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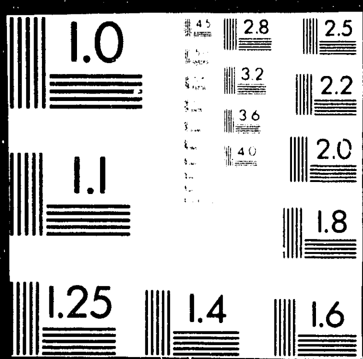

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INDUSTRIAL HYGIENE OF SELECTED HEAVY METALS

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INDUSTRIAL HYGIENE OF SELECTED HEAVY METALS

The industrial hygiene of heavy metals consists of recognition, evaluation, and control of exposures in the occupational environment. Several of these metals have been in use since ancient times. Reports of health effects and poisonings from overexposures also have a long history.

Lead

Lead was recognized as an occupational hazard in the first century. Lead is used in many industries to produce metal products, pigments, chemicals, and ballasts. More than 100 occupations have been listed by the National Institute of Occupational Safety and Health (NIOSH) as potentially exposed to lead. Some, such as brass and bronze foundry workers, smelter workers, and painters, are old occupations in which overexposures still occur.

Where exposures occur in a factory production environment, control can usually be achieved by enclosing the operation and/or providing local exhaust ventilation. However, in field work and construction more reliance on personal protective equipment such as respirators is needed.

Figure 1 - Lead handling in a warehouse, with respirator use.

Figure 2 - Torch-cutting a lead-contaminated iron shielding block.

Figure 3 - Lead exposures at a firing range.

In fact, recent attempts at containing lead for environmental protection are, leading to high potential for exposures to workers engaged in removing paint from bridges, tanks, and water towers. This is one of the "hot topics" in lead exposure control. Several reports have been made of multiple hospitalizations for lead poisoning at lead paint removing operations. The problem occurs because this operation is conducted using high-powered abrasive blasting machines. *Figure 4 - Photo of water tower with containment skirt in place.* When this work is conducted inside enclosures designed to prevent environmental contamination, very high lead concentrations can result which overwhelm the normally used respiratory protection.

Figure 5 - OSHA occupational lead exposure limits.

Figure 6 - Reported lead concentrations inside containment enclosures.

Figure 7 - Table of protection factors for NIOSH-approved respirators.

Figure 8 - Photo of new type of mini-enclosure for lead abatement work, courtesy of Datanet Engineering, Inc., Baltimore, MD.

This new mini-enclosure is claimed to be "state of the art" in controlling lead exposures from these projects. A small tubular enclosure is constructed over part of the tank and is ventilated to give about 200 fpm airflow through the working tunnel. A large blower/filter unit on the ground separates the reusable steel shot and collects lead paint dust into barrels. Compared with about 175 tons (18 container trucks) of lead-contaminated silica sand from an older method, lead waste is concentrated into about eight 55-gallon drums. The lead is concentrated enough for possible use as lead smelter feedstock.

It should be noted that workplace exposure to lead is covered under two rather detailed regulations: 1910.1025, covering lead exposure in General Industry, which went into effect February 1, 1979; and 1926.62, applying to construction activities, which went into effect June 3, 1993.

Figure 9 - Main provisions of Construction lead standard.

Mercury

Mankind's use and exposures to mercury goes back past written history when cave dwellers used the red mercury sulfide ore cinnabar to make drawings on cave walls. Uses through the ages produced a rich history of applications, including reddening the face of a statue of Jupiter in Rome to binding gold leaf to copper objects. Early in the history of this country it was used as a nitrate solution for dipping furs to make them pliable for molding into hats. Poisoning was so common around Danbury, Connecticut, that mercury disease was known as the Danbury shakes, because of its attack on the nervous system. Today mercury is claimed to have over 3,000 different uses.

Exposures had ended in some applications due to regulatory restrictions, including application of organic mercury compounds to preserving seeds and as a mildew preventative in paint.

Figure 10 - Saturation concentration, 0-30°C.

A major problem in controlling exposure to mercury is that it is the only metal liquid at room temperature and has a significant vapor pressure. This graph shows the mercury saturation concentration from 0-30°C.

Figure 11 - Saturation concentration of mercury, multiples of TLV.

Accumulation of spilled mercury in plants which have wooden flooring or other work surfaces with many cracks and crevices, combined with inadequate ventilation, can produce excessive exposures.

Figure 12 - Mercury in Thermometer plant.

Mercury vapor exposures in a thermometer manufacturing plant are shown in Figure 12. Concentrations were well in excess of the 50 ug/m^3 TLV. Elevated urine mercury levels were also found (up to 344 μg/g creatinine). Medical findings included static tremor and difficulty walking heel to toe.

Figure 13 - Mercury vapor concentrations in dental offices.

Mercury is used to make an amalgam with silver/copper/tin for dental fillings. Spills can contaminate carpeting, vacuum cleaners, and the workroom air.

Figure 13 shows mercury vapor concentrations found in 88 dental offices. Other surveys have estimated that 5-10% of dental offices have concentrations exceeding the 1993 Threshold Limit Value of 50 $\mu g/m^3$. *Figure 14 - Shows range of concentration found in a single dental office.*

Control of mercury exposure requires careful attention to housekeeping, good ventilation, and monitoring of air concentrations, which is normally done with portable direct-reading instruments. *Figure 15 - Shows a gold film mercury vapor monitor (Arizona Instruments).* This device collects mercury on a gold film and calculates the concentration in air by the change in resistance of the film. The film is regenerated for reuse by heating. Mercury vapor can also be collected on solid media and sent for lab analysis.

Cadmium

Figure 16 - Occupational Cd Exposure Sources

Cadmium is a widely used metal which has caused numerous poisonings and deaths due to occupational overexposure. Exposure to cadmium oxide fume by inhalation causes irritation of deep lung tissue, which can lead to chemical pneumonia. Serious or even fatal exposures can occur without warning or irritation. Symptoms of shortness of breath can be delayed for hours after exposure ceases. Typically, exposures occur due to use of a welding or cutting torch on cadmium-plated bolts or parts, or in remelting scrap metal plated with cadmium. Cadmium is also widely used in silver solder and applications such as electric heating apparatus and air conditioning/refrigeration tubing. Cadmium is added to improve the flowability of the solder and may be present in the 20-25 percent range. I have conducted many surveys for cadmium at silver solder operations in industrial plants and found that cadmium is easily volatilized during the torch use. Unless local exhaust ventilation is carefully applied, it is the rule rather than the exception that exposures above the OSHA limit will occur. A new OSHA standard on cadmium exposure, which went into effect this year, established the current Permissible Exposure Limit at 5 $\mu g/m^3$ of air (as Cd) for cadmium oxide fume.

Long-term exposure to levels of cadmium too low to produce a chemical pneumonia may produce damage to the kidney as a primary target organ. This is a more widespread problem than the acute form of chemical pneumonia.

Figure 17 - Lists major provisions of the OSHA cadmium standard.

Manganese

Manganese is an important component in steel making and several other industries.

Figure 18 - Lists some of the more common uses of manganese.

Manganese has many valuable uses but is also treacherously toxic on overexposure and has produced many poisoning cases over the years. Acute poisoning deaths in the form of manganese "pneumonia" were reported as early as 1937. Chronic poisoning is a more common concern today. One of the primary targets is the nervous system. Brain damage can result in symptoms resembling Parkinson's disease. In fact, the drug L-dopa has been used to treat manganese poisoning as well as Parkinson's disease.

The current OSHA standard for manganese is 5 mg/m^3, with a 1 mg/m^3 limit for fume. One standard setting organization (American Conference of Governmental Industrial Hygienists, which produces the Threshold Limit Values) has announced an intended change of their standard to 0.2 mg/m^3 for elemental and inorganic manganese compounds.

Figure 19 - Pouring steel.

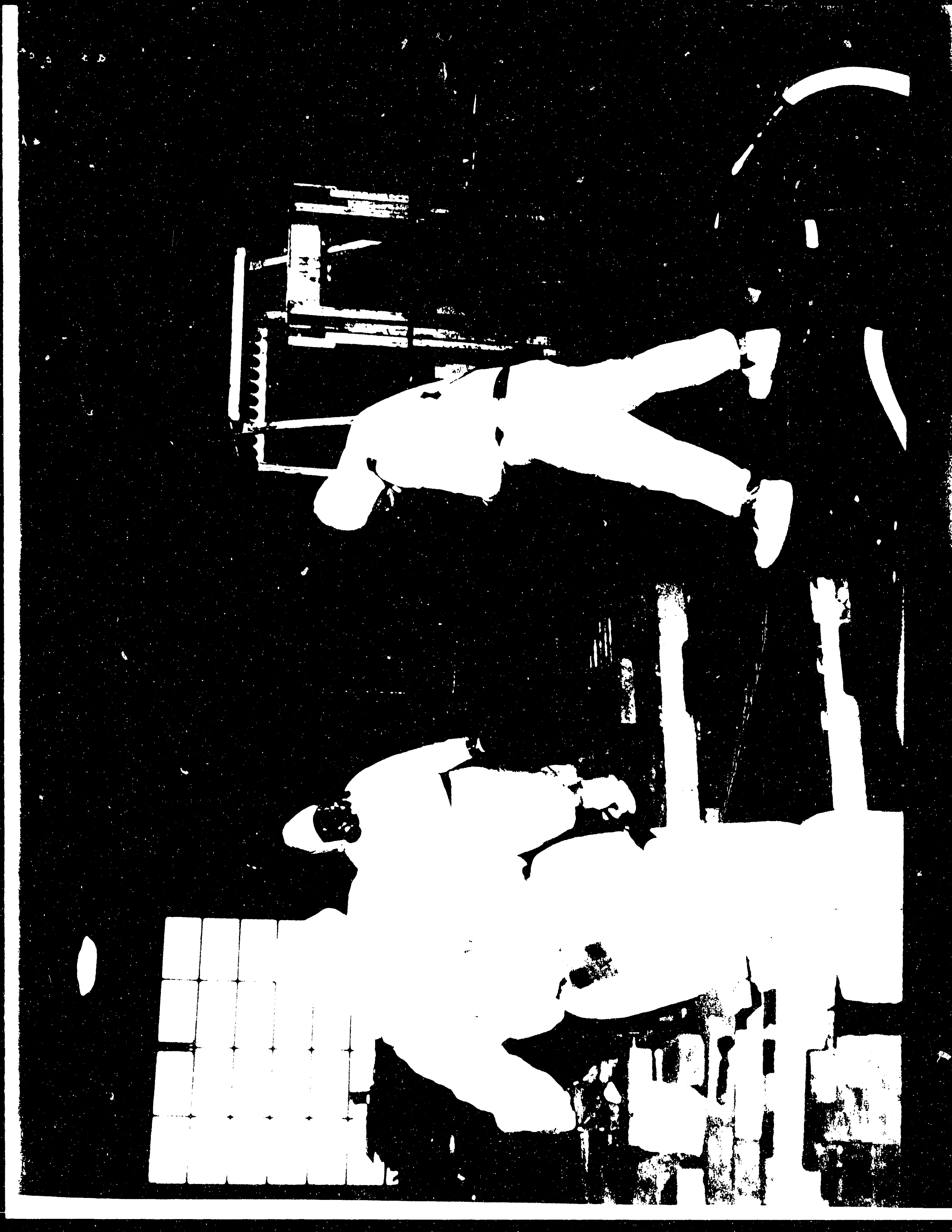
Pouring steel alloyed with manganese presents a potential for excessive exposure.

Figure 20 - Scarfing steel.

Likewise, torch cutting can generate high levels of fume, creating a potential hazard if the alloy is high in manganese. Welding rods used for hardfacing repair of earth-moving blades and rock crushers can contain a significant percentage of manganese. Last year the relative of an employee was hospitalized with mysterious neurological symptoms. He had worked several months at a hardfacing welding project. We were able to confirm the manganese content of the welding rods through the material safety data sheet. This was passed on to the patient and his physician. A diagnosis of manganese poisoning was later confirmed.

Figure 21 - Summary of exposure standards for Pb, Hg, Cd, Mn.

These examples have only touched the surface of a vast literature of information available on the hazards of exposure to these and other toxic materials. In most cases the problem is not so much the lack of knowledge of the toxic effects, or of sampling and analytical procedures, but of effectively disseminating this information to those responsible for controlling the workplace environment and those directly involved in doing the work.



LEAD EXPOSURES AT AN INDOOR FIRING RANGE*

BOOTH	ROUNDS FIRED .38 Cal Revolver	AIRBORNE LEAD CONCENTRATION µg/m³ SAMPLE	8Hr TWA
2	110	2200	780
3	110	2100	770
4	110	2600	950
INSTRUCTOR	30	1500	580

* AIRFLOW AT BOOTH: APPROX. 40 feet per minute

Ref: Davis J.T., Woodrey D.Co. Lead Exposures ~~at Indoor~~ and Control Measures at Indoor and Outdoor Firing Ranges, American Industrial Hygiene Conference, Portland, OR May, 1981.

TO GA 8/12/83

LEAD EXPOSURE IN CONSTRUCTION
29 CFR 1910.62
June 3, 1993

PEL 50 $\mu g/m^3$ 8HR TWA
AL 30 $\mu g/m^3$ 8HR TWA
Initial Exposure Assessment
Periodic Monitoring
Compliance Program
Respirator Program
Protective Clothing
Housekeeping
Hygiene Facilities
Biological Monitoring
Medical Examination
Information and Training
Signs
Recordkeeping

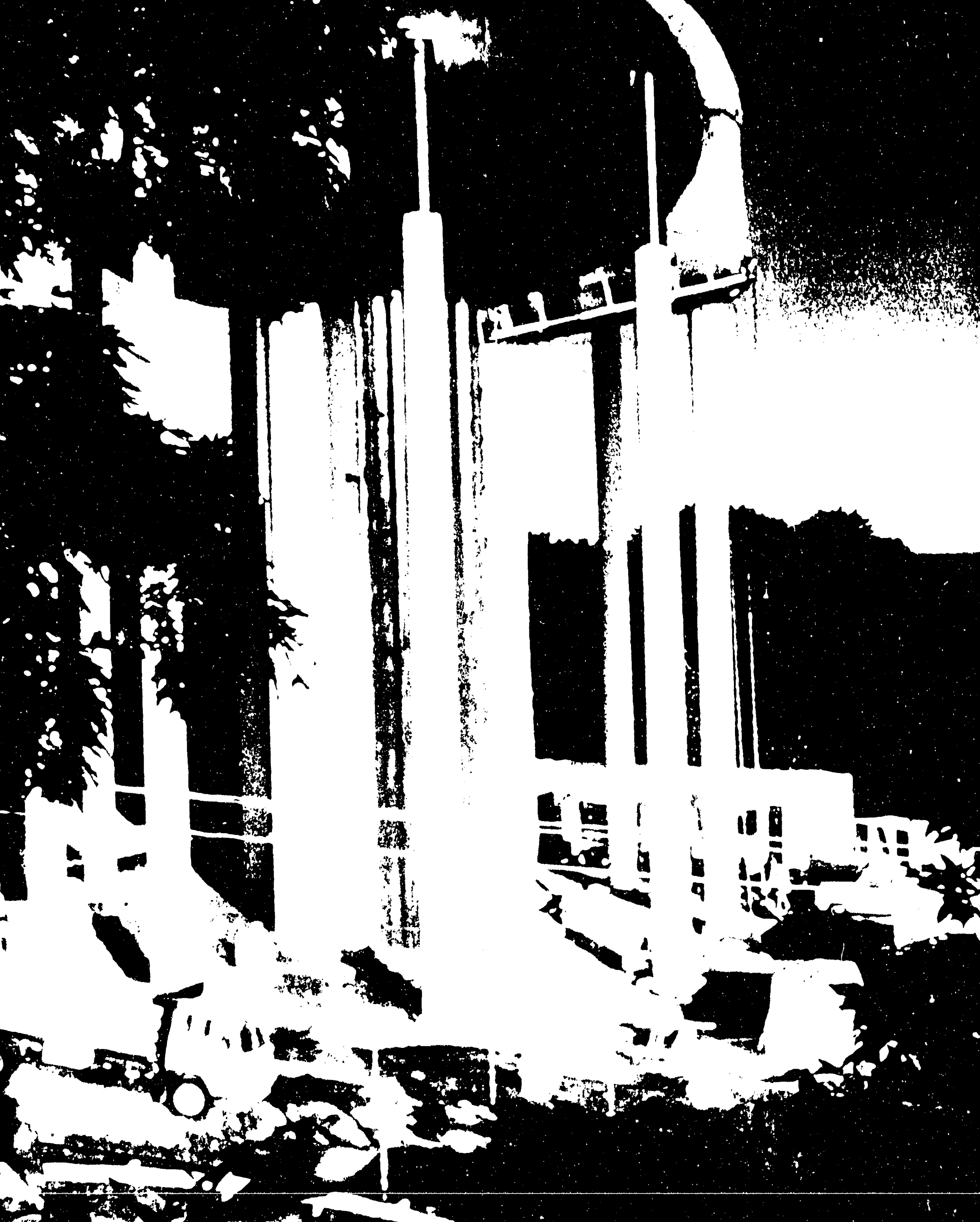
AIRBORNE LEAD CONCENTRATIONS DURING PAINT REMOVAL*

	Micrograms per cubic meter of air
ABRASIVE BLASTING	37,300
ENCLOSURE MOVEMENT	1,156
POWER TOOL USE	1,314
HAND SCRAPING	96

*FED REGISTER 5/14/93, P. 26,613

RESPIRATORY PROTECTION
OSHA LEAD STANDARD
CONSTRUCTION

Concentration Not Exceeding (microgm/m^3)	Protection Factor	Respirator Type
500	10	1/2 FP
1250	25	1/2 FP Negative Pressure
2500	50	Hood or Helmut PAPR or Supplied Air
50,000	1000	Full FP Tight Face Piece PAPR 1/2 FP Continuous Flow
10,000	2000	Full FP Positive Pressure Supplied Air



LEAD EXPOSURE IN CONSTRUCTION
29 CFR 1910.62
June 3, 1993

PEL 50 µg/m^3 8HR TWA

AL 30 µg/m^3 8HR TWA

Initial Exposure Assessment

Periodic Monitoring

Compliance Program

Respirator Program

Protective Clothing

Housekeeping

Hygiene Facilities

Biological Monitoring

Medical Examination

Information and Training

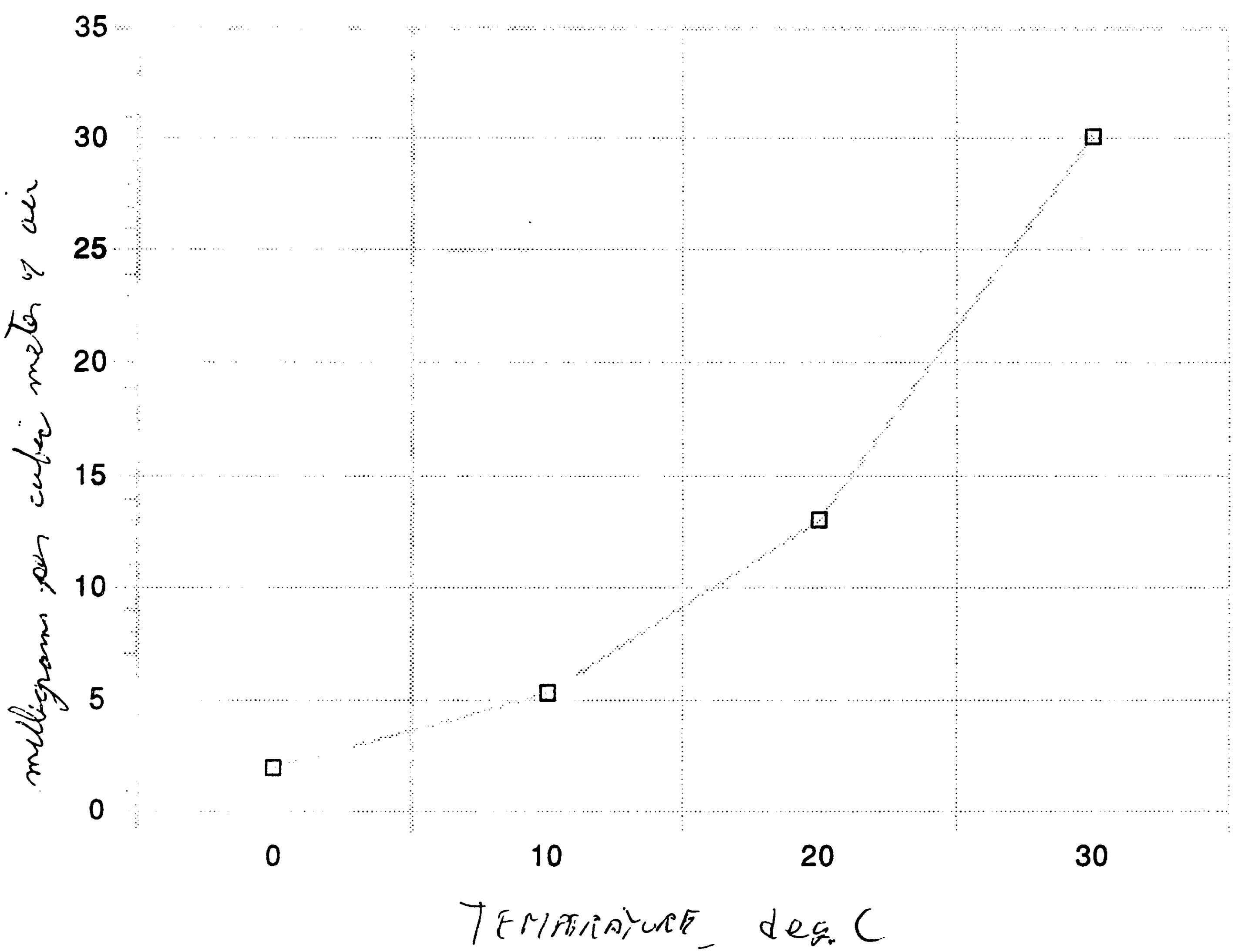
Signs

Recordkeeping

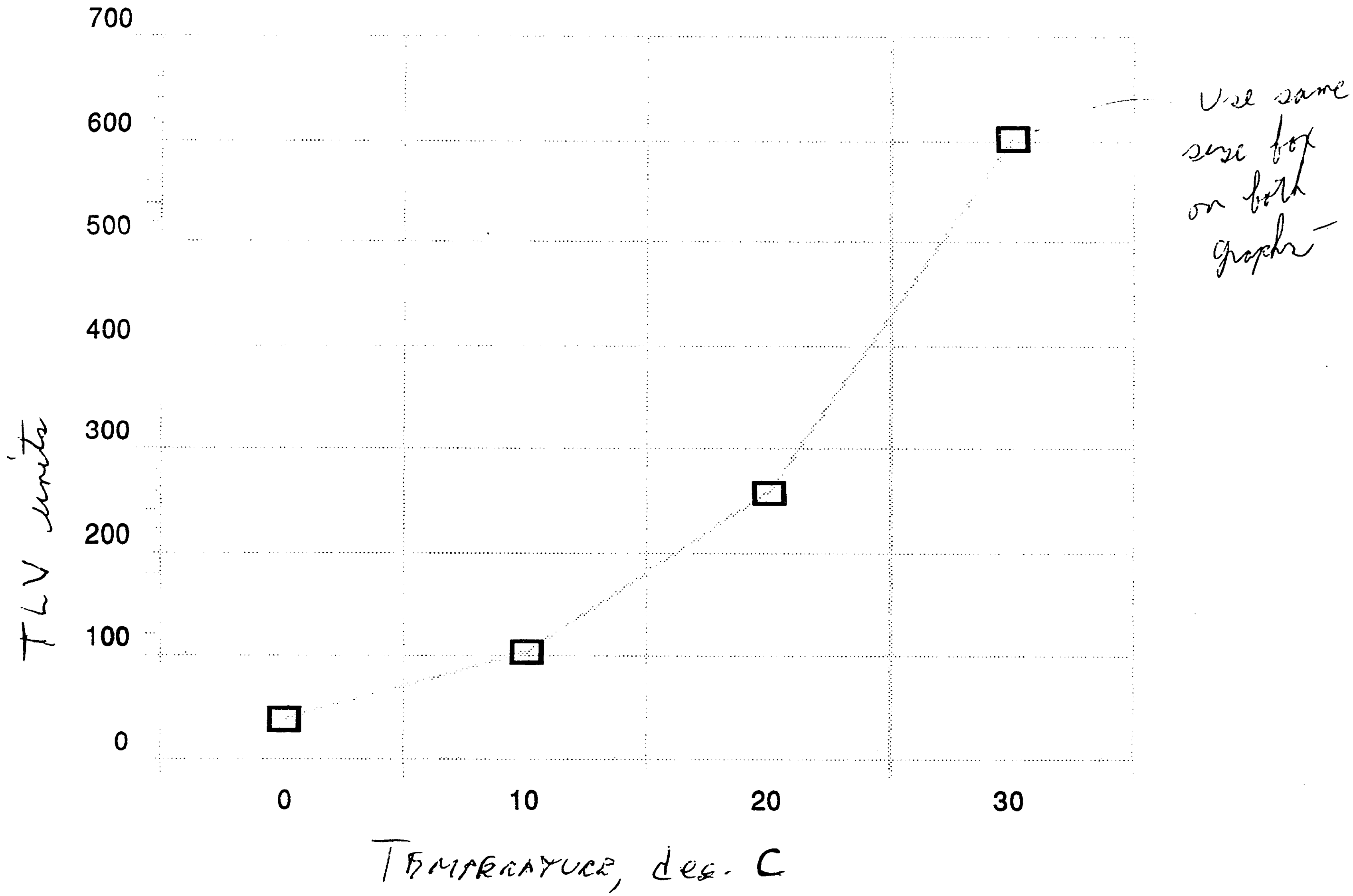
1993 TLV

MERCURY SATURATION CONCENTRATION

0.05 MG/M³ — "LC mg/m3"



MERCURY SATURATION CONCENTRATION
1993 ~~PEL~~ TLV: 0.05 ~~MG/M³~~ mg/m³



Mercury Vapor Exposure
At A
Thermometer Plant

Personal Exposure (n = 84)   26-271 $\mu g/m^3$

Ref: American Journal Industrial Medicine Volume 19, No. 4, 1991

MERCURY VAPOR IN DENTAL OFFICES

	Hg Concentration µg/m³
RANGE (860 Samples), 88 Offices	0.5-740
29%	0.5-5
38%	5-25
32%	> 25

1993 TLV: 50µg/m³

Ref: Arch. Env. Contam. and Tox. Volume 3, pp 229-243 1975

MERCURY VAPOR IN A DENTAL OFFICE

	Hg CONC. µg/m3
Full Shift, Breathing Zone	16-22
Instantaneous Direct Reading	48-66
Directly Above Surfaces	27-1200

1993 TLV: 50µg/m3

All caps

Ref: Niosh Heta-87-265-1975

OCCUPATIONAL CADMIUM EXPOSURE SOURCES

u not "mu"

Smelting [Cμ, Pb, Zn]

Electroplating

Battery Manufacturer

Welding on Cd Plating

Silver Soldering

Plastic Stabilizers [PVC Film]

Pigments

Jewelry Manufacturer

Set up similar to Lead exposure slide —

CADMIUM EXPOSURE IN CONSTRUCTION

29 CFR 1926.63

PEL 5 $\mu g/m^3$ 8HR TWA

AL 2.5 $\mu g/m^3$ 8HR TWA

Investigate/Test for Cd at Construction Site

- Initial Exposure Assessment — SAME FONT AS ABOVE

Periodic Monitoring

Compliance Program

PPE Controls for < 30 days Exposure

Restrictions on Abrasion (ve) Blasting, Heating, Saws, Sprays

Respiratory Protections Program

- Medical Surveillance
- Biological Monitoring
- Information/Haz Com
- Signs/Labels
- Record Keeping

— SAME FONT AS ABOVE

CENTER EACH LINE

TO DELETE BOX

MANGANESE USES

Ferromanganese Alloys (Deoxidize Steel)
Silicomanganese (Springs, High-Strength Steel)
Copper Alloys
Dry Cell Batteries
Glass
Inks
Ceramics
Paints
Welding Rods
Fuel Additives
Wood Preservatives

OCCUPATIONAL EXPOSURE LIMITS

(Micrograms per cubic meter of air)

	OHSA PEL[1]	ACGIH TLV[2] 1993	ACGIH TLV[2] PROPOSED
Lead	50	150	50
Cadmium Fume	5	50 Ceiling	10
Mercury	100 Ceiling*	50	25
Manganese Fume	1000*	1000	200

[1] OSHA Permissible Exposure Limit
* Delisted 1992 Court Decision
[2] Threshold Limit Value (8-Hour TWA) by American Conference of Governmental Industrial Hygienists

END

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10/15/93