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Revised

BENZOL

Health Practices Pamphlet No. 14

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Introduction

1. Benzol can be safely used if certain precautions are taken to guard against those properties which make it injurious to health. Care must be taken, too, to obviate the possibility of fire and explosion.

2. Benzol is the liquid product of the destructive distillation of coal followed by the subsequent destructive distillation of the distillate (coal tar). This substance is sometimes called benzene, the term being used in chemical nomenclature to describe the substance having the formula C_6H_6 and certain characteristic properties. The commercial grade of benzene (C_6H_6) is commonly known as benzol. This name will be used throughout the pamphlet in order to avoid confusing it with benzine, a petroleum derivative of the hydrocarbon series. It should be remembered, too, that it is possible to recover benzol from petroleum, in varying percentages, depending upon the sources of petroleum. This is especially true in cracking operations where elevated temperatures and pressures are employed. The specific gravity of benzol is 0.881 at 60° F./60° F. (liquid), while the specific gravity of the vapor at 60° F. and 760 mm. pressure is 2.73, (Air = 1), or the vapors are 2.73 times heavier than air. In its natural liquid state, benzol boils at 176.2° F. The flash point is 10.4° F. at 760 mm. pressure (See paragraph 42).

3. Benzol is miscible in alcohol, ether, acetic acid, and carbon disulphide. Benzol is an excellent solvent for rubber, gums, fats and resins.

4. There are two distinct types of industrial uses:

a) In closed systems of pipes or tanks—
   1) The blending of motor fuels.
   2) Manufacture of chemicals including dye and dye intermediate manufacturing, the manufacturing of paints, varnishes and stains, and also the manufacture of paint and varnish removers. It is also used in the refinement of petroleum products.

   Note: These uses in the first group offer no appreciable health hazard except when accidents occur to the equipment.

b) In open processes—
   1) Rubber industry.
   2) Textile fabric makers (artificial leather).
   3) Sanitary can manufacturing.
   4) Dry cleaning, particularly "spotting."
   5) Handling of paints, varnishes and stains.

> 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.

5. According to the Division of Labor Standards, United States Department of Labor Industrial Health and Safety Series Bulletin No. 8, the workers in the following trades are most likely to be exposed to benzol:

Airplane-dope workers
Textile fabric makers
Benzol still-men
Blenders (motor fuel)
Brake lining makers
Cementers (rubber)
Compounders (rubber)
Degreasers (fertilizer and leather)
Dryers (rubber)
Dry cleaners
Dye makers
Enamel makers
Enamelers
Engravers
Explosives workers
Glue workers
Lacquer makers
Lacquerers
Linoleum workers
Nitro-benzene makers
Nitro-cellulose workers
Oilcloth makers
Paint remover makers
Paint makers
Paraffin workers
Phenol makers
Photo-engravers
Pyroxylin plastic workers
Reclaimers (rubber)
Shade cloth makers
Shellac makers
Shoe finishers
Varnish makers
Varnishers
Vulcanizers

6. Three types of benzol are in commercial use:

a) Crude 90% benzol (density 0.86-0.88) which distills up to 212° F. (100° C.) and contains 84% benzene, 13% toluene, and 3% xylene.
b) Refined 90% benzol.
c) 50% benzol (density 0.88) of which 50% will distill at 212° F. (100° C.).

Other substances such as carbon bisulphide, thiophene, ethylene, olefine, paraffin and naphthalene may be present in small quantities in the commercial grades of benzol.

Benzol Poisoning

7. Certain individuals are apparently more susceptible to benzol poisoning than others. It is known, for instance, that the chances of contracting benzol poisoning are much increased when the individual presents certain abnormal conditions. (See paragraph 26.)

Acute poisoning

8. The breathing of excessive amounts of benzol vapor will produce acute poisoning which may be rapidly fatal unless prompt medical attention is obtained. These cases often occur

when there is an accident such as the bursting of a pipe, or the overflowing of large containers, or when workmen enter a tank for cleaning or repair work without the proper protective equipment. Most hydrocarbon vapors are much heavier than air and remain near the bottom of the enclosure. Tanks in which these materials have been stored or transported often become coated inside with a film of gum or resin, or there is a deposit of sludge in the bottom. The hydrocarbons become absorbed in these deposits and are given off for a considerable time after supposedly thorough cleaning.

9. Workmen should never enter tanks or enclosed spaces where benzol, or solutions of benzol and other substances, have been stored and which have not been thoroughly steamed and aired, without being protected with a Type A supplied-air respirator hose mask, which supplies fresh air from outside the enclosure, or oxygen breathing apparatus. There should be a safety rope (life line) around the body. A helper should also be stationed outside the tank at all times while the workman is inside, to render assistance in an emergency. Most companies insist, to insure safety, that the worker use the mask and life line even though the tank, or enclosed space, has been steamed and aired and is apparently free from benzol vapor. Another point to be remembered is that the improper use of lights, that is, those not of the explosion-proof type, may present a fire or explosion hazard. (See paragraphs 42 to 64.)

10. The nervous system is principally affected in cases of acute benzol poisoning. As a result, the respiratory center is paralyzed and the individual affected may consequently die of asphyxia. In such a case, one would not expect to find any changes in the blood, such as are observed in chronic poisoning.

11. Where massive doses of benzol vapor have been inhaled, death may result in a short time (from one-half to one hour). Profuse sweating, hyperesthesia, hallucinations, delirium, coma, and death follow in rapid order. These signs vary, of course, with the amount of vapor inhaled and the predisposition of the victim. Frequently, vertigo, headache, nervous excitement (drunkenness), cough, dry skin, flushed face, and subnormal temperature are noted. In severe cases, there follows a stage of depression, feeling of illness, nausea, vomiting, mental dullness, loss of consciousness, tremor, respiratory and circulatory trouble, sensory and motor paralysis, and a pinkish coloration of the mucous membrane. The narcotic action of the poison may result in complete general anesthesia, total elimination of reflexes, and death in a state of coma.

12. Where large doses have been inhaled, death may follow rapidly, as stated above, or recovery without subsequent harm may take place in a short time. Investigators have discovered, however, that while cases due to slight exposure may recover, the after-results may be very severe. The need of adequate medical supervision of all such cases is, therefore, strongly emphasized by most authorities.

13. When acute poisoning has occurred, the patient should be removed from the danger zone to pure air immediately and placed in a reclining position. If the clothing is, or was, wet with benzol, it should be removed at once and the victim's body washed with soap and water while the following steps are being taken. If the patient is not breathing, the prone pressure method of resuscitation should be started instantly and continued until breathing has been restored. (See Safe Practices Pamphlet No. 29, "Electric Equipment in Industrial Plants," for description of prone pressure resuscitation.) It is important that the person be kept warm and, if necessary, heat should be applied. If a carbon dioxide-oxygen apparatus is available, the gas should be administered at once. Oxygen, alone, may be used. Stimulants such as strong coffee, (never alcohol in any form), may be given after breathing is resumed; however, the victim should never be left alone while a stimulant is being obtained, since it may be necessary to again start artificial respiration if breathing should cease. Medical aid should be summoned at once. It is especially important to note that nothing should interfere with the instant application of prone pressure resuscitation. Any other treatment that must be administered should be given while prone pressure resuscitation is being conducted.

Chronic poisoning

14. Chronic poisoning differs from the acute type in that benzol is absorbed by the body in small quantities over a considerable period of time (usually weeks or months), hence the importance of periodic examinations so that chronic poisoning may be recognized and treated even before outward signs become apparent. The chief effects are observed in the blood and the blood-forming organs. Chronic benzol poisoning is characterized by pallor of the skin, which may be an indication of beginning anemia, and should be checked by blood count; hemorrhages from various parts of the body; small purple spots under the skin; ease of fatigue; shortness of breath, and a dry cough.

15. Since the chief changes in chronic benzol poisoning are in the blood, these will be considered somewhat in detail. The normal blood contains about 5,000,000 red cells and 7,500 white cells per cubic mm. of blood. Ordinarily, the polymorphonuclear cells comprise about 70 per cent of the white cells, and the lymphocytes about 20 per cent. In benzol poisoning, however, this relationship is disturbed to the extent that we find a ratio of 40 and 60 per cent or 40 and 35 per cent instead of the normal 70 and 20 per cent. This change can be observed early in benzol absorption.

16. There is also a drop in the total number of white cells to 5,000 or 4,000, and even in certain cases to 1,500 or 1,000. The red cells likewise decrease in number and may go down to less than 1,000,000 per cubic mm. There is a corresponding diminution of the hemoglobin, or coloring matter of the red cells. Since the red cells are the oxygen carriers, any decrease in their number means an increase in the pulse and respiration rate. This is the body's effort to pump the decreased number of cells more quickly, and furnish oxygen more rapidly, so the normal oxygen demand will be satisfied.

17. It has been found that the "platelets" of the blood decrease in these cases from the normal of 100,000 to 200,000 per cubic mm. to 50,000 or less. The chief function of these platelets is to assist in the clotting of the blood. This decrease of platelets explains the tendency to hemorrhages and the purple spots on the skin of workmen who have absorbed benzol.

18. The anemia induced by benzol is not the result of direct destruction of blood cells but rather the failure of the blood cell-forming tissues to keep up the production of cells to meet normal body losses. It is termed aplastic anemia. Such a condition is produced when the bone marrow is impaired in its usual function of forming and regenerating the blood elements, at the normal and sufficient rate.

Diagnosis

19. Among the important points in the diagnosis of chronic benzol poisoning are:

a) Occupational exposure.

b) Blood changes.

1) Change in the ratio of the different forms of white blood cells.

2) Decrease in the total number of white blood cells.

3) Decrease in the total number of red blood cells.

4) Decrease in the number of platelets. (Delayed coagulation.)

5) Decrease in the amount of coloring matter, or hemoglobin, in the blood.

c) Other signs are:

1) Headache, vertigo, ease of fatigue.

2) Skin or nasal hemorrhages.

3) Pink color of mucous membranes.

4) Absence of cyanosis (blue coloring of nails, lips, etc.)

20. Since the signs of benzol poisoning are not specific and may have resulted from other causes, only qualified physicians should attempt the diagnosis.

Urine sulphate test

21. The United States Bureau of Mines has developed the urine sulphate test as a means of determining the existence of benzol exposure. The test is based on the fact that when a small amount of benzol is taken into the body, a marked decrease in the normal ratio of inorganic sulphates to total sulphates present in the urine occurs. Hence, a determination of this ratio gives an indication of benzol exposure and thereby gives a definite warning signal before the health of the worker is affected. The test is a measure of exposure only; it is not a means for diagnosing poisoning. It can easily be made by an industrial

22. The urine specimen should be taken after the worker has been exposed to benzol for three or four days. If he has not been working over the week-end, the sample should not be taken on Monday, but a waiting period should ensue to insure accurate results. The sample should be obtained at the end of a working shift rather than at the beginning. The specimen for the test for inorganic sulphate should be placed on ice immediately after voiding unless the test is made at once. The barium chloride specified for the test should be added within 24 hours.

Inorganic sulphates

23. Twenty cc. of urine, 100 cc. of water, and 10 cc. of dilute hydrochloric acid (one part concentrated hydrochloric acid and four parts water by volume) are measured into a 200-250 cc. Erlenmeyer flask. If the urine is dilute (this may be recognized by its weak color or by a specific gravity of less than 1.005), 100 cc. of urine is taken and 4 cc. of concentrated hydrochloric acid (HCl) is added, 25 cc. of water may be added also. Ten cc. of a 5% barium chloride solution is added slowly, drop by drop. The urine solution should not be shaken, stirred, or otherwise disturbed while the barium chloride is being added. The solution is allowed to stand one hour or longer, according to convenience, and then shaken up and filtered through a Gooch crucible (No. 42 Whatman filter paper may be substituted for the Gooch crucible). The precipitate is washed with about 250 cc. of cold water, dried, ignited and weighed.

Total sulphates

24. Twenty-five cc. of urine and 20 cc. of dilute hydrochloric acid (1 to 4), or 100 cc. of dilute urine and 8cc. of concentrated hydrochloric acid are boiled gently in an Erlenmeyer flask (200-250 cc.) for 20 to 30 minutes. The mouth of the flask should be covered with a small watch crystal to retard the loss of steam during the boiling. The flask is cooled in running water for 2 to 3 minutes and the contents, if turbid, are filtered and then diluted to about 150 cc. with cold water. To this cold solution, 10 cc. of a 5% barium chloride is added and the procedure continued as

TABLE No. 1

Per Cent Inorganic Sulphates in Urine	Benzol Hazard	Precautions Indicated
Above 75%	No exposure	Normal range of sulphates.
Below 50%	Unsafe	Additional ventilation is necessary.
Below 25%	Dangerous	Stop exposure until ventilation is improved.

Notes—1. See paragraphs 21 to 24.

2. The results of these determinations may be expressed as ratios of inorganic sulphates to total sulphates, or as percentages. Numerically the values will be identical.

3. Where a definite decrease in the ratio is found, the results can be checked if when the person is transferred to a non-benzol environment, and placed under medical supervision, subsequent testing shows a normal sulphate ratio.

25. There are other methods that can be used to determine benzol exposure, such as the micro-colorimetric method, as described in the United States Bureau of Mines Bulletin No. R.I. 3287, or by using a special combustible gas indicator calibrated for benzene. Detectors can be obtained that will indicate a concentration of 20 parts per million.

Medical Supervision

26. A careful pre-employment examination of all workers who may be subjected to exposure of benzol can be instrumental in decreasing the chances of benzol poisoning in the general industrial population. Persons showing the following abnormalities should be excluded from benzol processes, according to competent authorities:

a) Organic disease of heart, lungs or kidneys.

b) Tendency to hemorrhages.

c) Any type of anemia or any unusual blood findings.

d) Chronic disease of the liver.

Note: Most authorities recommend that young people not be exposed to benzol.

27. Re-examinations are also necessary, it being customary in most plants to make a careful examination of the blood once every three months, or more often, if indicated.

28. Where workers show any of the

most companies make it a practice to transfer them immediately to work where they will not be exposed. The recommendation of the industrial physician should be followed in every such case.

29. Contact of benzol with the skin may produce dermatitis similar to that seen in exposure to other hydrocarbons. The skin, for mild exposures, may be protected by the use of a bland ointment composed of one part of gum tragacanth and three parts of lanolin. Gloves smeared with protective ointment may also be used. It should be remembered, however, that benzol is a fat solvent; hence, too much dependence should not be placed on this type of protection. The best prevention is avoidance of contact. There is also the hazard that benzol poisoning may be contracted through absorption of the material through the skin. Recent industrial experience has indicated that this is a strong possibility; hence, every precaution should be taken to avoid contact.

30. Treatment of both acute and chronic cases of benzol poisoning should be under the direction of a competent physician except that in acute cases, first aid should be rendered. Where breathing has ceased, prone pressure artificial respiration should be given at once. (See paragraph 13.)

31. In the chronic cases, removal from fumes, dietary measures, cooked liver, sunlight or ultra-violet, raw embryonic liver, and transfusion have been found to be the most effective treatment and are often necessary. These latter measures are such that they demand the services of a medical specialist. If the anemia is serious, the physician will order transfusion without delay. The victim should be carefully observed for signs of infection, colds, or pneumonia, since he will be more than usually susceptible to such conditions.

32. The following measures are important in the prevention of chronic poisoning:

a) Enclosure of benzol processes wherever possible.

b) Proper installation and maintenance of adequate exhaust systems. (See discussion of exhaust ventilation.)

c) The frequent measurement of the concentration of benzol vapors and the maintenance of concentrations below toxic limits at all times. (A maximum concentration permissible in the breathing atmosphere of 100 parts of benzol per 1,000,000 parts of air was the standard mentioned by the Benzol Report of the National Safety Council, May, 1926. Experience since this report was submitted indicates that the recommended maximum permissible concentration may be too high. Most authorities suggest as a standard for maximum permissible concentration not more than 50 parts per million. The United Soviet Socialist Republic goes even further and suggests a concentration of between 15 and 50 parts per million.) Such tests can be made through the courtesy of firms manufacturing benzol. Organizations desiring this service should write the Industrial Division of the National Safety Council.

d) Proper medical supervision which includes a pre-employment examination, a quarterly periodic examination of all exposed employees (including an examination of the blood), and proper placement of workers according to examination findings. Some companies have instituted the practice of making regular urine sulphate tests of exposed employees.

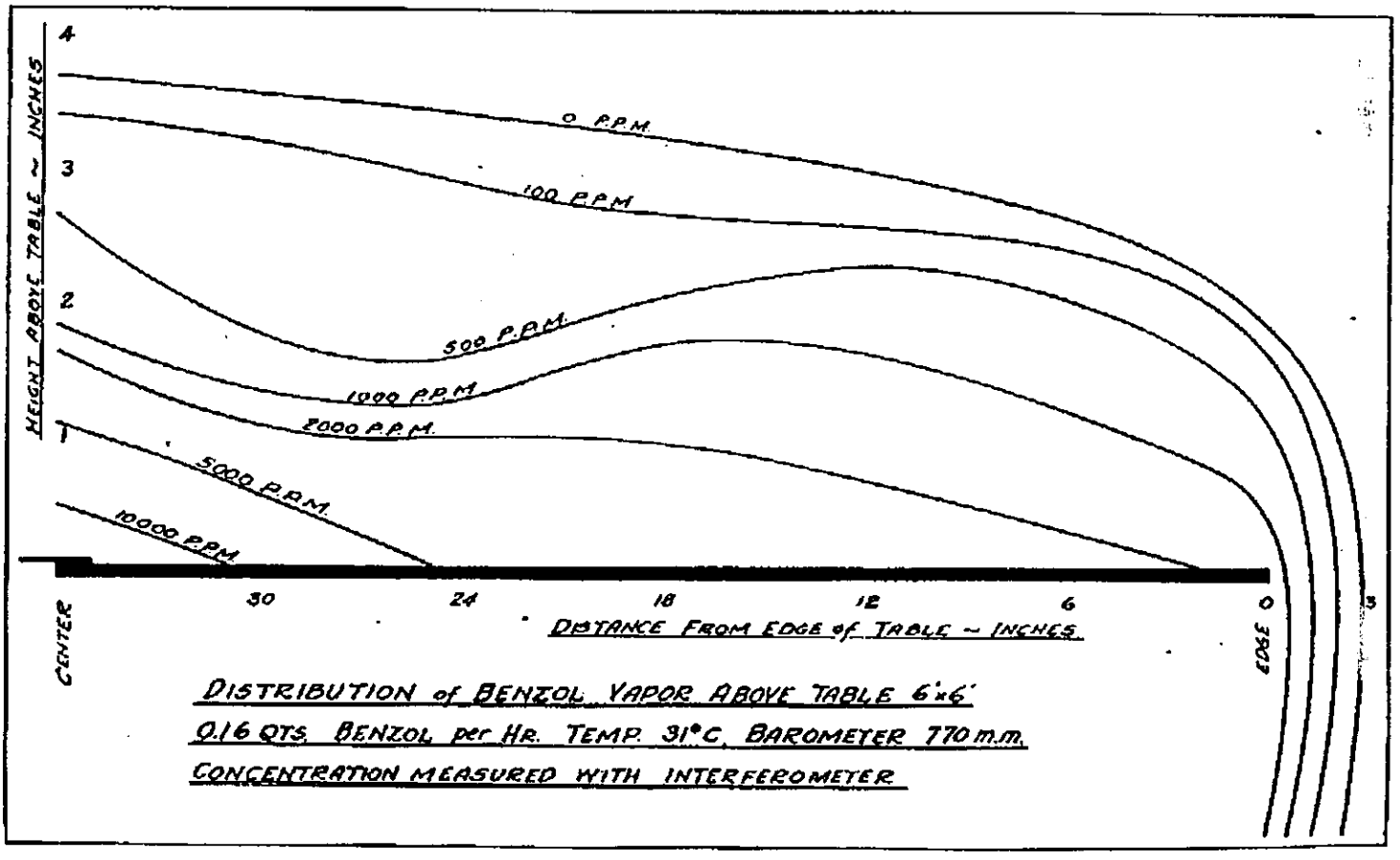

Figure 1. (See paragraph 34.)

Exhaust Ventilation

33. Evaporation of benzol in manufacturing processes occurs both at room temperature and more rapidly at a higher temperature. In the former, the natural tendency of the vapors is to descend to the floor, because benzol vapors are nearly three times as heavy as air. Tests made in factories where benzol is used at room temperature show a great increase in the amount of benzol vapor removed per cubic foot of air, if the intake to the exhaust fan is at the floor level instead of near the ceiling. A mechanical exhaust system is more effective when it aids natural circulation rather than opposing it. Too often the effectiveness of a ventilating system is measured by its cost or by the amount of air removed per minute. The purpose of the system should be to remove the benzol vapors before they reach the breathing zone of the workmen. Effectiveness can be greatly increased if vapors are removed where concentration is greatest, near the floor, or better at the point of evaporation. Arrangements can be made for the entrance of fresh air through ceiling openings.

34. The tendency of benzol vapors to flow down to the floor is illustrated by the curves in Figure 1. These data were obtained by allowing benzol to drop at a constant rate upon a sheet of blotting paper in the center of a table 6 feet square. The diffusion of the vapors upward from the table was so small in these observations that measurements taken at a distance of 4 inches above the table showed that there was no determinable amount of benzol present.

35. This knowledge has been used effectively in ventilating work benches and tables where benzol is used. Figure 2 shows an application of this principle. A rim 4 inches high is built around the edge of the table. Openings at the surface of the table lead to a small exhaust. This method of ventilation can be economically installed as the required amount of suction at such tables and the movement of the air are very slight. Cross currents or drafts from open windows should be avoided.

36. Figure 3 shows an operation where the nature of the work requires that uncovered pans of benzol be used on both sides of the room nine hours each day. Careful tests of the air in this room showed no indication of the presence of benzol. A shallow, open pan of benzol was placed inside a larger vessel leaving an air space of about 2 inches from the bottom. A small exhaust suction apparatus was connected to the bottom of the large container.

37. Although it is a better practice to limit benzol operations to an enclosed cabinet or room and exclude all other processes, occasionally it is necessary to use considerable quantities of benzol in a small portion of a large room. In this case, the vapors should be confined to a portion of the room by building a gas-tight, sheet iron fence, 4 feet high, around the operation as shown in Figure 4. Exhaust ventilation is applied to one side of the enclosure at the floor. Doors are installed to allow passage of workmen or materials.

38. All rooms where benzol is used, even in small quantities, should have some ventilation at the surface of the floor. Open windows are not efficient as they do not remove the vapors below the level of the sill, but tend to diffuse them through the room. They are also apt to be closed during inclement

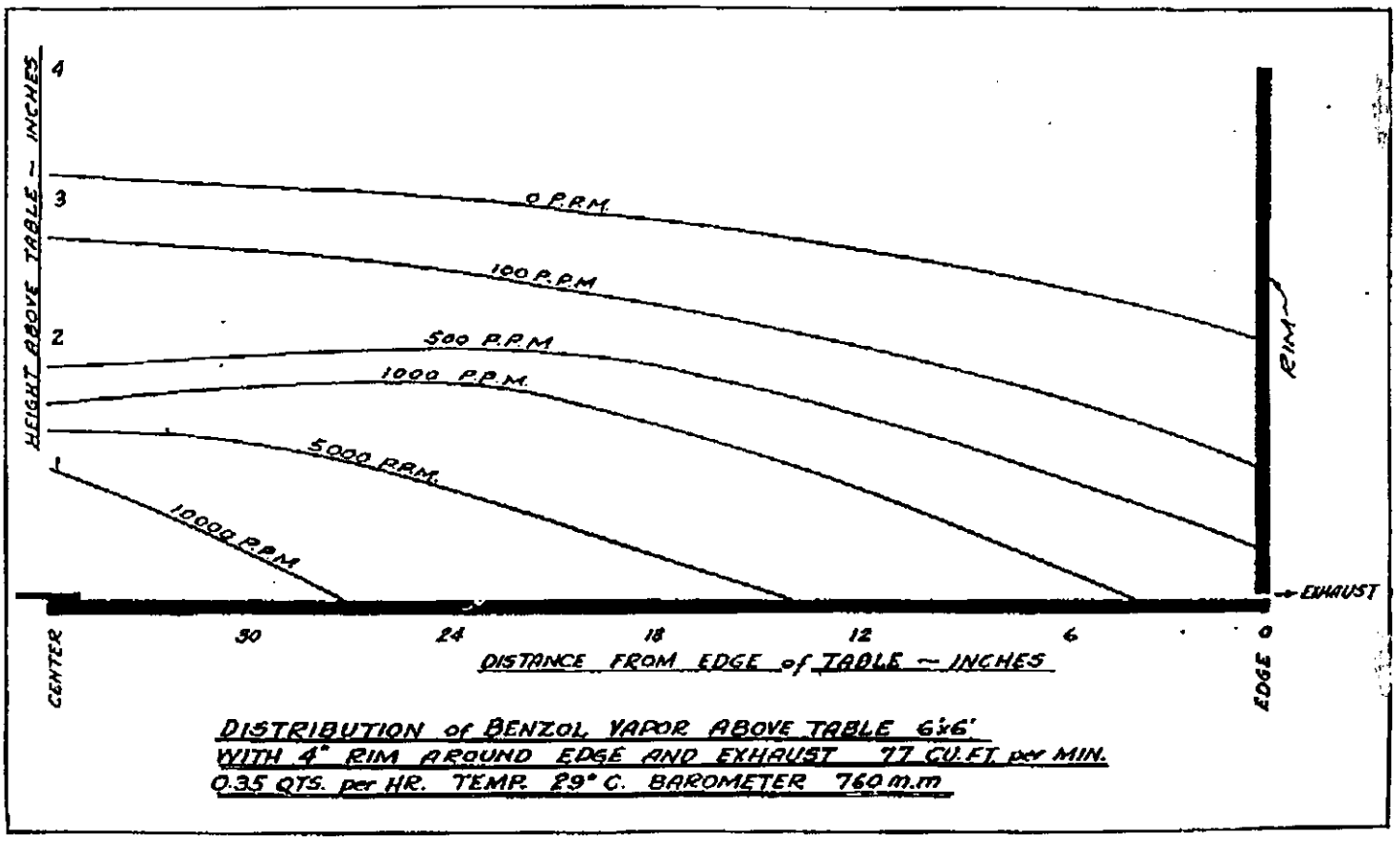

Figure 2. (See paragraph 35.)

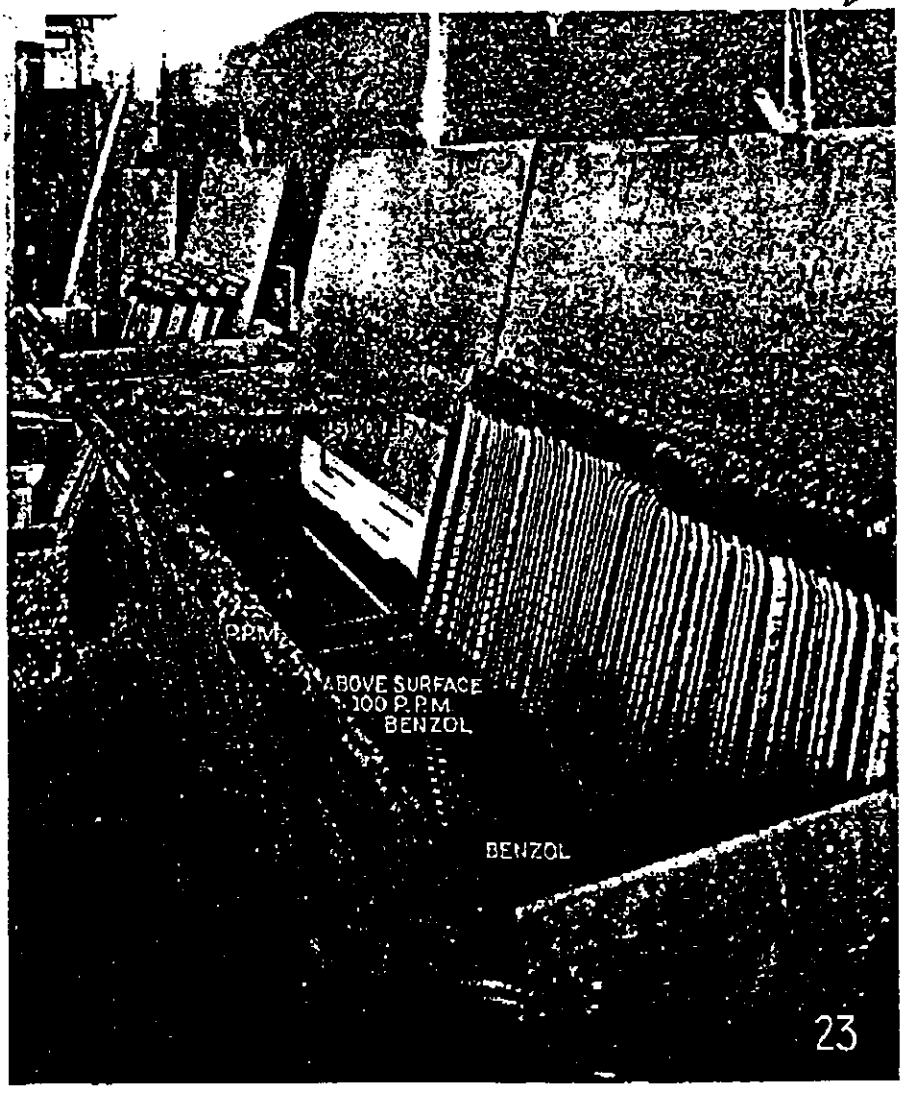

Figure 3. Benzol process tanks with good exhaust system. (See paragraph 36.)

also: Transactions 1930 Vol. 1 p. 469

weather and at the will of the operators. Where it has been customary to use window ventilation, it is still desirable to have special exhaust ventilation at the floor level. This provides an additional safety factor in removing any fumes that may escape window ventilation.

39. Processes of manufacture requiring heat to increase the evaporation of benzol necessitate special care in designing the ovens and other equipment. Hot air currents carry benzol vapors upward. Later, however, when cooled to room temperature, they may descend. Such behavior of benzol vapors makes them doubly hazardous to the employee. The only effective measure in such a case is to remove the vapors at the point of origin through a properly installed and supervised exhaust system. Hot benzol vapors are thus drawn out-

to the oven or the enclosures, sufficient to maintain a pressure slightly lower than the atmospheric pressure within the enclosure. Provision should also be made for fresh air entering the room at ceiling levels.

40. Figure 6 shows a coating machine with only a ½-inch slot at the rear of the machine for exit of the fabric. Metal is preferable to wood or wallboard, as the joints can be made tight. Reference may be made to Safe Practices Pamphlets No. 32, "Exhaust Systems," and No. 37, "Industrial Ventilation."

41. Instead of the use of uncovered, portable vessels containing benzol or benzol mixed with other ingredients such as rubber, bakelite, or artificial leather "dope," the use of a fountain cup which may be used for rubber cement and other materials is suggested. the operation requires that large vessels containing benzol remain uncovered, the vapors can readily be removed by placing the vessel within a larger container and applying a small amount of suction at the bottom of the larger container as discussed in paragraph 36.

Fire and Explosion Hazards

42. The fire and explosion hazards of benzol are similar to those of other volatile solvents. Benzol is flammable and its vapors, when mixed with air in certain proportions, are explosive, if ignited by friction heat, static, other electric spark, or by flame. The lower explosive limit in air is 1.41 per cent by volume, while the upper is 6.75 per cent. The Underwriters' Laboratories' classification for benzol is 95-100. (See also Safe Practices Pamphlet No. 34, "Industrial Explosion Hazards.")

Storing and handling

43. Benzol, as in the case of all flammable solvents, should be stored and handled in accordance with the regulations of the National Fire Protection Association on "Storing and Handling Flammable Liquids." (Such regulations may be obtained from the association office at 60 Batterymarch Street, Boston, Massachusetts.) In general, quantities in storage should be limited and all containers and piping systems, even though empty, should be properly vented. To assure positive identification of solvent piping systems, all such lines should be painted or stencilled in accordance with the adopted code. (See Safe Practices Pamphlet No. 88, "Iden-

Figure 4. Enclosed and exhausted benzol

tification of Piping Systems.") Frequent inspections should be made to determine whether the containers or piping systems are broken or leaking, and all such defects of this kind should be corrected at once. When such repairs are being made, careful supervision should be given all workers because of the hazards involved.

44. Large quantities of benzol should be stored outside buildings, preferably in underground tanks unless the structures are specially designed for benzol storage. Tanks should be vented. Small quantities may be stored inside buildings in suitable containers if the containers are kept in metal cabinets vented to the outside atmosphere. Each storage room or cabinet should have warning signs posted on the doors and only authorized workers should be given access.

45. Handling benzol in buckets, cans and other containers, except approved type safety cans, should be avoided. Where the amount to be handled exceeds a few gallons a day, the use of pumps enables the employee to draw the benzol which is transported to the container in which it is to be used or stored. The pump, of course, facilitates the measuring of the liquid, as well as reducing the fire hazard and the evaporation of benzol in the air of the work room.

46. In cleaning tanks and dipping machines, great care should be exercised in the scraping off of "dope." Such friction may produce a spark which will cause an explosion of fumes. Non-ferrous scrapers of soft metal, such as brass or copper, are recommended.

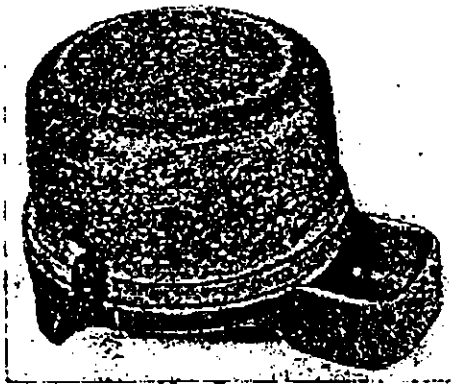

Figure 5. Safety cup for rubber cement. (See paragraph 41.)

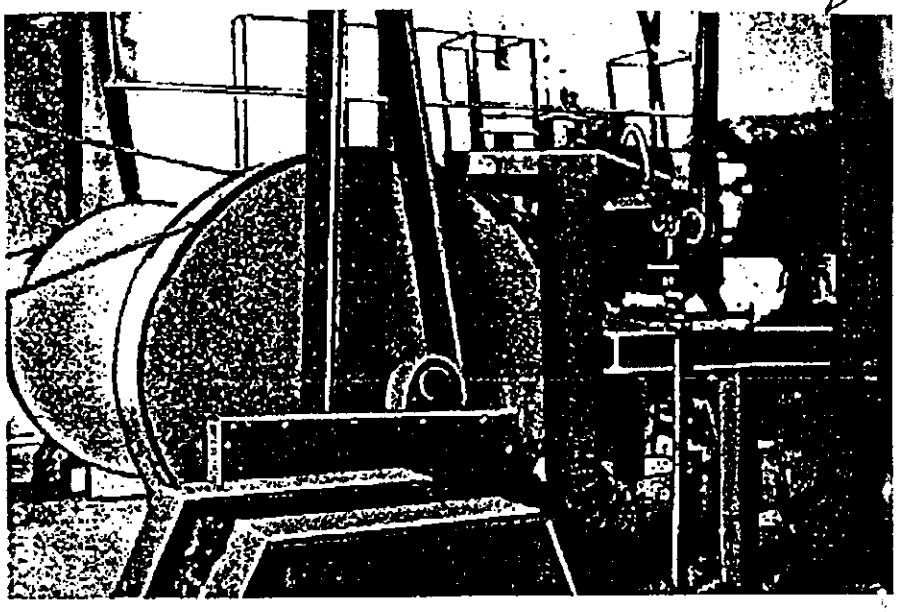

Figure 6. Well enclosed and exhausted textile coating machine. (See paragraph 40

also: Transactions 1930 Vol. I p. 472

Exhaust ventilation (fire and explosion)

47. It is obvious that the use of proper exhaust ventilation systems, which are adequately supervised and maintained, will reduce fire and explosion hazards. Many operations are performed in enclosed systems, or within partial enclosures such as booths or hoods; in such cases, exhaust systems can be installed with comparative ease. Where flammable vapors are being exhausted, other exhaust systems should never be connected with the same ducts, because of the possibility of ignition. Such installations should conform to the regulations of the National Fire Protection Association on "Blower and Exhaust Systems." Other valuable suggestions are contained in Safe Practices Pamphlets No. 32, "Exhaust Systems," and No. 91, "Spray Coating."

48. In general, all enclosures and exhaust ducts should be made of noncombustible material. The ducts should be rounded rather than square, and as short, direct, and straight as possible. Because of the possibility of communicating fire, a duct should never pass through partitions or other roms. Where ducts pass near combustible materials, a ventilated collar should be provided to prevent excessive radiation of heat in case of fire in the exhaust system.

49. The ducts should not have low places or pockets which will permit accumulation of vapors or flammable residue thus increasing the hazard of explosion. Duct systems should be carefully constructed and inspected at regular intervals to determine that joints are closed and tight.

50. Exhaust ducts should discharge at a point where the vapors will not endanger other property or return into the building through windows or other openings. While exhaust ducts should discharge at points where sparks or flames are not likely to occur, it may be necessary in certain cases, if there is possibility of sparks entering the duct, to protect the outlets with bronze or copper screens.

51. Each room or operation should have its own individual exhaust system. In some instances, disastrous fires have resulted where other exhaust systems have been connected with the one removing a flammable vapor.

52. Ducts and cabinets should be cleaned frequently to prevent accumulation of spray residues.

Preventing ignition

53. Adequate precautions should be taken to prevent the ignition of benzol vapors.

54. All tools used in atmospheres containing flammable vapors should be made of non-sparking material. Windows and openings of buildings housing benzol processes should be carefully screened with copper or bronze screening to eliminate the possibility of sparks

from locomotives or other sources entering and causing ignition.

55. Indirect heating systems are preferable to direct systems. No heating apparatus should ever be located close enough to flammable liquids that splashes might strike heated surfaces and ignite. This includes, of course, both direct and indirect type of heating equipment.

56. The "no smoking" and "no match" rules should be rigidly enforced. Open flames, such as torches, or heating and welding apparatus, coal stoves, gas burners, should never be used in the same room with open benzol operations. Even when used in other rooms, a possibility of the vapors coming into contact with them should be thoroughly investigated before allowing open-flame apparatus to be installed.

57. Employees' shoes should have the soles sewed on and fastened with wooden pegs rather than nails. There are shoes on the market which are constructed entirely without metal parts. They are known as "powder shoes."

58. Electrical installations should be made in accordance with the National Electrical Code (See Article 500). Additional information on such installations may also be secured from the National Electrical Safety Code.

59. Wiring should be housed in conduits and these should be bushed and sealed to prevent entrance of flammable vapors. Switches, fixtures and lamps should be of vapor-proof type. Open switches, if used, should be placed outside the room in which benzol operations are carried on. Portable extension lamps should never be used within such rooms. If required in an emergency, such lamps and plug connections should be of the approved vapor-proof type and a "heavy armored type" extension cable should be used.

60. Motors should be of explosion-proof enclosed type to prevent ignition of benzol vapors from sparks. A regular inspection and maintenance program should be instituted to make certain that the motors remain explosion-proof.

61. The prevention of static discharges should be accomplished by the use of electrical grounds which are to be installed on all parts where there is possibility of static accumulations. (See Safe Practices Pamphlet No. 52, "Static Electricity.") This will include the grounding of pipe lines, metal ducts, booths, stands, motor frames, brush contacts, belts and moving parts. A satisfactory dressing has been developed for both rubber and leather belts which practically eliminates static. (See Safe Practices Pamphlet No. 7, "Belts and Belt Guards.")

62. Motors for exhaust fans, unless of the approved explosion-proof type, should never be placed in exhaust ducts. Clearance should be left between the duct and fan blades to prevent friction or rupture of the duct. Fan blades or housing should be of non-sparking material.

63. Fan bearings should be outside the duct and of self-oiling types. Otherwise, an extension oil pipe should be provided to bring in the oil from the outside.

64. A very important procedure in the limitation of the possibility of static fires is the maintenance of humidity of from 60 to 70 per cent where any kind of flammable solvent is used. This has proved to be an efficient practice in many instances.

Fire protection

65. Sufficient hand and automatic fire protection apparatus should be provided where open benzol processes are used. Carbon dioxide or foam type extinguishers furnish excellent protection. Steam has also been found satisfactory in extinguishing flammable vapor and liquid fires. Automatic sprinkler protection is indicated since, even though it will not extinguish the fire, the water will absorb the heat and minimize damage. Tanks and vats should be provided with heat actuated automatic covers and other fire protection such as sprinklers, CO_2 systems, or other extinguishing media should be automatic. The location of the hand apparatus is very important; it should be easily accessible to the place where the benzol is used. For additional information on such equipment, see National Fire Protection Association regulations on "First-Aid Fire Appliances."

Summary

66. Benzol may be used saf through careful, proper engineering pervision, maintaining at predetermin safe level the concentration of ben vapors in air breathed by workmen; proper attention to possible fire and plosion hazards; by making tests the air in the breathing zone of wo men; and by adequate medical super sion of employees.

67. Through such procedures man facturing processes may be maintain and justice done both to the wor and the job.

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