Proposed Revision

LEAD

Health Practices Pamphlet No. 3

(Final Draft)

This pamphlet is one of more than 150 Safe Practices and Health Practices Pamphlets. It is a compilation of experience in accident prevention from many sources. It should not be assumed, however, that it includes every acceptable procedure in the field covered. It must not be confused with American Standard safety codes; federal laws; insurance requirements; state laws, rules and regulations; and municipal ordinances. Additional copies of this pamphlet are available to members of the National Safety Council. Price: 25 cents per copy, less in quantities.

Contents

1. This pamphlet is confined principally to a discussion of methods of detecting lead poisoning hazards through chemical-physical tests and analyses, safeguarding lead processes through properly designed ventilation and exhaust equipment, and selecting and training employees to work safely in lead exposures. While the effects of lead on systems of the body, manifestations of poisoning, and avenues of lead absorption into the body will be listed, such presentation is only for the purpose of indicating the importance of adequate protective measures.

Properties of Lead and Lead Compounds

2. Lead and its compounds are among the most widely used materials in industry. Metallic lead is silvery gray, very soft, and has a very low tensile strength. The density of lead is 11.34 (19.94°/4° C.), its melting point is 327.4° C. (621.32° F.), and its boiling point is 1620° C. (2948° F.) at atmospheric pressure. Lead is only very slightly soluble in either cold or hot water, while it is soluble in nitric acid and hot concentrated sulphuric acid. It withstands the action of most acids to a marked degree at ordinary temperatures. Molten lead gives off noxious fumes of lead and lead oxide (in measurable quantities at 800° C.) and the quantity of fumes increases with the temperature. The crystalline form of lead is monoclinic. (See paragraph 48 and Figure 1.)

3. While lead is the softest of all base metals used in the commercial arts, it is also the heaviest. It contracts considerably on cooling; hence, it is not adapted for casting in the unalloyed state, if shrinkage is important. Lead is very malleable and may be beaten out to

any desired shape, but it can be easily torn since it lacks tenacity. On exposure to air, lead oxidizes very quickly, and its oxide forms a protective coating which limits, to some extent, further oxidation.

4. Galena, or lead sulphide, is the most widely-distributed form of lead ore. This is found principally in England (in Wales and Derbyshire), in the United States (principally in Missouri, Idaho, Utah, Montana and Arizona, and also in Illinois, Oklahoma and some other states), and in Spain and Germany. This ore is usually found in quarts veins or limestone beds. Another lead ore found in the United States is white lead ore, or cerussite (lead carbonate).

5. Lead has many compounds which are used in industry, and where these are encountered a lead hazard may exist. Among the common compounds are the following:

Lead acetate (sugar lead)
Lead arsenate
Lead borate
Lead carbonate
Lead carbonate, basic (white lead)
Lead chlorate
Lead chloride
Lead chromate (chrome yellow)
Lead chromate, basic (chrome red)
Lead cyanate
Lead cyanide
Lead dioxide
Lead fluoride
Lead monoxide (massicot)
Lead monoxide, basic (litharge)
Lead nitrate
Lead oleate
Lead, red (minium)
Lead silicate
Lead stearate
Lead suboxide
Lead sulphate
Lead sulphide

cription gives no indication that lead is present. As a result, employees may, through ignorance, be exposed to a serious lead hazard, or may even contract lead poisoning before it is discovered that a lead compound is in use. Suppliers of lead-containing materials should issue definite warning of the lead content by clearly worded labels; and purchasers should insist on this policy.

Manifestations of Poisoning

9. Some knowledge regarding the action of lead on the body and the symptoms of lead poisoning is valuable to the industrial hygienist and other personnel charged with functional responsibility for results in safety work, notwithstanding the fact that these are primarily the problems of the industrial physician. For this reason, the discussion in this pamphlet is confined principally to the prevention of lead poisoning but there is a brief treatment of selected portions of the medical aspects.

10. In considering the effects of lead on the body, it is important to recognize that there may be individual variations in susceptibility. This and other factors, such as length of exposure, have made it difficult to establish a standard poisonous dose of lead which would apply to all persons and conditions. There are, however, generally accepted maximum permissible limits for 8 hours' continuous exposure. (See Paragraph 39.) Wherever there is a lead exposure there may be a potential lead poisoning hazard. The effects of the toxicity of lead may be very widespread. The following systems of the body may be concerned:

The blood.
The gastro-intestinal system.
The nervous system.
Cardio-vascular system (heart-circulation).
The urinary system (particularly the kidneys).
The reproductive system.

11. The first thing the layman must realize about lead poisoning is that there is no one subjective symptom or objective clinical sign, which is positively indicative of lead poisoning. In some cases so-called "chronic" lead poisoning may be one of the most difficult of the occupational diseases to diagnose. A physician must make the diagnosis in the light of the history of lead exposure, occupational or otherwise; subjective symptoms; objective clinical signs; and information based on laboratory tests.

12. There are, however, general manifestations of the poisonous effect of lead absorption. It should be remembered that whenever there is lead exposure there is potential danger from absorption of the lead. The degree of danger depends upon the extent and duration of the exposure and the control measures in effect. Some of the usual manifestations of lead absorption are listed below. Where these manifestations are noted, the individual should at once be referred to a physician for thorough examination and any necessary treatment.

a. Disturbances of the digestive system, in the form of lack of appetite, constipation, vague abdominal discomfort, and in more severe cases severe cramping abdominal pains (colic).

b. Pain and stiffness in joints, bones, and muscles (particularly the muscles most used.)

c. General weakness, loss of weight, and pallor.

d. Loss of strength in the fingers, hands, or forearm, and inability to use them in the performance of customary tasks. (See Fig

e. Damage to the blood, possibly causing anemia.

13. In addition to the manifestations listed above, there may be nervousness, muscular twitching and tremors, particularly of the fingers. The incidence of fever is rare, but there may occasionally be a slight jaundice and sometimes increased blood pressure. Sometimes in lead encephalopathy (disorder of the brain) irritability, excitement, delirium, convulsions, and ocular disturbances such as amblyopia or blindness occur.

14. Acute lead poisoning cases may fall into one of the definite types familiar to industrial physicians, but the co-existence of more than one type is also recognized. This merely emphasizes that the above recital of manifestations of lead poisoning are for use in prevention of the occurence of disabling diseases and that there should be thorough medical supervision of all employees exposed to lead hazards. It is obvious that where cases of lead absorption are detected in the initial stages, the individual can be removed from the hazard and the onset of lead poisoning prevented. Even where individuals are thought to be exposed to only a minor lead absorption hazard and are referred to a physician, urine and blood tests may indicate too much lead absorption. Here, again, when the victim can be removed from the exposure and adequate treatment given, development of lead intoxication will be prevented. (See paragraphs 17 and 18)

15. The second point which should be clarified is the difference between "ingested lead," "lead absorption," and "lead poisoning." Lead

as compared to either ingestion or absorption through the skin, users of lead compounds should not assume that the danger is negligible where only an ingestion or hazard of absorption through the skin exists. Absorption through the skin is important in the case of lead tetraethyl and other organic lead compounds. If sufficient lead is ingested day after day because of improper personal hygiene, lead poisoning will certainly occur. Likewise, if lead tetraethyl or possibly other lead compounds are handled carelessly, absorption will take place through the skin in sufficient quantities to cause poisoning. (It has been stated by one authority that absorption through the skin is a factor where actors paint the whole body.) Where the skin is scratched or irritated, it is possible to absorb considerably more lead than if the skin is unharmed. Where tetraethyl is used, this hazard is acute and must be guarded against. (See paragraph 7.)

Inhaled lead

20. When minute particles of lead and its compounds are inspired with air, much of it is carried into the mouth or throat and is either swallowed, expectorated, or blown out with the expired air. The remainder is drawn into the lungs and deposited on the lung tissues. Lead in the lungs is capable of rapid absorption and distribution into body tissues, since here it is in intimate contact with the body fluids. Lead, after dissolving in the lung fluid, is absorbed by the blood, and then circulated through the body. When this occurs, the lead is dangerous and is capable, in sufficient quantities, of producing systemic damage.

23. According to Drs. Fairhall and Sayers, who have conducted extensive experiments, all lead compounds do not have the same relative degree of toxicity. Some are highly toxic, while others are toxic only after long exposure. These two authorities, in United States Public Health Bulletin No. 253, "Relative Toxicity of Lead and some of its Common Compounds," have developed, as the result of their experiments, a table of the relative toxicities of certain lead compounds based on their solubilities, which should be of particular interest to industrial hygienists and toxicologists.

24 Regardless of the relative toxicity of lead compounds to which an individual is exposed, lead poisoning can and will occur if sufficient concentrations of lead compounds are breathed, or if the worker swallows sufficient quantities over a long enough period. It should not be considered that preventative measures can be neglected or even minimized because the compound in use is allegedly less toxic than others.

25. According to some authorities, the comparative toxicity of lead compounds is based on a number of variables, the most important of which is their solubility in the body fluids. Among the other factors affecting the toxicity are:

a. Portal of entry.
b. Quantity present in the circulation at any given time.
c. Speed with which compound goes into solution.
d. Size and weight of particles.
e. Length of time in contact with body fluid.
f. Quantity inhaled or swallowed.
g. Degree of acidity of body fluid.

Maximum permissible concentration

38. The maximum concentration of lead in workroom air should not be permitted to exceed 0.15 milligrams per cubic meter (or 1.5 milligrams per 10 cubic meters) for continuous exposure. This standard is generally accepted in the United States; among the several regulating bodies that adhere to this value are the United States Public Health Service, the Connecticut Department of Health, the Massachusetts Department of Labor, the California Industrial Accident Commission, the Illinois Department of Labor, the New York State Department of Labor, and the Wisconsin Industrial Commission.

39. Where tests of workroom air show a greater concentration than 0.15 milligrams per cubic meter, check tests should be made at once to determine whether or not the excess of lead found is due to a permanently existing condition in the process or merely to some temporary or unusual condition. Where check tests show that the maximum permissible limit is being exceeded, steps should be taken at once to lower the concentration to a safe limit. After safeguards have been applied, routine tests should be made to determine adequacy. In determining whether the maximum permissible limit is being exceeded, it is important that tests be made over an entire cycle of the operation, and not merely some high or low point.

Prevention

Control of environment

40. The most obvious method of preventing lead poisoning is to substitute for lead and its compounds other materials that are non-toxic. How-

ever, this is rarely practicable, and recourse must be had to control of environment and training of employees to prevent the absorption of lead.

41. When new plants are to be erected for lead processes, they should be designed to minimize lead exposure. All floors should be of impervious material and easily cleaned. Ledges, window sills, structural iron work or other projections on which dust might lodge should be filled in or angled off. The layout of machines and equipment should be such that maintenance is made easy. Arrangements should be made, wherever possible, to isolate all lead operations so that the least number of employees will be exposed. Vacuum cleaning systems, discharging the exhaust air in a safe place, should be built-in while the building is being erected, and the wash, locker and lunch rooms should be separate from the general work room. In existing plants where it is not possible to build-in permanent vacuum cleaning systems, portable vacuum cleaning apparatus should be used. Such equipment not only makes the cleaning of the plant easier, but in addition makes it possible to remove dust from walls and ledges which otherwise might not be cleaned. Care must be exercised in dumping or cleaning dross from the vacuum cleaners, so that a further lead exposure will not be created. The danger of dust on walls and ledges, of course, is that some vibration or draft may cause it to be swept into the general workroom air.

42. In designing locker rooms, it is preferable that employees exposed to lead hazards be provided with double lockers, one side for their clean clothes and one side for their work clothes. A liberal supply of warm water and soap should be provided, and a sufficient number of shower baths

and wash fountains should be installed so that employees will not neglect cleaning up because of possible overcrowding. (See Figure 7, and Safe Practices Pamphlet No. 27, "Industrial Sanitation (Drinking Water, Wash and Locker Rooms, and Toilet Facilities.)")

Ventilation

43. The type of general ventilation and local exhaust equipment applied to lead hazards will depend in great measure on the type of building, the particular compounds used, and the method of manufacture. There are certain fundamentals which should be considered by the engineer designing the system. These are as follows:

a. All requirements of the state department of labor in which the plant is located should be carefully followed, and plans should be submitted for approval where this is required or where the service is available.

b. Care should be taken when laying out the system that the air inlet is in such a location that only uncontaminated air is drawn into the system. The inlet volume should be commensurate with the exhaust volume. Sometimes it is necessary in cold weather to heat the incoming air so that the exhaust system will function properly.

c. It is preferable not to recirculate to other departments exhaust air from a department with lead exposure. Where air is so recirculated or exhausted directly to the outside it is highly advisable to install some system for

First aid

65. There is no recognized first aid for lead poisoning. All cases of suspected lead absorption or acute attacks should be immediately referred to a physician. To delay proper treatment may lead to complications.

Supporting activities for training

66. The personnel, medical and safety engineering departments should use every facility for stimulating and maintaining the health and safety interest of employees exposed to lead hazards. For example applicable posters should be used on centrally located bulletin boards, and should be changed regularly to maintain interest.

67. Other mediums for maintaining interest and training employees (many of them available through the National Safety Council) are:

a. Payroll inserts containing health hints. When paying by check some companies clip the insert to the check.

b. Sound film strips or moving pictures on industrial health and safety.

c. Company publications.

d. Talks by outside engineers, plant engineer, plant medical officer, or local Safety Council representatives.

68. It may be thought that too much effort directed toward training employees through the use of meetings, literature, rule books and other mediums will focus attention upon an existing occupational disease hazard. This has not proved true in many large companies where hazards of the operation were carefully explained and the methods for avoiding them made clear. (See

Safe Practices Pamphlets No. 67, "Maintaining Interest in Safety," No. 77, "Safety Meetings," and No. 93. "Topics for Safety Meetings.")

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