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SIMS RADIATOR SHOP
DECATUR, GEORGIA

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## I. SUMMARY

In May l989, the National Institute for Occupational Safety and Health (NIOSH) received a request from Sims Radiator Shop located in Decatur, Georgia to: 1) evaluate occupational exposures to lead during the cleaning and repair of automobile and commercial radiators, and 2) assist with the design and implementation of a complete environmental and medical monitoring program meeting the Occupational Safety and Health Administration's (OSHA's) lead standard.

On May 3l, l989, NIOSH conducted an environmental and medical evaluation. The environmental evaluation consisted of: 1) collecting personal breathing zone (PBZ) air samples to determine the concentrations of airborne lead among 4 employees repairing radiators, 2) collecting 2 general air samples, 3) observing work practices, and 3) observing the overall room ventilation. The medical evaluation consisted of a self-administered questionnaire, a medical and occupational history, a limited physical examination, and blood lead level and free erythrocyte protoporphyrin (FEP) concentration.

The 8-hour time-weighted average (TWA) PBZ concentrations of lead for 4 radiator mechanics were 50, 30, 20, and 10 micrograms per cubic meter (ug/$M^3$). Although sampling was not conducted for the full 8-hours of the workshift, the concentrations measured should closely approximate 8-hour TWA exposures based on the uniformity of the work activities performed over the shift. One of these 4 concentrations are at or above OSHA's Permissible Exposure Limit (PEL) of 50 ug/$M^3$ as an 8-hour TWA. The lack of any general room or local ventilation appeared to be responsible for the elevated PBZ lead concentrations.

All seven employees of the shop (5 mechanics and 2 delivery employees) participated in the medical evaluation. The blood lead levels of the 5 radiator mechanics were 64, 46, 30, 28, and 23 micrograms per deciliter (ug/dl); the blood lead levels of the 2 delivery personnel were 17 and 18 ug/dl. One mechanic had a blood lead level over 40 ug/dl (the level at which the OSHA lead standard requires blood lead testing every two months), and another mechanic had a blood lead level over 50 ug/dl (the level at which the OSHA standard requires removal from the area where the airborne lead exceeds the action level (30 ug/$M^3$). Both employees with elevated blood lead levels also had elevated FEP levels (155 and 70 ug/dl). None of the 7 shop employees reported symptoms or had physical findings suggestive of lead poisoning.

This shop was not conducting activities specified by OSHA's lead standard (exposure monitoring, respiratory protection, housekeeping, hygiene practices, providing clothing, medical surveillance, and a written compliance program).

On the basis of the environmental and medical data, a health hazard existed from over-exposures to lead during the routine cleaning and repairing of radiators. Recommendations are provided in Section VIII of this report that will assist in eliminating this hazard.

Keywords: SIC 3714 (motor vehicle parts and accessories), radiator shops, lead, inorganic lead, blood lead, free erythrocyte protoporphyrin, FEP.

## II. INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request in May 1989 from Sims Radiator Shop located in Dacatur, Georgia to evaluate occupational exposures to lead during the cleaning and repair of automobile and commercial radiators. In addition to evaluating employees' lead exposure, the owner requested assistance in developing an environmental and medical program in order to comply with the Occupational Safety and Health Administration's (OSHA's) lead standard.[1]

The facility owner was informed of the environmental results by telephone in June, l989. Results and interpretation of individual blood lead tests were mailed to participating employees in June, 1989.

## III. BACKGROUND

### A. Process Description

This shop cleans and repairs automobile and truck radiators. Delivery employees drop off radiators needing repair to the shop which, are then soaked in an alkaline bath (sodium hydroxide) for approximately 30 minutes to remove corrosion. After removal from the bath, the radiators are checked for "cooling flow" by forcing air through the coils at high pressure while they are submerged in water. If "cooling flow" is restricted, the radiator's top is removed and the internal coils are individually purged. The radiator's top is removed using a gas torch which melts the lead-based solder holding the top to the radiator's metal casing. This torch (compressed air and propane) heats the solder (65% lead, 35% tin) to approximately 1500ºF; this produces lead fume. Once the internal coils are cleaned, the radiator's top is once again soldered to its metal casing. Only radiators needing this cleaning procedure (purging the internal coils to allow adequate "cooling flow") result in potential airborne lead exposure. This shop processes approximately 30 radiators per day, with approximately 10 requiring internal coil purging.

Some newer car models, particularly the foreign imports, utilize plastic radiators. Removing the top portion of plastic radiators does not require the melting or application of solder; therefore, the potential for lead exposure does not exist. Of the 30 radiators this shop processes per day, approximately 2 or 3 are made of plastic.

### B. Workforce

At the time of this evaluation Sims Radiator Shop in Chamblee, Georgia employed 7 people: 4 radiator mechanics, 1 shop manager, and 2 delivery employees. Although the shop manager administer the business from the front of the building, he also frequently assists the mechanics with repairs.

## IV. EVALUATION DESIGN AND METHODS

### A. Environmental

Four breathing zone air samples were collected using mixed cellulose ester filters (AA) and vacuum pumps operated at 2.0 liters per minute. The samples were analyzed for lead according to NIOSH Phyical and Chemical Analytic Methods (P&CAM l73).[2]

### B. Medical

All 7 shop employees (5 radiator mechanics which included the shop manager, and the 2 delivery employees) were invited to participate in the survey. The study consisted of: 1) a medical and occupational history, 2) an examination of the gums for the presence of a "lead line", 3) blood analysis for lead and free erythrocyte protoporphyrin (FEP), and 4) a self-administered questionnaire. The questionnaire was designed to gather demographic information and identify symptoms associated with lead poisoning. The blood was analyzed in one of the OSHA approved laboratories for blood lead analysis based on proficiency testing.[3] Blood lead was analyzed by anodic stripping voltimetry, and FEP was determined by photofluorometric techniques.[4]

## V. EVALUATION CRITERIA

### A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. However, not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH criteria documents and recommendations, (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and (3) the U.S. Department of Labor (OSHA) occupational safety and health standards. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits

(STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Toxicology and Medical Criteria

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in the industrial setting. A secondary source of lead exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead interferes with red blood cell production and can damage the kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women. There is some evidence that lead can also impair fertility in occupationally exposed men.[5]

The blood lead test is one measure of the amount of lead in the body and is the best available measure of recent lead absorption. Adults not occupationally exposed usually have a blood lead concentration less than 30 ug/dl; the average is less than l5 ug/dl.[6,7] In l985, the Centers for Disease Control (CDC) recommended 25 ug/dl as the highest acceptable blood level for young children.[8] Since the blood lead concentration of a fetus is similar to that of its mother, and since the fetus's brain is presumed to be at least as sensitive to the effect of lead as a child's, the CDC advised that a pregnant woman's blood level be below 25 ug/dl.[8] Recent evidence suggests that the fetus may be adversely affected at blood lead concentrations well below 25 ug/dl.[9] Furthermore, there is evidence to suggest that levels as low as l0.4 ug/dl affect the performance of children on educational attainment test, and that there is a dose-response relationship with no evidence of a threshold or safe level.[10-12] Lead levels between 40-60 ug/dl in lead exposed workers indicate excessive absorption of lead and may result in some adverse health effects; levels of 60-100 ug/dl represent unacceptable elevations which may cause serious adverse health effects (Table 1). Levels over l00 ug/dl are considered to be extremely dangerous and often require hospitalization and medical treatment.
The OSHA standard for lead in air is 50 ug/$M^3$ calculated as an 8-hour time weighted average for daily exposure.[1] Blood lead and zinc protoporphyrin levels must be monitored at least every 6 months for workers exposed to air lead levels above 30 ug/$M^3$ for more than 30 days per year, and at least every 2 months if the workers' last blood lead was at or exceeded 40 ug/dl whole blood. The standard also dictates that workers with blood lead levels greater that 60 ug/dl whole blood must be immediately removed from further lead exposure if confirmed by a follow-up test. Workers with average lead levels of 50 ug/dl or greater must be removed. Removal is also possible on medical grounds. Removed workers have protection for wage, benefits, and seniority for up to l8 months or until they can return to lead exposure areas.[1]

The free erythrocyte protoporphyrin (FEP) and zinc protoporphyrin (ZPP) levels are measures of interference with hemoglobin production at the time the red cells are made. Although some diseases and iron deficiency anemia can cause a rise in FEP or ZPP, in a healthy individual working with lead, lead absorption is the most likely cause for such an increase. Further, the FEP or ZPP levels increase abruptly when blood lead levels reach about 40 ug/dl, and they tend to stay elevated for 3-4 months (the average life span of a red blood cell). Normal values are below 50 ug/dl.[13]

The OSHA lead standard requires air monitoring for lead every 6 months if the initial air monitoring is above the action level (30 ug/$M^3$), and every 3 months if the initial air monitoring is above the PEL (50 ug/$M^3$). In addition, the OSHA lead standard requires blood monitoring for lead every 6 months if an employee is exposed to airborne lead above the action level for more than 30 days per year. If the blood lead level is above 40 ug/dl, a blood lead test needs to be performed every 2 months. If a blood lead concentration

averages 50 ug/dl or more, the affected employee must be removed from further exposure and monthly blood lead tests performed until the level drops below 40 ug/dl.

## VI. RESULTS AND DISCUSSION

### A. Environmental

#### 1. Air Samples

Results of the environmental samples for inorganic lead are presented in Table 2. One of the 5 employees who repaired radiators had lead exposures at or above OSHA's PEL of 50 ug/$M^3$ as an 8-hour TWA. Although sampling was not conducted for the full 8-hours of the workshift, the concentrations measured should closely approximate 8-hour TWA exposures based on the uniformity of the work activities performed over the shift. One of the 2 general area samples was also above OSHA's PEL and NIOSH's REL of 50 ug/$M^3$ as an 8-hour TWA.

#### 2. Ventilation

Although not measured in a quantitative manner, this shop did not have any general room or local exhaust ventilation. During NIOSH's survey the shop's doors were kept, open providing fresh air; however, these doors were reportedly closed during the winter months.

#### 3. Hygiene and Housekeeping

Lead ingestion could also be occurring from poor workplace hygiene (smoking, drinking, and eating in the work area), all three of which were noted during NIOSH's survey.

### B. Medical

#### 1. Blood Lead Tests

The blood lead and the FEP levels for the 7 shop employees are listed in Table 3. The mean blood lead level was higher among the radiator mechanics (38 ug/dl) than among the delivery employees (18 ug/dl), but this difference was not statistically significant [(t-test, p=0.16) Table 3)]. One of the 5 radiator mechanics had a blood lead level above 40 ug/dl (the level at which the OSHA standard requires monitoring the blood lead every 2 months), and another mechanic had a blood lead level over 50 ug/dl [(the level at which the OSHA standard requires removal from the area where the airborne lead exceeds the action level (30 ug/$M^3$)].. Both employees with elevated blood lead levels also had elevated FEP levels (155 and 70 ug/dl). (Table 3)

#### 2. Symptoms and Physical Findings

None of the 7 shop employees reported symptoms suggestive of lead poisoning. None of the 7 employees had a lead line on their gums.

## VII. CONCLUSION

On the basis of the environmental and medical data, a health hazard existed from over-exposures to lead during the

routine cleaning and repairing of radiators. This shop was conducting certain activities specified by OSHA's lead standard (exposure monitoring, respiratory protection, housekeeping, hygiene practices, providing clothing, medical surveillance, and a written compliance program). Recommendations are provided in the following section to prevent lead over-exposures, and develop an environmental and medical program in compliance with OSHA's lead standard.[1]

## VIII. RECOMMENDATIONS

To ensure that workers are adequately protected from the adverse effects of lead, a comprehensive program of prevention and surveillance is needed. The guidelines for such a program are presented in the OSHA lead standard.[1] In addition to specifying a PEL for airborne lead, the OSHA lead standard also contains specific provisions dealing with mechanical ventilation, respirator usage, protective clothing, housekeeping, hygiene facilities, employee training, and medical monitoring.[1] The implementation of the provisions of this standard will help to ensure that the employees are protected against any potential adverse health effects of lead exposure.

A copy of the OSHA lead standard accompanies this report. To assist the employer in implementing the standard's key provisions, a brief overview as they relate to the findings of this survey follow:

1. This radiator shop should install a local exhaust ventilation system at the source of lead fume generation. Ventilation needs to be installed in the immediate area where the torch is used for melting the top off the radiators. This ventilation would capture the lead fumes before they mix with the general room air.

2. All workers repairing radiators should have their blood drawn and analyzed for lead and ZPP content every 6 months. If the blood lead level is above 40 ug/dl, a blood lead test needs to be performed every 2 months. If a blood lead concentration averages 50 ug/dl or more, the affected employee must be removed from further exposure until the blood lead level drops below 40 ug/dl.

3. There should be no smoking, eating, tobacco chewing, or drinking in the radiator repair area.

4. Workers should shower and change from work clothes to street clothes after their tour of duty.

5. Workers removed from exposure for elevated blood lead or lead-related illness should have protection for wage, benefits, and seniority for up to l8 months or until they can return to lead exposure areas.

6. Given that our environmental monitoring found lead levels above OSHA's PEL, environmental monitoring needs to be conducted quarterly until at least two consecutive measurements, taken seven days apart, are below the PEL.

## IX. REFERENCES


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## XI. Distribution and Availability of Determination Report

Copies of this Determination Report are temporarily available upon request from NIOSH, Hazard Evaluation and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), 5285 Port Royal, Springfield, Virginia 22l6l. Information regarding its availability through NTIS can be obtained from the NIOSH publications office at the Cincinnati, address. Copies of this report have been sent to:

A. Sims Radiator Shop, Decatur, Georgia
B. Mr. Alan Sims
C. NIOSH Regional Offices/Divisions
D. U.S. Department of Labor, OSHA-Region lV.

For the purposes of informing the affected employees, copies of this report must be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

TABLE 1

Lowest Blood Lead Levels Reported To Cause Health Effects In Adults

| Blood Lead Level | Health Effect |
|---|---|
| 100-120 ug/dl | Cental Nervous System Toxicity (Encephalopathy) |
| 100 ug/dl | Chronic Renal Damage |
| 80 ug/dl | Low Blood Count (Anemia) |
| 60 ug/dl | Pregnancy Complications |
| 50 ug/dl | Decrease Hemoglobin Production<br>Mild Central Nervous System symptoms |
| 40 ug/dl | Decrease Peripheral Nerve Conduction<br>Pre-term Delivery |
| 30 ug/dl | High Blood Pressure |

TABLE 2

PERSONAL BREATHING ZONE AND GENERAL AREA LEAD CONCENTRATIONS
Sims Radiator, Decatur, Georgia
May 31, 1989

| Sample Number | Job/Location | Sampling Time | ug/M3 **Lead** |
|---|---|---|---|
| **l** | **Radiator Mechanic** | **9:08-3:30** | **50** |
| **2** | **Radiator Mechanic** | **9:10-3:35** | **30** |
| **3** | **Radiator Mechanic** | **9:12-3:15** | **20** |
| **4** | **Radiator Mechanic/Manager** | **9:14-3:30** | **10** |
| **5** | **Mechanic Bench** | **9:15-3:30** | **90** |
| **6** | **Entrance to Mechanic Area** | **9:20-3:20** | **20** |

| | |
|---|---|
| **Evaluation Criteria** | **50 ug/M$^3$** |
| **Laboratory Limit of Detection** | **20 ug/sample** |

**TABLE 3**

**Blood Lead* and FEP** Results**
**Sims Radiator, Decatur, Georgia**
**May 31, 1989**

| | Job Title | Blood Lead (ug/dl)* | FEP(ug/dl)** |
|---|---|---|---|
| 1. | Mechanic | 64 | 70 |
| 2. | Mechanic | 46 | 155 |
| 3. | Mechanic | 30 | 23 |
| 4. | Mechanic | 28 | 23 |
| 5. | Mechanic | 23 | 37 |
| 6. | Delivery | 18 | 19 |
| 7. | Delivery | 17 | 15 |

* - Blood lead, reference range for occupational exposure: less than 40 ug/dl.
** -FEP = Free erythrocyte protoporphyrin, normal range: less than 50 ug/dl.

**TABLE 4**
**Comparison of Mean Blood Lead* and FEP* Results between Job Titles**
**Sims Radiator, Decatur, Georgia**
**May 31, 1989**

| Job Title | N | Blood Lead (ug/dl)* | FEP(ug/dl)** |
|---|---|---|---|
| Mechanics | 5 | 38 | 62 |
| Delivery | 2 | 18 | 17 |
| P value+ | | 0.16 | 0.32 |

* - Blood lead, reference range for occupational exposure: less than 40 ug/dl.
** -FEP = Free erythrocyte protoporphyrin, normal range: less than 50 ug/dl.
+ - Student's T test.