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AMERICAN NATIONAL STANDARD
PRACTICES FOR RESPIRATORY PROTECTION

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PRACTICES FOR RESPIRATORY PROTECTION

A

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 for establishing and regulating respirator programs. This standard is a revision of ANSI Z88.2-1969.

1.1 Scope

The scope of this standard covers the use of respirators for protecting persons against the inhalation of harmful air contaminants and from oxygen deficient atmospheres in the workplace. Excluded are: 1) underwater breathing devices, 2) aircraft oxygen systems, 3) military masks, and 4) medical inhalators and resuscitators.

1.2 Purpose

The purpose of this standard is to provide information and guidance on the proper selection and use of respirators that will help safeguard the health and life of the industrial worker. This standard is written for all persons concerned with respiratory protection but especially for those primarily responsible for establishing and administering an acceptable respirator program. The standard contains recommended requirements for use by enforcement authorities in establishing regulations or codes on respiratory protection.

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 this standard may be granted by an appropriate regulatory agency, provided that equally acceptable requirements are established.

2. Definitions

abrasive-blasting respirator. See respirator. A respirator designed to protect the wearer against inhalation and against impact and abrasion from rebounding abrasive material.

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

aerosol. A system consisting of particles, solid or liquid, suspended in air.

air-purifying respirator. See respirator.

air-regulating valve. An adjustable valve used to regulate airflow to the facepiece, helmet, hood or suit 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 respirators.

approved. Tested and listed as satisfactory by the Bureau of Mines (BM) of the U.S. Department of Interior, or jointly by the Mining Enforcement and Safety Administration (MESA) of the U.S. Department of Interior and the National Institute for Occupational Safety and Health (NIOSH) of the U.S. Department of Health, Education and Welfare.

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

canister (air-purifying). A container with a filter, and/or sorbent, and/or catalyst that purifies air drawn through it.

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

carcinogen. A substance known to cause cancer.

cartridge (air-purifying). A small canister.

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

ceiling concentration. The concentration of an airborne substance that should not be exceeded.

chemical-cartridge respirator. See respirator.

confined space. An enclosure, usually having limited means of egress, such as a storage tank, process tank, tank car, boiler, duct, sewer, tunnel, pipeline, pit and tube.

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.

demand. See demand type self-contained breathing apparatus and demand type airline respirator in Tables 3 and 4.

detachable coupling. A device by means of which the respirator wearer, without using hand tools, may detach the air-supply line from that part of the respirator worn on the person or from the air-supply source.

dust. See Table 2.

emergency respirator use. Wearing a respirator when a hazardous atmosphere suddenly occurs which requires immediate use of a respirator for escape from the hazardous atmosphere or for entry into the hazardous atmosphere to carry out maintenance or some other task.

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

face shield. A device worn in front of the eyes and a portion of, or all of, the face, whose predominant function is protection of the eyes and the face.

fibrosis-producing dust. Dust, which when inhaled, deposited, and retained in the lungs, may produce findings of fibrosis growth in the lungs which causes pulmonary disease.

filter respirator. See respirator.

filter. A fibrous media component used in respirators to remove solid or liquid particles from the inspired air.

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.

goggle. A device, with contour-shaped eyecups or facial contact with glass or plastic lenses, worn over the eyes and held in place by a headband or other suitable means for the protection of the eyes and eye sockets.

half-mask facepiece. See facepiece

hazardous atmosphere. Any atmosphere, either immediately or not immediately dangerous to life or health, which is oxygen deficient or which contains a toxic or disease producing contaminant.

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

helmet. That portion of a respirator which shields the eyes, face, neck, and other parts of the head.

high efficiency filter. A filter which has an efficiency equal to or exceeding 99.97 percent for removal of dust, fume, and mist particles having a particle size of 0.3 micrometer from air.

hood. That portion of a respirator which completely covers the head, neck and portions of the shoulders.

hose mask. See respirator.

immediately dangerous to life or health (IDLH). Any atmosphere that poses an immediate hazard to life or produces irreversible debilitating effects on health.

irrespirable. Unfit for breathing.

mist. See Table 2.

mouthpiece. That portion of a respirator which is held in the wearer's mouth and is connected to an air-purifying device or respirable gas source or both. It is designed to make a gas-tight or particle-tight fit with the mouth.

MPC_a. Maximum permissible airborne 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.

maximum use limit of filter, cartridge, or canister. It is the maximum concentration of a test agent in a test atmosphere used in approval testing of an air-purifying respirator equipped with the filter, cartridge, or canister.

non-routine respirator use. Wearing a respirator when carrying out a special task that occurs infrequently.

nose clamp. A device used with a respirator equipped with a mouthpiece that closes the nostrils of the wearer.

not immediately dangerous to life or health. Any hazardous atmosphere which may produce physical discomfort immediately, chronic poisoning after repeated exposure, or acute adverse physiological symptoms after prolonged exposure.

odor threshold limit. The lowest concentration of a contaminant in air that can be detected by the olfactory sense.

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.

powered air-purifying respirator. See respirator.

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

pressure-demand. See pressure-demand type self-contained breathing apparatus and pressure-demand type airline respirator in Tables 3 and 4.

protection factor. The ratio of the ambient concentration of an airborne substance to the concentration of the substance inside the respirator at the breathing zone of the wearer. The protection factor is a measure of the degree of protection provided by a respirator to the wearer.

rescue respirator use. Wearing a respirator for entry into a hazardous atmosphere to rescue a person(s) in the hazardous atmosphere.

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 and Tables 3 and 4.

respiratory-inlet covering. That portion of a respirator which connects the wearer's respiratory tract to an air-purifying device or respirable gas source or both. It may be a facepiece, helmet, hood, suit or mouthpiece/nose clamp.

routine respirator use. Wearing a respirator as a normal procedure when carrying out a regular and frequently repeated task.

sanitization. The removal of dirt and the inhibiting of the action of agents that cause infection or disease.

self-contained breathing apparatus. See respirator.

service life. The period of time that a respirator provides adequate protection to the wearer, such as the period of time that an air-purifying device is effective for removing a harmful substance from inspired air.

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

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.

time weighted average (TWA). The average concentration of a contaminant in air during an 8-hour workday.

valve (air or oxygen). A device which controls the pressure, direction, or rate of flow of air or oxygen.

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

welding helmet. A device designed to provide protection for the eyes, face, ears and neck against intense radiant energy and molten metal splatter encountered in arc or gas welding and cutting of metals.

window indicator. A device on a cartridge or canister which visually denotes the service life of the cartridge or canister.

Program Requirements

1 Purpose. This section establishes requirements for the use of respirators. The following requirements are supplemented by recommended practices in subsequent sections of this standard.

2 Permissible Practice. In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fumes, sprays, mists, fogs, smokes, vapors, or gases, 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 or evaluated appropriate respirators shall be used pursuant to the following requirements.

3 Employer Responsibility

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

3.2 The employer shall provide the respirators which are applicable and suitable to the purpose intended.

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

4 Employee Responsibility

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

4.2 The employee shall guard against damage to the respirator.

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

3.5 Minimal Acceptable Respirator Program

3.5.1 Standard Operating Procedures. Written standard operating procedures covering a complete respirator program shall be established and implemented to include Sections 3.5.2 through 3.5.15.

3.5.2 Program Administration. The plant or company industrial hygiene, health physics, or safety engineering department shall administer the respirator program in close liason with the medical department. Responsibility and authority for the respirator program shall be assigned to a single person. In small plants or companies having no formal industrial hygiene, health physics, or safety engineering department, the respirator program shall be administered by an upper-level superintendent, foreman, or other qualified person responsible to the principal manager. The administrator shall have sufficient knowledge of respiratory protection to properly supervise the respirator program.

3.5.3 Physical and Psychological Limitations for Respirator Wearers. A physician shall determine what physical and psychological conditions are pertinent for the wearing of different types of respirators. The respirator program administrator or his designee, using guidelines established by a physician, shall determine whether or not a person must be assigned to a task requiring the use of a respirator. This determination shall be reviewed at least annually. (See Appendix A4.)

3.5.4 Approved Respirators. Approved respirators shall be used. For exceptions, see Section 1.4. Modification of an approved respirator unauthorized by the approval agencies voids the approval.

3.5.5 Respirator Selection. The selection of the proper type of respirator shall be based upon (a) the nature of the hazardous operation or process, (b) the type of respiratory hazard (including physical properties, chemical properties, warning properties,

psychological effects on the body, concentration of toxic material or airborne radioactivity level, established permissible time weighted average concentration for toxic material or established maximum permissible airborne concentration for radioactive material, and established immediately dangerous to life or health concentration for toxic material), (c) the location of the hazardous area in relation to the nearest area having respirable air, (d) the period of time for which respiratory protection must be provided, (e) the activities of workers in the hazardous area, and (f) the function and physical characteristics of the various types of respirators. (See Sect. 6)

3.5.6 Training. Each respirator wearer shall be given training which shall include

(a) an explanation of the respiratory hazard and what happens if the respirator is not used properly, (b) a discussion of what engineering and administrative controls are being used and why respirators still are needed for protection, (c) an explanation of why a particular type of respirator has been selected, (d) a discussion of the function, capabilities, and limitations of the selected respiratory, (e) instruction in how to don the respirator and to check its fit and operation, (f) instruction in the proper wearing of the respirator, (g) instruction in respirator maintenance, and (h) instruction in recognizing and handling emergency situations.

(See Section 7.2.3.)

3.5.7 Respirator Fit. Each respirator wearer shall be provided with a respirator that fits him as determined by Section 6.10. Each respirator wearer shall be required to check the seal of the respirator by appropriate means prior to entering a harmful atmosphere. (See Section 7.5.)

3.5.8 Facial Hair, Contact Lenses, Spectacles, and Goggles.

A respirator equipped with a facepiece shall not be worn if facial hair comes between the sealing periphery of the facepiece and the face or if facial hair interferes with valve function. The wearer of a respirator equipped with a full facepiece,

helmet hood, or suit shall not be allowed to wear contact lenses. If spectacle or goggles or faceshield must be worn with a facepiece, they shall be worn so as not to adversely affect the seal of the facepiece to the face. (See Sections 7.4 and 9.1)

3.5.9 Issue of Respirators. The proper type of respirator for each respiratory hazard shall be listed in written standard operating procedures. Only persons trained to insure that proper respirators are issued shall be permitted to issue respirators to persons needing them. (See Sections 7.2.2 and 7.6.)

3.5.10 Respirator Inspection. The respirator shall be inspected by the wearer prior to its use to insure that it is in proper working condition. Each respirator stored for emergency or rescue use shall be inspected at least monthly. (See Sections 7.7 and 8.3)

3.5.11 Monitoring Respirator Use. Supervisory personnel shall periodically monitor the use of respirators to insure that they are worn properly. (See Section 7.8.)

3.5.12 Monitoring Respiratory Hazard. The concentration or the airborne radioactivity level of the respiratory hazard in the work area shall be monitored as necessary to insure proper respiratory protection. (See Section 7.9)

3.5.13 Medical and Bioassay Surveillance. Medical, including bioassay surveillance, when applicable of respirator wearers shall be carried out periodically to determine if respirator wearers are receiving adequate respiratory protection. A physician shall determine the requirements of the surveillance program. (See Section 10.4)

3.5.14 Respirator Maintenance. Respirator maintenance shall be performed regularly. Maintenance shall be carried out on a schedule which insures that each respirator wearer is provided with a respirator that is clean and in good operating condition. Maintenance shall include (a) washing, sanitizing, rinsing, and drying, (b) inspection for defects, (c) replacement of worn or deteriorated parts, (d) repair if necessary, and (e) storage to protect against dust, sunlight, excessive heat, extreme cold, excessive moisture, damaging chemicals, and physical damage. (See Section 8).

3.5.15 Respirator Program Evaluation. An appraisal of the effectiveness of the

respirator program shall be carried out at least annually. Action shall be taken to correct defects found in the program. (See Section 10.)

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 (aerosols including 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 Section 9.6) Further information on the hazards of and use of respirators in high temperatures is presented in a National Fire Protection Association publication, Fire Officers Guide to Breathing Apparatus for the Fire Service, published in 1975.

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.

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. This information is presented in two tables. Table 3 covers the classification and description of respirators according to the general classifications concerning mode of operation. Table 4 covers capabilities and limitations of respirators arranged to correspond to the subject headings in Table 3. . . .
Respirators fall into the following general classifications, according to mode of operation:

- (1) atmosphere-supplying respirators
 - (a) self-contained
 - (b) supplied-air
 - (c) combination self-contained and supplied-air
- (2) air purifying respirators
 - (a) gas and vapor
 - (b) particulate (aerosols including dust, fog, fume, mist, smoke, and sprays)
 - (c) combination gas, vapor, and particulate
- (3) combination atmosphere-supplying and air-purifying respirators

More detailed information on specific types of respirators can be obtained from

TABLE I

CLASSIFICATION OF RESPIRATORY HAZARDS ACCORDING TO THEIR BIOLOGICAL EFFECT

Oxygen Deficiency (19.5 percent: Minimum legal requirement for respirable air at sea level conditions.)		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)		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).	Relatively inert: May cause discomfort and minor irritation, but generally without injury at reasonable concentrations (for example: marble, gypsum).
Atmospheric O_2 content (percent by volume) versus expected conditions:			Pulmonary fibrosis-producing: Produce nodulation and fibrosis in the lung, possibly leading to complications (for example, quartz, asbestos).
20.9 percent: Oxygen content of normal air at sea level conditions.			Carcinogens: Produce cancer in some individuals after "latent" period (for example: asbestos, chromates, radioactive particulates).
Oxygen Vol. % at Sea Level	Physiological Effects	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).	Chemical irritants: Produce irritation, inflammation and ulceration in upper respiratory tract (for example: acidic mists, alkalies).
16-12	Loss of peripheral vision, increased breathing volume, accelerated heart-beat, impaired attention and thinking, impaired coordination.	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: Produce pathologic reactions in various systems of the body (for example: lead, manganese, cadmium).
14-10	Very faulty judgement, very poor muscular coordination, muscular exertion causes fatigue that may cause permanent heart damage, intermittent respiration.	Sensitizers: Cause increased probability of physiological reactions (for example: isocyanates, epoxy resins).	Allergy-producing: Produce reactions such as: itching, sneezing and asthma (for example: pollens, spices and animal fur).
10-6	Nausea, vomiting, inability to perform vigorous movement, unconsciousness followed by death.	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)).	Febrile reaction-producing: Produce chills followed by fever (for example, fumes of zinc and copper).
less than 6	Spasmodic breathing, convulsive movements, death in minutes.		

TABLE 1 (continued)

Gas and Vapor Contaminants

Carcinogens: Produce cancer in some persons after a latent period (for example: vinyl chloride, benzene).

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.

(CLASSIFICATION OF RESPIRATORY HAZARDS ACCORDING TO THEIR PROPERTIES
WHICH INFLUENCE RESPIRATOR SELECTION

A

Gas and Vapor Contaminants	Particulate Contaminants
Inert: They do not react with other substances under most conditions, but 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 and a PH of less than 7. 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.
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-) and a PH greater than 7. They taste bitter, and many are corrosive to tissues, (for example, ammonia, amines, phosphine, arsine, and stibine).	Spray: A liquid mechanically produced particle with sizes generally in the visible or macroscopic range.
Organic: These are the compounds of carbon. Examples are saturated hydrocarbons (methane, ethane, butane), unsaturated hydrocarbons (ethylene, acetylene), alcohols (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, and xylene).	Fume: A solid condensation particle of extremely small particle size, generally less than one micron in diameter.
Organometallic: Compounds in which metals are chemically bonded to organic groups (for example, ethyl silicate, tetraethyl lead, and organic phosphates).	Mist: A liquid condensation particle with sizes ranging from submicroscopic to visible or macroscopic.
Hydrides: Compounds in which hydrogen is chemically bonded to metals and certain other elements, for example, diborane and lithium hydride.	Fog: A mist of sufficient concentration to perceptibly obscure vision.
	Smoke: A system which includes the products of combustion, pyrolysis, or chemical reaction, of substances in the form of visible and invisible solid and liquid particles and gaseous products in air. Smoke is usually of sufficient concentration to perceptibly obscure vision.

TABLE 3

CLASSIFICATION AND DESCRIPTION OF RESPIRATORS BY MODE OF OPERATION

Atmosphere-Supplying Respirators		Air-Purifying 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 may be equipped with a quarter-mask facepiece, half-mask facepiece, helmet, hood, or mouthpiece and nose clamp. (1) Closed-Circuit SCBA (oxygen only) (a) Compressed or liquid oxygen type equipped with a facepiece or mouthpiece and nose clamp. 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		Ambient air, prior to being inhaled is passed through a filter, cartridge, or canister which removes particles, vapors, gases, or combinations of these contaminants. Breathing action of wearer operates non-powered type. Powered type contains a blower, stationary, or carried by wearer, which pulls ambient air through an air-purifying component and then supplies purified air to the respiratory-inlet covering. Non-powered type is equipped with a facepiece or mouthpiece and nose clamp. Powered type is equipped with a facepiece, helmet, hood, or suit.	
Supplied-Air Respirators (1) Equipped with a respiratory-inlet covering (facepiece, helmet, hood, or suit), nonkinking breathing tube, rugged safety harness and a large diameter heavy-duty non-kinking air supply hose. The breathing tube and hose are securely attached to the harness. A facepiece is equipped 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.		Vapor- and Gas-Removing Respirator Equipped with cartridge(s) or canister(s) to remove a single vapor or gas (for example, chlorine gas), a single class of vapors or gases (for example, organic vapors), or a combination of two or more classes of vapors or gases (for example, organic vapors and acid gases) from air.	Particulate-Removing Respirator Equipped with filter(s) to remove a single type of particulate matter (for example dust) or a combination of two or more types of particulate matter (for example, dust and fume) from air. Filter may be a replaceable part or a permanent part of the respirator. Filter may be single-use type or reusable type.
		Combination Particulate-, Vapor-, and Gas Removing Respirator Equipped with cartridge(s) or canister(s) to remove particulate matter, vapors, and gases from air. The filter may be a permanent part or a replaceable part of a cartridge or canister.	

TABLE 3 (cont.)

Atmosphere-Supplying Respirators

Air-purifying Respirators

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. Equipped with a facepiece or mouthpiece and nose clamp. 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. 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, liquid oxygen). A bypass system is provided in

(2) Air-Line Respirator. Respirable air is supplied through a small-diameter hose from a compressor or compressed air cylinders. The hose is attached to the wearer by a 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, helmet, hood, suit). Up to 300 feet of air-line is permissible.

(a) Continuous-flow class. Equipped with a facepiece, hood, helmet, or suit. At least four cubic feet of air per minute to tight-fitting facepieces and six cubic feet per minute to loose-fitting helmets, hoods, and suits are required. Air is supplied to a suit through a system of internal tubes to the head, trunk, and extremities through valves located in appropriate parts of the suit.

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

(c) Pressure-demand type. Equipped with a full facepiece only. A positive pressure is maintained in the facepiece.

TABLE 3 (cont.)

case of regulator failure except on escape-type units.

(a) Demand type. *Equipped with a facepiece or mouthpiece and nose clamp. The demand valve permits oxygen or air flow only during inhalation. Exhaled breath passes to ambient atmosphere through a valve(s) in the facepiece.

(b) Pressure-demand type. ** Equipped with facepiece only. Positive pressure is maintained in the facepiece. The wearer may have the option of selecting the demand or pressure-demand mode of operation.

Combination Airline Respirator with Auxiliary Self-Contained Air Supply

Includes an airline respirator with an auxiliary self-contained air supply. To escape from a hazardous atmosphere in the event the primary air supply fails to operate, the wearer switches to the auxiliary self-contained air supply. Devices approved for both entry into and escape from dangerous atmospheres have a low pressure warning alarm and contain at least a 15-minute self-contained air supply.

Combination Atmosphere-Supplying and Air-Purifying Respirators

An atmosphere-supplying respirator with an auxiliary air-purifying attachment to provide protection in the event the air supply fails. An air-purifying respirator with an auxiliary self-contained air supply which is used in case the atmosphere unexpectedly exceeds safe conditions for use of an air-

*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 positive pressure is maintained in the facepiece by a spring-loaded or balanced regulator and exhalation valve.

Table 4

Capabilities and Limitations of Respirators

Atmosphere-Supplying Respirators		Air-Purifying Respirators	
(See 5.3 for specifications on respirable atmospheres.)		General Limitations: Air-purifying respirators do not protect against oxygen-deficient atmospheres nor against skin irritations by, or sorption through the skin of airborne contaminants. See 6.3.5.1.	
Atmosphere-supplying respirators provide protection against oxygen deficiency and toxic atmospheres. The breathing atmosphere is independent of ambient atmospheric conditions.		The maximum contaminant concentration against which an air purifying respirator will protect is determined by the design efficiency and capacity of the cartridge, canister, or filter and the facepiece to face seal on the user. For gases and vapors, the maximum concentration for which the air purifying unit is designed is specified by the manufacturer, or on approved cartridges or canisters, by the maximum use concentration specified in the approval.	
General Limitations: Except for some airline suits, 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 6.3.4.1. Facepieces present special problems to individuals required to wear prescription lenses (See 9.1 and 9.2).		Non-powered air purifying respirators will not provide the maximum design protection specified unless the facepiece or mouthpiece/nose clamp, 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, of filter type, concentration of contaminant, humidity levels in the ambient atmosphere, and the wearer's respiratory rate.	
Use of atmosphere-supplying respirators in atmospheres immediately dangerous to life or health is limited to specific devices under specified conditions (See 6.1.2.3.1).		The proper type of canister, cartridge, or filter must be selected for the particular atmosphere and conditions. Non-powered, air-purifying respirators may cause discomfort due to a noticeable resistance to inhalation. This problem is minimized in powered 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.	
Self-Contained Breathing Apparatus (SCBA)	Supplied Air Respirator	Use of air-purifying respirators in atmospheres immediately dangerous to life or health is limited to specific devices under specified conditions. (See 6.1.2.3.1).	
The wearer carries his own breathing atmosphere.	The respirable air supply is not limited to the quantity the individual can carry, and the devices are light weight and simple.	Vapor and Gas Removing Respirators	Particulate-Removing Respirators
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. Some SCBA devices have a short service life (less than 15 min.) 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.	Limitations: Limited to use in atmospheres from which the wearer can escape unharmed without aid of the respirator.	Limitations: No protection is provided against particulate contaminants. A rise in canister or cartridge temperature indicates that a gas or vapor is being removed from the inspired air.	Limitations: Protect against non-volatile particles only. No protection against gases and vapors.
	The wearer is restricted in movement by the hose and must return to a respirable atmosphere by retracing his route of entry. The hose is subject to being severed or pinched off. (1) Hose Mask The hose inlet or blower must be located and secured in a respirable atmosphere.		

(1) Closed- Circuit SCBA

The closed circuit operates conserves oxygen and permits longer service life at reduced weight. A negative pressure in the respiratory inlet covering is created during inhalation in most closed circuit devices and may permit inward leakage of contaminants.

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

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

(a) Hose mask with blower. If the blower fails, the unit still provides protection, although a negative pressure exists in the facepiece during inhalation.

(b) Hose mask without blower. Maximum hose length may restrict application of device.
(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 a positive pressure in the respiratory inlet covering and are less apt to permit inward leakage of contaminants.

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

Limitations: Air-line respirators provide no protection if the air supply fails. Some contaminants, such as tritium, may penetrate the material of an airline suit and limit its effectiveness.

Other contaminants, such as fluorine, may react chemically with the material of an airline suit and damage it. See 6.3.5.1.

An uncomfortably high temperature indicates a high concentration of gas or vapor and requires an immediate return to fresh air.

Should avoid use in atmospheres where the contaminant(s) lacks sufficient warning properties (that is, odor or irritation).

(1) Full Facepiece Respirator

Provides protection against eye irritation in addition to respiratory protection.

(2) Half and Quarter Mask Respirator

Not approved for use in atmospheres immediately dangerous to life or health. A fabric covering (facelet) available from some manufacturers shall not be used.

(3) Mouthpiece Respirator

Shall be used only for escape applications. Mouth breathing prevents detection of contaminant by odor. Nose clamp must be securely in place to prevent nasal breathing.

A small, lightweight device that can be donned quickly.

(1) Full Facepiece Respirator
Provides protection against eye irritation in addition to respiratory protection.

(2) Half and Quarter Mask Respirator

Not approved for use in atmospheres immediately dangerous to life or health. A fabric covering (facelet) available from some manufacturers shall not be used.

(3) Mouthpiece Respirator (Filter)
Shall be used only for escape applications. Mouth breathing prevents detection of contaminant by odor. Nose clamp must be securely in place to prevent nasal breathing.

A small, lightweight device that can be donned quickly.

respirator manufacturers and from the following manuals: Respiratory Protective Devices Manual published by the American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists in 1963 (out of print); A Guide to Industrial Respiratory Protection published by the Los Alamos Scientific Laboratory in 1977; Energy Research and Development Administration, Division of Safety, Standards, and Compliance Respirator Manual published by the Los Alamos Scientific Laboratory in 1976; Manual of Respiratory Protection Against Airborne Radioactive Materials published by the U. S. Nuclear Regulatory Commission in 1976.

The colors assigned to cartridges and canisters of air-purifying respirators are listed in the American National Standard for Identification of Cartridges and Canisters used in Air-Purifying Respirators, K13.1-1973.

5.2 Respirable Air and Oxygen for Self-Contained Breathing Apparatus and Air-Supplied Respirators. Compressed air, compressed oxygen, liquid air, and liquid oxygen used for respiration shall be of high purity. Oxygen shall meet the requirements of the United States Pharmacopoeia for medical or breathing oxygen. Gaseous air shall meet at least the requirements of the specification for Type I, Grade D breathing air and liquid air shall meet at least the requirements for Type II, Grade B breathing air as described in American National Standard Commodity Specification for Air, Z86.1-1976.

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

Breathing air may be supplied to respirators from cylinders or air compressors.

Cylinders shall be tested and maintained in accordance with applicable Department

Table 4 (cont.)

Combination Airline Respirator With Auxiliary SC Air Supply

The auxiliary self-contained air supply on this type device allows the wearer to escape from a dangerous atmosphere. This device with auxiliary self-contained air supply is approved for escapes and some devices are approved for both entry into and escape from dangerous atmospheres.

Combination Particulate and Vapor and Gas Removing Respirators

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

of Transportation specifications for shipping containers (Title 49, Code of Federal Regulations, Part 173 General Requirements for Shipments and Packagings and Part 178 Shipping Container Specifications). 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.

Breathing air couplings shall be incompatible with outlets for plant air or 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 (R1971); Federal Specification BB-A-1034a, June 21, 1968, Air, Compressed for Breathing Purposes; or Interim Federal Specification GG-B-00675c, October 7, 1974, 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, Compressed Air for Human Respiration.

6. Selection of Respirators

6.1 Approved Respirators. Approved respirators shall be selected. For exceptions, see Section 1.4. See Appendix A.3.

6.2 General Considerations. The selection of a proper respirator for any given situation shall require consideration of the following factors:

- (1) Nature of the hazard (See Sections 6.3 and 6.4)
- (2) Characteristics of the hazardous operation or process (See Section 6.5)
- (3) Location of the hazardous area with respect to a safe area having respirable air (See Section 6.6)

- (4) period of time for which respiratory protection must be provided (See Section 6.7)
- (5) activity of workers in the hazardous area (See Section 6.8)
- (6) physical characteristics and functional capabilities and limitations of respirators of various types (See Section 6.9)
- (7) respirator protection factors, (See Sections 6.10, 6.11, and 6.12)

6.3 Nature of Hazard. The following factors concerning the nature of the hazard shall be considered in respirator selection:

- (1) type
 - (a) oxygen deficiency
 - (b) contaminant
- (2) physical properties
- (3) chemical properties
- (4) physiological effects on the body
- (5) actual concentration or airborne radioactivity level
 - (a) average
 - (b) peak
- (6) established permissible time weighted average and or peak concentration or established maximum permissible airborne radioactivity level
- (7) immediately dangerous to life or health concentration
- (8) warning properties

See Section 4 for classification and discussion of respiratory hazards.

6.4 Monitoring of Respiratory Hazard. Recognition and evaluation of the respiratory hazard (oxygen deficiency or contaminant(s)) shall be an essential part of respirator selection. Monitoring of the respiratory hazard by air

sampling shall be carried out to obtain data needed for selection of proper respiratory protection. Air sampling data should include:

- (1) identification of the type of respiratory hazard
 - (a) oxygen deficiency
 - (b) specific contaminant(s)
- (2) nature of contaminant(s)
 - (a) particulate matter
 - (b) vapor(s) or gas(es)
- (3) concentration of respiratory hazard

6.5 Characteristics of Hazardous Operation or Process. The following factors concerning the hazardous operation or process shall be taken into account in selecting the proper respirator:

- (1) operation or process characteristics
- (2) work area characteristics
- (3) materials including raw materials, end products, and by-products
(actual and potential)
- (4) worker activities

Changes in the operation or process shall be taken into account.

6.6 Location of Hazardous Area. The location of the hazardous area with respect to a safe area having respirable air shall be considered in respirator selection since this will permit planning for escape of workers if an emergency occurs, for entry of workers to perform maintenance duties under emergency conditions, and for rescue conditions.

6.7 Respirator Use Time Period. The period of time that a respirator must be worn is an important factor that shall be taken into account in respirator selection.

Also, consideration shall be given in respirator selection to the type of respirator application such as routine, non-routine, or emergency. It would not be desirable to select respirators that are heavy or that offer high resistance to breathing for routine respirator application which require the wearing of respirators for many hours each day.

6.8 Worker Activity. A thorough knowledge of worker activities shall be obtained and considered in selecting the proper respirator. The characteristics of the job and the location of the worker in the hazardous area shall be considered. It shall be known if the worker is in the hazardous area continuously or intermittently during the work shift. It shall be known if the work rate is light, medium, or heavy.

6.9 Respirator Characteristics, Capabilities, and Limitations. The physical characteristics, the functional capabilities, and the performance limitations of the various types of respirators shall be considered in respirator selection (see Section 5 for classification and discussion of respirators).

6.9.1 Respirators for Oxygen-Deficient Atmosphere. Only respirators that provide an independent, respirable atmosphere shall be used in an oxygen-deficient atmosphere. Respirators which are approved for this purpose include a self-contained breathing apparatus and a combination airline respirator with auxiliary self-contained air supply. See Table 5.

6.9.2 Respirators for Atmospheres Immediately Dangerous to Life or Health. Respirators for use in atmospheres that contain adequate oxygen but are immediately dangerous to life or health because of the presence of toxic contaminants are listed in Table 5.

6.9.3 Respirators for Atmospheres Not Immediately Dangerous to Life or Health.

The respirators for use in contaminated atmospheres that contain adequate oxygen but are not immediately dangerous to life or health are listed in Table 5.

6.10 Respirator Protection Factor (PF). Respirators shall be selected according to the characteristics of the hazards, the capabilities and limitations of the respirators, and the ability of each respirator wearer to obtain a satisfactory fit with a respirator. Taking into account the capabilities and limitations of respirators and the results of respirator fitting tests, a table of Respirator Protection Factors has been prepared (See Table 5.)

A respirator protection factor is a measure of the degree of protection provided by a respirator to a wearer. Multiplying the permissible time weighted average concentration or the permissible ceiling concentration, whichever is applicable, for a toxic substance, or the maximum permissible airborne concentration for a radionuclide by a protection factor assigned to a respirator gives the maximum concentration of the hazardous substance for which the respirator can be used.

When applicable, a qualitative or quantitative respirator fitting test shall be used to determine the ability of each individual respirator wearer to obtain a satisfactory fit with a respirator. The results of qualitative or quantitative respirator fitting tests shall be used to select specific types, makes, and models of respirators for use by individual respirator wearers.

A. Qualitative Respirator Fitting Tests

A person wearing a respirator is exposed to an irritant smoke, an odorous vapor, or other suitable test agent. An air-purifying respirator must be equipped with an air-purifying element(s) which effectively removes the test agent from inspired air. If the respirator wearer is unable to detect penetration of the test agent into the respirator, the respirator wearer has

achieved a satisfactory fit with the respirator. (See Appendix A5.)

B. Quantitative Respirator Fitting Test

A person wears a respirator in a test atmosphere containing a test agent in the form of an aerosol, vapor, or gas. Instrumentation, which samples the test atmosphere and the air inside the respiratory-inlet covering of the respirator, is used to measure quantitatively the penetration of the test agent into the respiratory-inlet covering.

(See Appendix A6.)

When carrying out respirator fitting tests, it shall be acceptable procedure to make the following modifications to respirators provided that such modifications do not affect the seal of the respirators to wearers.

- (1) When carrying out a qualitative or quantitative respirator fitting test which uses an aerosol as the test agent, it shall be acceptable procedure to equip an air-purifying respirator with a high efficiency filter.
- (2) When carrying out a qualitative or quantitative respirator fitting test which uses a vapor or gas as the test agent, it shall be acceptable procedure to equip an air-purifying respirator with an appropriate cartridge or canister which removes the vapor or gas from air.
- (3) When carrying out a quantitative respirator fitting test, it shall be acceptable procedure to attach a sampling probe to the respirator which is connected by Flexible tubing to an instrument which measures the penetration of the test agent into the respirator.

When carrying out quantitative respirator fitting tests, it shall be an acceptable procedure to carry out a single test for each available make and model respirator to select a make and model respirator for use by a person. However, three

additional quantitative respirator fitting tests involving the wearing of the selected make and model respirator by the person shall be carried out to determine a protection factor for the make and model respirator worn by the person. The lowest penetration factor determined by these three tests shall be assigned to the wearing of the make and model respirator by the person.

If a qualitative respirator fitting test has been used in respirator selection, a person shall be allowed to use only the specific make(s), and model(s), of respirator(s) for which the person obtained a satisfactory fit and the respirator protection factor listed for the particular type of respirator in Table 5 shall apply. Under no circumstances shall a person be allowed to use a specific make, and model of respirator if the results of the qualitative respirator fitting test indicates that the person is unable to obtain a satisfactory fit.

If a quantitative respirator fitting test has been used in respirator selection, test results shall be used to assign a respirator protection factor to a person for each specific make, and model of respirator used in testing. The respirator protection factor applied when a person wears a specific make, and model of respirator in a hazardous atmosphere shall not exceed the respirator protection factor listed for the particular type of respirator in Table 5.

6.10.1 Respirator Fitting Test Records

Records of respirator fitting tests shall be kept. These records shall include the following information.

- (1) type of respirator fitting test used
- (2) specific make and model of respirator tested
- (3) name of person tested
- (4) results of respirator fitting test
 - (a) success or failure of person to obtain satisfactory fit if a qualitative respirator fitting test was carried out
 - (b) respirator protection factor based upon test results if a quantitative

TABLE 5

Respirator Protection Factors^a

Type of Respirator	Permitted for use in O ₂ Deficient Atmosphere	Permitted for Use in Immediately Dangerous to Life or Health Atmosphere	Respirator Protection Factor	
			Qualitative Test	Quantitative Test
Particulate-filter, quarter-mask or half-mask facepiece	No	No	10	As measured on each person with maximum of 100 if dust fume, or mist filter is use maximum of 3,000 if high ef- ficiency filter is used, whichever is less.
Vapor- or gas-removing, quarter-mask or half- mask facepiece	No	No	10, or maximum use limit of cartridge or canister for vapor or gas, whichever is less	As measured on each person with maximum of 3000, maximum use limit of car- tridge or canister for vapor or gas, whichever is less
Combination particulate- filter and vapor- or gas-removing, quarter- mask or half-mask facepiece	No	No	10, or maximum use limit of cartridge or canister for vapor or gas, whichever is less	As measured on each person with maximum of 100 if dust fumes or mist filter is use maximum of 3,000 if high ef- ficiency filter is used or maximum use limit of cart- ridge or canister for vapor or gas, whichever is less.

TABLE 5

Respirator Protection Factors^a

(Continued)

Type of Respirator	Permitted for Use in O ₂ Deficient Atmosphere	Permitted for Use in Immediately Dangerous to Life or Health Atmosphere	Respirator Protection Factor	
			Qualitative Test	Quantitative Test
Powered particulate- filter, any respira- tory-inlet cover- ing b, c, or d	No	No (Yes, if escape provisions are provided ^d .)	N/A 100, if dust, fume, or mist filter is used, 3,000 if high efficiency filter is used, whichever is less	N/A
Powered vapor- or gas-removing; any respiratory-inlet covering b,c, or d	No	No (Yes, if escape provisions are provided ^d .)	N/A 3,000, or maximum use limit of cartridge or canister for vapor or gas, whichever is less	N/A
Powered combination particulate-filter and vapor- or gas- removing, any res- piratory-inlet covering b,c or d	No	No (Yes, if escape provisions are provided ^d .)	N/A 100 if dust, fume, or mist filter is used, 3,000, if high efficiency filter is used, or maximum use limit of cartridge or can- ister for vapor or gas, whichever is less	N/A

Respirator Protection Factors^a

(continued)

Type of Respirator	Permitted for Use in O ₂ Deficient Atmosphere	Permitted for Use in Immediately Dangerous to Life or Health Atmosphere	Respirator Protection Factor	
			Qualitative Test	Quantitative Test
Particulate-filter, full facepiece	No		100	As measured on each person with maximum of 100 if dust, fume, or mist filter is used, maximum of 3,000 if high efficiency filter is used, whichever is less
Vapor-or gas-removing, full facepiece	No	Yes, if concentration of hazardous substance does not exceed product of respirator PF and permissible concentration, and/or maximum use limit of cartridge or canister for vapor or gas	100, or maximum use limit of cartridge or canister for vapor or gas, whichever is less	As measured on each person with a maximum of 3,000 or maximum use limit of cartridge or canister, whichever is less
Combination particulate-filter and vapor- or gas-removing, full facepiece	No		100, or maximum use limit of cartridge or canister for vapor or gas, whichever is less	As measured on each person with maximum of 100 if dust, mist or fume filter is used, maximum of 3,000 if high efficiency filter is used, or maximum use limit of cartridge or canister for vapor or gas, whichever is less

Table 5

Respirator Protection Factor^a

(continued)

Type of Respirator	Permitted for Use in O ₂ Deficient Atmosphere	Permitted for Use in Immediately Dangerous to Life or Health Atmosphere	Respirator Protection Factor	
			Qualitative Test	Quantitative Test
Airline, demand, quarter-mask or half-mask face- piece, with or without escape provisions ^{c,e}	No	No	10	As measured on each person with maximum of 3,000, whichever is less
Airline, demand, full-facepiece, with or without escape provis- ions ^{c,e}	No	No	100	As measured on each person with maximum of 3,000, whichever is less
Airline; con- tinuous flow or pressure demand, any facepiece, with- out escape pro- visions ^c	No	No	N/A 3,000	N/A

TABLE 5

Respirator Protection Factors^a

(Continued)

Type of Respirator	Permitted for Use in O ₂ Deficient Atmosphere	Permitted for Use in Immediately Dangerous to Life or Health Atmosphere	Respirator Protection Factor	
			Qualitative Test	Quantitative Test
Airline, continuous flow or pressure demand, any face- piece, with escape provisions ^{c,e}	Yes	Yes	N/A	N/A
				10,000
Airline, continuous flow, helmet, hood, or suit, without escape provisions	No	No	N/A	N/A
				3,000
Airline, continuous flow, helmet, hood, or suit, with escape provisions ^e	Yes	Yes	N/A	N/A
				10,000
Hose mask, with or without blower, quarter-mask or half-mask facepiece ^c	No	No	10	As measured on each person with maximum of 3,000, whichever is less
Hose mask, with or without blower, full facepiece	No	No	100	As measured on each person with maximum of 3,000, whichever is less

Respirator Protection Factors^a

(continued)

Type of Respirator	Permitted for Use in O ₂ Deficient Atmosphere	Permitted for Use in Immediately Dangerous to Life or Health Atmosphere	Respirator Protection Factor	
			Qualitative	Quantitative
Self-contained breathing apparatus, open-circuit demand, or closed-circuit, quarter-mask or half-mask facepiece	Yes	No	10	As measured on each per- son with maximum of 3,000 whichever is less
Self-contained breathing apparatus, open-circuit demand or closed-circuit, full facepiece or mouthpiece/nose clamp	Yes	No (Yes, if respirator is used for mine rescue)	100	As measured on each per- son with maximum of 3,000 whichever is less
Self-contained breathing apparatus, open-circuit pressure- demand, quarter-mask or half-mask facepiece, full facepiece, or mouthpiece/nose clamp	Yes	Yes	N/A	N/A
			1,000	
Combination respirators not listed	The type and mode of operation having the lowest respirator protection factor shall be applied to the combination respirator.			

TABLE 5

Footnotes

N/A means not applicable since a respirator fitting test is not carried out.

- a A respirator protection factor is a measure of the degree of protection provided by a respirator to a respirator wearer. Multiplying the permissible time weighted average concentration or the permissible ceiling concentration, whichever is applicable, for a toxic substance, or the maximum permissible airborne concentration for a radionuclide by a protection factor assigned to a respirator gives the maximum concentration of the hazardous substance for which the respirator can be used.
- b When the respirator is used for protection against airborne particulate matter having a permissible time weighted average concentration less than 0.05 milligram particulate matter per cubic meter of air or less than 2 million particles per cubic feet of air, or for protection against airborne radionuclide particulate matter, the respirator shall be equipped with a high efficiency filter(s).
- c If the air contaminant causes eye irritation, the wearer of a respirator equipped with a quarter-mask or half-mask facepiece shall be permitted to use a protective goggle or to use a respirator equipped with a full facepiece.
- d If the powered air-purifying respirator is equipped with a facepiece, the escape provision means that the wearer is able to breathe through the filter, cartridge, or canister and through the pump. If the powered air-purifying respirator is equipped with a helmet, hood or suit, the escape provisions shall be an auxiliary, self-contained supply of respirable air.
- e The escape provisions shall be an auxiliary, self-contained supply of respirable air.

NOTE: Respirator protection factors for air-purifying type respirators equipped with a mouthpiece/nose clamp form of respiratory-inlet covering are not given since such respirators are approved only for escape purposes.

respirator fitting test was carried out

6.10.2 Respirator Protection Factor Assignment.

When a group of persons wear respirators in a given work area, a single respirator protection factor shall be assigned to all respirator wearers in the group. This respirator protection factor shall be a value which has been achieved or surpassed in qualitative or quantitative respirator fitting tests by each person in the group with the specific make, or model of respirator the person is wearing in the given work area.

6.11 Face Dimensions and Facepiece Sizes. The wide range of face dimensions requires more than a single size of respirator facepieces to provide a proper fit to all respirator users. Therefore, respirator facepieces of more than a single size shall be available in any respirator selection program involving respirators equipped with facepieces.

6.12 Employee Acceptance. Employee acceptance of a particular respirator model within a class shall be considered in respirator selection since this may determine whether or not he wears the respirator properly. Acceptance factors to be considered include discomfort, breathing resistance, weight, and interference with vision. If the results of respirator fitting tests shows that the person can obtain an acceptable fit with two or more respirator models of the selected class of respirator, then the person should be permitted to use the respirator model which he or she prefers.

7. Use of Respirators

7.1 Standard Operating Procedures. Written standard operating procedures shall include information necessary for the proper use of respirators including training

of respirator wearers, respirator sealing tests, issuance of respirators, inspection of respirators prior to use, monitoring respirator use, monitoring respiratory hazard, and planning for routine, non-routine, emergency and rescue uses of respirators.

The written standard operating procedures shall include plans necessary to insure the safe routine use and non-routine use of respirators. Emergency and rescue uses of respirators shall be anticipated and the written standard operating procedures shall include plans necessary to insure the safe emergency and rescue uses of respirators. Persons who wear respirators routinely, who wear respirators non-routinely, and who may be required to wear respirators for emergency and rescue shall be given adequate information concerning plans covering these respirator uses which shall be contained in the written standard operating procedures to insure the safe use of respirators.

7.1.1 Standard Operating Procedures for Emergency and Rescue Use of Respirators.

It is recognized that it is not possible to foresee every emergency and rescue use of respirators for every kind of operation. Nevertheless, a wide variety of possible conditions requiring the emergency or rescue use of respirators can be envisioned and through a serious effort to anticipate the worst possible consequences of particular malfunctions or mishaps, an adequate emergency and rescue respirator response capability can be achieved.

The written standard operating procedures governing the emergency and rescue uses of respirators shall be developed in the following manner:

- (1) An analysis of what emergency and rescue uses of respirators may occur in each operation shall be made by careful consideration of materials, equipment, processes, and personnel involved. Such an analysis shall be reviewed by the person who is thoroughly familiar with the particular

operation.

Consideration shall be given to past occurrences requiring emergency or rescue uses of respirators as well as conditions which resulted in such respirator applications.

The possible consequences of equipment or power failures, uncontrolled chemical reactions, fire, explosion, or human error shall be given consideration. All potential hazards which may result in emergency or rescue use of respirators shall be listed.

- (2) Based upon the analysis, appropriate types of respirators shall be selected, an adequate number of respirators shall be provided for each area where they may be needed for emergency or rescue use, and these respirators shall be maintained and stored so that they are readily accessible and operational when needed.

7.2 Training. The supervisor, the person issuing respirators, and the respirator users shall be given adequate training by a qualified person(s) to insure the proper use of respirators. Written records shall be kept of the name of persons trained and the dates when training occurred.

7.2.1 Training of Supervisor. A supervisor, i.e., a person who has the responsibility for overseeing the work activities of one or more persons who must wear respirators routinely or non-routinely, shall be given adequate training to insure the proper use of respirators. Supervisor training shall include but not necessarily be limited to the following subjects:

- (1) basic respiratory protection practices
- (2) nature and extent of respiratory hazards to which persons under his supervision may be exposed
- (3) respirator selection
- (4) training of respirator wearers

- (5) issuance of respirators
- (6) respirator inspection
- (7) use of respirators including monitoring of use
- (8) maintenance and storage of respirators
- (9) regulations concerning respirator use

2.2 Training of Person Issuing Respirators. A person assigned the task of issuing respirators to persons who must wear respirators for protection against harmful atmospheres shall be given adequate training to insure that the correct respirator is issued for each application.

2.3 Training of Respirator Wearer. To insure the proper and safe use of a respirator, the minimum training of each respirator wearer shall include the following elements:

- (1) reasons for the need of respiratory protection
- (2) nature, extent and effects of respiratory hazards to which the person may be exposed
- (3) explanation of why engineering controls are not being applied or are not adequate and what effort is being made to reduce or eliminate the need for respirators
- (4) explanation of why a particular type of respirator has been selected for a specific respiratory hazard
- (5) explanation of the operation, capabilities, and limitations of the selected respirator
- (6) instruction in inspecting, donning, checking the fit, and wearing the respirator
- (7) explanation of how maintenance and storage of the respirator is carried out
- (8) instructions in how to recognize and cope with emergency situations
- (9) instructions as needed for special respirator use (See Section 7.10)
- (10) regulations concerning respirator use

Training shall provide each respirator wearer an opportunity to handle the respirator, learn how to don and wear it properly, check its seal, and wear it in a safe atmosphere.

Each respirator wearer shall be retrained at least annually.

7.3 Respirator Wearing Procedures. Each respirator wearer shall be given wearing instructions and training.

7.3.1 Wearing Instructions and Training. Wearing instructions and training including demonstrations shall cover:

- (1) donning, wearing and removing the respirator
- (2) adjusting the respirator so that its respiratory inlet covering is properly sealed on the wearer and so that the respirator causes a minimum of discomfort to the wearer
- (3) allowing the respirator wearer to wear the respirator in a safe atmosphere for an adequate period of time to insure that the wearer is familiar with the operational characteristics of the respirator.

7.4 Respirator Sealing Problems. Respirators shall not be worn when conditions prevent a seal of the respirator to the wearer.

A person who has hair (stubble, moustache, sideburns, beard, low hairline, bangs) which comes between the sealing surface of the facepiece of the respirator shall not be permitted to wear such type of respirator.

A person who has hair (moustache, beard) which interferes with the function of a respirator valve(s) shall not be permitted to wear the respirator.

A spectacle which has temple bars or straps which pass between the sealing surface of a respirator full facepiece and the respirator wearer's face shall not be used when a respirator with a full facepiece must be worn.

A head covering which passes between the sealing surface of a respirator facepiece and the respirator wearer's face shall not be used.

A spectacle, a goggle, a face shield, a welding helmet, or other eye and face protective device which interferes with the seal of a respirator to the wearer shall not be allowed.

6 scars, hollow temples, excessively protruding cheekbones, deep creases in facial skin, the absence of teeth or dentures, or unusual facial configurations prevent a seal of a respirator facepiece to a respirator wearer's face, the person shall not be permitted to wear the respirator.

7.4 missing teeth or dentures prevent a seal of a respirator mouthpiece in a person's mouth, the person shall not be allowed to wear a respirator equipped with a mouthpiece.

7.5 if a person has a nose of a shape or size which prevents the closing of the nose by the nose clamp of a mouthpiece/nose clamp type respirator, the person shall not be permitted to wear this type of respirator.

7.5 Respirator Sealing Tests. To assure proper protection, the wearer of a respirator equipped with a facepiece shall check the seal of the facepiece prior to each entry into a hazardous atmosphere. This may be done using procedures recommended by respirator manufacturers or by any of the field tests described in Appendix A7.

7.6 Issuance of Respirators. The proper respirator shall be specified for each application and shall be listed in the written standard operating procedures. If a respirator is marked for whom it is assigned or for other identification purposes, the markings shall not affect the respirator performance in any way.

7.7 Respirator Inspection Prior to Use. Each person issued a respirator for routine, non-routine, emergency, or rescue use shall inspect the respirator prior to its use to insure that it is in good operating condition.

7.8 Monitoring Respirator Use. The use of respirators on a routine or non-routine basis shall be monitored to insure that the correct respirators are being used, that the respirators are being worn properly, and that the respirators being used are in good working condition.

7.9 Monitoring Respiratory Hazard. The level of the respiratory hazard to which a person wearing a respirator routinely or non-routinely is exposed shall be monitored. Both the time weighted average concentration and the peak concentration of the respira-

any hazard shall be determined. These values of the concentrations shall be used to insure that the proper type of respirator is being utilized (See Appendix A8).

7.10 Leaving Hazardous Area. A respirator wearer shall be permitted to leave the hazardous area for any cause. Reasons which may cause a respirator wearer to leave hazardous area include, but are not limited to the following:

- (1) Failure of a respirator to provide adequate protection
- (2) Malfunction of respirator
- (3) Detection of leakage of air contaminant into respirator
- (4) Increase in resistance of respirator to breathing
- (5) Severe discomfort of wearing respirator
- (6) Illness of respirator wearer including: sensation of dizziness, nausea, weakness, breathing difficulty, coughing, sneezing, vomiting, fever and chills.

8. Respirator Care

8.1 General. A program for the care of respirators shall include the following:

- (1) cleaning and sanitizing
- (2) inspection for defects
- (3) repair
- (4) storage

Each respirator shall be properly maintained to retain its original shape and effectiveness.

8.2 Cleaning and Sanitizing. Each respirator shall be cleaned and sanitized to insure that the respirator wearer is provided with a clean and sanitized respirator at all times. Non-personal issue respirator including that for routine, non-routine emergency, or rescue use shall be cleaned and sanitized after each use.

8.3 Inspection. Each respirator shall be inspected routinely before and after use. A respirator shall be inspected by the user immediately prior to each use to insure that it is

proper working condition.

After cleaning and sanitizing, each respirator shall be inspected to determine if it is in proper working condition, if it needs replacement of parts or repairs, or if it should be discarded.

Each respirator stored for emergency or rescue use shall be inspected at least monthly.

Respirator inspection shall include a check for tightness of connections; condition of the respiratory-inlet covering, head harness, valves, connecting tubes, harness assemblies, filters, cartridges, canisters, end of service life indicator, shelf life date(s); and proper function of regulators, alarms and other warning systems.

Each rubber or other elastomeric part shall be inspected for pliability and signs of deterioration. Each air and oxygen cylinder shall be inspected to insure that it is fully charged according to the manufacturer's instructions.

A record of inspection dates, findings, and remedial actions shall be kept for each respirator maintained for emergency or rescue use.

2.4 Part Replacement and Repair. Replacement of parts or repairs shall be done only by persons specially trained in proper respirator assembly and to correct possible respirator malfunctions and defects. Replacement parts shall be only those designed for the specific respirator being repaired. Reducing or admission valves and regulators shall be returned to the manufacturer or to a technician trained and certified by the manufacturer for repair or adjustment. Instrumentation for valve and regulator adjustment must be approved by the valve or regulator manufacturer.

2.5 Respirators shall be stored in a manner that will protect them against dust, sunlight, heat, extreme cold, excessive moisture, or damaging chemicals. Respirators shall be stored to prevent distortion of rubber or other elastomeric parts. Respirators shall be stored in such places as lockers and tool boxes unless they are protected from contamination, distortion and damage. Emergency and rescue use respirators placed in work areas shall be quickly accessible at all times, and the storage cabinet or container

shall be clearly marked.

9. Special Problems

9.1 Vision. When a respirator user must wear corrective lenses, a protective spectacle or goggle, a face shield, a welding helmet, or other eye and face protective device, the item shall be fitted to provide good vision and shall be worn in such a manner so as not to interfere with the seal of the respirator to the wearer.

Temple bars or straps of corrective spectacles which pass between the sealing surface of a respirator full facepiece and the respirator wearer's face may prevent a good seal of the facepiece to the face. Therefore, spectacles that have temple bars or straps as mentioned shall not be used when a respirator equipped with a full facepiece must be worn.

As a temporary measure, corrective spectacles with short temple bars that do not protrude between the sealing surface of a full facepiece and the respirator wearer's face may be taped to the respirator wearer's head. Special corrective lenses which are made to be mounted inside a full facepiece are available and should be used by a person who needs corrective lenses.

The wearing of contact lenses by persons who must wear a respirator equipped with a full facepiece, helmet, hood, or suit shall not be permitted.

9.2 Communications. Speech transmission while wearing a respirator often is necessary to perform specific tasks. Although a respirator facepiece distorts the human voice to some extent, the respirator's exhalation valve usually provides a pathway for some speech transmission over short distances in relatively quiet areas. However, talking while wearing a respirator equipped with a facepiece may adversely affect the seal of the facepiece, especially a quarter-mask or half-mask facepiece, to the wearer's face.

A mechanical speech transmission device, called a speaking diaphragm, is an integral part of the facepiece in some respirators. The speaking diaphragm usually consists of a resonant cavity and diaphragm which transmits sound. The diaphragm also acts as a

rier to the ambient atmosphere and thus should be handled carefully to prevent possible puncture which would permit leakage of an air contaminant into the respirator. Various methods of electronically transmitting and amplifying speech through the respirator are available. These utilize a microphone connected to a speaker, telephone, or a radio transmitter. Usually, the microphone is mounted inside the respiratory-inlet covering, while the amplifier, power pack, and speaker or transmitter are attached to the exterior of the respiratory-inlet covering, carried on the body, or are remotely located. Respirators with electronic speech transmission devices having a battery power supply should be used with caution in explosive atmospheres. When an electronic speech transmission device is used in underground mining, it shall be certified as complying with the Mining Enforcement and Safety Administration's requirements for permissibility and intrinsic safety set forth in Part 18, Subchapter D of Bureau of Mines Schedule 2G. Sealed power sources shall be checked for integrity of seals. Connecting cables from microphones inside the respiratory-inlet covering shall have gas-tight seals where they pass through the covering. When the speaker 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. A microphone mounted on the respirator wearer's throat or a microphone/speaker worn in the respirator wearer's ear does not require penetration of a respirator facepiece by a cable.

9.3 Use of Respirators for Entry into Atmospheres Immediately Dangerous to Life or Health. When respirators are required for entry into atmospheres immediately dangerous to life or health, at least one standby person shall be present in a safe area. The standby person shall have the proper equipment available to assist the respirator wearers in case of emergency. Communications (visual, voice, signal line, telephone, radio or other suitable means) shall be maintained between the standby person and the respirator wearers. If feasible, respirator wearers in atmospheres immediately dangerous to life or

health shall be equipped with safety harnesses and safety lines to permit them to be moved from the dangerous atmospheres to safe areas if necessary, or equivalent provisions for the rescue of the respirator wearers from the dangerous atmospheres shall be used.

9.4 Respirator Use in Confined Spaces. All confined spaces shall be considered to be immediately dangerous to life or health unless proven otherwise. Before a person is allowed to enter a confined space, tests shall be carried out to determine the concentration of any known or expected flammable or toxic contaminant present and to determine the concentration of oxygen. A person shall not be allowed to enter a confined space without wearing the proper type of respirator if the concentration of any air contaminant is above the permissible time weighted average concentration for toxic substances or above the maximum permissible airborne concentration for radionuclides, if the concentration of a substance is above the lower flammable limit, or if an oxygen deficiency exists. Even if the concentrations of air contaminants in a confined space are found to be below the established limits and sufficient oxygen is present, the safest procedure is to continuously ventilate the enclosed space and to continuously monitor the concentration of air contaminants and oxygen concentration if persons are to work in the confined space without wearing respirators.

An air-purifying respirator, an airline type supplied-air respirator, or a hose mask type supplied-air respirator may be worn by a person in a confined space only if tests indicate that the atmosphere in the confined space contains adequate oxygen and if the concentrations of air contaminants are below levels that are immediately dangerous to life or health. While a person is wearing any of the mentioned types of respirators in a confined space, the level of respiratory hazards in the atmosphere of the confined space shall be monitored. If the results of monitoring the atmosphere in a confined space, prior to the entry of a person into the space, shows that the atmosphere is immediately dangerous to life or health, then a person who is required to enter the confined space shall wear either a positive

pressure self-contained breathing apparatus or a combination positive pressure airline respirator with an auxiliary self-contained air supply. An oxygen type open-circuit self-contained breathing apparatus shall not be worn in a confined space where the possibility of fire or explosion hazard is increased. When respirators are used in a confined space, the provisions for a standby person given in Section 9.3 shall be carried out.

9.5 Respirator Use in Low Temperature Environments. A low temperature environment may cause fogging of the lens in a respiratory-inlet covering and freezing of the exhalation valve. Coating the inside surface of the lens may prevent fogging at low atmospheric temperatures approaching 0°C (32°F), but severe fogging of the lens may occur at temperatures below -18°C (0°F). Full facepieces are available with nose cups that direct the warm and moist exhaled air through the exhalation valve without contacting the lens and these facepieces should provide satisfactory vision at temperatures as low as -34°C (-30°F). At very low atmospheric temperatures, the exhalation valve of a respirator may freeze open or closed due to the presence of moisture. Dry respirable air should be used with an airline respirator and with the type of self-contained breathing apparatus that employs a cylinder of air when these devices are used in a low temperature atmosphere. The dewpoint of this breathing air should be appropriate to the temperature of the atmospheric air. High pressure connections on self-contained breathing apparatus may leak because of metal contraction at low atmospheric temperature. These connections should not be overtightened since they may break when the apparatus is returned to an atmosphere at normal room temperature. An airline type supplied-air respirator may be equipped with a device called a vortex tube to warm the air supplied to the respirator-inlet covering of the respirator. Emergency use respirators that are stored in low temperature environments may require special elastomeric components that will retain their elasticity at low temperatures (regulator diaphragms, gaskets and breathing tubes). Facepieces stored in low temperature environments can become stiff and distorted

to a degree that may prevent an adequate facepiece to face seal. Special care shall be used to prevent distortion of facepieces stored at low temperatures. Some self-contained breathing apparatus models have cold temperature accessories that may be utilized to help overcome these problems. The manufacturers instructions shall be followed when utilizing these cold temperature accessories.

9.6 Respirator Use in High Temperature Environments. A person working in an atmosphere at high temperature is under stress. Wearing a respirator in such an environment applies additional stress on the person. The additional stress due to the wearing of a respirator in a high temperature environment should be minimized by using a respirator having a low weight and offering a low resistance to breathing. The airline type supplied-air respirator is recommended for use in a high temperature environment. Airline type supplied-air respirators equipped with a vortex tube to cool the air supplied to the respiratory-inlet covering will substantially reduce heat stress. Elastomeric components of respirators stored in high temperature environments may deteriorate at an accelerated rate and the facepieces may become permanently distorted. Special care shall be used to prevent facepiece distortion. All such respirators shall be inspected and maintained at a frequency rate that will prevent the use of respirators with deteriorated elastomeric components.

10. Evaluation of Respirator Program Effectiveness.

10.1 General. Periodic evaluation of the effectiveness of the respirator program is essential to insure that persons are being provided with adequate respiratory protection. Improvement of the program and elimination of any deficiencies in the program cannot be carried out unless the program is appraised for effectiveness at periodic intervals. The effectiveness of the respirator program shall be evaluated at least annually and corrective action shall be taken to correct defects found in the program.

10.2 Wearer Acceptance. Wearer acceptance of respirators is an important matter to

consider in evaluating the effectiveness of the respirator program. Respirator wearers shall be consulted periodically about their acceptance of wearing respirators. Numerous factors affect the acceptance of respirators. These factors include: comfort, resistance to breathing, fatigue, interference with vision, interference with communications, restriction of movement, interference with job performance, and confidence in the effectiveness of the respirator to provide adequate protection.

10.3 Inspection of Respirator Program Operation. Frequent inspection of the operation of the respirator program shall be conducted to insure that proper types of respirators are selected, that respirator wearers are trained properly, that the correct respirators are issued and used, that respirators are worn properly, that respirators being used are in good operating condition, that respirators are inspected and maintained properly, that respirator storage is satisfactory, that respiratory hazards are monitored, and that medical and when necessary, bioassay surveillance of respirator wearers is carried out.

10.4 Appraisal of Protection Afforded. Medical and when necessary, bioassay surveillance of respirator wearers shall be conducted periodically to determine if respirator wearers are being provided with adequate respiratory protection. These data, when considered with the results of monitoring respiratory hazards, can serve as an indication of the degree of protection provided by the respirators and the effectiveness of the respirator program.

10.5 Evaluation. The results of investigating wearer acceptance of respirators, inspecting respirator program operation, and appraising protection provided by respirators shall be utilized to evaluate the effectiveness of the respirator program. Evidence of excessive exposure of respirator wearers to respiratory hazards shall be followed up by investigation to determine why inadequate respiratory protection was provided. Action shall be taken to correct any defects found in the respirator program. The findings of the respirator program evaluation shall be documented and this document shall list

plans to correct faults in the program and target dates for the implementation of the plans.

11. References to Other Standards, Regulations and Manuals.

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

11.1.1 American National Standard Identification of Air-Purifying Respirator Canisters and Cartridges, K13.1-1973

11.1.2 American National Standard Method of Marking Portable Compressed Gas Containers to Identify the Material Contained, Z48.1-1954(R1971)

11.1.3 American National Standard Commodity Specification for Air, Z86.1-1972

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

11.1.5 American National Standard Practices for Respiratory Protection, Z88.1-1969

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

11.2.1 Respiratory Protective Devices Manual, 1963

11.3 Compressed Gas Association.

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

11.4 National Fire Protection Association.

11.4.1 Respiratory Protective Equipment for Fire Fighters, NFPA 19B, 1971

11.4.2 Breathing Apparatus for the Fire Service, A Fire Officer's Guide, FSP-29B, 1975

11.5 University of California, Los Alamos Scientific Laboratory

11.5.1 Energy Research and Development Administration, Division of Safety, Standards and Compliance, Respirator Manual, LA-6370-M, August 1971

11.5.2 A Guide to Industrial Respiratory Protection, LA-6671-M, March 1977

11.6 U.S. Department of the Interior, Bureau of Mines.

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

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

11.6.3 Schedule 19B, Supplied-Air Respirator, Code of Federal Regulations, Part 14, Chapter 1, Subchapter B, Title 30

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

11.6.5 Schedule 23B, Nonemergency Gas Respirators (Chemical Cartridge Respirators), Code of Federal Regulations, Chapter 1, Subchapter B, Title 30

11.6.6 Respiratory Protective Devices; Tests for Permissibility; Fees, Code of Federal Regulations, Chapter 1, Subchapter B, Title 30

11.6.7 Information Circular 8559, Respirators Approved by the Bureau of Mines as of May 24, 1972

11.7 U.S. Department of Health, Education and Welfare, National Institute for Occupational Safety and Health

11.7.1 NIOSH Certified Personal Protective Equipment (February 1974 and supplements published periodically)

11.8 U.S. Department of Labor, Occupational Safety and Health Administration

11.8.1 General Industry Safety and Health Standards, Part 1910, Title 29, Code of Federal Regulations, Subpart Z-Toxic and Hazardous Substances (published periodically)

11.9 U.S. Department of Transportation, Interstate Commerce Commission.

11.9.1 Code of Federal Regulations, Title 49, Part 173, General Requirements for Shipments and Packagings, and Part 178, Shipping Container Specifications (published periodically)

- 11.10 U.S. Nuclear Regulatory Commission, Office of Standards Development
- 11.10.1 Manual of Respiratory Protection Against Airborne Radioactive Materials, NUREG-0041, October 1976
- 11.11 General Services Administration.
- 11.11.1 Federal Specification BB-A-1034a (June 21, 1968). Air, Compressed for Breathing Purposes
- 11.11.2 Interim Federal Specification GG-B-00675c (October 7, 1974). Breathing Apparatus, Self-Contained

APPENDIX

(This Appendix is not part of American National Standard Practices for Respiratory Protection, Z88.2-197, but is included for informational purposes).

A1. Approval Agencies

A1.1 Bureau of Mines (BM). The Bureau of Mines (BM), U.S. Department of Interior, tested and approved respirators from 1919 until 1972. Approvals were issued under the provisions of various Schedules until May 25, 1972, the effective date of Title 30, CFR, Part II, "Respiratory Protective Devices, Tests for Permissibility; Fees". Title 30, CFR, Part II superceded and revoked the previous respirator approval Schedules.

A1.2 National Institute for Occupational Safety and Health (NIOSH). Title 30, CFR, Part II gave jurisdiction for joint approval of respirators to the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education and Welfare, and to the Bureau of Mines (BM), U.S. Department of the Interior.

A1.3 Mining Enforcement and Safety Administration (MESA). In 1974, a reorganization of the U.S. Department of the Interior resulted in the formation of the Mining Enforcement and Safety Administration (MESA), which assumed the health and safety activities of the Bureau of Mines (BM), including the respirator testing and approving functions. Subsequent respirator approvals are issued jointly by the National Institute for Occupational Safety and Health (NIOSH) and by the Mining Enforcement and Safety Administration (MESA).

A2. Status of Approved Respirators

The status of respirators approved under the provision of BM Schedules is different from the status of respirators approved under provisions of Title 30, CFR, Part II, published in the Federal Register on November 22, 1974. These amendments provide that:

A2.1 After June 30, 1975, respirators are approved for purchase and use if they have been approved jointly by MESA (formerly BM) and NIOSH under provisions of Title 30, CFR, Part II. However, gas masks which have been approved by the BM under provisions of BM Schedule 14F continue to be approved for purchase and use until further notice.

A2.2 Respirators, other than gas masks, which have been approved by the BM under provisions of certain BM Schedules, if purchased on or before June 30, 1975 and which are maintained in approved condition, shall be approved for use until the following dates: March 31, 1979 for self-contained breathing apparatus approved under provisions of BM Schedules 13-13E; March 31, 1980 for supplied-air respirators approved under provisions of BM Schedule 19B; March 31, 1976 for particulate-removing respirators approved under provisions of BM Schedule 21B; March 31, 1976 for chemical cartridge type vapor- and gas-removing respirators approved under provisions of BM Schedule 233.

. Lists of Approved Respirators

Respirators approved by the BM under provisions of BM Schedules were listed periodically through the years in BM Information Circulars. The last BM Information Circular listing approved respirators is IC-8559, "Respirators Approved by the Bureau of Mines as of May 24, 1972"

Respirators approved jointly by NIOSH and MESA under provisions of Title 30, CFR, Part II are listed in "NIOSH Certified Personal Protective Equipment". Supplements are issued periodically. Copies are available from:

Office of Technical Publications
National Institute for Occupational Health and Safety
U.S. Department of Health, Education and Welfare
Post Office Building
Cincinnati, Ohio 45202

A4. Physical and Psychological Limitations for Respirator Wearers

It is recommended that a person should not be assigned to a task which requires the wearing of a respirator if the person has any of the following:

- (a) Emphysema
- (b) Chronic pulmonary obstructive disease
- (c) Bronchial asthma
- (d) X-ray evidence of pneumoconiosis
- (e) Evidence of reduced pulmonary function
- (f) Coronary artery disease
- (g) Severe or progressive hypertension
- (h) Epilepsy, grand mal or petit mal
- (i) Anemia, pernicious
- (j) Diabetes, insipidous or mellitus
- (k) Experiences breathing difficulty when wearing a respirator
- (l) Experiences claustrophobia or anxiety when wearing a respirator

A5. Suggested Procedures for Carrying Out Qualitative Respirator Fitting Tests

A5.1 Irritant Smoke Test. The irritant smoke test can be used for both air-purifying respirators and atmosphere-supplying respirators. When an air-purifying respirator is tested, it should be equipped with a high efficiency filter. The irritant smoke is produced by air through a commercially available smoke tube normally used to check the performance of ventilation systems. Ventilation should be provided when carrying out a test to prevent contaminating the room where the test is carried out with smoke. The respirator wearer should keep his eyes closed during the test, even if the respirator offers eye protection. If the respirator wearer detects the penetration of the smoke into the respirator during the test, the wearer should be permitted to readjust the seal of the respirator. The person operating the smoke tube directs smoke over the respirator keeping the smoke tube about two feet from the respirator and the test

operator watches the reactions of the respirator wearer. If the respirator wearer does not detect penetration of smoke into the respirator, the test operator moves the smoke tube closer to the respirator and observes the reactions of the respirator wearer. When the smoke tube has been moved to within six inches of the respirator and the respirator wearer still has not detected penetration of smoke into the respirator, the smoke may be directed at potential sources of leakage in the seal of the respirator to the wearer. If the respirator wearer still does not detect penetration of the smoke into the respirator, the wearer may carry out a series of exercises such as: deep breathing, turning head from side to side, nodding head up and down, and talking while smoke is directed at the respirator. If the respirator wearer is unable to detect the penetration of smoke into the respirator, the wearer has achieved a satisfactory fit with the respirator.

A5.2 Odorous Vapor Test. The odorous vapor test can be used for both air-purifying respirators and atmosphere-supplying respirators. When an air-purifying respirator is tested, it should be equipped with a cartridge or canister which removes the vapor from the air. An odorous material commonly used in the test is isoamyl acetate. If isoamyl acetate is employed as the test agent, an air-purifying respirator should be equipped with an organic vapor cartridge or canister. The simplest means of carrying out the test is to saturate a piece of fabric or sponge with liquid isoamyl acetate or to fill a stencil brush with liquid isoamyl acetate and then move the fabric, sponge, or stencil brush around the respirator worn by a person. The fabric, sponge or stencil brush should be passed close to the potential sources of leakage in the seal of the respirator to the wearer. If the respirator wearer detects the odor of isoamyl acetate vapor during the test, the wearer should be permitted to readjust the seal of the respirator. If the respirator wearer is unable to detect the odor of isoamyl acetate vapor, the wearer has achieved a satisfactory fit to the respirator. An improved qualitative respirator fitting test using isoamyl acetate vapor as the test agent may be carried out using a hood, chamber or room containing a known concentration of isoamyl acetate vapor in the air. The concentration of isoamyl

acetate vapor in air commonly used is 100 parts per million by volume. The respirator wearer enters the enclosure containing the test atmosphere and carries out a series of exercises such as: normal breathing, deep breathing, turning head from side to side, nodding head up and down, and talking. If the respirator wearer detects the odor of isoamyl acetate vapor during the test, the wearer should be permitted to readjust the seal of the respirator. If the respirator wearer is unable to detect the odor of isoamyl acetate vapor, the wearer has achieved a satisfactory fit with the respirator. Major drawbacks of a test using isoamyl acetate vapor as the test agent are that the odor threshold varies widely among persons although most persons can detect by odor a concentration of isoamyl acetate vapor in air as low as 0.1 parts per million by volume and that olfactory fatigue may cause a person to fail to detect the odor of a low concentration of isoamyl acetate vapor in air.

A5.3 Other Qualitative Respirator Fitting Tests. A stream of coal dust or talcum powder may be directed at the seal of a respirator facepiece to the wearer's face. After removal of the respirator facepiece from the wearer's face, observation of coal dust or talcum powder on areas of the wearer's face which had been covered by the facepiece indicates that the wearer did not obtain a satisfactory fit with the facepiece. A spray of fluorescein liquid particles may be directed at the seal of a respirator facepiece to the wearer's face. After removal of the respirator facepiece from the wearer's face, and with the wearer's eyes closed, ultraviolet light is directed at the wearer's face and observation of fluorescein on areas of the wearer's face which had been covered by the facepiece indicate that the wearer did not obtain a satisfactory fit with the facepiece.

A6. Suggested Procedures for Carrying Out Quantitative Respirator Fitting Tests. All quantitative respirator fitting tests involve exposing the respirator wearer to a test atmosphere containing an easily detectable, relatively non-toxic aerosol, vapor

or gas, as the test agent, and measuring the penetration of the test agent into the respirator. While wearing the respirator in the test atmosphere, the respirator

wearer carries out a series of exercises simulating work movements. The respirator is equipped with a sampling probe which is connected by means of flexible tubing to an instrument which measures the penetration of the test agent into the respirator. Quantitative respirator fitting tests can be used for both air-purifying respirators and atmosphere-supplying respirators. When carrying out a quantitative respirator fitting test which uses an aerosol as the test agent, it is acceptable procedure to equip an air-purifying respirator with a high efficiency filter. When carrying out a quantitative respirator fitting test which uses a vapor or gas as the test agent, it is acceptable procedure to equip an air-purifying respirator with an appropriate cartridge or canister which removes the vapor or gas from the air.

A6.1 Exercises Carried Out by Respirator Wearers. A respirator wearer should carry out a series of exercises which simulate work movements. The kinds of exercises carried out depend on the types of respirators. Each exercise should be carried out for at least two minutes.

The following series of exercises should be carried out when a respirator equipped with a facepiece is being tested:

- (1) Normal breathing
- (2) Deep breathing
- (3) Turning head from side to side
- (4) Nodding head up and down
- (5) Talking
- (6) Normal breathing

The following series of exercises should be carried out when a respirator equipped with a helmet, hood, or suit is being tested:

- (1) Standing still, arms hanging downward along sides of body, normal breathing
- (2) Bending forward and touching toes
- (3) Raising arms upward above head and looking upward
- (4) Bending knees and squatting
- (5) Standing, while holding a tubular rod of about 76 centimeters length with hands approximately 30 centimeters apart, and twisting torso from side to side, in an 180 degree arc, and slowly raising the arms from a downward direction to an upward direction having an angle of 45 degrees with the horizontal plane.
- (6) Running in place
- (7) Standing still, arms hanging downward along sides of body, normal breathing

A6.2 Test Atmospheres. Test atmospheres containing the following test agents are suitable for carrying out quantitative respirator fitting tests:

<u>Test Agent</u>	<u>Concentration of Test Agent in Test Atmosphere</u>	<u>Particle Size if Test Agent is an Aerosol</u>
Polydisperse sodium chloride aerosol	10 to 20 milligrams particulate matter per cubic meter of air	Mass median aerodynamic diameter of 0.5 to 0.7 micrometer with standard deviation of 2.0 to 2.4
Polydisperse DOP (dioctyl phthalate) aerosol	20 to 30 milligrams particulate matter per cubic meter of air	Mass median aerodynamic diameter of 0.5 to 0.7 micrometer with standard deviation of 2.0 to 2.4
Dichlorodifluoromethane (Freon 12) gas	250 to 1,000 parts per million by volume	

A6.3 Test Chambers. It is recommended that test chambers used to carry out quantitative respirator fitting tests have the following characteristics:

- (1) The chamber and equipment used to generate the test atmosphere should insure that the concentration of the test agent in the test atmosphere inside the chamber does not vary more than plus or minus five percent during a test.
- (2) The chamber and equipment used to disperse the test atmosphere in the chamber should insure that the test agent is uniformly distributed in the test atmosphere throughout the chamber.
- (3) The size of the chamber must permit a respirator wearer to carry out all of the designated exercises.
- (4) The chamber should contain provision to permit the test operator to visually observe the respirator wearer inside the chamber.

A6.4 Protection Factor Determination. The instrument which measures the penetration of the test agent into the respirator worn by a person in the test atmosphere should be connected to a fast response recorder which records the penetration values. The average of the peaks of the penetration of the test agent into the respirator for each type of exercise carried out by the respirator wearer should be determined. The protection factor for a given make and model respirator worn by the person in a test should be calculated by using the following equation:

$$\text{Protection Factor} = \frac{100}{\frac{\text{sum of average peak penetrations for all exercises in percent}}{\text{number of exercises}}}$$

A7. Recommended Procedures for Field Testing Respirator Seal

The seal of a respirator to a wearer can be tested in the field by procedures recommended by respirator manufacturers or by any of the following tests:

A7.1 Irritant or Odorous Test Agent. The person wearing a respirator is exposed to an irritant smoke, odorous isoamyl acetate vapor, or other suitable test agent easily detectable by irritation, odor, or taste (an air-purifying respirator must be equipped with the appropriate air-purifying element). If the respirator wearer is unable to detect the penetration of the test agent into the respirator, it can be reasonably assured that the seal of the respirator to the wearer is satisfactory.

A7.2 Negative Pressure Sealing Test. A negative pressure respirator sealing test can be used on air-purifying respirators equipped with tight-fitting respiratory-inlet coverings and on atmosphere-supplying respirators equipped with tight-fitting respiratory-inlet coverings and breathing tubes which can be squeezed to prevent the passage of air. The test consists of closing off the inlet opening of the respirator's canister(s), cartridge(s), or filter(s) by covering with the palm of the hand(s), by replacing the inlet seal on a canister(s), or by squeezing a breathing tube so that it will not allow the passage of air, inhaling gently, and holding the breath for several seconds. If a facepiece collapses slightly and no inward leakage of air into the facepiece is detected, it can be reasonably assured that the fit of the respirator to the wearer is satisfactory. For a respirator equipped with a mouthpiece and nose clamp, if leakage of air into the nose and into the mouth cannot be detected, then it can be reasonably assured that the fit of the respirator to the wearer is satisfactory.

A7.3 Positive Pressure Sealing Test. A positive air pressure respirator fitting test can be used on respirators equipped with tight-fitting respiratory-inlet coverings which contain both inhalation and exhalation valves. The test is conducted by closing off the exhalation valve and exhaling gently. The fit of a respirator equipped with a facepiece is considered to be satisfactory if a slight positive air pressure can be built up inside the facepiece without detection of any outward leakage of air between the sealing surface of the facepiece and the respirator wearer's face. The fit of a respirator equipped with a mouthpiece and nose clamp is considered satisfactory if the respirator wearer senses a build up of positive air pressure and is unable to detect

any outward leakage of air through the nose and between the mouth and the mouthpiece.

For some respirators, this test method requires that the respirator wearer first remove an exhalation cover from the respirator and then replace it after completion of the test and these tasks often are difficult to carry out without disturbing the fit of the respirator to the wearer.

A8. Monitoring of Respiratory Hazards.

The intensity of potential exposures and actual exposures of respirator wearers to respiratory hazards is determined by using instruments to measure the concentrations of air contaminants or oxygen in the breathing zone of the respirator wearers. Adequate air sampling using instruments should be carried out to determine both the time weighted average concentration and the peak concentration of the respiratory hazard to which a respirator wearer may be potentially exposed or is actually exposed. Concentrations of a substance causing a respiratory hazard should be measured during the entire work shift in order to determine accurately both the time weighted average concentration and the peak concentration of the substance.

The concentrations of a substance in air may be affected by changes in process operation, changes in rate and direction of air movement, changes in temperature from day to night operation, and changes in seasons and these factors should be taken into account in carrying out a program of monitoring of respiratory hazards.

It is essential that the volume of air sampled during a sampling test contain a sufficient quantity of the hazardous substance for accurate determination of the concentration of the substance in the work place atmosphere. The volume of air to be sampled, or the duration of the air sampling period depends upon the following factors:

- (1) Estimated concentration of the substance in air
- (2) Sensitivity of the sampling instrument and sampling procedures

- (3) Established permitted time weighted average concentration and established permitted peak concentration for the substance in air.

Although it is recognized that the concentration of a hazardous substance which occurs during an emergency cannot always be measured, every reasonable effort should be made to estimate what this concentration would be.

Consideration should be given to the use of a continuous operating air monitor and alarm to alert respirator wearers when a high concentration of a hazardous substance suddenly occurs.

A9. Recommended Procedures for Cleaning and Sanitizing Respirators

- (1) Remove, when necessary, the following components of respiratory-inlet covering assemblies before cleaning and sanitizing:
 - (a) filters, cartridges, canisters
 - (b) speaking diaphragms
 - (c) demand and pressure-demand valve assemblies
 - (d) any components recommended by the respirator manufacturers
- (2) Wash respiratory-inlet covering assemblies in warm (49°C or 120°F maximum temperature) cleaner-sanitizer solution. A stiff bristle (not wire) brush may be used to facilitate removal of dirt or other foreign materials.
- (3) Rinse respiratory-inlet covering assemblies in clean, warm (49°C or 120°F maximum temperature) water.
- (4) Drain all water and air dry respiratory-inlet covering assemblies.
- (5) Clean and sanitize all parts removed from respiratory-inlet covering as recommended by the manufacturers.
- (6) Hand wipe respiratory-inlet covering assemblies, all parts, all gasket and valve sealing surfaces with damp, lint-free cloth as necessary to remove water residues and all foreign materials.
- (7) Inspect parts and replace any which are defective.

- (8) Reassemble parts on respiratory-inlet covering assemblies.
- (9) Attach new filters, cartridges, and canisters to respiratory-inlet coverings.
- (10) Visually inspect, and where possible, test parts and respirator assemblies for proper function.
- (11) Place assembled respirators in appropriate containers for storage.

Machines may be used to expedite the cleaning, sanitizing, rinsing, and drying of large numbers of respirators. Extreme care must be taken to insure

against tumbling, agitation, or exposure to temperatures above those recommended by the manufacturer (normally 49°C or 120°F maximum) as these conditions are likely to result in damage to the respirators. Ultrasonic cleaners, clothes and dishwashers, and clothes dryers have been specially adapted and successfully used for cleaning and drying respirators.

Cleaner-sanitizers that effectively clean the respirator and contain a bactericidal agent are commercially available. The bactericidal agent frequently used is a quaternary ammonium compound.

Strong cleaning and sanitizing agents and many solvents can damage rubber or elastomeric respirator parts. These materials must be used with caution.

Alternatively, respirators may be washed in a detergent solution then sanitized by immersion in a sanitizing solution. Some sanitizing solutions which have proven effective are: 1) a hypochlorite solution (50 parts per million of chlorine), 2 minute immersion 2) an aqueous iodine solution (50 parts per million of iodine), 2 minute immersion or 3) a quaternary ammonium solution (200 parts per million of quaternary ammonium compounds in water with less than 500 parts per million total hardness), 2 minute immersion.

Different concentrations of quaternary ammonium salts are required to achieve a sanitizing solution with waters of varying hardness. Inflammation of the skin, dermatitis, may occur on the respirator user if the quaternary ammonium compounds are not completely rinsed from the respirator. The hypochlorite and iodine solutions are unstable and break down as time progresses, they may cause deterioration of rubber or other elastomeric parts, and may be corrosive to metallic parts. Immersion times should not be extended beyond the mentioned time periods and the sanitizers must be thoroughly rinsed from the respirator parts.

Respirators may be contaminated with toxic materials. If the contamination is light, normal cleaning procedures should provide satisfactory decontamination; otherwise separate decontamination step(s) may be required before cleaning.