NFPA 1989

Standard on

Breathing Air Quality for Fire and Emergency Services

Respiratory Protection

2003 Edition

This edition of NFPA 1989, *Standard on Breathing Air Quality for Fire and Emergency Services Respiratory Protection*, was prepared by the Technical Committee on Respiratory Protection and Personal Alarm Equipment, released by the Technical Correlating Committee on Fire and Emergency Services Protective Clothing and Equipment, and acted on by NFPA at its November Association Technical Meeting held November 16–20, 2002, in Atlanta, GA. It was issued by the Standards Council on January 17, 2003, with an effective date of February 6, 2003.

This edition of NFPA 1989 was approved as an American National Standard on January 17, 2003.

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, Georgia, on 20 November 2002.

In Memoriam, 11 September 2001

We pay tribute to the 343 members of FDNY who gave their lives to save civilian victims on 11 September 2001 at the World Trade Center. They are true American heroes in death, but they were also American heroes in life. We will keep them in our memory and in our hearts.

They are the embodiment of courage, bravery, and dedication. May they rest in peace.

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Committee Scope: This Committee shall have primary responsibility for documents on the design, performance, testing, and certification of protective clothing and protective equipment manufactured for fire and emergency services organizations and personnel, to protect against exposures encountered during emergency incident operations. This Committee shall also have the primary responsibility for documents on the selection, care, and maintenance of such protective clothing and protective equipment by fire and emergency services organizations and personnel.

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Bruce W. Teele, NFPA Staff Liaison

Committee Scope: This Committee shall have primary responsibility for documents on protective equipment that provides respiratory protection for fire fighters or other emergency services responders during incidents involving operations conducted in hazardous or oxygen deficient atmospheres. These operations include the activities of rescue, fire suppression, hazardous materials mitigation, and property conservation where exposures to an oxygen deficient atmosphere or an atmosphere contaminated with harmful particulate, fog, fume, mist, gas, smoke, spray, or vapor will or could occur.

These lists represent the membership at the time the Committees were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

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Standard on
Breathing Air Quality for Fire and Emergency Services Respiratory Protection
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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 fire and emergency services organizations that use atmosphere-supplying respirators.

1.1.2 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*.

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

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

1.1.5 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.

1.1.6 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 fire and emergency service personnel who use atmosphere-supplying respirators that provide life support during fire fighting, rescue, hazardous materials 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 fire and 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 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 could be 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 Publication.

National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* 2002 edition.

2.3 Other Publications.

2.3.1 ASTM Publication.

American Society for Testing and Materials, 100 Barr Harbor Drive, 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 Publication.

International Standards Organization, 1 Rue de Varembé, Case postale 56, CH-1211 Genève 20, Switzerland.

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

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 included, common usage of the terms shall apply.

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.

Where terms are not defined in Section 3.3, those terms shall have the ordinarily accepted meanings or the meaning that the text implies. Terms used in the present tense shall include the past and future tenses, terms used in the masculine gender shall include the feminine and neuter genders, terms used in the singular shall include the plural, and terms used in the plural shall include the singular.

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 3.3.11, *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; types include self-contained breathing apparatus (SCBA) and supplied air respirators (SAR). *[See also 3.3.10, Self-Contained Breathing Apparatus (SCBA), and 3.3.11, Supplied Air Respirator (SAR).]*

3.3.5 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 3.3.12, Synthetic Breathing Air.)*

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

3.3.7 ppm. Parts per million, volume per volume.

3.3.8 SAR. An abbreviation for supplied air respirator. *[See also 3.3.11, Supplied Air Respirator (SAR).]*

3.3.9 SCBA. An abbreviation for self-contained breathing apparatus. *(See also 3.3.10, Self-Contained Breathing Apparatus.)*

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

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

3.3.12 Synthetic Breathing Air. A manufactured breathing air that is produced by blending nitrogen and oxygen. *(See also 3.3.5, Breathing Air.)*

Chapter 4 Accreditation

4.1 General.

4.1.1 All breathing air quality verification testing as specified in Chapter 6 shall be performed by a laboratory that is accredited 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.

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

4.2.4 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.

Chapter 5 Air Quality Requirements

5.1 Testing Frequency.

5.1.1 Periodic.

5.1.1.1 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.

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

5.1.1.3* The organization shall maintain documentation from the accredited testing laboratory of the results of all air sample tests.

5.1.2 Special Conditions — Maintenance.

5.1.2.1 Where breathing air contamination could occur after any event including, but not limited to, alterations, maintenance, repairs, or relocation of any breathing air compressor or breathing air cascade system, including intake and discharge assemblies, air samples shall be

taken and shall be submitted to an accredited testing laboratory that meets the requirement in Chapter 4.

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

5.1.2.3* The organization shall maintain documentation from the accredited testing laboratory of the results of all air sample tests.

5.1.3 Special Conditions — Synthetic Breathing Air.

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

5.1.3.2 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.

5.1.3.3 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.

5.1.3.4 The organization shall have the synthetic breathing air samples tested to verify the oxygen content is not less than 19.5 percent and not greater than 23.5 percent by volume.

5.1.3.5 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.

5.1.3.6* The organization shall maintain documentation of the results of all air sample tests.

5.2 Air Samples.

5.2.1 Breathing air samples shall be obtained directly at the point of air transfer to the supplied air respirator from each breathing air source.

5.2.2 Breathing air samples shall be obtained by filling a sample container from the same outlet and in the same manner as the respirator breathing air cylinders.

5.2.3* Synthetic breathing air shall not be used unless each and every container used to deliver such air to the organization is tested to verify that the oxygen content meets the requirements of 5.3.1.

5.2.3.1 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.

5.2.3.2 Where the organization blends its own synthetic breathing air, the oxygen content of each mixing container shall be tested. This requirement shall be in addition to the regular quarterly laboratory testing required by 5.1.1.

5.2.4 Where any breathing air sample fails to comply with the breathing air quality requirements specified in Section 5.3, the organization shall determine the cause of the failure and take corrective action.

5.2.5 Following the corrective action, a new air sample shall be taken and shall be submitted to the accredited testing laboratory for testing.

5.3* Breathing Air Quality Levels.

5.3.1 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.

5.3.2 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 10 ppm by volume.

5.3.3 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.

5.3.4 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 5 mg/m^3 at 22°C (72°F) and 760 mm (30 in.) of Hg.

5.3.5 Where breathing air supply for respirators is stored at pressures exceeding 14 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.

5.3.6 Breathing air shall be tested for hydrocarbon content as specified in Section 6.6, Hydrocarbon Content Test, and shall not have a hydrocarbon content exceeding 25 ppm by volume as methane.

5.3.7* 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.

Chapter 6 Test Methods

6.1 Oxygen Content Test.

6.1.1* 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.

6.1.2 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.

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

6.1.4 Analytical equipment shall be operated and properly calibrated in accordance with the

manufacturer's instructions.

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

6.1.6 Pass/fail shall be determined in accordance with 5.3.1 and shall be reported.

6.2 Carbon Monoxide Content Test.

6.2.1* The carbon monoxide content shall be determined by any instrument that can demonstrate a minimum detection limit of 1 ppm or less and has a minimum accuracy of ±1 ppm at 10 ppm.

6.2.2 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.

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

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

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

6.2.6 Pass/fail shall be determined in accordance with 5.3.2 and shall be reported.

6.3 Carbon Dioxide Content Test.

6.3.1* 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.

6.3.2 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.

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

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

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

6.3.6 Pass/fail shall be determined in accordance with 5.3.3 and shall be reported.

6.4 Condensed Oil and Particulate Content Test.

6.4.1 The sample for the oil content shall be collected at the same average flow rate used to fill an SCBA cylinder.

6.4.2 Oil content shall be determined by passing at least 500 L of air through a weighed, dry, glass fiber, binder-free filter or its equivalent, contained in a suitable holder. The filter shall be sized to capture and hold the oil at the flow rate required in 6.4.1.

6.4.3 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*. 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.

6.4.4 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 weighed.

6.4.5 As an alternative to 6.4.4, 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 weighed.

6.4.6 The mass gain of the filter shall be used to determine the mass of collected 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.

6.4.7 The procedures used for measuring condensed oil and particulate content shall demonstrate a minimum detection limit not exceeding 0.5 mg/m^3 and shall have an accuracy of ±0.5 mg/m^3 at 5 mg/m^3.

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

6.4.9 Pass/fail shall be determined in accordance with 5.3.4 and shall be reported.

6.5 Water Concentration Test.

6.5.1* The procedure for determining water concentration shall have a minimum detection limit not exceeding 10 ppm and shall have an accuracy of ±8 ppm at the specified limit of 24 ppm.

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

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

6.5.4 Pass/fail shall be determined in accordance with 5.3.5 and shall be reported.

6.6 Hydrocarbon Content Test.

6.6.1* The total volatile hydrocarbon content, as methane, shall be determined by any instrument with a detection limit not exceeding 2.5 ppm and shall have a minimum accuracy of ±2.5 ppm at 25 ppm.

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

6.6.3 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.

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

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

6.6.6 The total volatile hydrocarbon content, including methane, of the air sample shall be recorded and reported.

6.6.7 Pass/fail shall be determined in accordance with 5.3.6 and shall be reported.

6.7 Determination of Odor Test.

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

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

6.7.3 The disposition of the odor of the air sample shall be recorded and reported as “no odor,” “pronounced odor,” or “unusual odor.”

6.7.4 Pass/fail shall be determined in accordance with 5.3.7 and shall be reported.

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.3.3.6 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.5.1.1.3 Some records and reports can be created and stored electronically while other items, such as forms, notices, stickers, and tags, could only be practical and effective if tangible.

A.5.1.2.3 See A.5.1.1.3.

A.5.1.3.6 See A.5.1.1.3.

A.5.2.3 Synthetic breathing air is produced by mixing pure oxygen with pure nitrogen to produce a product that has the proper 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. There have been deaths from the use of synthetic breathing air, even though the cylinders involved were from "lots" that had been "tested" by the supplier. This is why the organization using synthetic breathing air is required to test or have a third party test each delivery container for its oxygen content and not depend on the supplier's tests.

A.5.3 The air quality requirements are based in part on Grade D (Quality Verification Level) air defined in ANSI/CGA G7.1, *Commodity Specification for Air*. As CGA G7.1 contains general industry requirements for air, this standard for fire and emergency services breathing air quality includes additional requirements that are necessary for quality breathing air used in supplied air respirators.

A.5.3.7 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.

A.6.1.1 Breathing air normally has approximately 78 percent nitrogen and 1 percent argon. Suggested analytical procedures for determination of oxygen concentration are as follows:

(1) A paramagnetic-type analyzer should be 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 should contain 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 should be calibrated at appropriate intervals by the use of calibration gas standards using nitrogen as the base gas.

(4) A gas chromatograph should be 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.6.2.1 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.

(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 6.2.1. The gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.

A.6.3.1 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 6.3.1. The gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.

A.6.5.1 Suggested analytical procedures for determination of water concentration are as follows:

(1) An electrolytic hygrometer should have an indicator graduated in ppm (v/v) 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) An apparatus employing a detector tube filled with a color-reactive chemical could be used.

(6) 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.6.6.1 Suggested analytical procedures for determination of total hydrocarbon 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 6.6.1. The gas chromatograph should be calibrated at appropriate intervals by the use of calibration gas standards.

Annex B Informational References

B.1 Referenced Publications.

The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

B.1.1 NFPA Publications. (Reserved)

B.1.2 Other Publications.

B.1.2.1 ANSI Publication. American National Standards Institute Inc., 11 West 42nd Street, 13th floor, New York, NY 10036.

ANSI/CGA G7.1, *Commodity Specification for Air*, 1989.

B.2 Informational References. (Reserved)

B.3 References for Extracts. (Reserved)