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BULLETIN 226

Respiratory Protective Equipment



U.S. DEPARTMENT OF LABOR
Arthur J. Goldberg, Secretary
BUREAU OF LABOR STANDARDS
Arthur W. Motley, Director

002757

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Safety in Industry

ENVIRONMENTAL AND CHEMICAL HAZARDS

RESPIRATORY PROTECTIVE EQUIPMENT

EFFICIENT respiratory protective equipment is available to protect against many of the respiratory hazards encountered in industry. Unfortunately this equipment is not always used correctly, or the wrong equipment is used, and injury occurs. This bulletin, one of a series on Environmental and Chemical Hazards as related to Safety in Industry, is intended to provide information helpful in selecting and using the right protective equipment for a particular respiratory hazard. Of equal importance, the limitations of such equipment are also given.

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If industrial work methods or processes present hazards of exposure to harmful vapors, gases, dusts, mists, or fumes, these processes should, if possible, be enclosed or ventilated to eliminate or minimize the hazards. If enclosure, ventilation, or other engineering means of control are not possible, respiratory protective equipment should be provided to workers exposed to possible danger. Even though the process is enclosed or ventilated, a supply of appropriate protectors should be readily available for use if emergency work or repairs become necessary in contaminated environments. Personal respiratory protective equipment should be considered a last resort, or as standby protection, and never as a substitute for effective engineering control.

Respiratory protective equipment should be suitable for a specific purpose. By suitable is meant a device designed and built to operate satisfactorily in protecting against a particular contaminant. There are two sources of information available which can be used to assure that respiratory protective devices are suitable for their intended use. They are (1) The American Standard Safety Code for Head, Eye, and Respiratory Protection;[1] and (2) the approval service of the U.S. Bureau of Mines.

[1] Much of the material in this bulletin is reproduced from the American Standard Safety Code for Head, Eye, and Respiratory Protection, Z2.1–1959, copyrighted by American Standards Association. Copies may be purchased from the American Standards Association at 10 East 40th Street, New York 16, N.Y.

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CODE REQUIREMENTS

The American Standard Safety Code for Head, Eye, and Respiratory Protection, Z2.1–1959, suggests, in broad terms, where protection is needed. The Code does not spell out in detail the specific hazardous conditions requiring respiratory protection. Instead, it provides that respiratory protection "shall be provided where a process presents the hazard of exposure to harmful vapors, gases, dusts, mists, or fumes." A complete listing of all situations requiring respiratory protection would not be possible, but every process which generates air contaminants should be investigated to determine the degree of possible hazard.

The Code further points out that hygienic standards for industrial atmospheric contaminants are published by the American Standards Association, the American Industrial Hygiene Association, and the American Conference of Governmental Industrial Hygienists. While these values should be used as guides in the control of health hazards, they should not be regarded as fine lines between safe and dangerous concentrations. They merely represent the conditions to which, it is felt, workers may be exposed continually for 8-hour periods, day after day, without adverse effects on health.

Hygienic standards are expressed in terms of "maximum allowable concentrations" (MAC) in the American Standards Allowable Concentration of Toxic Dusts and Gases; in the recommendations of the American Conference of Governmental Industrial Hygienists they are referred to as "threshold limits." The list of threshold limit values of the latter organization enumerates and gives recommended values for over 150 gases and vapors; 75 toxic dusts, fumes, and mists; and 15 mineral and nonmetallic inorganic dusts. Each year the list of the American Conference of Governmental Industrial Hygienists also includes "tentative values" for certain other materials in cases where exact threshold limits have not yet been determined. Because of the large number of toxic materials covered, the list is valuable for reference purposes.

Maximum allowable concentrations, or threshold limits, are expressed in parts of vapor or gas per million parts of air by volume (ppm), or in approximate milligrams per cubic meter of air (approx. mg. per cu. m.) for gases and vapors; in milligrams per cubic meter of air (mg. per cu. m.) for dusts, fumes, or mists; and in millions of particles per cubic foot of air (m.p.p.c.f.) for mineral and nonmetallic inorganic dusts.

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UIREMENTS

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APPROVED DEVICES

A further check on the suitability of protectors is provided by an approval service rendered by the Bureau of Mines, U.S. Department of the Interior. The Bureau of Mines maintains a testing laboratory where respiratory protective equipment is tested for compliance with standards of performance, comfort, and endurance under conditions which may be encountered in actual operation. If a protector meets Bureau of Mines standards, an approval for the protector within prescribed limits is issued to the manufacturer. Submission to the Bureau of Mines for approval is purely voluntary, but most manufacturers seek such approval for protective devices for which approval is available. Where the Bureau of Mines has issued an approval of a protector, the purchaser may accept such approval as prima-facie evidence of compliance with the ASA Code. It is therefore acceptable for use provided the limits, within which the Bureau of Mines approval has been granted, are not exceeded.

At the present time the U.S. Bureau of Mines approves respiratory protective devices in the following categories:

1. Self-contained breathing apparatus.
   (a) compressed oxygen cylinder.
      (1) recirculating type.
      (2) demand type.
   (b) compressed air cylinder, demand type.
   (c) self generating oxygen, recirculating type.
2. Gas masks.
   (a) acid-gas masks (Type A).
   (b) organic-vapor masks (Type B).
   (c) organic-vapor, toxic-dust, fume, mist, and fog masks (Type BE).
   (d) acid-gas and organic-vapor masks (Type AB).
   (e) acid-gas, organic-vapor, toxic-dust, fume, mist, and fog masks (Type ABE).
   (f) ammonia-gas masks (Type C).
   (g) carbon monoxide-gas masks (Type D).
   (h) universal gas masks (Type N).
3. Supplied-air respirators.
   (a) hose masks with blower (Type A). The Type A supplied-air respirator (hose mask with blower) is approved for respiratory protection in any atmosphere provided enough respirable air is supplied to the wearer by means of the blower.

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· other pneumoconiosis-producing
› blood stream but remain in the
⁀ ɔnary impairment. Examples

calcined diatomaceous earth
free silica (quartz, flint, sandstone, agate)

oducing particles (so-called nui-
issolve and pass directly into the
ıe lungs producing neither local
:

fur
pollen
wood
wool

ɔntoxic and nonfibrosis-producing
.y such dusts may be irritating or
e persons. And extremely high
e viewed with suspicion.
classified further, according to
:oad groups:

and
quid, such as silica-water sprays

⁀ nts are not immediately dan-
even years of exposure may
ɛd. Notable exceptions are dusts
ıosphorous insecticides which, if
ıcapacitate or even kill a man in
ıseous contaminants, all processes
hould be thoroughly investigated

ırticulate Contaminants

ıing gaseous or particulate con-
ɔoth types occur simultaneously.
ferent substances, such as carbon
ɔduced by blasting and the dust
' be the same substances in liquid

and in vapor form, such as slightly volatile liquids that are atomized. The simultaneous occurrence of both gaseous and particulate contaminants in an atmosphere complicates the procedure for providing adequate respiratory protection against them. Where such a combination occurs, special care should be taken to obtain protection against both contaminants. If one of the contaminants is "immediately dangerous to life" this will, of course, dictate the type of protector needed.

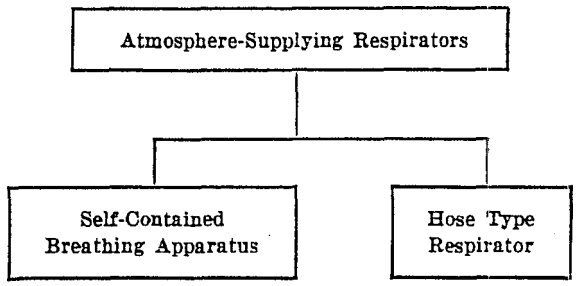
CLASSIFICATION OF RESPIRATORY PROTECTIVE DEVICES, THEIR LIMITATIONS, AND PRECAUTIONS IN THEIR USE

Respiratory protective devices fall into two broad groupings on the basis of their mode of functioning: atmosphere-supplying respirators; and air-purifying respirators.

A more detailed classification, along with a brief description and the limitations of the various types of respirators follows:

ATMOSPHERE-SUPPLYING RESPIRATORS

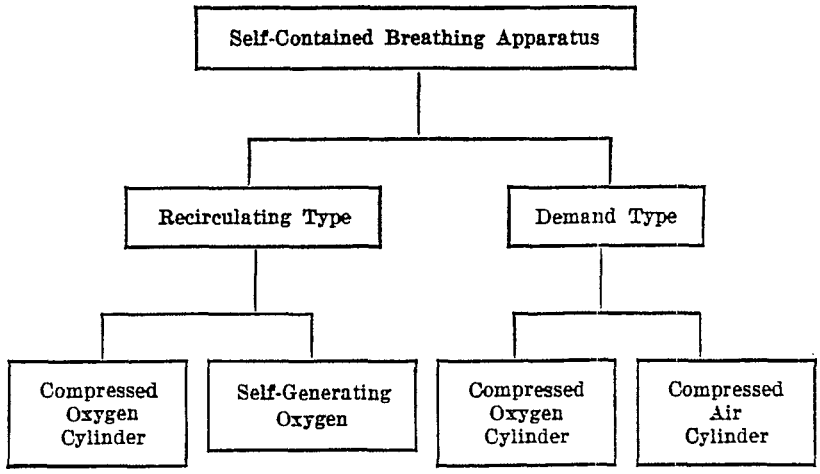
Atmosphere-supplying respirators provide a respirable atmosphere to the wearer independent of his immediate atmospheric environment. They are divided into two main subgroups:



Self-Contained Breathing Apparatus

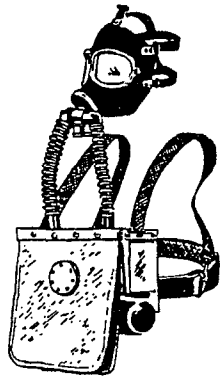
A self-contained breathing apparatus is a device by means of which the user obtains respirable air or oxygen from a supply of air, oxygen, or oxygen-generating material which is an integral part of the device. These devices are further subdivided into two main types with specific equipment under each type as follows:

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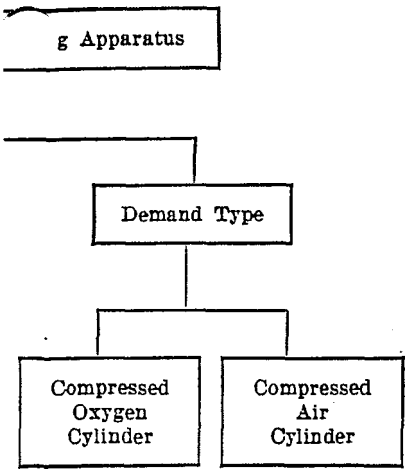


Compressed Oxygen Cylinder—Recirculating Type

In a compressed oxygen cylinder recirculating type of self-contained breathing apparatus, high-pressure oxygen from the cylinder passes through a pressure-reducing-and-regulating valve and an admission valve into a breathing bag. The wearer inhales this oxygen through a corrugated breathing tube connected to a mouthpiece or facepiece through a one-way check valve, commonly called an inhalator valve. The wearer's exhaled breath passes through another check valve, called the exhalator valve, and through a corrugated breathing tube to a canister containing chemicals which absorb the exhaled carbon dioxide. It then passes through a cooler and enters the breathing bag. In normal use, oxygen enters the breathing bag from the supply cylinder only when the volume of gas in the bag has decreased sufficiently to allow a pressure plate to act upon the admission valve which then admits oxygen until the wearer exhales. In the event the pressure-reducing-and-regulating valve or the admission valve does not function properly, the main valve may be shut off and oxygen may be admitted directly from the oxygen cylinder to the bag through a manually operated bypass valve. Suitable pressure release and saliva traps are provided.



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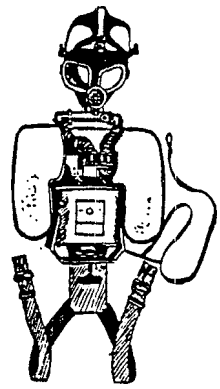


Recirculating Type

er recirculating type of self-con- pressure oxygen from the cylinder -and-regulating valve and an ad- . The wearer inhales this oxygen ibe connected to a mouthpiece or facepiece through a one-way check valve, commonly called an inhala- tor valve. The wearer's exhaled breath passes through another : valve, called the exhalator valve, and through a corrugated breathing tube to a canister con- taining chemicals which absorb the exhaled carbon dioxide. It then passes through a cooler and enters the breathing bag. In nor- mal use, oxygen enters the breath- ing bag from the supply cylinder only when the volume of gas in the w a pressure plate to act upon the oxygen until the wearer exhales. nd-regulating valve or the admis- ly, the main valve may be shut off y from the oxygen cylinder to the bypass valve. Suitable pressure ed.

Self-Generating Oxygen—Recirculating Type

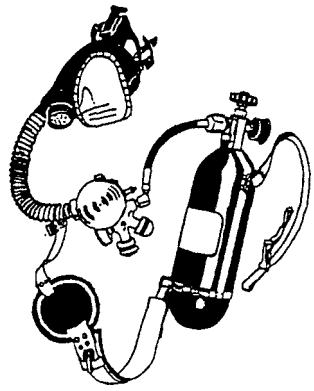
In the self-generating oxygen recirculating type of self-contained breathing apparatus, moisture content from the wearer's exhaled breath reacts with the granular chemical fill of the canister to lib- erate oxygen. This oxygen then enters the breathing bag from which the wearer inhales through a corrugated breathing tube and inhalation valve connected to a facepiece. Check valves maintain a unidirectional flow of gases in the closed system. The rate of evolution of oxygen is governed by the volume rate of breathing of the wearer. Exhaled carbon dioxide is absorbed by the chemicals in the canister. A suitable manually operated pressure-relief valve is provided.



Compressed Oxygen or Air Cylinder—Demand Type

Demand-type self-contained apparatus is designed to supply air or oxygen to the wearer. These gases are not used interchangeably; that is, oxygen should never be used in an apparatus designed for compressed air, and vice versa.

In the demand-type self-contained breathing apparatus, oxy- gen or air is admitted to the facepiece from a cylinder of the compressed gas through a two- stage pressure-reducing mecha- nism only when the wearer inhales, and in quantities governed by his breathing. The wearer's exhaled breath escapes to the surrounding atmosphere.



Limitations of Self-Contained, Atmosphere-Supplying Breathing Apparatus.—From a respiratory point of view, self-contained breathing apparatus has no limitation as to the concentration of gas or particulate matter, or as to a deficiency of oxygen in the atmos- phere in which it is worn. Other factors may, however, limit the time that the wearer can remain in a contaminated atmosphere. Many gases are very irritating to the skin and to mucous membranes when

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present in high concentrations; and hydrocyanic acid gas can be absorbed in dangerous amounts through the unbroken skin.

The length of time that the wearer may remain in the irrespirable atmosphere is dependent upon the amount of oxygen or air made available to him by the apparatus, and upon his activity. Self-contained breathing apparatus is rated according to whether it will protect for 2 hours, 1 hour, three-quarters of an hour, or one-half hour while doing heavy work. The wearer has complete freedom of movement, and should leave the work area only through the same route through which he entered, wherever possible. However, if such route is blocked he may leave the work area through any available exit. If this type of respirator is to be used safely and with confidence, rather extensive training is required not only in its care and use but also in an understanding of its limitations.

Precautions To Be Taken in the Use of Self-Contained, Atmosphere-Supplying Breathing Apparatus.—If self-contained, atmosphere-supplying breathing apparatus is to be used safely, certain precautions are necessary. The following are considered important:

(1) The wearer of a self-contained breathing apparatus should be in reasonably good physical condition and should be thoroughly trained in the construction, testing, use, care, and limitations of the apparatus before he attempts to wear such apparatus in a hazardous situation.

(2) Make certain that the self-contained breathing apparatus is in good operating condition before using.

(3) Make certain that the apparatus is capable of supplying air or oxygen for the period that the wearer must remain in the contaminated area.

(4) Adjust the apparatus to the wearer and test for tightness according to the manufacturer's instructions.

(5) If the wearer is to enter a confined space containing an atmosphere that is extremely hazardous, connect a strong lifeline to his body. This will serve (*a*) as a means of guiding him to the exit; (*b*) as a means of transmitting prearranged signals between him and the man at the fresh-air base; and (*c*) as a means of aiding in rescue operations in case of an emergency or accident. This lifeline should be held by two attendants, one of whom is wearing a similar apparatus.

Where a lifeline is used, a signal code to enable the wearer to communicate with the lifeline tender, and the tender to the wearer is necessary. The following code is suggested:

Tender to Wearer	*Wearer to Tender*
1 pull—Are you okay?	1 pull—I am okay.
2 pulls—Advance.	2 pulls—I am going ahead.
3 pulls—Back out.	3 pulls—Keep slack out of line.
4 pulls—Come out immediately.	4 pulls—Send help.

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Wearer to Tender

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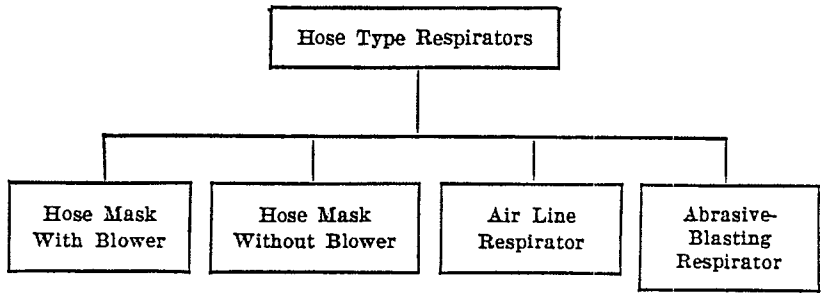
(6) If upon entering a contaminated area the wearer is able to detect the contaminant by odor or taste, or by eye, nose, or throat irritation, he should return to fresh air immediately and ascertain what is wrong with the equipment or the manner in which it is being worn.

(7) Bear in mind the time limitations of the apparatus and allow an adequate margin of time for the return to fresh air.

(8) The mouthpiece and nose clip, or the facepiece, should not be removed until the wearer is certain that he is in respirable air.

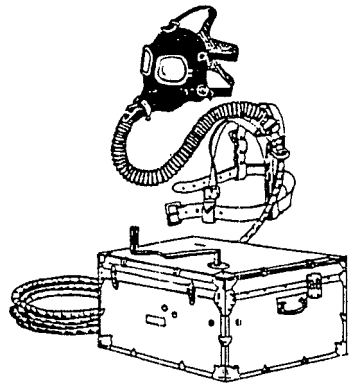
Hose Type Respirators

Hose-type atmosphere-supplying respirators make air available to the wearer through a hose connected to a supply of air. They are divided into four main groups.



Hose Mask With Blower

The hose mask with blower consists of a full facepiece to which respirable air is forced through a large-diameter flexible hose by a hand- or motor-operated blower. The hose is large enough so that the wearer can inhale whether or not the blower is operated. Check valves allow airflow only toward the facepiece. The hose is attached to the wearer's body by means of a rugged safety harness which has provision for the attachment of a safety line. With this harness and line, the wearer may be drawn to safety in an emergency. Usually, the hose mask with blower is designed so that two facepiece-harness-and-hose assemblies may be attached to a single, double-outlet blower.



Limitations of Hose Mask With Blower.—The hose mask with blower has no limitations as to concentration of gas, or particulate

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matter, or a deficiency of oxygen in the atmosphere in which it is worn. However, many gases are very irritating to the skin and mucous membranes when present in high concentrations, and this might limit the time the wearer could remain in a contaminated atmosphere. Hydrocyanic acid gas can also be absorbed in dangerous amounts through the unbroken skin. The wearer is limited by the length of the air-supply hose to travel within 150 feet of the blower which must be in respirable air. He must return to fresh air by retracing his route in the contaminated atmosphere, otherwise the air-supply hose would become entangled. The hose mask with blower provides respiratory protection for an unlimited period.

Precautions To Be Taken in the Use of Hose Mask With Blower.—(1) Make certain that the hose mask is in good operating condition.

(2) Set the blower in an assured source of respirable air.

(3) Connect the proper length of hose (not over 150 feet) to the blower and to the facepiece, making sure that all gaskets are in place and that the connections are tight. Where more than one hose line is to be used, each should originate at the blower.

(4) Before entering a confined space, such as a tank or sewer containing an atmosphere that is extremely hazardous, connect a strong lifeline to the D-ring of the body harness. This lifeline should be held by an attendant so that the wearer can be removed from the contaminated atmosphere in case of accident or emergency.

(5) Operate the blower for a minute or two at a rapid rate to blow any dust out of the hose and to make sure that air is being delivered to the facepiece.

(6) Adjust the body harness securely to the wearer.

(7) Adjust the facepiece to the wearer so that it makes a gastight fit with his face. There are two means of testing for a satisfactory facepiece fit: (*a*) Close off the exhalation valve and exhale gently into the facepiece. If a slight positive pressure can be built up on the facepiece without any indication of outward leakage of air between the facepiece and the face, it is adjusted properly. (*b*) Close off the breathing tube or tubes, inhale so that the facepiece starts to collapse, and hold the breath for about 10 seconds. If the facepiece stays in its partially collapsed condition and no inward leakage of air is detected, it is adjusted properly.

(8) Operate the blower, and adjust the flow of air to the wearer's satisfaction. The blower should be operated continuously during the use of the mask.

(9) Check on the prearranged signals between the wearer and the blower operator.

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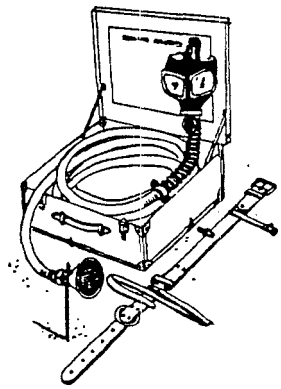
(11) Be careful that the hose and the lifeline, when required, are not endangered by sharp edges or falling objects, and remember that the wearer must retrace his steps and leave by the same route that he entered.

(12) If the continuous flow of air to the facepiece is interrupted, the wearer should return to fresh air and ascertain the cause.

(13) The facepiece should not be removed until the wearer is certain that he is in respirable air.

Hose Mask Without Blower

The hose mask without blower consists of a full facepiece to which a supply of respirable air may be drawn through a large-diameter flexible hose by the wearer's breathing effort. Check valves allow airflow only toward the facepiece. The hose is attached to the wearer's body by a suitable harness. The air-inlet end of the hose is provided with a fine-mesh screen to prevent entrance of coarse particulate matter and with a means of anchoring the inlet in respirable air.



Limitations of Hose Mask Without Blower.—The hose mask without blower is limited to use in an atmosphere from which the wearer can escape unharmed without the aid of the respirator. The wearer is limited by the length of the air-supply hose to travel within 75 feet of an assured source of respirable air in which the air-inlet end of the hose must be placed. It provides respiratory protection for an unlimited period.

Precautions To Be Taken in the Use of Hose Mask Without Blower.—(1) Make certain that the hose mask is in good operating condition.

(2) Securely fasten the air intake of the respirator in an assured source of respirable air. The tailpiece should be protected against accidental displacement or a warning sign should be posted on it.

(3) Connect the proper length of hose (not over 75 feet) to the air intake and to the facepiece, making sure that all gaskets are in place and that the connections are tight.

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(4) Adjust the body harness to the wearer.

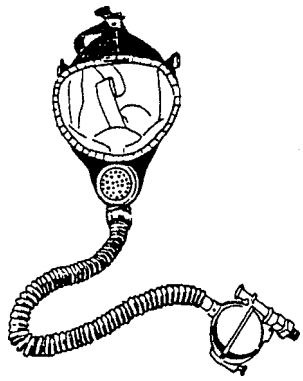
(5) Adjust the facepiece to the wearer so that it makes a gastight fit with his face. (To test for a satisfactory facepiece fit, follow the same procedure as given for Hose Mask With Blower (see p. 13),)

(6) Make certain that the atmosphere to be entered is not so hazardous that the wearer cannot escape unharmed without the aid of the respirator.

(7) Enter the contaminated area cautiously and leave by the same route.

Air-Line Respirators

Air-line respirators consist of a half-mask facepiece, full facepiece, or a loose-fitting helmet or hood to which respirable air is supplied through a small diameter hose. They may be divided into two classes: (1) continuous-flow class and (2) demand class.



Continuous-flow class air-line respirators supply a continuous flow of respirable air to the facepiece, helmet, or hood through a small diameter hose. The wearer's exhaled air and the excess air entering the facepiece, helmet, or hood covering escapes to the surrounding atmosphere. Provision is made for attaching the air-supply hose to the wearer and for detaching the air-supply hose rapidly in an emergency. The respirator is designed to allow at least 4 cubic feet of air per minute to enter the facepiece and at least 6 cubic feet of air per minute to enter the helmet or hood.

Demand-class air-line respirators supply respirable air to the facepiece only when the wearer inhales, and at a rate governed by his volume rate of breathing. A source of respirable air, either an air compressor or a container of compressed air, is attached by a small diameter hose to a demand valve which is actuated by a slight negative pressure created when the wearer inhales. Upon actuation, it allows air to blow to the facepiece through a flexible corrugated breathing tube. Upon exhalation, the demand valve closes and permits no air to flow to the respirator. The exhaled breath escapes to the surrounding atmosphere through an exhalation valve or valves. The demand valve is attached to the wearer so as to allow the air-supply line to be dragged behind the wearer without exerting a pull on the

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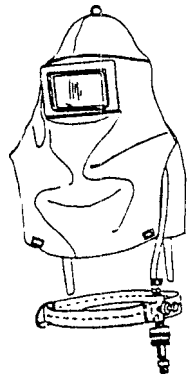
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Abrasive-Blasting Respirator

The principle of operation of the abrasive-blasting respirator is the same as that of the continuous-flow class air-line respirator. However, it is constructed so that it will protect the head and the neck of the wearer and the eyepiece of the respirator from the rebounding abrasive. The respirator is designed to allow at least 4 cubic feet of air per minute to enter the facepiece and at least 6 cubic feet of air per minute to enter the helmet or hood. Only a full facepiece or hood and helmet is used with this respirator.



Limitations of Air-Line Respirators and Abrasive-Blasting Respirators.—The air-line respirator and the abrasive-blasting respirator are limited to use in concentrations of gases or vapors that are not immediately harmful, or from which the wearer can escape unharmed without the aid of the respirator. They are not to be worn in an oxygen-deficient atmosphere. There wearer's travel is limited by the length of the air-supply hose, and he must retrace his route in the contaminated atmosphere to return to fresh air while wearing the respirator. These respirators are to be used within the limits set by the manufacturer for air-supply hose length and range of air pressure applied to the inlet of the air-supply hose. They provide respiratory protection for an unlimited period.

Precautions To Be Taken in the Use of an Air-Line Respirator and an Abrasive-Blasting Respirator.—(1) Make certain that the air supply is respirable. Close attention should be paid to the location of the intake to the air-supply device to make certain that the entering air is not contaminated from the exhaust of the compressor engine or from any other source. A suitable filter should be provided to remove objectionable odors, oil, and water mist, and rust particles from the air delivered to the air-supply line. A suitable reducing-type or demand-type valve and an excess-pressure relief valve should also be provided. For supplying respirable air, low-pressure externally lubricated blowers are preferable to high-pressure internally lubricated compressors, since the latter may add objectionable odors to the air and may produce carbon monoxide upon overheating.

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Internally lubricated compressors should be equipped with an automatic shut-off which is actuated if they become overheated.

(2) Make certain that the air-line respirator is in good operating condition.

(3) Attach the proper length of air-supply hose to the source of compressed air and to the breathing tube.

(4) Adjust the pressure of the air at the inlet to the air-supply hose so that it is within the proper pressure range.

(5) Adjust the facepiece, helmet, or hood to the wearer according to the manufacturer's instructions. A full facepiece or half-mask facepiece should be adjusted so that all the excess air leaves the facepiece through the exhalation valve and none is felt leaking out under the edge of the facepiece.

(6) When the rate of flow of air into the facepiece, helmet, or hood seems to be excessive, the wearer may decrease the flow of air by means of the air-regulating valve with which most air-line respirators are equipped. However, to prevent the contaminant in the surrounding air from reaching the wearer's breathing zone, the flow of air should not be decreased below 4 cubic feet per minute for facepieces, or below 6 cubic feet per minute for helmets or hoods. Hence, the air-regulating valve should be used judiciously on an air-line respirator.

(7) Enter the contaminated area cautiously and leave by the same route.

(8) Each air-line respirator is equipped with a quick-acting detachable coupling by means of which the wearer can quickly disconnect the respirator from the air-supply line to facilitate escape in an emergency such as fire. The wearer should practice using this coupling before wearing the respirator in a contaminated atmosphere.

The following additional precautions should be taken in the use of an abrasive blasting respirator:

(9) Make certain that the shatterproof eyepiece and the protective cover glass are in place. Under no circumstances should regular window glass be used in place of the shatterproof eyepiece. Clean the inner and outer surfaces of all eyepieces.

(10) Make certain that the protective wire screen or perforated-metal eyepiece is clean and in place.

AIR-PURIFYING RESPIRATORS

Air-purifying respirators remove gaseous or particulate contaminants, or both, from otherwise respirable air that is inhaled by the wearer. They are of no use where an oxygen deficiency exists. They are divided into classes and types as follows:

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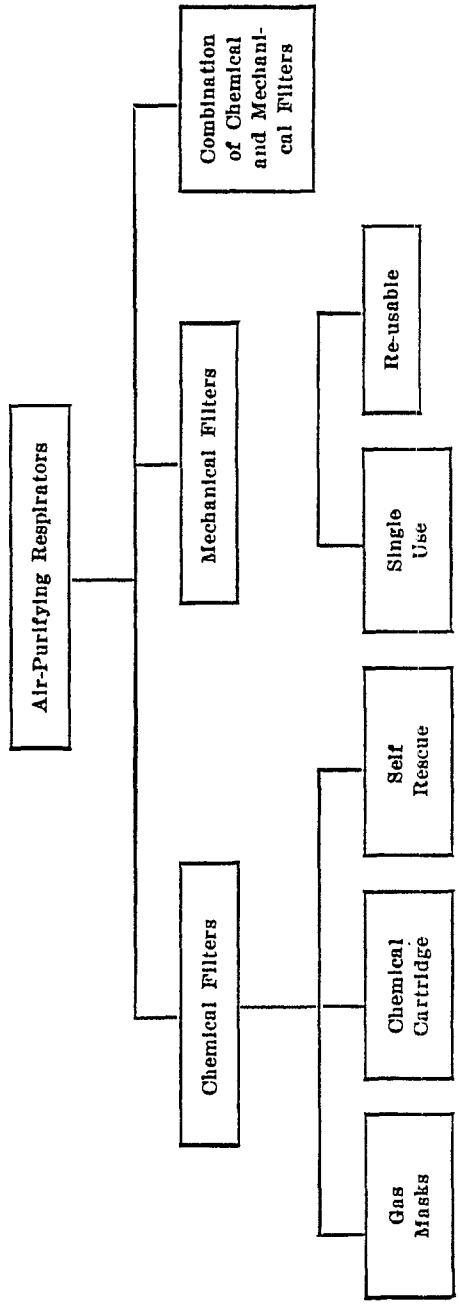
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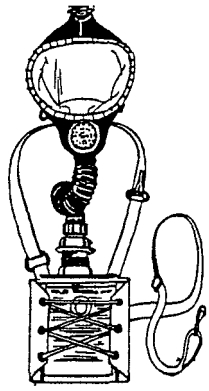
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Chemical-Filter Respirators

Chemical-filter respirators include gas masks, chemical-cartridge respirators (nonemergency gas respirators), and self-rescue-type respirators. They remove toxic gases and vapors from inspired air by sorption, chemical reaction, or oxidation by the granular fill of the canister or cartridge. The exhaled breath escapes to the surrounding atmosphere.

Gas Masks

Gas masks consist of a canister, containing the appropriate granular fill, a full facepiece, and a body harness to hold the canister securely in place on the body of the wearer. The inspired air is drawn through the canister and enters the facepiece in such a manner as to inhibit the accumulation of moisture on the eyepieces. A check valve prevents exhaled breath from entering the canister and allows it to be forced out through an exhalation valve in the facepiece to the surrounding atmosphere. The facepiece is held securely to the wearer's face by an elastic head harness. Universal gas masks have an indicator or timer which shows when the canister should be changed for protection against carbon monoxide.



Gas masks are designed to provide respiratory protection against a specific gas such as chlorine, a class of gases or vapors such as organic vapors, or a combination of two or more classes of gases or vapors such as acid gases and organic vapors or all gases and vapors. The canisters of many types of gas masks are manufactured in two sizes, namely, regular or "industrial size," and the large or "supersize" canisters. Everything else being equal, the large canister provides a longer service time than the regular size between changes of canisters, but the limitations are the same in regard to maximum concentration of gas against which they will protect. In most cases, a canister designed for a single gas or a single class of gases and vapors will afford respiratory protection for a considerably longer period than will a canister of the same size designed for protection against a multiplicity of gases and vapors.

Gas-mask canisters manufactured in the United States are marked in bold letters with the name of the atmospheric contaminants for which the canister is intended to be used, or with the words "Universal Gas-Mask Canister" in capitals (for protection against a variety of contaminants, including carbon monoxide) as well as being given a

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distinctive color in accordance with the American Standard Safety Code for Identification of Gas-Mask Canisters, K13.1–1950.[2] These colors serve as an aid to rapid identification of canisters. The table from sec. 6.1 of the above code is reproduced here for ready reference.

Color Code for Gas-Mask Canisters

Canister, type letter	Atmospheric contaminants to be protected against	Color assigned [1]
A	Acid gases	White.[2]
A	Hydrocyanic acid gas	White with ½-inch green stripe around the canister near the bottom.
A	Chlorine gas	White with ½-inch yellow stripe around the canister near the bottom.
B	Organic vapors	Black.[2]
C	Ammonia gas	Green.
D	Carbon monoxide	Blue.
AE, etc	Dust, fumes, mists, fogs, and smokes in combination with any of the above gases or vapors.	½-inch contrasting black or white stripe around canister near the top.
AB	Acid gases and organic vapors	Yellow.
ABC	Acid gases, organic vapors, and ammonia gas.	Brown.
N	All of the above atmospheric contaminants.	Red. Filters are included in the canister, but stripes to indicate them are unnecessary.

[1] Gray shall not be assigned as the color for any gas-mask canister.
[2] Canisters for a single gas or vapor other than ammonia or carbon monoxide shall have a ½-inch colored stripe around the canister near the bottom.

Limitations of Gas Masks.—The gas mask is limited to use in atmospheres containing at least 16 percent of oxygen and not more than 2 percent of most toxic gases (3 percent of ammonia). Other factors may, however, limit its use. Many gases are very irritating to the skin and to the mucous membranes when present in maximum concentrations; and hydrocyanic acid gas can be absorbed in dangerous amounts through the unbroken skin, its effect depending mainly upon the concentration of the gas and the duration of the exposure. The wearer has complete freedom of movement. A gas mask provides respiratory protection for a period that depends on the type of canister, the concentration of the gas, and the activity of the wearer. A gas mask with canister for protection against carbon monoxide should have an indicator to show when the canister is to be replaced. No practicable method is available to warn the

[2] Copies may be purchased from the American Standards Association, 10 East 40th Street, New York 16, N.Y. This code is now under revision; no target date for completion is available.

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wearer of leakage of relatively odorless gases through the canister. It is important that the proper gas-mask canister be used for the intended purpose. For instance, an ammonia gas-mask canister will not afford respiratory protection against acid gases, organic vapors, or carbon monoxide.

Precautions To Be Taken in the Use of Gas Masks.—(1) Make certain that the contaminated atmosphere is not deficient in oxygen; it should have at least 16 percent.

(2) Make certain that the canister to be used is suitable for protection against the particular atmospheric contaminant.

(3) Make certain that the gas mask is in good operating condition.

(4) Adjust the canister harness on the body so that, when the facepiece is put on, there is some slack in the breathing tube when the wearer's head is in the normal position.

(5) Adjust the facepiece to make a gastight fit on the wearer's face. (To test for a satisfactory facepiece fit, follow the same procedure as given for Hose Mask With Blower (see p. 13).)

(6) Test the complete gas mask for gastightness by closing off the air intake at the bottom of the canister, either with the palm of the hand or with the bottom canister seal, and inhaling so that the facepiece starts to collapse, and hold the breath for about ten seconds. If the facepiece stays in its partially collapsed condition and no inward leakage of air is detected, it is adjusted properly.

This test checks the gastightness of the canister or timer gaskets and of the connection between the breathing tube and the canister or timer.

(7) Enter the contaminated area cautiously. If the odor of the contaminant is noted, return to fresh air immediately and ascertain the cause of the leakage.

(8) A fresh canister should be attached to the mask before entering a contaminated area, especially an extremely hazardous atmosphere, or one containing a gas that has poor warning properties, such as methyl bromide.

(9) The facepiece should not be removed or a fresh canister attached until the wearer is certain that he is in respirable air.

(10) After leaving the contaminated area, replace the bottom seal on the canister to prevent deterioration of the canister contents. This is particularly important in the case of universal gas-mask canisters.

If the total amount of time that the canister has been used is unknown, or if the major part of the canister time limit has been exceeded, a new canister should be installed.

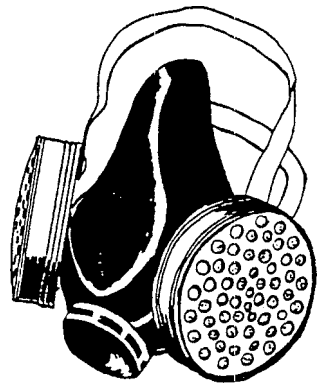
(11) Where the contaminant is a single gas or vapor, or a mixture of two or more gases or vapors of the same type, longer service time will be obtained if the canister used is one designed especially for pro-

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tection against the specific contaminant than would be the case if a universal gas-mask canister were used.

Chemical-Cartridge Respirators

Chemical-cartridge respirators (nonemergency gas respirators) consist of a half-mask facepiece to which is attached one or two cartridges. Like canisters, the cartridges are filled with granular materials that absorb gases or vapors from the air drawn through them. Check valves prevent exhaled breath from entering the cartridges and allow it to be forced out through an exhalation valve in the facepiece to the surrounding atmosphere. The facepiece is held securely to the wearer's face by elastic headbands. The cartridges are usually designed to provide respiratory protection against single gases or vapors, or against single classes of gases and vapors. They are easily removed and replaced.



Limitations of Chemical-Cartridge Respirators.—The chemical-cartridge respirator (nonemergency gas respirator) is limited to use in atmospheres that are not immediately dangerous to life; it should not be worn in an atmosphere deficient in oxygen. The wearer has complete freedom of movement. A chemical-cartridge respirator provides respiratory protection for a period that depends on the type of cartridge used, the concentration of the gas or vapor, and the wearer's activity. Its use is limited to low concentrations of certain gases and vapors such as a maximum of 0.1 percent (1,000 ppm) of organic vapors. It should not be used for protection against (1) harmful gases or vapors that cannot be detected by the sense of smell; (2) gases or vapors that are highly toxic in low concentration, such as phosgene and arsine; or (3) concentrations of gases and vapors that are highly irritating to the eyes. It is important that the proper chemical cartridge be used for the intended purpose; for instance, an organic vapor cartridge will not afford respiratory protection against ammonia. Knitted cotton covers for the face-contacting surface of the facepiece should not be used since they are not gastight.

Precautions To Be Taken in the Use of Chemical-Cartridge Respirators.—(1) Make certain that the atmosphere to be entered is not dangerous to life.

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(2) Make certain that the respirator is in good operating condition, that the gaskets are in place, and that the proper chemical cartridges are securely mounted in the respirator.

(3) Adjust the respirator to the wearer's face so that it makes a gastight fit with his face. There are two means of testing for a gastight fit: (*a*) Close off the exhalation valve and exhale gently into the facepiece. If a slight positive pressure can be built up in the facepiece without any indication of outward leakage of air between the facepiece and the face, it is adjusted properly. (*b*) Close off the inlets to the facepiece by cardboard discs or stoppers usually furnished by the manufacturer, inhale so that the facepiece starts to collapse, and hold the breath for about 10 seconds. If the facepiece remains in its partially collapsed condition and no inward leakage of air is detected, it is adjusted properly. If the second method is used, the cardboard discs or stoppers must be removed and the cartridges assembled with the facepiece.

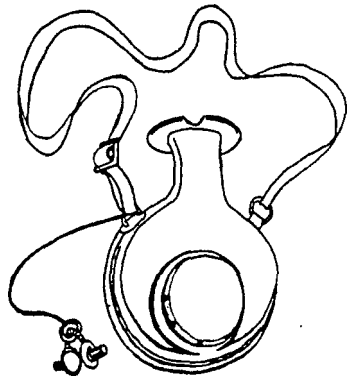
(4) Enter the contaminated area cautiously.

(5) When leakage of the contaminant is noted by the wearer, he should discard the used cartridges and replace them with fresh ones.

(6) Knitted cotton cloth must never be used to cover the face-contacting edges of chemical-cartridge respirators, since the cloth cover is not gastight.

Self-Rescue Type Respirators

The self-rescue-type respirator is designed to provide the greatest possible respiratory protection consistent with the practicability of carrying the device at all times, so that it is always available for use during escape in the event of a catastrophe. It consists essentially of a small filter element, a mouthpiece, a nose clip, and a means of carrying the device conveniently on the body or storing it near the work location. Most filter elements are similar to chemical cartridges made for protection against specific gases or vapors, but particulate filters are also available. One self-rescue-type respirator offers protection against carbon monoxide present in the atmosphere following an explosion or fire in a mine. The filter cartridge for this type should be protected from moisture to keep the chemical fill active.



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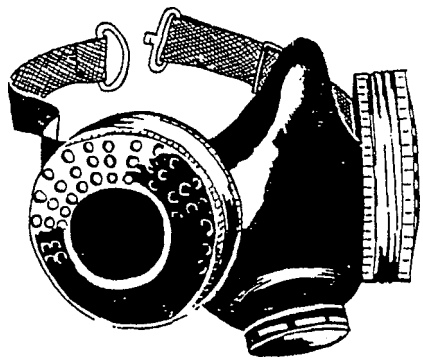
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Limitations of Self-Rescue Type Respirators.—A self-rescue-type respirator should never be used as a working tool, but only as a protective device while trying to escape from a contaminated area to a safe atmosphere, or to reach a more positive type of respiratory protective equipment. The extent of protection afforded is usually between that provided by a gas mask and that provided by a chemical-cartridge respirator. For example, the self-rescue-type respirator for protection against carbon monoxide will provide at least 30 minutes service in an atmosphere containing 1 percent by volume of carbon monoxide.

Mechanical-Filter Respirators

Mechanical-filter respirators such as dust, fume, or mist respirators remove particulate matter from the inspired air by capture on the filter, which is usually a fibrous pad. These respirators consist of a full or half-mask facepiece to which is attached one or two filters through which the inspired air is drawn. Check valves, present in most mechanical-filter respirators, prevent exhaled breath from passing through the filters and allow it to be forced out through an exhalation valve in the facepiece to the surrounding atmosphere. The facepiece is held securely to the wearer's face by elastic headbands. Knitted cotton covers are sometimes used to cover the face-contacting surface of the facepiece to absorb perspiration and to prevent irritation of the skin when the respirator is worn in hot places or in air containing certain irritating dusts such as lime.



Mechanical-filter respirators are designed to provide respiratory protection against a single specific dust, fume, or mist, a single class such as toxic dusts, or a combination of several classes of particulate matter such as dusts, fumes, and mists.

The filters may be of the single-use or reusable type. Single-use filters cannot be cleaned and reused, but should be discarded after they have served their purpose. Reusable filters, cleaned mechanically according to the manufacturer's instructions, may be reused. They should never be washed or treated with solvents.

Limitations of Mechanical-Filter Respirators.—There is a practical limit for the concentration in which a mechanical-filter respirator

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should be used. This is determined by the time required to plug the filter. For example, if the concentration is so high that the filter must be changed several times an hour in order that the wearer can inhale without undue resistance, a more suitable type of respiratory protective device should be selected. Mechanical-filter respirators should not be used in sand- or shot-blasting operations in which one might be exposed to heavy concentrations of particulate matter and to rapidly rebounding particles of the abrasive. For such conditions, the abrasive-blasting respirator should be used.

Mechanical-filter respirators do not protect against gases and vapors or against an atmosphere deficient in oxygen. The wearer has complete freedom of movement. The useful life of the filters is limited by the buildup of resistance to inhalation as the contaminant is removed by the filter. The higher the concentration of contaminant in the air drawn into the filter, and the greater the wearer's activity, the more rapidly the resistance to inhalation increases. This applies particularly to dusts and fumes. Hence, the use of dust and fume respirators in high concentrations of these contaminants requires frequent replacement of disposable filters or frequent cleaning of reusable filters.

Precautions To Be Taken in the Use of Mechanical-Filter Respirators.—(1) Make certain that the respirator is in good operating condition and that the proper filters are securely fastened in place.

(2) Adjust the respirator to the wearer's face so that it makes a dusttight fit with his face. (To test for a satisfactory facepiece fit, follow the same procedure as given for Chemical-Cartridge Respirators.) (See p. 23.)

(3) As the total amount of solid particulate matter removed from the inspired air by the filter increases, the resistance to inhalation increases and finally reaches a point where the wearer is conscious of increased difficulty in breathing. At this time, disposable-type filters should be discarded and replaced by fresh filters, and recleanable-type filters should be cleaned in accordance with the manufacturer's instruction. Under no circumstances should respirator filters be washed or dry cleaned.

(4) In atmospheres containing particulate matter that is irritating to the skin, or where excessive perspiration may occur, a knitted cotton cloth, furnished by the manufacturer, may be used over the edge of the facepiece to prevent contact between the rubber portion of the facepiece and the wearer's face. This must not be used on fume respirators.

As a check on the effectiveness of a mechanical-filter respirator, the wearer may obtain visual evidence when the facepiece is removed of

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the dusttightness of the facepiece fit by looking at his reflection in a mirror and noting the presence or absence of dust streaks on that portion of his face that was covered by the facepiece.

Combination Chemical-and-Mechanical-Filter Respirators

Combination chemical-and-mechanical-filter respirators remove toxic gases and vapors and particulate matter from inspired air. Some gas-mask canisters contain special filters which provide respiratory protection against particulate matter, in addition to the respiratory protection against gases and vapors furnished by their granular fill. Some chemical-cartridge respirators contain filters for the same purpose. Others have filters attached so that the filter may be changed one or more times before the cartridges are changed. The type of protection afforded by the filters in gas-mask canisters and the cartridges of chemical-cartridge respirators is stated on their labels.



Limitations of Combination Chemical-and-Mechanical-Filter Respirators.—The limitations of combination chemical-and-mechanical-filter respirators generally are the same as for each type of respirator. (See page 23 for limitations for chemical cartridge type respirator, page 25 for limitations of mechanical-filter type.) The limitations of gas masks or chemical-cartridge respirators against gases and vapors are usually more important than those against dust in determining the limitations of combination respirators.

SELECTION OF RESPIRATOR ACCORDING TO HAZARD

In choosing a respirator to be used for respiratory protection in any given situation, the following factors should be considered: (1) The nature of the hazard; (2) the severity of the hazard; (3) the type of contaminant; (4) the concentration of the contaminant; (5) the period for which respiratory protection must be afforded; (6) the location of the contaminated area with respect to a source of respirable air; (7) the expected activity of the wearer; and (8) the operating characteristics and limitations of the available respirators.

A brief discussion of these factors is as follows:

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1. Nature of the Hazard

The user should determine whether or not the atmosphere is deficient in oxygen, and whether the contaminant is gaseous or particulate, or a combination of the two.

2. Severity of the Hazard

The user should first determine whether or not the atmosphere is immediately dangerous to life. If so, this factor alone will determine the choice of protection needed.

In some cases, particularly in emergency situations, it is impossible to determine either the nature or severity of the hazard. Under such conditions, the hazard should be considered as immediately dangerous to life and protection provided on that basis.

3. Type of Contaminant

Gaseous

Where the contaminant is gaseous, the user should determine whether it is an acid gas, an organic vapor, ammonia, carbon monoxide, or a mixture of two or more of these gaseous contaminants. This information is essential to the choice of the proper gas mask or chemical-cartridge respirator, because the different types of gases require different absorbents or combinations of absorbents to remove them from the inspired air.

Particulate

Where the contaminant is particulate, the user should know its physical form; that is, whether it is a dust, fume, or mist. Furthermore, he should know whether it is a toxic type (containing, for instance, arsenic, antimony, cadmium, or lead), a pneumoconiosis-producing type (containing, for instance, asbestos or free silica), or a type having a low order of toxicity and being nonfibrosis producing (containing, for instance, flour or wood). This information is essential to the choice of the proper dispersoid respirator, as a respirator designed to protect against one type of particulate matter does not necessarily afford adequate protection or service life against the other types.

4. Concentration of Contaminant

Gaseous

Where the contaminant is gaseous, the maximum expected concentration of the gas should be known. Where this is above 3 percent by volume of ammonia gas, or 2 percent by volume of other gases, a gas

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mask is not adequate and should not be used. If it is above 0.1 percent by volume (1,000 ppm) of organic vapors, an organic-vapor chemical-cartridge respirator is not adequate and should not be used.

Particulate

Where the contaminant is particulate, the proper type of dispersoid respirator may give an adequate degree of protection, yet its service life may be too short for its use to be practicable or economical. That is, the filter may plug too readily with a rapid increase in the inhalation resistance, thus necessitating frequent changing or cleaning of the filter material. Where practicable, an air-line respirator should be used in high concentrations of particulate matter.

5. Period of Required Respiratory Protection

The period of respiratory protection required has considerable bearing on a decision as to which type of respirator to use in a given situation. The self-contained breathing apparatus, the gas mask, and the chemical-cartridge respirator provide respiratory protection for a limited period, whereas the hose mask with blower, the air-line respirator, and the abrasive-blasting respirator do so for an unlimited period; thus, for protracted periods of use, the latter types offer some advantages.

6. Location of Contaminated Area With Respect to Source of Respirable Air

This is a factor that is frequently overlooked when choosing a respirator. In using a hose mask, air-line respirator, or abrasive-blasting respirator, the distance that the wearer can go into a contaminated atmosphere is limited by the length of the hose connected to the source of respirable air. Furthermore, the presence of the hose requires that he enter and leave the area by the same route. When wearing a self-contained breathing apparatus or gas mask, a person may leave the contaminated area by another exit, but he should make certain that the device will afford protection for a period adequate for him to reach fresh air, taking into account possible delays. For instance, in mine-rescue work, the maximum distance from fresh air that a crew, wearing 2-hour self-contained breathing apparatus, should cover is 1,000 feet (2,000 feet round trip) under ideal conditions. This distance is decreased to not more than 50 feet from fresh air if the crew has to crawl in a low passage.

7. Activity of the Wearer

In many instances, the respirator that would be first choice from the standpoint of respiratory protection or period of protection can-

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not be used because it would limit the activity of the wearer. For instance, a hose mask would not be practicable for use where the wearer has to weave in and out of a series of obstructions, such as pipes, because of the difficulty of pulling the heavy hose after him and his inability to escape quickly to fresh air in the event of danger. An air-line respirator would likewise be unsatisfactory where the wearer must be moving about constantly in the contaminated area, or going from one room to another, because of inconvenience and tripping hazard of the air-supply hose.

The activity of the wearer has a marked effect on the life to be expected from a self-contained breathing apparatus, gas mask, chemical-cartridge respirator, or dispersoid respirator. The volume of air breathed by a man walking at a rate of 4 miles per hour is more than three times that breathed when he is standing still. Hence, the supply of oxygen in a self-contained breathing apparatus is used up faster, the absorbent capacity of a gas-mask canister or a chemical cartridge is exhausted faster, and the filter of a dispersoid respirator becomes plugged faster while the wearer is exercising than when he is at rest.

8. Operating Characteristics and Limitations of the Available Respirator

The following table may be used in selecting the type of protector based on the known hazard:

Selection of Respiratory Protective Device

Hazard	Respirator
Oxygen deficiency	Self-contained breathing apparatus Hose mask with blower
Gaseous contaminant: Immediately dangerous to life	Self-contained breathing apparatus Hose mask with blower Gas mask
Not immediately dangerous to life	Air-line respirator Hose mask without blower Chemical-cartridge respirator
Particulate contaminant	Dust, mist, or fume respirator Air-line respirator Abrasive-blasting respirator
Combination gaseous and particulate contaminant: Immediately dangerous to life	Self-contained breathing apparatus Hose mask with blower Gas mask with special filter
Not immediately dangerous to life	Air-line respirator Hose mask without blower Chemical-cartridge respirator with special filter

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INSTRUCTION IN THE USE OF RESPIRATORS

For the safe use of any device, it is essential that the user be properly instructed in its selection, use, and maintenance. This is particularly important with respect to respirators. Competent persons should give such instruction to the supervisors of all groups who may be required to wear respirators at their work. The supervisors, in turn, should instruct their men. No person should be allowed to wear a respirator of any type until he has received such instruction. Such instruction should cover:

(1) An explanation of the need for using the respirator.
(2) Its operating principle.
(3) Steps to be taken to assure that it is in good operating condition.
(4) Proper adjustment of the respirator to the wearer.
(5) Proper use and maintenance of the respirator.

For air purifying respirators, an explanation of the need for using may be very important. The contaminant may give no discomfort and illness, or damage may occur only after long exposure. Since this is the case, it may be difficult to convince the persons exposed of the necessity of wearing the respirator.

The very presence of self-contained breathing apparatus, hose masks with blowers, or gas masks on the property of any organization is an indication that they are expected to be used in an emergency situation, or in one that is dangerous to life. All persons who may have occasion to use these respirators, or cause them to be used, should be properly trained in their use before circumstances require that they use them to protect their lives and the property of their employer. In addition to this, efforts should be made to anticipate possible emergencies and plans of action should be formulated so that when respiratory protection is needed, rescue or repair operations will proceed smoothly and safely.

Merely talking about such respirators as the self-contained breathing apparatus, the hose mask with blower, and the gas mask is not enough. The men should be given an opportunity to handle the respirator, have it fitted to them properly, test the gas-tightness of the facepiece fit, wear it in normal air for a period long enough for them to become familiar with it, and, finally, they should actually wear it in an irrespirable atmosphere. Such an atmosphere can be created by burning a half-ounce formaldehyde candle in a room of about 4,000-cubic-foot capacity.

This atmosphere is similar to that used by the Bureau of Mines in training men in the use of the self-contained breathing apparatus. After a person has worn one of these devices for a prolonged period

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in this formaldehyde-air mixture without any ill effect, he need only remove the facepiece or nose clip momentarily to be convinced of the efficacy of the respirator. Such training breeds confidence in the trainees that should stand them in good stead in an emergency situation.

A less severe training atmosphere that can be built up in any room without damage to its contents, or to other people in the same building, may be prepared by vaporizing isoamyl acetate to the amount of 173 cubic centimeters per 1,000-cubic-foot capacity of the room. The liquid isoamyl acetate is vaporized from a cloth wick placed in front of a fan in the room. This produces a concentration of about 1,000 parts of isoamyl acetate per million parts of air (0.1 percent) by volume. If the odor of isoamyl acetate is detected by a person wearing an emergency-type respirator, he would be able to detect the odor of phosgene or chlorine should he enter a 2-percent concentration of either of these gases while wearing the device. Isoamyl acetate vapor in this concentration is used by the Bureau of Mines as a preliminary means of testing the gastightness of gas-mask facepieces before actually wearing them in highly toxic concentrations of gases.

CARE OF RESPIRATORS

It is especially important that respirators be properly maintained and stored. The life of the wearer may be dependent on their proper functioning and ready availability. Adequate attention to cleaning and disinfecting is also required because the respiratory inlet coverings are worn on the face. Whenever possible, a centralized maintenance, cleaning, and storage station should be established to care for equipment of this type. It should be equipped adequately and manned by trained personnel.

Inspection

All respirators should be inspected at regular intervals to make sure that they are ready for use. For respirators that are used and maintained daily, inspection becomes an automatic function; however, it is often neglected for respirators that are stored throughout a plant for use in emergency situations. These devices should be checked as regularly as fire extinguishers; as a matter of fact, it is good practice to integrate these inspection and maintenance programs.

All rubber parts such as facepieces, mouthpieces, exhalation valves, breathing tubes, and headbands should be inspected carefully for signs of deterioration such as hardening, checking, or tackiness. During the inspection, time should be given to "working" the rubber between

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the fingers with a stretching and massaging action. This will reveal defects in rubber parts and prolong the life of nondefective parts. Particular care should be used in inspecting rubber parts when used around petroleum products because of the deleterious effect of petroleum products on rubber.

A check should be made to see that all gaskets are present and that they are held in place tightly.

Metal parts should be checked for signs of corrosion, and plastic and glass parts for breakage.

Maintenance

When it is necessary to replace worn or deteriorated parts, only those made specifically for the device should be used, and the repair work should be accomplished by experienced personnel. Makeshift repairs for respiratory protective equipment are not to be tolerated. After equipment that is used frequently is cleaned and disinfected, it should be repaired routinely; emergency equipment should be repaired immediately after inspection reveals the need for repairs.

Repairs to intricate parts should not be attempted unless adequate facilities and trained personnel are available. For most users, it is preferable that parts of this type be replaced as a unit or returned to the manufacturer for repair.

Cleaning and Disinfecting

Respiratory protective equipment should be cleaned and disinfected after each use. However, because of the wide variety of materials used in these devices, the manufacturer should be consulted for the cleaning and disinfecting method best suited to his products.

In general, facepieces and mouthpieces for respiratory protective devices are made from rubber or rubber-like compounds. Usually, these can be cleaned with detergent and lukewarm water by hand-brushing or agitation in a washing machine. Formaldehyde, modified phenolics, hypochlorite, or quaternary ammonium compounds in the proper strength can be used to disinfect the parts. Normally all detergent is rinsed from the protective device before disinfecting; however, there are several combination cleaning and disinfecting materials available in both liquid and powder form which contain a detergent and quaternary ammonium salts and this permits combining the washing and disinfecting operations. After cleaning and disinfecting, the parts should be rinsed in clean water and dried quickly. It may not be desirable to rinse parts treated with quaternary ammonium compounds since their disinfectant properties will continue

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indefinitely and may not produce a skin irritation. After reassembly, the device should be placed in a clean and dusttight container.

Hot water, steam, solvents, and ultraviolet light should be avoided in the cleaning and disinfecting of rubber parts because all have deteriorating effects. If paint or other difficult-to-remove substances are encountered, it is preferable that they be removed by mild caustic cleaners rather than by solvents.

Storage

All types of respirators should be stored in clean and dry compartments under conditions of moderate temperature. Most devices of this type are received in re-usable cartons or cases and should be kept in these containers during the period of storage. Exposure to heat, sunlight, extreme cold, and excessive moisture is harmful to respiratory protective devices if the exposure continues over extended periods.

In some cases, it is necessary to locate respiratory protective devices at convenient stations throughout the work area for ready availability in the event of an emergency. Special care must be taken to insure adequate storage under these conditions. In some instances, it is necessary to construct special compartments to protect the equipment from the process materials as well as from the elements.

Additional emergency-type respiratory protective devices should be stored just outside the immediate danger area so that men can retreat to them and don them for judicious re-entry into the contaminated area to carry out rescue or repair operations.

No respirator can be adequately stored outside its carrying case or carton in a toolbox or clothing locker.

The American Standard Safety Code for Head, Eye, and Respiratory Protection contains additional suggestions for maintaining, cleaning, disinfecting, and storing each type of respirator. It should be consulted for details.

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Compliance with the suggestions contained in this bulletin will help to assure that respiratory protection, when provided, will accomplish its purpose.

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