Heavy metal pollution among autoworkers. I. Lead

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ABSTRACT Lead pollution was evaluated in 216 individuals working in 10 garages on the Island of Funen, Denmark and related to data from biochemical and medical examinations. Clinical symptoms were recorded by means of a questionnaire. Increased blood lead levels were found in 59%, with 9% having above 80 µg lead/100 ml (3.86 µmol/l) whole blood. Mechanics in eight out of ten garages had significantly increased blood lead levels. A decrease in δ-aminolevulinic acid dehydratase (ALAD) activity was associated with increased blood lead levels but the latter were not related to haematological changes, tobacco consumption or to length of service in the trade. Particulate lead air pollution was not the sole cause of increased blood lead levels. Raised lead values were maximal among diesel engine workers who are exposed to high pressure-resistant lubricants containing lead naphthenate. As these workers complained of skin damage, lead absorption may have occurred through the skin. Assay of lead content showed 9290 ppm in gear oil and 1500-3500 ppm in used motor oils. The data are discussed in relation to the occupational risks in auto repair shops.

The use of automobiles has increased during the last 25 years and the result has been a rising number of service stations and repair shops (autoworkshops). Furthermore, in Europe there has been an increase in the use of leaded petrol. Lead present in motor exhaust gases may be one of the major sources of environmental lead pollution (Danielson, 1967; Schroeder and Tipton, 1968; Barltrop, 1969; Goyer, 1971; Hicks, 1972; Institute of Petroleum 1972; Goyer and Phyne, 1973). A population exposed to lead may have higher blood lead levels than an unexposed population (Ludwig *et al.*, 1965; Department of Public Health, California, 1967; Thomas *et al.*, 1967; Hammond, 1969).

Subjective complaints from those employed in autoworkshops (autoworkers), mainly mechanics, led us to attempt a systematic occupational and epidemiological study of this group of workers. Although it is recognised that they are exposed to various types of hazardous chemicals, priority was given to lead because of the many sources of lead in this industry, for example lead in petrol and motor exhaust gas, lead-containing lubricants and grease

(lead naphthenate), paints, and lead given off during the process of welding. Estimation of other heavy metals (cadmium, copper, chromium, nickel, manganese) described in Part II (pages 216-219).

Material and methods

EXPOSED AND CONTROL SUBJECTS

216 employees in 10 autoworkshops from the Funen area of Denmark were studied. They were divided into groups comprising 106 mechanics, 32 apprentice mechanics, 13 platesmiths and welders (metal workers) 16 painters and 49 miscellaneous workers including clerical staff, warehousemen and workmen (Table 1). Blood samples randomly collected from donors to the Blood Bank of Odense County Hospital, and laboratory personnel were used for control purposes. None of the control subjects was employed in the accumulator, garage or metal industry. These 31 men and 23 women matched the autoworkers with regard to age.

STAFF INTERVIEW AND MEDICAL EXAMINATION

The interview enabled the staff to give a detailed description of past and present occupations (including training), materials handled during their work, smoking and drinking habits and finally, their symptoms in relation to different organs. The blood

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Table 1 Classification of subjects

Subject	Total	Age group (years)
Controls		
Male	31	21-71
Female	23	21-73
Staff of autoworkshops		
Mechanics	106	17-68
Apprentice mechanics	32	16-25
Smiths and welders	13	22-63
Painters	16	16-65
Miscellaneous workers:		
Precision mechanics	1	47
Electricians	8	24-45
Greasers and service men	23	20-58
Sundry apprentices	7	16-21
Office workers:		
Male	5	28-49
Female	5	20-64

pressure was measured three times and the lowest value was recorded. The figures obtained were compared with the lower limit of 160/95 mmHg for blood pressure in hypertension (World Health Organization, 1962). This limit for hypertension corresponds well with the mean value of systolic blood pressure of 137 ± 19 mmHg in Danish men (Hagerup, 1974).

BIOCHEMICAL ASSAYS

Assay of δ -aminolevulinic acid dehydratase (ALAD) activity and lead content in whole blood and determination of δ -aminolevulinic acid (ALA) in urine have been described previously (Melgaard *et al.*, 1976a). Lead in dust and oil samples (about 30 mg) was extracted by heating them twice to 100°C for two hours with 2 ml concentrated hydrochloric acid-nitric acid (1:1) mixture. Lead in the extracts was determined by flameless atomic absorption spectrophotometry at 283.3 nm. The method of standard additions was employed to draw a standard curve. Haematological examination of blood, and serum enzyme assays were routinely carried out in the Clinical Chemistry Department at Odense Hospital.

COLLECTION AND ANALYSIS OF AIR SAMPLES
EEC-recommended equipment for the determination of ambient air pollution was used. Approximately 1000 m³ air was sucked in at various points, at a height of 2.5 m, through Whatman Glass Filter paper Type GF/A, which can retain particles over 1.5 μ m in diameter.

STATISTICAL METHODS

Because distribution of data was non-Gaussian, Wilcoxon's test (Documenta Geigy, 1962) was used to detect significant differences between groups of data. Spearman's rank correlation test (Documenta Geigy, 1962) was carried out to establish the correlation between lead and ALAD levels in blood. Groups of data are presented as mean and median values together with their 5% and 95% quartiles.

The quantitative relationship between lead and ALAD levels in blood was analysed by the 2×2 table method of Zielhuis and Verberk (1974).

Results

The heavy metal content and ALAD activity of whole blood from the control group has been previously defined (Melgaard *et al.*, 1976a). The lead content and ALAD activity in the blood of autoworkers is shown in Table 2. Figs. 1 and 2 show ALAD activity as a function of blood levels in normal subjects and autoworkers respectively. Spearman's rank analysis showed that there was a significant correlation between the lead level and ALAD activity in blood from both the groups ($P < 0.001$). The ALAD activity in the blood of autoworkers was depressed as a result of the higher blood lead levels (ALAD: 1097 ± 309 μ mol PBG/h/l RBC in control subjects and 695 ± 295 μ mol PBG/h/l RBC in autoworkers).

The lead levels in whole blood of all autoworkers was significantly higher than that of control subjects (Wilcoxon's test $P < 0.002$). The mean values were respectively 44.8 ± 22.8 μ g/100 ml (2.16 ± 1.10 μ mol/l) and 18.6 ± 9.6 μ g/100 ml (0.90 ± 0.46 μ mol/l). Nine per cent of the autoworkers had a blood lead level above the acceptable biological limit (80 μ g/100 ml, 3.86 μ mol/l). Taking mechanics as a special group, 52% showed a blood lead level significantly higher than that of control subjects ($P < 0.01$, Wilcoxon's test). Among other groups within our survey metal workers (smiths) and painters also showed significantly higher values for blood lead ($P < 0.01$, Wilcoxon's test), while the clerical staff had normal values. A comparison of median and mean values of different occupational groups is indicated in Table 2. Whereas the mean and median values of the controls were identical (within the 5% limit) both the median and the mean values of whole blood lead of mechanics was more than twice the normal mean. Blood lead levels in autoworkers were neither related to their tobacco consumption (number of tobacco years), nor to the length of their service in the trade.

Table 2 ALAD activity and lead content of blood of controls and autoworkers

Subject	ALAD activity			Lead in whole blood											
	(μmol PBG/h/l RBC)			(μg/100 ml)						(μmol/litre)					
	Mean	SD*	SE	Mean	SD*	SE	Median	5%Q	95%Q	Mean	SD*	SE	Median	5%Q	95%Q
Normal:															
Men	976	±52	±288	23.4	±1.7	±9.4	24.2	9.5	28.5	1.1	±0.1	±0.5	1.2	0.5	1.4
	(452-1282)			(11.5-46.0)						(0.6-2.2)					
Women	1189	±77	±368	12.1	±1.1	±5.2	12.5	7.5	22.3	0.6	±0.1	±0.3	0.6	0.4	1.1
	(670-1713)			(2.5-32.0)						(0.1-1.5)					
Mean of both sexes	1079	±309		18.6			20.5	7.2	29.6	0.90			1.0	0.3	1.4
				±9.6						±0.5					
Autoworkers:															
(all)	695	±295		44.8	±22.8		29.5	13.0	87.0	2.2	±1.1		1.4	0.6	4.2
				(2.4-125)						(0.1-6.0)					
Mechanics				44.6	±29.8		41.0	11.1	81.5	2.2	±1.4		2.0	0.5	3.9
				(11.0-125)						(0.5-6.0)					
Apprentice mechanics				40.0	±25.6		31.4	13.5	72.0	1.9	±1.2		1.5	0.7	3.5
				(5.0-78)						(0.2-3.8)					
Smiths				38.3	±19.1		34.8	3.9	53.0	1.9	±0.9		1.7	0.2	2.6
				(2.4-89.0)						(0.1-4.3)					
Painters				42.8	±22.3		32.7	10.8	92.5	2.1	±1.1		1.6	0.5	4.5
				(8.1-97.5)						(0.4-4.7)					
Miscellaneous workers				42.0	±17.2		37.7	13.5	83.0	2.0	±0.8		1.8	0.7	4.0
				(13.0-92.5)						(0.6-4.5)					

Range in parentheses
SD* values are only indicative because of non-Gaussian distribution. Q = quartile

Fig. 1 Relationship between lead in whole blood and ALAD activity in normal subjects. (n = 57; Spearman's correlation coefficient $r = 0.4694$; $P < 0.001$).

Fig. 2 The relationship between lead in whole blood and ALAD activity in workers at garages (auto repairshops). (n = 96; Spearman's correlation coefficient $r = 0.7850$; $P < 0.001$).

Table 3 Lead content in the air of various workshops

Workshops	Total no. of samples	Dust content ($\mu\text{g}/\text{m}^3$ air)	Lead content ($\mu\text{g}/\text{m}^3$ air)
Autoworkshops	17	119.8 $\pm$ 47.6 (54.6-234.6)	3.19 $\pm$ 2.29 (0.2-9.2)
Plate workshop	4	367.5 $\pm$ 165.5 (224.0-642.0)	3.8 $\pm$ 0.95 (2.4-5.1)
Paint workshops	3	378.5 2995.0 123.6	2.7 35.5 0.9
Outside the workshops	8	76.8 $\pm$ 49.9 (29.3-185.5)	0.9 $\pm$ 0.7 (0.2-2.2)

Range in parentheses

The comparison of mean blood lead levels of mechanics in the ten different garages, showed that the workers in eight of these garages had significantly increased mean blood lead levels. The two workshops with normal mean lead levels were a state-owned bus repairing workshop and a small privately owned firm.

Table 3 shows dust and particulate lead content in the air in various rooms and in the ambient air outside the workshops. Variation in the amount of dust as well as in lead content was observed in the air of different workshops.

The lead burden may also originate from petrol, gear oils, grease and lubricants, from skin absorption; oils used in the autoworkshops were therefore assayed for their lead content. Table 4 shows the

lead concentration in some used and unused oils employed in the autoworkshops. Gear oil was found to contain 9280 ppm lead and various used motor oils contained between 1500 and 3500 ppm lead.

Abnormal haematological findings among autoworkers (Table 5) were more often encountered among mechanics and their apprentices. Abnormal haematological findings were in a few cases related to high lead levels in the blood. None of the autoworkers had an erythrocyte count or haemoglobin concentration which was abnormal.

High blood pressure (over 160/95) was found in 37% of the mechanics, 7% apprentice mechanics and 18% of the miscellaneous workers. Fourteen per cent of mechanics showed increased serum bilirubin and thymol reaction and 11% of mechanics had raised serum ALT (alanine aminotransferase; SGPT), serum AsT (aspartate aminotransferase; SGOT) and lactate dehydrogenase enzyme levels in the serum. Twelve per cent of mechanics and 9% of apprentice mechanics had raised serum alkaline phosphatase levels. A few workers in other groups also had these abnormalities.

Thirty-seven per cent of autoworkers had urinary ALA levels between 4.5-10 mg/l (34.33-76.3 $\mu\text{mol}/\text{l}$), 10% above 10 mg/l and the remainder below 4.5 mg/l. Four autoworkers had a reduced blood leucocyte count.

Autoworkers' symptoms are shown in Table 6. Symptoms relating to the central nervous system were encountered more often among painters than in metal workers (smiths, plate fitters and welders), mechanics or their apprentices. Twenty-nine per cent of the mechanics complained of skin rash on the arms and hands. Only a few had tremor of the hands and digital paraesthesiae. The relationship between high blood lead levels and skin rash is shown in Table 7. As raised serum transaminase attributable to increased lead burden has been reported (de Bruin, 1971), Table 7 relates transaminase to blood lead levels. Only 14% and 2% of the auto-

Table 4 Lead content* of various unused and used oils

Unused oils		Lead content (ppm)	
Oil type			
Mobil Oil 46-SAE-90 Gear oil		9279.6	
Motor Oil Motor cleaner		18.7	
Motor Oil FK Tyre cleaner		11.0	
Mobil Oil Super 10 W 50		14.9	
Mobil Oil Special Oil 10-SAE-40		4.6	
Mobil Oil code No. 80-90		6.2	
Mobil Oil code No. 2023		9.3	
Melkylen cleaner Perfection A/S		13.3	
Brake-washing oil		2.1	
Hydraulic Oil (Mobil Oil)			
Lockheed Brake Oil Univ. Series 329S		24.5	
Used oils		Lead content (ppm)	
Car type	Oil used	Motor driven (km)	
Ford Cortina 1969	Gulf Multi-G 20-50	1700	2632.3
Renault 4, 1973	Chevron (type ?)	2600	2423.0
Mascot 1965	Mobil Special SAE 10 W 50	4000	1876.5
Datsun 1973	Mobil Special SAE 10 W 50	1600	1455.6
Ford Taunus 1300 1971	Esso Uniflow SAE 10 W 50	4500	3437.8
Volvo 142, 1973	Shell Spiras Gear Oil HD 80	5500	696.5

* = assayed in triplicate

Table 5 *Relation between lead content and abnormal haematological findings in whole blood of autorepair workers*

Blood No.	Occupation	Haematocrit	MCV	MCH	Hb	Pb	
		(%)	(fl)	(pg)	(g/dl)	(μ g/100 ml)	(μ mol/l)
BN 7380	Automechanic	n	n	l	n	38.0	1.84
BN 7379	"	l	l	l	n	12.0	0.58
BN 7384	"	l	n	l	n	not done	—
BN 7225	"	l	n	l	n	45.0	2.17
BN 7268	"	l	n	n	n	27.0	1.30
BN 7266	"	l	n	n	n	34.0	1.64
BN 7287	"	l	n	n	n	27.0	1.30
BN 7288	"	n	l	l	n	19.5	0.94
BN 7333	"	l	n	n	n	39.5	1.91
BN 7319	"	l	n	n	n	7.1	0.34
BN 7337	"	n	n	l	n	56.0	2.71
BN 7335	"	n	n	l	n	not done	—
AJ 6035	"	n	n	l	n	not done	—
BN 7388	Apprentice automechanics	l	n	n	n	50.0	2.42
BN 7296	"	"	n	n	n	14.0	0.68
BN 7292	"	l	n	n	l	28.5	1.38
BN 7295	"	l	n	n	n	24.0	1.16
BN 7299	"	l	n	n	n	20.9	1.01
BN 7308	"	n	l	l	n	27.0	1.30
BN 7335	"	n	n	n	l	not done	—
AJ 5756	"	n	n	l	n	24.5	1.18
AJ 5780	"	n	n	l	n	not done	—
BN 7291	Sundry workers	l	n	l	l	20.0	0.97
BN 7278	" "	n	l	l	n	26.0	1.26
BN 7371	" "	n	l	l	n	30.0	1.45
BN 7315	" "	l	l	l	n	68.0	3.28
Range of normal values		40-52	81-109	28-35	12.6-16.8	11.5-46.0	0.6-2.2
n = normal							
l = lower than lower normal range							

Table 6 *Occurrence of subjective symptoms among autoworkshop workers*

Symptom		Mechanics	Apprentice mechanics	Smiths	Painters	Miscellaneous workers*
Nervous						
Daily giddiness	Morning	3 (3%)	0	2 (15%)	2 (13%)	5
	Evening	6 (6%)	0	0	0	1
Daily headache	Morning	13 (14%)	0	2 (15%)	5 (33%)	10
	Evening	19 (20%)	4 (13%)	1 (8%)	5 (33%)	4
Tremor in hands		10 (11%)	5 (17%)	0	2 (13%)	1
Reduced muscle power		0	0	0	0	0
Muscular spasm		4 (4%)	1 (4%)	0	0	1
Nausea		3 (3%)	0	0	0	2
Gastrointestinal:						
Daily stomach pain		8 (8%)	2 (7%)	2 (15%)	1 (7%)	7
Constipation		0	0	0	0	0
Loss of appetite		0	0	2 (15%)	0	0
Weight loss		0	0	0	0	0
Weakness		0	0	0	0	0
Dermatological:						
Rash on hands and arms		28 (29%)	4 (13%)	2 (15%)	2 (13%)	8
Rash on face		9 (10%)	5 (17%)	0	0	3
Various:						
Impotence		0	0	1 (8%)	0	0
Rheumatic pain		14 (15%)	0	3 (23%)	0	6

* Percentages not shown because of diversity of workers in this group

mechanics with high blood lead levels showed altered AIT and AsT levels respectively.

No other signs of lead poisoning such as reticulocytosis and increased basophil cells in the peripheral blood were observed. There was no lead deposition in the gum margins in the mouth.

Discussion

The risk factors for employees in autoworkshops depend upon the site and type of work. Potential sources of lead pollution are automobile exhaust gas, welding, and lead-containing grease and petrol

Table 7 Relationship between blood lead level, skin rash and serum transaminase activity in automechanics

Workshop†	Blood lead		Skin rash	Hand tremor	Digital paraesthesia	Serum transaminases	
	($\mu\text{g}/100\text{ ml}$)	($\mu\text{mol/l}$)				AsT	ALT
I	81.5	3.94				n	*
	78.0	3.77	×			n	n
	53.0	2.56		×		n	n
	45.0	2.17				n	n
	48.0	2.32			×	n	n
	66.0	3.19				n	n
	60.0	2.90	×	×		n	*
	83.0	4.01				n	n
II	91.0	4.40	×		×	n	n
	125.0	6.04	×			n	*
	80.0	3.86				n	n
	43.0	2.08	×			n	n
	52.0	2.51	×			n	n
	72.0	3.48	×			n	n
	44.0	2.13	×			n	n
	45.0	2.17	×			n	n
IV	43.5	2.10	×	×		n	n
	51.5	2.49	×	×		n	n
	47.5	2.29	×			n	n
	56.0	2.71	×			n	n
V	70.0	3.38	×			n	n
	56.0	2.71	×			n	n
	62.5	3.02				n	n
	56.0	2.71	×			n	n
VI	77.0	3.72				n	n
	49.5	2.39				n	n
	not done					*	*
	not done					n	*
VII	53.6	2.59				n	n
	61.0	2.95				n	n
	54.0	2.61	×		×	n	n
	41.0	1.98				n	n
	89.0	4.23			×	n	n
	52.5	2.54				n	n
	68.0	3.28	×			n	n
	56.5	2.73				n	n
VIII	45.0	2.14				n	n
	49.5	2.39				n	n
	57.5	2.78			sometimes	n	n
	48.5	2.34				n	*
X	63.0	3.04	×	×		n	n
	83.0	4.01	×	×		n	n
	50.0	2.42	×			n	n
	45.0	2.17				n	n

†; workers in workshops III and IX had normal blood lead levels

× = sign is present

n = normal

* = high

ALT = alanine aminotransferase (GPT)

AsT = aspartate aminotransferase (GOT)

penetrating the skin. In eight out of ten workshops autoworkers were found to have blood lead levels significantly higher than the mean for controls. Overall, 59% of the autoworkers had a mean blood lead level higher than the mean of the control subjects. Nine per cent of the autoworkers were found to have a blood lead level above the acceptable limit of $80\text{ }\mu\text{g}/100\text{ ml}$, $3.86\text{ }\mu\text{mol/l}$ (Kehoe, 1971). Garage mechanics have previously been shown to have a mean blood lead level of $38\text{ }\mu\text{g}/100\text{ ml}$, $1.84\text{ }\mu\text{mol/l}$ (Hammond, 1969), which is in close agreement with our data.

Airborne particles of over $1.5\text{ }\mu$ in diameter were collected on filters and represent a major portion of particulate lead pollution due to motor

exhausts (Nozaki, 1966; Stankovic, 1971).

The lead content of air samples collected outside the workshops was much less than that of the air in various rooms (Table 3). Nevertheless the lead pollution of the workshop air could not alone explain the high blood lead levels observed among autoworkers. Assuming that the airborne lead is maximally $5\text{ }\mu\text{g}/\text{m}^3$ in the workshop, according to Blokner (1970) a worker will inhale about $34\text{ }\mu\text{g}$ lead/day, of which 40% will be absorbed. All other factors being constant, this will give a 100% rise in the blood lead values compared to the normals (approx. $40\text{ }\mu\text{g}/100\text{ ml}$, $1.93\text{ }\mu\text{mol/l}$). However, the blood lead level in many mechanics exceeded $40\text{ }\mu\text{g}/100\text{ ml}$. An indirect method of evaluating

blood lead levels in mechanics would be the application of Danielson's formula (1967) which relates lead in whole blood to lead absorbed over a 24-hour period. In order to reach a whole blood lead level of $50 \mu\text{g}/100 \text{ ml}$ ($2.42 \mu\text{mol/l}$), the lead intake per day will be $150 \mu\text{g}$. Assuming that the tidal air is 500 ml air, 150 ml of which is the dead space, and that respiration occurs 20 times a minute during an eight-hour period of work, the intake will be approximately $0.35 \times 20 \times 60 \times 8 = 3370 \text{ l}$ air, or 3.37 m^3 . Thus, with a blood lead level of $50 \mu\text{g}/100 \text{ ml}$ ($2.42 \mu\text{mol/l}$), the working room air should contain approximately $45 \mu\text{g}/\text{m}^3$ lead, which is higher than the levels found in the present study. It is therefore reasonable to assume that high blood lead levels among the mechanics are not due to airborne lead alone. Among other potential sources, organic lead derivatives which are added to petrol as anti-knock agents (tri- and tetraethyl lead) or to lubricating oils and greases (lead naphthenate) may be considered. Lack of sufficient protection might allow organic lead to be taken up by the body through direct skin contact. Inadequate protection of workers cleaning storage tanks in which leaded fuel had been stored, resulted in high blood lead levels (Beattie *et al.*, 1972). Among workers using tetraethyl lead, 60% have been shown to have blood lead levels of $30\text{--}50 \mu\text{g}/100 \text{ ml}$ ($1.45\text{--}2.42 \mu\text{mol/l}$) (Robinson, 1976). Lead naphthenate may be absorbed through the skin giving rise to high lead values in workers who are using lubricants and greases, and gear oils (Van Peteghem and De Vos, 1974). Cutaneous application of lead naphthenate solution has been found to produce chronic lead toxicity in rats (Rastogi *et al.*, 1976). In the present investigation, high levels of blood lead (mean $57.4 \mu\text{g}/100 \text{ ml}$, $2.77 \mu\text{mol/l}$) were found in mechanics, especially in the workshops where diesel engines were repaired. Thus a rash on the arms of 29% of mechanics, due to the defatting effect of mineral oil and petrol may in part give rise to lead absorption from petrol, lubricants and greases. Workers in one of the shops admitted that lubricants containing lead naphthenate were used for cleaning hands. These oils effectively removed carbon particles probably due to their detergent content. In none of the workshops was any mention made of the risk incurred in using these oils.

A significant correlation between an increase in blood lead levels and ALAD activity was found in the present study. The blood lead levels in control subjects were found to be in agreement with the findings in a normal Danish and Swedish population (Grandjean, 1973; Haeger-Aronsen *et al.*, 1974) and the higher lead values with lower ALAD activity in blood were parallel to those values found by

Haeger-Aronsen *et al.*, (1974) among accumulator workers. Our data also confirm that a low ALAD activity is a sensitive indicator of lead absorption. We were unable to confirm the theory advanced by Kehoe (1971) that the determination of ALAD activity was not a positive indicator of lead exposure.

Table 8 shows the validity of the correlation between ALAD activity and the lead level in whole blood calculated according to Zielhuis and Verberk (1974). It is evident that at all the chosen limit values,

Table 8 Relationship between increased lead level and depressed ALAD activity in whole blood*

	Lead level		
	> 40 $\mu\text{g}\%$ (1.93 $\mu\text{mol/l}$)	> 60 $\mu\text{g}\%$ (2.9 $\mu\text{mol/l}$)	> 80 $\mu\text{g}\%$ (3.86 $\mu\text{mol/l}$)
Sensitivity	1.00	0.75	0.33
Specificity	0.63	0.91	0.96
Validity	1.63	1.66	1.29

*Zielhuis and Verberk, 1974.

validity = sensitivity + specificity > 1, meaning that a positive correlation exists between the two functions. It can be noticed that at the limit value of $80 \mu\text{g}/100 \text{ ml}$ ($3.86 \mu\text{mol/l}$) (Kehoe, 1965) high specificity and low sensitivity are revealed. Thus ALAD activity in blood is a more relevant marker for blood lead levels at the limits 40 or $60 \mu\text{g}/100 \text{ ml}$ ($1.93\text{--}2.90 \mu\text{mol/l}$) compared to $80 \mu\text{g}/100 \text{ ml}$ ($3.86 \mu\text{mol/l}$). The validity of selecting the following limits: $40 \mu\text{g}/100 \text{ ml}$ ($1.93 \mu\text{mol/l}$) lead and 50% decrease in ALAD activity as differential limits for intoxication is similar to that described by Zielhuis and Verberk (1974).

None of the workers showed any signs of anaemia similar to those found by McCallum *et al.* (1968) in workers in shipbreaking yards. Kehoe (1965) mentioned that no clinical symptoms were seen below blood lead levels of $80 \mu\text{g}/100 \text{ ml}$ and this is in agreement with the present study.

There is a relatively low incidence of rheumatic complaints (15%) among the workers. Complaints related to the central nervous system may be due to heavy lead load (Carson *et al.*, 1974), possibly as a result of working with organic lead derivatives (Frost and Myschetzky, 1969); Lansdown *et al.*, 1974; Konat and Clausen, 1974; Melgaard *et al.*, 1976a and b). However, dizziness and headaches may also be due to organic solvents such as hexane. It is not possible to interpret more fully the significance of hypertension among 37% of the people interviewed in the present study without a closer clinical investigation. The percentage of hypertension was comparatively high among the young workers, as Hagerup (1974) found hyper-

tension in a normal Danish population in only 21% of the individuals studied.

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