Designation: F3387 – 23

Standard Practice for Respiratory Protection[1]

This standard is issued under the fixed designation F3387; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice sets forth minimally accepted practices for occupational respirator use; provides information and guidance on the proper selection, use, and maintenance of respirators; and contains requirements for establishing, implementing, and evaluating respirator programs.

1.2 This practice covers the use of respirators to protect persons against the inhalation of harmful air contaminants and oxygen-deficient atmospheres in the workplace. The following are not covered by this practice:

1.2.1 Underwater breathing devices,

1.2.2 Aircraft oxygen systems,

1.2.3 Supplied-air suits,

1.2.4 Use of respirators under military combat conditions, and

1.2.5 Medical inhalators and resuscitators.

1.3 *Units*—The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3537 Guide for Respirator Fit Testing Methods

F3620 Practice for Respiratory Protection—Respirator Use—Physical Qualifications for Personnel

2.2 *ANSI Standards:*[3]

ANSI/ASSE Z117.1 Safety Requirements for Entering Confined Spaces

ANSI/ASSE Z88.2 Practices for Respiratory Protection

ANSI Z88.10 Respirator Fit Testing Methods

2.3 *CAN/CSA Standards:*[4]

CAN/CSA Z94.4 Selection, Use, and Care of Respirators

CAN/CSA Z180.1 Compressed Breathing Air and Systems

2.4 *CGA Standards:*[5]

CGA C-7 Guide to Classification and Labeling of Compressed Gases

CGA G-7.1 Commodity Specification for Air

2.5 *NFPA Standards:*[6]

NFPA 1851 Standard on Selection, Care, and Maintenance of Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting

NFPA 1981 Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services

2.6 *Federal Standards:*[7]

29 CFR Part 1910.134 Respiratory Protection

29 CFR Part 1910.146 Permit-Required Confined Spaces

[1] This practice is under the jurisdiction of ASTM Committee F23 on Personal Protective Clothing and Equipment and is the direct responsibility of Subcommittee F23.65 on Respiratory.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from Canadian Standards Association (CSA), 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada, http://www.csagroup.org.

[5] Available from Compressed Gas Association (CGA), 14501 George Carter Way, Suite 103, Chantilly, VA 20151, http://www.cganet.com.

[6] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

[7] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

42 CFR Part 84 Respiratory Protective Devices
49 CFR Part 180 Continuing Qualification and Maintenance of Packagings

3. Terminology

3.1 *Definitions:*

3.1.1 *abrasive blasting respirator, n*—airline respirator designed to protect the wearer from inhalation of, impact of, and abrasion by materials used or generated in abrasive blasting.

3.1.2 *aerodynamic diameter, n*—diameter of a unit density sphere having the same terminal settling velocity as the particle in question.

3.1.3 *aerosol, n*—particles, solid or liquid, suspended in air (for example, dust, fumes, mists, or fibers).

3.1.4 *airline respirator (supplied-air respirator, SAR), n*—atmosphere-supplying respirator in which the respirable air is supplied from a hose or breathing tube rather than being carried by the wearer.

3.1.5 *air-purifying respirator, n*—respirator in which ambient air is passed through an air-purifying element by either inhalation or by means of a blower.

3.1.6 *ambient air pump, n*—motorized blower used to supply air to a continuous-flow airline respirator.

3.1.7 *approved, v*—respirator for which a formal certificate was issued by the National Institute for Occupational Safety and Health (NIOSH) or by NIOSH and the Mine Safety and Health Administration (MSHA) in accordance with 42 CFR Part 84 and is maintained in full compliance with the certificate.

3.1.8 *assigned protection factor, APF, n*—minimum expected workplace level of respiratory protection that would be provided by a properly functioning and used respirator or a class of respirators to properly fitted and trained wearers when all elements of an effective respirator program are established and being implemented.

3.1.9 *atmosphere-supplying respirator, ASR*—class of respirators that supply a respirable atmosphere independent of the workplace atmosphere.

3.1.9.1 *Discussion*—This class includes airline respirators and self-contained breathing apparatus (SCBA).

3.1.10 *bioaerosol, n*—liquid droplet (generated, for example, by coughing, sneezing) or a solid particle (generated, for example, by sweeping, shoveling) suspended in the air that is living or originates from living organisms.

3.1.10.1 *Discussion*—Bioaerosols include living or dead microorganisms, fragments, toxins, and particulate waste products from all varieties of living things. They are capable of causing infection and an adverse or allergic response potentially leading to disease. Individual bioaerosols most often range in size from 0.4 to 3937 µin. (0.01 to 100 µm) in diameter.

3.1.11 *biomonitoring, v*—determination of the concentration of a substance in biological fluids or tissue and used for occupational exposure surveillance.

3.1.12 *canister (air purifying), n*—container with (*1*) gas- and vapor-removing sorbent or catalyst, or (*2*) gas- and vapor-removing sorbent or catalyst that removes gases and vapors and filter that removes particles from inspired air (or air drawn through the unit).

3.1.12.1 *Discussion*—Typically attached to a full-face piece, either mounted directly to the chin or connected to a breathing tube so the canister may be worn in the front or back of the person. Respirators with air-purifying canisters are approved by NIOSH as gas masks and contain an approval number TC-14G-xxxx.

3.1.13 *canister (carbon dioxide scrubbing), n*—container filled with a chemical used to remove carbon dioxide from exhaled air before that air is rebreathed in a closed-circuit SCBA.

3.1.14 *canister (oxygen generating), n*—container filled with a chemical that generates oxygen by chemical reaction used in closed-circuit SCBA.

3.1.15 *cartridge, n*—small container filled with sorbents or catalysts that remove gases and vapors from the inspired air.

3.1.15.1 *Discussion*—The cartridge may also have particulate filters that are an integral part or ones that are replaceable.

3.1.16 *ceiling limit, n*—maximum allowable concentration of an airborne contaminant that shall not be exceeded at any time.

3.1.17 *certified, v*—see *approved*.

3.1.18 *change schedule, n*—time interval after which a used filter, cartridge, or canister is replaced with a new one.

3.1.19 *confined space, n*—enclosed space not designed for human occupancy that has the following characteristics: restricted entry and exit, primary function is something other than human occupancy, and contains potential or known respiratory hazards.

3.1.19.1 *Discussion*—Examples of confined spaces include, but are not limited to: tanks, silos, vessels, pits, sewers, pipelines, tank cars, boilers, septic tanks, and utility vaults. See 29 CFR 1910.146 and ANSI/ASSE Z117.1 for more details on permit-required confined spaces.

3.1.20 *contaminant, n*—potentially harmful, irritating, or nuisance airborne material.

3.1.21 *continuous-flow respirator*—atmosphere-supplying respirator that provides a continuous flow of respirable air to the respiratory inlet covering.

3.1.22 *demand respirator, n*—atmosphere-supplying respirator that admits respirable air to the respiratory inlet covering only when a negative pressure is created inside the respiratory inlet covering by inhalation.

3.1.23 *dust, n*—aerosol consisting of mechanically produced solid particles derived from the breaking up of larger particles.

3.1.24 *end-of-service-life indicator, ESLI, n*—system or device that warns the wearer of the approach of the end of adequate respiratory protection.

3.1.25 *escape-only respirator, n*—respirator intended only for use during emergency egress from a hazardous atmosphere.

3.1.26 *filter, n*—material used in air-purifying respirators to remove solid or liquid aerosols from inspired air; some filters are encapsulated in a container and some are not.

3.1.26.1 *HE filter, n*—NIOSH classification for a 99.97 % efficiency filter used in a powered air-purifying respirator (PAPR) that is effective against all particulate aerosols.

3.1.26.2 *N-series particulate filter, n*—NIOSH classification for particulate filters effective against particulate aerosols free of oil; time-use restrictions may apply.

3.1.26.3 *P-series particulate filter, n*—NIOSH classification for particulate filter effective against all particulate aerosols.

3.1.26.4 *R-series particulate filter, n*—NIOSH classification for particulate filter effective against all particulate aerosols; time-use restrictions may apply.

3.1.26.5 *Discussion*—N-, R-, and P-series particulate filters are tested at 99.97, 99, and 95 % efficiency levels, referred to as Classes 100, 99, and 95, respectively.

3.1.27 *filtering face piece, n*—negative-pressure respirator in which the filter is an integral part of the face piece or comprises the entire face piece.

3.1.28 *fit factor, n*—numeric expression of how well a tight-fitting respirator fits a wearer during a quantitative fit test, and it is the ratio of the measured challenge agent concentration outside the respirator (C_{out}) to its concentration inside the respirator (C_{in}).

$$\text{Fit factor} = C_{out} / C_{in} \quad (1)$$

3.1.28.1 *Discussion*—A fit factor resulting from a qualitative fit test has been validated to 100 (Annex A5).

3.1.29 *fit test, n*—use of a qualitative or quantitative protocol to evaluate sealing surface leakage of a specific tight-fitting respirator while worn by an individual.

3.1.30 *fume, n*—aerosols formed by condensation of a vaporized solid.

3.1.31 *gas, n*—fluid that has neither an independent shape nor volume and tends to expand indefinitely.

3.1.31.1 *Discussion*—In contrast, liquids have independent volume but not independent shape.

3.1.32 *hazard ratio, n*—number obtained by dividing the concentration of a contaminant by its occupational exposure limit.

3.1.33 *hazardous atmosphere, n*—atmosphere that contains a contaminant(s) in excess of the occupational exposure limit or is oxygen deficient.

3.1.34 *helmet, n*—hood that offers head protection to the wearer against impact and penetration.

3.1.35 *high-efficiency particulate air (HEPA) filter, n*—HEPA filters are considered N100, R100, P100, and HE.

3.1.35.1 *Discussion*—P100 and HE filters are identified with a magenta color.

3.1.36 *hood, n*—tight- or loose-fitting respiratory inlet covering that completely covers the head and neck and may cover portions of the shoulders.

3.1.37 *immediately dangerous to life or health, IDLH, n*—any atmosphere that poses an immediate hazard to life or immediate irreversible debilitating effects on health.

3.1.38 *loose-fitting face piece, n*—respiratory inlet covering that is designed to form a partial seal with the face, does not cover the neck and shoulders, and may or may not offer head protection against impact and penetration.

3.1.39 *mass median aerodynamic diameter, MMAD, n*—calculated aerodynamic diameter that divides the aerosol particles based on the weight of the particles.

3.1.39.1 *Discussion*—By weight, 50 % of the particles will be larger than the MMAD and 50 % of the particles will be smaller than the MMAD.

3.1.40 *maximum use concentration, MUC, n*—maximum atmospheric concentration of a hazardous substance from which a wearer can be expected to be protected when wearing a respirator and is frequently determined by the assigned protection factor of the respirator or class of respirators and the exposure limit of the hazardous substance.

3.1.40.1 *Discussion*—The MUC can frequently be determined mathematically by multiplying the assigned protection factor specified for a respirator by the required time-weighted average occupational exposure limit (OEL), short-term exposure limit, or ceiling limit. When no OEL is available for a hazardous substance, an employer shall determine a MUC on the basis of relevant available information and informed professional judgment.

3.1.41 *mist, n*—aerosol composed of liquid droplets produced either mechanically or by condensation of vaporized liquid.

3.1.42 *mouthpiece and nose clamp assembly, n*—respiratory inlet covering that is held in the wearer's mouth and shall always be used in conjunction with a nose clamp.

3.1.43 *negative-pressure respirator, n*—respirator in which the air pressure inside the respiratory inlet covering is negative during inhalation with respect to the ambient air pressure.

3.1.44 *occupational exposure limit, OEL, n*—maximum allowable concentration of a contaminant in the air to which an individual may be exposed over a period of time.

3.1.44.1 *Discussion*—Commonly used OELs include Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) and ACGIH® threshold limit values (TLVs®).[8] These may be time-weighted averages, short-term limits, or ceiling limits.

3.1.45 *physician or other licensed healthcare professional, PLHCP, n*—individual whose legally permitted scope of practice (that is, license, registration, or certification) allows them to independently provide, or be delegated the responsibility to provide, some or all of the healthcare services required by 29 CFR 1910.134(e).

3.1.46 *positive-pressure respirator, n*—respirator in which the pressure inside the respiratory inlet covering is normally positive with respect to ambient air pressure (Annex A6).

3.1.47 *powered air-purifying respirator, PAPR, n*—air-purifying respirator that uses a blower to move the ambient atmosphere through air-purifying elements into the respiratory inlet covering.

[8] ACGIH® and TLVs® are registered trademarks of the American Conference of Governmental Industrial Hygienists.

3.1.48 *pressure-demand respirator, n*—atmosphere-supplying respirator in which the pressure inside the respiratory inlet covering, in relation to the pressure surrounding the outside of the respiratory inlet covering, is positive during both inhalation and exhalation.

3.1.49 *qualitative fit test, QLFT, n*—pass/fail fit test that relies on the subject's sensory response to detect a challenge agent.

3.1.50 *quantitative fit test, QNFT, n*—fit test that uses an instrument to measure face seal leakage.

3.1.51 *required fit factor, RFF, n*—numeric value established as pass/fail point or acceptance criterion for a quantitative fit test.

3.1.52 *respirator, n*—personal protective equipment (PPE) designed to protect the wearer from inhalation of hazardous atmospheres.

3.1.53 *respirator manufacturer, n*—entity that designs or manufactures (or both) a respirator, or has a respirator designed or manufactured (or both) for them under their name or trademark.

3.1.54 *respirator user instructions, n*—instructions and information provided by the respirator manufacturer.

3.1.55 *respiratory inlet covering, n*—that portion of a respirator that connects the wearer's respiratory tract to an air- or atmosphere-supplying respirator.

3.1.55.1 *Discussion*—They may be either tight fitting or loose fitting in design. It may be a face piece, helmet, hood, or mouthpiece/nose clamp.

3.1.56 *self-contained breathing apparatus, SCBA, n*—atmosphere-supplying respirator in which the respirable gas source is designed to be carried by the wearer.

3.1.57 *service life, n*—period of time that a respirator provides adequate protection to the wearer.

3.1.58 *shall, v*—denoting a mandatory requirement.

3.1.59 *should, v*—denotes a recommendation.

3.1.60 *sorbent, n*—material that removes specific gases and vapors from the inhaled air.

3.1.61 *supplied-air respirator, n*—see *airline respirator*.

3.1.62 *tight-fitting respiratory inlet covering, n*—respirator component designed to form a complete seal with the face or neck.

3.1.62.1 *Discussion*—A half-face piece (includes quarter-masks, filtering face piece, and half-face piece with elastomeric face pieces) covers the nose and mouth; a full-face piece covers the nose, mouth, and eyes. Tight-fitting hoods seal at the neck.

3.1.63 *user, n*—person or organization who makes use of the respirator; for example, one involved in selecting, maintaining, or wearing the respirator.

3.1.64 *vapor, n*—gaseous phase of matter that normally exists in a liquid or solid state at room temperature and pressure.

3.1.65 *wearer, n*—person who wears the respirator.

3.1.66 *wearer seal check (namely, user seal check), n*—procedure conducted by the wearer to determine if a tight-fitting respirator is properly donned; see Section 11.

3.1.67 *written record, n*—documentation, either paper or electronic, of any record-keeping requirements and details of the respirator program.

4. Significance and Use

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

4.2 *Exceptions*—Users of this practice shall be aware that regulatory agencies may have requirements that are different from this practice.

5. Respirator Program Requirements

5.1 *Purpose*—This section establishes requirements for using respirators in the workplace. The following requirements are supplemented by recommended practices in subsequent sections of this practice.

5.2 *Permissible Practice*—In the control of those occupational diseases or injuries caused by breathing contaminated air or oxygen-deficient atmospheres, the primary objective shall be to minimize the workplace exposure. 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 implemented or evaluated, appropriate respirators shall be used according to the requirements of this practice.

5.3 *Employer Responsibility:*

5.3.1 The employer shall select approved respirators according to the airborne hazards likely to be encountered in the workplace and provide them at no cost to the employee. The selection process shall include workplace and user factors that are specific and unique to each workplace.

5.3.2 The employer shall be responsible for establishing and maintaining a respirator program that shall include the requirements outlined in 5.5.

5.3.3 The employer shall allow a respirator wearer to leave the hazardous atmosphere for any respirator-related cause. Reasons may include, but are not limited to:

5.3.3.1 Respirator fails to provide adequate protection;

5.3.3.2 Respirator malfunction;

5.3.3.3 Detecting air-contaminant leakage into the respirator;

5.3.3.4 Increased breathing resistance;

5.3.3.5 Unusual discomfort in wearing the respirator;

5.3.3.6 Illness of the respirator wearer, including sensation of dizziness, nausea, and weakness;

5.3.3.7 Breathing difficulty, coughing, sneezing, vomiting, fever, and chills;

5.3.3.8 To wash their face and the respirator face piece to minimize skin irritation;

5.3.3.9 To change the air-purifying elements or other components whenever needed; and

5.3.3.10 When the respirator reaches the limits of its service life.

5.3.4 The employer shall investigate malfunctions of respirators to determine the cause and ensure corrective measures are taken. Suspected manufacturing defects should be reported to the manufacturer and the certifying agency.

5.3.5 The employer shall use a respirator equipped with an end-of-service-life indicator or establish a change schedule for filters, cartridges, and canisters. Guidance for determining a change schedule is contained in Annex A1.

5.3.6 The employer shall train the wearer in the proper and effective use of the provided respirators, including the proper egress from the hazardous environment before the end of service is reached and during failures of the respirator according to Section 9.

5.3.7 For all tight-fitting respirators, the employer shall ensure that employees perform a wearer seal check each time they put on the respirator using the procedures described in Section 11. Either the positive or negative pressure checks according to the respirator manufacturer's recommended wearer seal check method shall be used. Wearer seal checks are not substitutes for qualitative or quantitative fit tests.

5.4 *Wearer Responsibility:*

5.4.1 The wearer shall use the provided respirator in accordance with instructions and training received.

5.4.2 The wearer shall guard against damage to the respirator.

5.4.3 The wearer shall immediately leave the contaminated area according to established procedures if the wearer detects contaminant by odor, taste, or irritation; an ESLI indicates end of cartridge service life; or a respirator malfunction occurs. The wearer shall also immediately report the situation to the person designated by the employer in the written standard operating procedures (SOP).

5.4.4 The wearer shall report to the person designated by the employer in the written SOP any physical or medical condition that could impair the ability to wear a respirator properly.

5.4.5 The wearer who uses a tight-fitting respirator shall perform a wearer seal check to ensure that an adequate seal is achieved each time the respirator is worn.

5.5 *Minimal Acceptable Respirator Program Elements:*

5.5.1 *Program Administration*—Responsibility and authority for the respirator program shall be assigned to a single person (Section 6). That person shall be identified to all respirator wearers as the respirator program administrator in the written SOP.

5.5.2 *SOP*—Written SOP covering the complete respirator program shall be established and implemented (Section 7).

5.5.3 *Medical Evaluation*—A physician or other licensed healthcare professional (PLHCP) shall determine whether or not an employee has any medical conditions that would preclude the use of respirators, limitations on use, or other restrictions.

5.5.3.1 The program administrator shall advise the PLHCP of the following conditions to aid in determining the medical evaluation required:

(1) Type and weight of the respirator to be used by the employee;

(2) Duration and frequency of respirator use (including use for rescue and escape), typical work activities, and environmental conditions (for example, temperature and humidity extremes);

(3) Hazards for which the respirator will be worn, including potential exposure to reduced-oxygen environments; and

(4) Additional protective clothing and equipment to be worn.

5.5.3.2 Written records of medical evaluations shall be secured and maintained as medical records.

5.5.3.3 For additional information on medical evaluations, refer to Practice F3620.

5.5.4 *Respirator Selection*—The selection of the proper type(s) of respirator(s) shall be based upon their capabilities, limitations, and respiratory hazards (Section 8).

5.5.5 *Training*—Each respirator wearer shall be given training and retraining according to Section 9.

5.5.6 *Fit Testing*—Each wearer shall be fit tested before being assigned a tight-fitting respirator (Section 10).

5.5.7 *Maintenance, Inspection, and Storage*—Maintenance shall be carried out by properly trained individuals according to the respirator user instructions and on a schedule that ensures that each respirator wearer is provided with a respirator that is clean, sanitary, and in good operating condition. Each respirator shall be inspected by the wearer before its use to ensure that it is in proper working condition. Respirators shall be stored in a convenient, clean, and sanitary location according to the respirator user's instructions (Section 12).

6. Program Administration

6.1 *Respirator Program Administrator*—An individual shall be assigned responsibility and authority for administering the respirator program. This individual shall have access and direct communication to the site manager for matters impacting worker safety and health. It is preferable that the administrator be in the company's industrial hygiene, environmental, health physics, or safety engineering department. A third-party entity meeting these requirements may provide this service.

6.2 *Respirator Program Administrator Qualifications*—Respirator program administrators shall be knowledgeable in respiratory protection and competent in the administration of their duties. Program administrators shall keep abreast of current issues, advances, and regulations.

6.3 *Responsibilities:*

6.3.1 *Respirator Program Administrator Responsibilities*—The administrator's responsibilities shall ensure that the following components of the respirator program are conducted:

6.3.1.1 Measurement, estimation, or review of information on the concentration of airborne contaminant(s) in the work area before respirator selection and periodically during respirator use;

6.3.1.2 Ensuring that medical evaluations, training, and fit testing are performed;

6.3.1.3 Selection of the appropriate type or class of respirator that will provide adequate protection for each contaminant, present or anticipated;

6.3.1.4 Maintenance of records and written procedures in a manner that documents the respirator program and allows for the evaluation of the program's effectiveness;

6.3.1.5 Evaluation of the respirator program's effectiveness; and

6.3.1.6 Revision of the program as necessary.

6.3.2 *Respirator Program Audit*—The most comprehensive respirator program is of little value if it is not maintained and implemented as designed and corrected when deficiencies are identified. Therefore, in addition to ongoing surveillance, the program administrator shall annually audit the respirator program to ensure that the program procedures reflect the requirements of current applicable regulations and industry-accepted standards and the program as implemented reflects the written procedures.

6.3.2.1 To aid objectivity, an additional audit shall be conducted by a knowledgeable person not directly associated with the program, rather than the respirator program administrator. The frequency of this outside audit should be determined by the size and complexity of the respirator program and previous audit findings. An audit checklist, or equivalent, shall be prepared and updated as necessary.

6.3.2.2 The audit shall focus, as a minimum, on the following areas:

(1) Respirator program;
(2) Program administration;
(3) Training;
(4) Medical evaluation;
(5) Fit testing;
(6) Air sampling and classification of hazard(s);
(7) Selection and issuance;
(8) Use;
(9) Equipment cleaning, maintenance, and inspection;
(10) Breathing air quantity and quality;
(11) Storage;
(12) Emergency preparedness;
(13) Special problems; and
(14) Corrective action.

6.3.2.3 Action shall be taken to correct any defects or shortcomings found during the audit. Findings shall be documented, including plans to correct problem areas with target dates for completion and tracking mechanisms to ensure completion.

6.3.3 *Medical Surveillance*—When applicable, medical surveillance, which may include biomonitoring, shall be carried out periodically to determine if respirator wearers are adequately protected. An occupational health professional (for example, industrial hygienist, health physicist), in conjunction with a PLHCP, shall determine the medical surveillance program requirements.

7. Standard Operating Procedures (SOP)

7.1 Written SOP shall be established by the employer and shall cover a complete respirator program for routine and emergency situations. Copies of the procedures shall be available for all wearers to read. The procedures shall be reviewed in conjunction with the annual respirator program audit and revised by the program administrator as necessary.

7.2 *Operating Procedure Elements for Respirator Use*—Written SOP shall include information necessary, as appropriate, for the proper use of respirators, including:

7.2.1 Hazard assessment;
7.2.2 Respirator selection;
7.2.3 Medical evaluation;
7.2.4 Training;
7.2.5 Fit testing;
7.2.6 Issuance;
7.2.7 Maintenance, inspection, and storage;
7.2.8 Air-purifying element change schedule;
7.2.9 Breathing air quality;
7.2.10 Monitoring respirator use;
7.2.11 Hazard re-evaluation;
7.2.12 Employer policies; and
7.2.13 Program evaluation and auditing.

7.3 *Special Considerations for Respirators Used for Emergency Escape*—Written SOP shall be developed covering respirators used for emergency escape. Using guidance in Section 8, a hazard assessment shall be performed to determine if, during an emergency, the use of respirators for escape is required and, if so, the appropriate type of respirator for escape shall be selected. Consideration should be given to past emergencies and occurrences that required using respirators for escape, as well as conditions that may have necessitated their use, such as equipment or power failures, uncontrolled chemical reactions, fire, explosion, or human error.

7.3.1 An adequate number of escape respirators shall be provided and accessible where they may be needed.

7.3.2 *Personnel Assigned to Work Areas Where Escape Respirators Are Required*—Personnel assigned to areas where respirators may be required for escape shall be enrolled in the complete respirator program, including medical evaluation and training in the use and limitations of escape respirators.

7.3.3 *Visitors and Personnel Not Assigned to Work Areas Where Escape Respirators Are Required*—Medical approval is not required for visitors and personnel not assigned to work areas where hooded or mouthpiece escape-only respirators are provided for potential emergencies. However, they shall be trained in how to don and use the escape-only respirator according to the respirator user instructions.

7.3.3.1 For work areas where self-contained breathing apparatus having a tight-fitting respiratory inlet covering, gas masks, or other non-escape-only respirators are selected for emergency escape, visitors shall receive medical evaluation, respirator training, and fit testing.

7.3.4 *Operating Procedure Elements for Emergency Respirator*—Written SOP shall be developed for all emergency use and anticipated emergency use.

8. Respirator Selection

8.1 Respirator selection for routine and emergency use shall involve:

8.1.1 Hazard assessment;

8.1.2 Respirator selection of type or class of respirators that can offer adequate protection; and

8.1.3 Maintaining written records of hazard assessment and respirator selection (Section 14).

8.2 *Hazard Assessment*—Perform a hazard assessment including evaluation of potential respiratory hazards (oxygen deficiency or airborne contaminants) and any other hazardous conditions present such as eye and skin hazards, humidity and temperature extremes, and other environmental conditions to assist in the selection of an appropriate respirator

8.2.1 When the only hazard identified is a bioaerosol, the guidance in 8.3.3 shall be followed.

8.2.2 *Hazard Assessment Steps for the Inhalation Hazard:*

8.2.2.1 The nature of the inhalation hazard shall be established by determining:

(1) Which contaminant(s) may be present in the workplace;

(2) The physical state and chemical properties of all airborne contaminants;

(3) By measurement or estimation, the likely airborne concentration of the contaminant(s);

(4) If the potential for an oxygen-deficient environment exists;

(5) Whether there is an occupational exposure limit for each contaminant;

(6) If an IDLH atmosphere exists;

(7) If there is an applicable health regulation or OSHA substance-specific standard (for example, lead, asbestos) for the contaminant(s); and

(8) If the contaminant(s) can be absorbed through the eyes or skin, produce skin sensitization, or be irritating or corrosive to the eyes or skin.

8.2.2.2 Determine which contaminant(s) may be present in the workplace. The following factors concerning an operation or process shall be taken into consideration:

(1) Operation or process characteristics as they relate to the release of air contaminants through routine or non-routine procedures, malfunctioning of equipment, or processes or spills;

(2) Materials used, produced, or stored, including raw materials, end products, by-products, chemical reactivity, and wastes; and

(3) Emergency repair, shutdown procedures, escape, and rescue operations.

8.2.2.3 Determine the physical state and chemical properties of all airborne contaminants. The physical states for all airborne contaminants as they are likely to be encountered shall be identified as follows:

(1) Gas or vapor, or

(2) Particle.

8.2.2.4 If the contaminant is a particulate hazard, determine if it is an oil or if an oil aerosol is present along with the particulate contaminant.

NOTE 1—Knowledge of the presence of airborne oil is needed to select a particulate filter properly (8.3.2.11 and Annex A2).

NOTE 2—Examples of activities that are known to produce airborne oil include use of air compressor systems with oil lubricators and operation of motor vehicles.

8.2.2.5 Determine the likely airborne concentration of the contaminant(s). An estimate of the airborne concentrations of contaminants to which persons might be exposed shall be conducted as follows:

(1) Air sampling and analysis conducted in accordance with recognized occupational hygiene practices **(1)**;[9]

(2) Mathematical modeling or estimating based on the workplace volume and physical properties (for example, vapor pressure); or

(3) Experience from similar circumstances and materials.

8.2.2.6 Anticipated exposures should account for variations in process operation, rate and direction of air movement, temperature (ambient or process), and seasonal variations. The workplace atmosphere shall be assessed on a regular basis for respiratory hazards to confirm that the proper type of respirator is being used.

8.2.2.7 Determine if the potential for an oxygen-deficient environment exists. Where the potential for an oxygen-deficient atmosphere exists, the oxygen concentration shall be measured. Where oxygen concentration is below 159 mmHg (21 kPa) (20.9 % oxygen at sea level), the cause of the deficiency shall be identified and understood or monitored if appropriate, or both. Where oxygen concentration is confirmed to be below 19.5 % (at sea level), the cause of the deficiency shall be determined and ongoing monitoring shall be performed (Annex A3) or the atmosphere shall be assumed to be IDLH until the cause of the deficiency is understood and controlled to greater than 122 mmHg (16.27 kPa) (16 % oxygen at sea level); see 8.2.2.10.

8.2.2.8 Oxygen deficiency is classified as either IDLH or non-IDLH by this practice.

(1) Oxygen-Deficiency IDLH—An oxygen partial pressure less than 122 mmHg (16.27 kPa) (16 % oxygen at sea level) shall be considered IDLH.

(2) Oxygen-Deficiency Non-IDLH—An oxygen partial pressure of ≥122 mmHg (16.27 kPa) (16 % oxygen at sea level) and less than 148 mmHg (19.73 kPa) (19.5 % oxygen at sea level) shall be considered an oxygen-deficient atmosphere that is not immediately dangerous to life.

8.2.2.9 Determine whether there is an occupational exposure limit for each contaminant. Occupational exposure limits shall be identified such as published threshold limit value, permissible exposure limit, derived air concentration (radiological protection limits), or any other available exposure limits or estimate of toxicity for the contaminant(s).

8.2.2.10 Determine if an IDLH atmosphere exists. A location shall be considered to be IDLH when:

[9] The boldface numbers in parentheses refer to a list of references at the end of this standard.

(1) The identity or concentration of a contaminant is unknown (for example, interior structural fire-fighting) or it is an atmosphere known or suspected to have concentrations above the IDLH level for that contaminant (see Ref **(2)** for IDLH values for specific substances);

(2) It is a space that contains less than the normal 159 mmHg (21 kPa) (20.9 % oxygen at sea level) oxygen, unless the source of the oxygen reduction is understood and controlled or the oxygen concentration is unknown;

(3) Oxygen partial pressure is below 122 mmHg (16.27 kPa) (16 % oxygen at sea level);

(4) Total atmospheric pressure less than 584 mmHg (77.86 kPa) equivalent to 7000 ft (2134 m) altitude or any combination of reduced percentage of oxygen and reduced pressure that leads to an oxygen partial pressure less than 122 mmHg (16.27 kPa) (for example, areas other than sea level) (8.3.4 and Annex A3); or

(5) Any confined space containing less than 159 mmHg (21 kPa) (20.9 % oxygen at sea level) oxygen, unless the source of the oxygen reduction is understood and controlled (8.3.4 and 8.3.5). This restriction is imposed because any reduction in the percentage of oxygen present is proof, at a minimum, that the confined space is not adequately ventilated.

8.2.2.11 Determine if there is an applicable OSHA substance-specific standard for the contaminant(s). Determine if there is an applicable substance-specific standard by reviewing applicable standards, for example, OSHA, MSHA. If so, there may be specific respirators required that will influence the selection process.

8.2.2.12 *Determination of Other Hazards:*

(1) Determine whether the contaminant(s) can be absorbed through the eyes or skin, produce skin sensitization, or be irritating or corrosive to the eyes or skin.

(2) Determine the nature of other hazards and environmental conditions that may exist that would affect respirator selection, such as:

(a) Heat, cold, humidity;
(b) Head impact hazards;
(c) Welding arc;
(d) Splash; and
(e) Eye impact.

8.3 *Respirator Selection:*

8.3.1 *General Considerations:*

8.3.1.1 Proper respirator selection for any situation shall consider the following:

(1) The nature of the hazard;
(2) Worker activity and workplace factors;
(3) Respirator use duration;
(4) Respirator limitation; and
(5) Use of approved respirators.

8.3.1.2 *Nature of the Hazard*—Nature of the hazardous atmosphere shall be determined by the hazard assessment:

(1) IDLH;
(2) Non-IDLH;
(3) Oxygen deficient; or
(4) Bioaerosol.

8.3.1.3 *Worker Activity*—Worker activity and worker location in a hazardous area shall be considered in selecting the proper respirator. These considerations shall include:

(1) The period of time for which the respirator is to be used, whether the worker is in the hazardous area continuously or intermittently during the work shift;

(2) Physical demands made on the worker, whether the work rate is light, medium, or heavy;

(3) Work area layout;

(4) Work activities; and

(5) Temperature and humidity of the work environment (8.3.8.5) or concern for heat stress, or both, based on other personal protective equipment (PPE) selected.

8.3.1.4 Several of these considerations may apply. For example, extreme physical exertion can cause the wearer to deplete the air supply in a SCBA such that service life is significantly reduced.

8.3.1.5 *Respirator Use Duration*—The period of time that a respirator shall be worn is an important factor that shall be taken into account in selecting a respirator. Consideration shall be given to the type of use, such as routine, non-routine, emergency, or rescue. Respirator wearers shall be given breaks throughout the day. The work/rest period may be dependent on other factors such as heat stress, work rate, and intended service life of the respirator.

8.3.1.6 *Respirator Limitations*—Performance limitations of the various types of respirators shall be considered during the selection process. Types of respirators and considerations for their use are described in Annex A2. For example:

(1) Service Life—The expected service time of a cartridge or filter, or the amount of breathing air available;

(2) Worker Mobility—Limits for hoses may include length, entry, and exit points. Bulkiness may limit entry into tight spaces;

(3) Compatibility with Other Protective Equipment—Respirator fit when used with other equipment, for example, the need for safety glasses, face shield, or welding equipment;

(4) Durability—Physical limitations of a specific respirator;

(5) Comfort Factors—Respirator fit, weight, breathing resistance, and ease of use;

(6) Compatibility with the Environment—For example, if flammable, explosive, or corrosive substances are present; and

(7) Compatibility with Job and Workplace Performance—For example, use of a firearm with different types of face pieces.

8.3.1.7 *Approved Respirators*—Approved respirators shall be used. Under 42 CFR Part 84, respirators are approved by NIOSH except respirators used in mine rescue and other mine emergencies, which are required to be approved by both NIOSH and MSHA. Any change or modification, however minor, may adversely affect the performance of the respirator and the resulting respirator configuration will not be NIOSH approved. Respirators approved by NIOSH and NIOSH/MSHA under provisions of 42 CFR Part 84 are listed in the NIOSH Certified Equipment List, which is available on the NIOSH website at: http://www.cdc.gov/niosh/npptl/topics/respirators/cel/.

8.3.2 *Selection Steps*—The following shall be considered or known for the respirator selection:

8.3.2.1 If there is an oxygen-deficient atmosphere, the type of respirator selected depends on the partial pressure of oxygen and the concentration of other contaminant(s) that may be present; go to 8.3.2.2.

8.3.2.2 If the atmosphere is oxygen-deficient IDLH, go to 8.3.4 and 8.3.5; if not, go to 8.3.2.3.

8.3.2.3 If an OSHA substance-specific standard or regulation exists for the contaminant, those guidelines or requirements for respirator selection shall be followed.

8.3.2.4 If unable to determine what potentially hazardous contaminant(s) may be present, the atmosphere shall be considered IDLH; go to 8.3.5.

8.3.2.5 If no exposure limit is available or can be determined, the atmosphere shall be considered IDLH; go to 8.3.5.

8.3.2.6 If the contaminant concentration is unknown, the atmosphere shall be considered IDLH; go to 8.3.5.

8.3.2.7 If the measured or estimated concentration of the contaminant(s) is considered IDLH, go to 8.3.5.

8.3.2.8 *Determine the Hazard Ratio:*

(1) Hazardous Substance(s) with Independent Toxicological Effect—Divide the measured or estimated concentration (Co) by the occupational exposure limit or guideline (OEL) to obtain a hazard ratio (HR) (HR = Co/OEL) of each contaminant. A respirator type and respiratory inlet covering with an assigned protection factor greater than the largest hazard ratio shall be selected (refer to OSHA assigned protection factors in 29 CFR 1910.134).

(2) Two or More Hazardous Substances with Similar Toxicological Effect—When two or more substances with similar toxicology are present, the combined effect of exposure shall be considered rather than considering each substance individually. Refer to ACGIH® threshold limit values (TLVs®) and biological exposure indicies (BEIs®) guides,[10] which address calculating threshold limit values for mixtures of components that additively affect the same target organ. If the calculated result for the mixture is greater than one, this indicates a respirator is required and this result is also the hazard ratio. A respirator type and respiratory inlet covering with an assigned protection factor greater than the hazard ratio shall be selected to ensure an appropriate level of protection (refer to OSHA assigned protection factors in 29 CFR 1910.134). If an air-purifying respirator is selected, continue with 8.3.2.9;

8.3.2.9 If the contaminant(s) is a gas or vapor only, go to 8.3.2.12. If an aerosol-only contaminant is present, go to 8.3.2.11.

8.3.2.10 If the contaminant is a bioaerosol, go to 8.3.3.

8.3.2.11 If a high-efficiency (HEPA) filter is required by a specific regulation or standard, then an HE, N100, R100, or P100 filter shall be used. If no such regulation or standard exists, an appropriate N-, R-, or P-series filter may be used. If an oil is present or its presence unknown, an R, P, or HE filter shall be selected. If no oil is present, an N, R, P, or HE filter can be selected (refer to Annex A2 for description of these filters). Refer to 8.3.6 for filter change schedule.

8.3.2.12 If the contaminant is a gas or vapor, an atmosphere-supplying respirator shall be used unless:

(1) The air-purifying respirator has an end-of-service-life indicator (ESLI) that will indicate to the wearer before contaminant breakthrough, or

(2) Chemical cartridge/canister change schedule is implemented. Some substance-specific regulations include specific chemical cartridge/canister change schedules. (See 8.3.7 and Annex A1 for guidance in establishing a change schedule.)

8.3.2.13 When aerosols and gases/vapors are both present, a filter in combination with a chemical cartridge/canister shall be selected. Substances from the TLV booklet with the inhalable fraction vapor (IFV) footnote should be considered to be present in both aerosol and vapor form unless determined otherwise.

8.3.2.14 If the material can be absorbed through the skin or is a skin or eye irritant, other appropriate PPE, which is compatible with the respirator, shall be used.

8.3.3 *Bioaerosols*—For respirator selection for bioaerosols, refer to CAN/CSA Z94.4. Respirator selection for bioaerosols without OELs cannot follow the procedures in this practice. Where regulations or guidelines exist that are specifically applicable to some bioaerosols, they shall be considered during the respirator selection process. These guidelines may come from agencies such as Centers for Disease Control and Prevention (CDC) or OSHA.

8.3.4 *Respirator Selection for Oxygen Deficiency*—Air-purifying respirators shall not be used in atmospheres with a partial pressure of oxygen (PO_2) less than 148 mmHg (19.73 kPa) (19.5 % oxygen at sea level). For atmospheres with a PO_2 equal to or greater than 122 mmHg (16.27 kPa) (16 % oxygen at sea level) and less than 148 mmHg (19.73 kPa) (19.5 % oxygen at sea level), an atmosphere-supplying respirator shall be selected. Under these conditions, an airline respirator is allowed if the source of the oxygen reduction is understood and controlled. For atmospheres with a PO_2 less than 122 mmHg (16.27 kPa) (16 % oxygen at sea level) or a confined space with an oxygen concentration less than 159 mmHg (21 kPa) (20.9 % oxygen at sea level) (unless the source of the oxygen reduction is understood and controlled), a full-face pressure-demand SCBA or combination multifunctional full-face pressure-demand airline respirator with self-contained air cylinder shall be selected. Table 1 summarizes the respiratory protection required for protection against reduced-oxygen atmospheres. Acclimatized workers can continue to perform their work without atmosphere-supplying respirators at altitudes up to 14 000 ft (4267.2 m), as long as the ambient oxygen content remains above 148 mmHg (19.73 kPa) (19.5 % oxygen at sea level) and the wearer has no medical condition that would require the use of supplemental oxygen.

8.3.5 *Respirators for Use Under IDLH Atmospheres:*

8.3.5.1 *Respirator Selection*—Respiratory protection for IDLH conditions caused by the presence of toxic materials or a reduced percentage of oxygen as described in conditions in 8.3.4 shall be a full-face-piece, pressure-demand SCBA or a

[10] ACGIH®, TLVs®, and BEIs® are registered trademarks of the American Conference of Governmental Industrial Hygienists.

TABLE 1 Respirator Selection for Combined Effect of Altitude and Reduced Percentage of Oxygen

NOTE 1—Oxygen partial pressures <122 mmHg dictate the need for an SCBA or a combination airline respirator with auxiliary air cylinder and assumes a normal, healthy, un-acclimatized worker. Also, see Annex A3 for other considerations in using respirators in reduced-oxygen atmospheres.

NOTE 2—For oxygen partial pressures between 159 and 148 mmHg, air-purifying respirators may be worn if the source of the oxygen reduction is understood and controlled and the type of other inhalation hazards and their concentrations are such that the protection provided by air-purifying respirators is adequate.

NOTE 3—For oxygen partial pressure ≥122 and <148 mmHg, airline respirators may be worn if the source of the oxygen reduction is understood and controlled.

NOTE 4—At 10 000 ft (3048 m) or higher, or in any space where the total ambient pressure is less than 523 mmHg, specially designed and approved SCBA supplying enriched oxygen or a closed-circuit SCBA shall be used. At least 23 % oxygen is required at 10 000 ft (3048 m) or a total ambient pressure of <523 mmHg and 27 % oxygen at 14 000 ft (4267 m) or a total ambient pressure of less than 450 mmHg.

Altitude/Total Pressure	20.9 % PO_2 [mmHg]	Percent O_2 <19.5 % PO_2 [mmHg]	<16 % and below (Table Note 1) PO_2 [mmHg]
Sea level 760 mmHg	159 to 148 (19.5 % O_2) Air-purifying respirator if needed for non-oxygen-deficient inhalation hazards (Table Note 2).	<148	<122
1000 ft 733 mmHg	153	143	117
2000 ft 707 mmHg	147.8	138 O_2 deficiency non-IDLH	113
3000 ft 681 mmHg	142	133 Airline respirator (Table Note 3)	109
4000 ft 656 mmHg	137	128	105
5000 ft 632 mmHg	132	123	101
6000 ft 609 mmHg	127	119	97
7000 ft 584 mmHg	122	114	93
8000 ft 565 mmHg	118[A]	110 O_2 deficiency IDLH	90
9000 ft 543 mmHg	113[A]	106 Pressure demand, full-face SCBA or combination airline/SCBA	87
10 000 ft (Table Note 4) 523 mmHg	109[A]	102	84
11 000 ft 503 mmHg	105[A]	98	80
12 000 ft 484 mmHg	101[A]	94	77
13 000 ft 465 mmHg	97[A]	91	74
14 000 ft 450 mmHg	94[A]	88	72

[A] Acclimatized workers can continue to perform their work without atmosphere-supplying respirators, at altitudes up to 14 000 ft, as long as the ambient oxygen content remains above 19.5 % and the wearer has no medical condition that would require the use of supplemental oxygen.

full-face-piece, multifunctional, pressure-demand supplied-air respirator with self-contained air supply. Respirators that provide a minimum flow rate of 100 lpm shall be selected. Demand SCBA respirators shall not be used for entering IDLH atmospheres. The respirator shall be selected to ensure that the capacity of the auxiliary cylinder is sufficient for the anticipated egress from an IDLH atmosphere.

8.3.5.2 *Standby Personnel*—When respirators are worn under IDLH conditions, at least one standby person shall be present in a safe area. Standby personnel shall be trained and

have the proper equipment available to assist the respirator wearer in case of difficulty. Communications (visual, voice, signal line, telephone, radio, or other suitable means) shall be maintained between the standby person and the wearer. While working in the IDLH atmosphere, the wearer shall be equipped with safety harness, safety lines, hoist, and so forth if necessary to permit removal to a safe area. Provisions for rescue other than safety harness and lines may be used, if equivalent.

8.3.5.3 *Interior Structural Fire-Fighting*—For respiratory protection in interior structural fire-fighting, a full-face-piece, positive-pressure SCBA that meets the requirements of NFPA 1981 should be used.

8.3.6 *Filter Change Schedules*—Filters shall be replaced if damaged for hygienic reasons or if any increase in breathing resistance is noted. For detailed information on use limitations of filters, refer to the respirator user instructions or contact the manufacturer directly. See NIOSH for more details on filter efficiency degradation **(3, 4)**.

8.3.6.1 R-series filters shall be replaced after 8 h of use (continuous or intermittent) when oil is present. However, service time for the R-series filter can be extended using the same two methods described above for N-series filters **(3, 4)**.

8.3.7 *Chemical Cartridge/Canister Change Schedules*—For gas and vapor cartridges or canisters that do not have ESLI, a change schedule shall be established (Annex A1). The schedule should be based on a determination of the service life from testing, modeling, or other means of estimating capacity.

8.3.7.1 Warning properties shall not be used as a method of determining end of service life.

8.3.7.2 For cartridges and canisters with an ESLI, the respirator user instructions shall be followed.

8.3.8 *Additional Considerations Affecting Respirator Selection:*

8.3.8.1 *Alternative Respirators for Problematic Fitting Characteristics*—A tight-fitting respirator shall not be selected if a situation is encountered whereby a worker cannot obtain a satisfactory fit with a tight-fitting respirator as described in 10.4. Recommended alternatives to provide adequate respiratory protection are:

(1) Providing the wearer with a loose-fitting respiratory inlet covering of sufficient assigned protection factor for the hazard, or

(2) Transferring the worker to a job or worksite where respiratory protection is not required.

8.3.8.2 *Communications*—Ambient noise and communication needs shall be considered when specific respirators are selected. A respirator with communication aids should be selected if communication is critical and the noise levels interfere with communication (Annex A4).

8.3.8.3 *Vision Correction:*

(1) Spectacles—When a half-face-piece respirator wearer uses eyewear, it shall be fitted to provide good vision and shall be worn in such a manner as not to interfere with the seal of the respirator. Spectacles with straps or temple bars that pass through the sealing surface of full-face-piece respirators shall not be used. If corrective lenses are required, the respirator manufacturer's spectacle kit shall be used.

(2) Contact Lenses—Contact lenses may be worn with respirators if permitted by the employer. The contact lens wearer shall practice wearing the respirator while wearing contact lenses.

8.3.8.4 *Headwear Worn with Respirators*—A head or face covering that passes between the sealing surface of a tight-fitting respirator face piece and the wearer's face shall not be used. Headwear or other equipment shall not be worn if it interferes with the respirator performance.

8.3.8.5 *Respirator Use in Temperature Extremes:*

(1) Respirator Use in Low-Temperature Environments—Low temperatures may cause detrimental effects on the performance of respirators and may add undue physiological stress. The effects of low temperatures shall be considered in the selection and maintenance of respirators and respirable gas supplies.

(2) Respirator Use in High-Temperature Environments—High temperatures may affect the performance of the respirator and may add undue physiological stress. The effects of high temperatures shall be considered in respirator selection.

8.3.8.6 *Negative- or Positive-Pressure Atmospheres*—When working in negative-pressure (that is, hypobaric) atmospheres, the partial pressure of oxygen shall be considered and, if below 122 mmHg, a closed-circuit respirator having enriched oxygen source shall be used.

(1) When used in positive-pressure (that is, hyperbaric) atmospheres, breathing with a closed-circuit SCBA gradually increases inspired carbon dioxide concentrations. The resulting arterial carbon dioxide tension ($PaCO_2$) may become unacceptable. Respirator program administrators shall consider workplace factors before use in positive-pressure atmospheres to ensure arterial carbon dioxide levels ($PaCO_2$) are maintained within acceptable levels.

8.3.9 *Specific Applications Involving the Use of a Respirator:*

8.3.9.1 *Abrasive Blasting*—Respirators specifically approved for abrasive blasting shall be selected when there is a potential for abrasive rebound.

8.3.9.2 *Welding and Cutting*—Respirators specifically designed for welding and cutting shall be used. These respirators have a variety of respirator accessories for use during welding operations including, but not limited to:

(1) Welding shields to protect the filters against sparks and spatter;

(2) Spark-resistant filters;

(3) Filters that can be worn on the back; and

(4) Shaded lenses for flame cutting and grinding.

8.3.9.3 *Welding in Confined Spaces*—Welding in a confined space can present an atmospheric hazard because of the generation of contaminants and displacement of oxygen. A pressure-demand SCBA or a multifunctional pressure-demand supplied-air respirator with self-contained air supply shall be used during welding in confined spaces when welding can reduce the ambient oxygen level and supplemental ventilation and atmospheric monitoring are not provided according to 29 CFR 1910.146 and ANSI/ASSE Z117.1. For more information on respirator types, refer to Annex A2.