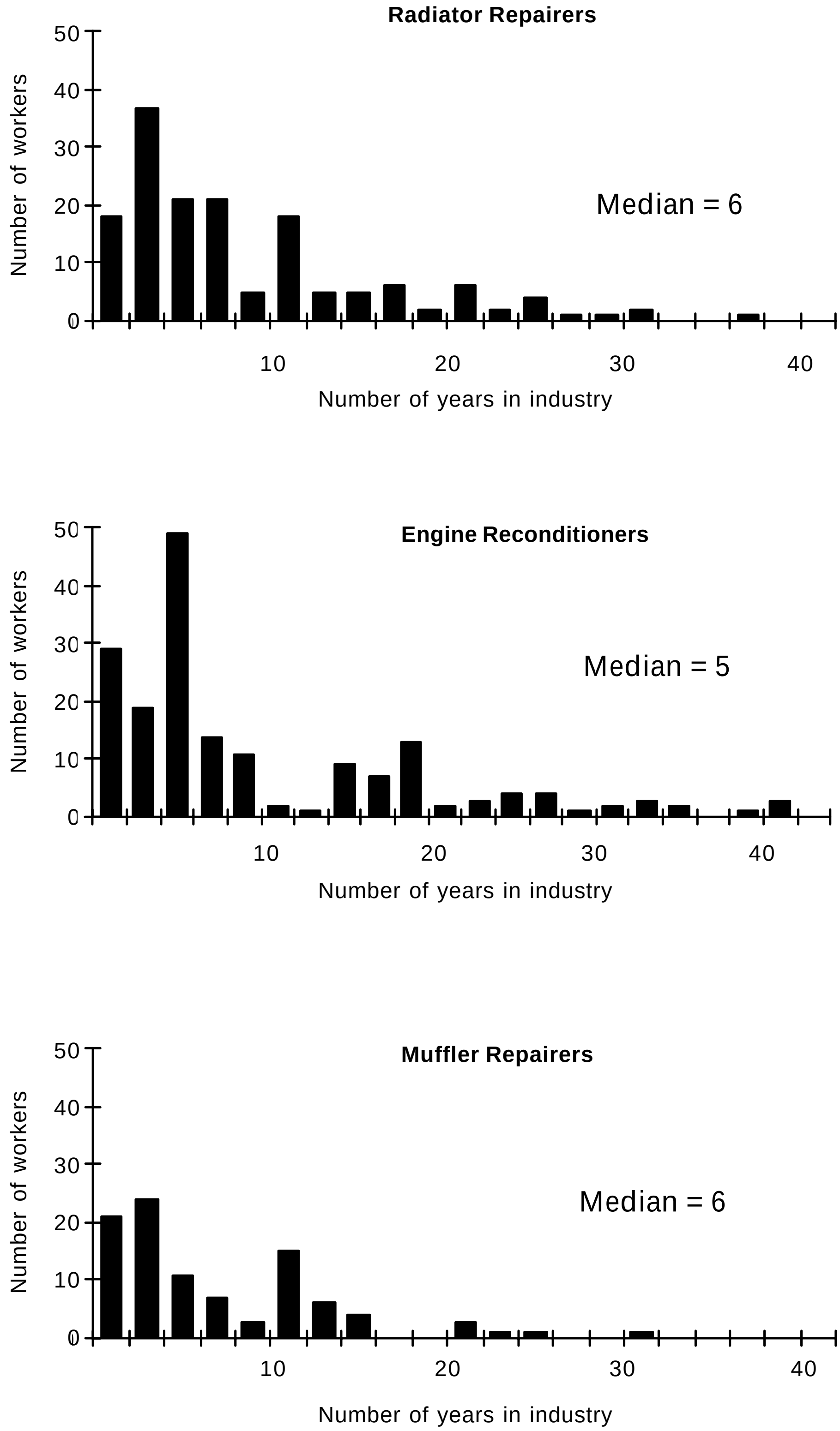

Fig 1. Number of years workers have been employed in industry

criteria were employed: for the data to be included results for at least 3 of the 6 years (1988-1993) had to be available; at least one of the workers must have had 3 or more blood lead tests; the company must have been operating prior to 1988. Also excluded were results from workers that had been in the industry for less than 6 months.

Figure 4 examines the relationship between the length of time workers have been in the respective industries and the blood lead level. In order to highlight the input from the first few years of employment, the plot has been truncated at the 5-year point.

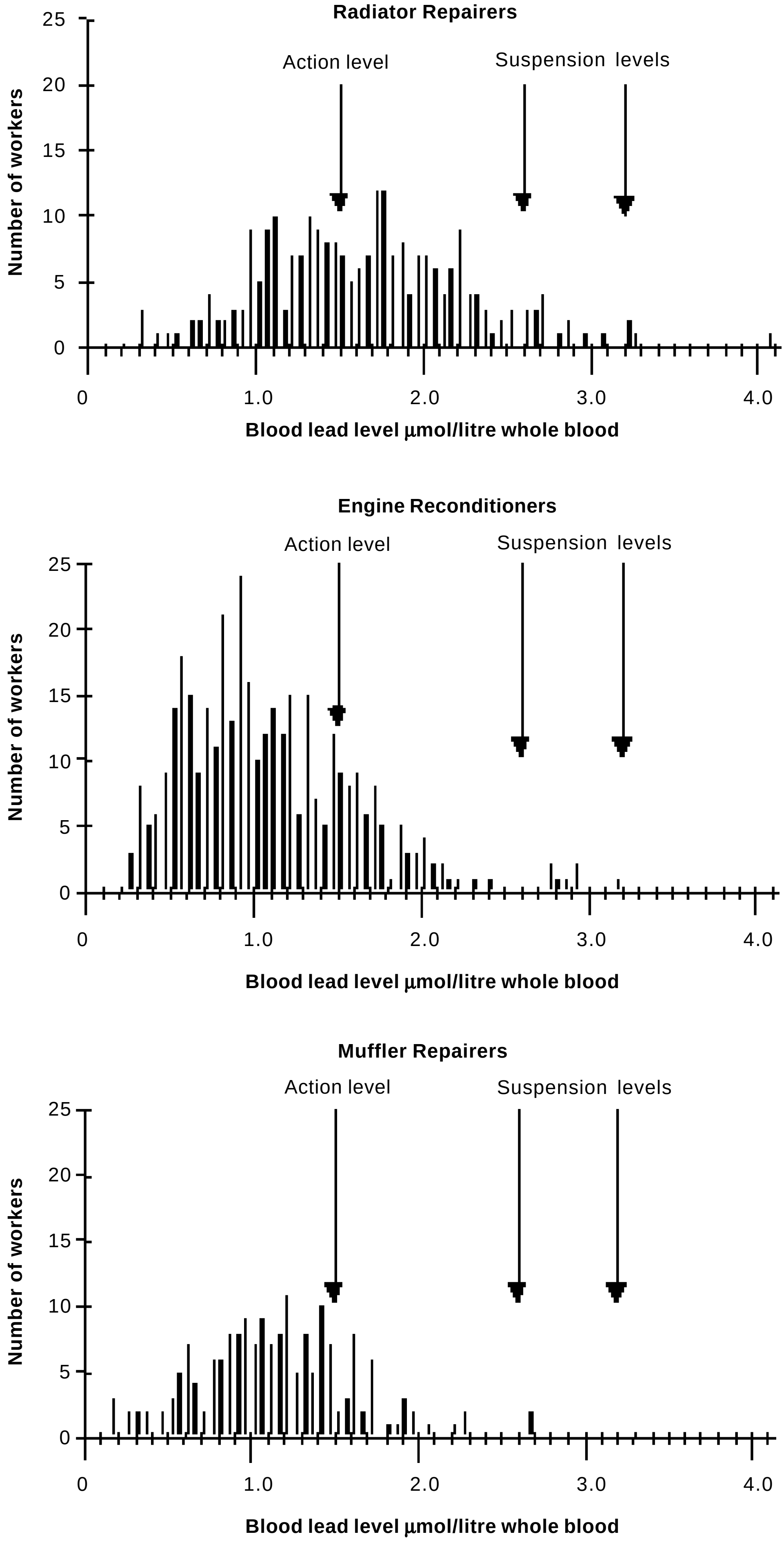

Figure 2. Distribution of Blood Lead Levels Within Industry Groups

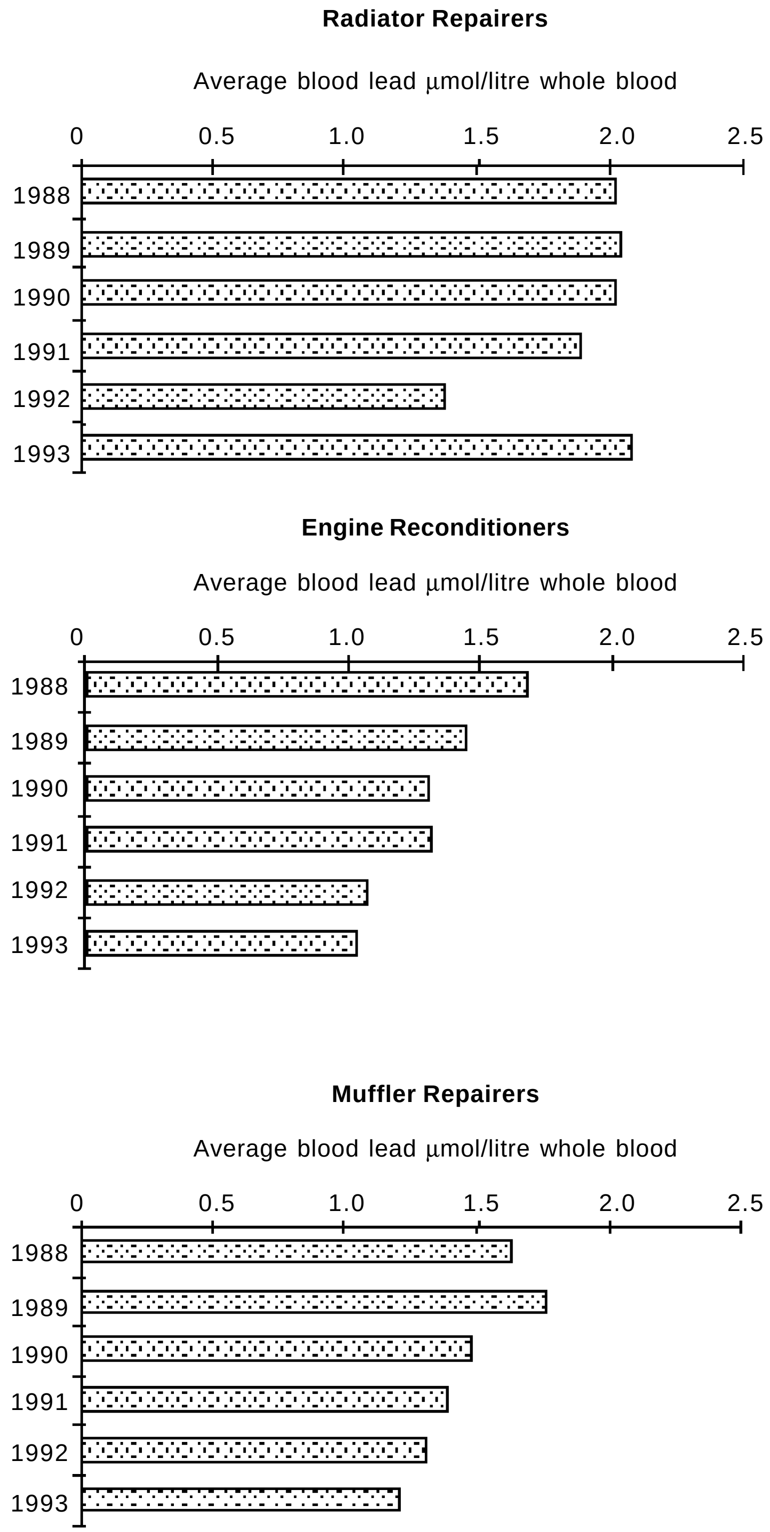

Figure 3. Trends in Blood Lead Levels 1988 - 1993

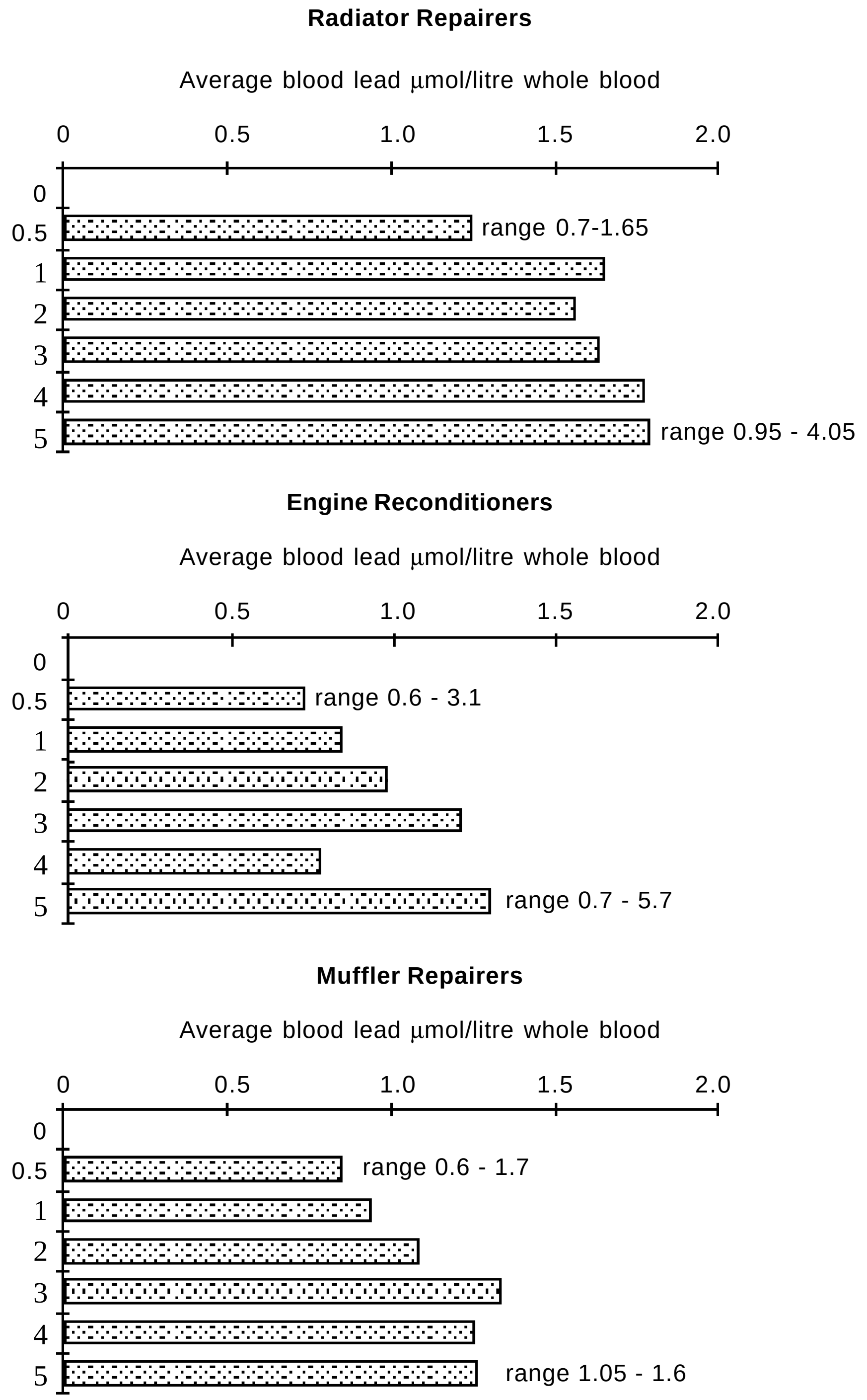

Figure 4. Blood Lead Level and Years Worked in Industry

Information on the extent of "ownership" the firms have taken towards monitoring the worker's blood lead level was examined in the audit by collecting information on who arranged the monitoring and who paid for the monitoring. The results for this section of the audit are set out in Tables 2 and 3. The figure in parentheses is the percentage with respect to the total number of firms from the respective industries in the audit.

Industry	**Number of firms that arrange own blood lead test**	**Number of firms that use GPs or Occ Health Service to arrange blood lead test**	**Total firms identified in audit**
Radiator Repair	7 (6%)	4 (3.5%)	113
Engine Reconditioning	3 (2.5%)	1 (1%)	121
Muffler Repair	2 (2%)	1 (1%)	100
Total	12	6	334

Table 2 Arrangements for Blood Lead Testing

Industry	**Firm has paid for monitoring since**			**Total firms identified in audit**
	Prior to 1988	**1990**	**1993**	
Radiator Repair	31 (27%)	40 (35%)	60 (53%)	113
Engine Reconditioning	6 (5%)	14 (12%)	29 (24%)	121
Muffler Repair	9 (9%)	12 (12%)	26 (26%)	100

Table 3 Payment for Blood Lead Testing

The final question in the audit looked at whether or not sampling for lead in air exposure had been carried out. The number of firms that were identified as having had either personal lead exposures or area sampling performed over the last 5 years are set out in Table 4.

Industry	**Number sampled**	**Total firms identified in audit**
Radiator Repair	13	113
Engine Reconditioning	3	121
Muffler Repair	1	100

Table 4 Premises where Air Sampling has been Conducted

Discussion

The current criteria for assessing whether or not excessive absorption of lead has occurred in the workplace is set out in the 1994 OSH publication *Guidelines for the Medical Surveillance of Lead Workers*. The relevant blood lead values are:

- 1.5 µmol/litre whole blood - all workers employed in a process where they may experience a blood lead level in excess of 1.5 µmol/litre whole blood are to be under regular surveillance until it can be demonstrated that excessive exposure is unlikely to occur.
- A worker will normally be suspended by the departmental medical practitioner where:
  - a single blood lead result is 3.2 µmol/litre whole blood or greater; or
  - three consecutive monthly estimations are 2.6 µmol/litre whole blood or above.

In Figure 2, the proportion of workers that have blood lead levels above the action or suspension levels is indicated. For the radiator repairers, 47.9% of the results were above the action level of 1.5 µmol/litre whole blood with 9.1% above the suspension level of 2.6 µmol/litre and 1.9% above the immediate suspension level of 3.2 µmol/litre.

Proportionally fewer of the engine reconditioners or the muffler repairers had blood lead levels of concern. Engine reconditioners 20.5% > 1.5 µmol/litre, 2.4% > 2.6 µmol/litre; muffler repairers 23.8% > 1.5 µmol/litre, 1.1% > 2.6 µmol/litre.

The average blood lead level for the engine reconditioners and the muffler repairers seems to have dropped over the last 5 years. This could be a consequence of the increasing use of lead free petrol. In 1987 the most dramatic fall in the amount of lead used in petrol occurred and while the rate of fall has slowed over the last 5 years, the consumption in 1993 was in the order of 40% less than that of 1989. It would seem likely that this trend will continue with more late model Japanese cars that require 91 octane lead-free petrol, and the possibility that high octane lead-free petrol will become available.

Changes in the engine reconditioning industry will have also influenced the lead exposure experienced by workers. The availability of relatively cheap second-hand engines from Japan has seen a decrease in the activity of complete engine reconditioning. Whether this has influenced the intensity of lead exposure experienced by individuals, or simply reduced the number of persons exposed is not clear. Looking at the trends in the blood lead levels for engine reconditioners and muffler repairers, it would seem that maintaining all blood lead levels below 1.5 µmol/litre whole blood would be an achievable goal.

The situation with radiator repairers is less promising. The average blood lead for the workers in the industry is close to 2 µmol/litre whole blood with no consistent indication that this is dropping (see Figures 2 and 3). It is interesting to note that there is considerable variation throughout the country. In the following table the blood lead results for the radiator repairers are set out by OSH branches with those areas with more than 4 firms identified in the audit being included.

Area	Mean Blood Lead µmol/litre Whole Blood	Range
Tauranga	1.29	0.3 - 2.85
Hamilton	1.29	0.6 - 2.7
Rotorua	1.36	0.8 - 2.85
Whangarei	1.37	0.4 - 2.65
West Auckland	1.38	0.45 - 2.15
New Plymouth	1.50	0.65 - 2.3
Wellington	1.54	0.7 - 2.5
Lower Hutt	1.63	0.95 - 2.7
Penrose	1.81	1.05 - 2.8
Christchurch South	1.83	0.85 - 2.5
Manukau City	1.85	1.0 - 3.2
Christchurch North	1.88	0.3 - 4.05

Table 5 Blood Lead Levels of Radiator Repairers by Area

There are a number of possible reasons for the variations between centres–one of the more obvious being the workload of the radiator repairers. There does seem to be an increase in the blood lead levels as you go South. This is further highlighted when the figures for the other South Island areas (that identified fewer than 4 firms in the audit) are considered.

Area	Mean Blood Lead µmol/litre Whole Blood	Range
Nelson	1.50	1.45 - 2.2
Invercargill	1.60	0.9 - 2.2
Dunedin	2.25	1.2 - 3.2

Without intending to be critical of the Southern climate, one explanation for the trend could be the difficulty in achieving effective natural ventilation in cooler weather. There is no tangible information supporting a relationship between temperature and exposure but it does seem reasonable that a building would be kept “tighter” in cool weather, resulting in elevated lead in air concentrations. The effectiveness of advice and intervention could also be an influence. Once again there is no information available that can be used to verify this.

The current biological exposure indices for lead were set in 1993. At the time these figures were set WorkSafe Australia was discussing a national standard for lead. The Australian standard(4), finally approved in September 1994, is in line with the New Zealand indices for men but it takes a much tighter line for females of reproductive capacity. The policy applied in setting New Zealand workplace exposure standards is to, where practicable, maintain consistency with Australian national figures. Considering this it is likely that next time the biological exposure indices for lead are considered they will be modified to gain consistency with the Australian standard. A comparison between the Australian levels in the Australian standard that require removal of the worker from the work process and the current New Zealand criteria is set out below (all values are in the units µmol/litre whole blood).

	New Zealand	Australian National Standard
Men	recommend suspension where: singe result is 3.2 or 3 consecutive results 2.6	Removal from the work process at 2.5
Women of reproductive capacity	Suggest that they do not work with lead. Recommended that a blood lead level less than 1.5 be maintained	Removal from the work process at 1.0
Pregnant or breast-feeding women	As above	Removal from the work process at 0.75

Table 6. Comparison Between Current Biological Exposure Indices for Blood Lead Used in New Zealand and the Suspension Levels Proposed in the Australian National Standard.

An important consideration in any programme to limit the uptake of lead at work is the training and information provided to those starting in the industry–both from the aspect of ensuring that good habits are instilled and that the early deposition of lead is kept to a minimum. In looking at the relationship between the time spent in the industry and the blood lead level, it is apparent that in some instances a very rapid increase in blood lead may occur. There were several examples where a blood lead level in excess of 1.5 µmol/litre whole blood was achieved in 2 months or less. The graphs in Figure 4 suggest that after 6 months in the industries the workers' blood lead levels have almost reached equilibrium and that after that time there is only a slow increase.

The risk associated with exposure to toxic substances is related to the intensity and period of exposure. In Figure 1, the distribution of the number of years the workers have spent in the various industries is plotted. The median is in the order of 6, but a reasonable number of workers have spent in excess of 20 years in a job where they have been exposed to lead. In any future investigation into the health status of lead workers that may be initiated by OSH, consideration should be given to the exposure history as well as the current exposure level.

Carrying out blood lead testing should not be seen as an end in itself as the blood lead level merely gives an indication of current exposure. In order to effectively minimise the risk presented by lead, the blood lead results must be used in conjunction with other information relevant to the uptake of lead with the bottom line being what is achievable, not what the status quo is. This requires knowledge of the work process and an ability to see recommended changes to the workplace and work practices instituted. In larger organisations, the company safety officer or occupational health nurse may be in a position to ensure that any changes are made but this is unlikely to be the case with smaller firms. There are encouraging signs, however, that service providers such as occupational health nursing practices are giving a value added service and not simply providing their client with the blood lead levels of the workforce.

It was interesting to note that few workplaces had seen air sampling for lead carried out. There seems to be an increasing trend towards using the blood lead results as the sole indicator of lead exposure. The biological measurement is a convenient one in that it integrates all exposures contributing to uptake - not only the contaminant that is inhaled. Air sampling can be used effectively when there is some doubt as to the relative contribution that personal hygiene and the airborne lead is having on uptake. Once again this aspect is more likely to be exploited by the larger firms that have the resources to devote to ongoing investigations. It is an activity that OSH itself could carry out in a smaller workplace in situations where the OSH officer judges that the information gained will assist in making changes that will reduce the risk of excessive lead exposure.

One of the disappointing findings of the study was the lack of ownership that the employers have taken towards monitoring their employees' exposure to lead (blood lead monitoring). This may have improved in the last year, but at 1993 there was considerable room for improvement, as demonstrated by the figures in Tables 3 and 4. It would seem that many of the employers still rely on a push from OSH to get the blood lead test done.

References

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Discussion

1. Results

These two studies investigated blood lead levels in the vehicle service industry, in particular, radiator repairers, engine reconditioners and muffler repairers. The earlier study by Keith Briggs looked specifically at engine reconditioners. It measured blood lead in 79 workers in 12 workshops noting a median blood lead of 1.7 µmols of lead per litre of whole blood (35.4 micrograms per 100 ml whole blood) and a total of 29 workers or 39% with blood lead levels of 1.9 µmol/litre whole blood or greater. (39.5 micrograms per 100 ml whole blood).

The later study by Errol Hodgkinson looks at the three vehicle service activities: radiator repairers, engine reconditioners and muffler repairers. The results indicated that radiator repairers had higher blood lead levels overall compared with the other two groups with 57% of radiator repairers above 1.5 µmol/litre of whole blood (31 micrograms/100 ml whole blood), 22.9% of engine reconditioners above 1.5 and 24.9% of muffler repairers.

Comparing engine reconditioners between the two studies is not strictly possible as the raw data is not included and different "cut-off" levels are used. 1.7 µmols for the Briggs report and 1.5 µmols for the Hodgkinson report. Even so, the table below does suggest a fall in blood lead levels between 1980 and 1992/93.

Study	PbB (µmol/litre WB)	% of workers
Briggs	1.7	35
	2.5	4
Hodgkinson	1.5	20.5
	2.6	2.4

The comparison results support one of the conclusions of Hodgkinson, namely "the average blood lead level for the engine reconditioners and the muffler repairers seems to have dropped over the last five years". He suggests as reasons the increasing use of lead-free petrol with a dramatic fall in the amount of lead used in petrol in 1987 together with changes in the engine reconditioning industry and the availability of relatively cheap second-hand engines from Japan.

With regard to radiator repairers, the situation remains hazardous with an average blood lead of 2 µmol/litre whole blood and no indication of a fall. Hodgkinson also notes the considerable variation throughout the country.

In another important comment he also notes the stricter control standards of Australia compared with New Zealand.

2. Effects

In a recent review of the occupational health risks of lead at work (1) Table 1 below, from that report, notes the lowest observed effect levels for lead-induced and related effects in adults. To convert the Australian units of microgram/dl of lead in whole blood to the New Zealand µmol/1 of lead in whole blood the following formula is used:

µg/dl divided by 20.7 = µmol/1 whole blood.

Taking the mean figure for radiator repairers reported by Hodgkinson of 2µmol/l which converts to 41mg/µg/dL, it can be seen from Table 1 that both haematological and neurological effects can occur with reduced haemoglobin synthesis and increased coproporphyrin as well as peripheral nerve dysfunction and central nervous system congnitive defects. Clinical experience with individuals in the industry confirms that mood, memory and concentration difficulties occur to workers in this industry. These symptoms not only affect the worker so exposed but have effects on the family and interpersonal relations at work and at home.

Lowest observed effect level	*Haem synthesis/ haemotological effects*	*Neurological effects*	*Renal system effects*	*Cardiovascular effects*	*Reproduction, women*	*Reproduction, men*
80-100µg/dL		Encephaolopathic signs and symptoms	Chronic nephropathy	Heart injury		Infertility ?
70µg/dL	Clinical anaemia					Testicular Dysfunction
60µg/dL		Peripheral neuropathy ↓			Pregnancy complications ↓	
50µg/dL		?				Increase in abnormal and decrease in sperm count
40µg/dL	Reduced haemoglobin synthesis Increase in coproporphyrin	Peripheral nerve dysfunction CNS cognitive effects ↓				
30µg/dL		?	Altered Vitamin D metabolism ↓	Elevated blood pressure ↓	Premature birth ↓ ↓	Chromosomal aberrations
15µg/dL	Increase in erythrocyte protoporphyrin	Altered CNS electrophysiology ↓	↓ ?	↓ ?	↓ ↓ ↓	?
10µg/dL	Inhibition in ALA-D Inhibition in Py-5-N ↓ ?	↓ ?			Deceased growth ↓ ↓ ↓ ↓ ?	
0µg/dL						

Table 1: Lowest observed effect levels for lead-induced-related effects in adults

3. Intervention With Effect - Control of Lead Hazards

The Health and Safety in Employment Act 1992 (HSE Act) outlines the hierarchy of interventions.

Where a significant hazard has been identified, the HSE Act requires that the hazard be managed by considering the following hierarchy of action:

- Elimination; then
- Isolation; and, finally
- Minimisation

Application of the hierarchy of control measures involves firstly assessing whether the use of a substance hazardous to health can be completely eliminated. Where this is not practicable, substitution is to be considered.

If elimination cannot be achieved, all practicable steps shall then be taken to isolate the substances hazardous to health. If this cannot be effectively achieved, consideration shall be given to each of the control measures – engineering controls, administrative controls, or the use of personal protective equipment.

To date, intervention in this industry has relied very much on personal monitoring of blood lead. Clearly, from the two reports presented, this is inadequate. It fails to address the cause, being content to monitor the outcome.

Control of fumes, dusts and vapours at source is critical in dealing with the predominant cause of high blood lead in this industry. The question is asked, "Can this be done for the small scale enterprise given the constraints on capital in such enterprises.?".

In the paper by Goldfield et al (2) a proposal for a cost effective radiator repair ventilation control scheme is outlined. This will be discussed in detail below.

The study was carried out on a radiator repair shop with two work stations as shown in figure 1. The source of ventilation was two 20-inch propeller fans mounted in the back wall. Environmental measurements of lead in air were not satisfactory, and in winter with the door closed there was reduced air movement. It is also well recognised that as distance from the exhaust fan increases so its effectiveness declines (at several feet it is negligible).

A decision was made to develop an exhausted enclosure which would trap the contaminated lead fume at source. Figure 2 illustrates this enclosure. The walls were constructed of a curtain of silicone coated fibreglass cloth 1.5 mm thick. This cloth had a temperature rating of 1000 degrees Fahrenheit, it would not support combustion and will not corrode. (It was observed that steel exhaust ducts and fans in the plant had a limited life possibly due to the chloride fumes used in soldering).

The curtains were hung from the ceiling with the back wall forming the back of the enclosure. The front wall (curtain) had an opening to allow the operator to work and, in addition, this space had movable strips of plastic material to further reduce the opening and in this way increase the face velocity at the opening. The original 20-inch fan was incorporated in the system. It was now possible for the radiator repairer to always use the welding flame inside this effectively exhausted enclosure.

The installation took two hours with the existing fan. The cost, even with a new back wall fan if one did not exist, was under $US1,000 (1991).

Testing of lead in air, personal breathing zone samples on the altered work site compared with the unaltered work site showed excellent results, see figure 3 and table 1.

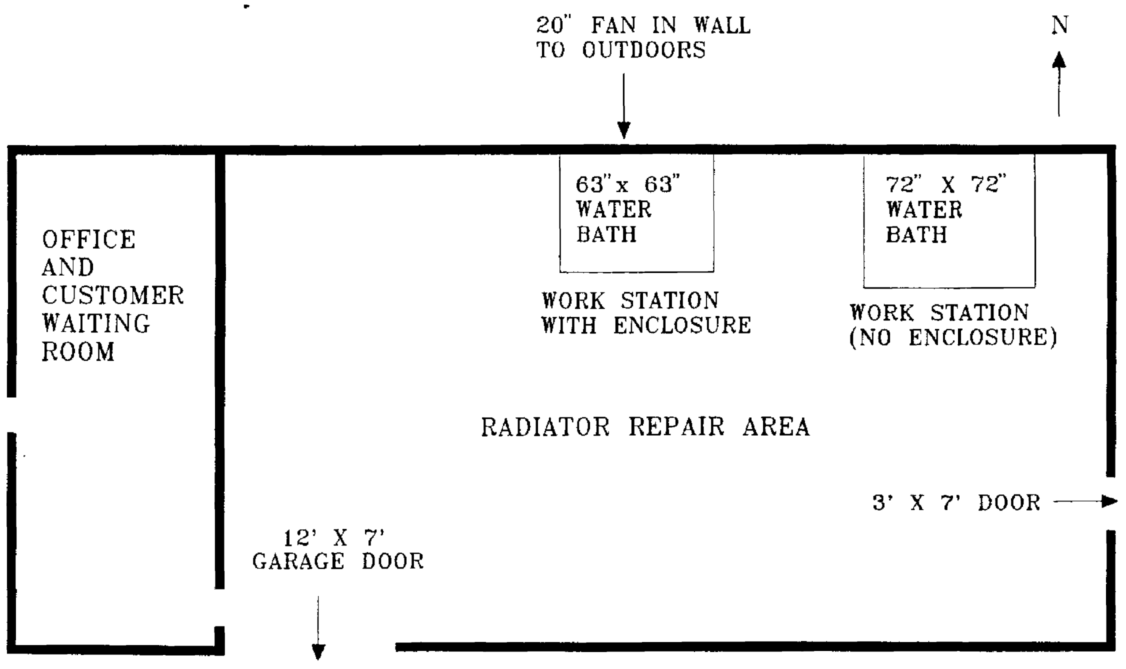

Figure 1. Layout of radiator repair workstations (not to scale).

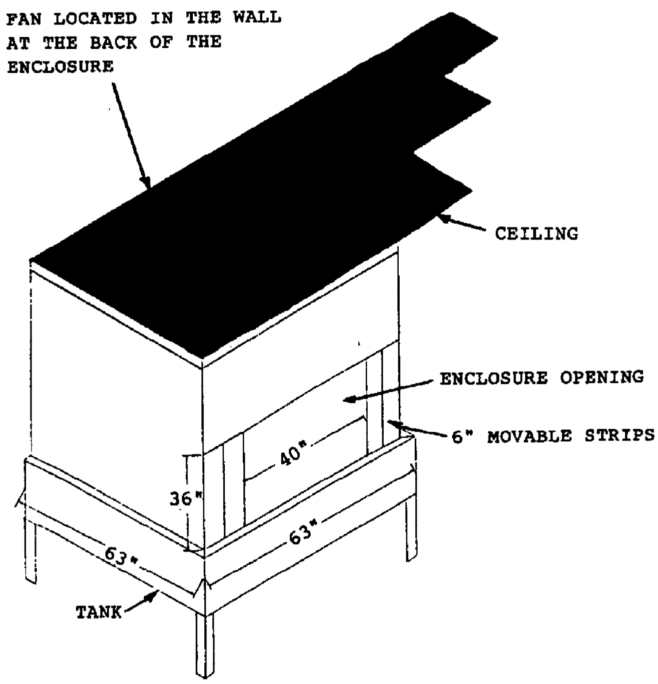

Figure 2. Schematic of ventilated enclosure.

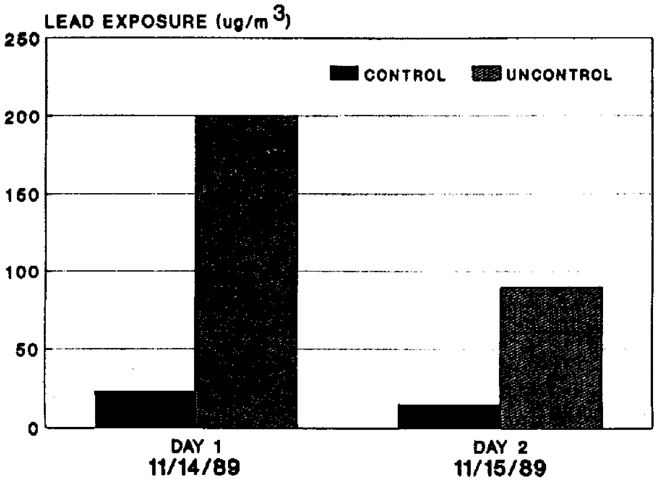

Figure 3. Comparison of TWA airborne lead exposures between controlled and uncontrolled workstations (OSHA PEL 50 µg/m³)

	Controlled Booth			Uncontrolled Tank		
	Concentration (µg/m³)	**Sample Time (min)**	**Date**	**Concentration (µg/m³)**	**Sample Time (min)**	**Date**
Both tanks in use	52.0	173	11/14	433.0	150	11/14
Only uncontrolled tank in use				247.0 680.0	83 42	11/15 11/15
Only controlled tank in use	7.1 6.8 11.0 5.6 3.9 22.5 10.4 12.3 10.1	106 37 26 72 73 68 163 46 46	11/14 11/14 11/14 11/14 11/14 11/15 11/15 11/15 11/15			
No work being done	10.7 20.8	107 156	11/14 11/15	9.5	184	11/14

Table 1. Summary of Lead Exposures

Conclusion

This example shows that control of lead hazard at source in a radiator repair shop could be achieved quickly and at a small cost. It thus solves both the problem of the lead fume and of control at source in a small workplace where costs are a major factor.

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