Respiratory Protective Equipment

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1. The hazards to life and health from working in certain dusts, fumes, vapors, and gases have long been recognized, and it is generally agreed that employers should provide protection for workers exposed to these hazards. Progressive employers are making rapid progress in eliminating various dusts, fumes, vapors and gases through engineering means, such as by the enclosure of processes, and by the installation of exhaust systems, but there are many operations where it is necessary to provide the workers with suitable respiratory protective equipment.

2. There are numerous types of respirators on the market today that are known as gas masks, hose masks, oxygen breathing apparatus, dust respirators, chemical fume respirators, air-line masks, etc., but many industrialists do not understand their various characteristics and differences. This pamphlet, therefore, has been prepared to serve as a guide for such persons. The data herein presented parallel the "American Standard Safety Code for the Protection of the Heads, Eyes, and Respiratory Organs," as well as the official publications of the United States Bureau of Mines. The latter of these two organizations has established a testing and labelling service, and persons who buy such equipment are advised to purchase only those devices that have been so tested and labelled, and to use them only under the conditions for which they have been approved.

3. Another precaution that should be borne in mind is that some atmospheres contain gases like hydrocyanic acid gas that may be absorbed through the skin. Certain respirators will protect the lungs of persons in such atmospheres, but it is obvious that no respirator will protect against absorption of such gases through other exposed portions of the skin.

This pamphlet is one of more than 150 Safe Practices and Health Practices Pamphlets. It is a compilation of experience in accident prevention. It should not be assumed, however, that it inludes every acceptable procedure in the field covered. It must not be confused with federal, state or insurance requirements, or with the American Standard safety codes. Attention is called to the American Standard Safety Code for the Protection of the Heads, Eyes and Respiratory Organs of Industrial Workers, to which reference should be made; this code was formulated under the sponsorship of the National Bureau of Standards and under the procedure of the American Standards Association, 70 E. 45th St., New York 17, N. Y. The suggestions contained in this pamphlet do not conflict with the requirements in the code. *Additional copies of this pamphlet are available. Member price 35 cents each. Quantity and non-member prices on request.*

Types of Industrial Respiratory Equipment

4. There are two general classes of respiratory equipment:

Courtesy, Mine Safety Appliances Co.

Figure 1. Self-contained oxygen breathing apparatus provides respiratory protection for one hour in any atmosphere. (See paragraph 6.)

I. Supplied-air respiratory equipment. (See paragraph 5.)

II. Air-purifying respirators. (See paragraph 11.)

But in each of these two classifications, there is a variety of types.

Supplied-Air Equipment

5. In this classification there are four distinct types, plus three types adapted for abrasive-blasting operations:

I. Self-contained oxygen breathing apparatus. (See paragraph 6.)

II. Hose mask with hand-operated blower. (Type A supplied-air respirator.) (See paragraph 7.)

III. Hose mask without blower. (Type B supplied-air respirator.) (See paragraph 8.)

IV. Air-line respirator. (Type C supplied-air respirator.) (See paragraph 9.)

V. Abrasive-blasting respirators. (Types AE, BE, and CE supplied-air respirators.) (See paragraph 10.)

6. *Self-contained oxygen-breathing apparatus.* The wearer carries all of his equipment with him and is not dependent upon the surrounding air nor upon any other device or person. He receives oxygen from a container of compressed oxygen. Such equipment can be used in any harmful or objectionable atmosphere and is particularly useful if the wearer must move about in an unrestricted manner. (See Figure 1.) This makes it applicable especially in exploring and rescue operations as in the mining industry and in fire-fighting. It is not discussed in detail in this pamphlet; for further information see N.S.C. Safe Practices Pamphlet No. M. 2, "Mine Rescue Work."

7. *Hose mask with hand-operated blower.* (Type A supplied-air respirator.) This respirator has a tight-fitting face-piece to which is attached a large

Courtesy, E. D. Bullard Co.

Figure 2. Hose mask with hand-operated blower provides respiratory protection in any atmosphere. (See paragraph 7.)

diameter hose that offers low resistance to the air that passes through it. Air is forced through the hose by a hand-operated blower. The device as a whole is so arranged that the wearer can continue to breathe through it even though the blower ceases to operate. This is the only supplied-air respirator (except oxygen-breathing apparatus) that is approved for use in almost any atmosphere, even in an atmosphere that is immediately dangerous to life. The supply-hose length should not exceed 150 feet from the blower to each man. Anyone using this type of respirator also wears a body harness equipped with the necessary attachments for a life-line and for carrying the weight of the hose. Only full or Tissot-type face-pieces are used on such respirators. They form a pocket over the face and allow breathing through the nose and mouth. An exhalation valve is provided in the face-piece to allow the escape of exhaled air and any excess of air delivered by the blower. A check valve is provided to allow flow of fresh air through the hose toward the face-piece only. (See Figure 2.)

8. *Hose mask without blower.* (Type B supplied-air respirator.) This type of respirator is similar to type A (see paragraph 7), but it has no blower nor any other source of air under pressure. The hose should be not more than 75 feet long. The inlet to the hose should have a terminal fitting or chamber that provides for drawing air through a screen made of corrosion-resistant material. The inlet should also have a device for fastening or anchoring the end to a fixed object in a zone of clean fresh air. This type of respirator is not approved for use in atmospheres that are immediately harmful nor in those from which the wearer could not escape without the aid of the device. The harness worn by anyone using this respirator is so arranged that a pull on the hose will not exert a pull on the face-piece. The face-piece may be of the full or Tissot-type, or half-mask, and an exhalation valve as well as a check valve are provided as on the type A supplied-air respirator.

9. *Air-line respirator.* (Type C supplied-air respirator.) This type of respirator is designed to protect workers against harmful or objectionable atmospheres that are not immediately dangerous to life. In other words, it provides protection against atmospheres that otherwise may cause harm only from continuous exposure. Air for this type of respirator is provided by either a mechanically-operated blower or a source of compressed-air. If air comes from a compressed-air system no internal lubricant should be used that could produce gases or mists that may be objectionable or injurious to health. (See paragraph 36.) If it is impracticable to follow this suggestion, suitable filters, temperature regulators and alarms should be installed in the system. A hand-operated detachable coupling should be provided in the hose so the wearer can easily and quickly attach or detach the hose at a point near the harness. If the air pressure at any point in the system exceeds 25 pounds per square inch gage, a pressure-release mechanism should be installed that will prevent the pressure at the hose connection to the blower or manifold from exceeding 25 pounds per square inch gage. The air-supply line should not exceed 250 feet in length. The rate of air flow to the face-piece should not be less than 2 or more than 20 cubic feet per minute. The body harness may be similar to that for type B. Any type of face-piece may be used except one that has a direct nose or mouth connection.

10. *Abrasive-blasting respirators.* (Types AE, BE, and CE supplied-air respirators.) Supplied-air respirators of the A, B, and C types may be modified for use in abrasive blasting. The letter E added to the regular-type letter indicates that the regular-type respirator has been properly modified or provided with additional equipment. Such changes consist primarily of adding a covering to protect the head and shoulders against impact and abrasion by the rebounding material. The windows in the covering are shielded with glass or woven wire or perforated sheet metal. Types AE, BE, and CE supplied-air respirators are the only types that are approved for use in abrasive blasting operations. (See Figure 3.)

Air-Purifying Respirators

11. There are 11 types of air-purifying respirators. The first seven are chemical-filter respirators (usually called gas masks if filters are contained in canisters; if filters are in cartridges, they are called cartridge-type chemical-filter respirators); No. VIII is a combination chemical and mechanical-filter respirator; and the last three are mechanical-filter respirators.

I. Acid gas mask. (Type A chemical-filter respirator.) (See paragraph 12.)

II. Organic vapor gas mask. (Type B chemical-filter respirator.) (See paragraph 13.)

III. Ammonia gas mask. (Type C chemical-filter respirator.) (See paragraph 14.)

IV. Carbon monoxide gas mask. (Type D chemical-filter respirator.) (See paragraph 15.)

Courtesy, Pangborn Corp.

Figure 3. Abrasive-blasting respirator of the air-line type. (See paragraph 10.)

Courtesy, Acme Protection Equip. Co., Inc.

Figure 4. Organic vapor gas mask for protection against organic vapors. (See paragraph 13.)

V. Combination acid gas and organic vapor gas mask. (Type AB chemical-filter respirator.) (See paragraph 16.)

VI. Combination acid gas, organic vapor, and ammonia gas mask. (Type ABC chemical-filter respirator.) (See paragraph 17.)

VII. Combination acid gas, organic vapor, ammonia, and carbon monoxide gas mask. (Type ABCD chemical-filter respirator.) (See paragraph 18.)

VIII. All-gas respirator. (Type N respirator.) (See paragraph 19.)

IX. Type A mechanical-filter respirator. (See paragraph 20.)

X. Type B mechanical-filter respirator. (See paragraph 21.)

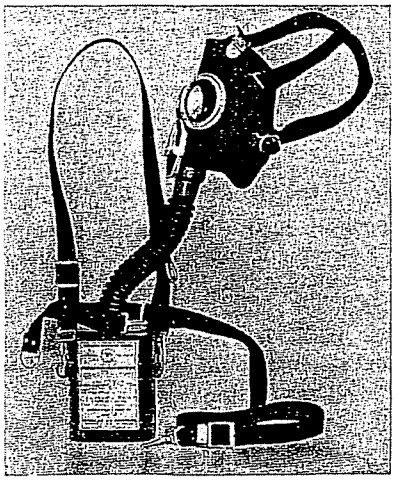
XI. Type C mechanical-filter respirator. (See paragraph 22.)

12. *Acid gas masks* (type A chemical-filter respirators) provide protection against acid gases such as hydrochloric acid, hydrogen sulphide, sulphur dioxide, chlorine, etc., in concentrations not exceeding two per cent. The chemical filter is contained in a canister or cartridge that is colored white so it can easily be distinguished from other canisters used for other purposes. The chemical for this respirator usually consists of soda lime or caustic soda fused on pumice granules. The time of protection decreases rapidly as the concentration of gas increases. (See Notes A, B, C, and D.)

13. *Organic vapor gas masks* (type B chemical-filter respirators) provide protection against organic vapors such as aniline, benzene, ether, gasoline, etc., in concentrations not exceeding two per cent. Black canisters are used for these respirators; they usually contain activated charcoal. (See Notes A, B, C, and D.) (See Figure 4.)

14. *Ammonia gas masks* (type C chemical-filter respirators) provide protection against ammonia in concentrations not exceeding three per cent. Green canisters are used for these respirators; they usually contain silica gel or malic acid. The three per cent maximum concentration cannot be long endured by the wearers of this type of respirator because of the severe skin irritation from ammonia gas. (See Notes A, B, C, and D.) (See Figure 5.)

15. *Carbon monoxide gas masks* (type D chemical-filter respirators) provide protection against carbon monoxide in concentrations not exceeding two per cent. Blue canisters are used for these respirators; they usually contain "hopcalite." "Hopcalite" catalyzes carbon monoxide with oxygen of the air to produce relatively harmless carbon dioxide. These respirators protect in concentrations exceeding two per cent, but the air becomes noticeably warmer as the percentage of carbon monoxide encountered increases. (See Notes A, B, C, and D.)



Courtesy, American-LaFrance and Foamite Industries, Inc.

Figure 5. Ammonia gas mask with chemical filter contained in canister. (See paragraph 14.)

Courtesy, Davis Emergency Equipment Co.

Figure 6. Chemical-filter respirator for protection against acid gases and organic vapors. (See paragraph 16.)

16. *Combination acid gas and organic vapor gas masks* (combination type chemical-filter respirators AB) provide protection against acid gases and organic vapors in concentrations not exceeding two per cent acid gases and two per cent organic vapors. Yellow canisters are used with these respirators; they usually contain activated charcoal and soda lime. (See Notes A, B, C, and D.) (See Figure 6.)

17. *Combination acid gas, organic vapor, and ammonia gas masks* (combination type chemical-filter respirators ABC) provide protection against two per cent acid gases, two per cent organic vapors, and two per cent ammonia. Brown canisters are used with these respirators; they usually contain soda lime, activated charcoal, and silica gel. As the number of gases encountered increases, the service time of the canisters decreases. (See Notes A, B, C, and D.)

18. *Combination acid gas, organic vapor, ammonia, and carbon monoxide gas masks* (combination type chemical-filter respirators ABCD) provide protection against two per cent acid gases, two per cent organic vapors, three per cent ammonia, and two per cent carbon monoxide. The canisters used with these

Courtesy, Mine Safety Appliances Co.

Figure 7. All-gas respirator for protection against acid gases, organic vapors, carbon monoxide, ammonia, smokes, dusts and mists. (See paragraph 19.)

respirators usually contain soda lime, activated charcoal, silica gel and "hopcalite." (See Notes A, B, C, and D.)

19. *All-gas respirators* (type N respirators) provide protection against combinations of acid gases, organic vapors, ammonia, carbon monoxide, dusts, fumes, and mists if the concentrations do not exceed two per cent acid gases, two per cent organic vapors, three per cent ammonia, and two per cent carbon monoxide. Red canisters are used with these respirators; they usually contain soda lime, activated charcoal, silica gel, hopcalite, and cotton wool filters. (See Note C.) (See Figure 7.)

Courtesy, American Optical Co.

Figure 8. Mechanical-filter respirator for protection against pneumoconiosis-producing or nuisance dusts. (See paragraph 20.)

Note A: These chemical-filter respirators are provided with a body harness to support the weight of the canister.

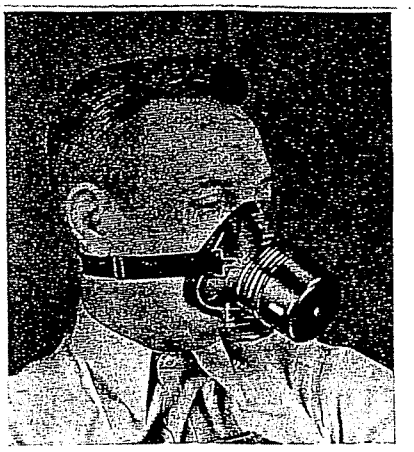
Note B: These chemical-filter respirators have check valves and exhalation valves.

Note C: No chemical-filter respirator will provide protection where the atmosphere is deficient in oxygen.

Note D: The resistance of a chemical-filter respirator to a flow of air of 3 cubic feet per minute should not exceed 3 inches of water pressure and the resistance to exhalation should not exceed 1 inch of water.

20. *Type A mechanical-filter respirators* provide protection against pneumoconiosis-producing or nuisance dusts such as quartz, asbestos, iron ores, cement, limestone, gypsum, coal, coke, charcoal, wood, cellulose, flour and aluminum. They are not approved for protection against dusts whose main harmful constituents are metals or their compounds, such as antimony, arsenic, cadmium, chromium, lead, manganese, mercury, selenium, tellurium, thallium, uranium and vanadium, or against harmful smoke, gases and fumes. (See Notes E and F.) (See Figures 8 to 12 inclusive.) Certain respirators of this type have been adapted by the manufacturers to provide protection against lead dust; others protect against pneumoconiosis-producing or nuisance dusts, also against lead dust. That is, such respirators protect against mechanically-generated lead dust such as that generated in manufacturing storage batteries; enameling; pottery making; rubber compounding; sandpapering and chipping painted surfaces; paint making; preparing litho-transfers; and mining, milling, and processing lead ores. These respirators are not approved for protection against the inhalation of lead fumes generated by heating and volatilizing lead, such as the fumes generated in lead burning and soldering, smelting, type founding, and fusing lead glaze and enamel; or protection against dusts of other poisonous metals or their compounds, or harmful smokes, fumes or mists. (See Figures 13 and 14.)

21. *Type B mechanical-filter respirators* provide protection against the fumes of metals such as aluminum, arsenic, antimony, cadmium, chromium, copper, iron, lead, magnesium, manganese, mercury (except vapor), and zinc. (See Notes E and F.)



Courtesy, Willson Products, Inc.

Figure 9. Mechanical-filter respirator for protection against pneumoconiosis-producing or nuisance dusts. (See paragraph 20.)

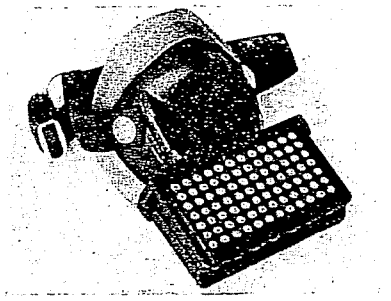
22. *Type C mechanical-filter respirators* provide protection against the mist of chromic acid as produced in chromium plating; the mist produced by spray coating with lead paint and vitreous enamels. (See Notes E and F.)

Note E: In all mechanical-filter respirators having a rate of air flow of three cubic feet per minute, the resistance to the flow of air shall not exceed two inches of water pressure, and the resistance to exhalation shall not exceed one inch of water pressure.

Note F: No mechanical-filter respirator will provide protection where the atmosphere is deficient in oxygen.

Respirator Maintenance

23. Practically all respirators have rubber and rubberized fabric in their



Courtesy, B. F. McDonald Co.

Figure 10. Mechanical-filter respirator for protection against pneumoconiosis-producing or nuisance dusts. (See paragraph 20.)

Courtesy, H. S. Cover

Figure 11. Mechanical-filter respirator for protection against pneumoconiosis-producing or nuisance dusts. (See paragraph 20.)

construction, and since heat, air, light, water and oil cause such substances to deteriorate, respirators should be stored in a cool dry place and protected from light and air as much as possible. Wood, fiber, or metal cases are provided with many respirators, and the respirators will last much longer if kept in such cases when not in actual use.

24. After a respirator has been used, it should be carefully wiped with a damp cloth and dried before it is placed back in the case. Care should be taken to make sure there are no sharp folds or creases in the respirator when it is put away.

Courtesy, Standard Safety Equipment Co.

Figure 12. Mechanical-filter respirator for protection against pneumoconiosis-producing or nuisance dusts. (See paragraph 20.)

25. If the same respirator is used by several persons, it is always advisable to clean and disinfect it after each person has used it. To clean a respirator, it may be washed with a brush and soap in warm water. Sterilizing may be accomplished in either of three ways:

a. Immerse for 10 minutes in a solution of 1 part of 40 per cent formaldehyde and 9 parts of water.

b. Dip in a 3 per cent solution of carbolic acid or a 2 per cent solution of lysol.

c. Place in a moist atmosphere of antiseptic gas, preferably formaldehyde, for 10 minutes at room temperature.

The respirator should then be rinsed with water and hung up to dry in an inverted position. No attempt should be made to sterilize elastic head-bands, canisters and filters.

26. There should be a "time card" in each gas mask container, on which a record should be kept of the number of hours and minutes that each canister is used. If there is any reason to believe that a canister is almost or entirely exhausted, a fresh canister should be attached to the mask.

27. A timer should be used on the type N all-gas respirator; this has a hand that moves around a dial in about two hours of normal breathing, and one revolution indicates that a new canister should be attached even if the respirator has not been worn in contaminated air.

28. Manufacturers deliver canisters with plugged seals covering the bottom valve, and with corks closing the hose nipple unless the latter is attached to the face-piece. Canisters should be stored and used as directed by the canister manufacturers.

29. Canisters should be protected, especially from possible absorption of dampness when not in use. If a canister has become saturated with moisture, it should not be used again. When a respirator with a canister is stored for future use, the seal on the bottom opening of the canister should not be broken; if it has already been broken it should be closed with the plug stopper furnished with the canister.

Courtesy, Chicago Eye Shield Co.

Figure 13. Mechanical-filter respirator for protection against pneumoconiosis-producing or nuisance dusts, also against lead dust. (See paragraph 20.)

30. In some organizations, one or more selected individuals are given the responsibility for maintaining all respirator equipment in good condition.

Use of Respirators

31. The man who is to wear a chemical-filter respirator should test the face-piece to make sure it fits and does not leak before he enters a gaseous location. To do this, the respirator is put on and the head-bands adjusted until it fits closely and comfortably. There should be no kinks in any of the tubes

Courtesy, Pulmosan Safety Equipment Corp.

Figure 14. Mechanical-filter respirator for protection against pneumoconiosis-producing or nuisance dusts, also against lead dust. (See paragraph 20.)

or hose. Resistance to natural breathing should be very slight. The intake to the canister should be closed with the palm of the hand, and suction exerted with the lungs until the face-piece collapses. The face-piece should remain collapsed for about 15 seconds. If the respirator is tight, the wearer can proceed, but he should enter the gas cautiously to see that the canister is active. If the respirator leaks or if the canister is used up, as indicated by odor, taste, or eye, nose or throat irritation, the wearer should immediately return to fresh air and ascertain the cause. If the canister is used up a new one should be attached, care being exercised to make sure that the right canister is selected for the gas to be encountered. Special care should be used when the respirator is worn in gases or vapors that have no warning properties.

32. Each person who learns to use a supplied-air respirator or a chemical-filter respirator should first undergo a physical examination, especially as to the condition of the heart and lungs.

33. When respirators with hose connections are used, care must be exercised to prevent injury to the hose; for instance, it should not be permitted to lie in water or oil.

34. If respirators are provided for emergency use, they should be kept handy to the place where the emergency may be created. For instance, at least one type C chemical-filter respirator should be available in an ice plant for use in case of ammonia leak. The respirator, however, should not be kept too near the ice machine or ammonia piping. Instead, it is better to place it just inside or outside one of the exit doors so anyone can reach it quickly without exposing himself unnecessarily to the ammonia gas.

35. It is recommended that a safety belt and life-line be used in every case where the wearer of a respirator enters a confined irrespirable atmosphere. A man should be stationed outside to tend the life-line and to act in an emergency. In many cases, he should be provided with suitable respiratory protective equipment so he can put it on if it becomes necessary for him to go into the same irrespirable atmosphere to assist his co-worker.

Use of Compressed Air

36. If compressed air is used for air-line respirators, special filters or other means should be provided to prevent contamination of the air with oil, moisture, carbon monoxide, and other undesirable contaminants. Carbon monoxide is not likely to be created in compressed air equipment except under unusual circumstances, such as if any part of the equipment becomes considerably overheated. Thus, it is necessary to check the compressed air-equipment frequently to prevent overheating. (See paragraph 9.)

Getting Workers to Wear Respirators

37. Some workers consider respirators a nuisance, not realizing that failure to wear them may endanger their lives; they think they are super-men and "can take it" without protection. Usually the attitude of such men can be changed if someone in authority in the organization will honestly make an effort to do it. He should explain why specific types of respirators are necessary under certain conditions, show the men how to fit the respirators in proper position, and explain their operation. Then, after every possible effort has been made to convince such men that respirators are essential, the job becomes one of laying down certain shop rules and enforcing them through supervision—and discipline, if necessary, as a last resort.

ACKNOWLEDGMENT

This pamphlet was prepared by the Industrial Division, National Safety Council, in cooperation with engineers of the U. S. Bureau of Mines, representative members of the sectional committee for the "Safety Code for the Protection of the Heads, Eyes and Respiratory Organs of Industrial Workers," and various manufacturers of respiratory protective equipment. It has been reviewed by the Safe Practices Conference Committee and approved by the Executive Committee of the Council. The respirators illustrated in this pamphlet have all been approved by the U. S. Bureau of Mines; limited space makes it impossible to illustrate all respirators that have been so approved.

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