

NFPA 1981
Open-Circuit
Self-Contained
Breathing
Apparatus for
Fire Fighters
1992 Edition



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The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NFPA 1981

Standard on

**Open-Circuit Self-Contained Breathing
Apparatus for Fire Fighters**

1992 Edition

This edition of NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters*, was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 18-21, 1992 in New Orleans, LA. It was issued by the Standards Council on July 17, 1992, with an effective date of August 14, 1992, and supersedes all previous editions.

The 1992 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 1981

The first NFPA document to address fire fighter respiratory protection was NFPA 19B, *Standard on Respiratory Protective Equipment for Fire Fighters*. NFPA 19B was adopted on May 17, 1971 at the Association's Annual Meeting in San Francisco, California. It was developed by the Sectional Committee on Protective Equipment for Fire Fighters of the Technical Committee on Fire Department Equipment. After 1975, the Sectional Committee was removed from the Technical Committee on Fire Department Equipment and made its own technical committee. The main thrust of NFPA 19B was to prohibit filter-type canister masks for fire fighters and permit only self-contained breathing apparatus. NFPA 19B was officially withdrawn by the Association on May 19, 1981 at the Annual Meeting in Dallas, Texas.

NFPA 1981, *Standard on Self-Contained Breathing Apparatus for Fire Fighters*, was adopted at the same meeting to replace NFPA 19B. That first edition of NFPA 1981 essentially specified NIOSH/MSHA approved SCBA with a minimum rated service life of 30 minutes. Open-circuit SCBA was required to be positive pressure.

The Technical Committee on Protective Equipment for Fire Fighters undertook a complete revision of NFPA 1981 to state performance requirements and appropriate testing procedures designed to simulate various environmental conditions that fire fighters' SCBA can be exposed to during use and storage. These requirements are in addition to the basic NIOSH/MSHA certification requirements and now NFPA 1981 only applies to open-circuit SCBA. A similar document will be developed for closed-circuit SCBA.

The second edition of NFPA 1981 was completed in March, 1986 and adopted by the Association at the 1987 Annual Meeting in Cincinnati, Ohio.

Since the second edition, the name of the Technical Committee has changed to Fire Service Protective Clothing and Equipment and there is a standing Subcommittee on Self-Contained Breathing Apparatus.

This third edition, 1992, incorporates new requirements for third party certification and quality control, as well as a new total heat and flame test for the entire apparatus. Other test methods covering facepiece lens abrasion and communications have been revised.

This third edition was completed in December, 1991 and presented to the Association at the 1992 Annual Meeting in New Orleans, Louisiana.

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NFPA 1981**Standard on****Open-Circuit Self-Contained Breathing
Apparatus for Fire Fighters****1992 Edition**

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

Information on referenced publications can be found in Chapter 5 and Appendix B.

Chapter 1 Administration**1-1 Scope.**

1-1.1* This standard specifies minimum requirements for the design, performance, testing, and certification of open-circuit self-contained breathing apparatus (SCBA) used in fire fighting, rescue, and other hazardous duties.

1-1.2 This standard does not apply to closed-circuit self-contained breathing apparatus.

1-1.3 This standard is not intended to serve as a detailed manufacturing or purchase specification, but can be referenced in purchase specifications as minimum acceptable requirements.

1-2 Purpose.

1-2.1* The purpose of this standard is to provide minimum performance requirements for open-circuit SCBA utilized by fire fighters.

1-2.2* Controlled laboratory environmental and physical tests are used to determine compliance with the performance requirements of this standard. These tests shall not be deemed as establishing SCBA performance levels for all situations to which fire fighting personnel may be exposed.

1-2.3 Nothing herein is intended to restrict any jurisdiction from specifying or manufacturer from producing open-circuit SCBA that exceed these minimum requirements.

1-3 Definitions.

Approved.* Acceptable to the "authority having jurisdiction."

Authority Having Jurisdiction.* The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

Breathing Air. See Compressed Breathing Gas.

Certification/Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of this standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard, and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine continued compliance of labeled and listed products with the requirements of this standard.

Certification Organization. An independent third party organization that determines product compliance with the requirements of this standard with a labeling/listing/follow-up program.

Char. The formation of a brittle residue when material is exposed to thermal energy.

Closed-Circuit SCBA. A recirculation-type SCBA in which the exhaled gas is rebreathed by the wearer after the carbon dioxide has been removed from the exhalation gas and the oxygen content within the system has been restored from sources such as compressed breathing gas, chemical oxygen, and liquid oxygen, or compressed gaseous oxygen.

Compliance/Compliant. Meeting or exceeding all applicable requirements of this standard.

Compressed Breathing Gas.* Oxygen or a respirable gas mixture stored in a compressed state and supplied to the user in gaseous form.

Demand SCBA. See Negative Pressure SCBA.

Drip. To run or fall in drops or blobs.

End-of-Service-Time Indicator. A warning device on an SCBA that warns the user that the end of the service time of the SCBA is approaching.

Fabric Component. Any single or combination of pliable, natural, or synthetic material(s) made by weaving, felting, forming, or knitting that is used to secure the backplate assembly to the SCBA wearer, including but not limited to shoulder, waist, and chest straps.

Facepiece. The component of an SCBA that covers at a minimum the wearer's nose, mouth, and eyes.

Follow-Up Program. The sampling, inspections, tests, or other measures conducted by the certification organization on a periodic basis to determine the continued compliance of listed products that are being produced by the manufacturer to the requirements of this standard.

Gas. An aeriform fluid that is in a gaseous state at standard temperature and pressure.

Haze. Light that is scattered as a result of passing through a transparent object.

Identical SCBA. SCBA that are produced to the same engineering and manufacturing specifications.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed.* Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Melt. To change from solid to liquid, or become consumed, by action of heat.

Negative Pressure SCBA. An SCBA in which the pressure inside the facepiece, in relation to the pressure surrounding the outside of the facepiece, is negative during any part of the inhalation or exhalation cycle when tested by NIOSH in accordance with 30 CFR 11, Subpart H.

NIOSH/MSHA Certified. Tested and certified jointly by the National Institute for Occupational Safety and Health (NIOSH) of the U.S. Department of Health and Human Services and the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor in accordance with the requirements of Title 30, *Code of Federal Regulations*, Part 11, Subpart H (30 CFR 11). For the NIOSH/MSHA certification to remain in effect, the SCBA must be used and maintained in the approved condition.

Open-Circuit SCBA. An SCBA in which exhalation is vented to the atmosphere and not rebreathed. There are two types of open-circuit SCBA: negative pressure or demand type and positive pressure or pressure demand type.

Pink Noise. Noise that contains constant energy per octave band.

Positive Pressure SCBA. An SCBA in which the pressure inside the facepiece, in relation to the pressure surrounding the outside of the facepiece, is positive during both inhalation and exhalation when tested by NIOSH in accordance with 30 CFR 11, Subpart H.

Pressure Demand SCBA. See Positive Pressure SCBA.

Product Label. A label or marking affixed to the SCBA by the manufacturer containing general information, warnings, care, maintenance, or similar data. This product label is not the certification organization's label, symbol, or identifying mark; however, the certification organization's label, symbol, or identifying mark may be attached to it or be part of it. (*See also Labeled.*)

Rated Service Time. The period of time, stated on the SCBA's NIOSH/MSHA certification label, that the SCBA supplied air to the breathing machine when tested to 30 CFR 11.

SCBA. See Self-Contained Breathing Apparatus.

Self-Contained Breathing Apparatus (SCBA). A respirator worn by the user that supplies a respirable atmosphere that is either carried in or generated by the apparatus and is independent of the ambient environment.

Service Time. See Rated Service Time.

Shall. Indicates a mandatory requirement.

Should. This term, as used in the Appendix, indicates a recommendation or that which is advised but not required.

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

Chapter 2 Certification

2-1 General.

2-1.1 Prior to certification of SCBA to the requirements of this standard, SCBA shall be NIOSH/MSHA certified.

2-1.1.1 SCBA shall have NIOSH/MSHA certification as positive pressure.

2-1.1.2* SCBA shall have a NIOSH/MSHA certified weight not exceeding 35 lb.

2-1.1.3* SCBA shall have a NIOSH/MSHA certified rated service time of at least 30 minutes.

2-1.1.4 SCBA that is NIOSH/MSHA certified as positive pressure but capable of supplying air to the user in a negative pressure, demand-type mode shall NOT be certified to this standard.

2-1.2 SCBA that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified. This certification shall be to the program specified in Section 2-2 of this chapter and shall be in addition to, and shall not be construed to be the same as, NIOSH/MSHA certification as specifically defined in Section 1-3 of this standard.

2-1.3 All certification shall be performed by an approved certification organization.

2-1.4 Compliant SCBA shall be labeled and listed. Such SCBA shall also have a product label that meets the requirements specified in Section 2-5 of this chapter.

2-1.5 Any accessory that is to be attached to or integrated with the SCBA shall be tested with and certified as part of the SCBA under this standard.

2-1.6 The SCBA shall meet all of the performance requirements of the standard with the accessory installed. The accessory itself shall not be required to meet any of the performance requirements of this standard.

2-2 Certification Program.

2-2.1* The certification organization shall not be owned or controlled by manufacturers or vendors of the product being certified. The certification organization shall be primarily engaged in certification work and shall not have a monetary interest in the product's ultimate profitability.

2-2.2 The certification organization shall refuse to certify products to this standard that do not comply with all requirements of this standard.

2-2.3* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent upon compliance with all applicable requirements of this standard. There shall be no conditional, temporary, or partial certifications. Manufacturers shall not be authorized to use any label or reference to the certification organization on products that are not manufactured in compliance with all applicable requirements of this standard.

2-2.4* For certification, laboratory facilities and equipment for conducting proper tests shall be available, a program for calibration of all instruments shall be in place and operating, and procedures shall be in use to ensure proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented calibration and calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

2-2.5 Manufacturers shall be required to establish and maintain a program of production inspection and testing.

2-2.6 The manufacturers and the certification organization shall evaluate any changes affecting the form, fit, or function of the certified product to determine its continued certification to this standard.

2-2.7* Product certifications shall include a follow-up inspection program, with at least 2 random and unannounced visits per 12-month period.

2-2.8 The certification organization shall have a program for investigating field reports alleging malperformance or failure of listed products.

2-2.9 The operating procedures of the certification organization shall provide a mechanism for the manufacturer to appeal decisions. The procedures shall include the presentation of information from both sides of a controversy to a designated appeals panel.

2-2.10 The certification organization shall be in a position to use legal means to protect the integrity of its name and label. The name and label shall be registered and legally defended.

2-3 Inspection and Testing.

2-3.1 Four identical SCBA selected from the manufacturer's production SCBA and that are to be certified to this standard shall be subjected to the tests specified in Categories A, B, C, and D of Table 2-3.1, for each test series. The first SCBA shall be subjected to the tests listed in Category A, the second SCBA shall be subjected to the tests listed in Category B, the third SCBA shall be subjected to the tests listed in Category C, and the fourth SCBA shall be subjected to the tests listed in Category D as shown in Table 2-3.1. SCBA components shall be subjected to the tests specified in Category E of Table 2-3.1.

2-3.2 SCBA shall be initially tested and shall meet the performance requirements of three separate test series of Categories A, B, C, and D as specified in Table 2-3.1. All tests within Categories A, B, C, and D shall be conducted in the order specified and are designed as cumulative damage tests.

SCBA components shall be initially tested and shall meet the performance requirements of one test series of Category E as specified in Table 2-3.1. SCBA component testing in Category E shall be conducted on test specimens as specified in each respective test method.

2-3.3 After certification, compliant SCBA shall be tested annually within twelve months from previous tests and shall meet the performance requirements of one test series of Categories A, B, C, D, and E as specified in Table 2-3.1. This requirement shall be waived every fifth year when the testing required by 2-3.3.1 of this section is conducted.

2-3.3.1 Compliant SCBA shall be tested and shall meet the performance requirements of three separate test series of Categories A, B, C, and D as specified in Table 2-3.1 every fifth year from the date of the initial certification testing specified in 2-3.2 of this section.

SCBA components shall be tested and shall meet the performance requirements of one test series of Category E as specified in Table 2-3.1 every fifth year from the date of initial certification testing specified in 2-3.2 of this section.

2-3.4 No adjustment, repair, or replacement of parts is permitted to any SCBA being tested in accordance with this standard. Breathing-gas containers shall be permitted to be filled as required.

Table 2-3.1 Test Series

Test Order	Category A (SCBA #1)	Category B (SCBA #2)	Category C (SCBA #3)	Category D (SCBA #4)	Category E (Component Tests)
1.	Air Flow Section 3-1	Air Flow Section 3-1	Air Flow Section 3-1	Air Flow Section 3-1	Fabric Flame Section 3-4
2.	Communication Section 3-10	Accelerated Corrosion Section 3-7	Vibration Section 3-3	Heat and Flame Section 3-11	Fabric Heat Section 3-5
3.	Environmental Temperature Section 3-2				Thread Heat Section 3-6
4.	Particulate Section 3-8				Lens Abrasion Section 3-9

2-3.5 Inspection and testing for determining compliance with the requirements of this standard shall be performed on a complete SCBA unless otherwise specified within this standard.

2-3.6 After completion of these tests for a specific model SCBA or its variant, only those tests on other similar SCBA models or variants shall be required where, in the determination of the certification organization, the SCBA's test results can be affected by any components that are different from those on the original SCBA tested.

2-3.7 Any modifications made by the manufacturer to an SCBA after certification shall require the retesting and meeting of the performance requirements of all those individual tests that the certification organization determines may be affected by such changes. This retesting shall be conducted before certifying the modified SCBA as being compliant with this standard.

2-4 Manufacturer's Quality Assurance Program.

2-4.1 The manufacturer shall provide and maintain a quality assurance program that includes a documented inspection and product recall system. The manufacturer shall have an inspection system to substantiate conformance to this standard.

2-4.2 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe inspection and test of materials, work in process, and completed articles. Criteria for acceptance and rejection of materials, processes, and final product shall be part of the instructions.

2-4.3 The manufacturer shall maintain records of all pass/fail tests. Pass/fail records shall indicate the disposition of the failed material or product.

2-4.4 The manufacturer's inspection system shall provide for procedures that assure the latest applicable drawings,

specifications, and instructions are used for fabrication, inspection, and testing.

2-4.5 The manufacturer shall, as part of the quality assurance program, maintain a calibration program of all instruments used to ensure proper control of testing. The calibration program shall be documented as to the date of calibration and performance verification.

2-4.6 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in process, and finished goods.

2-4.7 The manufacturer shall establish and maintain a system for controlling nonconforming material, including procedures for the identification, segregation, and disposition of rejected material. All nonconforming materials or products shall be identified to prevent use, shipment, and intermingling with conforming materials or products.

2-4.8 The manufacturer's quality assurance program shall be audited by the third party certification agency to determine that the system is sufficient to ensure continued product compliance with this standard.

2-5 Product Labeling.

2-5.1 In addition to the NIOSH/MSHA certification label and the certification organization's label, each SCBA shall have a product label permanently and conspicuously attached upon which at least the following information and warning are printed in at least 1/16 in. (1.5 mm) high letters.

(a) The following statement:

"THIS SCBA MEETS THE REQUIREMENTS OF NFPA 1981, STANDARD ON OPEN-CIRCUIT SELF-CONTAINED BREATHING APPARATUS FOR FIRE FIGHTERS, 1992 EDITION."

(b) The following warning:

“WARNING

FOR RESPIRATORY PROTECTION, SCBA MUST BE WORN AND USED AS SPECIFIED IN MANUFACTURER’S INSTRUCTIONS. DO NOT USE SCBA ALONE FOR ANY FIRE FIGHTING OR HAZARDOUS MATERIALS OPERATIONS; ADDITIONAL PROTECTIVE CLOTHING AND EQUIPMENT IS REQUIRED FOR PROTECTION. USERS MUST CLEAN AND MAINTAIN THE SCBA ONLY IN ACCORDANCE WITH MANUFACTURER’S INSTRUCTIONS. NO PROTECTIVE EQUIPMENT CAN PROVIDE COMPLETE PROTECTION FROM ALL CONDITIONS—USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS. ACCESSORIES NOT CERTIFIED FOR USE WITH THIS SCBA MAY DEGRADE THE PERFORMANCE OF THIS SCBA OR MAY VOID NIOSH/MSHA CERTIFICATION. FAILURE TO COMPLY WITH THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH.”

(c) The identification of the major components of the SCBA that are required for certification to this standard.

(d) The following warning:

“DO NOT REMOVE THIS LABEL.”

2-5.2 The major components listed by the manufacturer in 2-5.1 of this section shall be identified with the lot number or serial number or the year and the month of manufacture.

2-5.3 All portions of the required product labels shall be printed at least in English.

2-6 User Information.

2-6.1 The SCBA manufacturer shall provide, with each SCBA, instructions and information for maintenance, cleaning, disinfecting, storage, and inspection.

2-6.2 The SCBA manufacturer shall provide, with each SCBA, specific instructions and training materials regarding the use, operation, safety considerations, and limitations of the SCBA.

Chapter 3 Performance Requirements

3-1* Air Flow Performance.

3-1.1 When tested in accordance with the air flow performance test specified in Section 4-1 of this standard, the SCBA facepiece pressure shall not be less than 0.00 in. (0.00 mm) water column nor greater than 3.50 in. (88.9 mm) water column above ambient pressure from the time the test begins until the time the test is concluded.

3-2 Environmental Temperature Performance.

3-2.1 SCBA shall be tested in accordance with the environmental temperature tests specified in Section 4-2 of this standard.

3-2.1.1 When conditioned in accordance with the cold environmental test specified in 4-2.4 of this standard, the SCBA shall meet the performance requirements of Section 3-1 of this chapter.

3-2.1.2 When conditioned in accordance with the hot environmental test specified in 4-2.5 of this standard, the SCBA shall meet the performance requirements of Section 3-1 of this chapter.

3-2.1.3 When conditioned in accordance with the hot to cold environmental test specified in 4-2.6 of this standard, the SCBA shall meet the performance requirements of Section 3-1 of this chapter.

3-2.1.4 When conditioned in accordance with the cold to hot environmental test specified in 4-2.7 of this standard, the SCBA shall meet the performance requirements of Section 3-1 of this chapter.

3-3 Vibration Resistance Performance.

3-3.1 When conditioned in accordance with the vibration tests specified in Section 4-3 of this standard, the SCBA shall meet the performance requirements of Section 3-1 of this chapter.

3-4 Fabric Flame Resistance Performance.

3-4.1 When tested to the fabric flame tests specified in Section 4-4 of this standard, the test specimens shall have an average char length of not more than 4.0 in. (101.6 mm), shall have an average afterflame of not more than 2.0 seconds, and shall not melt or drip.

3-5 Fabric Heat Resistance Performance.

3-5.1 When tested to the fabric heat tests specified in Section 4-5 of this standard, the test specimens shall not melt, separate, or ignite.

3-6 Thread Heat Resistance Performance.

3-6.1 When tested in accordance with the thread heat test specified in Section 4-6 this standard, the thread shall not melt or ignite.

3-7 Accelerated Corrosion Resistance Performance.

3-7.1 When conditioned in accordance with the accelerated corrosion test specified in Section 4-7 of this standard, corrosion shall not prohibit the proper use and function as specified in the manufacturer’s instructions of any control or operating feature of the SCBA. In addition, the SCBA shall meet the performance requirements of Section 3-1 of this chapter.

3-8 Particulate Resistance Performance.

3-8.1 When conditioned in accordance with the particulate resistance test specified in Section 4-8 of this standard, the SCBA shall meet the performance requirements of Section 3-1 of this chapter.

3-9* Facepiece Lens Abrasion Resistance Performance.

3-9.1 When tested in accordance with the facepiece lens abrasion test specified in Section 4-9 of this standard, the average value of the tested samples shall not exhibit a delta haze greater than 14.0 percent.

3-10* Communications Performance.

3-10.1 When tested in accordance with the communication test specified in Section 4-10 of this standard, the primary communication means as identified by the manufacturer shall have an average calculated value of not less than 72 percent.

3-11 Heat and Flame Resistance Performance.

3-11.1 When tested in accordance with the heat and flame test specified in Section 4-11 of this standard, the SCBA facepiece pressure shall not be less than 0.00 in. (0.00 mm) water column nor greater than 3.50 in. (88.9 mm) water column above ambient pressure from the time the test begins until the time the test is concluded.

3-11.2 When tested as specified in 4-11.17 of this standard, no components of the SCBA shall have an afterflame of more than 2.2 seconds.

3-11.3 When tested as specified in 4-11.17 and 4-11.19 of this standard, no component that secures the SCBA to the user's body or that secures the cylinder to the SCBA, such as chest, pull, facepiece, waist, cylinder, and shoulder straps, shall separate or fail in such a manner that would cause the SCBA to be worn and used in a position not specified by the manufacturer's instructions.

3-11.4 When tested as specified in 4-11.20 of this standard, the facepiece lens shall not obscure vision below the 20/100 vision criterion.

Chapter 4 Test Methods

4-1 Air Flow Performance Test.

4-1.1* The facepiece of the SCBA being tested shall be secured to Scott Aviation Model No. 803608-01 or 803608-02 test headform or equivalent. The facepiece shall be secured to the headform to assure that an initial pressure of 1.0 in. \pm 0.1 in. (25.4 mm \pm 2.5 mm) water column below ambient shall not decay by more than 0.2 in. (5.1 mm) water column in 5 seconds.

4-1.2 The remaining components of the SCBA shall be mounted in accordance with Figure 4-1.2 to simulate its typical wearing position, as specified by the manufacturer, on a fire fighter.

4-1.3 A pressure probe shall be attached to the test headform to monitor facepiece pressure. The pressure probe shall be a 0.25 in. (6.4 mm) O.D. with 0.062 in. (1.6 mm) wall thickness metal tube having one open end and one closed end. The closed end shall have 4 equally spaced

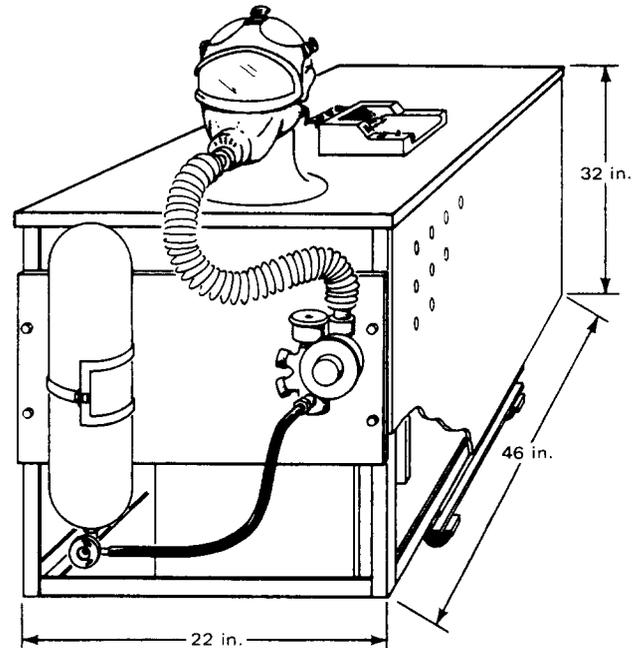


Figure 4-1.2 Typical apparatus configuration for air flow performance test.

holes, each 0.062 in. \pm 0.005 in. (1.6 mm \pm 0.1 mm), and positioned 0.250 in. \pm 0.02 in. (6.4 mm \pm 0.5 mm) from the end of the pressure probe.

4-1.4 The closed end of the pressure probe shall extend through the test headform exiting out the center of the left eye. The pressure probe shall extend 0.50 in. $+0.06/-0.0$ in. (12.7 mm $+1.5/-0.0$ mm) outward from the surface of the center of the left eye.

4-1.5 The open end of the pressure probe shall extend a maximum of 18 in. (457 mm) and a minimum of 1.0 in. (25.4 mm) outward from the back surface of the test headform.

4-1.6 A maximum of a 5 ft (1.5 m) length of nominal 0.188 in. (4.8 mm) I.D. flexible smoothbore tubing with a nominal 0.062 in. (1.6 mm) wall thickness shall be permitted to be connected from the open end of the pressure probe to the inlet of the pressure transducer.

4-1.7* A differential pressure transducer having the following characteristics shall be used:

- Range: 8.9 in. (226 mm) of water differential
- Linearity: \pm 0.5% Full Scale (FS) best straight line
- Line Pressure Effect: Less than 1% FS zero shift/1000 psig
- Output: \pm 2.5 Vdc for \pm FS
- Output Ripple: 10 mv peak to peak
- Regulation: FS output shall not change more than +0.1 percent for input voltage change from 22 to 35 Vdc
- Temperature, Operating: -65°F to 250°F (-54°C to 121°C)
- Temperature, Compensated: 0°F to 160°F (-18°C to 71°C)
- Temperature Effects: Within 2 percent FS/100 $^{\circ}\text{F}$ (55.6 $^{\circ}\text{C}$), Error band

4-1.8* The differential pressure transducer shall be appropriately connected to a strip chart recorder having the following characteristics:

- (a) A chart width of 9.8 in. (250 mm)
- (b) A pen speed of at least 29.5 in./sec (750 mm/sec) (0.333 sec FS)
- (c) An accuracy of ± 0.25 percent FS
- (d) An input voltage range of 1 V FS
- (e) A span set at 0.98 in. (25 mm) of chart per 1.0 in. (25.4 mm) water column.

4-1.9 The test headform shall be equipped with a stainless steel breathing tube having an 0.90 in. (22.9 mm) I.D. with 0.024 in. (0.6 mm) wall thickness. The metal breathing tube shall be located on the centerline of the mouth and shall be flush with the test headform.

4-1.10 The metal breathing tube shall extend outward from either the back or the base surface of the test headform a minimum of 8 in. (203 mm) and a maximum of 18 in. (457 mm).

4-1.11 If flexible smoothbore tubing is used from the metal breathing tube to the inlet connection of the breathing machine, it shall have a maximum length of 4 ft (1.2 m) and a 0.75 in. (19.0 mm) I.D. with nominal 0.125 in. (3.2 mm) wall thickness.

4-1.12* A Model 327-6 Breathing Machine as shown in Figures 4-1.12(a), (b), and (c) shall be used. The breathing machine shall be set to the following characteristics:

Ventilation Rate (liters/min)	Respiratory Frequency (breaths/min)	Tidal Volume (liters)
103 \pm 3	30 \pm 1	3.4 Nominal

4-1.13 The test conditions shall be as follows:

- Ambient temperature: 72°F \pm 5°F (22°C \pm 3°C)
- Relative humidity: 50 percent \pm 25 percent
- Barometric pressure: 725 mm Hg +50/-70 mm Hg.

The dew point of air charged into the SCBA breathing gas containers shall not be higher than -65°F (-54°C) at the outlet port of the charge line. The air shall meet or exceed the requirements of the specification for Grade D breathing air as specified in ANSI/CGA G-7.1, *Commodity Specification for Air*.

4-1.14* The test set-up for conducting the air flow performance test shall be calibrated at least once each day before conducting tests and shall be verified at least once each day after testing. The calibration procedure utilized for the differential pressure transducer shall consist of confirming at least three different pressures between 0.0 in. and 5.0 in. (0.0 mm and 127 mm) water column. The pressure shall be measured using an incline manometer or equivalent with a scale measuring in increments of ± 0.02 in. (± 0.5 mm) water column or less.

4-1.15 The SCBA being tested shall utilize a fully charged breathing gas container. The air flow performance test shall begin after five cycles of the breathing machine and continue to operate through 30 cycles of the breathing machine after actuation of the end-of-service-time indicator.

4-1.16 The facepiece pressure shall be read from the strip chart recorder to determine pass/fail.

4-2 Environmental Temperature Tests.

4-2.1 The environmental temperature tests specified in this section shall be permitted to be conducted in any sequence. After performing each test, the SCBA shall be placed in an ambient environment of 72°F \pm 5°F (22°C \pm 3°C) with a relative humidity of 50 percent \pm 25 percent for a minimum 12-hour dwell period.

4-2.2 The SCBA shall be placed in an appropriate environmental chamber and positioned to simulate the normal wearing position of the SCBA on a fire fighter as specified by the manufacturer. A test headform as specified in 4-1.1 of this chapter shall be equipped with a thermocouple or other temperature-sensing element to monitor SCBA test chamber temperature. The thermocouple or other temperature-sensing element used shall be attached to the test headform in a manner in which it will be directly exposed to the chamber atmosphere. The test headform shall be connected to the breathing machine in accordance with Section 4-1 of this chapter. The breathing machine shall be permitted to be located either inside or outside the environmental chamber.

4-2.3 The dwell period between environmental temperature tests shall be used for refilling the breathing gas container and visually inspecting the SCBA for any gross damage that could cause unsafe test conditions.

4-2.4 The SCBA shall be cold soaked at -25°F \pm 2°F (-32°C \pm 1°C) for a minimum of 12 hours. The SCBA shall be tested in accordance with Section 3-1 of this standard at an ambient temperature of -25°F \pm 10°F (-32°C \pm 5°C).

4-2.5 The SCBA shall be hot soaked at 160°F \pm 2°F (71°C \pm 1°C) for a minimum of 12 hours. The SCBA shall then be tested in accordance with Section 3-1 of this standard at an ambient temperature of 160°F \pm 10°F (71°C \pm 5°C).

4-2.6 The SCBA shall be hot soaked at 160°F \pm 2°F (71°C \pm 1°C) for a minimum of 12 hours. The SCBA shall then be transferred to a chamber with an air temperature of -25°F \pm 2°F (-32°C \pm 1°C). The SCBA shall then be tested in accordance with Section 3-1 of this standard at a chamber air temperature of -25°F \pm 10°F (-32°C \pm 5°C). The air flow performance test shall commence within 3 minutes after removal from hot soak.

4-2.7 The SCBA shall be cold soaked at -25°F \pm 2°F (-32°C \pm 1°C) for a minimum of 12 hours. The SCBA shall then be transferred to a chamber with an air temperature of 160°F \pm 2°F (71°C \pm 1°C). The SCBA shall then be tested in accordance with Section 3-1 of this standard at a chamber air temperature of 160°F \pm 10°F (71°C \pm 5°C). The air flow performance test shall commence within 3 minutes after removal from cold soak.

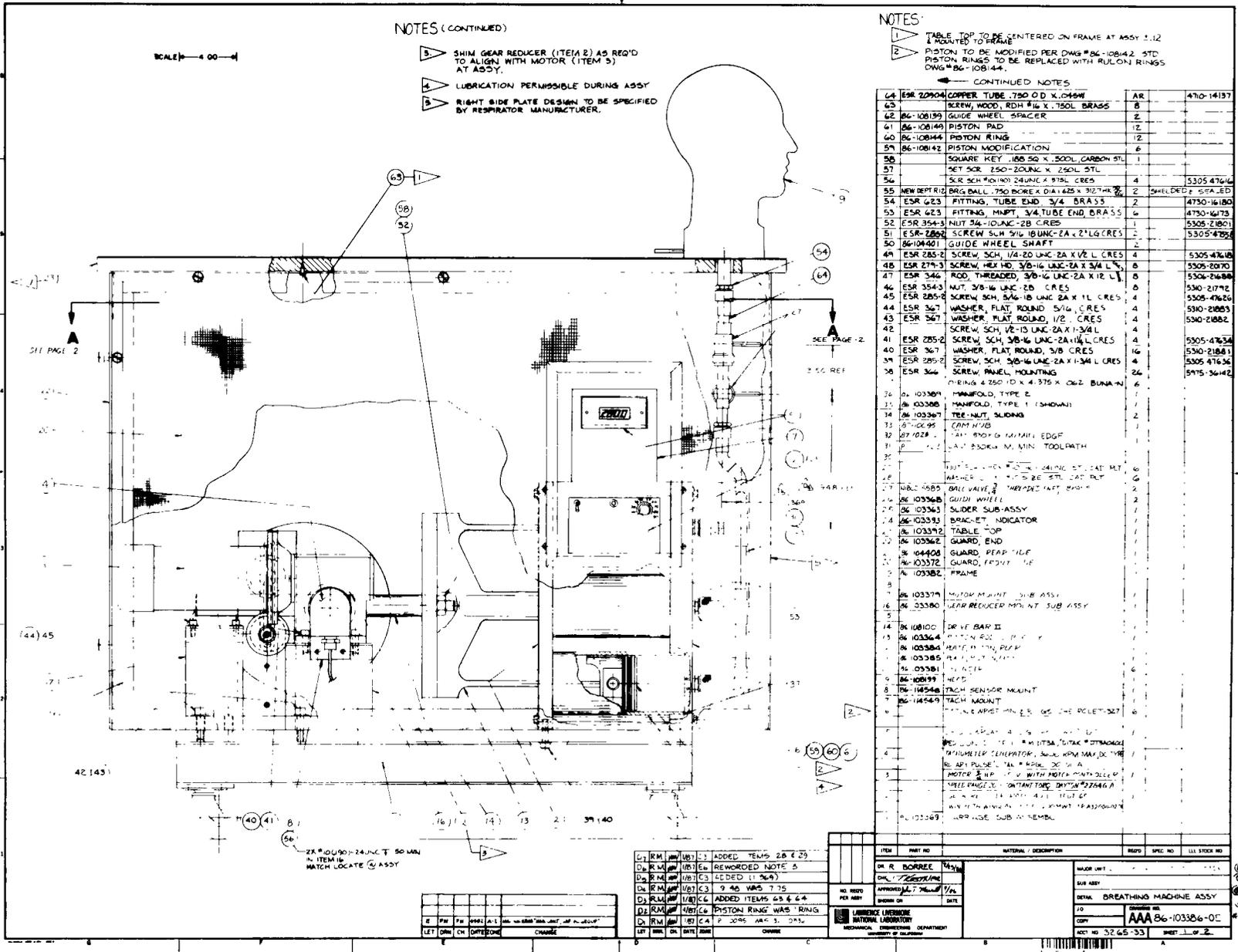


Figure 4-1.12(a) Model 327-6 Breathing Machine.

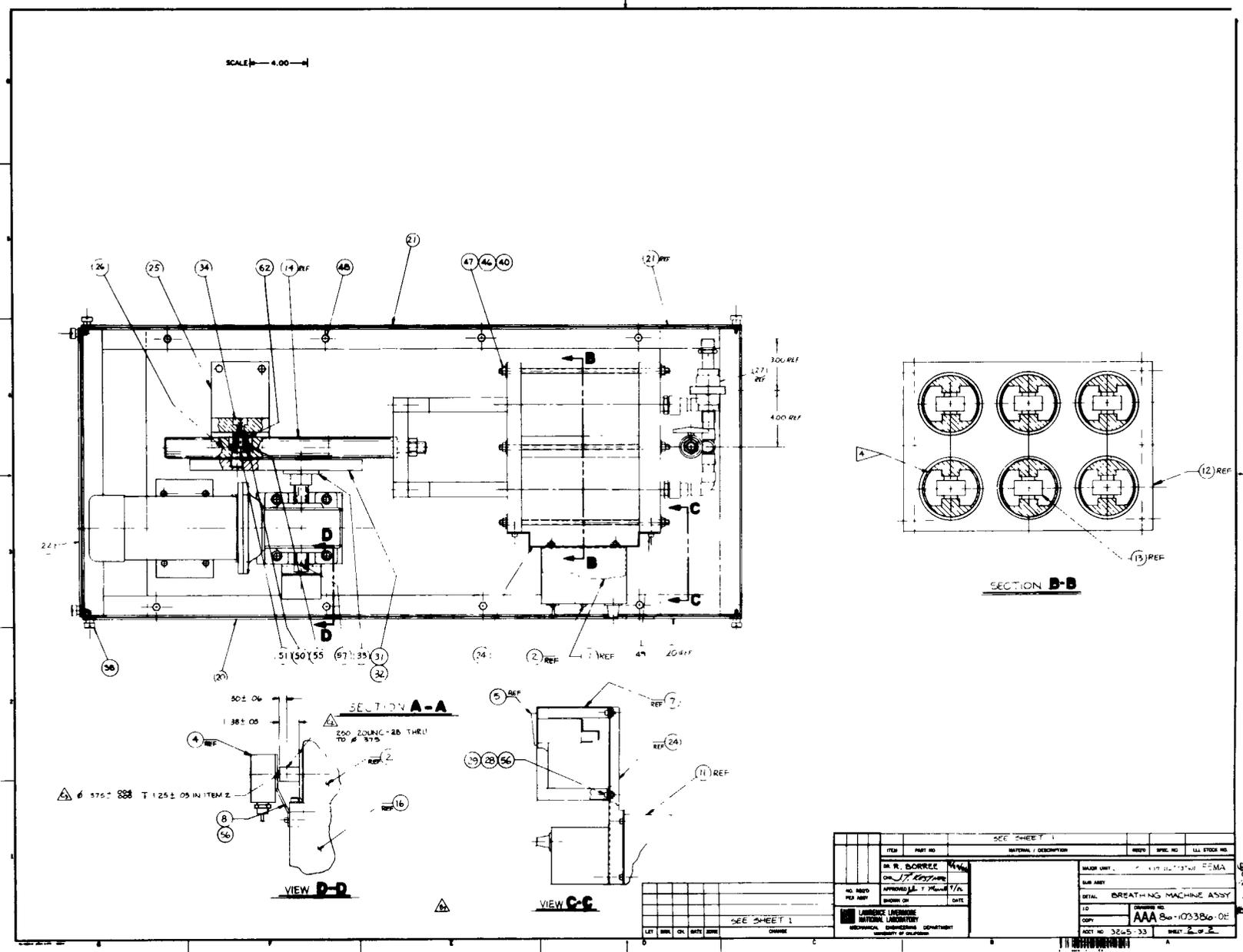


Figure 4-1.12(b).

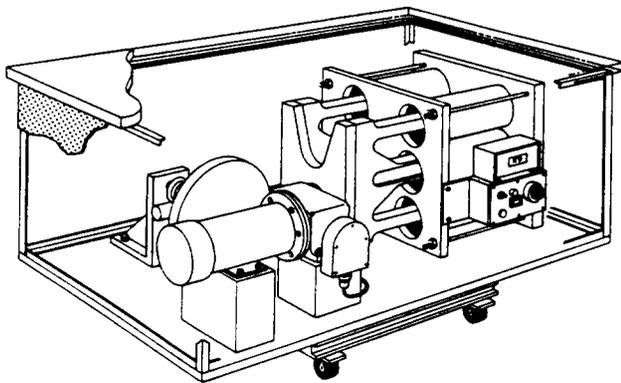


Figure 4-1.12(c) Model 327-6 Breathing Machine.

4-3 Vibration Tests.

4-3.1 The following test program shall be conducted according to sections in Method 514.4, Vibration, of MIL-STD-810E, *Environmental Test Methods*, specified herein. After being subjected to the tests, the SCBA shall be tested in accordance with Section 3-1 of this standard.

4-3.2 The complete SCBA, with full breathing gas container, shall be securely mounted on the vibration fixture/table using a suitable rigid mounting bracket designed to maximize vibration transfer directly to and through the breathing gas container. This restraining device shall be acceptable to both the manufacturer and the certification organization. The SCBA shall be vibrated as specified in the following frequency curves of MIL-STD-810E, *Environmental Test Methods*:

- (a) Figure 514.1-1, vertical,
- (b) Figure 514.4-2, transverse,
- (c) Figure 514.4-3, longitudinal.

The SCBA shall be vibrated to simulate cargo tied or blocked in all three axes with respect to the bed of the transport vehicle.

The definitions of the SCBA axes shall be as shown in Figure 4-3.2 of this standard. The total test duration shall be nine hours, consisting of three 3-hr periods: one period for each frequency curve.

4-3.3 Subsequently, the same complete SCBA shall be tested on a typical package tester similar to that shown in Figure 514.4-19 of MIL-STD-810E, *Environmental Test Methods*, within a plywood holding box(es) as specified in 4-3.4 of this section.

4-3.4 An SCBA holding box shall be constructed with nominal $\frac{3}{4}$ in. plywood to encase the complete SCBA. All SCBA regulators and hoses shall remain attached to the complete SCBA. The SCBA facepiece and those components, excluding regulators, that attach directly to the facepiece shall not be included in the holding box. The travel distance between the widest part of the SCBA and the sideboards of the holding box shall be a total of 1.0 in. \pm 0.2 in. or 0.5 in. \pm 0.1 in. per side (2.5 cm \pm 0.5 cm or 1.3 cm \pm 0.3 cm/side).

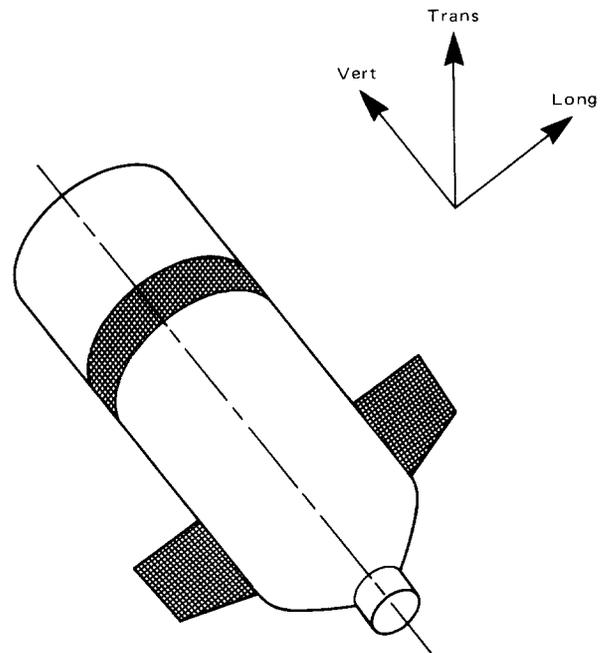


Figure 4-3.2 Test specimen axes definitions.

The travel distance between the highest point of the SCBA and the bottom of the box top shall be a total of 1.0 in. \pm 0.2 in. (2.5 cm \pm 0.5 cm).

4-3.4.1 A separate component holding box shall be constructed with nominal $\frac{3}{4}$ in. plywood to encase the facepiece and those components that attach directly to the facepiece, excluding the regulator and associated hoses. The total travel distance between the widest part of the SCBA components and the sideboards of the holding box shall be 1.0 in. \pm 0.2 in. or 0.5 in. \pm 0.1 in. per side (2.5 cm \pm 0.5 cm or 1.3 cm \pm 0.3 cm/side).

The total travel distance between the highest point of the facepiece and the bottom of the box shall be 1.0 in. \pm 0.2 in. (2.5 cm \pm 0.5 cm).

4-3.4.2 The total travel distances shall be measured with all movable components configured to minimize the size of the holding box. The SCBA shall be oriented with the back plate resting on the box bottom as shown in Figure 4-3.4.2. The SCBA facepiece shall be measured with the outer portion of the lens facing the component holding box top.

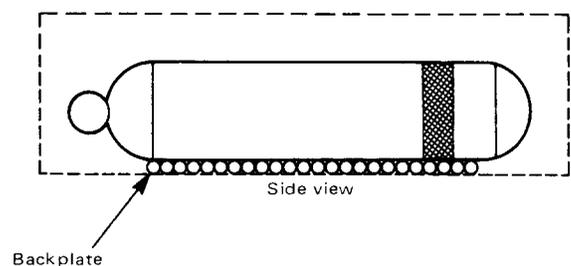


Figure 4-3.4.2 SCBA in holding box.

4-3.5 The test items shall be placed unrestrained in the holding box(es) described in 4-3.4 of this section and shall be tested to the level as specified in I-3.3.3.2 of Method 514.4, Vibration, of MIL-STD-810E, *Environmental Test Methods*.

4-3.6 The test shall be conducted with the test specimen situated in each of the two positions shown in Figure 4-3.6(a) and Figure 4-3.6(b). The total test duration shall be three hours, consisting of two 90-minute periods, one period for each position.

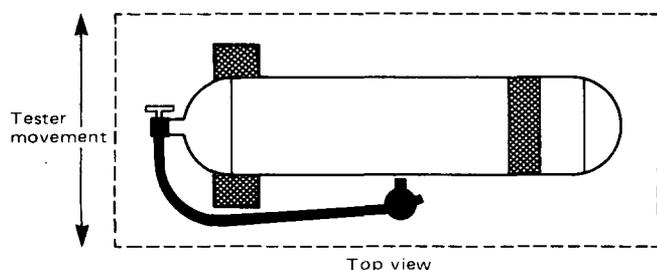


Figure 4-3.6(a) SCBA cylinder axis perpendicular to direction of tester movement.

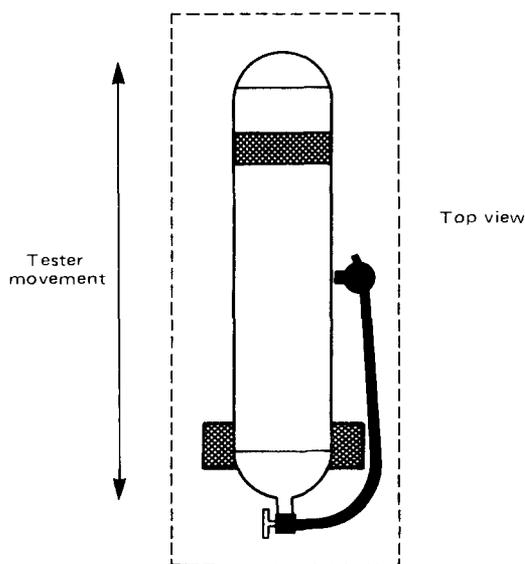


Figure 4-3.6(b) SCBA cylinder axis parallel to direction of tester movement.

4-3.7 For safety purposes, a restraining device or cover shall be secured to the top of the vibration box throughout testing. The restraining device shall be designed to contain the SCBA within the holding box without disrupting the normal motion of the SCBA in any manner during the test.

4-4 Fabric Flame Tests.

4-4.1 Five specimens of each different fabric component of the SCBA shall be tested in accordance with Method 5903.1, Flame Resistance of Cloth; Vertical, of Federal Test Method Standard 191A, *Textile Test Methods*.

4-4.2 Test specimens shall be a minimum of 12 in. (305 mm) long and shall be tested in the width specified by the prescribed test method. Test specimens shall be cut from a standard production run of the fabric components used in the SCBA. If the fabric components are not available in the width specified in Method 5903.1, the width of the test specimen shall be the widest width as used on the SCBA, but shall be a minimum of 12 in. (305 mm) long.

4-4.3 The five test specimens shall first be conditioned by five cycles of washing and drying in accordance with the procedures specified in Machine Cycle 1, Wash Temperature V, Drying Procedure Ai, of AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*, prior to flame resistance testing.

4-4.4 The char lengths and afterflame shall be recorded, and each shall be averaged to determine pass/fail. Melting and dripping shall be observed and recorded to determine pass/fail.

4-5 Fabric Heat Tests.

4-5.1 Five specimens of each different fabric component of the SCBA shall be tested in a forced circulating air oven capable of achieving and maintaining an air stream temperature of 500°F +10°/-0°F (260°C +5°/-0°C).

4-5.2 Test specimens shall be 15 × 15 in. ±0.5 in. (381 × 381 mm ±13 mm) and shall be cut from a standard production run of the fabric components used in the SCBA. If the fabric is not available in a 15-in. (381-mm) width, the width of the test specimen shall be the widest width as used on the SCBA, but shall be a minimum of 15 in. (381 mm) long.

4-5.3 The five test specimens shall first be conditioned by five cycles of washing and drying in accordance with the procedures specified in Machine Cycle 1, Wash Temperature V, Drying Procedure Ai, of AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*, prior to heat resistance testing.

4-5.4 The test specimen shall be suspended by a metal hook(s) at the top and centered in the oven so that the entire test specimen is not less than 2 in. (51 mm) from any oven surface or another test specimen. Oven air flow shall be parallel to the plane of the material.

4-5.5 Test specimens shall be exposed to the circulating air flow for 5 minutes +15/-0 seconds. Oven recovery time after the door is closed shall not exceed one minute. Test specimen exposure time shall begin when the oven has recovered to an air temperature of 500°F +10°/-0°F (260°C +5°/-0°C).

4-5.6 The fabric shall be observed for melting or ignition to determine pass/fail.

4-6 Thread Heat Test.

4-6.1 All thread utilized shall be tested in accordance with Method 1534, Melting Point of Synthetic Fibers, of Federal Test Method Standard 191A, *Textile Test Methods*, to a temperature of 500°F + 10°/-0°F (260°C + 5°/-0°C).

4-6.2 Thread shall be observed for melting or ignition to determine pass/fail.

4-7 Accelerated Corrosion Test.

4-7.1 An SCBA with a fully charged cylinder, and having the cylinder valve closed, shall be tested in accordance with Method 509.3, Salt Fog, Section II, of MIL-STD-810E, *Environmental Test Methods*.

4-7.2 The SCBA shall be attached to a mannequin to simulate its typical wearing position on a fire fighter as specified by the manufacturer. The mannequin shall then be placed in a test chamber. The test chamber temperature shall be adjusted to 95°F ± 3°F (35°C ± 2°C). The SCBA shall be placed in the chamber for 2 hours prior to the introduction of the salt solution.

4-7.3 The SCBA shall be exposed to a 5 percent ± 1 percent salt fog for a period of 48 hours.

4-7.4 The SCBA shall then be stored in an environment of 72°F ± 5°F (22°C ± 3°C) with 50 percent ± 5 percent relative humidity for a minimum of 48 hours.

4-7.5 The SCBA shall then be tested in accordance with Section 3-1 of this standard to determine pass/fail. All controls or operating features of the SCBA shall operate per the SCBA manufacturer's instructions to determine pass/fail.

4-8 Particulate Test.

4-8.1 A fully charged SCBA shall be subjected to Method 510.3, Sand and Dust, Section II-3, Procedure 1, of MIL-STD-810E, *Environmental Test Methods*.

4-8.2 The facepiece of the SCBA being tested shall be secured to a test headform as specified in 4-1.1 of this chapter.

4-8.3 The test headform shall be joined to a mannequin with the remaining components of the SCBA attached to the mannequin to simulate its typical wearing position on a fire fighter as specified by the manufacturer.

4-8.4 The test headform shall be connected as specified in Section 3-1 of this standard to a Model 327-6 Breathing Machine or other respiration simulator producing a minute volume of 40 liters, ± 2 liters at ambient conditions as specified in 4-1.13 of this chapter with a minimum tidal volume of 1.6 liters per breath at a minimum respiration of 10 breaths per minute.

4-8.5 The mannequin, including the test headform, shall be mounted upright and turned about its vertical axis 180 degrees midway through the test. The test duration shall

be 1 hour, and the breathing machine shall be operating throughout the entire test. The test shall be permitted to be interrupted to change the SCBA breathing gas container.

4-8.6 The test conditions as outlined per Method 510.3, Sand and Dust, of MIL-STD-810E, *Environmental Test Methods*, Section I-3d, shall be:

- (a) Air velocity: Refer to subparagraph I-3.2c (1).
- (b) Temperature: 72°F ± 5°F (22°C ± 3°C).
- (c) Test item configuration and orientation: mannequin upright and rotated 180 degrees midway through the test.
- (d) Dust composition: Refer to Section I-3.2d (1).
- (e) Dust concentration: Refer to Section I-3.2e (1).
- (f) Test duration: 1.0 hour.

4-8.7 After the completion of the above test, the SCBA shall be removed from the test compartment; it shall be lightly shaken or brushed free of dust and then shall be tested in accordance with Section 3-1 of this standard to determine pass/fail.

4-9 Facepiece Lens Abrasion Test.

4-9.1 The test apparatus shall be constructed in accordance with Figure 4-9.1.

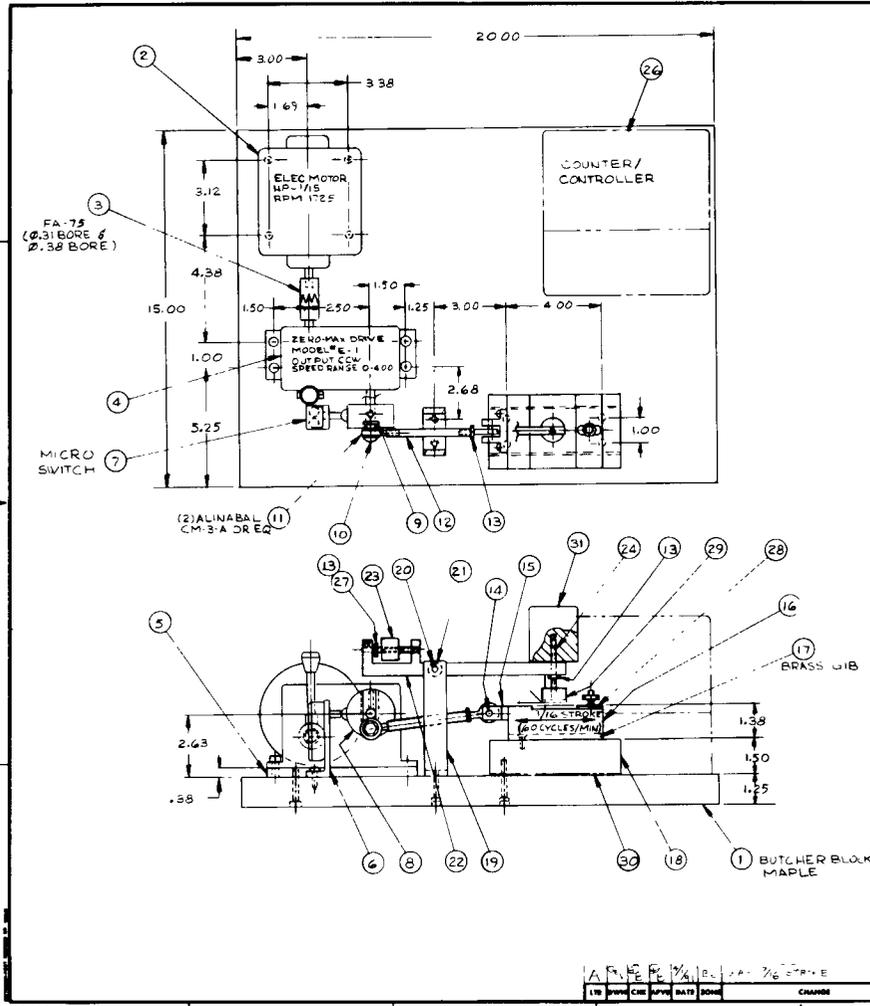
4-9.2 Seven samples shall be chosen from a minimum of three facepiece lenses. Four samples shall be taken from the left viewing area, and three samples shall be taken from the right viewing area. One of the four samples taken from the left viewing area shall be the set-up sample.

4-9.2.1 The left test samples shall include all of the following criteria:

- (a) The sample shall be a square measuring 2 × 2 in. (51 × 51 mm).
- (b) Two edges of the square section shall be parallel within ± 2 degrees of the axis of the cylinder or cone in the center of the sample.
- (c) At least 1½ in. (38 mm) of the 2 × 2 in. (51 × 51 mm) square shall be taken from the left side of the center line of the lens.
- (d) The 2 × 2 in. (51 × 51 mm) square shall be cut at approximately eye level.

4-9.2.2 The right test samples shall include all of the following criteria:

- (a) The sample shall be a square measuring 2 × 2 in. (51 × 51 mm).
- (b) Two edges of the square section shall be parallel within ± 2 degrees of the axis of the cylinder or cone in the center of the sample.
- (c) At least 1½ inches (38 mm) of the 2 × 2 in. (51 × 51 mm) square shall be taken from the right side of the center line of the lens.
- (d) The 2 × 2 in. (51 × 51 mm) square shall be cut at approximately eye level.



- NOTES
UNLESS OTHERWISE SPECIFIED:
1. ALL DIMENSIONS ARE IN INCHES.
 2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
 3. SURFACE TEXTURE PER ANSI B46.1-1978.
 4. TOLERANCE ±.01.
 5. DRAWING TRACED AND REDRAWN PER FOSTER GRANT CORPORATION DWG #L-403-16'2.

1	BRASS WEIGHT	Ø 2.00 x 2.32L BRASS	31
1	RUBBER CUSHION	.032THK x 3.00W x .550L	30
1	ABRADER HOLDER	Ø 1.00 x .63L AL	29
1	LENS CLAMP	.12THK x .118W x 3.00L AL	28
1	THD ROD WEIGHT	STL	27
1	COMMERCIAL	COUNTER/CONTROLLER	26
1	ABRADER ROD	#10-32 x 3.00L STL	25
1	WEIGHT	Ø 1.00 x .75L BRASS	24
1	BALANCE ARM	.25THK x .50W x 8.50L AL	22
2	COMMERCIAL	BEARING #77R2A N.D. OR EQ	21
1	PIVOT ROD	Ø.18 x 2.00L SST	20
1	BALANCE ARM BRACKET	1.00THK x 2.00W x 4.88L AL	19
1	BASE PLATE	1.50THK x 3.00W x 5.50L AL	18
1	BRASS GIB	.25THK x 2.00W x 4.50L BRASS	17
1	SLIDING BLOCK	1.38THK x 3.00W x 4.00L AL	16
1	PIVOT BRACKET	.50THK x 1.00W x 2.00L AL	15
1	COMMERCIAL	DOWEL Ø.18 x 1.00L STL	14
3	COMMERCIAL	LOCK NUT #10-32	13
1	CONNECTING ROD	Ø.31 x 3.25L AL	12
2	COMMERCIAL	BALL JOINT ROD END #10-32 STL	11
1	COMMERCIAL	PIVOT SCREW & WASHER #10-32 x .38 STL	10
1	GIB	.12THK x .50SQ BRASS	9
1	COMMERCIAL	CAM Ø 2.00 x 1.00L SST	8
1	COMMERCIAL	MICROSWITCH	7
1	SWITCH BRACKET	1.00THK x 1.00W x 3.25L AL	6
1	SPACER PLATE	.38THK x 2.00W x 6.25L AL	5
1	COMMERCIAL	VARIABLE SPEED DRIVE ZEROMAX #11	4
1	COMMERCIAL	COUPLING FA-75 Ø.31 BORE x Ø.38 BORE	EQ 3
1	COMMERCIAL	MOTOR HP 1/15 RPM 1725	EQ 2
1	BASE BUTCHER BLOCK MAPLE	1.25THK x 15W x 20L	1

NO REQD	PART / ILLN	DATE	DESCRIPTION / MATERIAL	SPEC NO	ITEM
	DWM DAIN CILLEY	11/29/85	CLASSIFICATION	U.S. Fire Administration/FEMA	
	CHK O. Bess	11/19/85		LIBRARY	
	APVD O. Bess	11/19/85		DETAIL N.F.P.A. LENS ABRASION TEST APPARATUS	
	RELEASING TR.			DRAWING NO	
	FILE	DATE		BOOKS ON SHIP	
			LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA	ACT NO 6668-85	
				DRAWING NO AAA 90-111621-0A	
				SCALE NO. 1.0 SHEET 1 OF 2	

Figure 4-9.1 Lens abrasion tester.

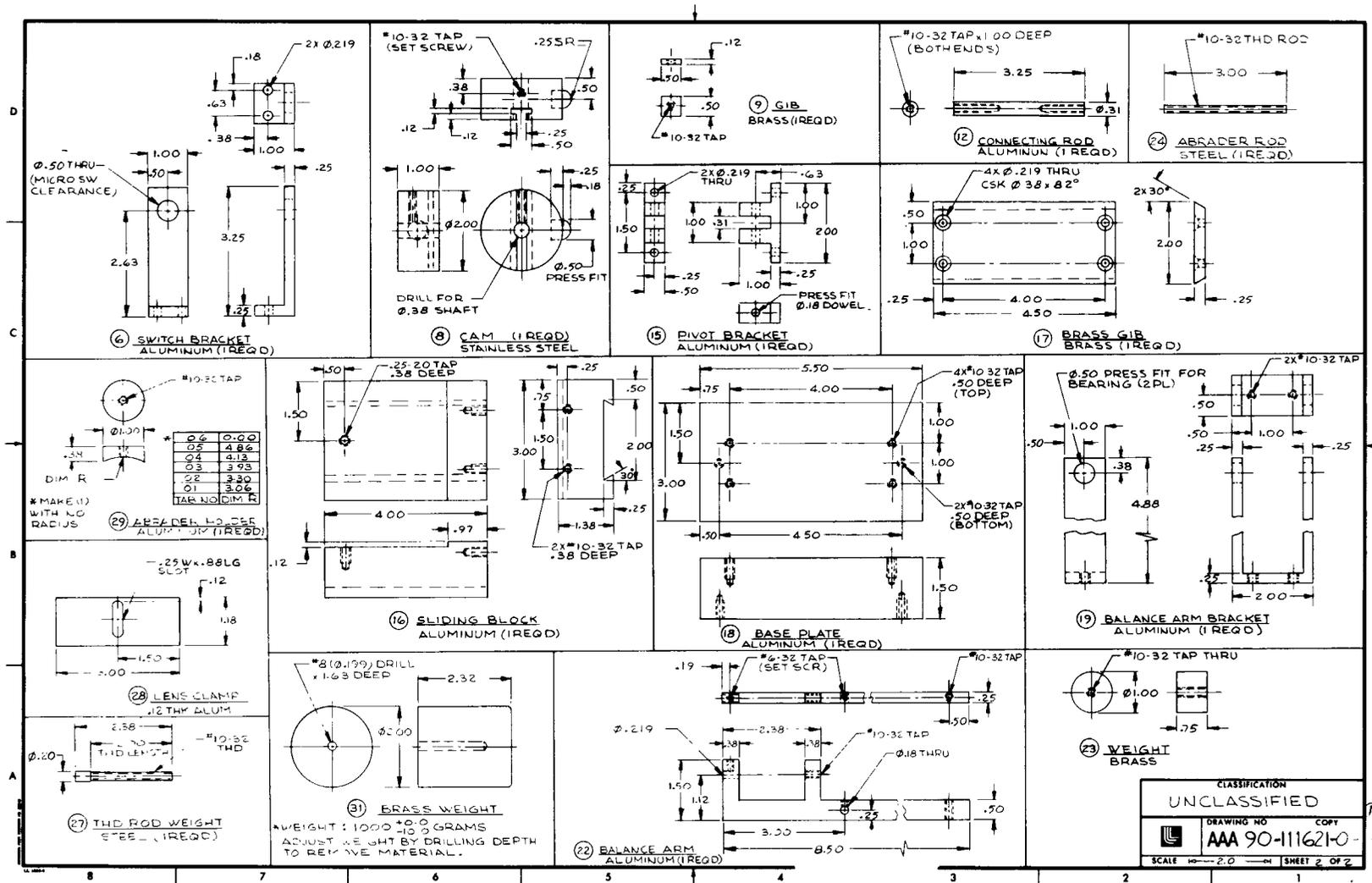


Figure 4-9.1 (continued).

4-9.3 Each of the samples shall be cleaned in the following manner:

- (a) The sample shall be rinsed with clean tap water.
- (b) The sample shall be washed with a solution of nonionic/low phosphate detergent and water using a clean, soft gauze pad.
- (c) The sample shall be rinsed with deionized water.
- (d) The sample shall be blown dry with clean compressed air or nitrogen.

4-9.4 The haze of the sample shall be measured using a haze meter in accordance with ASTM D 1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*, and recorded with the following additions:

- (a) The haze shall be measured in the middle of the sample $\pm 1/16$ in. (± 1.6 mm).
- (b) The sample shall be repositioned to achieve the maximum haze value within the area defined in (a).
- (c) The haze meter shall have a specified aperture of $7/8$ in. (22.4 mm).
- (d) The haze meter shall have a visual display showing 0.1 percent resolution.
- (e) The haze meter shall be calibrated before and after each day's use following procedures outlined in ASTM D 1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*.

4-9.5 The set-up sample shall be placed cover side up in the test apparatus sample holder. The sample holder shall be configured with a flat surface under the lens or with an inner radius support.

4-9.6 The pad holder shall consist of a cylinder $3/8$ in. (9.6 mm) high and 1 in. (25.4 mm) in diameter with a radius of curvature equal to the radius of curvature of the outside of the lens in the viewing area $\pm 1/4$ diopter. This cylinder shall be rigidly affixed to the stroking arm by a #10-32 UNF threaded rod.

4-9.7* The pad shall be a Blue Streak M306M wool felt polishing pad $15/16$ in. (23.8 mm) in diameter.

4-9.8* The abrasive disc shall be made from 3M Part Number 7415, Wood Finishing Pad. A disc $15/16$ in. (23.8 mm) in diameter shall be cut from the abrasive sheet. The marked side of the disc shall be placed against the pad. Care shall be exercised to maintain this orientation for each abrasive disc throughout the testing.

4-9.9 The pad holder, pad, and abrasive disc shall be installed on the stroking arm. The stroking arm shall be leveled to ± 3 degrees by adjusting the threaded pin. The pin shall be secured to prevent rotation of the pad holder. The axis of curvature of the pad holder shall be coincident with the axis of curvature of the lens.

4-9.10 The stroking arm shall be counterbalanced with the pad holder, pad, and abrasive disc in place.

4-9.11 The set-up sample shall be replaced with one of the six samples to be tested.

4-9.12 The 1000 g ± 5 g test weight shall be installed on the pin above the test sample.

4-9.13 The test shall be run for 200 cycles ± 1 cycle. One cycle shall consist of a complete revolution of the eccentric wheel.

4-9.14 The length of stroke shall be $9/16$ in. (14.4 mm) producing a pattern $1 1/2$ in. (38.1 mm) long. The frequency of the stroke shall be 60 cycles ± 1 cycle per minute. The center of the stroke shall be within $\pm 1/16$ in. (± 1.6 mm) of the center of the sample.

4-9.15 The sample shall be removed and cleaned following the procedure specified in 4-9.3 of this section. The abrasive disc shall be discarded.

4-9.16 The haze of the sample shall be measured following the procedure specified in 4-9.4 of this section.

4-9.17 The delta haze shall be calculated by subtracting the initial haze from the final haze.

4-9.18 The testing steps specified in 4-9.3 through 4-9.16 of this section shall be repeated five times with a new sample and abrasive disc.

4-9.19 The six delta haze values shall be averaged. The resultant value shall be compared to the value specified in 3-9.1 of this standard to determine pass/fail.

4-10 Communication Test.

4-10.1 The method for measuring word intelligibility shall be as specified in ANSI S3.2, *Method for Measuring the Intelligibility of Speech over Communication Systems*, as modified by the following requirements.

4-10.2 Testing shall be conducted in a chamber that absorbs a minimum of 90 percent of all sound from 500 to 5000 Hz.

4-10.3 Five listening subjects and five talkers consisting of four males and one female shall be available for testing. The subjects participating as listeners shall have "audiometrically normal" hearing as defined in Section 5.3 of ANSI S3.2, *Method for Measuring the Intelligibility of Speech over Communication Systems*. Talkers and listeners shall be selected and trained according to Section 7 of ANSI S3.2, *Method for Measuring the Intelligibility of Speech over Communication Systems*.

4-10.4 The five talkers shall not have facial hair, any unusual facial characteristics, or any other condition that could cause interference with the seal of the facepiece from either. The talkers shall perform and pass a qualitative fit check per the SCBA manufacturer's instructions. If the talker is qualified to wear several sizes of facepieces, then the talker shall choose the facepiece that is most comfortable.

4-10.5 The five talkers shall be trained in the donning and usage of the SCBA per manufacturer's instructions.

4-10.6 The five talkers shall have no obvious speech defect or strong regional accent. Distance between the talker and listener(s) shall be 5 ft + 1/-0 ft, and they shall be facing each other.

4-10.7 The test material shall be the reading of one complete list of phonetically balanced words as contained in Table 1 of ANSI S3.2, *Method for Measuring the Intelligibility of Speech over Communication Systems*. The words shall be spoken singularly in the following carrier sentence: "Would you write (list word) now?" The rate shall be approximately one test word every six seconds. The talkers shall be trained to talk at 65-75 dBA without an SCBA facepiece, measured at the listener's ear, placing no unusual stress on any word. Training shall include the use of background noise as defined in 4-10.9 of this section. The talkers shall not vary their voice level after the facepiece is donned from that used without the facepiece. The listeners shall write each word as they hear it.

4-10.8 The talkers shall conduct two tests in the chamber having an ambient noise field as specified in 4-10.9 of this section, using a different word list for each of the following conditions:

(a) With no SCBA,

(b) With SCBA worn and operated per the SCBA manufacturer's instructions.

4-10.9 The test chamber shall be filled with broadband "pink" noise with a tolerance of 6 dB per octave band from 400 to 4,000 Hz. The forward axis of the loudspeaker shall be oriented away from the listener group. The distance between the loudspeaker and the listeners shall be as great as possible so as to create a quasi-uniform sound field over the listening group. More than one loudspeaker shall be permitted to be used to achieve the desired sound field. The gain of the power amplifier shall be adjusted to achieve an A-weighted sound level of 60 dB \pm 2 dB at each listener's head position, without listeners present.

4-10.10 Each listener's response form shall be scored as to the number of correct responses out of the 50 words recited. Talkers' speech shall be recorded or monitored closely during the tests to determine if the talkers conform to the word list specified for that test. Listeners' scores shall be based on the words actually spoken by the talkers. Listeners' scores shall not be reduced because of speaking mistakes of the talkers or spelling errors that are phonetically correct.

4-10.11 All of the listeners' scores without the SCBA used by the talker shall be averaged. All of the listeners' scores with the SCBA used by the talker shall be averaged. The average score of the five listeners for the talker using the SCBA shall be divided by the average score of the five listeners for the talker without using the SCBA, and the result shall be called the "score value." This procedure shall be performed for each of the five talkers.

4-10.12 The average of the score values obtained in 4-10.11 shall be calculated.

4-10.12.1 If the average of the score values \geq 72 percent, this average score value shall be used to determine pass/fail as specified in Section 3-10 of this standard.

4-10.12.2 If the average of the score values $<$ 72 percent, the sample standard deviation (s.d.) of the score values shall be calculated in the following manner:

$$\text{s.d.} = \sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{N}}{N - 1}}$$

where x = score values

N = sample size (5).

4-10.12.3 If the calculated sample standard deviation of the test score values $>$ 10.0, the test shall be invalidated, and the procedures of 4-10.7 through 4-10.12.6 of this section shall be repeated.

4-10.12.4 If the calculated sample standard deviation of the test score values \leq 10.0, a test statistic T value shall be calculated to determine if the average of the score values obtained is or is not equivalent to 72 percent; it shall be calculated in the following manner:

$$T = \frac{(\bar{x} - \mu) \sqrt{N}}{\text{s.d.}}$$

where \bar{x} = average of the score values

N = sample size (5)

μ = 72 percent

s.d. = sample standard deviation.

4-10.12.5 For T values \leq 2.13, the score value shall be considered to be equivalent to a score value of 72 percent and shall be used to determine pass/fail as specified in Section 3-10 of this standard.

4-10.12.6 For T values $>$ 2.13, the score value shall be calculated in 4-10.12 of this section. This calculated score value shall be used to determine pass/fail as specified in Section 3-10 of this standard.

4-11* Heat and Flame Test.

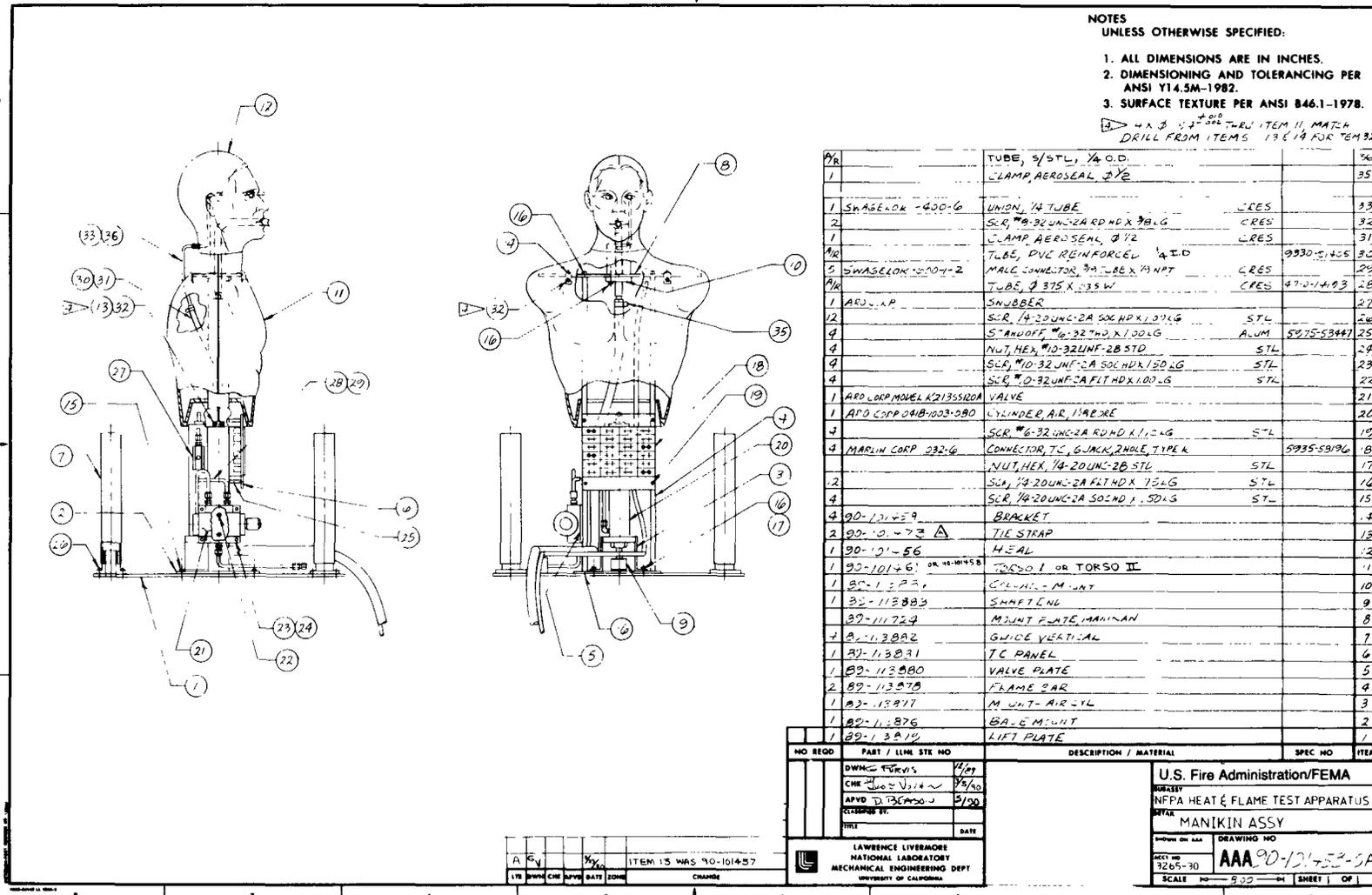
4-11.1 A test mannequin meeting the requirements specified in Figure 4-11.1 shall be provided.

4-11.2* The test mannequin shall have a protective covering. The protective covering shall be designed and constructed as follows.

4-11.2.1 The assembled protective covering composite consisting of an outer shell, moisture barrier, and thermal liner shall have an average Thermal Protective Performance (TPP) of not less than 35.0 when tested in accordance with Section 5-2 of NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*.

4-11.2.2 The outer shell shall be 40 percent PBI/60 percent Kevlar rip stop weave, weighing approximately 7.5 oz/sq yd with a water repellent finish. Color shall be natural, undyed.

4-11.2.3 The thermal liner shall be constructed of a 3.0 oz/sq yd rip stop pajama check NOMEX III facecloth quilt stitched to 100 percent NOMEX III batting of approximately 6.0 oz/sq yd.



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Figure 4-11.1.

4-11.2.4 The moisture barrier shall be constructed of approximately 2.25 oz/sq yd polyester/cotton fabric that is coated with approximately 6.5 oz/sq yd of flame resistant neoprene.

4-11.2.5 The moisture barrier shall be completely sewn to the thermal liner at its perimeter with the neoprene side facing outward from the thermal liner. All edges shall be sewn together and bound with non-wicking moisture barrier material. The liner/moisture barrier shall be no more than 3 in. (76 mm) from the coat hem.

4-11.2.6 The moisture barrier and thermal liner shall be completely detachable from the outer shell.

4-11.2.7 The protective covering shall be stitched with Kevlar thread using a minimum of 6-8 stitches per inch. All major seams are to be double stitched and felled locked with all inside seams to be finished with Kevlar thread. All stress points shall be reinforced. No metal shall pass from the outside of the protective covering through the moisture barrier and liner to cause the transfer of heat to the mannequin when the protective covering is completely assembled. The protective covering, including the front closure, shall be constructed in a manner that provides secure and complete moisture and thermal protection. If nonpositive fasteners, such as snaps or hook and pile tape, are utilized in garment closures, a positive locking fastener, such as hooks and dees or zippers, shall also be utilized. Pockets and fluorescent retroreflective trim shall not be installed.

4-11.2.8 The collar shall be made of four-piece construction consisting of outer shell material on both the back or outside and next to the mannequin neck. The two inner layers shall consist of a thermal liner and moisture barrier. No throat strap shall be attached.

4-11.2.9 Sleeve outside seams shall be felled, while inside seams shall be lock stitched.

4-11.2.10 All protective covers shall measure 35 in. (889 mm) long when measured from the center of the back collar seam to the hem. The protective cover size shall be 44-in. chest × 34 in. sleeve (118 mm × 864 mm).

4-11.2.11 The complete protective covering shall be discarded and shall not be used after three flame exposures of the flame and heat test.

4-11.3 A test headform meeting the requirements specified in 4-1.1 of this chapter shall be used on the test mannequin.

4-11.4 The test headform shall be attached to the Model 327-6 Breathing Machine as specified in Figures 4-1.12(a), (b), and (c), with the modification that a 0.75 in. I.D. breathing hose, not longer than 25 ft (7.6 m), shall be attached to the tee in the breathing machine and the throat tube of the test mannequin headform.

4-11.5 The test headform shall be covered with an undyed aramid hood for protection of the headform during testing. The protective hood shall meet the requirements of Section 6-1 of NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*.

4-11.6 The protective hood, when placed on the test headform, shall not affect the seal of the facepiece to the

headform. The protective hood shall not cover or protect any part of the facepiece or the facepiece retention system that holds the facepiece to the headform.

4-11.7 The SCBA shall be mounted on the test mannequin to simulate the correct wearing position on a fire fighter as specified by the SCBA manufacturer's instructions.

4-11.8 The facepiece shall be mounted and tested on the test headform as specified in 4-1.1 of this chapter.

4-11.9 The heat and flame test apparatus shall be as specified in Figure 4-11.9.

4-11.10 The test oven shall be a horizontal forced circulating air oven with an internal velocity of 200 linear ft (61 m) per minute. The test oven shall have minimum dimensions of 36 in. depth × 36 in. width × 48 in. height. (91 × 91 × 122 cm).

4-11.11 The test oven shall be calibrated using a 30-gauge exposed bead type J iron/constantin wire reference thermocouple that has been calibrated to set the 32.0°F (0.0°C) reference point with an ice bath containing ice and deionized or distilled water. Boiling water shall be used to set the 212°F (100°C) reference value. The reference temperatures shall be corrected to standard temperatures using a barometric pressure correction.

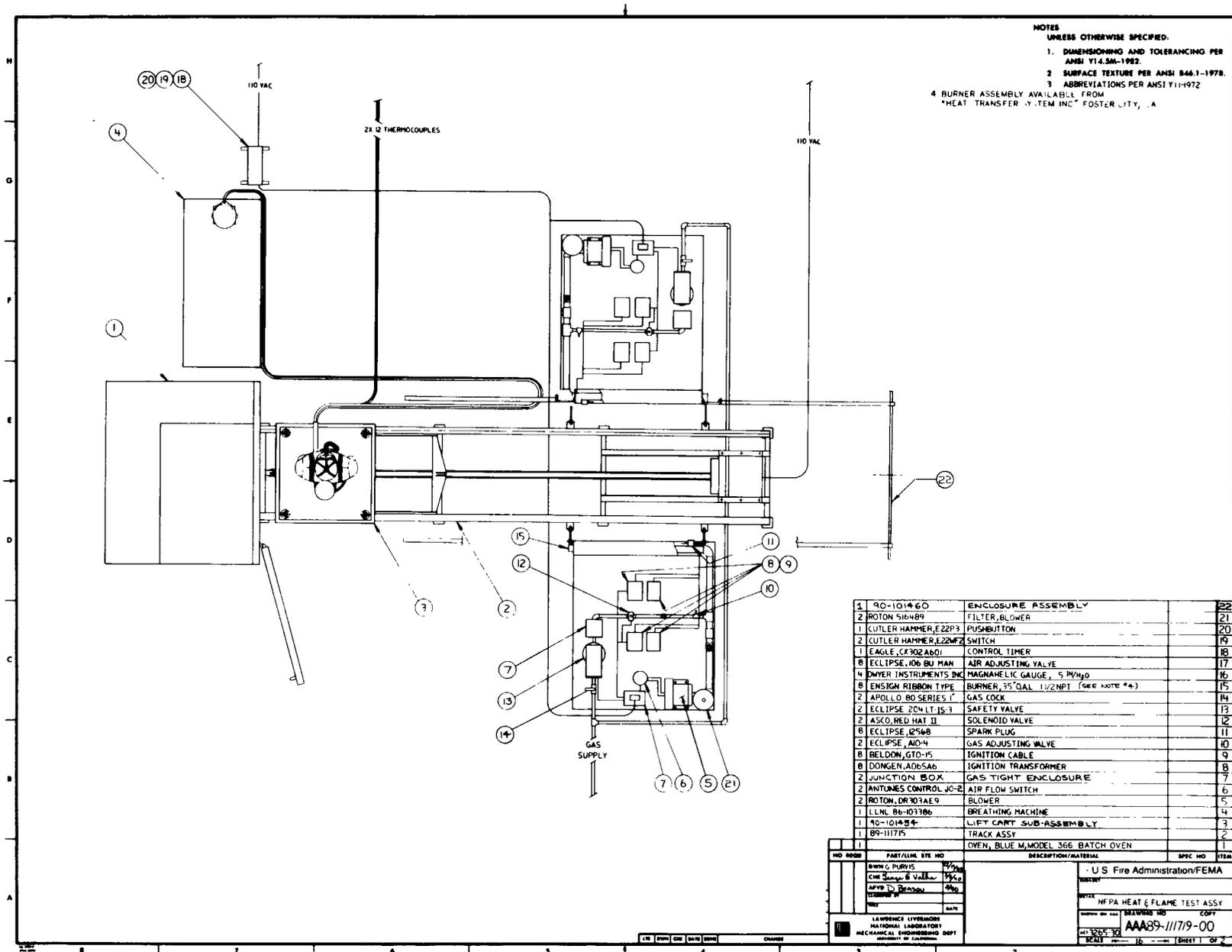
4-11.12 For calibration prior to the heat and flame test, the test mannequin shall be exposed to direct flame contact for 10 seconds using the heat and flame test apparatus as specified in Figure 4-11.9. All peak temperature readings shall be within a temperature range of 1500°F to 2102°F (815°C to 1150°C). The average mean of all peak temperature readings shall be no higher than 1742°F (950°C).

4-11.13 The test oven recovery time, after the door is closed, shall not exceed 1.0 minute.

4-11.14 The air flow performance test shall be conducted as specified in 4-1.12, 4-1.13, 4-1.14, and 4-1.15 of this chapter, with modifications to the ventilation rate specified in 4-11.15 of this section and with test temperatures specified in 4-11.12 and 4-11.15 of this section. The air flow performance test shall continue through the drop test as specified in 4-11.19 of this section.

4-11.14.1 The variation in pressure extremes caused by the flame and heat test mannequin configuration shall be determined in the following manner. The air flow performance test as specified in Section 4-1 of this chapter shall be carried out at a ventilation rate of 103 L/min ± 3 L/min, and 40 L/min ± 2 L/min. A second air flow performance test shall be carried out using the configuration specified in 4-11.4 of this chapter at the same ventilation rates. The difference in pressure between the two tests shall be calculated by subtracting the values obtained using the configuration defined in 4-11.4 from the values obtained using the configuration specified in Section 4-1.

4-11.15 The ventilation rate shall be set at 40 L/min ± 2 L/min, with a respiratory frequency of 12 ± 1 breaths/minute at ambient conditions as specified in 4-1.13 of this chapter. The SCBA mounted on the test mannequin shall be placed in the test oven that has been preheated to 203°F ± 4°F (95°C ± 2°C). After the door is closed and the oven temperature recovers to 203°F (95°C), the test exposure time of 15 minutes shall begin.



NOTES
UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982.
2. SURFACE TEXTURE PER ANSI B46.1-1978.
3. ABBREVIATIONS PER ANSI Y14.19-72
4. BURNER ASSEMBLY AVAILABLE FROM "HEAT TRANSFER SYSTEM INC" FOSTER CITY, CA

1	90-101460	ENCLOSURE ASSEMBLY	22
2	ROTON 516489	FILTER, BLOWER	21
1	CUTLER HAMMER E22P3	PUSHBUTTON	20
2	CUTLER HAMMER E22WF2	SWITCH	19
1	EAGLE CX302A601	CONTROL TIMER	18
8	ECLIPSE 106 BU MAN	AIR ADJUSTING VALVE	17
14	EMER INSTRUMENTS INC	MAGNETIC GAUGE, 5 IN/H ₂ O	16
8	ENSIGN RIBBON TYPE	BURNER, 35 GAL 1/2NPT (SEE NOTE *4)	15
2	APOLLO 80 SERIES 1	GAS COCK	14
2	ECLIPSE 20HLT-15-3	SAFETY VALVE	13
2	ASCO RED HAT II	SOLENOID VALVE	12
8	ECLIPSE 12548	SPARK PLUG	11
2	ECLIPSE A10-4	GAS ADJUSTING VALVE	10
8	BELDON GTO-15	IGNITION CABLE	9
8	DONGEN A065A6	IGNITION TRANSFORMER	8
2	JUNCTION BOX	GAS TIGHT ENCLOSURE	7
2	ANTUNES CONTROL J0-2	AIR FLOW SWITCH	6
2	ROTON DR303AE9	BLOWER	5
1	LLNL B6-103186	BREATHING MACHINE	4
1	90-101454	LIFT CART SUB-ASSEMBLY	3
1	89-11175	TRACK ASSY	2

NO	REV	PART/LENL STE NO	DESCRIPTION/MATERIAL	SPEC NO	ITEM
		BWV G PURVIS			
		CHK BY G. V. J.			
		APPR'D BY			
		DATE			
LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT			U.S. Fire Administration/FEMA		
			NFPA HEAT & FLAME TEST ASSY		
			DRAWING NO. AAA89-11179-00		
			REV. 15 SHEET 1 OF 2		

Figure 4-11.9.

4-11.16 At the completion of the 15-minute exposure, the ventilation rate shall be increased to 100 L/min as specified in 4-1.12 of this chapter. The oven door shall be opened and the SCBA mounted on the test mannequin shall be moved out of the oven and into the center of the burner array.

4-11.17 The SCBA shall then be exposed to direct flame contact for 10 seconds +0.25/-0.0 seconds. This exposure shall begin within 20 seconds of removal of the SCBA from the test oven.

4-11.17.1 The SCBA shall be observed for any afterflame, and the afterflame duration shall be recorded to determine pass/fail as specified in 3-11.2 of this standard.

4-11.18 Within 20 seconds after completing the direct flame exposure, the SCBA mounted on the test mannequin shall be raised 6 in. +0.25/-0.0 in. (152 mm +6.3/-0.0 mm) and dropped freely.

4-11.18.1 The SCBA shall be observed to determine pass/fail as specified in 3-11.3 of this standard.

4-11.19 The facepiece pressure during the entire test shall be read from the strip chart recorder and corrected by adding the value of the difference in pressure calculated in 4-11.14 of this section to determine pass/fail as specified in 3-11.1 of this standard. Any pressure spike caused by the impact of the drop test and measured within a duration of three cycles of the breathing machine after the apparatus drop shall be disregarded.

4-11.20 The SCBA facepiece shall be removed from the test headform and, without touching the lens, shall be donned by a test subject with visual acuity of 20/20 in each eye uncorrected or corrected with contact lenses. The test shall be conducted using a standard 20 ft (6.1 m) eye chart with normal lighting range of 100-150 ft-candles at the chart and with the test subject positioned at a distance of 20 ft (6.1 m) from the chart. The test subject shall then read the standard eye chart through the lens of the facepiece to determine pass/fail as specified in 3-11.4 of this standard.

Chapter 5 Referenced Publications

5-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

5-1.1* NFPA Publication.

NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*, 1991 edition

5-1.2* AATCC Publication.

AATCC 135, *Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics*, 1989

5-1.3* ANSI Publications.

ANSI S3.2, *Method for Measuring the Intelligibility of Speech over Communication Systems*, 1989

ANSI/CGA G-7.1, *Commodity Specification for Air*, 1989

5-1.4* ASTM Publication.

ASTM D 1003, *Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics*, 1988

5-1.5* GSA Publication.

Federal Test Method Standard 191A, *Textile Test Methods*, 20 July 1978

5-1.6* Navy Publication.

MIL-STD-810E, *Environmental Test Methods*, 14 July 1989

5-1.7* U.S. Government Publication.

30 CFR Part 11; *Respiratory Protective Devices, Tests for Permissibility*, 25 March 1972

Appendix A

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

A-1-1.1 The use of self-contained breathing apparatus (SCBA) by fire fighters is always assumed to be in atmospheres immediately dangerous to life or health (IDLH). There is no way to predetermine hazardous conditions, concentrations of toxic materials, or percentages of oxygen in air in a fire environment, during overhaul (salvage) operations, or under other emergency conditions involving spills or releases of hazardous materials. Thus, SCBA are required at all times during any fire fighting, hazardous materials, or overhaul operations.

A-1-2.1 The following performance requirement is new for this edition of the standard:

Heat and Flame Test. This test is intended to provide a reasonable level of assurance that, when a breathing apparatus is exposed to a variety of thermal and physical conditions and breathing rates that simulate the conditions of a flashover accident, the apparatus will perform and function properly.

The performance tests contained in the 1987 edition of this standard and continued or revised in this edition are:

1. *Air Flow Performance Test.* This test increases the current NIOSH breathing machine requirement of 40 L/min to 100 L/min. The 100 L/min ventilation rate was derived from a review of several studies indicating that a ventilation rate of 100 standard liters per minute encompasses the 98th percentile of all fire fighters studied.

2. *Environmental Temperature Resistance Tests.* This series of tests exposes the breathing apparatus to various temperature extremes and temperature cycles that breathing apparatus might be exposed to during storage conditions and certain environmental changes.

3. *Particulate Resistance Test.* This test exposes the breathing apparatus to a specified concentration of particulates to provide a reasonable level of assurance that the apparatus is designed to properly function when exposed to the dust conditions commonly present during fire fighting operations.

4. *Facepiece Lens Abrasion Resistance Test.* This test is designed to provide a reasonable level of assurance that the facepiece lens of the breathing apparatus is not easily scratched during fire fighting operations that could result in reduced visibility for the fire fighter.

5. *Communications Test.* This test is designed to assure that the facepiece of the breathing apparatus does not significantly reduce a fire fighter's normal voice communication.

6. *Accelerated Corrosion Resistance Test.* This test is to provide a reasonable level of assurance that the breathing apparatus is designed to resist corrosion that may form and interfere with the apparatus performance and function.

7. *Vibration Test.* This test is to provide a reasonable level of assurance that when the breathing apparatus is exposed to vibration and impact, such as being carried on a vehicle that often travels over rough road surfaces, the apparatus will properly perform and function.

8. *Fabric Components Test.* Flame, heat, and thread tests are added to provide a reasonable level of assurance that the fabric components of a harness assembly used to hold the backplate to the wearer's body will remain intact during fire fighting operations.

Users are cautioned that if more unusual conditions prevail, such as higher or lower extremes of temperatures than described herein, or if there are signs of abuse or damage to the SCBA or its components, the user's margin of safety may be reduced. All retrofits or repairs should be approved by the manufacturers whose SCBA complies with this standard.

A-1-2.2 Although SCBA that meet this standard have been tested to more stringent requirements than required for NIOSH/MSHA certification, there is no inherent guarantee against SCBA failure or fire fighter injury. Even the best-designed SCBA cannot compensate for either abuse or the lack of a respirator training and maintenance program. The severity of these tests should not encourage or condone abuse of SCBA in the field.

The environmental tests utilized in this standard alone might not simulate actual field conditions, but are devised to put extreme loads on SCBA in an accurate and reproducible manner by test laboratories. However, the selection of the environmental tests was based on summary values derived from studies of conditions that relate to field use.

A-1-3 Approved. The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedures or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items:

A-1-3 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agen-

cies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

A-1-3 Compressed Breathing Gas. The quality of breathing air to be used in open-circuit SCBA, as well as other SCBA use criteria, is contained in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

A-1-3 Listed. The means of identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

A-2-1.1.2 Since additional weight can reduce the fire fighter's ability to carry out assigned tasks, weight reduction is a prime concern of the Committee. The Committee recommends that SCBAs of rated 30-minute duration should be limited to a maximum weight of 25 lb (11 kg). Purchasers are advised to specifically address weight in their purchase specifications regardless of the rated service time.

A-2-1.1.3 SCBA that are certified by NIOSH/MSHA include a rated service time based on laboratory tests required by NIOSH. The SCBA is tested using a specified breathing machine with a breathing rate of 40 L/min. NIOSH uses this 40 L/min rate because it represents a moderate work rate that an average user can sustain for a period of time. To attain a rated service time of 30 minutes during this 40 L/min test, the typical SCBA cylinder must contain 1200 L or more of compressed breathable air. A 45-cu ft cylinder has a capacity of 1273.5 L, based on 28.3 L/cu ft. Because actual work performed by a fire fighter often results in a ventilation rate that exceeds 40 L/min, fire fighters will frequently not attain the rated service time of 30 minutes. During extreme exertion, for example, actual service time can be reduced by 50 percent or more.

To assure proper utilization of equipment in actual situations, after training and instruction, it is recommended that users gain confidence by actually using the SCBA in a series of tasks representing or approximating the physical demands likely to be encountered.

In addition to the degree of user exertion, other factors that may affect the service time of the SCBA include:

- (a) The physical condition of the user. (*See also ANSI Z88.6.*)
- (b) Emotional conditions, such as fear or excitement, that may increase the user's breathing rate.
- (c) The degree of training or experience the user has had with such equipment.

(d) Whether or not the cylinder is fully charged at the beginning of use.

(e) The facepiece fit.

(f) Use in a pressurized tunnel or caisson. At two atmospheres of pressure (29.4 psig), the duration will be one-half the duration obtained at one atmosphere of pressure (14.7 psig); at three atmospheres of pressure (44.1 psig), the duration will be one-third the duration obtained at one atmosphere of pressure.

(g) The condition of the SCBA.

(h) The SCBA effective dead air space. Dead air space is a volume proportional to the CO₂ concentration in the inhaled breathing gas.

During normal breathing without a facepiece, carbon dioxide, which is produced by the body's metabolism, is released to the environment on each breath. The facepiece of an SCBA reduces this environment to a small space around the face. On exhalation, a portion of the carbon dioxide-rich exhaled breath is trapped in this space. On inhalation, fresh air from the SCBA cylinder mixes with this carbon dioxide-rich air and then enters the lungs. The concentration of carbon dioxide is dependent on facepiece configuration, flow characteristics, and ventilation rate.

The full effect of increased dead air space has not been demonstrated. However, the scientific work done in this area shows that an increase of CO₂ in the inhalation air leads to increased ventilation and, consequently, shorter service time for a given air supply. Means to reduce CO₂ in the inhalation air by using, for example, a well-fitting nose cup have been demonstrated to give longer service time. Contact each manufacturer for specific data.

A-2-2.1 The certification organization should have sufficient breadth of interest and activity so that the loss or award of a specific business contract would not be a determining factor in the financial well-being of the agency.

A-2-2.3 The contractual provisions covering certification programs should contain clauses advising the manufacturer that if requirements change, the product should be brought into compliance with the new requirements by a stated effective date through a compliance review program involving all currently listed products.

Without these clauses, certifiers would not be able to move quickly to protect their name, marks, or reputation. A product safety certification program would be deficient without these contractual provisions and the administrative means to back them up.

A-2-2.4 Investigative procedures are important elements of an effective and meaningful product safety certification program. A preliminary review should be carried out on products submitted to the agency before any major testing is undertaken.

A-2-2.7 Such inspections should include, in most instances, witnessing of production tests. With certain products the certification organization inspectors should select samples from the production line and submit them to the main laboratory for countercheck testing. With other products, it may be desirable to purchase samples in the open market for test purposes.

A-3-1 The current NIOSH certification test method, 30 CFR 11, uses a ventilation rate of 40 L/min, while NFPA 1981 requires an air flow test based on a ventilation rate of 100 L/min. A ventilation rate of 100 standard L/min encompasses the 98th percentile of all fire fighters studied. The ability of the SCBA to supply the 100 L/min of breathing air is measured in this air flow performance test by monitoring the pressure within the facepiece.

Specific response times for both the pressure transducer and recorder are specified in this standard. It is important to note that if other types of recording devices, measuring equipment, and testing methods are used, pressure fluctuations might appear in the facepiece as short (millisecond) negative pressure spikes. The significance of these spikes to the actual protection afforded the user by the SCBA is not fully understood at this time. Additional studies are needed to determine the significance, if any, of these spikes. Because these negative spikes might affect the actual protection offered by the SCBA, it is recommended that a facepiece fitting program be established. Quantitative fitting tests are recognized to be the best method for determining the facepiece-to-face seal and should be performed by the fire service wherever SCBA are used. For departments that wish to perform quantitative fit testing, a suggested procedure for conducting such tests may be found in ANSI Z88.2, *Practices for Respiratory Protection*.

A-3-9 This standard contains an abrasion test that is used to evaluate the outside surface of the facepiece lens. This standard does not address the abrasion resistance of the interior surface of the facepiece lens. Current facepiece lens interior surfaces may be uncoated, coated with an anti-fog agent, coated with an abrasion-resistant agent that does not comply with the performance required in Section 3-9 of this standard, or coated with an abrasion-resistant coating that does comply with the performance required in Section 3-9 of this standard. Information regarding coatings on the lens interior surface should be obtained from the SCBA manufacturer.

A-3-10 As the communications test is the only test that requires human subjects, there were variations in the data used to determine the appropriate pass/fail criteria. Therefore, a statistical approach to analyze the data was required to determine whether an individual SCBA meets the pass/fail criteria of Section 3-10. A null hypothesis test utilizing the Student t-distribution is the appropriate method to do this.

The Student t-distribution of 2.13 results from the following conditions:

Degrees of freedom = 4

Confidence level = 95 percent.

Refer to any current statistical text for further information.

A-4-1.1 The headform, Models 803608-01 and 803608-02, can be obtained from Scott Aviation, 225 Erie St., Lancaster, NY 14086. Drawings can be obtained from NFPA for Model 803608-01 or 803608-02.

A-4-1.7 A Model P24 differential pressure transducer with a range of ± 8.9 in. (± 226 mm) of water differential is recommended and available from Validyne Engineering Corporation, 8626 Wilbur Avenue, Northridge, CA 91324.

A-4-1.8 A Model #1241 B00 one-pen recorder is recommended and available from Soltec Corporation, 11684 Pendleton Street, Sun Valley, CA 91352.

A-4-1.12 Complete engineering drawings to construct the Model 327-6 Breathing Machine can be obtained from NFPA. A fully fabricated machine can be obtained from Hy Tech Machine, Inc., 25 Leonburg Road, Mashuda Industrial Park, Mars, PA 16046.

The respiratory frequency is determined by dividing the minute volume by the tidal volume for each Model 327-6 Breathing Machine manufactured.

A-4-1.14 Calibration Procedure for NFPA Model 327-6 Breathing Machine.

**CALIBRATION PROCEDURE FOR
NFPA MODEL 327-6
BREATHING MACHINE**

I. Set Up Equipment.

1. Remove plug fitting and open valve at side port of the breathing machine (BM), then close the valve to the test headform.

2. Connect a non-return 2-way valve to the side port. (See Figure A-4-1.14.)

3. Make sure all gas has been expelled from a gas collection bag by rolling the bag up. Connect the bag to the dead-ended gas-collection port of a 3-way valve. (See Detail 2.) A recommended gas-collection bag is a 120-liter meteorological bag (Catalog No. 022631) or a 150-liter Douglas bag (Catalog No. 022622) available from Warren C. Collins, Inc., 220 Wood Road, Braintree, MA 02184. Equivalent or similar collection bags may be substituted. Collins also supplies a 3-way valve (T-shape stopcock - Catalog No. 021043).

4. Connect the common port of the 3-way valve to the exhalation port of the nonreturn 2-way valve. (See Detail 3.)

5. Connect the Validyne Transducer DP 24 to a pressure tap on the collection side of the 3-way valve. The transducer output goes to the Soltec Recorder.

II. Collect Gas

1. With the vent port of the 3-way valve open, start BM and allow BM to "warm up" for at least ten minutes.

2. After the 10-minute "warm up" period, adjust the speed to approximately 30 rpm if the machine has not been calibrated within the last few days. If the machine has recently been calibrated, leave it at its preset adjustment.

3. Set the chart speed on the Soltec Recorder to 60 cm/min and start the recorder.

4. At the start of an inhalation, turn the 3-way valve so that the air exhaled from the BM goes into the collection bag. (See Detail 4.)

5. Each exhalation stroke should produce a positive peak on the strip-chart recording, which can be used as a counter. The operator may use a substitute method to count the exhaled tidal volumes (TV) that go into the bag.

6. After 30 to 35 exhalations, turn the 3-way valve at the start of an inhalation so that the gas collection port is closed and the BM vents to atmosphere. Turn off the Soltec Recorder.

III. Measure the Volume (liters) of Gas Collected (V_L).

1. The recommended method to measure the volume of gas in the bag is to transfer the air into a Spirometer. Make sure the bag is completely empty by rolling it up.

2. Another method to measure the gas volume in the bag is to slowly empty the bag through a calibrated dry-gas meter. Ensure that a correction factor is applied as required.

IV. Calculate Minute Volume.

1. From the positive peaks on the strip chart recording, count the number of exhalations (NE) that were made into the bag or use your own counting method if you are sure it is correct.

2. Measure the total distance (in cm) between the peaks of 30 exhalations, which should be approximately 60 cm at a chart speed of 60 cm/min. (See Detail 5.) If the pressure in the gas-collection port has not been measured, the operator may use another method to accurately measure the breathing machine's rpms.

3. Calculate RPM,

$$\text{RPM} = \frac{30 \text{ breaths}}{\text{distance} \times \frac{\text{min}}{60 \text{ cm}}}$$

4. Determine the tidal volume (TV),

$$\text{TV} = \frac{V_L}{\text{NE}}$$

5. Determine the Minute Volume, V_M .

$$V_M = \text{TV} \times \text{RPM}$$

NOTE: A record of TV and RPM should be maintained for each machine. As the seals on the pistons wear, the TV for a given RPM may decrease, an indication that the seals should be replaced.

V. Minute Volume Adjustment.

1. If the V_M is between 100 liters and 106 liters, no adjustment is necessary and the BM is ready to perform the NFPA Air Flow Performance Test at the present RPM setting.

2. If the $V_M < 100$, the RPM must be increased and the V_M recalculated.

3. If the $V_M > 106$ liters the RPM must be decreased and the V_M recalculated.