

AUG 26 1942

Revision

Discontinued 7/51

To be rewritten as Data Sheet

# Lead

## Health Practices Pamphlet No. 3

Published by National Safety Council, Inc.  
20 North Wacker Drive, Chicago**Compliments of [www.Bellsystemleadpoisoning.com](http://www.Bellsystemleadpoisoning.com)**Killed and Walkie  
Destroyed per R.  
Benson's order 2/3/42

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 quickly,

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.*

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 quartz 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 commoner 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 (massicotite)
- Lead monoxide, basic (litharge)
- Lead nitrate
- Lead oleate
- Lead, red (minium)

- Lead silicate
- Lead stearate
- Lead suboxide
- Lead sulphate
- Lead sulphide

6. There are many other compounds of lead that may be used in industry and which may possibly set up a lead hazard. Among these are lead azide, lead bromate, lead bromide, lead dichromate, lead dithionate, lead formate, lead hydroxide, lead phosphate, lead selenide, lead thiosulphate, lead tungstate, and others. While most of these compounds do not have wide application in general industrial operations, they may, nevertheless, be used in quantities for certain industrial and chemical operations. Where this is the case, precautions should be taken against exposure of employees to lead hazards. (See Figure 2.)

7. Tetraethyl lead deserves separate discussion. It is the only type of lead compound that will be absorbed quickly through healthy, unbroken skin. It is an oily, liquid, organic compound of lead that is dangerously volatile at ordinary temperatures. For these reasons, it is a highly dangerous material and must be manufactured and handled with great care against inhalation of vapor and contact with the skin. The chief use of tetraethyl lead is an anti-knock for motor gasoline. It has also been used in small quantities in the manufacture of other chemicals. Regulations governing the use of tetraethyl lead have been developed by the principal manufacturers of the compound. These regulations are rigid and should be closely followed. (See "Regulations for Handling and Mixing Ethyl Fluid," issued by the Medical Department, Ethyl Gasoline Corporation.)

8. The presence of lead in commercial products is sometimes unknown to the management, the foreman, or the workers because the label or description gives no indication that lead is present.



sorption of lead is indicated by lead found in urine or blood examinations. Lead poisoning begins when the lead in the blood and the body organs actually begins to exert harmful effects. Lead poisoning is also referred to as "plumbism" or lead intoxication. Absorption of too much lead into the blood indicates that action must be taken to prevent further absorption by eliminating the source, and that medical treatment may be necessary to prevent the lead from causing systemic damage.

16. Lead absorption and poisoning may be indicated on physical examination by the finding of a typical lead line in the gums. The lead line under magnification will stand out as a distinct row of blue dots in the gum tissue near the tooth margin. Absence of a lead line does not necessarily indicate that lead absorption has not taken place and, too, according to one authority, if a lead line is absent in a mouth where marked oral sepsis exists, it usually indicates that there is no serious amount of circulating lead in the body.

17. Lead absorption is also indicated by lead in the urine. Here again, the results of such examinations must be judged by physicians in the light of clinical symptoms. In normal individuals with no occupational exposure, lead in the urine may range from 0.01 to 0.08 milligrams per liter, and occasional values as high as 0.10 milligrams per liter, the normal average being about 0.035 milligrams per liter. Lead concentrations in the upper range of normal values, i.e., well above the mean value, while not definitely indicative of occupational lead exposure, suggest the advisability of further investigation to establish the facts with reference to lead exposure. It is necessary that the samples tested be obtained by the most scrupulously careful means under the direction of an experienced person. Otherwise contamination of the samples in the process of collection is certain to occur. Depending upon the size of the plant, this supervision may fall to the industrial physician, chemist or laboratory technician. The source of abnormal lead absorption must be clearly established, and here consideration must be given to the possibility that lead may be absorbed from other than an occupational exposure.

18. The amount of lead in the blood as a criterion of lead poisoning is fre-

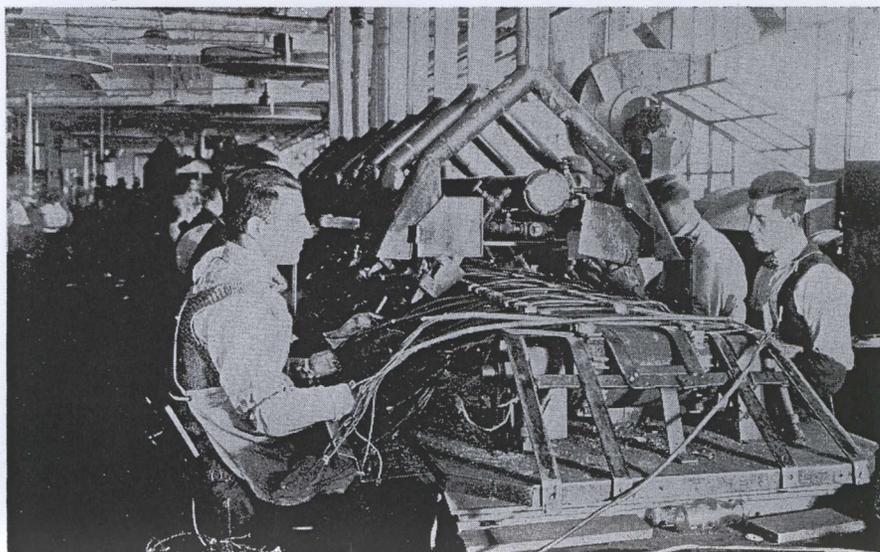


Figure 2. Exhaust system and stationary soldering irons protect these workers from lead fumes. (See paragraph 6.)

quently brought to the attention of personnel and safety men in connection with employees who are being routinely examined for lead absorption. In the normal individual, according to one authority, blood lead values will range from 0.01 to 0.06 milligrams per 100 grams of whole blood with an occasional value as high as 0.07. The mean value for the normal individual is approximately 0.03 per 100 grams of whole blood. Here, again, the advice of a physician is necessary since investigators have found that even where 0.15 to 0.2 milligrams of lead per 100 grams of whole blood are present, the individual is not necessarily suffering from lead poisoning. But this is an indication of a possible lead hazard and action is necessary to discover and eliminate it.

#### Entrance of lead into the body

19. Lead and its compounds can be taken into the body by inhalation, ingestion or absorption through the skin. Inhalation is now recognized as by far the principal means of absorption. The inhalation exposures, however, offer greatest possibilities for improvement or control by engineering means. In spite of the high amount of lead which may enter the body by inhalation, 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 absorption hazard through the skin exists. Absorption through the skin is important in the case of lead tetraethyl and other organic lead com-

pounds. 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 undamaged. 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.

#### Ingested lead

21. Where lead is swallowed, the greater part of it passes unchanged into



Figure 3. Illustration of wrist drop. (See paragraph 12.)

the gastro-intestinal system and thus is eliminated in the feces. The greater portion of the lead which is absorbed from the gastro-enteric tract is carried to the liver. It eventually finds its way into other tissues of the body and also back into the intestines by way of the bile. Lead in the blood may be deposited in the bones or body organs, or be eliminated through the urine. Where lead remains in the body, a high proportion of it is ultimately deposited in the bones. Authorities differ as to how damage to the body may take place subsequent to the deposition of lead in the bones. Some have suggested that the flow of lead may be reversed from the bones into the blood (where it may, if present in sufficient quantities, cause lead poisoning), because of acidosis, changes of diet, or respiratory illness. Other authorities doubt that the above factors are chiefly responsible for the mobilization of lead from the skeleton. It is generally agreed, however, that persons who may have lead deposited in their bones, or who are exposed to lead poisoning hazards, should be strongly advised to refrain from over-indulgence (particularly in alcoholic beverages), and faulty diet.

#### Dermatitis from lead compounds

22. Metallic lead itself has never been reported to cause dermatitis, but some of the lead compounds cause skin irritations among workers handling them. Schwartz and Tulipan, in "Occupational Diseases of the Skin," state that skin eruptions have been reported from contact with preparations containing lead acetate, and that lead arsenate and lead chromate may cause occupa-

tional dermatitis. Dermatitis has been reported as occurring among munitions workers from lead azide and lead styphnate. It is believed that the dermatitis caused by lead compounds is due to the acid radical part of the compound rather than to the lead.

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 preventive 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

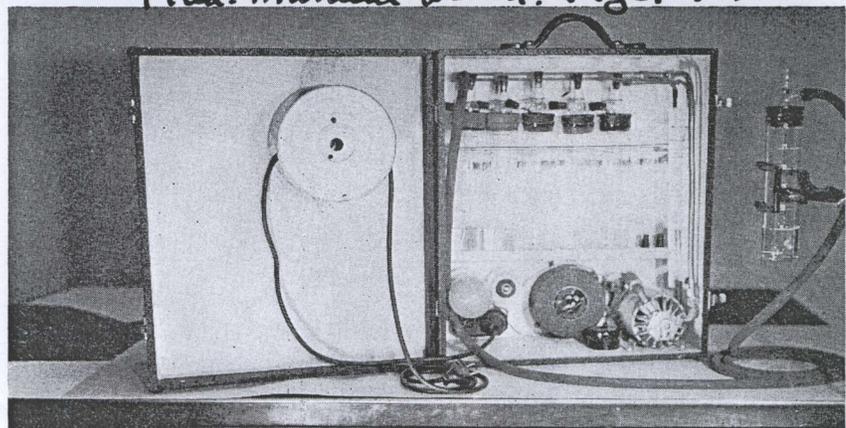
- c) Speed with which compound goes into solution
- d) Size and weight of particles
- e) Length of time in contact with body fluids
- f) Quantity inhaled or swallowed
- g) Degree of acidity of body fluids

#### Determination of Concentrations of Lead in Air

26. Where lead or lead compounds are used in industrial processes, it is important to know whether the measures of control in effect are adequate to protect the men exposed. Then, too, it is highly important at times to evaluate a possible hazard to determine whether control measures are necessary. Concentrations of lead in workroom air can be determined by accepted methods of collection, and subsequent analysis. Two devices in use for air sampling where lead is, or is thought to be, present, are the impinger and the electrostatic precipitator. The former is in greater general use, but the latter is considered more efficient for fumes. (For further information, see Littlefield, J. B., Feicht, P. L., and Schrenk, H. H., "Efficiency of Impingers for Collecting Lead Dusts and Fumes," Bulletin No. 3401, published by the United States Department of the Interior, Bureau of Mines, May, 1938.

#### Impinger

27. The impinger was originally designed by Greenburg, of the United States Public Health Service, and Smith, of the United States Bureau of Mines. There are now several varieties of the original design, but all operate on the same principle. An air sample is drawn through a collecting tube at a measured



Courtesy Illinois State Department of Labor  
Figure 4. Impinger for lead sampling.

rate of flow and is discharged under a liquid through a taper-pointed tube, which impinges the air and its entrained impurities against a glass plate or the bottom of the collecting flask. When a representative sample has been taken, the flask is disconnected from the apparatus and transported to the laboratory for analysis. (See Figure 4.)

28. Impingers may be obtained in several sizes, the one selected depending upon the volume of air that must be drawn through the apparatus to get a representative sample in a measured time. Two sizes are generally used, calibrated for a maximum flow of one cubic foot per minute, and 0.1 cubic foot per minute, respectively. The latter type is known as the "midget" impinger.

29. The sample of air to be tested may be drawn through the impinger by one of several methods: a compressed air ejector, an electrically driven blower or vacuum pump, or a manually driven suction pump. The hand-operated suction device is of especial value for field work where electrical power or compressed air is not available, or where samples must be taken in a flammable or explosive atmosphere.

#### Electrostatic precipitator

30. The electrostatic precipitator is especially adapted to the collection of lead fumes. As in the case of the impinger, there are variations of construction and design of precipitators, but the principle of operation is the same for each. One precipitator which has been used in the field, and is available commercially, consists chiefly of a small blower to pull in the air sample, a precipitation chamber, and a power supply. The precipitation unit is essentially a grounded cylindrical metal tube which acts as the collecting electrode and a central electrode which acts as the ionizing and precipitating electrode. The central electrode has one end spun in the shape of a bullet-nose and contains a small platinum wire extending from the spun end. Both electrodes are small aluminum tubes. For sampling, the electrodes are placed in a head which is supported on a telescoping tube which functions as an air connection to the blower. Particles collected are given an electric charge as they enter the precipitation chamber and are then forced to the outer electrode in a much stronger electrostatic field. Air flow is measured

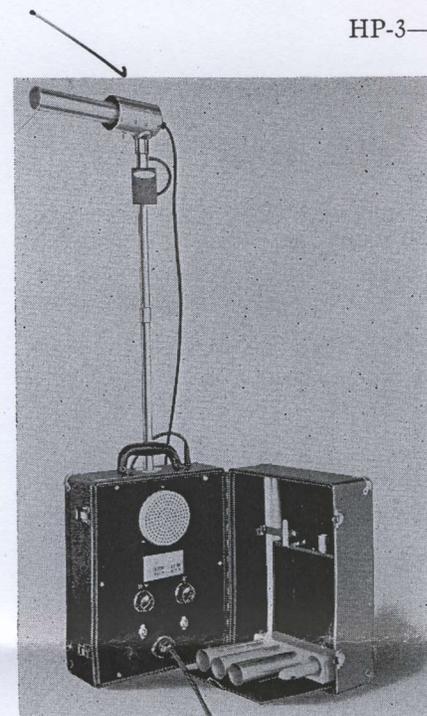
after passing through an orifice, by a manometer located near the head. Suction is obtained by use of a vacuum type motor and blower. Power supply is obtained with a transformer. (See Figure 5.)

#### Technique in collecting samples

31. The collection of samples with either the impinger or the electrostatic precipitator is a job for a highly trained and skilled technician. Precise technique and a thorough knowledge of the pitfalls to be avoided are an absolute necessity for accurate sampling. Samples must be truly representative of the average conditions of exposure, (preferably taken in the breathing zone), not merely indications of high or low concentrations at certain times. For this reason, the samples must be taken under normal operating conditions and over a period that will give the average exposure (sometimes an entire shift must be covered) and, too, care must be taken that normal ventilation is not disturbed by the sampling operations. The concentration of lead present also is a factor in governing the sampling time, for where not much lead is present, samples must be taken over a longer period to get measurable quantities for analysis. Great care must be exercised to prevent contamination of sampling equipment before and after the sampling period if the results are to be accurate. (For a complete description of the technique in using an impinger and electrostatic precipitator, see Brown, Carlton E., and Schrenk, H. H., "A Technique for Use of the Impinger Method," Information Circular 7026, Bureau of Mines, 1938, and Drinker, P.: "Alternating Current Precipitator for Sanitary Analysis. An inexpensive precipitator unit." *Journal of Industrial Hygiene and Toxicology*, 14, 364, 1932.)

#### Methods of lead analysis

32. There are a number of general methods by which collected lead may be quantitatively analyzed; the following four of which are probably best known: the colorimetric (dithizone); the spectrographic; the volumetric (Fairhall's chromate); and the dropping mercury electrode. Many of the general methods, including those just enumerated, are applicable for the analysis of lead in biological materials after suitable preparation of such samples.



Courtesy Mine Safety Appliances Co.

Figure 5. Electrostatic dust sampler outfit for lead fumes. (See paragraph 30.)

33. Various investigators have established standard chemical procedures for the separation of lead from other metals, as the chromate, sulphide, or sulphate; and the subsequent determination of the lead by colorimetric, titrimetric, or turbidimetric techniques, including several modifications. These procedures are successfully used only by skilled and careful analysts. Perhaps most widely used among these methods has been the dithizone (diphenylthiocarbazone) colorimetric method, of which there are more than 50 variations. It is sensitive enough to give results even where the concentration of lead is extremely low, involves relatively simple manipulations, and is specific under controlled conditions.

34. The dropping mercury electrode method of analysis, utilizing the polarograph, is coming into wider usage, especially for routine urine analysis. It has in its favor a comparatively simple technique and greater speed in the final determination of lead. However, this method, like others, necessitates time and care in the preparation of samples. When capably employed this method is said to yield results as accurate as those obtained by the dithizone and spectrographic method. (See Figure 6.)

35. Spectrographic analysis of materials containing lead results in a high degree of accuracy in the hands of a



Courtesy E. H. Sargent & Co.  
Figure 6. Polarograph for determination of lead. (See paragraph 34.)

capable technician. The equipment is highly specialized and very sensitive.

36. Various modifications of the Fischer-Leopoldi method (making use of dithizone as a means of extracting lead quantitatively from its aqueous solutions to form a color complex), have been developed in recent years and have come to occupy an important place among procedures. The method is sufficiently sensitive to be used to determine minute quantities of lead in small samples of urine, blood, and tissues. When carried out with proper chemical technique, it is specific for lead and quantitatively precise. Several of the modifications have been described in step-by-step detail and can be relied upon when employed by careful and experienced analysts.

37. Detailed information on the technique of the methods or modifications mentioned above, as well as the several methods of analysis and recent modifications of such methods, not mentioned in this pamphlet, will be furnished on request by the National Safety Council.

#### 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 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. However, 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 workroom. 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 recovering from exhaust air the lead compound which is picked up by the exhaust or ventilating system to prevent recirculation or contamination of air in the vicinity of the plant.
- d) The system should be laid out so that it is foolproof and so tamper-

ing by employees cannot take place without discovery.

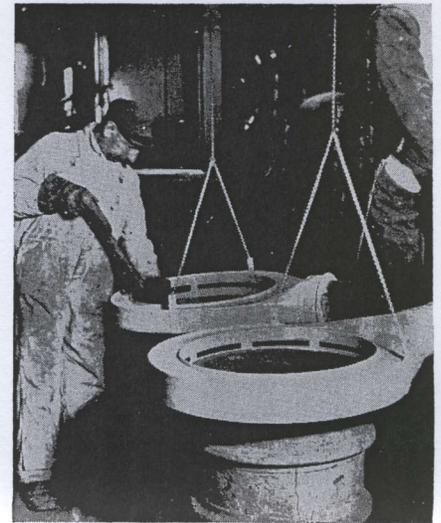
- e) On every job where lead dust or lead fumes are given off, local exhaust should be applied that will limit the concentration of dust or fumes in the breathing zone of workers at or below the maximum permissible concentration of 1.5 milligrams per 10 cubic meters of air for continuous exposure. (See paragraph 38.)
- f) Local exhaust systems, when applied, should be so designed that they will not interfere with the operating efficiency of the general ventilating system and vice versa. Cross currents of air and dead air pockets should be avoided. It is sometimes necessary to resort to air line respirators or masks for cutting or welding operations, particularly where large parts are involved. Such respiratory protective equipment is satisfactory, but care should be taken not to expose other employees in the area, who are not protected.
- g) Only exhaust and ventilation systems designed by experts in that field should be installed. Repairs to existing systems should never be made by amateurs. Where state laws require it, or where this service is available, repairs should never be made without first consulting the state department of labor.
- h) All ventilating, local exhaust, and dust collecting systems designed for control of lead exposures should be checked periodically for efficiency by a qualified engineer.

44. In many cases, exhaust equipment for specific operations will have to be especially designed for the particular job. For instance, Figure 8 illustrates a ring-type exhauster which effectively prevents lead carbonate dust

from spreading into the surrounding workroom air during loading of basic lead carbonate into metal drums or barrels. (See also paragraph 53.)

#### Respiratory protective equipment

45. For certain classes of exposure, such as general spray painting, spray painting structural steel, lead burning, cutting and welding of lead-coated steel, and for use during emergency, respirators of a type approved by the U. S. Bureau of Mines should be used. For continued protection against lead exposures, a properly designed, installed and maintained ventilation and exhaust system is highly advisable; however, where respirators offer the only practical type of protection their use should be insisted upon. Wherever respirators are in use, supervisory attention should be given to making the employees as comfortable in them as possible; and, particular care should be paid to the hygiene necessary in their maintenance. For lead dust, a lead dust respirator approved by the U. S. Bureau of Mines may be used. When exposure to lead fumes is involved, the U. S. Bureau of Mines approved respiratory protective equipment, such as air line respirators, or abrasive blasting helmets may be used. There is also the problem of making certain that air supplied to this type of equipment is clean and free from the compound against which protection is sought. Approved mechanical filter respirators may also be used for protection against lead fumes. These filters require renewal frequently, depending



Courtesy John P. Lewis & Bros. Co.  
Figure 8. Ring-shaped exhaust hoods for use at top of barrels. (See paragraphs 44 and 53.)

upon the fume concentration. For additional information on respiratory protective equipment, see Safe Practices Pamphlet No. 64, "Respiratory Protective Equipment," and Industrial Data Sheet D-Gen. 16, "Cleaning and Sterilizing Goggles and Respiratory Protective Equipment."

46. A complete discussion on ventilation and exhaust is not within the scope of this pamphlet. For additional information on ventilation and exhaust systems, see Safe Practices Pamphlets No. 32, "Exhaust Systems," and No. 37, "Industrial Ventilation."

#### Other control measures

47. Particular attention should be given to the possibility of entirely enclosing lead processes so the chance of fumes and dusts escaping in the workroom air is reduced to a minimum. For example, excellent work has been done in enclosing processes involving lead in the gasoline and battery manufacturing industries.

48. When it is necessary to melt lead, the temperature should be held as close as possible to the melting point, since greater quantities of fumes are given off at elevated temperatures. (See paragraph 2.)

49. Wet methods of production have long been looked on with favor by some industrial hygienists and industrial physicians for preventing the discharge of dust in the workroom air.

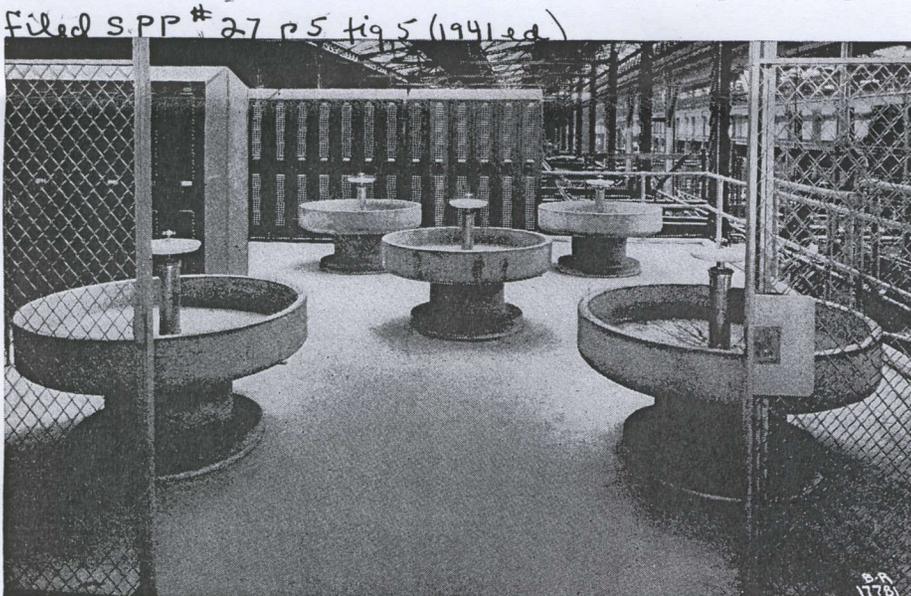


Figure 7. Good wash facilities near lead operations. (See paragraph 42.)

Name.....	Date seen.....	Lead study #.....
		For how long?.....
Address .....		
Hist. of water supply.....		Other lead sources.....
Medical attendant .....		
Age.....	M. F.....	W. O.....
S. M. W. D.....	Nationality.....	
Births .....	Miscarriages.....	Stillbirths.....
Deaths.....		
Pres. res.....		
Industry .....		Occupation .....
Dur. ind.....		Dur. pres. trade.....
Prev. emp.....		
Complaint .....		
Habits .....		
Appetite.....		
Constip.....	Dair.....	Naus.....
Vom.....	Eruct.....	Wt. loss.....
lbs. in.....		
Abdominal pain-distress .....		Where.....
When.....		
Memory .....	Vision.....	Headache.....
Vertigo.....	Ataxia.....	Asthenia.....
Joint pain.....		
Paresthesia.....		Strabismus.....
Pb line.....	Pallor.....	Weakness Flex.....
Ext.....	R. & L.....	Wr. Dr.....
Toe Dr.....		
Blood Hgb.....		
RBC.....		
Stippling .....	Diff.....	P.....
LM.....	LL.....	SL.....
M.....	E.....	Tr.....
Diagnosis .....		

Figure 9. One company has developed and used this special form for employment and periodical examinations of lead workers. (See paragraphs 9-18.)

Where wet methods of manufacture are applicable, they should be applied, bearing in mind the danger of lead dust, or dust of compounds of lead, being thrown into the air upon drying. Examples of wet methods are oil grinding of white lead in the paint industry, the English and German method of separating white lead powder (basic carbonate) from lead buckles by immersing them in a trough of running water, and wet pasting of lead plates in storage battery manufacture.

**Housekeeping**

50. In addition to the installation of vacuum cleaning apparatus, it is necessary that a regularly scheduled routine for housekeeping be instituted and followed. Where there is no regular cleaning crew, definite periods should be set aside each day and all men in the department should be required to take part in cleaning up. The practice of using compressed air for blowing lead dust or lead compound dust from floors,

walls and ledges should be strictly prohibited since this is one of the most dangerous methods of cleaning, and it is certain to leave a heavy concentration of dust in the air. In some plants, such as in glazing departments of potteries, the walls, floors, ledges, and ceilings are flushed off with a water hose, and all of the material is swept into a central drain. (See Safe Practices Pamphlet No. 45. "Industrial Housekeeping.")

51. Covered trash cans should be provided and employees should be instructed to use them instead of dropping material on the floor around machines or benches. Dross, especially, should be covered immediately after removing from the kettle and should be transported as soon as possible to suitable storage rooms or reducing furnaces.

52. The practice of vigorously sweeping up floors in departments in which lead or lead compounds are used, should be prohibited. If sweeping must be employed, soft push brooms should be used, and the floor should be liber-

ally sprayed with water *before* sweeping operations are started. Liberal quantities of oiled sawdust are used in some plants instead of sprinkling with water, to avoid dust being created if the water dries before sweeping is completed. The men doing the sweeping should be provided with and required to wear approved type respirators and should, if possible, perform their work at times when other employees are not exposed. Vacuum cleaning is preferable to sweeping.

53. All containers of lead compounds should be provided with covers, and should be kept closed at all times except when actually in use. Where powdered material is transferred from barrels to mixing or other process machines, covered scoops should be used for the purpose or some mechanical means of transferring should be employed that will prevent contamination of the workroom air. Ring-shaped exhaust hoods that fit the top of barrels may also be used. (See Figure 8 and paragraph 44.)

**Selection and Placement of Employees**

**Physical examinations**

54. All employees, before being put to work on operations where there is exposure to a lead hazard, should be given a thorough physical examination by an industrial physician. The recommendations of this physician should be followed in assigning to employment any man who is examined. (See Figure 9 and Health Practices Pamphlet No. 2, "Physical Examinations in Industry.")

55. Possible reasons for rejection from employment where a lead exposure exists include lead intoxication, indication of an abnormal content of lead in the blood or urine, kidney trouble, stomach ulcers, heart trouble, anemia, constipation, venereal disease, tuberculosis, alcoholism, and the use of drugs. Pregnant women and adolescent boys or girls should not be employed where there is a lead hazard. It should be noted that many of the reasons for possible rejection from employment given above would also prohibit any type of employment.

56. Re-examination of employees should be made at regular intervals, the intervals to depend on the recom-

mentation of the industrial physician making the examination, on the lead exposure that exists, or on state labor department requirements. In general, where lead or lead compounds are extensively used in the plant, employees should be given complete physical examinations at least once a year, preferably more often, and they should be examined monthly by the plant physician to determine whether or not lead absorption has taken place. Microscopic blood examinations (basophilic aggregation tests, stippled cells) or urinalysis should be made and the general health of the individual carefully studied. Employees should have the privilege of reporting to the plant physician for a further check-up anytime they do not feel well. One authority suggests that physical examinations be given every six months where metallic lead is used, monthly where molten lead or compounds are used, and every two weeks if white lead or red lead is used. (See Health Practices Pamphlet No. 5, "Health Service in Industry.") Where the question of frequency of examinations arises it should be answered by the industrial physician, after the engineering details of the physical environment have been carefully considered and evaluated for or by him.

57. The medical department plays an important part in plants where there is a lead hazard. Hence, its activities should be properly integrated with other prevention work. The medical department should act as a check on the efficiency of the control measures in the plant. For this reason, reports of the medical department should be closely studied and where, in spite of careful control measures in effect, a high lead absorption rate is shown by certain individuals, careful inspection should be made of their work locations for the purpose of correcting hazards.

### Training of Employees

58. There are certain minimum standards of education and adaptability that should be fulfilled by the prospective lead worker. These will vary considerably from industry to industry, but the minimum test should be whether or not the prospective worker is adaptable and can be trained to follow safety rules. For example, inability to speak English greatly complicates the training problem. However, there is no ob-

jection to employing non-English speaking workers if provision is made for training by supervisors or instructors who can explain the hazards and the proper work methods in the language of those employed.

59. Once it is decided that an individual is physically and mentally able to do work in lead processes, the general hazards of lead work should be carefully explained. At the same time, common sense rules of personal sanitation and company policy on safety should be presented. Before a man is finally put to work, he should be examined as to his understanding of these rules by a personnel man or the safety engineer.

60. When individuals are being "broken in" on jobs, a definite procedure should be followed that will insure their knowing exactly what is to be done and how it is to be done. This is best achieved by first thoroughly explaining the job and giving the reasons for the rules that are enforced. The employee should then be given a chance to state his idea of what he has been told; this gives the instructor an opportunity to correct any misunderstanding. The job should then be demonstrated by the instructors, several times if necessary, and the new employee should finally be permitted to perform the operation. Here again, an opportunity for correction of unsafe practices or inefficient work is presented. After the instructor is certain that the man understands and can do the operation safely and efficiently, he may be permitted to work alone, but he should be checked from time to time to make certain that all safety and health rules are obeyed. The same procedure should be followed in transferring workers from one department to another or from one operation to another. (See Safe Practices Pamphlet No. 65, "Teaching Safety to New Employees.")

### Personal hygiene

61. Personal cleanliness of the exposed portions of the body, the fingernails, mustaches and hair should be insisted upon. Employees should be urged to take a shower each night before leaving the plant and to change from their work clothing to street clothing. Where lead dust collects on the clothing and hair of employees, it may get into the workroom air when the clothing is brushed or shaken.

62. The medical department may, from time to time, issue bulletins on the subject of proper diets for workers exposed to lead and its compounds. In some exposures this may include the recommendation to drink milk. The workers, too, should be urged to get plenty of sleep and as much sunshine as possible.

63. Employees should be forbidden to use tobacco (smoking, chewing or snuff) while in the plant, except that this may be permitted in the regular plant lunchrooms or in other designated areas during lunch hour, *after* employees have thoroughly cleansed themselves.

64. Eating in a workroom where lead is handled should be absolutely prohibited. It will be difficult to enforce this rule unless a lunchroom is provided where employees can eat in comfort. In many plants, lunchrooms have been provided in which employees can purchase, at moderate cost, a nutritious and properly balanced meal. Lunchrooms should be isolated from any lead exposure and employees should be compelled to wash their faces and hands thoroughly before eating. In some cases, it may be desirable to urge employees to change clothing before eating.

### 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 media 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 media 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.")

#### ACKNOWLEDGMENT

*This pamphlet has been revised by Ernest J. Downing and John M. Roche, Industrial Division, National Safety Council, following the work of a special committee of which Harold Ohleheiser was chairman. The original drafts were reviewed by members of the special committee. Their valuable assistance and the original work of the committee is gratefully acknowledged.*

*The first draft of the revision was submitted for criticism to the Safe Practices Conference Committee, the Health Practices Conference Committee, and authorities on the subject of lead. The*

*final draft was approved by the Executive Committee of the National Safety Council.*

*Liberal use has been made of the published material and personal comments of Drs. Robert A. Kehoe, David C. Strauss, Elston L. Belknap, S. F. Meek, Lawrence T. Fairhall, R. R. Sayers, Louis Schwartz, J. C. Aub, Leonard Greenburg, Alice Hamilton, Carey P. McCord, Ludwig Teleky, A. G. Kammer, Milton H. Kronenberg and H. A. Cranston and others. The suggestions and help given by these authorities were invaluable in the preparation of the pamphlet.*