NFPA® 1989

Standard on Breathing Air Quality for Fire and Emergency Services Respiratory Protection

2008 Edition

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An International Codes and Standards Organization

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NFPA® 1989

Standard on

Breathing Air Quality for Emergency Services Respiratory Protection

2008 Edition

This edition of NFPA 1989, *Standard on Breathing Air Quality for Emergency Services Respiratory Protection*, was prepared by the Technical Committee on Respiratory Protection Equipment and released by the Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment. It was issued by the Standards Council on December 11, 2007, with an effective date of December 31, 2007, and supersedes all previous editions.

This edition of NFPA 1989 was approved as an American National Standard on December 31, 2007.

Origin and Development of NFPA 1989

In 1999, the NFPA Standards Council assigned the responsibility of documents covering breathing air quality for respiratory protection to the Technical Committee on Respiratory Protection and Personal Alarm Equipment. Previously, three documents, NFPA 1404, NFPA 1500, and NFPA 1981, carried different requirements about breathing air quality.

The Technical Committee developed this new standard, NFPA 1989, with the goal of establishing a single set of requirements for the quality of breathing air used in atmosphere-supplying respirators, including open-circuit self-contained breathing apparatus (SCBA), used by fire and emergency services personnel.

This first edition was acted on by the NFPA membership at the Fall Meeting in Atlanta, GA, on November 20, 2002.

This second edition, the 2008 edition, the title of NFPA 1989 has been modifed to *Standard on Breathing Air Quality for Emergency Services Respiratory Protection.* In this edition, a new Chapter 7 has been added that specifies requirements for a compressed breathing system. The chapter covers installation, compressors, maintenance, and records for the system. All air quality requirements and testing criteria were reviewed and refined to better assure high quality breathing air for emergency services personnel.

The 2008 edition of NFPA 1989 was issued with an effective date of December 31, 2007.

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Committee Scope: This Committee shall have primary responsibility for documents on respiratory equipment, including breathing air, for fire and emergency services personnel during incidents involving hazardous or oxygen deficient atmospheres.

This Committee shall also have primary responsibility for documents on the selection, care, and maintenance of respiratory protection equipment and systems by fire and emergency services organizations and personnel.

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Standard on

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Information on referenced publications can be found in Chapter 2 and Annex B.

Chapter 1 Administration

1.1* Scope.

1.1.1 This standard shall specify the minimum requirements for breathing air quality for emergency services organizations that use atmosphere-supplying respirators for the respiratory protection of their personnel.

1.1.2 This standard shall specify the requirements for the breathing air quality component of the respiratory protection program of any emergency services organization.

1.1.3 For fire departments, this standard shall specify the requirements for the breathing air quality component of the respiratory protection program required by NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

1.1.4 This standard shall not specify requirements for medical-grade oxygen.

1.1.5 This standard shall not specify requirements for air quality for any other applications.

1.1.6 This standard shall not be construed as addressing all of the safety concerns, if any, associated with its use. It shall be the responsibility of the persons and organizations that use this standard to establish safety and health practices and determine the applicability of regulatory limitations prior to use of this standard.

1.1.7 This standard shall not be construed as addressing all of the safety concerns associated with the use of atmosphere-supplying respirators and compliant breathing air supplies for the respiratory protection of their personnel. It shall be the responsibility of the persons and organizations that use compliant breathing air supplies to establish safety and health practices and determine the applicability of regulatory limitations prior to use.

1.1.8 This standard shall not be construed as addressing all of the safety concerns, if any, associated with the use of this standard by testing facilities. It shall be the responsibility of the persons and organizations that use this standard to conduct testing of breathing air and breathing air supply systems to establish safety and health practices and determine the applicability of regulatory limitations prior to using this standard for any designing, manufacturing, and testing.

1.1.9 Nothing herein shall restrict any jurisdiction or breathing air provider from exceeding these minimum requirements.

1.2 Purpose.

1.2.1 The purpose of this standard shall be to establish minimum quality requirements for breathing air, including the sampling and testing methods for determining breathing air quality.

1.2.2 The purpose of this standard shall also be to establish criteria for a safe supply of breathing air for emergency services personnel who use atmosphere-supplying respirators that provide life support during rescue; confined space operations; hazardous materials operations; technical rescue operations; fire fighting operations; chemical, biological, radiological, and nuclear radiation (CBRN) terrorism incident operations; and special operations where respiratory hazards can or do exist.

1.3 Application.

1.3.1 This standard shall apply to atmosphere-supplying respirators that provide the breathing air supply from a compressed breathing gas source that is independent of the ambient atmosphere.

1.3.1.1 This standard shall apply to atmosphere-supplying respirators used by emergency service organizations for respiratory protection of their personnel.

1.3.1.2 This standard shall apply to all compressed normal atmospheric air and all compressed synthetic breathing air regardless of the source of the breathing air.

1.3.2 For fire departments, this standard shall also apply to the requirements for breathing air quality component of the fire department's respiratory protection program as required by Section 7.9 of NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

1.3.3 This standard shall not apply to medical-grade oxygen used in patient care during emergency medical incidents and other pre-hospital or hospital patient care.

1.3.4 This standard shall not apply to air quality for any other purposes, including, but not limited to, industrial applications, utility applications, diving, pneumatic processes, cleaning, drying, and inflating.

1.4 Units.

1.4.1 In this standard, values for measurement are followed by an equivalent in parentheses, but only the first stated value shall be regarded as the requirement.

1.4.2 Equivalent values in parentheses shall not be considered as the requirement as these values are approximate.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* 2007 edition.

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2.3 Other Publications.

2.3.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D 2986, *Standard Practice for Evaluation of Air Assay Media by the Monodisperse DOP (Dioctyl Phthalate) Smoke Test*, 1995.

2.3.2 ISO Publications. International Organization for Standardization, 1, Ch. de la Voie-Creuse, Case postale 56, CH-1211 Geneva 20, Switzerland.

ISO 17025, *General requirements for the competence of calibration and testing laboratories*, 1999.

2.3.3 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1 Shall. Indicates a mandatory requirement.

3.2.2 Should. Indicates a recommendation or that which is advised but not required.

3.2.3 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Accreditation/Accredited. A program by which an accreditation body determines that a laboratory has demonstrated the ability to conduct testing as required by this standard.

3.3.2 Accreditation Body. An independent, third-party organization that determines the qualification of laboratories to conduct testing as required by this standard.

3.3.3 Airline Respirator. See 3.3.13, *Supplied Air Respirator (SAR).*

3.3.4 Atmosphere-Supplying Respirator. A respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere; includes self-contained breathing apparatus (SCBA) and supplied air respirators (SAR). *[See also 3.3.12, Self-Contained Breathing Apparatus (SCBA), and 3.3.13, Supplied Air Respirator (SAR).]*

3.3.5 Breathing Air. See 3.3.7, *Compressed Breathing Air.*

3.3.6* Breathing Air System. A complete assembly of equipment to compress, store, and deliver breathing air for the filling of respirator breathing air cylinders.

3.3.7 Compressed Breathing Air. A respirable gas mixture derived from either normal atmospheric air or from manufactured synthetic air, stored in a compressed state in storage cylinders and respirator breathing air cylinders, and supplied to the user in a gaseous form. *(See also 3.3.14, Synthetic Breathing Air.)*

3.3.8* Organization. The entity that provides the direct management and supervision for the emergency incident response personnel.

3.3.9 ppm. Parts per million, volume per volume.

3.3.10 SAR. An abbreviation for supplied air respirator. *[See also 3.3.13, Supplied Air Respirator (SAR).]*

3.3.11 SCBA. An abbreviation for self-contained breathing apparatus. *[See also 3.3.12, Self-Contained Breathing Apparatus (SCBA).]*

3.3.12* Self-Contained Breathing Apparatus (SCBA). An atmosphere-supplying respirator that supplies a respirable air atmosphere to the user from a breathing air source that is independent of the ambient environment and designed to be carried by the user.

3.3.13 Supplied Air Respirator (SAR). An atmosphere-supplying respirator, also known as an airline respirator, for which the source of the breathing air is not designed to be carried by the user. Also known as an "airline respirator."

3.3.14 Synthetic Breathing Air. A manufactured breathing air that is produced by blending nitrogen and oxygen. *(See also 3.3.7, Compressed Breathing Air.)*

Chapter 4 Accreditation

4.1 General.

4.1.1 All breathing air quality verification testing as specified in Chapters 5 and 6 shall be performed by a laboratory that is accredited for testing compressed breathing air by an accreditation body in accordance with ISO 17025, *General requirements for the competence of calibration and testing laboratories.*

4.1.2 The accreditation body shall meet the requirements for an accreditation program specified in Section 4.2 of this chapter.

4.2 Accreditation Program.

4.2.1 The accreditation body shall not be owned or controlled by manufacturers or vendors of equipment related to the laboratory being accredited.

4.2.2 For accreditation, laboratory facilities and equipment for conducting proper tests shall be available.

4.2.3 The accreditation body shall ensure that the laboratory has a written program for calibrating all instruments and devices used for measurement, including colorimetric tubes.

4.2.4 The accreditation program procedures shall be used to ensure proper control of all testing.

4.2.5 The accreditation body shall ensure that the laboratory follows good laboratory practice regarding use of laboratory manuals, form data sheets, documentation of calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

4.2.6 The accreditation certificate shall state the scope of accreditation.

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Chapter 5 Air Quality Requirements

5.1 Regular Periodic Testing.

5.1.1* At least quarterly, the organization shall take breathing air samples and shall submit such samples to an accredited testing laboratory that meets the requirements specified in Chapter 4.

5.1.2 Breathing air samples shall be submitted to an accredited testing laboratory that meets the requirements specified in Chapter 4 whenever contamination of the compressed breathing air system, the stored compressed breathing air, or breathing air in an SCBA breathing air cylinder is suspected.

5.1.3 The accredited testing laboratory shall test the samples for breathing air quality levels as specified in Section 5.3.

5.1.4* The organization shall maintain documentation from the accredited testing laboratory of the results of all air sample tests for a period of not less than five (5) years.

5.2 Special Testing and Procedures for Maintenance Conditions.

5.2.1 When breathing air contamination could occur, breathing air samples shall be taken after any event including, but not limited to, alterations, maintenance, repairs, or relocation of any breathing air system or system part.

5.2.1.1* Prior to replacement of air purification filters, a breathing air sample shall be taken for testing within 1 week before filter replacement.

5.2.1.2 Breathing air samples shall be taken after any such event covered in 5.2.1 and 5.2.1.1. Passing test results shall be received before returning the air compressor to service.

5.2.1.3 Breathing air samples taken for testing shall be submitted to an accredited testing laboratory that meets the requirements specified in Chapter 4.

5.2.2 The accredited testing laboratory shall test the samples for breathing air quality levels as specified in Section 5.3.

5.2.3* The organization shall maintain documentation from the accredited testing laboratory of the results of all air sample tests for a period of not less than five (5) years.

5.3* Special Testing and Procedures for Synthetic Breathing Air.

5.3.1 The organization shall document whether the breathing air is derived from normal atmospheric air or manufactured synthetic air.

5.3.2 Where the breathing air supply is synthetic breathing air, in addition to the quarterly testing specified in 5.1.1, air samples from each and every cylinder of synthetic breathing air shall be tested for oxygen content as specified in Section 6.1 of this standard. A supplier's analysis or certificate of oxygen content *shall not be sufficient* to comply with this requirement.

5.3.3 This testing shall occur when the organization takes delivery of a cylinder(s) of synthetic breathing air from a supplier or blends its own synthetic breathing air. The testing shall take place prior to filling any SCBA breathing air cylinders from the newly received synthetic breathing air supply.

5.3.4 The organization shall have the synthetic breathing air samples tested as specified in Section 6.1 of this standard to verify the oxygen content is not less than 19.5 percent and not greater than 23.5 percent by volume. A supplier's analysis or certificate of oxygen content *shall not be sufficient* to comply with this requirement.

5.3.5 Where any synthetic breathing air sample fails to comply with the breathing air quality requirements specified in 5.3.4, the organization shall reject the container and the synthetic breathing air shall not be used.

5.3.6 The organization shall have the synthetic breathing air tested for oxygen content as specified in 5.3.1 by an accredited testing laboratory that meets the requirements specified in Chapter 4.

5.3.7* The organization shall maintain documentation from the accredited testing laboratory of the results of all air sample tests for a period of not less than five (5) years.

5.4* Special Testing and Procedures for Contaminated Compressed Breathing Air.

5.4.1 Where any breathing air sample fails to comply with the breathing air quality requirements specified in Section 5.6, the organization shall remove from service the compressed breathing air system or stored breathing air system from which the sample was taken, shall determine the cause of the failure, and shall take corrective action.

5.4.2 Any compressed breathing air system or stored breathing air system that has been removed from service according to 5.4.1 shall not be returned to service until a compressed breathing air sample has been submitted to an accredited testing laboratory for analysis according to Section 5.6, and found to pass the breathing air quality requirements.

5.4.3 The accredited testing laboratory shall test the samples for breathing air quality levels as specified in Section 5.6.

5.4.4* The organization shall maintain documentation from the accredited testing laboratory of the results of all air sample tests for a period of not less than five (5) years.

5.4.5 The organization shall maintain documentation of actions taken to correct the problem for a period of not less than five (5) years.

5.5 Air Samples.

5.5.1* Quarterly breathing air samples shall be obtained directly at the point of air transfer from the breathing air system. The point of air transfer shall be any connection where breathing air cylinders or receivers are routinely filled.

5.5.2 When changing the breathing air system's purification components, two air samples shall be taken.

5.5.2.1 One air sample shall be taken before changing the purification components, and the second air sample shall be taken after changing the purification components.

5.5.2.2 Air samples shall be taken downstream from purification components and prior to or bypassing any air storage cylinders or receivers.

5.5.3* Compressed breathing air shall be allowed to flow through the fill hose for at least 1 minute prior to collecting the sample, only when the fill whip connection fitting is visibly free of foreign material, such as oil, particulate, and water. The sample shall be collected.

5.5.4 Where sampling apparatus cannot be operated correctly inside of the containment fill station, a remote fill hose or designated air sampling port shall be permitted to be used instead of the containment fill station.

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5.5.5 Synthetic breathing air shall not be used until the oxygen content is tested and found to meet the requirements specified in Section 5.3.

5.5.5.1 The organization using the synthetic breathing air shall test or have a third party test each delivery container for its oxygen content. A supplier's analysis or certificate shall not be sufficient to meet this requirement.

5.5.5.2 Where the organization blends its own synthetic breathing air, the oxygen content of the synthetic breathing air in each mixing container shall be tested. This requirement shall be in addition to the regular periodic laboratory testing required by Section 5.1 of this chapter.

5.6* Breathing Air Quality Requirements.

5.6.1 Breathing air shall be tested for oxygen content as specified in Section 6.1, Oxygen Content Test, and shall have an oxygen content not less than 19.5 percent and not greater than 23.5 percent by volume.

5.6.2* Breathing air shall be tested for carbon monoxide content as specified in Section 6.2, Carbon Monoxide Content Test, and shall not have a concentration of carbon monoxide exceeding 5.0 ppm by volume.

5.6.3* Breathing air shall be tested for carbon dioxide content as specified in Section 6.3, Carbon Dioxide Content Test, and shall not have a concentration of carbon dioxide exceeding 1000 ppm by volume.

5.6.4 Breathing air shall be tested for condensed oil and particulate content as specified in Section 6.4, Condensed Oil and Particulate Content Test, and shall not have a concentration of condensed oil and particulate exceeding 2.0 mg/m^3 at 22°C (72°F) and 760 mm (30 in.) of Hg.

5.6.5* Where breathing air supply for respirators is stored at pressures exceeding 15 bar (200 psi), the breathing air shall be tested for water content as specified in Section 6.5, Water Concentration Test, and shall not have a concentration of water exceeding 24 ppm by volume.

5.6.6 Breathing air shall be tested for nonmethane volatile organic compounds (VOCs) content as specified in Section 6.6, Hydrocarbon Content Test, and shall not have a nonmethane VOCs content exceeding 25 ppm as methane equivalents.

5.6.7* Breathing air shall be tested for odor as specified in Section 6.7, Determination of Odor Test, and shall not have a pronounced or unusual odor.

5.6.8 Breathing air shall be tested for nitrogen content as specified in Section 6.8, Nitrogen Content Test, and the concentration of nitrogen shall be not less than 75 percent and not greater than 81 percent.

Chapter 6 Test Methods

6.1 Oxygen Content Test.

6.1.1 Breathing air samples shall be obtained as specified in Section 5.5 of this standard.

6.1.2* The oxygen content shall be determined by any instrument that can demonstrate an accuracy of ±0.5 percent oxygen in the presence of nitrogen and argon normally found in ambient air.

6.1.3 Calibration standards containing the applicable gaseous components to an accuracy of ±2 percent relative shall be required to calibrate the analytical instruments used to determine the limiting characteristics of the breathing air.

6.1.4 Instrument calibration shall be conducted daily prior to sample analysis and confirmed at least every 10 air samples analyzed thereafter.

6.1.5 Analytical equipment shall be operated and properly calibrated in accordance with the manufacturer's instructions.

6.1.6 The percent oxygen content of the air sample shall be recorded and reported.

6.1.7 Pass or fail performance shall be determined in accordance with 5.6.1 and shall be recorded and reported.

6.2 Carbon Monoxide Content Test.

6.2.1 Breathing air samples shall be obtained as specified in Section 5.5 of this standard.

6.2.2* The carbon monoxide content shall be determined by any instrument that can demonstrate a minimum detection limit of 0.5 ppm or less and has a minimum accuracy of ±0.5 ppm at 5 ppm.

6.2.3 Calibration standards containing the applicable gaseous components to an accuracy of ±2 percent relative shall be required to calibrate the analytical instruments used to determine the limiting characteristics of the breathing air.

6.2.4 Instrument calibration shall be conducted daily prior to sample analysis and confirmed at least every 10 air samples analyzed thereafter.

6.2.5 Analytical equipment shall be operated and properly calibrated in accordance with the manufacturer's instructions.

6.2.6 The carbon monoxide content of the air sample shall be recorded and reported.

6.2.7 Pass or fail performance shall be determined in accordance with 5.6.2 and shall be recorded and reported.

6.3 Carbon Dioxide Content Test.

6.3.1 Breathing air samples shall be obtained as specified in Section 5.5 of this standard.

6.3.2* The carbon dioxide content shall be determined by any instrument that can demonstrate a minimum detection limit not exceeding 100 ppm and has a minimum accuracy of ±50 ppm at 1000 ppm.

6.3.3 Calibration standards containing the applicable gaseous components to an accuracy of ±2 percent relative shall be required to calibrate the analytical instruments used to determine the limiting characteristics of the breathing air.

6.3.4 Instrument calibration shall be conducted daily prior to sample analysis and confirmed at least every 10 air samples analyzed thereafter.

6.3.5 Analytical equipment shall be operated and properly calibrated in accordance with the manufacturer's instructions.

6.3.6 The carbon dioxide content of the air sample shall be recorded and reported.

6.3.7 Pass or fail performance shall be determined in accordance with 5.6.3 and shall be recorded and reported.

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6.4 Condensed Oil and Particulate Content Test.

6.4.1 Breathing air samples shall be obtained as specified in Section 5.5 of this standard.

6.4.2 The sample for the condensed oil and particulate content shall be collected at a flow rate that would not result in an underestimation of the actual concentration.

6.4.3 Calibration standards with an accuracy of ±2 percent relative shall be required to calibrate the analytical instruments used to determine the limiting characteristics of the breathing air.

6.4.4 Instrument calibration shall be conducted daily prior to sample analysis and confirmed at least every 10 air samples analyzed thereafter.

6.4.5 Condensed oil and particulate content shall be determined by passing at least 500 L of air through a preweighed, dry filter meeting the requirements of 6.4.6 and contained in a suitable holder. The filter shall be sized to capture and retain the condensed oil and particulate at the flow rate required in 6.4.2.

6.4.6 The filter shall provide 99.8 percent dioctyl phthalate (DOP) retention at 0.3 microns with a flow of 32 L/min through 100 cm^2 of media when measured in accordance with ASTM D 2986, *Standard Practice for Evaluation of Air Assay Media by the Monodisperse DOP (Dioctyl Phthalate) Smoke Test.*

6.4.7 The amount of air passing through the filter shall be determined by passing the air through the filter at a known flow rate and measuring the length of time it takes for the air to flow through the filter.

6.4.8 The filter shall be placed in a desiccator for 8 hours at a temperature of 25°C, ±3°C (77°F, ±5°F) to remove moisture, and then shall be reweighed. Desiccation shall be permitted to be omitted if the calculated concentration of oil and particulate is less than twice the limit of detection enumerated in 6.4.11.

6.4.9 As an alternative to 6.4.7, the filter shall be permitted to be heated to 38°C (100°F) for 1 hour in an air circulating oven, cooled in a desiccator, and then reweighed. Desiccation shall be omitted if the calculated concentration of oil and particulate is less than twice the limit of detection enumerated in 6.4.11.

6.4.10 The mass gain of the filter shall be used to determine the mass of collected condensed oil and particulate and, along with the volume of air passed through the filter as determined in 6.4.2, to calculate the combined concentration of condensed oil and particulate in the air sample.

6.4.11 The procedures used for measuring condensed oil and particulate content shall demonstrate a minimum detection limit not exceeding 0.1 mg/m^3 and shall have an accuracy of ±0.1 mg/m^3 at 1.0 mg/m^3.

6.4.12 The condensed oil and particulate content of the air sample shall be recorded and reported as mg/m^3.

6.4.13 Pass or fail performance shall be determined in accordance with 5.6.4 and shall be recorded and reported.

6.5 Water Concentration Test.

6.5.1 Breathing air samples shall be obtained as specified in Section 5.5 of this standard.

6.5.2* The procedure for determining water concentration shall have a minimum detection limit not exceeding 3 ppm and shall have an accuracy of ±8 ppm at the specified limit of 24 ppm.

6.5.3 Analytical equipment shall be operated and properly calibrated in accordance with the manufacturer's instructions.

6.5.4 The water content of the air sample shall be recorded and reported in ppm.

6.5.5 Pass or fail performance shall be determined in accordance with 5.6.5 and shall be recorded and reported.

6.6 Hydrocarbon Content Test.

6.6.1 Breathing air samples shall be obtained as specified in Section 5.5 of this standard.

6.6.2* The total nonmethane volatile organic compounds content, as methane equivalents, shall be determined by any instrument with a detection limit not exceeding 1.0 ppm and shall have a minimum accuracy of ±1.0 ppm at 25 ppm.

6.6.3 The total nonmethane volatile hydrocarbon content, as methane equivalents, for this test method shall be defined as the single carbon atom equivalent.

6.6.4 Calibration standards containing the applicable gaseous components to an accuracy of ±2 percent relative shall be required to calibrate the analytical instruments used to determine the limiting characteristics of the breathing air.

6.6.5 Instrument calibration shall be conducted daily prior to sample analysis and confirmed at least every 10 air samples analyzed thereafter.

6.6.6 Analytical equipment shall be operated and properly calibrated in accordance with the manufacturer's instructions.

6.6.7* The total nonmethane volatile organic compounds content of the air sample shall be recorded and reported.

6.6.8 Pass or fail performance shall be determined in accordance with 5.6.6 and shall be reported.

6.7 Determination of Odor Test.

6.7.1 Breathing air samples shall be obtained as specified in Section 5.5 of this standard.

6.7.2 Odor shall be determined by having persons conducting the test sniff a moderate flow of air from the container being tested.

6.7.3 Persons conducting the test shall not place their faces directly in front of the valve, but instead shall use a hand to direct toward the nose some of the gas being vented.

6.7.4 The disposition of the odor of the air sample shall be recorded and reported as "no/slight odor" or "pronounced or unusual odor."

6.7.5 Pass or fail performance shall be determined in accordance with 5.6.7 and shall be reported.

6.8 Nitrogen Content Test.

6.8.1 The nitrogen content shall be determined by any instrument that can demonstrate an accuracy of ±0.5 percent.

6.8.2 A calibration standard containing the applicable gaseous components to an accuracy of ±2 percent relative shall be required to calibrate the analytical instruments used to determine the limiting characteristics of the breathing air.

6.8.3 Instrument calibration shall be conducted daily prior to sample analysis and confirmed at least every 10 air samples analyzed thereafter.

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6.8.4 Analytical equipment shall be operated and properly calibrated in accordance with the manufacturer's instructions.

6.8.5 The nitrogen content of the air sample shall be recorded and reported.

6.8.6 Where the air being tested is synthetic air, the pass or fail performance shall be determined in accordance with 5.6.8 and shall be recorded and reported.

Chapter 7 Compressed Breathing Air Systems

7.1 Installation.

7.1.1 Where a breathing air compressor is used to supply the breathing air system, the breathing air compressor shall be installed, operated, and maintained in accordance with the compressor manufacturer's instructions.

7.1.2 The breathing air system air intake shall be located to minimize the introduction of contaminants into the system.

7.1.3 A sign or placard shall be posted near the air intake identifying it as an intake source for breathing air.

7.1.4 Purification cartridges shall be properly installed in the correct sequence, as specified by the cartridge manufacturer's instructions.

7.1.5 The system shall not be installed in a manner that would permit the compressed air stream to bypass one or more of the air purifying components.

7.2 Compressors.

7.2.1 Oil-lubricated compressors shall be equipped with a tamperproof carbon monoxide (CO) monitor with audible and visual alarms that shall shut down the compressor when the CO level exceeds 5.0 ppm, and shall have a resolution of at least a 1 ppm.

7.2.1.1 The CO monitor shall have a limit of detection of 1.0 ppm and shall have a resolution of at least 1 ppm.

7.2.1.2* The CO monitor shall be equipped with a user-operated calibration system.

7.2.1.3 The CO calibration system shall include calibration gas to be used when calibrating the system in accordance with the compressor manufacturer's instructions.

7.2.2 Oil-lubricated compressors shall be equipped with a tamperproof, audible, high temperature alarm that shall shut down the compressor at the temperature specified by the compressor manufacturer.

7.2.3 Oil-lubricated compressors shall be equipped with a tamperproof low oil level, low oil pressure, or both low oil level and low oil pressure audible and visual alarm that shall shut down the compressor if the oil level or the oil pressure drops below the limit specified by the compressor manufacturer.

7.2.4 All alarm activations shall be investigated and corrective action shall be taken before filling any cascade systems or SCBA breathing air cylinders.

7.3 Maintenance.

7.3.1 The breathing air system compressor shall be operated not less than 30 minutes each week, resulting in at least two condensate drain cycles.

7.3.2 The purification components of the breathing air system shall be replaced in accordance with the purification component manufacturer's instructions.

7.3.3 Compressed breathing air stored in steel cylinders or steel receivers of the breathing air system shall be replaced at least annually.

7.3.4 A positive pressure shall be maintained in depleted breathing air system cylinders and receivers until they are filled, to prevent the possibility of external contamination and condensation entering the cylinder or receiver.

7.4 Records.

7.4.1 The organization shall maintain records of at least installation, maintenance, purification component changes, operation, trouble reports, and corrective actions taken.

7.4.2 The organization shall maintain records of air quality test results of compressed breathing air sources and air quality test results of the compressed breathing air produced or purchased.

7.4.3 The organization shall maintain records of all SCBA breathing air cylinder fills, and all breathing air system storage cylinder and receiver fills other than those storage cylinders and receivers that are connected to breathing air compressors.

7.4.3.1* These records shall include, but not be limited to, the fill date identification of the person performing the fill, cylinder serial number, breathing air source, final cylinder pressure, and most recent hydrostatic test date.

7.4.3.2 The organization shall maintain these records for a period of not less than five (5) years.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 This standard sets criteria for breathing air quality for emergency services personnel who use atmospheric-supplying respirators and who perform their functions at high work levels during operations in hazardous and hostile environments. Other breathing air quality standards are focused on general industry and do not address emergency services needs.

A.3.3.6 Breathing Air System. The breathing air system components can include, but are not limited to, compressors, air purification systems, pressure regulators, safety devices, manifolds, cylinders and receivers, and interconnected piping.

A.3.3.8 Organization. Examples of such entities include, but are not limited to, fire departments, police departments, rescue squads, emergency medical service providers, and hazardous materials response teams.

A.3.3.12 Self-Contained Breathing Apparatus (SCBA). For the purposes of this standard, where the term is used without a qualifier, it indicates only open-circuit self-contained breathing apparatus or combination SCBA/SARs. For the purposes of this standard, combination SCBA/SAR are encompassed by the terms *self-contained breathing apparatus* or *SCBA*.

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A.5.1.1 All compressed breathing air samples submitted to an accredited testing laboratory should be accompanied by a document specifying the following:

(1) Name, address, and telephone number of the organization
(2) Date the compressed breathing air sample was collected
(3) Location point in the compressed breathing air system from which the compressed breathing air was sampled
(4) Highest pressure at which the compressed breathing air is stored or used
(5) Lowest temperature to which the compressed breathing air system or SCBA is exposed at any time during the year
(6) Number of operating hours since the purification component(s) were installed
(7) Brand, model, serial number, maximum rated operating pressure, actual operating pressure, maximum rated flow rate (L/min) at the maximum rated operating pressure, type of lubrication, purification components (e.g., mechanical separator, water vapor desiccant, activated charcoal, catalytic converter, particulate filter), order of the purification components in series with the compressor, and alarms (e.g., carbon monoxide alarm, high temperature alarm, low oil pressure alarm)
(8) Brand, model, serial number, maximum rated operating pressure, actual operating pressure, maximum rated flow rate (L/min) at the maximum rated operating pressure, and actual flow rate of the compressor used to produce the compressed breathing air

A.5.1.4 Some records and reports can be created and stored electronically, whereas other items, such as forms, notices, stickers, and tags, are only practical and effective if tangible.

A.5.2.1.1 The purpose of the air sample taken after changing the filters is to verify that compressed breathing air is being produced that meets this standard. This test should be expected to give the best possible results because the filters are new, but it does not guarantee that the system will continue to produce good air until the next scheduled filter change. If tests are taken only after filter changes, it is possible for a problem in the system to go undetected. The purpose of taking a sample before changing the filters is to determine if the system has been producing compressed breathing air meeting this standard for the period since the last air test.

A.5.2.3 See A.5.1.4.

A.5.3 Synthetic breathing air is produced by mixing pure oxygen with pure nitrogen to produce a product that has the correct percentage of each for breathing. The actual procedure used to do this varies from supplier to supplier. One of the most common procedures is to attach all the breathing air cylinders to be filled to a manifold, then open the cylinder valves and add nitrogen into all of the cylinders. Once the appropriate pressure has been reached, the cylinder valves are closed and the manifold is switched to oxygen. The cylinder valves are then reopened and oxygen is added to reach the final full cylinder pressure.

This and other procedures used to do the mixing are subject to human error and mechanical failure (e.g., a valve fails to open properly). These errors or failures can result in some cylinders of a "lot" receiving little or no oxygen. Such a cylinder can render an individual unconscious in a matter of seconds with almost no warning and can lead to death in minutes. It is also possible that a cylinder of pure oxygen could be delivered; although not necessarily dangerous to breathe, pure oxygen could be very hazardous in a fire-fighting situation.

Although synthetic breathing air is usually very clean and free of contaminants, it is potentially dangerous and should only be used where the end user can verify the oxygen content of each cylinder (not each "lot") supplied. The use of synthetic breathing air has resulted in deaths, even though the cylinders involved were from "lots" that had been tested by the supplier. For this reason, the organization using synthetic breathing air is required to test, or to have a third party test, each delivery container for its oxygen content, and not depend on the supplier's tests.

A.5.3.7 See A.5.1.4.

A.5.4 In the event of an emergency services personnel death, or if they become unconscious, or suffer a heart attack within 24 hours of using compressed breathing air, chain-of-custody procedures should be instituted, the respirator secured, the valve closed, and the respirator tagged and submitted to an accredited testing laboratory for analysis, as prescribed in Section 5.6.

A.5.4.4 See A.5.1.4.

A.5.5.1 The purpose of the air samples taken before and after changing the filters is to verify that the compressor is producing compressed breathing that meets this standard. The purpose is not to test the quality of air stored in cascade cylinders or receivers, or to test the air at the point of transfer to SCBAs. Therefore, these samples need to be obtained from a point downstream of the air purification system (but as close to it as possible), and upstream of any air cascade storage cylinders or receivers.

The quarterly samples test the compressed breathing air that is transferred to the SCBA. Therefore, these samples need to be obtained at the point of transfer to the SCBA breathing air cylinders downstream of the cascade storage cylinders or receivers.

A.5.5.3 Allowing compressed breathing air to flow through the fill hose for 1 minute will purge the line of room air and contaminants.

A.5.6 This standard sets criteria for breathing air quality for emergency services personnel who use atmospheric-supplying respirators and who perform their functions at high work levels during operations in hazardous and hostile environments. Other breathing air quality standards are focused on general industry and do not address emergency services needs.

A.5.6.2 The percent carboxyhemoglobin (%COHb) level of nonsmoking emergency services personnel doing heavy work while breathing air containing 5.0 ppm of carbon monoxide (CO) could rise to 3.5 percent. This is the biological exposure index (BEI) for COHb established by the American Conference of Government Industrial Hygienists (ACGIH). This represents a level below which nearly all workers should not experience adverse health effects.

A.5.6.3 Carbon dioxide levels higher than 500 ppm should be investigated.

A.5.6.5 Excessive moisture content in compressed breathing air can render the purification system ineffective in removing contaminants, lead to corrosion in the compressed breathing air system, and result in condensation of water with subsequent freeze-up of the SCBA regulator and blockage of air flow to the face piece.

A.5.6.7 Specific measurement of odor in gaseous air is impractical. Air normally can have a slight odor, but should not have a pronounced or unusual odor.

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A.6.1.2 Breathing air normally has approximately 78 percent nitrogen, 21 percent oxygen, and 1 percent argon. Suggested analytical procedures for determination of oxygen concentration are as follows:

(1) A paramagnetic-type analyzer calibrated (zeroed and spanned) at appropriate intervals by the use of calibration gas standards using nitrogen as the base gas.
(2) An electrochemical-type analyzer containing a solid or aqueous electrolyte. The electrochemical-type analyzer should be calibrated at appropriate intervals by the use of calibration gas standards.
(3) A thermal conductivity-type analyzer calibrated at appropriate intervals by the use of calibration gas standards using nitrogen as the base gas.
(4) A gas chromatograph capable of separating and detecting oxygen in nitrogen. The system should be able to distinguish oxygen from argon when testing atmospheric air. The system should be calibrated by the use of calibration gas standards containing an appropriate known amount of oxygen.

A.6.2.2 Suggested analytical procedures for determination of carbon monoxide concentration are as follows:

(1) A gas cell equipped infrared gas analyzer should be calibrated at appropriate intervals by the use of calibration gas standards at a wavelength of approximately 4.6 microns. *It should be noted that the accuracy of this method is relatively poor at these levels.*
(2) An electrochemical cell analyzer that is specific for carbon monoxide should be calibrated at appropriate intervals by the use of calibration gas standards.
(3) A catalytic methanator gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.
(4) The gas chromatograph technique utilized should be specific for the separation and analysis of carbon monoxide. Appropriate impurity techniques should be permitted to be used to attain the sensitivity required in 6.2.2. The gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.

A.6.3.2 Suggested analytical procedures for determination of carbon dioxide concentration are as follows:

(1) A gas cell equipped dispersive or nondispersive infrared analyzer should be calibrated at appropriate intervals by the use of calibration gas standards at a wavelength of approximately 4.3 microns.
(2) A gas chromatograph should be capable of separating and detecting carbon dioxide. The gas chromatograph technique utilized should be specific for the separation and analysis of carbon dioxide. Appropriate impurity techniques should be used to attain the sensitivity required in 6.3.2. The gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.

A.6.5.2 Suggested analytical procedures for determination of water concentration are as follows:

(1) An electrolytic hygrometer should have an indicator graduated in ppm (volume/volume) on a range that is no greater than 10 times the specified maximum moisture content.
(2) With a dewpoint analyzer, the temperature of a viewed surface should be measured at the time formation of moisture condensation is first observed.
(3) A piezoelectric sorption hygrometer should have a range that is no greater than 10 times the specified maximum moisture content.
(4) A metal oxide capacitor equipped analyzer should have a range that is no greater than 10 times the specified maximum moisture content.
(5) The gas chromatograph technique utilized should be specific to the separation and analysis of water content. Appropriate impurity techniques should be used to attain the sensitivity required in 6.5.2. The gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.

A.6.6.2 Suggested analytical procedures for determination of total nonmethane VOCs concentration are as follows:

(1) A flame ionization-type analyzer should be calibrated at appropriate intervals by the use of calibration gas (air balance) standards. The range used should not be greater than 250 ppm.
(2) A gas cell equipped dispersive or nondispersive infrared analyzer should be calibrated at appropriate intervals by the use of calibration gas standards at a wavelength of approximately 3.5 microns (the characteristic absorption wavelength for C.H stretching).
(3) The gas chromatograph technique utilized should be specific to the separation and analysis of hydrocarbon content. Appropriate impurity techniques should be used to attain the sensitivity required in 6.6.2. The gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.

A.6.6.7 Where nonmethane volatile hydrocarbon contaminant exceeds 10 ppm, individual species should be identified and quantified.

A.7.2.1.2 Gas monitors must be periodically calibrated to ensure accuracy and repeatability. It is recommended that calibration of the CO monitor be done before each day's use for best results.

A.7.4.3.1 See Figure A.7.4.3.1, Breathing Air Cylinder Fill Log.

Annex B Informational References (Reserved)

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BREATHING AIR CYLINDER FILL LOG

(Insert the Breathing Air Source)

Date	Name of Person Filling	Cylinder Serial Number	Final Cylinder PSI	Hydrostat Test Date

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FIGURE A.7.4.3.1 Breathing Air Cylinder Fill Log.

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- Proposed new Document or new edition of an existing Document is entered into one of two yearly revision cycles, and a Call for Proposals is published.

Step 2: Report on Proposals (ROP)

- Committee meets to act on Proposals, to develop its own Proposals, and to prepare its Report.
- Committee votes by written ballot on Proposals. If two-thirds approve, Report goes forward. Lacking two-thirds approval, Report returns to Committee.
- Report on Proposals (ROP) is published for public review and comment.

Step 3: Report on Comments (ROC)

- Committee meets to act on Public Comments to develop its own Comments, and to prepare its report.
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- "*Notices of intent to make a motion"* are filed, are reviewed, and valid motions are certified for presentation at the Technical Report Session. ("Consent Documents" that have no certified motions bypass the Technical Report Session and proceed to the Standards Council for issuance.)
- NFPA membership meets each June at the Annual Meeting Technical Report Session and acts on Technical Committee Reports (ROP and ROC) for Documents with "certified amending motions."
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3.3.78 Effective Ground-Fault Current Path. An intentionally constructed, permanent, low impedance electrically conductive path designed and intended to carry ~~underground~~ electric fault current ~~conditions~~ from the point of a ground fault on a wiring system to the electrical supply source.

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