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American National Standard

practices for respiratory protection

Z88.2-1969

american national standards institute, inc.
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American National Standard
Practices for Respiratory Protection

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Foreword

(This Foreword is not part of American National Standard Practices for Respiratory Protection, Z88.2-1969.)

This is a revision of the respiratory protection portion of American National Standard Safety Code for Head, Eye, and Respiratory Protection, Z2.1-1959. The United States Department of the Interior, Bureau of Mines, which acted as cosponsor of Z2.1-1959, accepted sponsorship of the project on respiratory protection when it was deemed advisable to separate the portions of that Z2.1 standard. A Z88 Standards Committee was organized and met on September 24, 1963, to review the section of Z2.1-1959 dealing with respiratory protection. The Committee decided to revise and rewrite that section. The fifth draft of the proposed standard was submitted to letter ballot and accepted by the Z88 Committee on May 2, 1969. It was approved as an American National Standard on August 11.

Since questions may arise from time to time concerning interpretation of this standard, an Interpretation and Review Committee has been established, to provide for the uniform handling of doubtful cases. Anyone using this standard and desiring an interpretation may communicate with the Standards Institute. The Committee will also review new developments in respiratory protection and determine the need for revision or supplementation of this standard.

Suggestions for improvement gained in the use of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

The Z88 Standards Committee had the following personnel at the time it approved this standard.

Robert H. Schutz, *Chairman* Francis X. Worden, *Secretary*

Organization Represented	*Name of Representative*
American Conference of Governmental Industrial Hygienists	E. C. Hyatt
American Foundrymen's Society	William B. Huelsen
American Gas Association	T. L. Powers H. W. Becker *(Alt)*
American Industrial Hygiene Association	E. C. Hyatt W. H. Revoir *(Alt)*
American Insurance Association	Robert R. Conroy Victor Bohn *(Alt)*
American Mutual Insurance Alliance	J. A. Houghton Frederick H. Deeg *(Alt)*
American Petroleum Institute	W. E. Carroll J. F. McKenna *(Alt)*
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American Society of Safety Engineers	Richard H. Burr Harold Ritchie *(Alt)*
American Welding Society	A. D. Brandt
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International Association of Fire Chiefs	Raymond J. Brady Donald M. O'Brien *(Alt)*
International Association of Governmental Labor Officials	Martin Slotkin
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Telephone Group	F. X. Worden
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The subcommittee which prepared the final draft on this standard had the following personnel.

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H. H. Ackerman
Raymond J. Brady
R. H. Burr
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W. H. Revoir

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Contents

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American National Standard Practices for Respiratory Protection

1. Introduction

This standard sets forth accepted practices for respirator users. It provides information and guidance on the proper selection, use, and care of respirators and sets forth recommended requirements suitable for adoption into regulations governing their use.

1.1 Scope. The scope of this standard includes safe practices and requirements for using respirators for protection of the respiratory system from inhalation of particulate matter, noxious gases and vapors, and oxygen deficiency. *Excluded* are 1) underwater protection, 2) high-altitude aircraft oxygen systems, and 3) protection against military munitions. Although the standard does not cover engineered protective measures (for example, ventilation), exposure control shall be accomplished as far as is feasible by accepted engineering methods before considering or instituting use of respirators.

1.2 Purpose. The standard is intended to provide guidance that will assist respirator users in safeguarding health and life through proper selection and use of respirators. Use of respirators implies that the wearer needs protection from an atmosphere that might threaten his life or health. Therefore, it is imperative that the level of protection needed be determined and provided in both normal and emergency conditions of use, particularly if exposure to the atmosphere could be immediately dangerous to life or health. Use of respirators in atmospheres that are dangerous to life or health is discussed in 6.3.

1.3 "Shall" and "Should". The provisions of this standard are mandatory in nature where the word "shall" is used and advisory in nature where the word "should" is used.

1.4 Exceptions. Exceptions to the requirements in Section 3, Recommended Requirements for Codes, may be granted by competent authority, provided that an equally acceptable mode and degree of protection is afforded.

2. Definitions

abrasive-blasting respirator. See *respirator.*

aerodynamic diameter. The diameter of a unit density sphere having the same settling velocity as the particle in question of whatever shape and density.

air-line respirator. See *respirator.*

air-purifying respirator. See *respirator.*

air-regulating valve. An adjustable valve used to regulate airflow to the facepiece, helmet, or hood of an air-line respirator.

air-supply device. A hand- or motor-operated blower for the hose mask, or a compressor or other source of respirable air for air-line and abrasive-blasting respirators.

approved. Tested and listed as satisfactory by an authority having jurisdiction, such as U.S. Department of the Interior, Bureau of Mines, or U.S. Department of Agriculture.

breathing tube. A tube through which air or oxygen flows to the facepiece, helmet, or hood.

canister (air-purifying). A container filled with sorbents and catalysts that remove gases and vapors from air drawn through the unit. The canister may also contain an aerosol (particulate) filter to remove solid or liquid particles.

canister (oxygen-generating). A container filled with a chemical which generates oxygen by chemical reaction.

cartridge. A small container filled with air-purifying media.

catalyst. In respirator use, a substance which converts a toxic gas (or vapor) into a less-toxic gas (or vapor).

chemical-cartridge respirator. See *respirator.*

contaminant. A harmful, irritating, or nuisance material that is foreign to the normal atmosphere.

corrective lens. A lens ground to the wearer's individual corrective prescription.

detachable coupling. A device by means of which the respirator wearer, without using hand-

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tools, may detach the air-supply line from that part of the respirator worn on the person or from the air-supply source.

disinfection. The destruction and removal of pathogenic organisms, especially by means of chemical substances.

dust. See Table 2.

exhalation valve. A device that allows exhaled air to leave a respirator and prevents outside air from entering through the valve.

eyepiece. A gastight, transparent window(s) in a full facepiece through which the wearer may see.

facepiece. That portion of a respirator that covers the wearer's nose and mouth in a half-mask facepiece or nose, mouth, and eyes in a full facepiece. It is designed to make a gas-tight or dust-tight fit with the face and includes the headbands, exhalation valve(s), and connections for air-purifying device or respirable-gas source or both.

filter respirator. See *respirator.*

filter. A fibrous media (canned or uncanned) used in respirators to remove solid or liquid particles from the airstream entering the respirator enclosure.

fog. See Table 2.

full facepiece. See *facepiece.*

fume. See Table 2.

gas. An aeriform fluid which is in the gaseous state at ordinary temperature and pressure.

gas mask. See *respirator.*

half-mask facepiece. See *facepiece.*

head harness. a device for holding the facepiece securely in place on the wearer's head.

helmet. A device that shields the eyes, face, neck, and other parts of the head.

hood. A device that completely covers the head, neck, and portions of the shoulders.

hose mask. See *respirator.*

immediately dangerous to life or health. Included are conditions that pose an immediate threat to life or health and conditions that pose an immediate threat of severe exposure to contaminants such as radioactive materials which are likely to have adverse delayed effects on health.

inhalation valve. A device that allows respirable air to enter the facepiece and prevents exhaled air from leaving the facepiece through the intake opening.

irrespirable. Unfit for breathing.

mist. See Table 2.

MPC. Maximum permissible concentration. These concentrations are set by the National Committee on Radiation Protection. They are recommended maximum average concentrations of radionuclides to which a worker may be exposed, assuming that he works 8 hours a day, 5 days a week, and 50 weeks a year.

particulate matter. A suspension of fine solid or liquid particles in air, such as dust, fog, fume, mist, smoke, or sprays. Particulate matter suspended in air is commonly known as an aerosol.

pneumoconiosis-producing dust. Dust, which when inhaled, deposited, and retained in the lungs, may produce signs, symptoms and findings of pulmonary disease.

resistance. Opposition to the flow of air, as through a canister, cartridge, particulate filter, or orifice.

respirable. Fit to be breathed.

respirator. A device designed to protect the wearer from inhalation of harmful atmospheres. See Section 5, Classification, Description, and Limitations of Respirators.

self-contained breathing apparatus. See *respirator.*

sorbent. A material which removes toxic gases and vapors from air inhaled through a canister or cartridge.

spray. See Table 2.

supplied-air respirator. See *respirator.*

supplied-air suit. A one- or two-piece suit that is impermeable to most particulate and gaseous contaminants and is provided with an adequate supply of respirable air.

TLV. Threshold limit value. A table of these values and accompanying precautions is published annually by the American Conference of Governmental Industrial Hygienists.

toxic dust. Dust that may be harmful to the respiratory system or to other parts of the body through passing from the respiratory tract into the blood stream.

valve (air or oxygen). A device which controls the direction of air or oxygen flow or the rate and pressure at which air or oxygen is delivered, or both.

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vapor. The gaseous state of a substance that is solid or liquid at ordinary temperature and pressure.

window indicator. A colorimetric indicator for gas mask canisters which denotes the service life for a particular gas.

3. Recommended Requirements for Codes

3.1 Purpose. This section includes recommended requirements for authorities considering establishment of respirator regulations or codes. The following recommended requirements are supplemented by recommended practices in subsequent sections of this standard.

3.2 Permissible Practice. In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, *the primary objective shall be to prevent atmospheric contamination.* This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to the following requirements.

3.3 Employer Responsibility

3.3.1 Respirators shall be provided by the employer when such equipment is necessary to protect the health of the employee.

3.3.2 The employer shall provide the respirators which are applicable and suitable for the purpose intended.

3.3.3 The employer shall be responsible for the establishment and maintenance of a respiratory protective program which shall include the general requirements outlined in 3.5.

3.4 Employee Responsibility

3.4.1 The employee shall use the provided respiratory protection in accordance with instructions and training received.

3.4.2 The employee shall guard against damage to the respirator.

3.4.3 The employee shall report any malfunction of the respirator to the responsible person.

3.5 Minimal Acceptable Program

I 3.5.1 Written standard operating procedures governing the selection and use of respirators shall be established.

II 3.5.2 Respirators shall be selected on the basis of hazards to which the worker is exposed. See Section 4, Classification of Respiratory Hazards.

III 3.5.3 The user shall be instructed and trained in the proper use of respirators and their limitations. See 7.4 and 7.5.

IV 3.5.4 Where practicable, the respirators should be assigned to individual workers for their exclusive use.

V 3.5.5 Respirators shall be regularly cleaned and disinfected. Those issued for the exclusive use of one worker should be cleaned after each day's use, or more often if necessary. Those used by more than one worker shall be thoroughly cleaned and disinfected after each use. See 8.3.

VI 3.5.6 Respirators shall be stored in a convenient, clean, and sanitary location. See 8.5.

VII 3.5.7 Respirators used routinely shall be inspected during cleaning. Worn or deteriorated parts shall be replaced. Respirators for emergency use such as self-contained devices shall be thoroughly inspected at least once a month and after each use. See 8.2.

VIII 3.5.8. Appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained. See 6.3.4 and 10.4.

IX 3.5.9 There shall be regular inspection and evaluation to determine the continued effectiveness of the program. See Section 8, Maintenance and Care of Respirators, and Section 10, Evaluation of Respirator Program Effectiveness.

3.6 Program Administration. The plant or company industrial hygiene, health physics, safety engineering, or fire department shall administer the program in close liaison with the plant medical department. Responsibility for the program shall be vested in one individual. In small plants having no formal industrial hygiene, health physics, safety, fire, or medical department, the respirator program shall be administered by an upper-level superintendent, foreman, or other qualified individual responsible to the principal manager. The administrator shall have sufficient knowledge of the subject to properly supervise the program.

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Table 1

Classification of Respiratory Hazards According to Their Biological Effect

Oxygen Deficiency	Gas and Vapor Contaminants	Particulate Contaminants *(Dust, fog, fume, mist, smoke, and sprays)*
Occurrence: Confined or unventilated cellars, wells, mines, ship holds, tanks, burning buildings, and enclosures containing inert atmospheres. (See Note 1.) **Atmospheric O_2 content (percent by volume) versus expected conditions:** **20.9 percent:** Oxygen content of normal air. **16 percent:** Flame of safety lamp or ordinary combustibles extinguished, and symptoms of anoxia begin to appear in humans.	**Asphyxiants:** Interfere with utilization of O_2 in the body. Simple asphyxiants: Physiologically inert substances that dilute O_2 in the air (for example, nitrogen, hydrogen, helium, methane). See Oxygen Deficiency, Column 1. Chemical asphyxiants: Low concentrations interfere with supply or utilization of O_2 in the body (for example, carbon monoxide, hydrogen cyanide, cyanogen and nitriles). **Irritants:** Corrosive in action. May cause irritation and inflammation of parts of the respiratory system (also skin and eyes) and pulmonary edema (for example, ammonia, hydrogen chloride, formaldehyde, sulfur dioxide, chlorine, ozone, nitrogen dioxide, phosgene, and arsenic trichloride). **Anesthetics:** Cause loss of feeling and sensation with unconsciousness and death possible (for example, nitrous oxide, hydrocarbons and ethers). Some anesthetics injure body organs; for example, carbon tetrachloride (liver and kidneys), chloroform (liver and heart), benzene (bone marrow), and carbon disulfide (nervous system). **Systemic poisons:** Damage organs and systems in the body; for example, mercury (nervous system and various organs), phosphorous (bone), hydrogen sulfide (respiratory paralysis), and arsine (red blood cells and liver).	**Relatively inert:** May cause discomfort and minor irritation, but generally without injury at reasonable concentrations (for example, marble, gypsum). **Pulmonary fibrosis-producing:** Produce nodulation and fibrosis in the lung, possibly leading to complications (for example, quartz, cristobalite, tridymite, asbestos). **Cancer-producing:** Produce cancer in some individuals after "latent" period of 20-40 years (for example, asbestos, chromates, radioactive particulates). **Chemical irritants:** Produce irritation, inflammation, ulceration, and so forth, in upper respiratory tract (for example, acid mists, alkalis). **Systemic poisons:** Produce pathologic reactions in various systems of the body (for example, lead, manganese, cadmium). **Allergy-producing:** Produce reactions such as itching, sneezing and asthma (for example, pollens, isocyanates, gums, spices). **Febrile reaction-producing:** Produce chills followed by fever (for example, fumes of zinc and copper).

Combinations of Gas, Vapor, and Particulate Contaminants

Combinations of contaminants may occur simultaneously in the atmosphere. Contaminants may be entirely different substances (dusts and gases from blasting) or the particulate and vapor forms of the same substance. Synergistic effects (joint action of two or more agents that results in an effect which is greater than the sum of their individual effects) may occur. Such effects may require extraordinary protective measures.

NOTE 1: The adverse effects of oxygen deficiency increase with decreasing atmospheric pressure or increased altitude.

NOTE 2: *Conditions Immediately Dangerous to Life or Health* (see Section 2, Definitions) may result from most of the above hazards with the probable exception of nuisance or low toxicity dusts. Such conditions constitute atmospheres that would rapidly lead to death or to injury that would eventually impair health. For example, a ten-minute exposure to 120 parts per million (ppm) of phosgene may be fatal, and exposure to very high concentrations of a radioactive material such as plutonium 239 could present a danger to health from delayed effects of radiation damage to body tissues.

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3.7 Medical Limitations. Persons should not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. The local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (for instance, annually).

3.8 Approval. Approved or accepted respirators shall be used when they are available (see Section 6, Selection of Respirators). The respirator furnished shall provide adequate respiratory protection against the particular hazard for which it is designed in accordance with standards established by competent authorities. The U. S. Department of the Interior, Bureau of Mines, and the U. S. Department of Agriculture are recognized as such authorities. (See Appendix, Respirator Approval and Acceptance Listings.) Although respirators listed by the U.S. Department of Agriculture continue to be acceptable for protection against specified pesticides, the U. S. Department of the Interior, Bureau of Mines, is the agency now responsible for testing and approving pesticide respirators.

4. Classification of Respiratory Hazards

4.1 Introduction. The purpose of this section is to list and briefly describe various categories of respiratory hazards that might be encountered and which may require use of respirators. The information provides a general background for relating the guidance in subsequent sections to the type of hazard encountered. Management, however, will find it necessary to consult references on industrial hygiene and toxicology and perhaps expert individuals to develop the necessary comprehensive information on specific airborne contaminants.

Respiratory hazards for the purpose of this standard, are classified as follows:

(1) oxygen deficiency

(2) gas and vapor contaminants
- (a) immediately dangerous to life or health
- (b) not immediately dangerous to life or health

(3) particulate contaminants (dust, fog, fume, mist, smoke, and spray)
- (a) immediately dangerous to life or health
- (b) not immediately dangerous to life or health

(4) combination of gas, vapor, and particulate contaminants
- (a) immediately dangerous to life or health
- (b) not immediately dangerous to life or health

Respirators may afford some protection against high temperature atmospheres. See 9.4. Further information on the hazards of and use of respirators in high temperatures is presented in a National Fire Protection Association publication, *Breathing Apparatus for The Fire Service*, published in 1966.

4.2 Classification and Description of Respiratory Hazards. The basic respiratory hazards listed in 4.1 are classified in Table 1 according to expected biological effects of the contaminants. Many respirators, particularly air-purifying respirators, are designed and selected on the basis of chemical and physical properties of the air contaminants. Therefore, gas, vapor, and particulate contaminants are also presented in Table 2 according to their physical and chemical properties.

Particle size distribution and solubility are important parameters for particulate contaminants. Particles smaller than 5 microns in aerodynamic diameter more readily reach the lungs and are more readily dissolved and absorbed into the bloodstream or deposited on lung tissue. The solubility of the material usually determines whether the resulting toxic effect, if any, is in the lungs or other organs. Particles larger than 5 microns aerodynamic diameter are generally trapped in the upper respiratory tract, cleared, and swallowed with possible subsequent absorption from the gastrointestinal tract, depending on their solubility.

5. Classification, Description, and Limitations of Respirators

5.1 Introduction. The purpose of this section is to provide a description of the various types of respirators, their limitations, and capabilities, as a background for subsequent sections which discuss their selection, use, and maintenance.

Respirators fall into the following general classifications, according to mode of operation:

(1) atmosphere-supplying respirators
- (a) self-contained
- (b) hose-mask
- (c) air-line
- (d) combination self-contained and hose-mask or air-line

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(2) air-purifying respirators
 (a) gas and vapor (gas mask and chemical cartridge)
 (b) particulate (dust, fog, fume, mist, smoke, and sprays)
 (c) combination gas, vapor, and particulate

(3) combination atmosphere-supplying and air-purifying respirators

5.2 Classification, Description and Limitations of Respirators. This information is presented in two tables. Table 3 covers the classification and description of respirators according to the general classifications in 5.1. Table 4 covers capabilities and limitations of respirators arranged to correspond to the subject headings in Table 3.

More detailed information on specific types of respirators can be obtained from respirator manufacturers and from the *Respiratory Protective Devices Manual* published by the American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists in 1963.

The canister color code table from American National Standard Identification of Gas Mask Canisters, K13.1-1967, is provided in Table 5. The code indicates the colors assigned to canisters to identify the types of atmospheric contaminants against which they will protect.

5.3 Respirable Air and Oxygen for Self-Contained Breathing Apparatus and Hose-Type Respirators. Compressed air, compressed oxygen, liquid air, and liquid oxygen used for res-

Table 2

Classification of Respiratory Hazards According to Their Properties which Influence Respirator Selection

Gas and Vapor Contaminants	Particulate Contaminants
Inert: They do not react with other substances under most conditions and create a respiratory hazard by displacing air and producing oxygen deficiency (for example, helium, neon, argon).	Particles are produced by mechanical means by the disintegration processes of grinding, crushing, drilling, blasting, and spraying; or by the physiochemical reactions such as combustion, vaporization, distillation, sublimation, calcination, and condensation. Particles are classified as follows:
Acidic: Substances that are acids or that react with water to produce an acid. In water they produce positively charged hydrogen ions. They taste sour and many are corrosive to tissues (for example, hydrogen chloride, sulfur dioxide, fluorine, nitrogen dioxide, acetic acid, carbon dioxide, hydrogen sulfide, and hydrogen cyanide).	Dust: A solid mechanically produced particle with sizes varying from submicroscopic to visible or macroscopic.
	Spray: A liquid mechanically produced particle with sizes generally in the visible or macroscopic range.
Alkaline: Substances that are alkalies or that react with water to produce an alkali. When in water solutions, they result in the production of negatively charged hydroxyl ions (OH^-). They taste bitter, and many are corrosive to tissues (for example, ammonia, amines, phosphine, arsine, and stibine).	Fume: A solid condensation particle of extremely small particle size, generally less than one micron in diameter.
	Mist: A liquid condensation particle with sizes ranging from submicroscopic to visible or macroscopic.
Organic: These are the compounds of carbon. Examples are saturated hydrocarbons (methane, ethane, butane), unsaturated hydrocarbons (ethylene, acetylene), alcohols (methyl alcohol, propyl alcohol), ethers (methyl ether, ethyl ether), aldehydes (formaldehyde), ketones (dimethyl ketone), organic acids (formic acid, acetic acid), halides (chloroform, carbon tetrachloride), amides (formamide, acetamide), nitriles (acetonitrile), isocyanates (toluene diisocyanate), amines (methylamine), epoxies (epoxyethane, propylene oxide), and aromatics (benzene, toluene, xylene).	Fog: A mist of sufficient concentrate to perceptibly obscure vision.
	Smoke: A system which includes the products of incomplete combustion of organic substances in the form of solid and liquid particles and gaseous products in air. Smoke is usually of sufficient concentration to perceptibly obscure vision.
Organometallic: Compounds in which metals are chemically bonded to organic groups (for example, ethyl silicate, tetraethyl lead, and organic phosphates).	
Hydrides: Compounds in which hydrogen is chemically bonded to metals and certain other elements (for example, diborane and lithium hydride).	

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piration shall be of high purity. Oxygen shall meet the requirements of the United States Pharmacopoeia for medical or breathing oxygen. Breathing air shall meet at least the requirements of the specification for Grade D breathing air as described in Compressed Gas Association Commodity Specification G-7.1-1966.

Compressed oxygen shall not be used in supplied-air respirators or in open-circuit self-contained breathing apparatus that have previously used compressed air. Compressed air might contain low concentrations of oil. When high-pressure oxygen passes through an oil- or grease-coated orifice, an explosion or fire may occur.

Breathing air may be supplied to respirators from cylinders or air compressors. Cylinders shall be tested and maintained in accordance with applicable Department of Transportation or Interstate Commerce Commission Specifications for shipping containers. Compressors shall be constructed and situated so as to avoid entry of contaminated air into the system and suitable in-line air purifying sorbent beds and filters installed to further assure breathing air quality. A receiver of sufficient capacity to enable the respirator wearer to escape from a contaminated atmosphere in event of compressor failure, and alarms to indicate compressor failure and overheating shall be installed in the system (see 6.3.2). Air-line couplings shall be incompatible with outlets for other gas systems to prevent inadvertent servicing of air-line respirators with nonrespirable gases or oxygen.

Breathing-gas containers shall be marked in accordance with American National Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained, Z48.1-1954; Federal Specification BB-A-1034a, June 21, 1968, Air, Compressed for Breathing Purposes; or Interim Federal Specification GG-B-00675b, April 27, 1965, Breathing Apparatus, Self-Contained. Further details on sources of compressed air and its safe use will be found in Compressed Gas Association Pamphlet G-7-1968.

6. Selection of Respirators

6.1 Approved or Accepted Respirators. Whenever possible, approved or accepted respirators shall be used. Respirator approval and acceptance tests and listings and selection of other than approved or accepted respirators are discussed in the Appendix.

6.2 General Considerations. The multiplicity of hazards that may exist in a given operation requires careful and intelligent respirator selection. This selection is made even more complex by the many types of respirators available. Each type has its limitations, areas of application, and operational and maintenance requirements.

The selection of a proper respirator for any given situation requires consideration of the following factors: 1) nature of the hazard (see Section 4); 2) extent of the hazard; 3) work requirements and conditions; and 4) characteristics and limitations of available respirators (see Section 5).

Table 6 is a quick reference guide for the selection of respiratory protection appropriate to the type and degree of hazard. The Table provides minimal guidance, however, and shall be used along with other information, such as that given in this standard and in directions provided by respirator manufacturers.

When there is doubt about the concentration of oxygen or hazardous material present in the atmosphere, only those respirators listed as suitable for respiratory protection against oxygen deficiency shall be used. Any erring in the selection of respirators shall be on the safe side.

6.3 Nature of the Hazard. The chemical and physical properties, toxicity, and concentration of the hazardous material shall be considered in respirator selection (see Section 4 for classifications and discussion of respiratory hazards).

6.3.1 ***Oxygen-Deficient Atmospheres.*** Only respirators that provide an independent, respirable atmosphere shall be used in oxygen-deficient atmospheres. Normally, a self-contained breathing apparatus, hose mask with blower, or air-line respirator with auxiliary self-contained air supply is used for this purpose. Air-line respirators without auxiliary air supply shall be used only with the precautions outlined in 6.3.2.

An attendant shall be standing by at the entrance to the oxygen-deficient atmosphere at all times with proper communications and rescue equipment in case of an emergency. See 7.3 for use of respirators in oxygen-deficient atmospheres.

6.3.2 ***Immediately Dangerous Atmospheres.*** If it is probable that atmospheres immediately dangerous to life or health may occur, then both the normally expected *inward leakage* (see 6.3.3) and the *reliability* of the respirator shall

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→ referenced in 1910.134

Table 3
Classification and Description of Respirators by Mode of Operation

Atmosphere-Supplying Respirators

A respirable atmosphere independent of the ambient air is supplied to the wearer.

Self-Contained Breathing Apparatus (SCBA)

Supply of air, oxygen, or oxygen-generating material carried by wearer. Normally equipped with full facepiece, but some with a mouthpiece for escape purposes.

(1) **Closed-Circuit SCBA** (oxygen only)

(a) **Compressed or liquid oxygen type.** High-pressure O_2 from a gas cylinder passes through a high-pressure reducing valve and, in some designs, through a low-pressure admission valve to a breathing bag or container. Liquid oxygen is converted to a low-pressure gaseous oxygen and delivered to the breathing bag. The wearer inhales from the bag through a corrugated tube connected to a mouthpiece or facepiece and a one-way check valve. Exhaled air passes through another check valve and tube into a container of carbon dioxide removing chemical and reenters the breathing bag. Make up O_2 enters the bag continuously or as the bag deflates sufficiently to actuate an admission valve. A pressure relief system is provided and a manual bypass system and saliva trap may be provided depending upon the design.

(b) **Oxygen-generating type.** Water vapor in the exhaled breath reacts with chemical in the canister to release O_2 to the breathing bag. The wearer inhales from the bag through a corrugated tube and one-way check valve at the facepiece.

Hose Mask and Air-Line Respirator

(1) **Hose Mask**

Equipped with full facepiece, nonkinking breathing tube, rugged safety harness and a large diameter heavy-duty nonkinking air supply hose. The breathing tube and hose are securely attached to the harness. A check valve allows airflow only toward the facepiece. The facepiece is fitted with an exhalation valve. The harness has provision for attaching a safety line.

(a) **Hose mask with blower.** Air is supplied by a motor-driven or hand-operated blower. The wearer can continue to inhale through the hose if the blower fails. Up to 300 feet of hose length is permissible.

(b) **Hose mask without blower.** The wearer provides motivating force to pull air through the hose. The hose inlet is anchored and fitted with a funnel or like object covered with a fine mesh screen to prevent entrance of coarse particulate matter. Up to 75 feet of hose length is permissible.

(2) **Air-Line Respirator**

Respirable air is supplied through a small-diameter air-line from a compressor or compressed air cylinders. The airline is attached to the wearer by belt and can be detached rapidly in an emergency. A flow-control valve or orifice is provided to govern the rate of airflow to the wearer. Exhaled air passes to the ambient atmosphere through a valve(s) or opening in the enclosure (facepiece, hood, suit). Up to 250 feet of air-line is permissible.

Air-Purifying Respirators

Half-mask, full facepiece, or mouthpiece respirator equipped with air-purifying units to remove gases, vapors, and particulate matter from the ambient air prior to its inhalation. Some air-purifying respirators are blower-operated and provide respirable air to the facepiece (or hood) under a slight positive pressure.

Gas- and Vapor-Removing Respirators

Packed sorbent beds (cartridge or canister) remove single gases or vapors (for example, chlorine gas), a single class of gases or vapors (for example, organic vapors) or a combination of two or more classes of gases and vapors (for example, acid gases, organic vapors, ammonia, and carbon monoxide) by absorption, adsorption, chemical reaction or catalysis or a combination of these methods.

(1) **Full Facepiece Respirator** (Gas Mask)

Equipped with a single large chin canister or harness mounted canister with breathing tube and inhalation and exhalation valves. Canisters come in the "super" size, "industrial" size (regular), and chin style. The service life is approximately proportional to the canister size for a given type of canister.

Canisters for protecting against CO have an indicator or timer that shows when the canister shall be changed. Canisters are marked in bold letters with the contaminant against which they protect and are color coded for quick identification according to the American National Standard Identification of Gas Mask Canisters, K13.1-1967 (see Table 5). The maximum concentration in which the canister can be safely used is indicated on the label.

Particulate-Removing Respirators

Filter media in pads, cartridges, or canisters remove dust, fog, fume, mist, smoke or spray particles. Filters are designed to remove a single type of particle (silica dust) or classes of particles (dusts and fumes). Filters may be replaceable or a permanent part of the respirator. Some filters can be used only once; others are reusable and should be cleaned according to the manufacturer's instructions.

(1) **Full Facepiece Respirator**

Normally equipped with a high-efficiency filter canister designed to protect against hazardous particulates. Equipped with inhalation and exhalation valves.

(2) **Half-Mask Respirator**

Normally equipped with one or two dust, mist or fume filters designed to protect against nuisance and low to moderate toxicity dusts, fumes, and mists, an exhalation valve, and (normally) inhalation valves. A knitted fabric cover is sometimes worn on dust respirators to decrease discomfort.

(3) **Mouthpiece Respirator**

Infrequently used as a particulate respirator. (See Mouthpiece Respirator, Gas- and Vapor-Removing, in column 3.)

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Exhaled air passes through a second check valve breathing tube assembly into the canister. The O_2 release rate is governed by the volume of exhaled air. CO_2 is removed by the canister fill.

(2) Open-Circuit SCBA (compressed air, compressed oxygen, liquid air, or liquid oxygen)

(a) Demand type.* The demand valve permits oxygen or air flow only during inhalation. Exhaled breath passes to ambient atmosphere through a valve(s) in the facepiece. A bypass system is provided in case of regulator failure except on escape-type units.

(b) Pressure-demand type.† Equipped with full facepiece only. Positive pressure is maintained in the facepiece at all times. The wearer usually has the option of selecting the demand or pressure-demand mode of operation.

(a) Continuous-flow class. Equipped with a half-mask or full facepiece, or a helmet (abrasive blasting) or hood covering the wearer's head and neck. At least four cubic feet of air per minute to tight-fitting facepieces and six cubic feet per minute to loose-fitting hoods and helmets shall be required.

(b) Demand type.* Equipped with a half mask or full facepiece. The demand valve permits flow of air only during inhalation.

(c) Pressure-demand type.† Equipped with a half-mask or full facepiece. A positive pressure is maintained in the facepiece at all times.

(3) Supplied Air Suit

A form of continuous air-line respirator (see air-line respirator above). The suit is one or two piece and of leak-resistant material. Air is supplied to the suit through a system of internal tubes to the head, trunk, and extremities. Air exhausts through valves located in appropriate parts of the suit.

(2) Half-Mask Respirator (Chemical-Cartridge Respirator)

Equipped with one or more cartridge and exhalation and inhalation valves.

(3) Mouthpiece Respirator

A compact device designed for quick application when the atmosphere unexpectedly is contaminated with a hazardous material. Normally consists of a housing with a mouthpiece and a single cartridge, a nose clamp, exhalation and inhalation valves, and a neckband.

Combination Gas, Vapor, and Particulate-Removing Respirators

Some canisters and cartridges contain both filters and sorbents to provide protection against contaminants. Some filters are designed to be attached to a sorbent cartridge as a pre-filter (for example, for paint spray operation).

Combination Self-Contained and Air-Line Respirators

Normally a demand or pressure-demand type air-line respirator with full or half-mask facepiece, together with a small compressed-air cylinder to provide air if the normal supply fails. Wearer immediately returns to a respirable atmosphere if the normal air supply fails.

Combination Atmosphere-Supplying and Air-Purifying Respirators

These provide the wearer the option of using either of two different modes of operation. They may be an airline respirator with an air-purifying attachment to provide protection in the event the air supply fails or an air-purifying respirator with a small air cylinder in case the atmosphere unexpectedly exceeds safe conditions for use of an air-purifying respirator.

*Equipped with a demand valve that is activated on initiation of inhalation and permits the flow of breathing atmosphere to the facepiece. On exhalation, pressure in the facepiece becomes positive and the demand valve is deactivated.

†A small positive pressure is maintained at all times in the facepiece by a spring-loaded or balanced regulator and exhalation valve.

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Table 4

Capabilities and Limitations of Respirators

Atmosphere-Supplying Respirators

(See 5.3 for specifications on respirable atmospheres.)

Atmosphere-supplying respirators provide protection against *oxygen deficiency* and *most toxic atmospheres*. The breathing atmosphere is independent of ambient atmospheric conditions.

General Limitations: Except for the supplied-air suit, no protection is provided against skin irritation by materials such as Ammonia and HCl, or against sorption of materials such as HCN, tritium, or organic phosphate pesticides through the skin. See 6.3.5.1. Facepieces present special problems to individuals required to wear prescription lenses (see 9.1 and 9.2).

Self-Contained Breathing Apparatus (SCBA)

The wearer carries his own breathing atmosphere. Use is permissible in atmospheres immediately dangerous to life or health.

Limitations: The period over which the device will provide protection is limited by the amount of air or oxygen in the apparatus, the ambient atmospheric pressure (service life is cut in half by a doubling of the atmospheric pressure), and work load. A warning device shall be provided to indicate to the wearer when the service life has been reduced to a low level. Some SCBA devices have a short service life (few minutes) and are suitable only for escape (self-rescue) from an irrespirable atmosphere. Chief limitations of SCBA devices are their weight or bulk or both, limited service life, and the training required for their maintenance and safe use.

(1) Closed-circuit SCBA

The closed circuit operation conserves oxygen and permits longer service life.

Hose Mask or Air-line Respirator

The respirable air supply is not limited to the quantity the individual can carry, and the devices are light weight and simple.

Limitations: The wearer is restricted in movement by the hose or air-line and must return to a respirable atmosphere by retracing his route of entry. The hose or air-line is subject to being severed or pinched off.

(1) Hose Mask

(a) **Hose mask with blower.** If the blower fails, the unit still provides protection, although a negative pressure exists in the facepiece during inhalation. Use is permissible in atmospheres immediately dangerous to life or health.

(b) **Hose mask without blower.** Limited to use in atmospheres from which the wearer can escape unharmed without aid of the respirator.

(2) Air-Line Respirators (Continuous-Flow, Demand and Pressure-Demand Types)

The demand type produces a negative pressure in the facepiece on inhalation whereas continuous flow and pressure-demand types maintain

Air-Purifying Respirators

General Limitations: Air-purifying respirators do not protect against oxygen-deficient atmospheres nor against skin irritation by, or sorption through the skin of, airborne contaminants. See 6.3.1. and 6.3.5.1.

The maximum contaminant concentration against which an air purifying respirator will protect is determined by the designed efficiency and capacity of the cartridge, canister, or filter. For gases and vapors and for particles having a TLV of less than 0.1 mg/m^3, the maximum concentration for which the air purifying unit is designed is specified on the label. Respirators without a blower to maintain a constant positive pressure within the facepiece will not provide the maximum design protection specified unless the facepiece is carefully fitted to the wearer's face to prevent inward leakage. See 7.5. The time period over which protection is provided is dependent on canister, cartridge, or filter type, concentration of contaminant, and the wearer's respiratory rate.

The proper type of canister, cartridge, or filter shall be selected for the particular atmosphere and conditions. Air-purifying respirators generally cause discomfort and objectionable resistance to breathing although these problems are minimized in blower-operated units. Respirator facepieces present special problems to individuals required to wear prescription lenses. (See 9.1 and 9.2.) These devices do have the advantage of being small, light, and simple in operation.

Gas- and Vapor-Removing Respirators

Additional Limitations: No protection is provided against particulate contaminants, unless specified on canister or cartridge label. A rise in canister or cartridge temperature indicates that a gas or vapor is being removed from the inspired air. This is not a reliable indicator of canister performance. An uncomfortably high temperature indicates a high concentration of gas or vapor and requires an immediate return to fresh air.

(1) Full Facepiece Respirator (Gas Mask)

Should avoid use in atmospheres immediately dangerous to life or health if the contaminant(s) lacks sufficient warning properties (that is, odor or irritation).

Particulate-Removing Respirators

Additional Limitations: Protect against non-volatile particles only. No protection against gases and vapors.

The filter shall be replaced or cleaned when breathing becomes difficult due to plugging by retained particles.

These respirators shall not be used during shot and sand blasting operations. Abrasive-blasting respirators shall be used.

(1) Full Facepiece Respirator

Should avoid use in atmospheres immediately dangerous to life or health if the contaminant(s) lacks sufficient warning properties (that is, odor or irritation).

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(2) Open-circuit SCBA—demand and pressure-demand

The demand type produces a negative pressure in the facepiece on inhalation whereas the pressure-demand type maintains a positive pressure in the facepiece and is less apt to permit inward leakage of contaminants.

a positive pressure in the facepiece at all times and are less apt to permit inward leakage of contaminants.

Limitations: Air-line respirators are limited to use in atmospheres not immediately dangerous to life or health except under conditions specified in 6.3.2 and 7.3. Air-line respirators provide no protection if the air supply fails.

(3) Supplied-Air Suit

These suits protect against atmospheres that affect the skin or mucous membranes or that may be absorbed through the unbroken skin.

Limitations: Some contaminants, such as tritium, may penetrate the suit material and limit its effectiveness. Other contaminants, such as fluorine, may react chemically with the suit material and damage it. See 6.3.5.1.

These suits are limited in use to atmospheres not immediately dangerous to life or health except under the conditions specified in 6.3.2 and 7.3.

(2) Half-Mask Respirator (Chemical-Cartridge Respirator)

Shall not use in atmospheres immediately dangerous to life or health and should be limited to low concentrations of gases and vapors. A fabric covering shall not be worn on the facepiece since it will permit gases and vapors to pass.

No protection is provided to the eyes.

(3) Mouthpiece Respirator (Chemical Cartridge)

Shall not be used in atmospheres immediately dangerous to life or health. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing.

No protection is provided to the eyes.

(4) Self-Rescue Mouthpiece Respirator

Designed for self-rescue from immediately dangerous atmospheres of gases and vapors. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing.

No protection is provided to the eyes.

(2) Half-Mask Respirator

Shall not be used in atmospheres immediately dangerous to life or health. A fabric covering on the facepiece is permissible only in atmospheres of coarse dusts and mists of low toxicity.

No protection is provided to the eyes.

(3) Mouthpiece Respirator (Filter)

Shall not be used in atmospheres immediately dangerous to life or health. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing.

No protection is provided to the eyes from irritating aerosols.

(4) Self-Rescue Mouthpiece Respirator (Filter)

Designed for self-rescue from atmospheres having immediately dangerous concentrations of toxic particles. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing.

No protection is provided to the eyes from irritating aerosols.

Combination Self-Contained and Air-Line Respirators

The equipping of an air-line respirator with a small cylinder of compressed air to provide an emergency air supply qualifies the respirator for use in immediately dangerous atmospheres. See 6.3.2.

Combination Particulate and Vapor- and Gas-Removing Respirators

The advantages and disadvantages of the component parts of the combination respirator as described above will apply.

Combination Atmosphere-Supplying and Air-Purifying Respirators

The advantages and disadvantages, expressed above, of the mode of operation being used will govern. The mode with the greater limitations (air-purifying mode) will mainly determine the overall capabilities and limitations of the respirator since the wearer may for some reason fail to change the mode of operation even though conditions would require such change.

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be given full consideration. In oxygen-deficient atmospheres with no toxic materials, inward leakage is normally not a problem unless the leakage exceeds a few percent. It is essential that, in highly toxic atmospheres, inward leakage, if any, be minute. See 6.3.2.1 and 7.3 for use of respirators in immediately dangerous atmospheres.

6.3.2.1 *Respirators Recommended for Immediately Dangerous Atmospheres.* The U. S. Bureau of Mines and responsible industrial hygiene and safety organizations recommend the following respirators, listed in decreasing order with regard to the protection they offer the wearer, for use in atmospheres immediately dangerous to life or health. These atmospheres include those which are oxygen deficient or where high concentrations of gases or vapors exist:

(1) pressure-demand open-circuit or pressure-type closed-circuit self-contained breathing apparatus

(2) combination pressure-demand air-line respirator with auxiliary self-contained air supply

(3) combination constant-flow air-line respirator with auxiliary self-contained air supply

Table 5

Color Code for Gas-Mask Canisters (ANSI K13.1-1967)

Atmospheric Contaminants to be Protected Against	Colors Assigned*
Acid gases	White
Hydrocyanic acid gas	White with ½-inch *green* stripe completely around the canister near the bottom
Chlorine gas	White with ½-inch *yellow* stripe completely around the canister near the bottom
Organic vapors	Black
Ammonia gas	Green
Acid gases and ammonia gas	Green with ½-inch *white* stripe completely around the canister near the bottom
Carbon monoxide	Blue
Acid gases and organic vapors	Yellow
Hydrocyanic acid gas and chloropicrin vapor	Yellow with ½-inch *blue* stripe completely around the canister near the bottom
Acid gases, organic vapors, and ammonia gases	Brown
Radioactive materials, excepting tritium and noble gases	Purple (Magenta)
Particulates (dusts, fumes, mists, fogs, or smokes) in combination with any of the above gases or vapors	Canister color for contaminant, as designated above, with ½-inch *gray* stripe completely around the canister near the top
All of the above atmospheric contaminants	Red with ½-inch *gray* stripe completely around the canister near the top

*Gray shall not be assigned as the main color for a canister designed to remove acids or vapors.

NOTE: Orange shall be used as a complete body, or stripe color to represent gases not included in this table. The user will need to refer to the canister label to determine the degree of protection the canister will afford.

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(4) demand-flow open-circuit or closed-circuit self-contained breathing apparatus (where there may be a negative pressure in the breathing system at any time)

(5) combination demand-flow air-line respirator with auxiliary self-contained air supply

(6) hose mask with blower

When self-contained breathing apparatus or hose masks with blowers are used in atmospheres immediately dangerous to life or health, standby men must be present with suitable rescue equipment.

6.3.2.2 *Other Respirators Which May Be Used under Certain Conditions in Atmospheres Immediately Dangerous to Life or Health.* Air-line respirators are not approved or recommended for use in immediately dangerous atmospheres because no respiratory protection is provided if the air supply fails. However, if routine protection or operational designs preclude use of the recommended types of respirators which workers should wear, the following air-line respirators may be considered, provided an adequate flow of respirable air is maintained. These are listed in decreasing order with regard to the protection they provide for the wearer.

(1) pressure-demand air-line respirator with full facepiece

(2) continuous-flow air-line respirator with full facepiece, helmet, hood, or suit

(3) demand-flow air-line respirator with full facepiece

(4) pressure-demand air-line respirator with half-mask facepiece (only for atmospheres that do not cause eye irritation or injury)

(5) continuous-flow air-line respirator with half-mask facepiece (only for atmospheres that do not cause eye irritation or injury)

Table 6

Guide for Selection of Respirators

Hazard	**Respirator** (See Note 1.)
Oxygen Deficiency	Self-contained breathing apparatus. Hose mask with blower. no! Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Gas and Vapor Contaminants Immediately dangerous to life or health. (See Note 2.)	Self-contained breathing apparatus. Hose mask with blower. no! Air-purifying, full facepiece respirator with chemical canister (gas mask). no! Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life or health.	Air-line respirator. Hose mask without blower. Air-purifying, half-mask or mouthpiece respirator with chemical cartridge.
Particulate Contaminants Immediately dangerous to life or health. (See Note 2.)	Self-contained breathing apparatus. Hose mask with blower. no! Air-purifying, full facepiece respirator with appropriate filter. no! Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life or health.	Air-purifying, half-mask or mouthpiece respirator with filter pad or cartridge. Air-line respirator. Air-line abrasive-blasting respirator. Hose mask without blower.
Combination gas, vapor, and particulate contaminants Immediately dangerous to life or health. (See Note 2.)	Self-contained breathing apparatus. Hose mask with blower. no! Air-purifying, full facepiece respirator with chemical canister and appropriate filter (gas mask with filter). no! Self-rescue mouthpiece respirator (for escape only). Combination air-line respirator with auxiliary self-contained air supply or an air-storage receiver with alarm.
Not immediately dangerous to life or health.	Air-line respirator. Hose mask without blower. Air-purifying, half-mask or mouthpiece respirator with chemical cartridge and appropriate filter.

NOTE 1: For details on descriptions, capabilities, and limitations of respirators, refer to Tables 3 and 4.

NOTE 2: For details on use of respirators in hazardous atmospheres, see 6.3.2 and 7.3.

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(6) demand-flow air-line respirator with half-mask facepiece (only for atmospheres that do not cause eye irritation or injury)

Pressure-demand or continuous-flow air-line respirators with full facepiece provide the wearer with a degree of respiratory protection equal to that afforded by a positive pressure self-contained breathing apparatus as long as an adequate flow of respirable air is maintained. Also, a demand-flow air-line respirator with full facepiece would be equivalent to a demand-flow open-circuit or closed-circuit self-contained breathing apparatus as long as an adequate supply of respirable air is maintained.

Persons using air-line respirators in atmospheres immediately hazardous to life or health shall be equipped with safety harnesses and safety lines for lifting or removing persons from hazardous atmospheres or other and equivalent provisions for the rescue of persons from hazardous atmospheres shall be used. A standby man or men with suitable self-contained breathing apparatus shall be at the nearest fresh air base for emergency rescue.

Before a person is permitted to wear an air-line respirator in a hazardous atmosphere, an industrial hygiene, health physics, or safety engineering department representative or a qualified industrial hygienist, health physicist, or safety engineer shall be responsible for compliance with the following:

(1) Air-line hose from a compressor or cylinder air supply shall be protected from damage, including cutting, kinking, crushing, or burning. In some cases an armored hose shall be used. Hose couplings shall be protected against disconnection. Trailing air-line hose shall be arranged to minimize tripping and to permit ready escape.

(2) The cylinder containing the air supply for an air-line respirator shall be tested for oxygen concentration and carbon monoxide content and shall be respirable. All air shall meet the minimum specification for Type I, Grade D gaseous air of the Compressed Gas Association *Commodity Specification for Air*, G-7.1-1966. The air supply in the cylinder shall be adequate for completion of the work and escape. *Oxygen must never be used with air-line respirators.*

(3) The compressor for supplying air shall be equipped with necessary safety and standby devices. A breathing air-type compressor shall be used. An air-storage receiver shall also be provided to furnish the wearer with an adequate supply of escape air if the compressor fails to operate. A compressor shutoff alarm and necessary aerosol and vapor and gas filters shall also be incorporated into the system.

If an oil-lubricated compressor is used, it shall have a high-temperature or carbon monoxide alarm, or both. If only a high-temperature alarm is used, the air from the compressor shall be frequently tested for carbon monoxide to insure that it meets the specifications in 6.3.2.2 (2).

(4) The wearer shall be properly trained in the use of the air-line respirator and shall be well-informed of the hazard. A standard operating procedure shall be prepared for each situation for which air-line respirators are employed in atmospheres immediately hazardous to life or health, and air-line respirator users shall be thoroughly familiar with this procedure.

(5) Continuous-flow air-line respirators are designed for maximum comfort with a minimum airflow that will adequately protect the wearer in a non-hazardous atmosphere. However, they are capable of providing adequate airflow to protect the wearer in a hazardous atmosphere. This adequate airflow is obtained when the airflow control valve is fully open.

The recommended minimum airflows for use of air-line respirators in hazardous atmospheres are five cubic feet per minute to tight fitting facepieces and seven cubic feet per minute to loose fitting hoods or helmets. Persons wearing supplied-air suits shall follow the manufacturer's instructions concerning minimum airflow.

For further information on furnishing compressed air to air-line respirators, refer to Compressed Gas Association Pamphlet G-7-1968. See 7.3 concerning safe procedures during use of respirators in atmospheres immediately dangerous to life or health.

6.3.3 ***Not Immediately Dangerous Atmospheres.*** If immediately dangerous atmospheres are not present or will not occur, then the consequences of respirator failure are lessened and emphasis can be placed on other factors such as long term protection, convenience, cost, comfort, and wearer acceptance. These factors should be weighed one against another since they are not always compatible. However, long term protection should be given priority over all other factors.

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Long term protection is determined primarily by the amount of inward leakage of atmospheric contaminants during normal usage of the respirator. The various types of respirators are grouped below according to the increasing amount of inward leakage one might expect during their routine use.

Group 1

Supplied-air suit

Pressure-demand full facepiece open-circuit and air-line devices

Pressure-type full facepiece closed-circuit self-contained breathing apparatus

Continuous-flow full facepiece air-line respirator

Air-line respirator with loose-fitting hood gathered around the waist

Hose-mask with blower and full facepiece mask

Group 2

Demand-type full facepiece open-circuit self-contained breathing apparatus

Demand-type full facepiece air-line respirator

Pressure-demand half-mask air-line respirator

Group 3

Continuous-flow half-mask air-line respirator

Demand-type half-mask air-line respirator

Air-line respirator with loose-fitting hood gathered around the neck

Group 4

Air-purifying respirator with blower and with full facepiece or hood gathered around the waist

Group 5

Air-purifying respirator with blower and with half-mask facepiece or hood gathered around the neck

Group 6

Hose mask without blower

Air-purifying full facepiece respirator without blower

Group 7

Air-purifying half-mask respirator without blower

Mouthpiece respirator

The negative pressure produced in the facepiece of many respirators (some in Groups 2 and 3 and all in Groups 6 and 7) during inhalation will cause inward leakage of ambient air if leaks exist. The amount of inward leakage expected for various types of respirators is vaguely understood and is related to the facepiece-to-face seal and leakage of various components including air-purifying units. For Group 1, inward leakage will normally be infinitesimal or nonexistent. For Groups 2, 3, 4, and 5, inward leakage will normally be minute. In Group 6, inward leakage with a good facepiece-to-face seal and with ideal wearing conditions may be as low as 0.1 percent. In practice, however, this low level leakage is usually not attained due to poor facepiece-to-face fit and adverse wearing conditions such as face movements and beard growth. For Group 7, inward leakage with good facepiece-to-face fit and ideal wearing conditions may be as low as 1 percent. This leakage level, however, is seldom attained for reasons similar to those cited for devices in Group 6. It is, therefore, important (particularly for devices in Groups 6 and 7) that due consideration be given to potential inward leakage in selecting devices.

Experience has demonstrated that not all persons can obtain a satisfactory facepiece-to-face seal with a single full facepiece or half-mask air-purifying respirator. Therefore, to provide an adequate facepiece-to-face seal on a variety of facial features, it may be necessary that two or more models of full facepiece or half-mask respirators be available. When an individual can be fitted with two or more respirators, he should be permitted to select the most comfortable device. See 7.5 for a discussion of face fit tests and procedures.

6.3.4 *Monitoring of Air Contaminants.* Evaluation of contaminant concentration to which a person wearing a respirator may be exposed is an integral part of an effective respirator program. Air sampling data are important in the selection of the proper respirator and should include: 1) identification of the contaminant; 2) nature of the hazard; and 3) concentration at the breathing zone. The data are also helpful in estimating the possible levels of exposure that may have occurred during use of respirators.

In an air monitoring program, sampling should be carried out over at least one cycle of operation and, preferably, over several cycles when production activity varies. Normally, samples should be collected at the worker's breathing zone. However, where necessary, general air samples should be collected in the vicinity of the operation. The sampling period will be determined by the sensitivity of the analytical method and the acceptable contaminant concentration.

It is important that representative samples be obtained. The number of samples to be taken depends on the variation in contaminant

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generation rate during the operation. Sampling data should permit estimation of the worker's time weighted exposure. The peak contaminant concentration should also be estimated to assure that the respirator selected will provide adequate protection against high transient air concentrations.

Breathing zone sampling is important since significant variations in concentrations are noted between general air and the worker's breathing zone. Use of personal or lapel air samplers is encouraged since they have been shown to more closely identify the true exposure.

Although it is recognized that in emergency situations air sampling cannot be carried out as outlined above, every reasonable effort shall be made to evaluate conditions of exposure and to provide appropriate respiratory protection. Where a high hazard potential exists, a conservative estimate should be made.

6.3.5 ***Unusual Hazards.*** Unusual factors can add new dimensions to a hazardous situation and should be anticipated in selecting respirators. Some examples are provided here.

6.3.5.1 *Absorption through or Irritation of the Skin.* Some airborne contaminants are extremely irritating to the skin (for example, ammonia and hydrochloric acid) while others are capable of being absorbed through the skin and into the blood stream with serious, possibly fatal, results. Hydrocyanic acid gas and many of the organic phosphate pesticides, such as parathion, malathion, and tetraethyl-pyrophosphate (TEPP), will penetrate the unbroken skin. A facepiece or hood respirator will not afford complete protection against these contaminants. If the concentration is high, or if exposure is prolonged, a full body-covering suit of impermeable material shall be worn with respiratory protection. A facepiece may not be required if the suit is leakproof and adequately ventilated.

6.3.5.2 *Radiation of Skin and Whole Body.* The respirator may not protect the skin or whole body against radiation from airborne concentrations of certain radionuclides including noble gas radionuclides and other relatively biologically inert gases.

6.4 Extent and Location of Hazard. The extent of the hazard in space and time and its physical location shall be considered in respirator selection. They include the length of time protection will be needed, entry and exit times, accessibility of a fresh air supply, and the ability to use air lines or move about freely while wearing the respirator.

The location of the contaminated area in respect to a possible source of respirable air requires special consideration. 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 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 unless the device is equipped with an auxiliary air cylinder, chemical canister or cartridge, or particulate filter appropriate for use in withdrawal. While wearing a self-contained breathing apparatus or a gas mask, a person may leave the contaminated area by any exit, but he should make certain that the device will afford protection until he reaches respirable air, taking into account possible delays.

6.5 Work Requirements and Conditions

6.5.1 ***Work Time.*** Work time usually determines the length of time for which respiratory protection is needed, including the time necessary to enter and leave a contaminated area. A self-contained breathing apparatus, gas mask, or chemical-cartridge respirator provide respiratory protection for relatively short periods, whereas the hose mask with blower, air-line respirator, and abrasive-blasting respirator provide protection for as long as the facepiece is supplied with adequate respirable air. Particulate-filter respirators can provide protection for long periods, without need for filter replacement, only if the atmospheric particulate loading is low. Therefore, for protracted periods of use, the hose mask with blower and air-line respirators offer definite advantages. They also cause less discomfort than air-purifying respirators.

Some respirators have a means for indicating the remaining service life. Some type of warning is available for all self-contained breathing apparatus and some gas masks. This may be a pressure gage, timer, audible or physical alarm, or window indicator in the canister. The user should understand the operation and limitations of each type of warning device. Most other gas masks and chemical-cartridge respirators have no indicator of remaining service life. Canisters and cartridges should be changed according to the manufacturer's directions.

6.5.2 ***Activity of Wearer.*** The work area to be covered, work rate, and mobility required of

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the wearer in carrying out his work should be considered in respirator selection.

Air-purifying respirators present minimal interference with the wearer's movement. Supplied-air respirators with trailing hoses severely restrict the area the wearer can cover and present a potential hazard where the trailing hose can come in contact with machinery. Self-contained breathing apparatus present a size and weight penalty which may restrict climbing and movement in tight places.

The wearer's work rate determines his respiratory minute volume, maximum inspiratory flow rate, and inhalation and exhalation breathing resistance. The respiratory minute volume is of great significance in self-contained and air-line respirators operated from cylinders since it determines their operating life. Useful life under moderate work conditions may be one-third that under rest conditions.

Peak airflow rate is important in the use of constant-flow air-line equipment. The air-supply rate should always be greater than the peak inspiratory flow rate to maintain the respiratory enclosure under positive pressure.

High breathing resistance of air-purifying respirators under conditions of heavy work can result in distressed breathing.

6.5.3 *Vision*. All facepieces will restrict, to some degree, the wearer's vision. This may increase accident potential. Other problems include wearing of prescription glasses and fogging of the respirator lens (see 9.1, 9.2, and 9.3).

6.5.4 *Communications*. Effective speech communication may be required in jobs for which the respirator is being selected. Section 9.5 provides information in this subject.

6.5.5 *Temperature Extremes*. The ability to cope with stress caused by temperature extremes is especially important in emergency situations when only immediately available respirators can be used. See 9.3 and 9.4 for further details on use of respirators in temperature extremes.

6.5.6 *Eye Protection*. Where required, full-facepiece respirator eyepieces and eye protection worn with half-mask facepieces shall meet the pertinent requirements of American National Standard Practice for Occupational and Educational Eye and Face Protection, Z87.1-1968.

6.6 Employee Acceptance and Face Fit. These factors are of prime importance in respirator selection. The wearer's acceptance of a particular respirator depends on the lack of facepiece discomfort, interference with vision, weight of the device, breathing resistance, and individual physical condition and psychological factors. The ability to form a good facepiece-to-face seal depends on respirator design and facial features, and is usually the most important factor in obtaining proper protection with an air-purifying respirator, particularly of the half-mask type. See 7.5 for a discussion of face-fit tests and procedures.

7. Use of Respirators

7.1 Operating Procedures. Standard procedures shall be developed for respirator use. These should include all information and guidance necessary for their proper selection, use, and care. Possible emergency and routine uses of respirators should be anticipated and planned for.

7.2 Issuance of Respirators. The correct respirator shall be specified for each job. The respirator type is usually specified in the work procedures by a qualified individual supervising the respiratory protective program. The individual issuing them shall be adequately instructed to insure that the correct respirator is issued. Each respirator permanently assigned to an individual should be durably marked to indicate to whom it was assigned. This mark shall not affect the respirator performance in any way. The date of issuance should be recorded.

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7.3 Use in Dangerous Atmospheres. Written procedures shall be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or in emergencies. Personnel shall be familiar with these procedures and the available respirators.

In areas where the wearer, with failure of the respirator, could be overcome by a toxic or oxygen-deficient atmosphere, at least one additional man shall be present. Communications (visual, voice, or signal line) shall be maintained between both or all individuals present. Planning shall be such that one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the other(s) in case of emergency. See 6.3.1 and 6.3.2 for guidance on selection of respirators for use in dangerous atmospheres.

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7.4 Training and Education in Proper Use. For safe use of any respirator, it is essential that the user be properly instructed in its selection, use, and maintenance. Both supervisors and workers shall be so instructed by competent persons.

Minimum training shall include the following:

(1) Instruction in the nature of the hazard, whether acute, chronic, or both, and an honest appraisal of what may happen if the respirator is not used.

(2) Explanation of why more positive control is not immediately feasible. This shall include recognition that every reasonable effort is being made to reduce or eliminate the need for respirators.

(3) A discussion of why this is the proper type of respirator for the particular purpose.

(4) A discussion of the respirator's capabilities and limitations.

(5) Instruction and training in actual use of the respirator (especially a respirator for emergency use) and close and frequent supervision to assure that it continues to be properly used.

(6) Classroom and field training to recognize and cope with emergency situations.

(7) Other special training as needed for special use.

Training shall provide the men an opportunity to handle the respirator, have it fitted properly, test its facepiece-to-face seal, wear it in normal air for a long familiarity period, and, finally, to wear it in a test atmosphere.

7.5 Facepiece Fit Tests and Procedures. Every respirator wearer shall receive fitting instructions including demonstrations and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits properly. Respirators shall not be worn when conditions prevent a good face seal. Such conditions may be a growth of beard, sideburns, a skull cap that projects under the facepiece, or temple pieces on glasses. Also, the absence of one or both dentures can seriously affect the fit of a facepiece. The worker's diligence in observing these factors shall be evaluated by periodic checks.

To assure proper protection, the facepiece fit shall be checked by the wearer each time he puts on the respirator. This may be done by following the manufacturer's facepiece-fitting instructions such as these two simple field tests:

(1) Positive Pressure Test. Close the exhalation valve and exhale gently into the facepiece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. For most respirators, this method of leak testing requires that the wearer first remove the exhalation valve cover and then carefully replace it after the test.

(2) Negative Pressure Test. Close off the inlet opening of the canister or cartridge(s) by covering with the palm of the hand(s) or by replacing the seal(s), inhale gently so that the facepiece collapses slightly, and hold the breath for ten seconds. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is probably satisfactory.

Potential users of respirators should also be required to test their facepiece fit by wearing the respirator under realistic test conditions. A concentration of 100 parts per million isoamyl acetate vapor (obtained by vaporizing 17.3 milliliters of isoamyl acetate for each 1,000 cubic feet of room volume) may be prepared in a special chamber, a small plastic enclosure, or in a vacant room. If the person wearing the respirator can enter and remain in this test atmosphere without detecting the odor of isamyl acetate, he has a good fit. If he detects the odor, he should retreat to fresh air, readjust the facepiece, and repeat the test. If leakage is still noted, it can be concluded that this particular respirator will not protect the wearer. The wearer should not continue to tighten the headband straps until they are uncomfortably tight, simply to achieve a gas-tight face fit. If fitted too tightly, the wearer will not wear the respirator or will wear it fitting comfortably loose and will not have a gas-tight seal.

Particulate-filter respirators can frequently be adapted for use with chemical cartridges and may also be tested for face fit in isoamyl acetate.

To check the fit of a respirator equipped with a high-efficiency particulate filter, an irritant smoke tube (glass tube 12 centimeters long by 1 centimeter diameter, filled with stannic chloride-impregnated pumice) produces a very irritating smoke when air is blown through it. The smoke is directed at the facepiece seal and leakage is indicated by irritation of the throat and lungs. (When testing half-mask facepieces,

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do not direct the smoke into the eyes and instruct the wearer to keep his eyes closed during the test.) Freshly produced smoke particles from this tube range from less than 0.1 to 3 microns in diameter. The glass tube is scored at each end for easy breaking. A squeeze bulb with a short rubber tube aspirates air through the tube; visible smoke is immediately formed by contact with moisture in the air. The irritant is hydrochloric acid absorbed on the particulate. A similar smoke is produced with a sulfur trioxide or titanium tetrachloride tube.

Several methods of determining facepiece fit are described in detail in the *Respiratory Protective Devices Manual*, published by the American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists in 1963.

8. Maintenance and Care of Respirators

#**8.1 General.** A program for maintenance and care of respirators shall be adjusted to the type of plant, working conditions, and hazards involved, and shall include the following basic services:

(1) inspection for defects (including a leak check)

(2) cleaning and disinfecting

(3) repair

(4) storage

Equipment shall be properly maintained to retain its original effectiveness.

n/ legal but good guide

#**8.2 Inspection.** All respirators shall be inspected routinely before and after each use. A respirator that is not routinely used but is kept ready for emergency use shall be inspected after each use and at least monthly to assure that it is in satisfactory working condition.

Self-contained breathing apparatus shall be inspected monthly. Air and oxygen cylinders shall be fully charged according to the manufacturer's instructions. It shall be determined that the regulator and warning devices function properly.

Respirator inspection shall include a check of the tightness of connections and the condition of the facepiece, headbands, valves, connecting tube, and canisters. Rubber or elastomer parts shall be inspected for pliability and signs of deterioration. Stretching and manipulating rubber or elastomer parts with a massaging action will keep them pliable and flexible and prevent them from taking a set during storage.

A record shall be kept of inspection dates and findings for respirators maintained for emergency use.

#**8.3 Cleaning and Disinfection.** Routinely used respirators shall be collected, cleaned, and disinfected as frequently as necessary to insure that proper protection is provided for the wearer. Each worker should be briefed on the cleaning procedure and be assured that he will always receive a clean and disinfected respirator. Such assurances are of greatest significance when respirators are not individually assigned to workers. Respirators maintained for emergency use shall be cleaned and disinfected after each use.

The following procedure is recommended for cleaning and disinfecting respirators:

(1) Remove any filters, cartridges, or canisters.

(2) Wash facepiece and breathing tube in cleaner-disinfectant or detergent solution (see following paragraphs). Use a hand brush to facilitate removal of dirt.

(3) Rinse completely in clean, warm water.

(4) Air dry in a clean area.

(5) Clean other respirator parts as recommended by manufacturer.

(6) Inspect valves, headstraps, and other parts; replace with new parts if defective.

(7) Insert new filters, cartridges, or canisters; make sure seal is tight.

(8) Place in plastic bag or container for storage.

Cleaner-disinfectant solutions are available that effectively clean the respirator and contain a bactericidal agent. The bactericidal agent is generally a quaternary ammonium compound. The respirator may be immersed in the solution, rinsed in clean, warm water, and air dried.

Alternatively, respirators may be washed in a liquid detergent solution, then immersed in: 1) a hypochlorite solution (50 parts per million of chlorine) for 2 minutes; 2) an aqueous iodine solution (50 parts per million of iodine) for 2 minutes; or 3) a quaternary ammonium solution (200 parts per million of quarternary ammonium compounds in water with less than 500 parts per million total hardness).

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Different concentrations of quaternary ammonium salts are required to achieve a disinfecting solution with waters of varying hardness. Also, dermatitis may occur if the quaternary ammonium compounds are not completely rinsed from the respirator. The hypochlorite and iodine solutions are not stable; they age rubber parts, and are corrosive to metallic parts. Therefore, immersion times should not be extended and the disinfectants shall be thoroughly rinsed from the respirator parts.

Strong cleaning and disinfecting agents can damage respirator parts. Temperatures above 185 degrees Fahrenheit and vigorous mechanical agitation should not be used. Solvents which affect elastomer or rubber parts should be used with caution.

Respirators may be contaminated with toxic materials (that is, organic phosphate pecticides and radionuclides). If the contamination is light, normal cleaning procedures should provide satisfactory decontamination; if heavy, a separate decontamination step may be required before cleaning.

For complete decontamination against phosphate pesticides, the respirator should be washed with alkaline soap and rinsed with 50 percent alcohol (ethyl or isopropyl).

Respirators used to protect against radioactive contaminants should be decontaminated to levels not exceeding 100 disintegrations per minute per 100 square centimeters fixed alpha and 0.2 millirad per hour of beta-gamma above background at contact. There should be no detectable removable activity using standard swipe techniques.

8.4 Repair. Replacement or repairs shall be done only by experienced persons with parts designed for the respirator. No attempt shall be made to replace components or to make adjustment or repairs beyond the manufacturer's recommendations. Reducing or admission valves or regulators shall be returned to the manufacturer or to a trained technician for adjustment or repair.

8.5 Storage. After inspection, cleaning, and necessary repair, respirators shall be stored to protect against dust, sunlight, heat, extreme cold, excessive moisture or damaging chemicals. Respirators placed at stations and work areas for emergency use should be stored in compartments built for the purpose, be quickly accessible at all times, and be clearly marked. Routinely used respirators, such as dust respirators, may be placed in plastic bags. Respirators should not be stored in such places as lockers or tool boxes unless they are in carrying cases or cartons.

Respirators should be packed or stored so that the facepiece and exhalation valve will rest in a normal position and function will not be impaired by the elastomer setting in an abnormal position.

Instructions for proper storage of emergency respirators, such as gas masks and self-contained breathing apparatus, are found in "use and care" instructions usually mounted inside the carrying case lid.

9. Special Problems

9.1 Corrective Lens with Full Facepiece. Providing respiratory protection for individuals wearing corrective glasses is a serious problem. A proper seal cannot be established if the temple bars of eye glasses extend through the sealing edge of the full facepiece. As a temporary measure, glasses with short temple bars or without temple bars may be taped to the wearer's head. Wearing of contact lenses in contaminated atmospheres with a respirator shall not be allowed.

Systems have been developed for mounting corrective lenses inside full facepieces. When a workman must wear corrective lenses as part of the facepiece, the facepiece and lenses shall be fitted by qualified individuals to provide good vision, comfort, and a gas-tight seal.

9.2 Eyewear with Half-Mask Facepiece. If corrective spectacles or goggles are required, they shall be worn so as not to affect the fit of the facepiece. Proper selection of equipment will minimize or avoid this problem.

9.3 Respirator Use in Low Temperatures. Major problems in the use of full facepieces at low temperatures are poor visibility and freezing of exhalation valves. All full facepieces are designed so that the incoming fresh air sweeps over the inside of the lens to reduce fogging. Otherwise, it would be impossible to wear a full facepiece in ordinary room temperatures without severe fogging. Antifog compounds can be used to coat the inside of the lens to prevent fogging at room temperatures and down to temperatures approaching 32 degrees Fahrenheit. However, below zero degrees Fahrenheit, antifog compounds will not prevent severe fogging.

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Full facepieces are available with nose cups that direct moist exhaled air through the exhalation valve. A properly fitted nose cup should provide satisfactory or adequate visibility at temperatures down to −30 degrees Fahrenheit.

At very low temperatures, the exhalation valve may collect moisture and freeze open, allowing the wearer to breathe contaminated air, or freeze closed, preventing normal exhalation. The Bureau of Mines has published two pamphlets on this subject: *Performance of Open-Circuit Self-Contained Breathing Apparatus at −25° F*, R.I. 7077 (1966), and *Low-Temperature Performance of Compressed-Oxygen Closed-Circuit Breathing Apparatus*, R.I. 7192 (1968). Dry respirable air shall be used with self-contained breathing apparatus or air-line respirators at low temperatures. The dewpoint of the breathing gas shall be appropriate to the ambient temperature.

High-pressure connections on self-contained breathing apparatus may leak because of metal contraction at low temperatures. The connections should not be overtightened since they may break when the temperature returns to normal.

9.4 Respirator Use in High Temperatures. A man working in areas of high ambient or radiant temperature is under stress. Any additional stress resulting from use of respirators should, therefore, be minimized. This can be done by selecting and using respirators having minimum weight and breathing resistance. Supplied-air respirators and hoods and suits having an adequate supply of cool breathing air are recommended. Further information on use of respirators in high temperatures may be found in *Breathing Apparatus for the Fire Service*, published by the National Fire Protection Association in 1966.

9.5 Communications. Although conventional respirators distort the human voice to some extent, the respirator exhalation valve usually provides a pathway for some speech transmission over short distances in relatively quiet areas. Talking can induce facepiece or component leakage and therefore should be limited while wearing a respirator, especially those with half-mask facepieces.

Mechanical speech transmission devices called speaking diaphragms are available as an integral part of some respirators. These consist of a resonant cavity and diaphragm which amplify sound in the frequency range most important to speech intelligibility. The diaphragm acts as a barrier to the ambient atmosphere. It should be carefully handled and protected by a cover to prevent puncture.

Various methods of electronically transmitting speech from the respirator are available. These utilize a microphone connected to a telephone or radio transmitter. Usually the microphone is mounted in the facepiece, while the amplifier, power pack, and loudspeaker or transmitter are attached to the exterior of the mask, carried on the body, or are remotely located.

Respirators with electric or electronic speech transmission devices having an integral or body-attached battery power supply should be used with caution in explosive atmospheres. Sealed power sources should be checked for integrity of seals. Connecting cables from microphones inside the facepiece shall have gas-tight seals where they emerge from the facepiece. When the loudspeaker diaphragm is part of the barrier between the respirator wearer and the ambient atmosphere, it shall be frequently inspected for leakage and should be adequately protected from puncture or rupture. The assembly of an electronic or electrical speech transmission device into a respirator shall be avoided if it results in a center of gravity and moment of inertia such that the mask may be dislodged from the face during wearer activity in a toxic environment. Removal of speech transmission devices may allow contaminant leakage into the facepiece.

9.6 Nonconventional Respirators. Special respirator designs, such as "neck respirators" for persons having a tracheotomy, may present problems not commonly encountered with conventional respirators. Therefore, the manufacturer should be consulted for special guidance or precautions.

10. Evaluation of Respirator Program Effectiveness

10.1 General. Feedback on how a respirator program is functioning is necessary if management is to maintain effective respiratory protection. Program improvements and elimination of deficiencies cannot be effected unless the program is monitored and evaluated on a continuing basis. The following techniques are used in evaluating the effectiveness of respirator programs.

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10.2 Wearer Acceptance. The effectiveness of a respirator program can be largely determined by the degree of worker acceptance. Numerous factors affect the worker's acceptance of respirators. These include comfort, ability to breathe without objectionable effort, adequate visibility under all conditions, provisions for wearing prescription glasses if necessary, ability to communicate, ability to perform all tasks without undue interference, and confidence in the facepiece fit. Failure to consider these factors is likely to reduce cooperation of the wearers in promoting a satisfactory program. How well these problems have been overcome can be determined by observing wearers during normal activities and by soliciting their comments.

10.3 Examination of Respirators in Use. Respiratory protection is no better than the respirator in use, even though it is worn conscientiously. Frequent random inspections shall be conducted by a qualified individual to assure that respirators are properly selected, used, cleaned, and maintained.

10.4 Evaluation of Protection Afforded. When respirators are worn in toxic atmospheres, the individual should be provided appropriate periodic laboratory tests. These may include urine, blood, or fecal analyses and other techniques to determine the intake and excretion of toxic substances. The findings of these tests, when correlated with other exposure data (especially air sampling data, as described in 6.3.4) for wearers of such equipment, can serve as an indication of the effectiveness of the program. Positive evidence of exposure shall be followed up to determine any relationship to inadequate respiratory protection and need for additional engineering controls.

Nasal or facepiece interior smears, or both, usually will detect any significant penetration of radioactive contaminants into the facepiece.

11. References to Other Codes, Standards and Manuals

11.1 American National Standards Institute. When any of the following American National Standards is superseded by a revision approved by the Standards Institute, the revision shall apply.

11.1.1 American National Standard Identification of Gas Mask Canisters, K13.1-1967

11.1.2 American National Standard Method of Marking Portable Compressed Gas Containers To Identify the Material Contained, Z48.1-1954

11.1.3 American National Standard Practice for Occupational and Educational Eye and Face Protection, Z87.1-1968

11.1.4 American National Standard Safety Guide for Respiratory Protection against Radon Daughters, Z88.1-1969

11.2 Compressed Gas Association

11.2.1 Commodity Specification for Air, Specification G-7.1, 1966

11.2.2 Compressed Air for Human Respiration, Pamphlet G-7, 1968

11.3 Interstate Commerce Commission; U.S. Department of Transportation

11.3.1 Code of Federal Regulations, Title 49, Parts 71-90, Rules and Regulations for the Transportation of Explosives and Other Dangerous Articles

11.4 U.S. Department of the Interior, Bureau of Mines. See A2.1 in the Appendix to this Standard.

11.4.1 Schedule 13E, Self-Contained Breathing Apparatus, Code of Federal Regulations, Part II, Subchapter B, Chapter 1 of Title 30.

11.4.2 Schedule 14F, Gas Masks, Code of Federal Regulations, Part 13, Subchapter B, Chapter 1 of Title 30.

11.4.3 Schedule 19B and Amendments to Schedule 19B, Supplied-Air Respirators, Code of Federal Regulations, Part 12, Subchapter B, Chapter 1 of Title 30.

11.4.4 Schedule 21B, Filter-Type Dust, Fume, and Mist Respirators, Code of Federal Regulations, Part 14, Subchapter B, Chapter 1 of Title 30.

11.4.5 Schedule 23B, Nonemergency Gas Respirators (Chemical-Cartridge Respirators Including Paint-Spray Respirators), Code of Federal Regulations, Part 14a, Subchapter B, Chapter 1 of Title 30.

11.4.6 Performance of Open-Circuit Self-Contained Breathing Apparatus at −25° F. R.I. 7077, 1966.

11.4.7 Low-Temperature Performance of Compressed-Oxygen Closed-Circuit Breathing Apparatus. R.I. 7192, 1968.

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11.4.8 Information Circular 8281 (October 1, 1965 and annual supplements). Respiratory Protective Devices approved by the U.S. Bureau of Mines.

11.5 U.S. Department of Agriculture

11.5.1 Respiratory Devices for Protection Against Certain Pesticides, ARS-33-76-2. February 1966 (addendum March 1, 1966).

11.6 General Services Administration

11.6.1 Federal Specification BB-A-1034a (June 21, 1968). Air, Compressed for Breathing Purposes.

11.6.2 Interim Federal Specification GG-B-00675b (April 27, 1965). Breathing Apparatus, Self-Contained.

11.7 American Industrial Hygiene Association and American Conference of Governmental Industrial Hygienists.

11.7.1 Respiratory Protective Devices Manual, 1963.

11.8 National Fire Protection Association

11.8.1 Breathing Apparatus for the Fire Service, 1966.

11.9 American Conference of Governmental Industrial Hygienists

11.9.1 Threshold Limit Value of Air-Borne Contaminants for 1968, Recommended and Indexed Values. (1968 or latest revision.)

11.9.2 Documentation of Threshold Limit Values, 1962. (1962 or latest revision.)

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Appendix

Respirator Approval and Acceptance Listings

(This Appendix is not a part of American National Standard Practices for Respiratory Protection, Z88.2-1969, but is included for information purposes only.)

A1. Approved or Listed Respirators

The Department of the Interior, Bureau of Mines, and the Department of Agriculture publish frequently revised lists of respirators. Samples of these have been tested and found to provide satisfactory respiratory protection against specific hazards or contaminants.

A1.1 Respirators Approved by the Department of the Interior, Bureau of Mines. A list of respirators approved by the Department of the Interior, Bureau of Mines, may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

A1.2 Respirators on Lists Published by the Department of Agriculture. A list of respirators for respiratory protection against certain pesticides may be obtained from the Department of Agriculture, Pesticide Chemicals Research Branch, Beltsville, Maryland 20705.

A2. Requirements for and Tests of Respirators

Requirements and testing procedures for respirators have been established and published by the Department of the Interior, Bureau of Mines, and the Department of Agriculture.

A2.1 Department of the Interior, Bureau of Mines, Requirements and Tests. Requirements for approval of most types of respirators used have been established. These requirements are published as the Department of the Interior, Bureau of Mines, schedules. A current list of these schedules appears in Section 11, References. These schedules are frequently revised and each subsequent revision is assigned a succeeding terminal letter (for example, schedule 19B is a revision of schedule 19A).

Copies of the most recent schedules may be obtained from the Publications Distribution Section, Department of the Interior, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pennsylvania 15213.

The Department of the Interior, Bureau of Mines, approval on a respirator continues in effect even though the schedule under which the respirator was approved has been revised one or more times. If the user wishes to check the minimum performance he may expect from an approved respirator, he should consult the schedule which was in effect when the approval was granted. Certain respirators are upgraded by the manufacturer to meet the requirements of more recent schedules. In general, each schedule revision makes the requirements more severe. A complete list of schedules and their effective dates, and a list of schedules under which each respirator has been approved, will be found in the Bureau's list of approved respirators.

Responsibility for testing and approval of pesticide respirators has been transferred to the Department of the Interior, Bureau of Mines.

A2.2 Department of Agriculture Requirements and Tests. The Department of Agriculture previously established requirements and tests for respirators intended to provide respiratory protection during the application and handling of pesticides. The requirements and tests are described in a publication of tests and requirements for respirators designed to provide respiratory protection against pesticides. The publication may be obtained from the Department of Agriculture, Pesticide Chemicals Research Branch, Beltsville, Maryland 20705.

In the Department of Agriculture's tests, pesticides were dispersed as water sprays, oil sprays, or dry dusts to simulate formulations used in field applications. Chemical cartridges were tested for one hour and gas mask canisters for four hours. Insect bioassay methods were used to determine the efficiency of canisters and cartridges.

The Department of Agriculture did not evaluate facepiece fit of chemical-cartridge respirators or gas masks. It did not test respirators for protection against rodenticides, herbicides, and fungicides.

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A3. Selection of Other Than Approved or Listed Respirators

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For special purposes the user may need to select a respirator ~~which has~~ not been submitted to the Department of the Interior, Bureau of Mines, or to the Department of Agriculture for testing, or cannot be tested by these agencies because it is outside their approval or testing authority. Among these are special-purpose respirators for which user demand does not warrant submitting the devices for testing or approval.

e.g. mercury vapor respirators

The user should compare unapproved respirators with similar approved or listed devices to evaluate the facepiece and other parts to assure himself that the manufacturer, or other reliable organization, has tested the filters, cartridges, or canisters, that they are adequate for the required service, and that quality control during manufacture can be expected. He should make or have made suitable tests of the respirators' effectiveness which, as far as feasible, simulate tests made by the official testing agencies.

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definition of accepted non-approved respirator

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American National Standards

The standard in this booklet is one of nearly 6500 standards approved to date by the American National Standards Institute.

The Standards Institute provides the machinery for creating voluntary standards. It serves to eliminate duplication of standards activities and to weld conflicting standards into single, nationally accepted standards under the designation "American National Standards."

Each standard represents general agreement among maker, seller, and user groups as to the best current practice with regard to some specific problem. Thus the completed standards cut across the whole fabric of production, distribution, and consumption of goods and services. American National Standards, by reason of Institute procedures, reflect a national consensus of manufacturers, consumers, and scientific, technical, and professional organizations, and governmental agencies. The completed standards are used widely by industry and commerce and often by municipal, state, and federal governments.

The Standards Institute, under whose auspices this work is being done, is the United States clearinghouse and coordinating body for voluntary standards activity on the national level. It is a federation of trade associations, technical societies, professional groups, and consumer organizations. Some 1000 companies are affiliated with the Institute as company members.

The American National Standards Institute is the United States member of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). Through these channels U.S. standards interests make their positions felt on the international level. American National Standards are on file in the libraries of the national standards bodies of more than 60 countries.

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