May, 1982

lead ENVIRONMENTAL HEALTH NEWSLETTER

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Emphasis on Training and Personal Hygiene Reduces Blood-Lead Levels in Japanese Battery Plants

Blood-lead levels of workers in Japanese battery plants were found to be considerably lower than those of workers in comparable American plants, even though Japanese workers do not wear respirators and there were no apparent differences in process equipment, process materials or work practices. Management practices and administrative controls seemed to be responsible for the lower blood leads according to a report issued by Jeff Burton of Radian Corporation, which conducted a study in three Japanese battery plants during 1979-1980 on behalf of NIOSH/EPA.*

Japanese management practices place a heavy emphasis upon employee participation in production, quality control and health maintenance. U.S. managers, on the other hand, have traditionally placed their faith in their ability to control lead exposure through engineering controls. As a nation long famous and justifiably proud of our technological expertise, it is only logical that managerial approaches have developed that stress technological solutions to business problems. This bias is even evident in federal regulation of business. The OSHA Lead Standard, for example, places primary reliance upon the use of engineering controls to reduce employee lead exposure and blood-lead levels. This attitude has some times led us to neglect the importance of the individual in controlling his own lead exposure and reducing his own blood lead levels. While technological advances and engineering controls are indeed important, the Radian study of Japanese management practices clearly illustrates the importance of management participation, employee training, and personal hygiene in the maintenance of health.

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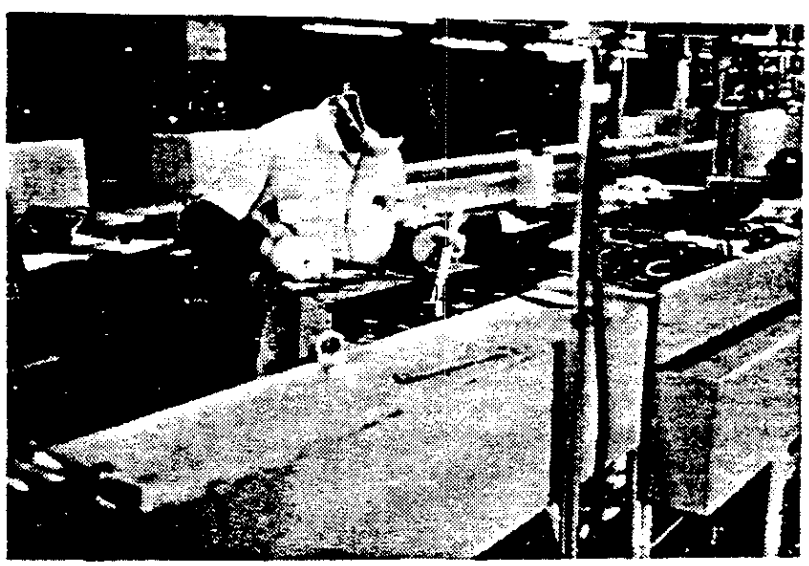
Japanese worker wearing gauze mask during post burning operation



* The study was conducted upon the urging of John Bitler of General Battery Corporation and we owe our thanks to him both for promoting the study in the first place and for bringing it to our attention.

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Air Lead - Blood Lead

Radian Corporation was unable to obtain time-weighted-average breathing-zone exposure levels for Japanese workers; however, lead-in-air samples were provided using tripod-mounted stationary collectors which drew air for ten minutes through 50mm glass-filters mounted at approximately breathing level height. The samples were analyzed by atomic absorption. The area air sampling results ranged from 1 to 148 $\mu gPb/m^3$, with the average air-lead levels ranging from 19 to 63 $\mu gPb/m^3$. Table 1 shows the air-lead levels (PbA) as measured in four different departments of three Japanese battery plants.

Radian Corporation also obtained summary data of the blood-lead levels (PbB's) of 1,079 Japanese workers. PbB determinations were made following familiar atomic absorption spectroscopy methods and were confirmed by sending split samples to university and government laboratories in Japan. Table 2 shows PbB data for the three plants studied. Most of the workers fell into 'class A' (PbB$<30\mu g/dl$) and no worker was included in 'class C' (PbB$>60\mu g/dl$). Figure 1 is even more startling, revealing that 95% of the employees sampled had PbB's lower than 40 $\mu g/dl$ with an average PbB level of 20 $\mu g/dl$. These results were achieved without the use of respirators! No conclusions were drawn by Radian concerning the relative contributions of inhaled and ingested lead to blood-lead levels, or the relation between exposure and blood-lead levels. Nor were they able to quantify the impact of administrative controls and management practices on the maintenance of blood-lead levels. However, faced with the evidence of three battery plants with PbA's reaching 148 $\mu g/m^3$ and average PbB's of 20 $\mu g/dl$ the report concludes "....it seems reasonable to assume that the methods (administrative controls and management practices) have had a significant impact on blood-lead levels, and that these methods might be useful in domestic lead user or production facilities."

Training

The Radian Corporation investigators were only able to visit one plant, a production facility for industrial batteries. The physical plant is 60 plus years old, but has been modernized. It employs 320 production personnel and consumes 600-650 metric tons of lead per month. Plant process equipment and technology were felt to be equivalent to those found in the U.S. The plant incorporates the following major processes or equipment:

- lead oxide production in an oxide mill
- pasting machinings
- grid casting
- electric forming
- post making
- battery assembly
- maintenance and auxiliary operation

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Table 1
Average Air-Lead Levels in Japanese Battery Plants by Department

		Oxide Milling	Casting & Pasting	Formation & Plate Finishing	Assembling
Plant A	Average reading (ug/m^3)	33	30	35	28
	Range (ug/m^3)	23-42	5-148	12-90	6-129
Plant B	Average reading (ug/m^3)	19	48	46	25
	Range (ug/m^3)	10-33	12-107	11-130	1-116
Plant C	Average reading (ug/m^3)	28	57	61	63
	Range (ug/m^3)	28	18-86	18-120	12-134

Table 2
Blood-lead levels of Workers in Japanese Battery Plants

	Plant A	Plant B	Plant C
No. of workers inspected	387	571	121
No. of workers judged as:			
Class A (below 30 ug/dl)	370	534	116
Class B (30-60 ug/dl)	17	37	5
Class C (over 60 ug/dl)	0	0	0

During the public hearings which were conducted by OSHA while formulating the present Lead Standard, a great deal was heard about the relationship between air lead levels (PbA) and blood lead levels (PbB), and, quite possibly, the debate is not over yet. The question is an important one, for the answer to it may provide the basis for much of OSHA's rulemaking during their announced reconsideration of the Lead Standard. Unfortunately, it is also a highly controversial issue and one which is sure to generate a lot of possibly very confusing testimony.

The question, simply stated, is this: Is there a correlation between PbA levels and PbB levels such that given a certain increase in PbA, a predictable increase in PbB will occur? If there is, then theoretically at least, one could regulate blood lead levels by controlling air lead levels. (Assuming that nothing else other than PbA impacts upon PbB). This, indeed, was the conclusion reached by OSHA following the original public hearings on the Lead Standard which resulted in the establishment of the 50 microgram PEL.

In reaching this conclusion, OSHA adapted what has become known as the "Bernard Model" to describe the dynamic behavior of human blood levels in response to changing industrial air-lead levels. Dr. Bernard used a 5-compartment mammillary model, together with information on baboons, humans, dogs, and rodents, to generate equations for retention of radioactive lead in the bone, liver, kidney, tissues and blood. The model postulates that lead first appears in the blood, and then is transported or diffused into a number of different compartments, corresponding to the different organ systems in the body. Using this model as a base, OSHA sponsored a second study, known as the 'Ashford Study', to determine what would happen in the various 'compartments' given an increase in air lead levels. In order to do this, three assumptions had to be made: 1) that the transfer rates of lead between the biological compartments are linear; 2) that the airborne lead to which workers are exposed consists of 12.5 micrograms of small particles absorbed with 37% efficiency and 87.5 micrograms of large particles absorbed with 8% efficiency; and 3) the blood-lead level of the average person starting work in a lead plant is 19 μg/100g ± .5 μg/100g. Relying on data compiled in the Ashford Study, OSHA concluded that an air lead level of 50 μg Pb/m^3 would result in average blood-lead levels of 40 μg/100g, and consequently established the PEL at that point.

However, during the past three years, additional study has been undertaken on the PbA-PbB relationship. One of the most recent studies ("The Impact of Air-Lead on Blood-Lead in Man - A Critique of the Recent Literature", *Food and Cosmetic Toxicology*, Vol. 19, pp 631-638, 1981) conducted by P. B. Hammond, E. J. O'Flaherty, and P. S. Gartside produced some startling results. Hammond *et al.* evaluated the PbA-PbB relationship using all the available data from published studies in which "the subjects were in an approximately steady state with regard to lead exposure, and blood-lead could be related to air-lead measurements made in the individual's breathing zone" (data drawn from studies conducted by Drs. Azar, Griffin and Kehoe). They then compared the observed PbA-PbB relationship with that which had been predicated by hypothetical models constructed by Rabinowitz *et al.* and Bernard. (See figure 2) They found the models predictions to be inconsistent with their observations. Where the models predicted a linear PbA-PbB relationship, the observed PbA-PbB relationship was curvilinear with the slope decreasing as blood-and-air-leads increased. In other words, after a short period of rapid rise, PbB tends to reach a plateau at which point it is relatively unaffected by increases in PbA. (See figure 3)

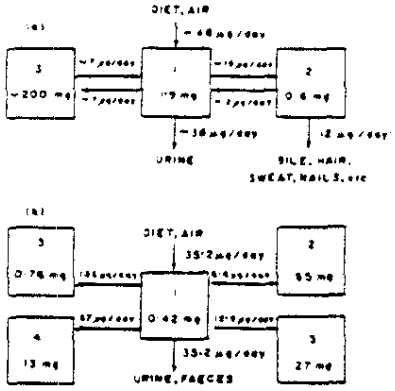

Fig. 2 Models proposed to describe lead disposition kinetics by (a) Rabinowitz *et al.*, (1976) and (b) Bernard (1977). The amounts of lead in each compartment, exchanging daily between compartments, and excreted daily are shown for steady state conditions of continous exposure to food, water, and air lead. The amounts of lead shown entering the central compartment in each case are the amounts that are assumed to be absorbed daily into the systemic circulation from all sources.

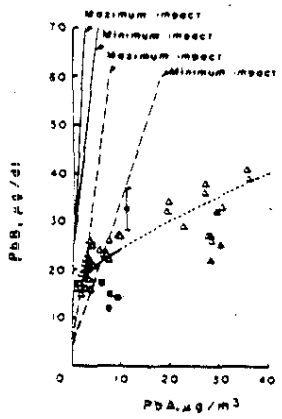

Fig. 3 Predicted and observed PbB level as a function of PbA. The Kehoe data points (△▲■) represent 12 individuals, some studied more than once; data points from individuals exposed to large particle aerosols (▲); points from one individual, DH, whose measured PbB from non-air lead sources was exceptionally high (■). All data points are adjusted to a PbB from non-air sources of 16 μg/dl. Standard deviations are shown for Griffin *et al.* points (●). The line of best fit to the Azar *et al.* data is shown dashed beyond the range of actual measurement. The Rabinowitz (—) and Bernard (–) predicted lines (after 5 yrs.) reflect maximum and minimum impact conditions.

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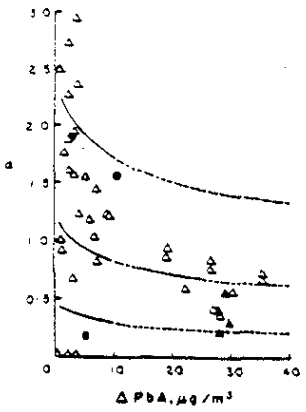

Fig. 4 α as a function of Δ PbA. The line of best fit to the Azar *et al.* data and the 95% confidence limits to the line (above and below) are shown dashed beyond the range of actual measurement. Griffin *et al.* mean values (●); Kehoe data points (△); Kehoe data points from individuals exposed to large-particle aerosols (▲); the only positive value of α from subject DH (Kehoe), whose measured PbB from non-air lead sources was exceptionally high (■). Four negative values for Kehoe subjects have not been plotted.

This curvilinearity with regard to α, the increment in PbB associated with a given increment of PbA (as illustrated in Figure 4) has important implications for OSHA, and the lead industry, during this period of reconsideration of the lead standard. The Hammond Study suggests that the 'Ashford Study', upon which OSHA relied to establish the 50 microgram PEL may have been inaccurate in its description of the kinetics of lead absorption and distribution.

The problems, however, don't stop even here, for none of the studies takes into account a myriad of other factors that can influence a person's blood lead level such as his personal hygiene habits, his smoking and drinking habits and his work practices. Indeed, it seems questionable that any meaningful correlation between PbA and PbB can be drawn at all. ★★★

Legal Briefs

OSHA has recently announced its decision to issue an interpretive and procedural rule which it hopes will "clear the air" regarding the legality of its inspectors' use of personal air monitoring devices.

OSHA which has been charged with the responsibility of assuring "....so far as possible....healthful working conditions,"has also been given the authority to inspect and investigate "during regular working hours and at other reasonable times, and within reasonable limits and in a reasonable manner any such place of employment and all pertinent conditions, structures, machines, operating devices, equipment and materials therein, and to question privately any such employer, owner, operator, agent or employee."

OSHA has always assumed that one of its "reasonable" investigative tools was the portable personal air sampling devices. In fact, based on 1903.7 which authorizes compliance officers "to take photographs and samples, (and) employ other reasonable investigative techniques," the Secretary issued a Field Operations Manual (FOM) which contained instructions regarding sampling methods. The first FOM was issuedin 1971 and every subsequent revision has included a section on personal air sampling. However, despite the apparent clarity of the intention of the regulation, air sampling through the use of personal monitors has had a long court history.

The Plum Creek Decision

In January of 1978, OSHA attempted an investigation of Plum Creek's plant in Columbia Falls, Montana but was denied permission

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From the Editor's Desk

Despite the attempts by OSHA chief Thorne Auchter to improve the climate between business and government, some businessmen are still distrustful of the regulatory agency - nor is this surprising considering the adverserial relationship which had existed between the two in the past. Unfortunately, as a result of that relationship, the history of government-business confrontation has been written, so far at least, in the court record.

Hopefully, that chapter of the history is complete and a new one being written, one in which the main idea is cooperation not confrontation. There is a slight, but nevertheless persistent sense of something new in the air. Call it a willingness to listen, an admission that, after all, management is not necessarily and always the enemy, a recognition that over regulation benefits no one.

Under the leadership of Thorne Auchter, OSHA has significantly revised the "Target Industries Program" and introduced some new programs which attempt to protect employee health and are more equitable to business. For the lead industry, perhaps one of the most promissing signs is OSHA's intention to reconsider segments of the Lead Standard.

I have heard some people complain that the regulatory relief they had hoped for has been too long in coming. Unfortunately, change occurs slowly; and mistrust is not easily laid by. But now the opportunity seems to exist for business and government to rewrite the record book. OSHA has taken the first step by reopening the record; business has taken the next step, by providing information on PbA's and PbB's to OSHA contractors. It is still too early to tell what will result from this new spirit of cooperation. Hopefully, it will produce legislation that is realistic, feasible and effective. ★

Legal Briefs

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to fit employees with personal air samplers. Plum Creek Lumber maintained that, since the men worked around moving machinery, the wearing of air monitoring devices created a safety risk which was unacceptable; it therefore instituted a company policy forbidding the wearing of such devices.

The district court which heard the case supported Plum Creek. Although it found the evidence concerning the safety of the devices "very questionable," it noted that they were not "specified by law, or by the regulations." The court further found that the use of personal samplers "would be reasonable," but concluded that "in the absence of law, the OSHA inspectors have no power to make Plum Creek do something simply because the inspectors think it reasonable."

The Metro-East, Century-Casting Decision

In May of 1980, OSHA attempted an investigation of two brass foundries, Metro-East and Century Brass Works, Inc.. After conducting a "walk around" inspection, the OSHA compliance officers were denied permission to attach personal sampling pumps to employee's belts. The problem eventually wound up in court with OSHA claiming it had the right to use personal sampling pumps and the two affected firms arguing that neither OSHA nor the court had the right to force the use of the devices. In this situation, the question was not one of safety. Metro-East and Century Casting contended that there was no existing rule or regulation authorizing the use of such devices, and that the regulation, as it was then constituted, failed to give "fair warning" that an employer must permit the use of personal monitoring devices during inspections. The court found in favor of Metro-East and Century Casting, agreeing with them that "...a regulation cannot be construed to mean what an agency intended but did not adequately express." Furthermore, the court found that the Secretary "...has the responsibility to state with ascertainable certainty what is meant by the standards he has promulgated," and added that "it would impose no hardship on the Secretary to amend the rules to give "fair warning" of the types of investigation deemed "reasonable."

In response to these court decisions, OSHA has in 47 FR 6530-6533 clarified the existing regulation, 29 CFR 1903.7 (b) to specifically include the use of personal air samplers during the course of inspection. OSHA is hopeful that by this action the legal battles over their use of these devices will be ended.

* * *

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While the plant itself is similar to many U.S plants, plant officials, however, differed from their U.S. counterparts in their belief that ingestion is a major route of exposure and in the lengths they were willing to go to minimize uptake by ingestion. They place great emphasis upon training. First of all, during preemployment training, employees receive general instruction regarding lead exposure, washing procedures, etc. Then, through periodic training sessions, personal hygiene practices are reviewed. Finally, each year the company sponsors a "Hygiene Campaign Week," which is designed to remind employees of the importance of ingestion protection, personal hygiene, proper work practices and the hazards associated with lead exposure. Three important aspects of the training program deserve special attention:

- One, training responsibilities lie directly with the manager of each manufacturing department. Daily instruction and the responsibility for on-going training rests with the foreman of each operation.

- Two, training is treated as an on-going and integral part of the manufacturing process and is repeated periodically throughout the year.

- Three, employees participate in the monitoring and implementation of training programs.

Protective Equipment

As in the U.S., protective devices such as rubber gloves, boots, aprons, etc. are distributed to the workers each day, although cartridge-type respirators are not used. Also as in the U.S. work clothing is laundered regularly, but the Japanese have found that adding acetic acid to the wash water assists in the removal of lead contamination from work clothing.

Instead of respiratory equipment, Japanese workers wear surgical guaze masks which are comfortable to wear and which prevent them from placing their hands or lead-contaminated objects in their mouths. While the mask may reject larger lead particulate which enters the breathing zone, its primary purpose is not filtration of respirable air, but prevention of accidental ingestion through the nose or mouth. Japanese workers are encouraged to wear the masks at all times and not to remove them until after their hands and forearms have been cleansed.

Hygiene Facilities and Procedures

Employees are not permitted to eat, drink or smoke in production areas. Rest stations and lunch rooms

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are provided but before entering, workers are required to remove their outer protective clothing, wash foot gear and wash hands, arms and faces thoroughly. They are also urged to gargle with a mouth wash prior to eating, drinking or smoking to remove any traces of lead which may have entered the mouth.

Change rooms are provided, as in the U.S., but stringent measures are taken to prevent the importation of lead dust from production areas into the hygiene facility. Before entering, employees are required to remove foot gear, and at the end of each shift they are required to bathe in a lukewarm tub of water which contains a very dilute solution of sodium sulfide, which combines with lead on the skin to produce a black lead sulfide spot everywhere there is Pb contamination. This contamination can be scrubbed off. The employee then rinses, enters a hot bath after which he again rinses prior to changing into street clothing. Although cultural differences between Japanese and American workers would, in all likelihood, preclude the use of such extensive wash facilities as those described above, it is clear that management insistance upon thorough cleaning before leaving work can have a significant impact upon employee health.

All areas of the plant are maintained relatively dust-free through the usual water and vacuum cleaning procedures. Daily cleaning is conducted once each shift, and once per week, a massive floor-to-ceiling clean-up is conducted.

Some Useful Management Principles

One thing becomes very obvious while reading the Radian report; the Japanese take ingestion protection, work practices, training, and personal hygiene very seriously and go to great lengths to teach and enforce good personal hygiene practices. The results, however, seem to show that their efforts are worth the trouble. Here, in summary, are some management principles observed by the Radian group which might prove helpful in reducing PbB's of U.S. workers.

- Provide intensive training on a plant-wide and individual basis.

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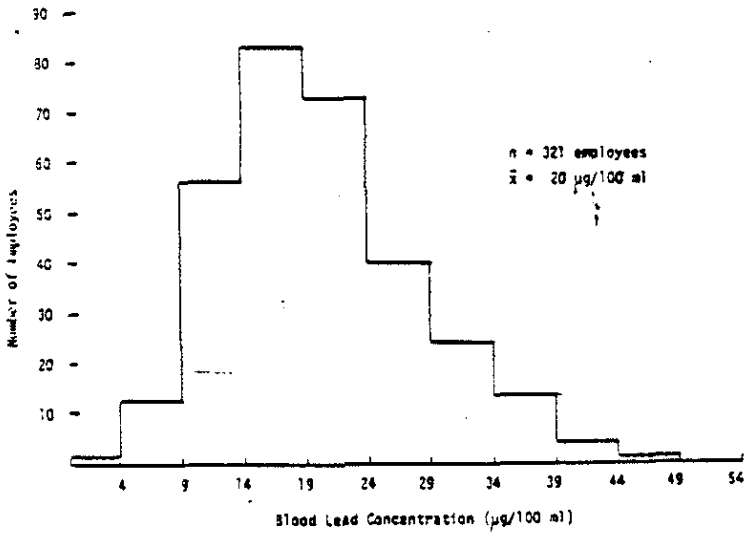

Fig. 1 Distribution of Employee Blood-lead Concentrations in Japanese Battery Plant.

Questions, Answers and Opinions

The article on smoking in the January edition of "Lead Environmental Health Newsletter" provoked quite a bit of interest. Below are two of the letters which were received on the subject.

> "I read your new Lead Occupational Health Newsletter with interest and particularly the article concerning smokers and blood levels. May I suggest that you include the sources of the information you used in the article so the reader may research the subject further.
>
> Our company has some employees who are exposed to lead fumes and we made a similar survey at one plant to determine if there was, in fact, a relationship between smokers and non-smokers and blood lead levels. Though not very scientific, our survey of 103 employees indicated that those who smoked had blood lead levels an average of 18% higher than non-smokers. In the group 56 were smokers. We used the information to stress work rules and housekeeping in areas we have lead exposure."
>
> Bob P.
> Corporate Director of Safety

Thanks for the information on smokers and PbB level. It is very interesting and certainly seems supportive of the data in the studies I used. By the way, the references are as follows:

Brown, C. Perry, *et al.*, "Cigarette Smoking and Lead Levels in Occupationally Exposed Lead Workers," *Journal of Toxicology and Environmental Health*, 6:877 - 833, 1980.

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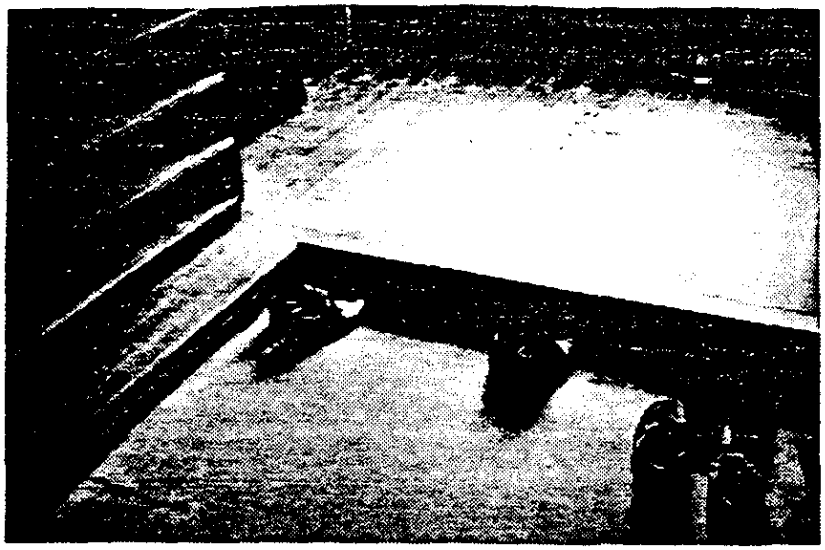

Japanese workers remove their shoes before entering hygiene facilities

Japanese Battery Workers

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- Make employee training the responsibility of the line manager.
- Establish a joint employer/employee committee to conduct lead related inspections, supervise weekly clean ups, provide training sessions and foster communication.
- Stress the importance of housekeeping and personal hygiene.
- Provide protective equipment daily and see that it is thoroughly cleaned.
- Establish a rigorous ingestion protection program which includes personal hygiene facilities and practices, prohibition of eating, drinking, and smoking except in safe areas, and then only after decontamination. Consider the use of surgical gauze masks where respirators are not already worn.
- Provide shower facilities and require their use before leaving work.

Most important of all, management must adopt a policy establishing the importance of personal and industrial hygiene and then support the implementation of that policy. If Burton's report is accurate, PbB's can be significantly lowered without recourse to expensive engineering controls which will result not only in savings on these items, but also in savings on MRP and related medical benefits. * * *

Focus on the Lead Standard

Along with engineering controls, *Medical Removal Protection (MRP)* is one the most controversial and costly requirements of the Lead Standard. It is also one of the most complex. Recently, OSHA denied an industry-wide petition for a delay of the 60–40 "triggers" for MRP, and even though several smelters and battery plants were granted interim relief, most of the lead industry has to abide by the new rules. This means that any worker whose blood lead level reaches or exceeds 60 micrograms lead per 100 grams of whole blood (60 $\mu g/m^3$) must be removed from any work area where the lead-in-air is equal to or greater than the "Action Level" (30 $\mu g/m^3$), and he or she cannot return to work (in an area > 30 $\mu g/m^3$) until his or her blood lead level decreases to 40 $\mu g/100$ g or lower.

The temporary removal of a worker is not based on a simple blood-lead test, however; the Standard provides that removal only takes place when two consecutive blood lead samples exceed the trigger level. Therefore, at the first warning sign that an employee's blood-lead level is elevated, administrative action ought to be taken to bring his or her blood

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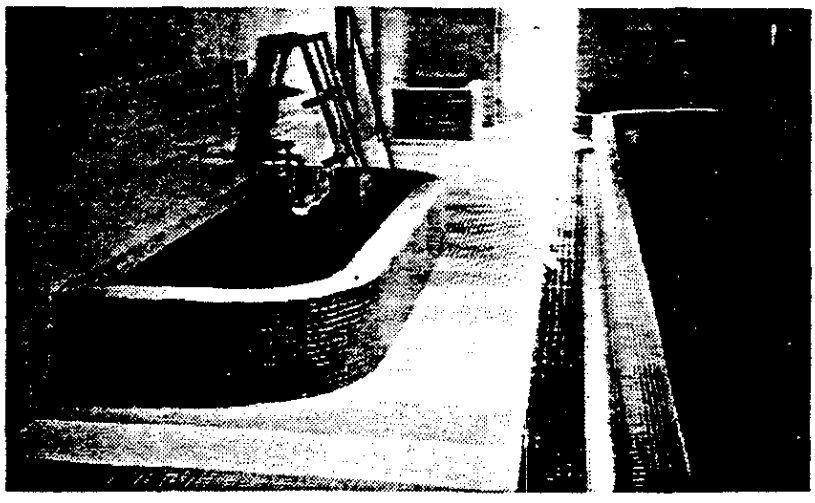

Bath facilities for Japanese battery workers

Questions & Answers
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Tola,S. and P.H. Norman, "Smoking and Blood Lead Concentration in Lead-Exposed Workers and an Unexposed Population," *Environmental Research* 13, 250-255 (1977).

"I have just read the January issue (1982) of the ILZRO Environmental Health Newsletter. There is a rather glaring error on pages 3 and 4. On page 3 reference is made to a study in Finland of lead workers and smoking habits, and attention is drawn to Fig. 1 giving the data, which is actually Table V from Olsen *et al.* on "Indicators of lead exposure in an adult Danish suburban population" published in the *Danish Medical Bulletin* (1981) and has nothing to do with lead workers. The median blood leads given in your Fig. 1 range from 11-14 µg/dl, not very impressive for lead workers (or perhaps very impressive!) and do not of course line up with the UCLA study as is stated and shown in Fig. 2 (incidentally since Fig. 1 and 2 are Tables, shouldn't they be so called)."

P. S. I. Barry,
Chief Medical Officer

Thanks for pointing out the errors. You are absolutely correct on both counts. The correct table appears below:

Blood Lead Concentrations (ug/100ml) of Workers Exposed to Lead According to Smoking Category

Smoking Category	Blood Lead Concentration (ug/100ml)		
Cigarettes daily	Mean (Heavy Exposure)	Mean (Moderate Exposure)	Mean (Light Exposure)
≥ 21	55.6	29.1	22.7
1-20	47.7	26.3	22.5
Stopped Smoking	43.8	25.1	20.7
Never Smoked	38.4	24.6	19.3

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lead down to acceptable levels before MRP is implemented. Employees may also be removed, even though their blood lead levels are below the trigger levels, if a physician discovers "a detected medical condition which places the employee at increased risk of material impairment from exposure to lead."

What to do with medically removed workers has been a problem for many companies. The Standard does not specify what an employer is to do with the removed worker other than to say that "OSHA intends that this transfer (to a low lead exposure) be to work that the employee is capable of performing and which is located in the same geographical area as the employee's normal job." Several possibilities, therefore, exist.

Most advantageous to the company would be to reduce the employee's exposure administratively; that is, reassigning him to a similar job which does not have lead exposure, or shortening his exposure through job rotation. Some firms have assigned workers on MRP to yard work, shipping or similar positions where lead exposure is low. And some firms have "bitten the bullet" and simply sent workers home. There doesn't seem to be a simple solution to this problem because even in those firms where a transfer is feasible, other complications arise. Suppose, for example, the transfer of one individual on MRP subsequently causes "bumping" on other jobs and the eventual layoff of another individual who now loses his job and income as a result of the first worker's medical problem. Are any benefits due the laid-off worker under MRP? And what if contractual agreements prevent the easy transfer of individuals?

While the worker is on MRP, he is entitled to the rate of pay he would normally earn plus benefits and seniority he would normally accumulate. He is also entitled to his former job back when he is medically able to return to it. The employer may, however, deny MRP benefits to employees who have been removed if the employee refuses to participate in "reasonable follow-up medical surveillance."

Finally, a worker may be returned to work when either (a) his blood lead reaches the return level, or (b) failing to accomplish that, at the end of 18 months, the physician recommends his return. At that time, the physician may also recommend either the continuance for a few more months on MRP, or severence if he deems the worker ought not undergo further lead exposure.

If the employee disagrees with the physician's recommendations, he may have a second physician, of his choice and at company expense, review the findings of the first physician. If the two physicians disagree, they must choose a third physcian who will arbitrate the dispute and whose decision is binding. ★★★

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