Report of the Committee on Fire Service Protective Clothing and Equipment

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Staff Liaison: **Bruce W. Teele**

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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

The Report of the Committee on Fire Service Protective Clothing and Equipment is presented for adoption in 5 parts.

Part I of this Report was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and proposes for adoption a complete revision of NFPA 1972, Standard on Helmets for Structural Fire Fighting, 1987 edition. NFPA 1972 is published in Volume 8 of the 1991 National Fire Codes and in separate pamphlet form.

Part I of this Report has been submitted to letter ballot of the Technical Committee on Fire Service Protective Clothing and Equipment which consists of 29 voting members; of whom 26 voted affirmatively, 1 negatively (Mr. Coombs), (1) abstained (Mr. Gardner), and 1 ballot was not returned (Mr. Goad).

Mr. Coombs voted negatively as he believes that the oven test criteria (for the Heat Resistance Test in Section 5-16) is incomplete and the document will not be influenced by the findings of the TaskForce that was created to further address this area. Mr. Coombs feels if the oven criteria is unchanged (as presented in the TCR text) it could have a big impact on the industry.

Part II of this Report was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and proposes for adoption a complete revision of NFPA 1974, Standard on Protective Footwear for Structural Fire Fighting, 1987 edition. NFPA 1974 is published in Volume 8 of the 1991 National Fire Codes and in separate pamphlet form.

Part II of this Report has been submitted to letter ballot of the Technical Committee on Fire Service Protective Clothing and Equipment which consists of 29 voting members; of whom 27 voted affirmatively, 0 negatively, 1 abstained (Mr. Gardner), and 1 ballot was not returned (Mr. Goad)

Part III of this Report was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and proposes for adoption a new document NFPA 1976, Standard on Protective Clothing for Proximity Fire Fighting, 1992 Edition.

Part III of this Report has been submitted to letter ballot of the Technical Committee on Fire Service Protective Clothing and Equipment which consists of 29 voting members; of whom 27 voted affirmatively, 0 negatively, 1 abstained (Mr. Gardner), and 1 ballot was not returned (Mr. Goad).

Part IV of this Report was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and proposes for adoption a complete revision of NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters, 1987 Edition. NFPA 1981 is published in Volume 8 of the 1991 National Fire Codes and in separate pamphlet form.

Part IV of this Report has been submitted to letter ballot of the Technical Committee on Fire Service Protective Clothing and Equipment which consists of 29 voting members; of whom 26 voted affirmatively, 1 negatively (Mr. Coombs), 1 abstained (Mr. Gardner), and 1 ballot was not returned (Mr. Goad).

Mr. Coombs voted negatively because he felt that more research was needed on the protective cover for the mannequin (used in the Heat and Flame Test in Section 4-11) to determine hor or if it affects the test and what adjustments are necessary to make the test more meaningful.

Part V of this Report was prepared by the Technical Committee on Fire Service Protective Clothing and Equipment and proposes for adoption a new document NFPA 1999, Standard on Protective Clothing for Medical Emergency Operations, 1991 Edition.

Part V of this Report has been submitted to letter ballot of the Technical Committee on Fire Service Protective Clothing and Equipment which consists of 29 voting members; of whom 26 voted affirmatively, 0 negatively, 2 abstained (Messrs. Coombs and Gardner), and 1 ballot was not returned (Mr. Goad).

PART I

(Log # 3)

1972-1 - (3-9.1): Reject
SUBMITTER: John M. Moore, Metrofire
RECOMMENDATION: Change wording of dimensioning to allow so called Bourke eyeshield (similar OSHA standard).
SUBSTANTIATION: We recommend that Section 3-9.1 on Face Shields be changed. It is our recommendation that the Bourke eye shield be allowed in place of the current full face shield.

The disadvantages of the full face shield are as follows:

1. When in the upright position the shield gets caught when entering windows and other confined spaces.

2. When the shield gets caught the leverage pushes the neck backwards.

3. SCBA is normally in use to provide eye protection.

4. The shield tends to get scratched easily.

5. Hardware to attach the shield breaks frequently.

6. The full shield sticks out 2" from each side of the helmet brim, at times it gets caught on other object.

7. During fire fighting and overhaul using SCBA the face shield gets obstructed with debris.

8. The shield takes more time to lock into place.

The advantages of the Bourke Shield are as follows:

1. This device stores easily.

2. The lenses flip into place easy.

3. It is easier and less costly to replace.

4. It is an OSHA approved device.

The committee notes in the Appendix A-1-B that the full face shield was not intended to provide complete protection and a firefighter might need goggles or SCBA in addition to the shield.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: Faceshields required by NFPA 1972, 1987 edition are designed to offer secondary protection to the wearers eyes and a specified area of the face. The so-called Bourke eyeshield covers a substantially smaller area of the face than current NFPA faceshields. The subcommittee feels that allowing a smaller faeshield or eliminating the faceshield requirement altogether would lessen the amount of protection offered to wearers of NFPA compliant helmets.

(Log # 1)

1972-2 - (3-10.2): Reject
SUBMITTER: J. Timothy Pedrotty, Reflexite Corporation
RECOMMENDATION: Revise text as follows:
3-10.2 Fluorescent retroreflective markings used to meet the requirements of 3-10.1 shall have a coefficient of retroreflectivity (CPL) of not less than 150 cp/ft-c/sq ft for materials reflecting a white color, 90 cp/ft-c/sq ft for materials reflecting a lime-yellow color, and 27 cp/ft-c/sq ft for materials reflecting a red-orange color when tested in accordance with 4-2 of this standard.
SUBSTANTIATION: Acceptance of TCR recommendation 1972-15 (3-10, 3-10.2) eliminates the use of fluorescent red-orange retroreflective material which has had wide spread satisfactory use by the fire services for numerous years. There has never been any evidence of the deficiency of red-orange reflective material. The Technical Committees' substantiation states "...establishes a minimum desired brightness...;" the submitter erroneously goes onto reference a measurement method that measures only luminance and has no provision for "brightness." The luminance of colors as measured with instruments does not directly correlate with the brightness as seen by the eye. Recent research published through the National Bureau of Standards states: "It has been known for a long time that if a strongly colored (saturated) light, such as red, for example, is examined side by side with a white light that measures the same luminance as the red on a light meter most people will say that the red appears to them to be considerably brighter." (From Linear Opponent-Colors Model Optimized for Brightness Prediction, Feb. 1986).
Because of this complex relationship, specifications use conversion factors to convert the instrument readings to mandated lighting requirements . There is nearly unanimous agreement that a luminance value of 25 for red warning light is at least as safe as a luminance value of 100 for a white warning light. The widespread use of red warning lights and red reflectors is evidence of this agreement. All over the world, in railroad, automotive, aviation, and marine applications, a vast amount of experience has been evaluated. There is virtually unanimous agreement that red is the single best color for safety light. As a result, virtually the entire world has standardized on the color red for the most dangerous applications including the stop signal in railroad semaphores, automotive taillights and brake lights, traffic stop lights and stop signs, airplane collision avoidance beacons, and ship collision warning lights. In general, red is the standardized color of prohibition.
If this recommendation is rejected, I request the substantiation include specific technical information relative to both (1) inappropriateness of the current test method in 3-10.2 of 1972-85 and (2) technical support for establishing the proposed desired minimum brightness.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: Presentation by submitter Company representatives showed that to achieve equal brightness of 4 square inch lime-yellow retro-reflective strips, other color markings would have to increase in size as follows:

COLOR	SIZE (SQ. INCHES)
Red	8.56
Orange	5.31
Pink	8.52
Green	11.71

The subcommittee felt that the various sized reflective strips would cause confusion among fire service users and would prove impractical due to the large amount of space needed on the helmet to meet the standard with colors other than lime-yellow.

(Log # 2)

1972-3 - (4-2.9): Reject
SUBMITTER: Christopher E. Coombs, Cairns & Brother Inc.
RECOMMENDATION: Change test to read as follows:
4-2.9 Retroreflectivity Testing. Test procedure shall be as stated in ASTM E809 with a test distance of 50 feet, observation angle of 0.2 degrees, entrance angle 4.0 degrees and a photoreceptor angular aperture and source angular aperture of 0.1 degrees. Intensity of the projector lamp shall be pre-adjusted to compensate for color reflectivity. The colored reflector shall be compared for brightness with a white reflector of the manufacturer's equivalent reflective material. The light projected at the white "standard" shall be increased until the intensity of reflection between the colored and white sample appears through the tester to be balanced. This increased intensity setting shall then be used to measure the luminescence of the colored trim. The adjustment shall not be negative on the white standard. Projector exit angle shall be a circle of diameter 1.0 in. Retroreflector reference angle shall be 90 degrees. Datum mark shall be places as specified by the manufacturer. Trim sample shall consist of a 12 ≤ 12 in. composite of multiple strips of trim.
SUBSTANTIATION: Recent studies indicate that the human eye picks up a color reflector with a higher degree of excitement than a white reflector. The test specified (ASTM E809) measures only white light retroreflection. The procedure described in the change proposed would compensate for this factor. Further substantiation concerning the reference research is available at Reflexite Corporation.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: Presentation by submitter Company representatives showed that to achieve equal brightness of 4 square inch lime-yellow retro-reflective strips, other color markings would have to increase in size as follows:

COLOR	SIZE (SQ. INCHES)
Red	8.56
Orange	5.31
Pink	8.52
Green	11.71

The subcommittee felt that the various sized reflective strips would cause confusion among fire service users and would prove impractical due to the large amount of space needed on the helmet to meet the standard with colors other than lime-yellow.

1972- 4 - (Entire Document): Accept
SUBMITTER: Technical Committee on Fire Service Protective Clothing and Equipment
RECOMMENDATION: Completely revise NFPA 1972, Standard on Helmets for Structural Fire Fighting, 1987 Edition.
SUBSTANTIATION: This complete revision includes a general revision of language to attempt to make the text clear and adds some new definitions of terms. The specifics of the test series (in Section 2-3 of the TCR) were clarified to be more explicit.
This edition includes third party certification of the helmet including listing, labeling, and manufacturer quality assurance. All of this criteria is now in a new Chapter2 (in the TCR).
The radiant heat conditioning and the heat resistance test were revised to 500°F, up from 482°F.
The test methods were reorganized for a more understandable presentation and editorial clean up occurred throughout the document.
COMMITTEE ACTION: Accept.

NFPA 1972

Standard on

Helmets for Structural Fire Fighting

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 6.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard provides minimum design and performance criteria, and test methods for helmets for structural fire fighting designed to mitigate adverse environmental effects to the fire fighter's head.

1-1.2 This standard does not provide performance criteria for accessory components that may be attached to the helmet.

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

1-2 Purpose.

1-2.1 The standard applies to helmets utilized for structural fire fighting. Organizations responsible for specialized functions, including wildland and aircraft fire fighting, are urged to use protective equipment specifically designed for those activities.

1-2.2 Tests for impact, penetration, flammability, thermal endurance, retention, and limited electrical insulation are used to ensure compliance with the minimum performance requirements of this standard. These tests shall not be deemed as establishing performance levels for all fire fighting situations to which structural fire fighting personnel may be exposed.

1-2.3* Helmets manufactured in accordance with this standard are designed to mitigate adverse environmental effects to the fire fighter's head.

1-2.4 Nothing herein is intended to restrict any jurisdiction or manufacturer from exceeding 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.

Basic Plane. The plane through the centers of the external ear openings and the lower edges of the eye sockets.

Basic Weight. Weight of the helmet including all components specified in 3-1.1 of this standard.

Bitragion Coronal Arc.* The arc between the right and left tragion as measured over the top of the head in a plane perpendicular to the mid-sagittal plane.

Bitragion Inion Arc.* The arc between tragion as measured over inion. For test purposes, the Bitragion Inion Arc is defined as Datum Plane 10 in Figure 5-6.2.

Brim. A part of the shell of the helmet extending around the entire circumference of the helmet.

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 compliance with the requirements of this standard.

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

Chin Strap. An adjustable strap, fitting under the chin, to secure the helmet to the head.

Coronal Plane. The plane, perpendicular to the basic and mid-sagittal planes, that passes through the centers of the external ear openings.

Crown. The portion of the helmet that covers the head above the reference plane.

Crown Straps. That part of the suspension that passes over the head.

Ear Covers. An integral part of the helmet that provides cover for the ears.

Energy Absorbing System. A material, suspension system, or combination thereof incorporated into the design of the helmet to attenuate impact energy.

Faceshield.* Limited protection for the face or portion thereof, and supplements primary eye protection.

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 products listed that are being produced by the manufacturer to the requirements of this standard.

Headband. The portion of a suspension that encircles the head.

Headform. A test device that conforms to the configuration of the human head.

Helmet. A device consisting essentially of a shell, an energy absorbing system, a retention system, fluorescent retroreflective markings, ear covers, and a faceshield.

Horizontal Center Plane. Any plane passing through the helmet whose intersection with the helmet surface is equidistant from the top of the helmet at all points.

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.

Mid-Sagittal Plane. The plane, perpendicular to the basic and coronal planes, that symmetrically bisects the head .

Model Weight. The basic weight of the helmet plus accessories for the specific model identified.

Nape Device. A device located below the Bitragion Inion Arc, used to aid in helmet retention.

Product Label. A label or marking affixed to the helmet or the helmet faceshield by the manufacturer containing general information, warnings, care, maintenance, or similar data. This product label is not the certification organization's label or identifying mark.

Reference Plane. The plane 60 mm ±1 mm (2.36 in. ±0.04 in.) above and parallel to the basic plane.

Retention System. The complete assembly that essentially consists of a chin strap, nape device, and suspension system by which the helmet is retained in position on the head.

Retroreflective Markings. A material that reflects and returns a relatively high proportion of light in a direction close to the direction from which it came.

Shall. Indicates a mandatory requirement.

Shell. The outmost part of the helmet.

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

Suspension. An energy attenuating system made up of headband and crown strap.

Sweatband. That part of a headband, either integral or attached, that comes in contact with the wearer's forehead.

Top. The intersection between the mid-sagittal plane and the bitragion-coronal arc extended to the helmet surface.

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 Helmets that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 All certification shall be performed by an approved certification organization.

2-1.3 Compliant helmets shall be labeled and listed. Such helmets shall also have product labels that meet the requirements specified in Section 2-5 of this chapter.

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 applicable requirements of this standard.

2-2.3* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on 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 vertification, 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 that meets the requirements of Section 2-4 of this Chapter.

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 continual 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 Sampling levels for inspection shall be established by the certification organization and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified as being compliant with the standard are compliant.

2-3.2 Testing for determining material and component compliance with the requirements specified in Chapter 5 of this standard shall be performed on samples representative of materials and components used in the actual construction of helmets. The certification organization shall be permitted to also use sample materials taken from representative helmets.

2-3.3 A test series shall consist of 10 helmets. A minimum of 3 test series shall be required for certification. Each helmet shall be subjected to the environmental conditioning and test or tests specified in Table 2-3.3. The order of testing shall be from left to right in Table 2-3.3. Where there is more than one environmental condition for a specific test, the order of environmental conditioning for test for that test shall be from top to bottom in Table 2-3.3.

(SEE Table 2-3.3 NEXT PAGE)

2-3.4 No substitution or repair of any helmet components shall be allowed during testing.

2-4 Manufacturer's Quality Assurance.

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 product conformance to this standard.

2-4.2 The characteristics to be inspected, or tested, or both shall be classified according to the potential effect of such defects and grouped into the following classes:

(a) Major A — a defect that will reduce protection and is not readily detectable by the user;

Table 2-3.3

Environmental Condition	Test											
	Flame	Heat	Retention	Elec.	Faceshield Luminous Transmittance	Top Impact	Impact Accel.	Penetration	Face-Shield Impact	Retro-Reflex-Markings	Label	Ear Covers
	5-9 5-10 5-11	5-16	5-14	5-12 5-13	5-18	5-6	5-7	5-8	5-17	5-19	5-22	5-21
Room 5-1	1	2	3	4	6	3	5	3	3	6	2	5
Water 5-4						4	6	4	4		4	
Radiant 5-2						7	8	7			7	
Low Temp 5-3						9	10	9	9		9	
Elevated Temp (Faceshield) 5-5									1		1	

(b) Major B — a defect, other than Major A, that is likely to result in reduced protection, and is detectable by the user; and

(c) Minor — a defect that is not likely to materially reduce the usability of the device for its intended purpose .

2-4.2.1 The acceptable quality level shall be as defined by Military Standard MIL-STD 105D, *Sampling Procedures and Tables for Inspection by Attributes*, Inspection Level II.

2-4.2.2 The acceptable quality level for all helmet defects shall be as follows: (a) Major A — 1.0, (b) Major B — 2.5, and (c) Minor — 4.0.

2-4.2.3 Performance tests shall be assigned the following classification of defects:

(a) Major A — Sections 3-2, 4-1, 4-2, 4-3, 4-4, 4-5, 4-6, and 4-9;

(b) Major B — Sections 3-1, 4-7, 4-8, and 4-10;

(c) Minor — Section 2-5 and 4-11.

2-4.3 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe inspection and test of materials, work in process, and completed articles. In addition, criteria for acceptance and rejection of product shall be included in the instructions.

2-4.4 The manufacturer shall maintain records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found and the quantities accepted or rejected.

2-4.5 The manufacturer shall take action to correct discrepant conditions which have resulted, or could result, in products which do not conform to the requirements of this Standard. The nature of the discrepancy and the corrective action taken shall be documented.

2-4.6 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.

2-4.7 Subcontracted or purchased supplies shall be subjected to inspection after receipt, as necessary, to assure conformance of the end item to the requirements of this standard. When manufacturers rely upon the supplier to provide data to demonstrate material conformance to this standard, or when the supplier is individually certified, that data shall become a part of the manufacturer's inspection records. The use of a supplier's test data or certification shall not relieve the manufacturer of their responsibility to furnish an end item which complies with all the requirements of this standard.

2-4.8 When the manufacturer conducts quality assurance testing, the 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.

2-4.8.1 The manufacturer, at their option, shall be permitted to utilize an outside test facility to conduct the quality assurance tests. When this option is selected, the outside test facility shall meet the requirements of 2-4.8 of this Section.

2-4.8.2 The test facility shall provide a written report to the manufacturer that describes the tests performed and the results. This report shall become a part of the manufacturer's inspection records.

2-4.9 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in-process, and finished goods.

2-4.10 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.

2-5 Helmet Labeling.

2-5.1 Each helmet shall have a product label or labels permanently and conspicuously attached to the helmet upon which at least the following information and warnings are printed in at least 1.5 mm (1/16 in.) high letters.

"THIS HELMET MEETS THE REQUIREMENTS OF NFPA 1972, STANDARD ON HELMETS FOR STRUCTURAL FIRE FIGHTING, 1992 EDITION.

WARNING

THE HELMET MUST BE PROPERLY ADJUSTED AND SECURED TO THE HEAD, WITH ALL COMPONENTS IN PLACE, AND USED AS SPECIFIED IN MANUFACTURER'S INSTRUCTIONS. DO NOT MODIFY OR REPLACE ANY COMPONENTS OF THIS HELMET, INCLUDING THE SHELL, ENERGY-ABSORBING SYSTEM, RETENTION SYSTEM, FLUORESCENT RETROREFLECTIVE MARKINGS, EAR COVERS, OR FACESHIELD WITH COMPONENTS OR ACCESSORIES OTHER THAN THOSE APPROVED BY THE MANUFACTURER. ANY SUCH MODIFICATION OR REPLACEMENT VOIDS COMPLIANCE WITH NFPA 1972. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Name or Designation of Manufacturer
Model Number or Design
Month and Year of Manufacture (uncoded)
Lot Number
Basic Weight of Helmet
Model Weight of Helmet
Recommended Cleaning Procedure
Helmet Size, or size range

"DO NOT REMOVE THIS LABEL"

2-5.2 Each helmet faceshield shall have a product label conspicuously attached to the faceshield that warns the user that the faceshield may not provide sufficient primary eye protection and additional protection may be required. A reference to ANSI Z87.1, Occupational and Educational Eye and Face Protection, shall be included in the faceshield label. The faceshield label shall be printed in at least 1.5 mm (1/16-in.) high letters.

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

2-6* User Information.

2-6.1 Helmet manufacturers shall provide the following instructions and information with each helmet:

(a) Proper use
(b) Cleaning
(c) Maintenance criteria
(d) Inspection frequency and details
(e) Painting
(f) Storage
(g) Warranty information

2-6.2 Helmet manufacturers shall furnish training materials that address, but are not limited to:

(a) Safety considerations
(b) Decontamination procedures
(c) Retirement considerations

2-6.3 The manufacturer shall provide to the purchaser upon request a statement regarding the helmet material resistance to deterioration by chemicals that may be specified by the purchaser.

Chapter 3 Design Criteria

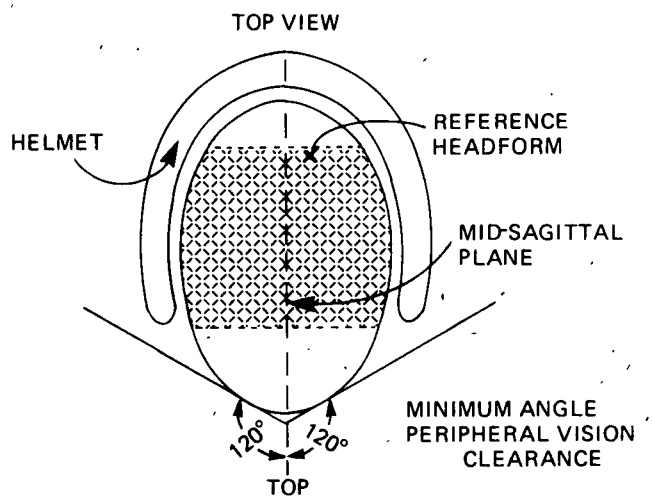
3-1* Configuration.

3-1.1* A helmet for structural fire fighting shall essentially consist of a shell, an energy absorbing system, a retention system, retroreflective markings, ear covers, and a faceshield.

3-1.2 There shall be no openings penetrating the shell other than those provided by the manufacturer for mounting energy absorbing systems, retention systems, and accessories.

3-1.3 The helmet shall provide peripheral vision clearance of at least 120 degrees to each side of the mid-sagittal plane as shown in Figure 3-1.3.

Figure 3-1.3 Peripheral Vision



3-1.4 The retention system shall include a chin strap and a nape device. The chin strap shall have a minimum width of 19 mm (0.75 in.).

3-1.5* The helmet shall be equipped with a faceshield. The helmet with faceshield deployed shall provide coverage parallel to the coronal plane from the helmet front edge to not less than 107 mm (4.2 in.) below the reference plane, not less than 45 degrees to each side of the mid-sigittal plane from the converge of the mid-sigittal and coronal planes.

3-1.6 The helmet shall have fluorescent retroreflective markings on the shell exterior. A minimum of 26 cm^2 (4 sq in.) of the retroreflective markings shall be visible when the helmet is viewed from any angle at or above the reference plane.

3-2 Accessories.

3-2.1* The addition of helmet accessories shall not interfere with the function of the helmet or its component parts and shall not degrade the helmet's performance below the requirements of this standard.

3-2.2 Helmet accessories provided by the manufacturer shall be certified as complying with 3-2.1 of this Section.

Chapter 4 Performance Requirements

4-1 Top Impact Requirement—Force Transmission.

4-1.1 Sample helmets with faceshield removed shall be tested in accordance with Section 5-6, Top Impact Testing-Force, of this standard. No sample shall transmit a force of more than 3780 N (850 lbs).

4-2 Top, Front, Side, and Back Impact Requirement-Acceleration.

4-2.1 Sample helmets with faceshield removed shall be tested in accordance with Section 5-7, Impact Testing-Acceleration, of this standard. The maximum acceleration shall be as indicated in Table 4-2.1.

Table 4-2.1

Maximum Accelerations

Impact Location	Maximum Acceleration*	(m/sec/sec)	(ft/sec/sec)
Top	150 × Gn	(1471.5)	(4830)
Front	300 × Gn	(2943.0)	(9660)
Sides	300 × Gn	(2943.0)	(9660)
Back	300 × Gn	(2943.0)	(9660)

*Gn denotes gravitational acceleration, which is defined as 9 81 meters per second per second (32 2 feet per second per second)

4-2.1.1 Any acceleration durations above 200 Gn shall not exceed three milliseconds; acceleration durations above 150 Gn shall not exceed six milliseconds.

4-3 Penetration Resistance.

4-3.1 Sample helmets with faceshield removed shall be tested in accordance with Section 5-8, Penetration Resistance Testing, of this standard and shall exhibit no electrical contact between the penetration test striker and the headform .

4-4 Heat Resistance.

4-4.1 Sample helmets shall be tested in accordance with Section 5-16, Heat Resistance Testing, of this standard and shall:

(a) have no parts of the complete helmet assembly that do not contact the headform before this test come in contact with the headform as a result of this test;

(b) have no shell distortion in the back extended more than 40 mm (1.6 in.) below the original position of the helmet;

(c) have no distortion of the front and sides of the shell extend more than 30 mm (1.2 in.) below the original position of the helmet;

(d) have no separation, melting, or dripping of retention system, energy-absorption system, or ear covers;

(e) have chin strap closure device remain functional;

(f) have no ignition of any part of the helmet assembly;

(g) have no part of the faceshield touch the headform or ear covers.

4-5 Flame Resistance.

4-5.1 Sample helmets shall be tested in accordance with Sections 5-9 and 5-10, Flame Resistance Tests One and Two, of this standard and shall show no visible flame or glow five seconds after removal from the test flame .

4-6 Electrical Insulation.

4-6.1 Sample helmets shall be tested in accordance with Sections 5-12 and 5-13, Electrical Insulation Tests One and Two, of this standard and shall not have a leakage current exceeding 3.0 milliamperes.

4-7 Retention System.

4-7.1 Sample helmets shall be tested in accordance with Section 5-14, Retention System Testing,of this standard without any break occurring and without any resulting slip or stretch of more than 2.0 cm (0.8 in.).

4-7.2 Suspension systems shall not separate from the helmet shell when tested in accordance with Section 5-15, Suspension System Retention Testing, of this standard.

4-8 Ear Covers.

4-8.1 Materials utilized for ear covers shall have a maximum char length of 100 mm (4.0 in.), and a maximum afterflame of 2.0 seconds when tested in accordance with Section 5-21, Ear Covers Testing, of this standard. Materials other than textiles shall meet these same performance requirements.

4-9 Faceshields.

4-9.1 Faceshields shall be tested for impact protection in accordance with Section 5-17, Faceshield Impact Testing, of this standard without any demonstrable electrical contact being made between the faceshield and the test headform contact sensor. The faceshield shall not crack or shatter.

4-9.2 Faceshields shall be tested for flame resistance in accordance with Section 5-11, Flame Resistance Test Three, of this standard and shall show no visible flame or glow 5 seconds after removal of test flame.

4-9.3 Faceshields shall be tested for scratch resistance in accordance with Section 5-20, Facepiece Scratch Resistance Testing, of this standard and shall not show more than 15 linear scratches per square inch (6.45 cm^2) in the abraded area.

4-9.4 The total luminous visible transmittance of clear or colored faceshields shall be determined in accordance with Section 5-18, Luminous Transmittance Testing, of this standard. Clear faceshields shall transmit not less than 85 percent of the incident visible radiation. Colored faceshields shall transmit not less than 43 percent of the incident visible radiation.

4-10 Fluorescent Retroreflective Markings.

4-10.1 Fluorescent retroreflective markings utilized to meet the requirements of 3-1.6 of this standard shall have a CPL of no less than 90 when tested in accordance with Section 5-19, Retroreflectivity Testing, of this standard.

4-11 Label Durability.

4-11.1 Labels shall remain attached to the helmet and legible to the unaided eye after testing in accordance with Section 5-22, Label Durability Testing, of this standard.

Chapter 5 Testing

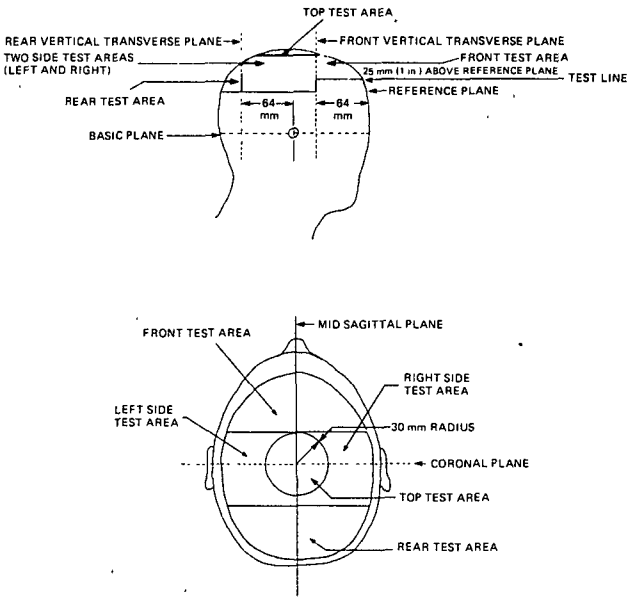
5-1 Room Temperature Environmental Conditioning.

5-1.1 Sample helmets shall be conditioned at a temperature of 20°—28°C (68°— 82°F) for at least 4 hours.

5-2 Radiant and Convective Heat Environmental Conditioning.

5-2.1 Sample helmets shall be conditioned by exposing the area to be impacted/penetrated to a radiant heat source. The top, sides, front, and back test areas to be impacted/penetrated shall be as specified in Figure 5-2.1.

Figure 5-2.1



5-2.2 The area to be impacted/penetrated shall be exposed to an irradiance of 1.0 W/cm^2 ±0.1 W/cm^2 for a length of time determined by exposure of a radiant heat transducer. The heat source shall be removed and the helmet shall be tested. The helmet shall be impacted/penetrated in 15 seconds, ±5 seconds after removal from the conditioning environment or the helmet shall be cooled to room temperature, reconditioned. and tested as above.

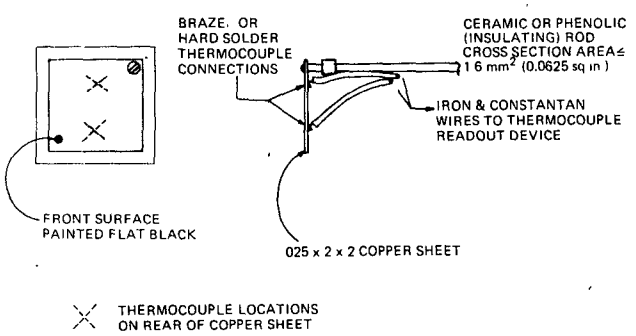
5-2.3 The radiometer shall have a spectral response flat within ±3 percent over a range of at least 1.0 to 10.1 microns and an overall accuracy of at least ±5 percent of the reading.

5-2.4 The radiant panel shall have an effective radiating surface at least 150 mm (6 in.) square. The spectral radiant emittance curve of the radiant panel shall be that of a blackbody at a temperature between 1000°K ±200°K.

5-2.5 The radiant heat transducer specified in Figure 5-2.5 shall be constructed from sheet copper, ASTM B 152, Type 110 ETP, half hard, 0.64 mm ±0.05 mm (0.025 in. ±0.002 in.) thick and 50.8 mm ±0.4 mm (2.00 in. ±0.02 in.) square. A constantan wire 0.81 mm ±0.05 mm (0.032 in. ±0.002 in.) in diameter, and an iron wire of the same diameter shall be silver soldered near the edges of the copper sheet on the same side, as illustrated in Figure 5-2.5. The side of the copper sheet opposite that with the wires attached shall be painted flat black. The resulting transducer is a Type J thermocouple that

shall be used in conjunction with appropriate instrumentation to monitor the heat exposure to which the helmet will be subjected.

Figure 5-2.5 Radiant Heat Transducer



5-2.6 Sample helmets shall be mounted in the position to be conditioned. The point of impact or penetration on the helmet shell shall be determined in accordance with the specific test to be performed. The helmet shall be temporarily removed and a radiometer shall be located at that point perpendicular to and facing away from the helmet surface.

5-2.7 The radiant panel shall be introduced in front of the radiometer with its effective radiating surface parallel to the plane tangent to the helmet surface at the center of the impact/penetration site on the helmet. The radiant panel shall be adjusted to obtain a stable uniform irradiance of 1.0 W/cm² ±0.1 W/cm² over at least a 75 mm (3-in.) diameter circle located on the above plane and centered at the center of impact or penetration. Stability shall be achieved when the irradiance changes by less than 10 percent during a 3-minute period.

5-2.8* The radiometer shall be replaced with the radiant heat transducer. The center of the transducer shall be positioned with its center coincident with the center of the impact/penetration site on the helmet and parallel to the plane tangent to the helmet surface at that point. The flat black surface of the transducer shall face the radiant panel. The time required for the transducer to reach a temperature of 260°C (500°F) shall be recorded. That time shall be 2.50 minutes ±15.0 seconds. A closed insulated chamber shall be required to achieve this exposure time.

5-2.9 The chamber and helmet shall be stabilized at 25°C ±5°C (77°F ±9°F). The helmet shall be positioned in the chamber in the same position as in 5-2.6 of this Section. The helmet shall be subjected to the exposure conditions specified in 5-2.1 of this Section for the time recorded in 5-2.8 of this Section. The exposure time shall be not less than the time recorded in 5-2.8, nor more than 5 seconds longer than that time.

5-3 Low Temperature Environmental Conditioning.

5-3.1 Sample helmets shall be conditioned by exposing them to a temperature of -32°C ±1°C (-25°F ±2°F) for at least 4 hours. The impact/penetration test shall be completed within 15 ± 5 seconds after removal from the cold temperature environment, or the helmet shall be reconditioned and tested as above.

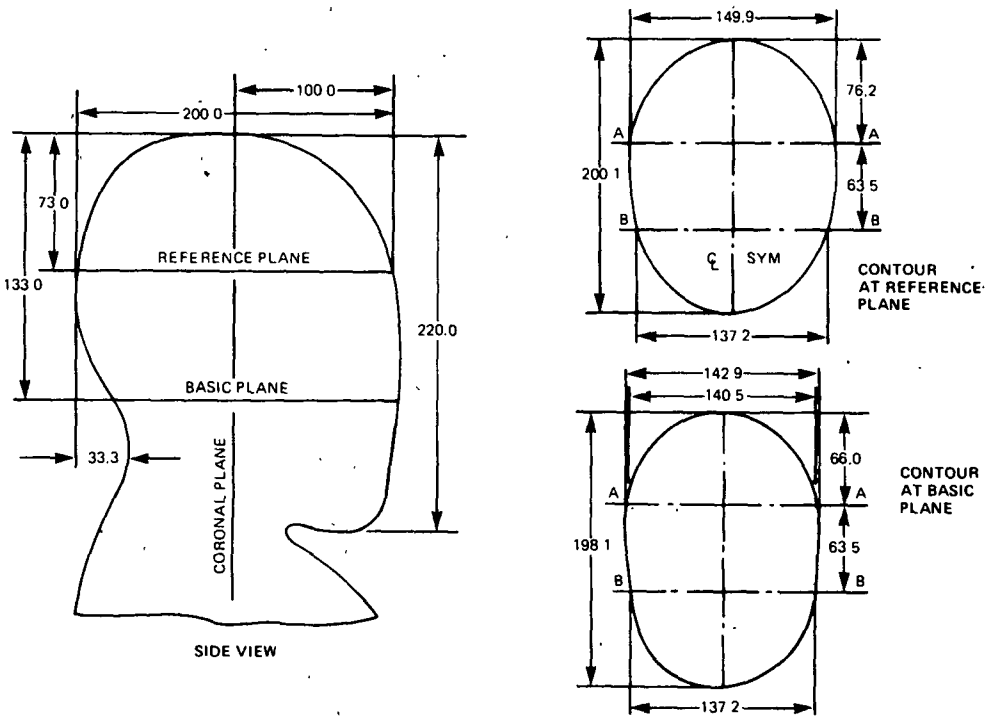
5-4 Water Environmental Conditioning.

5-4.1 Sample helmets shall be conditioned by immersing them in water at a temperature of 20°-28°C (68°-82°F) for 4 hours +2/-0 hours. The helmet shall be tested within 10 minutes after removal from water.

5-5 Faceshield Elevated Temperature Environmental Conditioning.

5-5.1 Sample faceshields, attached to the helmets, shall be conditioned by placing them on a room temperature, solid, nonmetallic headform conforming to the dimensions in Figure 5-5.1 and exposing them to a temperature of 107°C +2°/-0°C (225°F +3°/-0°F) for 20 minutes +15/-0 seconds. The impact test shall be completed within 15 seconds ±5 seconds after removal from the environmental chamber, or the faceshield shall be reconditioned and tested as above.

Figure 5-5.1



NOTE: All dimensions ± 5 mm

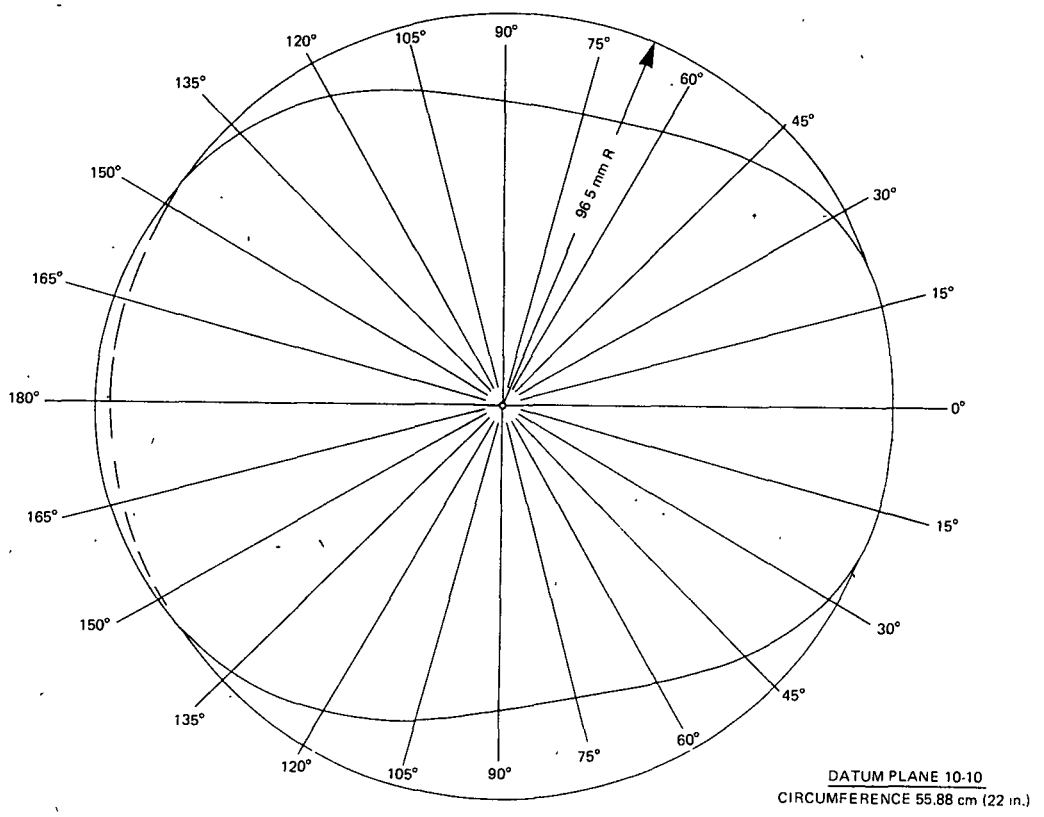
Figure 5-6.2(a)

Data for Contour Drawing of ISEA Headform
(all dimensions in mm)

	Horizontal Plane	Distance from Datum Plane	Vertical Sections												
			0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
	0-0	99	0	0	0	0	0	0	0	0	0	0	0	0	0
	1-1	95	22.5	22.5	23	25.5	26.5	28	28.5	31	33	36	39	38.7	40
	2-2	90	39.5	40	40	40.5	40.5	40.5	41.5	43.5	47.5	50	53	53	54.5
	3-3	85	53.5	54	55.7	51.5	50.5	50	51.5	53.5	57	60.5	64	64.5	65 5
	4-4	80	62.5	63	60.9	59	57	57	57.5	60.5	63.5	67.3	70.7	70.7	72 2
	5-5	70	72.5	74	71.5	68.2	65.5	64.5	65.3	68	72	75 7	79.1	80	82
	6-6	60	82	82	79.5	75	71.0	69.4	70.1	73	77.5	81.7	85.1	87.5	87.9
	7-7	50	87.3	87	84.5	79	74	71.5	72	75.7	80.9	85.8	89.4	91	92.3
	8-8	40	90.2	90.5	87.5	81.5	75.5	73.0	73.5	76.9	82.7	88.3	91.3	93.5	95
	9-9	20	94.0	94	90.5	83.5	77.1	73.7	74.2	77.8	84.3	91	95.5	97.6	98.5
Datum Plane	10-10	0	96.5	96.5	93.0	84.6	77.5	73.5	74.2	79	85	92.5	96.5	98.8	99.9
	11-11	20	96.5	96.5	93.0	84.6	77.5	73.5	72	70	78.5	84	90	91	95
	12-12	40	96.5	96.5	93.0	84.6	77.5	73.5	70	63.5	70	75	81	82	84
	13-13	60	96.5	96.5	93.0	84.6	77.5	73.5	68	58	57.5	63	69	69	72
	14-14	80	96.5	96.5	93.0	84.6	77.5	73.5	66	54	48	53	59	60	63
	15-15	100	96.5	96.5	93.0	84.6	77.5	73.5	64	52	48	49	54	56	59
	16-16	115.9	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96 5
	17-17	128.6	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5	96.5

NOTE: All dimensions ±5 mm.

Figure 5-6.2(b)



5-6 Top Impact Testing—Force.

5-6.1 Sample helmets shall be conditioned for each environmental condition specified in Sections 5-1, 5-2, 5-3, and 5-4 of this Chapter prior to each impact.

5-6.2 An aluminum headform, size 7, commonly known as the "ISEA Standard Headform" shall be used. The headform shall have a mass of 3.6 kg ±0.5 kg (8.0 lb ±1.0 lb). The test headform shall be the nominal dimensions of the headform in Figure 5-6.2.

(SEE Figure 5-6.2(a) PREVIOUS PAGE)

(SEE Figure 5-6.2(b) PREVIOUS PAGE)

(SEE Figure 5-6.2(c) BELOW)

(SEE Figure 5-6.2(d) NEXT PAGE)

5-6.3 A steel drop mass of 3.58 kg ±0.05 kg (7.90 lb ±0.10 lb) shall be used. The striking face of the drop mass shall be a spherical segment with a radius of 4.8 cm ±0.8 cm (1.9 in. ±0.3 in.) and a chord length of at least 7.6 cm (3.0 in.).

5-6.4 An electronic force measurement system with the following minimum specifications shall be used:

(SEE TABLE NEXT PAGE)

5-6.4.1 The system frequency response shall comply with SAE J211 Channel Frequency Class 1000 specifications. The minimum mechanical resonant frequency shall be calculated from the formula $f = (\sqrt{kg/m})/2\pi$ where kg is the load cell rigidity (N/m or lb/ft) and m is the mass of the structure on top of the load cell (kg or slugs).

5-6.4.2 All surfaces in contact with the load cell shall have a surface finish of at least 0.8×10^{-6}m (32×10^{-6} in.) rms. In addition, those surfaces in contact with the load cell shall be flat to within 12.7×10^{-6}m (500×10^{-6} in.).

5-6.5 The load cell shall have a backup mass of at least 540 kg (1,200 lbs). The load cell assembly shall be rigidly mounted between the headform structure and a steel plate at least 0.3 m (1 ft) square and 25 mm (1in.) thick. The backup mass shall be concrete or a rigid material of equal or greater density at least 0.6 m (2 ft) square.

5-6.5.1 The surface of the steel plate, in the area of the load cell assembly mounting, shall be flat within ±0.15 mm (±0.005 in.) and within one degree of level. The steel plate shall be rigidly attached to, and in intimate contact with, the backup mass.

5-6.6 The vertical center line of the drop mass, the headform, and the load cell shall all be collinear within 3 mm (.125 in.). The sensitive axis of the load cell shall be aligned within one degree of vertical. The guide or guides shall be vertical; or in the case of a double guide system, parallel; to within 6 mm (0.25 in.) per 3 m (10 ft) of length.

5-6.7* The instrumentation calibration shall be verified at least before and after each test series or at the beginning and end of each day of testing, whichever is the shorter length of time. The results of each system verification shall be made part of the test results for the helmets being tested. The verification tests shall demonstrate an accuracy of 2.5 percent or better in the measured force.

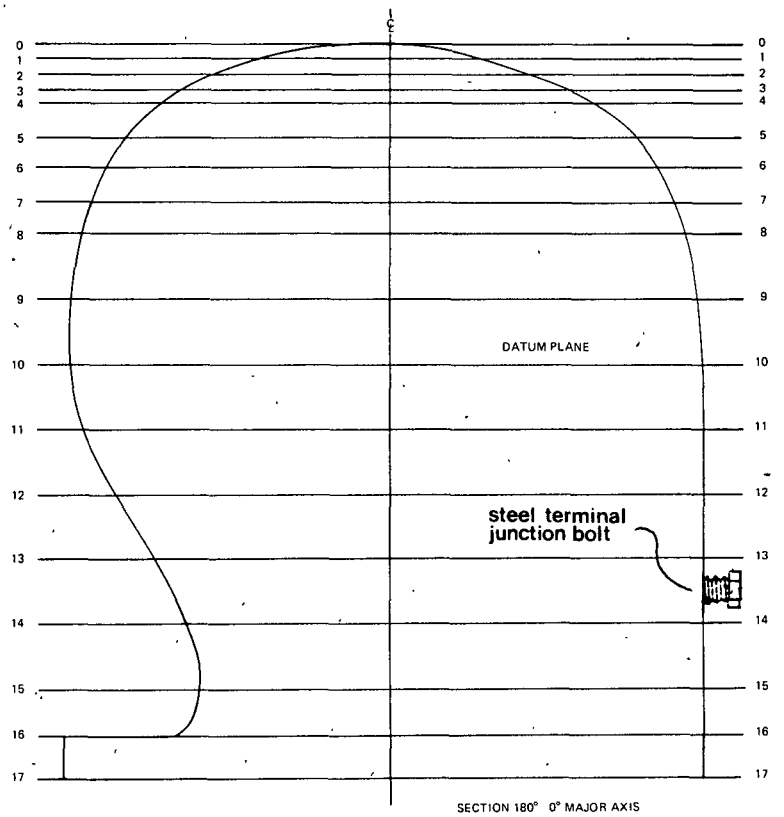
5-6.8 The test system shall be analyzed dynamically to assure that any mechanical resonances associated with transducer mountings do not distort the output data.

5-6.9 Prior to testing, the instrumentation shall be allowed to warm up until stability is achieved.

5-6.10 Throughout calibration, verification, and testing, the ambient temperature shall be 20-28°C (68-82°F) and the relative humidity shall be 30-70 percent.

5-6.11 Sample helmets shall be adjusted to size 7 1/4 or larger, to prevent binding. Sample helmets shall be positioned and secured

Figure 5-6.2(c)



Aluminum ISEA Size 7 Headform Modified with Steel Terminal Junction Bolt

Figure 5-6.2(d)

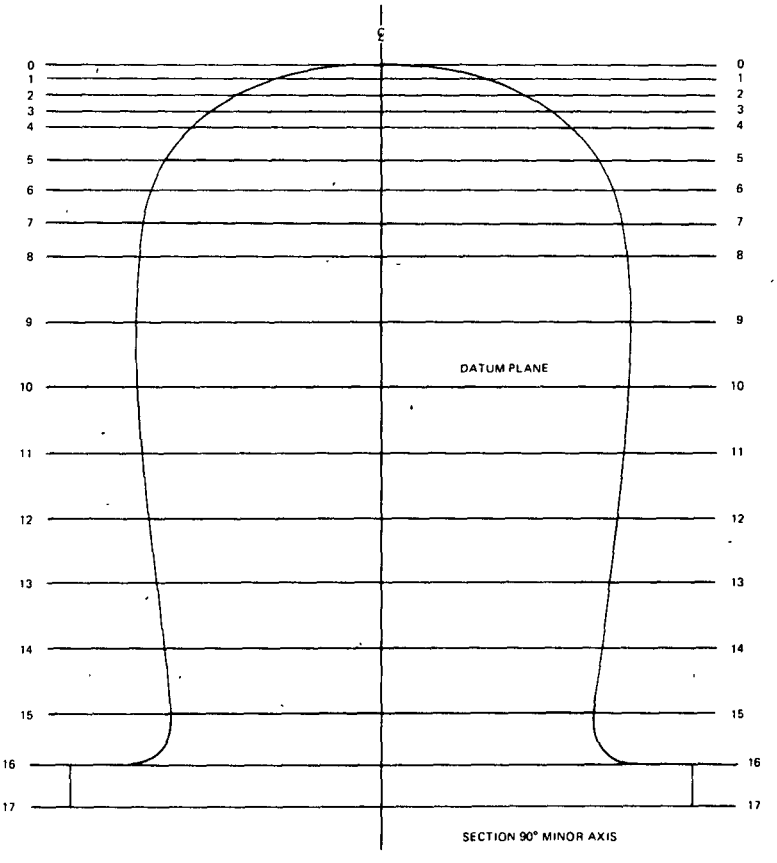


Table 5-6.4

Range	4450N (1,000 lbs)
Peak force measurement accuracy	±2.5 percent
Resolution	22N (5 lbs)
Load cell rigidity	4.4×10^9 N/m (2.5×10^7lb/in.)
Minimum mechanical resonant frequency of the headform/load cell system	5000 Hz
Load cell diameter	7.6 cm (3.0 in.)

with the helmet's retention systems on the headform with the horizontal center plane parallel within 5 degrees of the reference plane. The front-to-back centerline of the shell shall be within 13 mm (0.5 in.) of the mid-sagittal plane of the headform. Helmets shall be subjected to the environmental conditions specified in 5-6.1 of this Section prior to each impact and within the specified time after being removed from conditioning.

5-6.12 The impactor shall be dropped from a height that yields an impact velocity within two percent of 5.47 m/sec (17.9 ft/sec). A means of verifying the impact velocity to within 2 percent for each impact shall be incorporated.

5-6.13 The peak force and impact velocity shall be recorded for each test, and pass/fail shall be determined.

5-7 Impact Testing — Acceleration.

5-7.1 Sample helmets shall be conditioned for each environmental condition specified in Sections 5-1, 5-2, 5-3, and 5-4 of this chapter, prior to each impact. The impact areas shall be as specified in Figure 5-2.1 of the chapter. The edge of the test anvil shall be no lower than the test line. The top, front, back, and side areas of the helmet shall be tested.

5-7.2 The size 7 1/4 test headform shall be the nominal dimensions in Figure 5-7.2. It shall exhibit no resonant frequencies below 3000 Hz; it shall be made of any low-resonance alloy, such as magnesium K-1A.

(SEE FIGURE 5-7.2 NEXT PAGE, TOP)

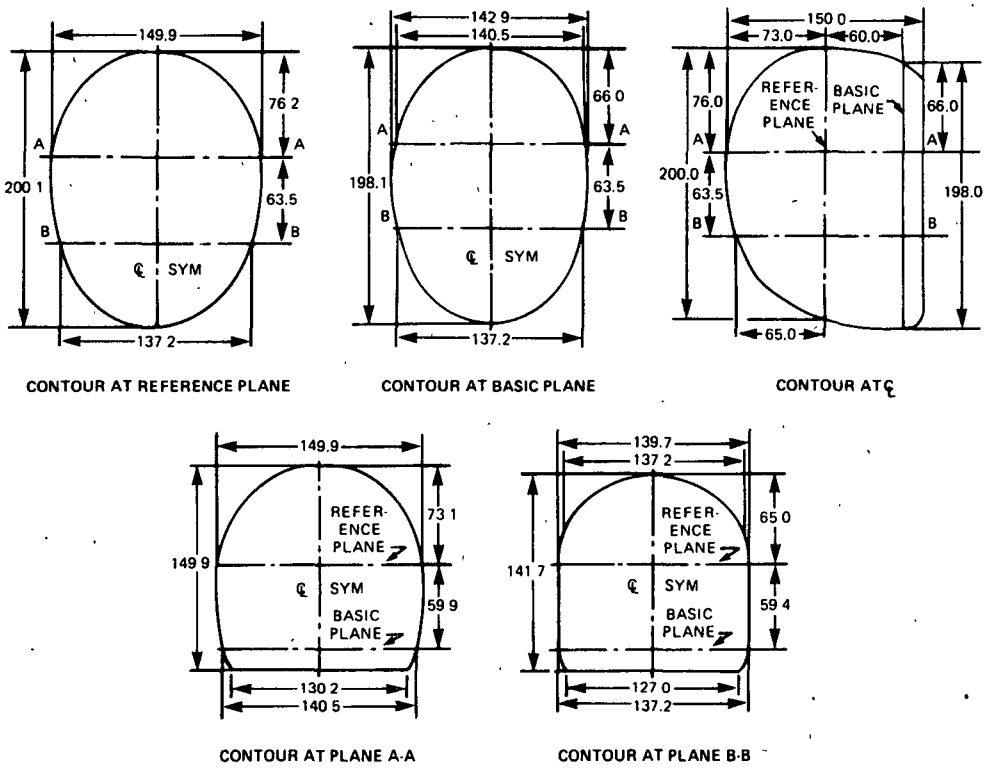
5-7.3 There shall be a drop assembly consisting of the test headform, the accelerometer, and moving portion of the headform guidance assembly. The drop assembly shall have a total mass of 5.17 kg ±0.18 kg (11.4 lb ±0.4 lb).

5-7.3.1 The guidance assembly shall comprise not more than 20 percent of the total mass of the drop assembly.

5-7.3.2 The center of mass of the drop assembly shall lie within a cone of 10 degrees included angle about the vertical, with apex at the point of impact.

5-7.4 A steel test anvil shall be used and shall have a smooth, flat striking surface 127 mm ±15 mm (5.0 in. ±0.6 in.) in diameter. The anvil shall be firmly mounted on a steel plate at least 0.3 m (1 ft)

Figure 5-7.2 Test Headform Size 7 1/4 (dimensions in mm)



NOTE: All dimensions ± 5 mm.

square and 25 mm (1 in.) thick. The steel plate shall be rigidly attached to and in intimate contact with a backup mass of at least 540 kg (1,200 lbs). The backup mass shall be of concrete or a rigid material of equal or greater density at least 0.6 m (2 ft) square.

5-7.5 An electronic acceleration measurement system with the following minimum specifications shall be used.

(SEE TABLE BELOW)

5-7.5.1 The system frequency response shall comply with SAE J211 Channel Frequency Class 1000 specifications. The time duration of acceleration levels shall be measured to within ±0.2 millisecond.

5-7.6* A reference anvil shall be substituted for the test anvil to verify the calibration of the acceleration measurement system. The reference anvil shall be constructed on any material that will yield reproducible test results during a period of at least four months.

5-7.7* For calibration, the center of the reference anvil shall be aligned within 3 mm (0.125 in.) of the impact point on the headform. The sensitive axis of the accelerometer shall be aligned within 1 degree of vertical and collinear within 3 mm (0.125 in.) with the center of the reference anvil and the impact point on the headform. The guide or guides shall be vertical; and, in the case of a double guide system, parallel, to within 6 mm (0.25 in.) per 3 m (10 ft) of length.

5-7.7.1 The instrumentation calibration shall be verified at least before and after each test series or at the beginning and end of each day of testing, whichever is the shorter length of time.

5-7.7.2 The results of each system verification shall be made part of the test results for the helmets being tested.

5-7.7.3 The verification tests shall demonstrate an accuracy of 20 percent or better in the measured acceleration.

5-7.7.4 The test system shall be analyzed dynamically to assure that any mechanical resonances do not distort the output data.

5-7.8 Prior to testing, the instrumentation shall be allowed to warm up until stability is achieved.

5-7.9 Throughout calibration, verification, and testing, the ambient temperature shall be 20°-28°C (68°-82°F) and the relative humidity shall be 30-70 percent.

Table 5-7.5

Range	500 Gn
Peak acceleration measurement accuracy	±2.5 percent
Resonant frequency	5000 Hz
Accelerometer shock limit	2000 Gn
Resolution	5 Gn

5-7.10 A conditioned helmet shall be positioned on the headform with the horizontal center plane of the helmet parallel within 5 degrees of the reference plane of the headform, and shall be secured to the drop assembly by its retention system so as to maintain this position during the test. No part of the helmet shell shall be cut away to accommodate the test system, and no part of the test system shall contact the helmet shell either as mounted or during an impact test.

5-7.11 The drop assembly with a helmet attached shall be dropped from a height that yields an impact velocity within 2 percent of 6.0 m/sec (19.7 ft/sec). A means of verifying the impact velocity within 2 percent for each impact shall be incorporated in the test system. The acceleration-time duration values, peak acceleration, and impact velocity shall be recorded for each test. Each helmet shall be environmentally conditioned prior to each impact and shall be impacted in each of the five impact areas specified in Figure 5-2.1.

5-8 Penetration Resistance Testing.

5-8.1 Sample helmets shall be conditioned for each environmental condition specified in Sections 5-1, 5-2, 5-3, and 5-4 of this chapter, prior to each penetration.

5-8.2 The size 7 1/4 test headform shall be the nominal dimensions in Figure 5-7.2 or in Figure 5-5.1 of this chapter. Above the test line, it shall have an electrically conductive surface that is electrically connected to the contact indicator.

5-8.3 The penetration striker shall have a mass of 1 kg, +0.02/-0.00 kg (2.2 lb, +0.01/-0.00 lb.). The point of the striker shall be a cone with an included angle of 60° ±0.5 degrees, a height of 38 mm (1.5 in.) and a tip radius of 0.5 mm ±0.1 mm (0.020 in. ±0.004 in.). The hardness of the striking tip shall be Rockwell Scale C-60, minimum. The penetration striker shall be electrically connected to the contact indicator.

5-8.4 The contact indicator shall indicate when electrical compact has been made between the penetration striker and the conductive surface of the test headform. The contact indicator shall have a response time of less than 0.5 millisecond.

5-8.5 The test shall be conducted at an ambient temperature of 20°-28°C (68°-82°F) and the relative humidity shall be 30-70 percent.

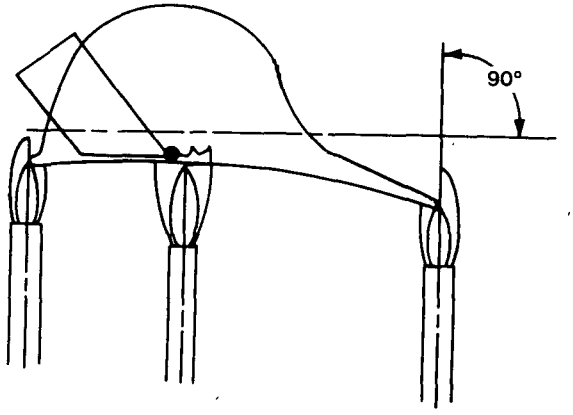
5-8.6 The environmentally conditioned helmet shall be placed on the rigidly mounted test headform and secured by the helmet retention system or by other means that will not interfere with the test. The helmet shall be positioned so that the penetration striker shall impact perpendicular to the helmet anywhere above the test line. The impact site shall be at least 75 mm (3.0 in.) from the center of a previous penetration or impact site.

5-8.7 The drop height of the penetration striker shall be adjusted so that the velocity at impact is at 7.0 m/sec, ±0.1 m/sec (23.0 ft/sec ±0.5 ft/sec). A total of two penetration tests for each of the four environmental conditions specified in Sections 5-1, 5-2, 5-3, and 5-4 of this chapter shall be conducted in such a manner that at least one penetration test shall be performed in each of the test areas defined in Figure 5-2.1 of this chapter. The helmet shall be environmentally conditioned prior to each penetration test. A minimum of two penetration test blows shall be applied at different test areas on each helmet.

5-9 Flame Resistance Test One.

5-9.1 Sample helmets shall be positioned on the headform with the horizontal center plane parallel within five degrees of the reference plane with the faceshield in the stowed position and tested as shown in Figure 5-9.1.

Figure 5-9.1



5-9.2 The tip of the inner cone of a Bunsen burner flame of 25-38 mm (1-1.5 in.) in length shall be placed at the outer edge of the helmet shell, at the front, sides, and rear. When a helmet, hanger is provided, the test flame shall be applied off the edge of the helmet hanger, at the shell edge.

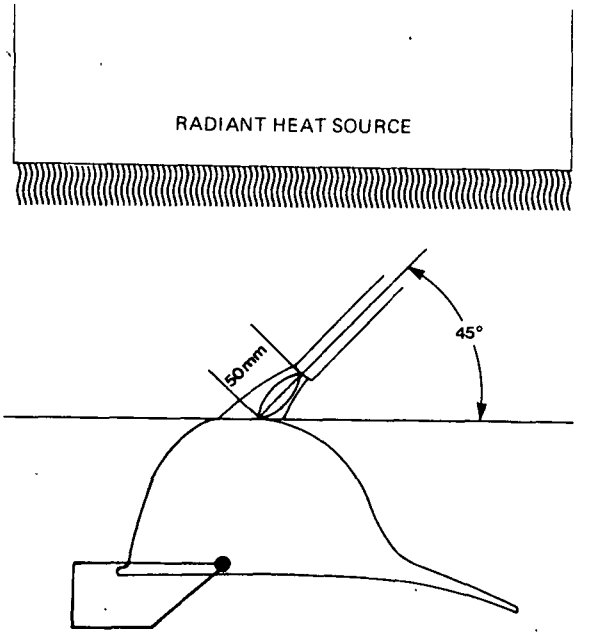
5-9.3 The Bunsen burner shall be fueled by a bottled methane gas, lab grade or better of 1000 Btu ±50 Btu per cubic ft. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 0.5 psi +0.1/-0.0 psi at the burner shall be utilized. The barrel of the Bunsen burner shall be 12 mm ±3 mm (0.5 in. ±0.125 in.) in diameter. A flame spreader shall not be used.

5-9.4 After 15 seconds +1/- 0 seconds, the flame shall be removed and the duration of the afterflame and afterglow shall be measured.

5-10 Flame Resistance Test Two.

5-10.1 Sample helmets shall be placed on an appropriate test headform in front of the radiant heat source specified in 5-2.2 of this chapter. The basic plane of the head form shall be parallel to the radiant heat source as shown in Figure 5-10.1.

Figure 5-10.1



5-10.2 Sample helmets shall be positioned so that the area to be tested receives a radiant flux of 1.0 W/cm^2 ±0.1 W/cm2. After 60 seconds +5/-0 seconds exposure to the radiant flux and without removing the radiant heat source, the tip of the inner cone of a Bunsen burner flame of 25-38 mm (1-1.5 in.) in length shall be placed against the helmet test area so that the flame makes an angle of 45 degrees ±10 degrees with the plane tangent to the test area at the point of contact.

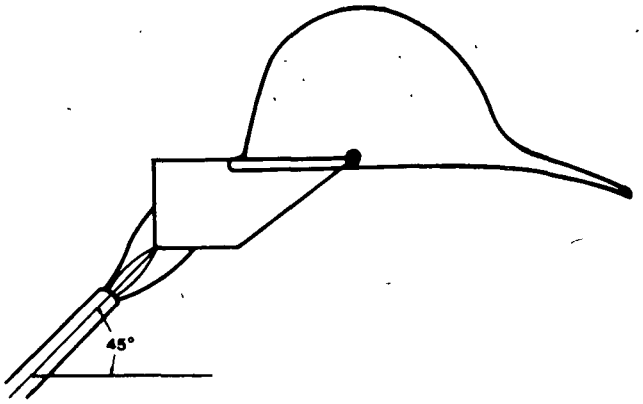
5-10.3 The Bunsen burner shall be fueled by a gas of 1000 Btu ±50 Btu per cubic ft. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 0.5 psi +0.1/-0.0 psi at the burner inlet shall be utilized. The barrel of the Bunsen burner shall be 12 mm ±3 mm (0.5 in. ±0.125 in.) in diameter. A flame spreader shall not be used.

5-10.4 After 15 seconds +1/-0 seconds, the flame shall be removed and the duration of afterflame and afterglow shall be measured.

5-11 Flame Resistance Test Three.

5-11.1 Sample helmets with faceshield deployed shall be positioned on the headform with the horizontal center plane parallel within 5 degrees of the reference plane and tested as shown in Figure 5-11.1.

Figure 5-11.1



5-11.2 The tip of the inner cone of a Bunsen burner flame of 25-28 mm (1-1.5 in.) in length shall be placed on the lower edge of the faceshield at the intersection of the mid-sagittal plane. The burner shall be held in the mid-sagittal plane at an angle of 45 degrees ±10 degrees with the flame centered at the edge of the faceshield.

5-11.3 The Bunsen burner shall be fueled by a gas of 1000 Btu ±50 Btu per cubic ft. A control valve system with a delivery rate designed to furnish gas to the burner under a pressure of 0.5 psi +0.1/-0.0 psi at the burner inlet shall be utilized. The barrel of the Bunsen burner shall be 12 mm ±3 mm (0.5 in. ± 0.125 in.) in diameter. A flame spreader shall not be used.

5-11.4 After 15 seconds +1/-0 seconds, the flame shall be removed and the duration of afterflame and afterglow shall be measured.

5-12 Electrical Insulation Test One.

5-12.1 The following equipment shall be provided for the test:

(a) A source of 60 Hz alternating current variable from 0 to 2,200 volts true R.M.S.

(b) Wiring and terminals for application of voltage across the crown of the test specimen.

(c) A voltmeter to measure the applied voltage within 2 percent.

(d) A milliampmeter to measure the leakage current to within 2 percent.

(e) A vessel, containing fresh tap water, of sufficient size to submerge an inverted helmet shell to within 13 mm ±6 mm (0.5 in. ±0.25 in.) of the reference plane.

(f) A frame for suspending the test specimen in water.

5-12.2 The inside of the helmet shall be filled with fresh tap water within 13 mm ±6 mm (0.5 in. ± 0.25 in.) below the reference plane with the helmet inverted. The helmet shall then be submerged in the same type of water to the same level as the water on the inside of the helmet.

5-12.3 A 60 Hz alternating current voltage shall be applied and increased to 2,200 volts R.M.S. The voltage shall be maintained at 2,200 volts ±2 percent for one minute. Any current leakage or evidence of breakdown shall be recorded.

5-13 Electrical Insulation Test Two.

5-13.1 The following equipment shall be provided for the test:

(a) A source of 60 Hz alternating current variable from 0 to 2,200 volts true R.M.S.

(b) Wiring and terminals for application of voltage across the crown of the test specimen.

(c) A voltmeter to measure the applied voltage within 2 percent.

(d) A milliampmeter to measure the leakage current to within 2 percent.

(e) A vessel, containing fresh tap water, of sufficient size to completely submerge a complete helmet.

(f) An aluminum size 7 ISEA headform modified per Figure 5-6.2 of this chapter.

5-13.2 The sample helmet and retention system shall be completely submerged in fresh tap water for a period of 15 minutes +2/-0 minutes. The helmet shall be removed from the water and allowed to drain for not longer than two minutes.

5-13.3 The sample helmet shall then be mounted on the modified ISEA Size 7 aluminum headform, with chin strap firmly secured to the headform by means of the conductive terminal junction bolt.

5-13.4 A lead carrying 60 Hz alternating voltage shall be attached to all metal parts on the helmet's exterior, at or above the brim edge. A second pickup lead shall be attached to the terminal junction bolt. A voltage shall be applied to the external helmet shell lead and increased to 2,200 volts ±2 percent volts. The voltage shall be maintained for fifteen seconds. Any current leakage or evidence of breakdown shall be recorded.

5-14 Retention System Testing.

5-14.1 A size 7 1/4 headform shall be used and shall be the nominal dimensions of Figure 5-7.2 of this chapter.

5-14.2 The mechanical chin structure shall consist of two rollers 12.7 mm (0.5 in.) in diameter with centers 75 mm (3.0 in.) apart. The mechanical chin structure shall conform with Figure 5-14.2.

(SEE Figure 5-14.2 NEXT PAGE)

5-14.3 The mechanical chin structure shall be designed to be used with a calibrated tensile test machine which shall be capable of measuring the force applied to the retention system within two percent at the specified force.

5-14.4 The test shall be conducted at an ambient temperature of 20°-28°C (68°-82°F) and the relative humidity shall be 30-70 percent.

5-14.5 Prior to testing, the test machine shall be allowed to warm up until stability is achieved.

5-14.6 The headform and mechanical chin structure shall be positioned such that the distance between the bottom of the rollers and the top of the headform is 210 mm ±10 mm (8.3 in. ±0.4 in.). The chin strap shall be passed around the rollers, and the helmet shall be secured to the headform. The chin strap shall be adjusted and preloaded to 45 N ±5 N (10 lb ±1 lb). The distance between the top of the helmet and the rollers shall be measured and recorded to the nearest 0.5 mm (0.02 in.).

5-14.7 The force applied to the retention system shall be slowly increased to 445 ±5 N (100 ±1 lb). The force shall be increased smoothly from 45 N (10 lbs) to 445 N (100 lbs) at between 9.0 N/sec (2.0 lb/sec) and 45 N/sec (10 lb/sec).

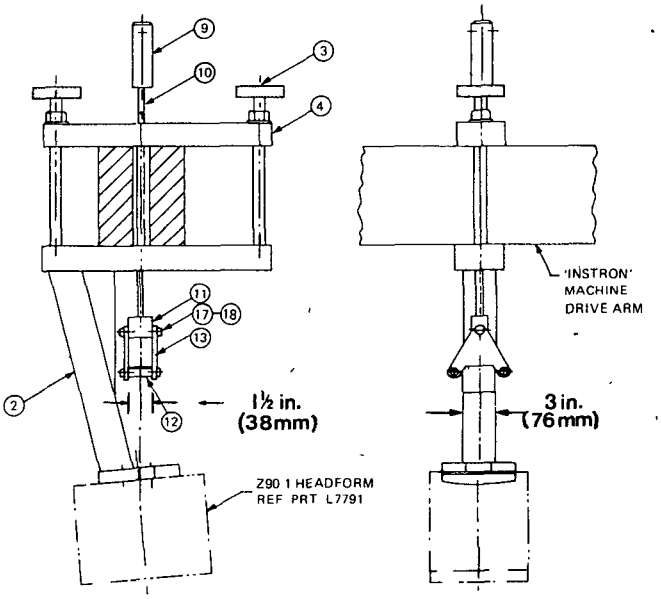
5-14.7.1 When using a tensile testing machine, the load rate shall be 25 mm (1 in.) per minute to a limit of 445 N (100 lbs).

5-14.8 The distance between the top of the helmet and the rollers shall be measured and recorded again after the force has been maintained at 445 N (100 lbs) for 60 seconds +15/-0 seconds. The difference between the second measurement and the first shall be the retention system elongation.

5-15 Suspension System Retention Testing.

5-15.1 The suspension system retention test fixtures shall consist of rigid material of sufficient thickness and optional design to facilitate firm attachment to the helmet suspension and the tensile test machine as shown in Figure 5-15.1.

Figure 5-14.2 Retention System Test Set-up



ITEM NO	PART NO	SHT NO	DESCRIPTION	MAT'L	VEND. OR STR SIZE	QTY
1	L8539	1	Retention Test Fixt Assy	–	–	1
2		2	Main Support Assy	–	–	1
3		2	Knurled Knob Assy	–	–	2
4		2	Rect Alum Bar	6061-T6	1 1/2 x 3 x 14 Lg	1
5		2	Rect Alum Bar	6061 T6	1 1/2 x 3 x 14 Lg	1
6		2	Alum Bar	6061 T6	2 x 2 x 7 1/2 Lg	1
7		2	Alum Bar	6061-T6	2 x 2 x 12 96 Lg	1
8		2	Alum Flat	6061-T6	3/4 x 4 1/2 x 5 Lg	1
9		2	C F Steel Rod	Stl	1 1/4 Dia x 4 Lg	1
10		2	C F Steel Rod	Stl	3/8 Dia x 22 Lg	1
11		2	C F Steel Flat	Stl	1 x 1 1/4 x 1 1/2 Lg	1
12		2	Hollow Steel Tube	Stl	500 O D 384 I D x 1 1/2	2
13		2	C F Steel Flat	Stl	1/4 x 3 1/4 x 3 3/4 Lg	2
14		2	C F Steel Flat	Stl	39 x 3/4 Thk	2
15		2	C F Steel Rod	Stl	3/4 ϕ x 10 1/2 Lg	2
16		2	Hex Nut	Stl	3/4 10 Unc	2
17		1	Hex Hd Bolt	Stl	3/8 24 Unf x 2 1/2 Lg	3
18		1	Hex Nut	Stl	3/8 - 24 Unf	3

NOTES

1 REMOVE BURRS AND BREAK SHARP EDGES

2 ALL STEEL PARTS ARE TO BE SOLVENT CLEANED AND ZINC PLATED 0003 TO 0010 THICK

3 HEADFORM IS TO BE BOLTED IN PLACE USING - 3 SOCKET HEAD CAP SCREWS 1/2 - 13 UNC x 1 1/2 Lg

(SEE Figure 5-15.1 NEXT PAGE TOP RIGHT)

5-15.2 Sample helmets shall be positioned and secured so that the helmet's reference plane is horizontal. Each attachment point of the crown straps shall be tested by applying a pull force perpendicular to the reference plane, to a maximum load of 45 N ±5 N (10 lb ±1 lb). The force shall be increased from 0 N (0 lb) to 45 N ±5 N (10 lb ±1 lb) at a load rate of 25 mm ±5 mm (1 in. ±0.2 in.) per minute. The force shall be applied through the centerline of each attachment point.

5-15.3 The individual pass/fail results for each attachment point shall be recorded.

5-16 Heat Resistance Testing.

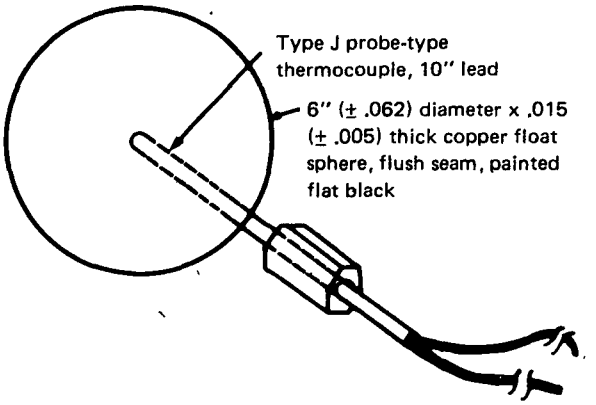
5-16.1* The test oven shall be a horizontal flow circulating air oven with minimum interior dimensions of 61 ≤ 61 ≤ 61 cm (24 ≤ 24 ≤ 24 in.). The test oven shall be calibrated using a black ball thermocouple conforming to Figure 5-16.1. This black ball thermocouple shall be stabilized for at least three minutes at ambient conditions specified in 5-6.10 of this chapter. The test oven shall be preheated and stabilized for a minimum of three minutes immediately before calibration. The black ball thermocouple shall then be suspended in the center of the test oven. The test oven door shall not remain open for more than 15 seconds and the air circulation in the test oven shall be shut off while the door is open. The oven shall be pre-heated and stabilized at a temperature not less than 260°C (500°F), but sufficient to cause the temperature recorded by the thermocouple to rise to 93°C ±7 °C (200°F ±20°F) after 1.5 minutes, to 160°C ±3°C (320°F ±10°F) after 3.0 minutes, and to 215°C ±3°C (420°F ±10°F) after 5 minutes, +15/-0 seconds.

(SEE Figure 5-16.1 AT RIGHT)

5-16.2 Sample helmet with ear covers deployed and faceshield in the stowed position shall be mounted on a solid, nonmetallic headform conforming to the dimensions in Figure 5-5.1 of this chapter, with the retention system securely fastened. The helmet and headform shall be stabilized at ambient conditions specified in 5-6.10 of this chapter. The headform with helmet attached shall be placed in the center of the test oven. The oven door shall not remain open more than fifteen seconds. The air circulation shall be shut off while the door is open, and turned on when the door is closed.

5-16.3 After 5 minutes, +15/-0 seconds, the helmet and headform shall be removed and allowed to cool at room temperature for not less than two minutes. The shell distortion shall then be measured at the front, back, and sides, at eight points radially separated by 45

Figure 5-16.1 Black Ball Thermocouple



degrees relative to their original position. The helmet shall be examined to ascertain any adverse effects of the heat exposure.

5-17 Faceshield Impact Test.

5-17.1 A sample faceshield attached to a helmet shall be preconditioned for each of the environmental conditions specified in Sections 5-1, 5-3, 5-4, and 5-5 of this chapter.

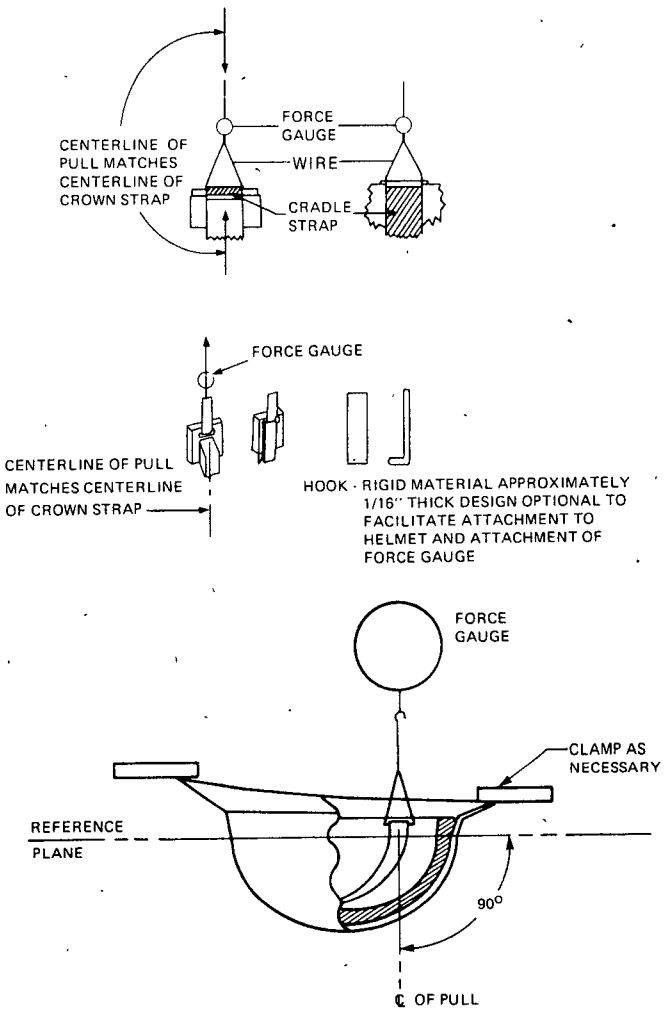
(SEE Figure 5-17.1 AFTER NEXT PAGE)

5-17.2* The test headform shall be size 7 1/4, be made of rigid material, have the dimensions shown in Figure 5-17.1, and be fitted with a contact sensor as shown in Detail AA of Figure 5-17.1. Alternately, a 50th percentile, SA-150 *Anthropometric Head Assembly*, that meets the requirements of 49 CFR 572.6, shall be permitted to be used.

5-17.3 A contact indicator shall indicate when electrical contact has been made between the conductive surface of the faceshield and the test headform contact sensor.

5-17.4 An impactor shall be a steel ball 38 mm (1 1/2 in.) in diameter with a mass of 225 grams (8 ozs.).

Figure 5-15.1



5-17.5 The test equipment shall be set up as specified in Figure 5-17.5. The concave surface of each faceshield shall be lined with a conductive material. The faceshield shall be attached to the helmet in accordance with the manufacturer's instructions and shall remain attached throughout the conditioning and testing.

(SEE Figure 5-17.5 AFTER NEXT PAGE)

5-17.6 The test sequence specified in Table 2-3.3 shall be followed for each of the faceshield samples.

5-17.7 The helmet with a preconditioned faceshield attached shall be positioned squarely on the test headform and the chinstrap shall be securely fastened. The helmet shall not be allowed to rotate. The faceshield liner shall be electrically connected through the contact indicator, to the test headform contact sensor. The test headform with helmet attached shall be positioned face up and firmly supported with the coronal plane horizontal and the midsagittal plane vertical.

5-17.8 The impactor shall be suspended inside a vertical drop tube of inside diameter of 43 mm ±2 mm such that the impactor is one meter (39.87 in.) above the contact sensor on the nose of the headform. The lower end of the drop tube shall be positioned 76 mm (3 in.) above the faceshield. The faceshield shall be impacted by releasing the impactor and allowing it to fall freely.

5-17.9 The contact indicator shall be observed to determine if the faceshield has made electrical contact with the headform contact sensor.

5-18 Luminous (Visible) Transmittance Testing.

5-18.1* The standard source of radiant energy used in the measurement of luminous transmittance of filter lenses shall be a projection-type lamp No. T-8. or other high-powered, gas-filled, tungsten-filament incandescent lamp, operated at the color temperature corresponding to Commission Internationale de l'Eclairage (CIE), Source A.

5-18.2 Luminous transmittance shall be determined by one of the following means:

(a) By measuring the spectral transmittance and calculating the luminous transmittance through the use of published data on the spectral radiant energy of CIE, Source A and the relative luminous efficiency of the average eye.
(b) By using a Gardner pivotal sphere hazemeter and the standards of luminous transmittance maintained by the National Bureau of Standards.

5-19 Retroreflectivity Testing.

5-19.1 The test procedure shall be in accordance with ASTM E 810, *Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting*, with an observation angle of 0.2 degrees and an entrance angle of minus 4 degrees.

5-20 Scratch resistance.

5-20.1 A cycling apparatus shall consist of a mounting base which conforms to the shape of the facecshield and provides a rigid backing to prevent deflection and/or slippage of the faceshield during testing and an abrader which conforms to the shape of the faceshield in the area to be tested.

5-20.2 The abrader shall have a surface area of at least 12.9 cm^2 (2 sq in.) and shall be covered with chrome-tanned split leather. A constant load of 0.68 kg/cm^2 (4 psi) shall be applied to the abrader during test.

5-20.3 The cycle stroke shall be at least 5.08 cm (2 in). The cycle stroke shall consist of one complete back and forth movement and shall be accomplished by either moving the abrader against the faceshield or by moving the faceshield against the abrader.

5-20.4 Using the cycling apparatus, a faceshield shall be mounted with the outer surface facing the abrader. Eight grams (0.28 oz) of 100-140 mesh sand-blast silica spheres shall be applied to the faceshield directly under the abrader. The abrader shall be lowered to contact the faceshield being sure to cover the silica spheres with the abrader surface. A pressure of 0.68 kg/cm^2 (4 psi) shall be applied to the abrader and the apparatus shall be cycled for 50 strokes. The faceshield shall be applied and any residual silica spheres shall be washed from the surface. The faceshield shall be dried and the tested area shall then be removed under 10X magnification to determine pass/fail.

5-21 Ear Covers Testing.

5-21.1 Materials utilized for ear covers shall be tested as specified in Method 5903.1 Flame Resistance of Cloth: Vertical, of Federal Test Method Standard 191A, Textile Test Methods.

5-22 Label Durability Testing.

5-22.1 Helmets with labels attached shall be submitted to the conditionings specified in Sections 5-1, 5-2, 5-3, 5-4, and 5-5 of this Chapter.

5-22.2 After each conditioning, the labels shall be examined to determine pass/fail.

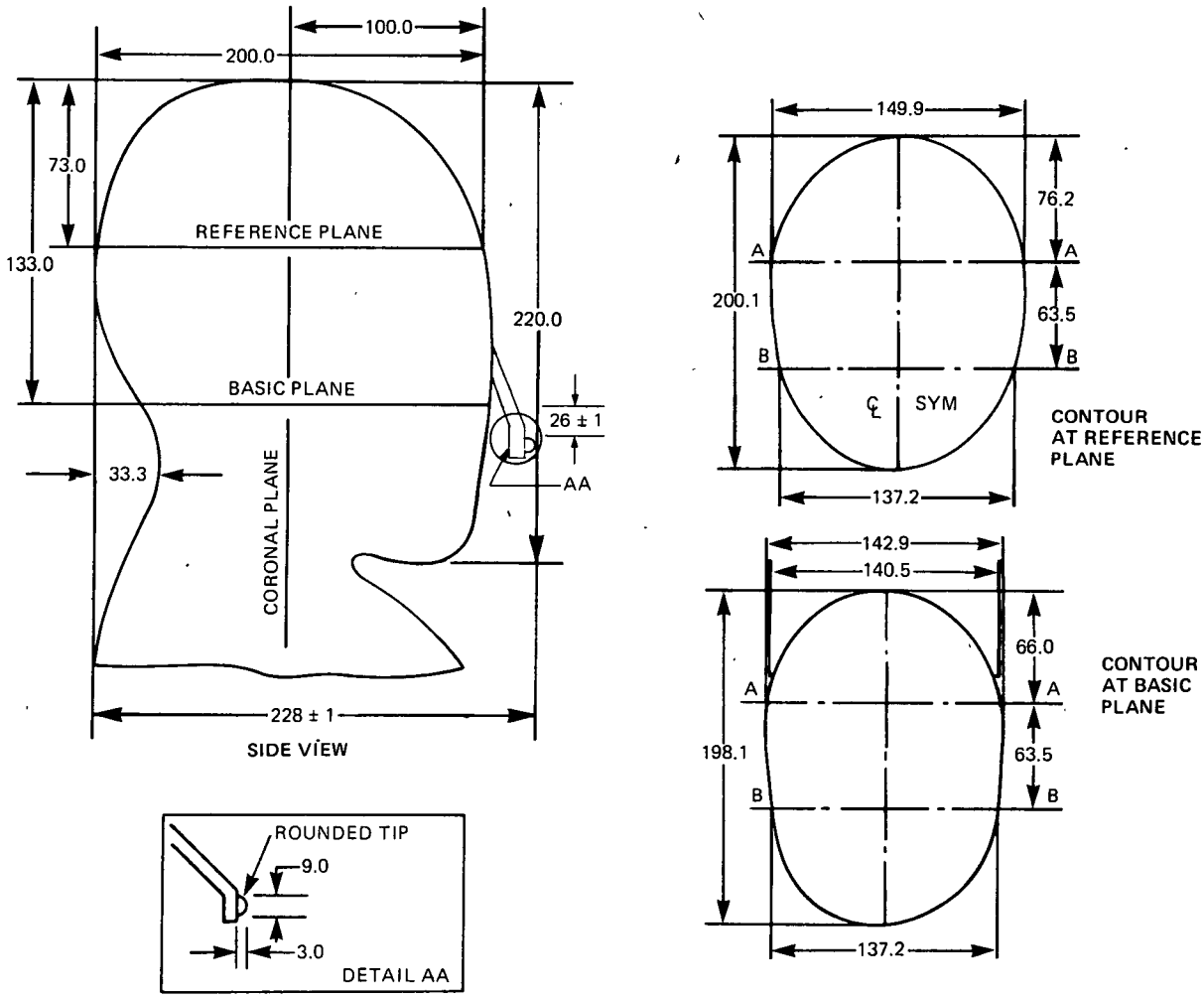
Chapter 6 Referenced Publications

6-1 The following documents or portions thereof are referenced within this document and shall be considered part of the requirements of this document. The edition indicated for each reference shall be the current edition as of the date of the NFPA issuance of this document.

ASTM B 152, *Specification for Copper Sheet, Strip Plate, and Rolled Bar*, 1986.

ASTM E 810, Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting, 1981.

Figure 5-17.1



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

Military Standard MIL-STD-105D, *Sampling Procedures and Tables for Inspection by Attributes*, 29 April 1983

ANSI Z87.1, Occupational and Educational Eye and Face Protection, 1989 Edition

Title 49 Code of Federal Regulations, Part 572 Subpart B (49 CFR 572.6) 1 October 1990

Appendix A

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

A-1-1.1 There are ten major performance requirements in Chapter 4 and tests in Chapter 5 of NFPA 1972. The following is an explanation of those requirements and tests .

The first five sections of Chapter 5 set forth environmental conditions to which the helmet is subjected before undergoing impact and penetration testing. These conditions are:

1. Room temperature
2. Radiant heat exposure of 1.0 W/cm²
3. Low temperature of -25°F
4. Water soak
5. Faceshield heat exposure

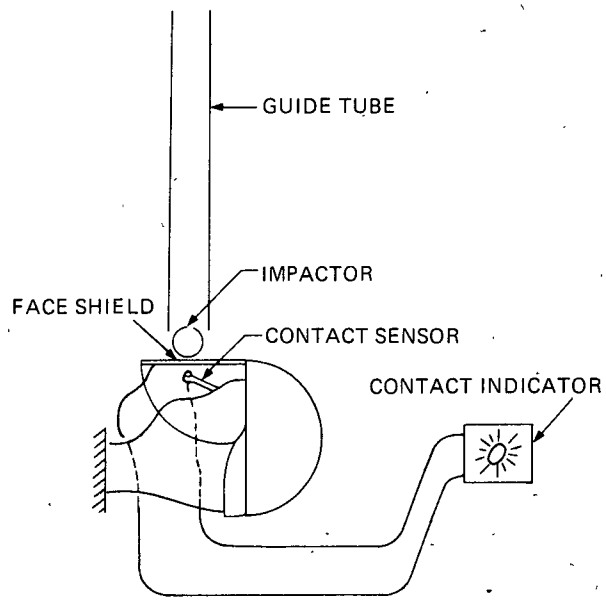
The conditions were chosen to represent some typical fire ground conditions. It is recognized that other conditions could have been chosen.

1. The first requirement is top impact force. This test comes directly from ANSI Z89.1 for industrial helmets. The helmet is placed on a stationary headform over a force-measuring device and a weight is dropped onto it. "Force" refers to the failure criteria, specifically prohibiting a force of greater than 850 pounds from being transmitted to the head when the helmet is subjected to a 40 ft lb energy impact. This is not to be confused with a static loading of 850 lbs. The helmet absorbs approximately 80 percent of the impacting energy. The helmet is tested only on top.

2. The second requirement is impact-acceleration. To facilitate testing on five locations (top, front, both sides, and back), the helmet is strapped to a headform and the assembly is dropped on a flat steel plate. A force measurement cannot be made directly in this case so the failure criteria is in acceleration units, or "g's". The drop height is 6 ft and the energy level is approximately 80 ft lbs, depending on the weight of the helmet. The maximum g's permitted are 300, except for top impact where the maximum is 150. This reduction reflects the fact that the human neck is weaker than the head under this type of compressive loading.

3. The next requirement is penetration resistance. A specific weight (2.2 lbs) with a specific sharpness is dropped onto the helmet and is not permitted to penetrate the shell and contact the headform. This represents a more localized loading than the impact tests above,

Figure 5-17.5



and may be thought of as representing a jagged piece of glass, as opposed to a brick.

4. Another performance requirement is for heat resistance. The helmet is placed in a calibrated circulating air oven at 500°F and tested for distortion, melting, dripping, and ignition. Only specific, minor amounts of distortion are permitted.

5. The flame resistance test measures the helmet's ability to withstand direct flame contact. Both the surface and edges of the helmet shell are exposed to a Bunsen burner flame, as is the lower edge of the faceshield. No burning is permitted five seconds after removal of the test flame.

6. There are two tests that measure the resistance of the helmet to electric current. The first test measures the resistance of the materials used in the construction of the helmet. The helmet is placed upside down in a container of water and the inside is filled with water. A 2,200-volt AC current is then applied across the helmet. The water becomes uniformly charged and allows every part of the helmet to be tested simultaneously. This way, weak areas are uncovered that could be missed if the test method consisted of random sampling with an electrically "hot" probe.

The second test measures the electrical insulation inherent in the design of the helmet. A 2,200-volt ac source connected to the outside of the shell cannot travel around or through the helmet to a grounded metallic headform. The test is performed on a worst-case basis in that a soaking wet helmet is tested.

7. The helmet can only be effective if it stays on the head. The retention test subjects the chin strap to a 100 lb load and does not allow it to break or stretch to a point where the helmet could be dislodged. A second test subjects the suspension system to a 10 lb load on each strap, and does not permit any strap to release from the helmet.

8. There are flammability requirements for the ear covers based on Federal Test Method Standard 191A.

9. The faceshield must meet requirements for heat, flammability, and abrasion. Sample faceshields are preconditioned to low temperature, elevated temperature, and room temperature prior to being tested for impact, utilizing a ANSI Z87.1-type impact test.

10. The last performance requirement covers the fluorescent retroreflective markings. Minimum brightness and minimum surface areas are specified.

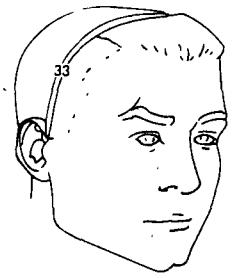
An effort was made to keep the tests as representative of actual fire ground conditions as possible. However, the overriding need in any test program is for repeatability, and laboratory equipment is necessary. For example, a steel penetrator is used since no two shards of glass could ever be the same; and a laboratory burner is used to assure a consistent flame for the flammability tests.

A-1-2.3 Users are cautioned that if unusual conditions prevail, such as higher or lower extremes of temperature than described herein, or if there are signs of unauthorized alteration, abuse, or mutilation of the helmet or any component, the margin of protection may be reduced. All renewals, repairs, or additions of accessories should utilize parts approved by the helmet manufacturer whose helmet complies with this standard. See also A-2-6.1.

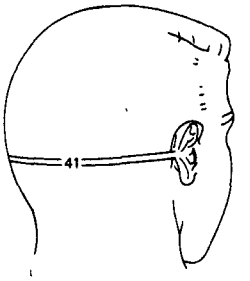
A-1-3 Approved. The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority 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, procedure 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" agencies 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 Bitragion-Coronal Arc.



A-1-3 Bitragion-Inion Arc.



A-1-3 Faceshield. The faceshield does not provide complete face/eye protection against flying particles, splash, gases, and vapors.

For known eye hazards such as, but not limited to, cutting with power saws, chopping, drilling, and using extrication equipment, the faceshield should be worn with additional eye protection suitable for the specific hazard.

As examples, additional eye protection might be either suitable protective goggles or the SCBA full facepiece. (*See 29 CFR 1910.133 and ANSI Z87.1 for further information.*)

A-1-3 Listed. The means for 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-2-2.1 The certification organization should have a 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 factory 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-2-6 Advisory Information for User.

(a) Cleaning. Shells should be scrubbed with a mild detergent and rinsed in clear water [approximately 60°C (140°F)]. After rinsing, the shell should be carefully inspected for signs of damage. Removal of tars, paints, oils, and other materials can require the use of a solvent. Since many solvents can attack and damage the shell, the helmet manufacturer should be consulted with regard to an acceptable solvent for a particular helmet.

(b) Painting. Caution should be exercised if shells are to be painted, since some paints and thinners can attack and damage the shell, reduce protection, or increase flammability. The manufacturer should be consulted with regard to paints or cleaning materials for its particular products.

(c) Periodic Inspection. All components, shells, suspensions, headbands, sweatbands, and any accessories should be inspected before use for signs of dents, cracks, penetration, or any damage due to impact, rough treatment, or wear that might reduce the degree of protection originally provided. Any helmet that requires replacement, or replacement of any worn or damaged part, should be removed from service until the condition of wear or damage has been corrected.

NOTE: Ultraviolet and chemical degradation. All items constructed of thermoplastic are susceptible to ultraviolet and chemical degradation that is present when there is a loss of surface gloss followed by a flaking away of the surface. Periodic examination should be made for these conditions and the shell replaced immediately when they are evident.

(d) Precautions. Because helmets can be damaged, they should not be abused. They should be kept free from abrasions, scrapes, and nicks and should not be dropped, thrown, or used as supports. This applies especially to helmets intended to afford protection against electrical hazards. Helmets should be stored at room temperature and out of direct sunlight.

A-3-1 The purchaser can require a seal to minimize the risk of flame or superheated gases entering the air space between the helmet and the head.

A-3-1.1 Although maximum weight restrictions specified in several head-protection standards are alleged to significantly influence comfort and acceptability, such restriction can severely limit design options which could be considered to obtain the performance requirements specified in this standard. Kamin and Scalone's review paper on NIOSH research states: "Recent attempts to conduct clinical research on helmet comfort reveal that, for the most part, the perception of weight on the head and weight contribution to discomfort are based on: (a) fatigue of muscles that move the head, (b) restriction of the blood vessels by excess pressure at points of contact between the head and the helmet, (c) pressure exerted on joints, and (d) strain induced in tendons. (Kamin, J. I., and Scalone, A. A., "NIOSH Safety Research in Protective Helmets," *American Industrial Hygiene Association Journal*, 489-502(1974).)

A-3-1.5 The purchaser can require a seal between the faceshield and helmet to prevent debris or liquids from passing between the faceshield and helmet. (See also A-1-3, Faceshields, for further information.)

A-3.2.1 Helmet accessories may include insignia, helmet shields, marking or identification trim, lights and communication devices.

A-5-2.8 A radiant heat test for helmets is specified. Under controlled conditions, a radiant heat load of one watt/cm^2 is applied until a temperature of 260°C (500°F) is reached on a transducer. This temperature alone does not simulate actual field conditions, but is a test devised to put extreme heat loads on helmets in an accurate and reproducible manner by test laboratories. However, the radiant heat load of one watt/cm^2 was selected as a summary value based on studies of fire conditions that relate to field use.

A-5-6.7 Calibration Procedures. The following multiple-step procedure is suggested:

Procedure 1. Medium and System Calibration. This calibration step should be carried out with an accelerometer, as described in Section 5-7, mounted in the impactor. The accelerometer should be mounted with its sensitive axis within 5 degrees of vertical.

A calibrating medium should be mounted over the load cell, as described in Section 5-6. The centers of the load cell, medium, impactor, and accelerometer should be collinear within 3 mm (0.125 in.), T.I.R. The impactor should be dropped from a height that yields a peak force of 9000 N ±500 N (2,000 lbs ±110 lbs). A means of verifying the impact velocity within two percent should be utilized. The measured peak force should equal (within 2 1/2 percent) the measured peak acceleration (in g's) times the weight of the impactor. This accuracy should be repeatable through at least five impacts.

Procedure 2. System Calibration Only. A calibrating medium that has been tested according to Procedure 1 above can be used without accelerometer or guided mass. The force value obtained when testing according to Procedure 1 should be recorded and provided with the calibrating medium. The calibrating medium should be mounted over the load cell. The centers of the load cell, medium, impactor, and accelerometer should be collinear within 3 mm (.125 in.), T.I.R. The impactor should be dropped onto the medium, and the peak force measured by the load cell should be recorded. The peak force should be within 2 1/2 percent of that recorded while testing according to Procedure 1. The calibrating medium should be retested according to Procedure I at not more than four-month intervals.

Procedure 3. Electronics Calibration. When in use, electronic calibration of the normally used instrumentation scales should be undertaken at least every six months. This should be accomplished by following the procedures recommended by the manufacturer of the instrumentation .

A-5-7.6 Open Blue or Green Modular Elastomer Programmers, available from United States Testing Company, 291 Fairfield Avenue, Fairfield, NJ 07006, have been found to be suitable reference anvils.

A-5-7.7 Calibration Procedures. The following multiple-step calibration should be used:

Procedure 1. Medium and System Calibration. This calibration step should be carried out with a guided-fall system with an accelerometer mounted in the drop assembly, and a load cell mounted under the reference anvil. The load cell should be mounted in compliance with the requirements of 5-6.4, 5-6.5, and 5-6.6. The drop assembly should be dropped onto the reference anvil from a height that yields a peak acceleration of 400 Gn ±20 Gn and accelerations above 200 Gn of at least one millisecond duration. A means of verifying the impact velocity within two percent should be utilized. The measured peak force should equal (within twenty percent) the measured peak acceleration (in g's) times the weight of the drop assembly. This accuracy should be repeatable through at least five impacts.

Procedure 2. Electronics Verification. When in use, electronic verification of the normally used instrumentation scales should be undertaken at least weekly. This should be accomplished by following the procedures recommended by the manufacturer of the instrumentation .

A-5-16.1 Oven-calibration black ball thermocouple, Part #UST2003. is available from United States Testing Company, 291 Fairfield Avenue, Fairfield, NJ 07006.

A-5-17.2 The 5A-150 Anthropometric Head Assembly is often referred to as an Alderson Headform.

A-5-18.1 The Gardner pivotal sphere hazemeter is described in ASTM D 1003.

PART II

(Log # 3)

1974- 1 - (1-3): Reject
SUBMITTER: Charles H. Rule, Manteca, CA
RECOMMENDATION: Revise text as follows:
Development of a standard for an "overshoe" or "overboot" to be worn in conjunction with protective footwear. (REF: to cover boot, Figure 1-3 on p. 1974-4 of "87" addition).
SUBSTANTIATION: This would provide water/some chemical protection for wearers of protective footwear as identified in 3 above. Protective footwear could then be part of the system instead of current time consuming removal and wearing of uncomfortable, foot/ankle destroying and stocking demolition of current rubber boots.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The proposal is beyond the scope of this standard which addresses protective footwear for structural firefighting. A Task Force established by the Technical Committee for Fire Service Protective Clothing and Equipment is addressing this particular issue from a more focused hazardous materials exposure perspective.

(Log # 4)

1974- 2 - (1-3, 3-1.4): Accept in Principle
SUBMITTER: Richard J. Navaroli, Nashua, NH
RECOMMENDATION: Include new or revised criteria for puncture resistance that will prevent puncture through the sides of the sole, bypassing the puncture resistant insole. (This may also include changes to 3-1.7).
SUBSTANTIATION: We are experiencing the continuing problem of puncture injuries where the puncture is at or above the puncture resistant insole. All of the attached injury reports are from such incidents. Newer boots meet NFPA 1974. Punctures are not through the insole but bypass the insole.
COMMITTEE ACTION: Accept in Principle.
Changes are proposed to Section 1-3, Definitions to read:
Puncture Resistant Device. Reinforcement to the bottom of the protective footwear located between the sole with heel and the insole, designed to provide puncture resistance to the maximum area of the insole allowable by the footwear construction.
Changes are also proposed to Section 3-1.4 to read:
The puncture resistant device shall cover the maximum area of the insole allowed by the construction of the footwear.
COMMITTEE STATEMENT: The Sub-committee recognizes the need to revise the definition and amend design requirements relative to the puncture resistant device.
Current manufacturing technology and construction materials will not allow for side puncture resistancy equal to bottom puncture resistancy protection without adversely affecting protective footwear flexibility, weight and comfort.

(Log # 1)

1974- 3 - (2-1.2): Reject
SUBMITTER: Jack Sawicki, Arlington, VA
RECOMMENDATION: Revise text as follows:
"...not less than 12.0 in. ...".
SUBSTANTIATION: Boots shorter than 12.0 in do not interface with protective trousers, allowing ankle/leg exposure when climbing ladders and stairs.
COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: There now exists interface systems for protective trousers used with footwear less than 12 in. high that address this issue. Interface overlap requirements between protective ensemble components is beyond the scope of NFPA 1974.

(Log # 2)

1974- 4 - (4-4.4.3): Reject
SUBMITTER: Adolfo Ferriera, Cairns & Brother, Inc.
RECOMMENDATION: Revise as follows:
"The sample shall be placed on the plate in the upright position for 30.0 seconds> does not specify the loading requirement to the boot. Since this will be most important to the thermal conductivity and contact areas, and since the ball of the foot would normally be loaded by the fire fighter, it is suggested that a loading of one body weight be specified. Body weight might be defined relative to boot size or simply be taken as a reasonable average of say, 200 lbs or more."
SUBSTANTIATION: The heat transfer through the sole, in order to be realistic has to consider the fireman's and the equipment weight. This applied load will increase the heat transfer by increasing the contact area, and reducing the thickness and air gaps on the outsole threads.

COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: The submitter has not provided definitive proposed wording in his recommendation. The committee felt the duration and temperature of the Conductive Heat Resistance Test compensated for the extremely small effect a load factor would have on altering the contact area of the outsole.

1974- 5 - (Entire Document): Accept
SUBMITTER: Technical Committee on Fire Service Protective Clothing and Equipment
RECOMMENDATION: Completely revise NFPA 1974, Standard on Protective Footwear for Structural Fire Fighting, 1987 Edition.
SUBSTANTIATION: This complete revision includes a general revision to the language to attempt to make the text clear and adds some new definitions of terms.
A new Chapter 2 (in this TCR) adds the requirements for a third party certification program including labeling, listing, and manufacturer quality assurance.
Some revision to the heat resistance test (Section 5-2 in the TCR) was done to better control the temperatures during the test and test oven recovery time. The ladder shank bend test has been changed to clarify the testing procedure. The puncture test was changed to reference an established test method. Label testing was added. Editorial clean-up occurred throughout the document.
COMMITTEE ACTION: Accept.

NFPA 1974

Standard for

Protective Footwear for Structural Fire Fighting

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 6 and Appendix B.

Chapter 1 Administration

1-1 Scope.

1-1.1 This standard establishes minimum design and performance criteria and test methods for protective footwear designed to mitigate adverse environmental effects to the foot and ankle during structural fire fighting.

1-1.2 This standard does not apply to specialized protective footwear for hazardous materials emergencies or wildland fire fighting, and does not provide criteria for protective footwear or criteria for proximity, approach, or fire entry protection from chemical, radiological, or biological agents.

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

1-2 Purpose.

1-2.1 This standard applies to protective footwear to be utilized for structural fire fighting.

1-2.2 Tests and inspections are used to indicate compliance with the requirements of this standard and shall not be deemed as establishing protection levels for all situations to which fire fighters may be exposed.

1-2.3* Protective footwear manufactured in accordance with this standard is designed to mitigate adverse environmental effects to the fire fighter's foot and ankle.

1-2.4 Nothing herein is intended to restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

1-3 Definitions.

Approach Footwear. Protective footwear designed to provide protection from radiant heat.

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.

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 compliance 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.

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

Entry Footwear. Protective footwear that is designed to provide protection from conductive, convective, and radiant heat and permit entry into flames.

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 labeled and listed products that are being produced by the manufacturer to the requirements of this standard.

Insole. That part of the protective footwear next to the bottom of the foot designed to afford support and padding.

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.

Ladder Shank. Reinforcement to the shank area of protective footwear designed to provide additional support to the instep when standing on a ladder rung.

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.

Protective Footwear. Footwear meeting all of the requirements of this standard.

Protective Toecap. Reinforcement to the toe area of protective footwear. Toecaps are designed to protect the toes from impact and compression.

Proximity Footwear. Reflective protective footwear that is designed to provide protection against conductive, convective, and radiant heat.

Puncture-Resistant Device. Reinforcement to the bottom of protective footwear located between the sole with heel and the insole, designed to provide puncture resistance to the maximum area of the insole allowable by the footwear construction.

Shall. Indicates a mandatory requirement.

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

Structural Fire Fighting. The activities of rescue, fire suppression, and property conservation in buildings, enclosed structures, vehicles, vessels, or like properties that are involved in a fire or emergency situation.

Top Line. The top edge of the protective footwear which includes the tongue, gusset, quarter, collar, and shaft.

Upper. That part of the protective footwear including but not limited to the toe, vamp, quarter, shaft, collar, and throat; and other than the sole with heel, puncture-resistant device, and insole as shown in Figure 1-3.

Wear Surface. Bottom of the sole, including heel.

Figure 1-3 Indentification of Footwear Terms.

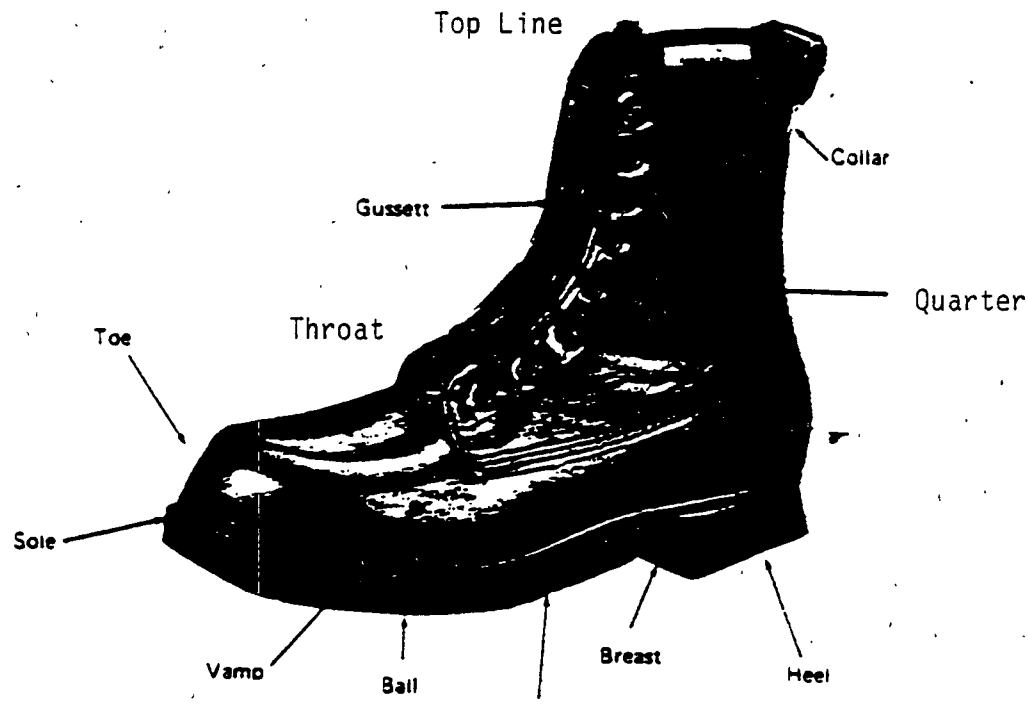
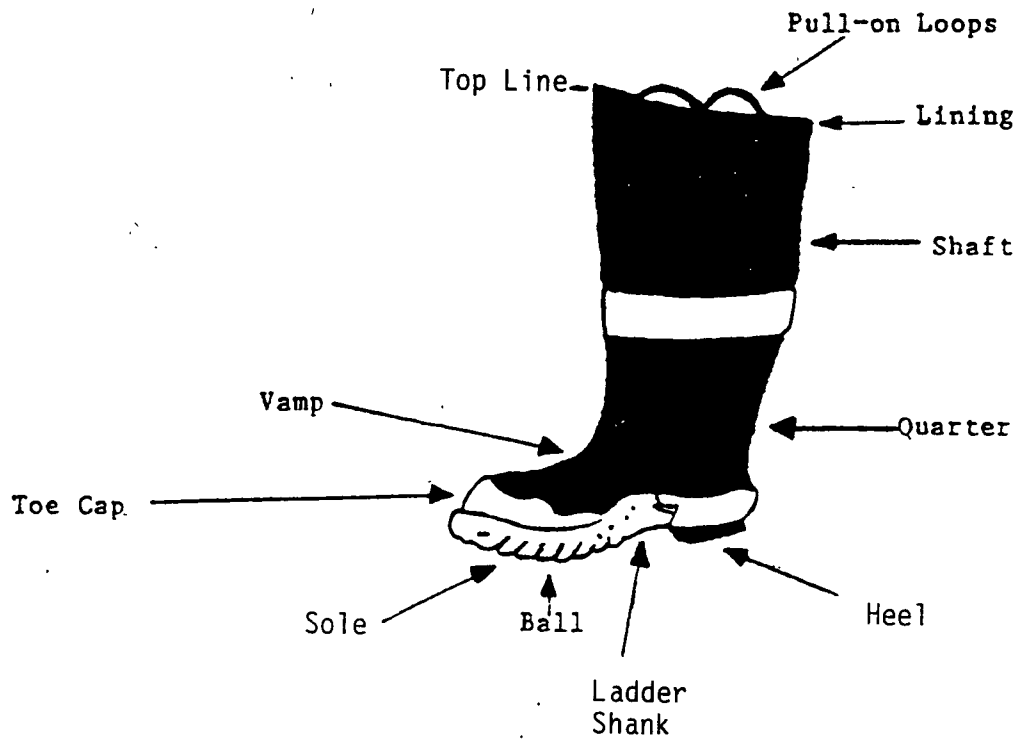


Figure 1-3 Indentification of Footwear Terms.



1-4 Units.

1-4.1 In this standard, values for measurement are followed by an equivalent in parenthesis, but only the first stated value shall be regarded as the requirement. Equivalent values in parenthesis shall not be considered as the requirement as these values might be approximate.

Chapter 2 Certification

2-1 General.

2-1.1 Protective footwear that is labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 All certification shall be performed by an approved certification organization.

2-1.3 Compliant footwear shall be labeled and listed. Such footwear shall also have a product label or labels that meet the requirements specified in Section 2-5 of this chapter.

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 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 a listing is contingent on 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 Manufacturers shall be required to establish and maintain a program of production inspection and testing as specified in Section 2-4 of this chapter.

2-2.5 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 insure proper control of all testing. Good practice shall be followed regarding the use of laboratory manuals, form data sheets, documented calibration routines, performance verification, proficiency testing, and staff qualification and training programs.

2-2.6 The manufacturer 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 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 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant. This information shall be provided to the purchaser on request.

2-3.2 Testing for determining material and component compliance with the requirements specified in Chapter 4 of this standard shall be performed on samples representative of materials and components used in construction of the protective footwear. The certification organization shall be permitted to also use sample materials cut from representative protective footwear.

2-4 Manufacturer's Quality Assurance.

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 product conformance to this standard.

2-4.2 The characteristics to be inspected, or tested, or both shall be classified according to the potential effect of such defects and grouped into the following classes:

(a) Major A — a defect that will reduce protection and is not readily detectable by the user;

(b) Major B — a defect, other than Major A, that is likely to result in reduced protection, and is detectable by the user; and

(c) Minor — a defect that is not likely to materially reduce the usability of the device for its intended purpose .

2-4.2.1 The acceptable quality level shall be as defined by Military Standard MIL-STD 105D, *Sampling Procedures and Tables for Inspection by Attributes*, Inspection Level II.

2-4.2.2 The acceptable quality level for all garment defects shall be as follows: (a) Major A — 1.0, (b) Major B — 2.5, and (c) Minor — 4.0.

2-4.3 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe inspection and test of materials, work in process, and completed articles. In addition, criteria for acceptance and rejection of product shall be included in the instructions.

2-4.4 The manufacturer shall maintain records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found and the quantities accepted or rejected.

2-4.5 The manufacturer shall take action to correct discrepant conditions which have resulted, or could result, in products which do not conform to the requirements of this standard. The nature of the discrepancy and the corrective action taken shall be documented.

2-4.6 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.

2-4.7 Subcontracted or purchased supplies shall be subjected to inspection after receipt, as necessary, to assure conformance of the end item to the requirements of this standard. When manufacturers rely upon the supplier to provide data to demonstrate material conformance to this standard, or when the supplier is individually certified, that data shall become a part of the manufacturer's inspection records. The use of a supplier's test data or certification shall not relieve the manufacturer of their responsibility to furnish an end item which complies with all the requirements of this standard.

2-4.8 When the manufacturer conducts quality assurance testing, the 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.

2-4.8.1 The manufacturer, at their option, shall be permitted to utilize an outside test facility to conduct the quality assurance tests. When this option is selected, the outside test facility shall meet the requirements of 2-4.8 of this Section.

2-4.8.2 The test facility shall provide a written report to the manufacturer that describes the tests performed and the results. This report shall become a part of the manufacturer's inspection records.

2-4.9 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in-process, and finished goods.

2-4.10 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.

2-5 Product Labeling.

2-5.1 Protective footwear shall have a label(s) permanently and conspicuously attached to each half pair upon which at least the following warnings and information are printed in at least 1/16 in. (1.5 mm) high letters.

"THIS FOOTWEAR MEETS THE REQUIREMENTS OF NFPA 1974, STANDARD ON PROTECTIVE FOOTWEAR FOR STRUCTURAL FIRE FIGHTING, 1992 EDITION.

WARNING

DO NOT USE PROTECTIVE FOOTWEAR ALONE FOR STRUCTURAL FIRE FIGHTING OPERATIONS; OTHER PROTECTIVE EQUIPMENT — HELMET, COAT, TROUSERS, SCBA, GLOVES, PASS — IS REQUIRED FOR PROTECTION. THIS FOOTWEAR ALONE MAY NOT PROVIDE PROTECTION FOR PROXIMITY OR FIRE ENTRY SITUATIONS, OR FOR PROTECTION FROM CHEMICAL, RADIOLOGICAL, OR BIOLOGICAL AGENTS. USERS MUST CLEAN, MAINTAIN, AND ALTER ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE FOOTWEAR CAN PROVIDE COMPLETE PROTECTION FROM ALL CONDITIONS — USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS. FAILURE TO COMPLY WITH THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's lot number or other method that identifies date of manufacture
Country of manufacture
Model or stock number
Size and width

"DO NOT REMOVE THIS LABEL"

2-5.2 All portions of the required protective footwear label(s) shall be printed at least in English.

2-5.3 Labels shall be permanently affixed to all protective footwear by stamping, embossing, gluing, or stitching.

2-6 User Information.

2-6.1* The manufacturer of protective footwear certified as being compliant with this standard shall provide, with each pair, instructions for storage, marking, inspection, maintenance, and retirement criteria. Also to be included are cleaning and drying instructions, including applicable warnings regarding detergents, soaps, cleaning additives and bleaches.

2-6.2* The manufacturer shall provide to the purchaser upon request a statement regarding the footwear materials resistance to deterioration by chemicals that may be specified by the purchaser.

Chapter 3 Design Requirements

3-1 Configuration.

3-1.1 Protective footwear shall consist of a sole with heel, upper with lining, and insole with a puncture-resistant device and an impact-and compression-resistant toecap permanently attached.

3-1.2 Protective footwear shall not be less than 8.0 in. (20.3 cm) in height when measured from the plane of the wear surface at the heel to the lowest point of the top line.

3-1.3 Heel breast shall not be less than 0.5 in. (1.27 cm) nor more than 1.0 in. (2.54 cm). Heel breasting angle shall not be less than 90 degrees nor more than 135 degrees. Sides and rear of heel shall not be flared or tapered, and edges shall not be less than, or extend more than, 0.5 in. (1.27 cm) laterally from the upper at any point.

3-1.4 The puncture resistant device shall cover the maximum area of the insole allowed by the construction of the footwear.

3-2 Sizing.

3-2.1 Protective footwear shall be available in all of the following sizes when measured in accordance with Footwear Industries of America, *Shoe Size Conversion, Research Results and Recommendations*:

Mens: 5-13, including half sizes, and a minimum of 2 widths.

Womens: 5-10, including half sizes, and a minimum of 2 widths.

3-3 Construction.

3-3.1 Metal parts shall not penetrate from the outside into the lining or insole at any point.

3-3.2 No metal parts, including but not limited to nails or screws, shall be present or utilized in the construction or attachment of the sole with heel to the puncture-resistant device, insole, or upper.

Chapter 4 Performance Requirements

4-1 Test Series.

4-1.1 Protective footwear shall be tested as specified in Section 5-2, Heat Resistance Test, of this standard. No part of footwear shall melt and all accessories shall remain functional. Labels shall remain attached and legible to the unaided eye.

4-1.2 All metal parts of protective footwear, including but not limited to toe cap, ladder shank, puncture-resistant device, and accessories shall be tested as specified in Section 5-8, Corrosion Resistance Test, of this standard. Metals inherently resistant to corrosion, including but not limited to stainless steel, brass, copper, aluminum, and zinc shall show no more than light surface type corrosion or oxidation. Ferrous metals shall show no corrosion of the base metal. Accessories shall remain functional.

4-1.3* Protective footwear shall not allow puncture through sole area and heel area when tested as specified in Section 5-9, Puncture Resistance Test, of this standard.

4-1.4* Protective footwear shall have no leakage in excess of 5.0 milliamperes when tested as specified in Section 5-10, Electrical Resistance Test, of this standard.

4-1.5 Protective footwear toe shall be tested in accordance with Section 1.4 of ANSI Z41, *Standard for Safety-Toe Footwear.* Compression requirement shall be 2500 pounds (11,121 N). Impact requirement shall be 75 foot-pounds (101.7 J).

4-1.6 Protective footwear upper shall not allow any cut through the lining at any point when tested as specified in Section 5-3, Upper Cut Resistance Test, of this standard.

4-1.7 Protective footwear upper shall not puncture under an average applied force of 13.2 lbs (6 kg) when tested as specified in Section 5-4, Upper Penetration Resistance Test, of this standard.

4-1.8 Protective footwear shall have a maximum afterflame of not more than 2.0 seconds, and shall not melt or drip when tested as specified in Section 5-11, Flame Resistance Test, of this standard.

4-1.9 Protective footwear sole with heel shall have an abrasion-resistance rating of not less than 65 when tested in accordance with Footwear Industries of America Standard 301, *NBS Abrasion.*

4-1.10 Protective footwear insole surface in contact with foot shall not exceed 111.0°F (44.0°C) when tested as specified in Section 5-5, Conductive Heat Resistance Test, of this standard.

4-1.11 Protective footwear upper lining surface in contact with the skin shall not exceed 111.0°F (44.0°C) when tested as specified in Section 5-6, Radiant Heat Resistance Test, of this standard.

4-1.12 Protective footwear exterior shall show no signs of water penetration when tested as specified in Section 5-12, Flex Testing, of this standard.

4-1.13 Ladder shanks for protective footwear shall not deflect more than 0.25 in. (0.6 cm) when tested as specified in Section 5-7, Ladder Shank Bend Resistance Test, of this standard.

4-1.14 Labels shall remain in place and shall not be torn or otherwise damaged when tested in accordance with ASTM D 4966, *Standard Test Method for Abrasion Resistance of Textile Fabrics.*

Chapter 5 Test Methods

5-1 Conditioning.

5-1.1 Where indicated, samples shall be preconditioned in accordance with Section 4, *Atmospheric Conditions for Testing,* of Federal Test Method Standard 191A, *Textile Test Methods.* Testing shall begin not more than 5.0 minutes after removal from preconditioning.

5-1.2 Where indicated, samples shall be preconditioned by immersion in 70.0°F (21°C) tap water for not less than 1.0 hour. Samples shall be drained upside down for 5.0 minutes. Testing shall be done not less than 5.0 minutes after draining.

5-2 Heat Resistance Test.

5-2.1 The oven shall be of circulating-air design and shall have a minimum interior size of 24 in. wide x 24 in. deep x 36 in. tall (61 x 61 x 82 cm).

5-2.2 Protective footwear shall be tested after preconditioning in accordance with 5-1.1 of this chapter.

5-2.3 Protective footwear shall be filled with bone-dry vermiculite to not less than 1.0 in. (2.5 cm) of the lowest point of the throat. Any closures shall be fastened.

5-2.4 The test oven shall be calibrated using a black ball thermocouple conforming to Figure 5-2.4. This black ball thermocouple shall be stabilized for at least three minutes at 20°-28°C (68°-82°F) and the relative humidity at 30 to 70 percent. The test oven shall be preheated and stabilized for a minimum of three minutes immediately before calibration. The black ball thermocouple shall then be suspended in the center of the test oven. The test oven door shall not remain open for more than 15 seconds and the air circulation in the test oven shall be shut off while the door is open and turned on when the door is closed. The oven shall be preheated and stabilized at a temperature not less than 260°C (500°F), but sufficient to cause the temperature recorded by the thermocouple to rise to 93°C ±7°C (200°F ±20°F) after 1 minute 30 seconds, to 160°C ±3°C (320°F ±10°F) after 3 minutes, and to 215°C ±3°C (420°F ±10°F) after 5 minutes, +15/-0 seconds.

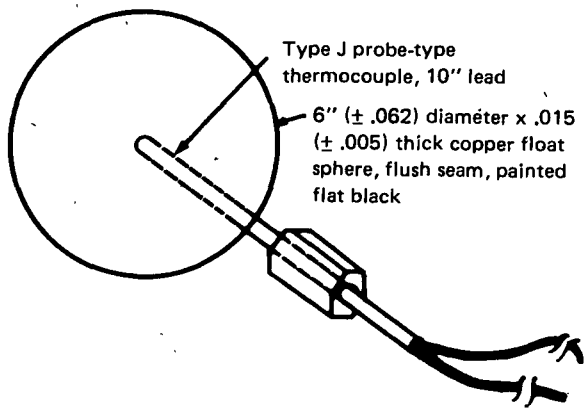


Figure 5-2.4 Black Ball Thermocouple

5-2.5 The protective footwear shall be placed in the calibrated circulating-air oven for 5 minutes +15/-0 seconds. Footwear exposure time shall begin when the oven door is shut.

5-2.6 Protective footwear shall be examined on outside and inside for melting, and all accessories shall be evaluated for function to determine pass/fail.

5-3 Upper Cut Resistance Test.

5-3.1 Apparatus shall consist of an L-shaped metal frame and a pivoted arm that lowers a sharp-edged blade onto a specimen, as shown in Figure 5-3.1(a). A locking mechanism shall be mounted on the L-frame upright to engage the pivoted arm and secure it in a neutral position above the material specimen. The locking mechanism shall be used when the blade is being replaced or when the

specimen is being moved into or out of the testing position. The blade shall be mounted in a blade holder at the outer end of the pivoted arm, as shown in Figure 5-3.1(b). The blade shall be mounted so its sharp edge is tangential to the material specimen. The pivoted arm, blade holder, and blade shall be weighted together to a total of 16.0 lb (7.6 kg). The sharp-edged blade shall be made of hardened tool steel with an edge having a 60 degree included angle and a 0.001-in. (0.025-mm) radius as shown in Figure 5-3.1(c). The specimen support assembly shall consist of a 2.0 x 2.0 x 4.0-in. (5.1 x 5.1 x 10.2-cm) soft wood block and a 0.75-in. (1.9-cm) diameter, half-rounded, soft-wood rod mounted to the block as shown in Figure 5-3.1(d). A 0.05-in. (0.13-cm) thick soft leather strip shall be draped over the rod and block as shown in Figure 5-3.1(d).

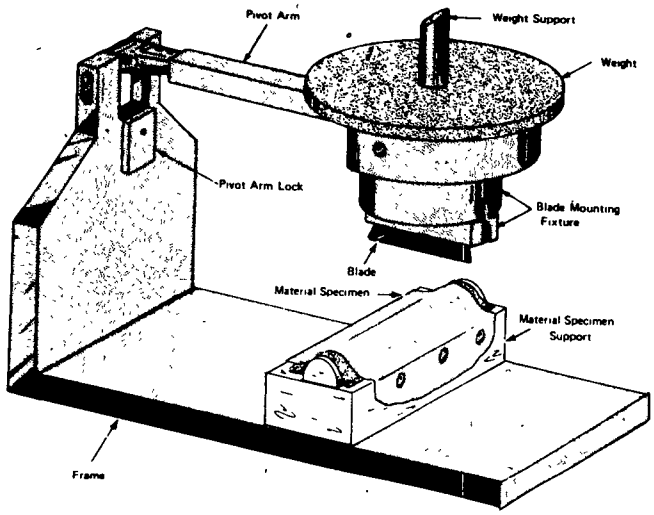


Figure 5-3.1(a) Static Cut Test Apparatus.

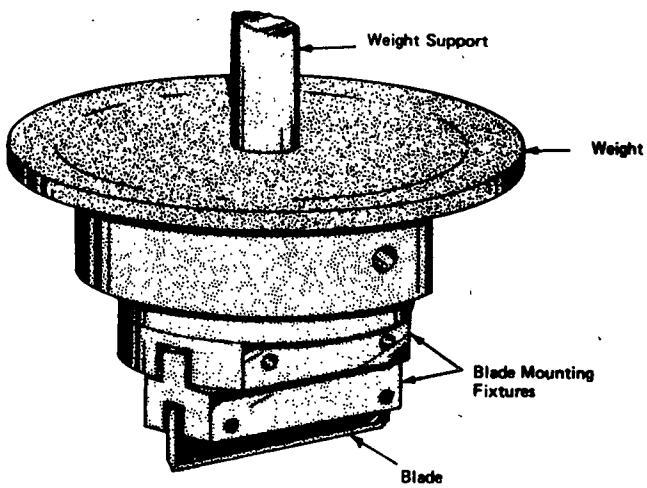


Figure 5-3.1(b) Test Blade Holder.

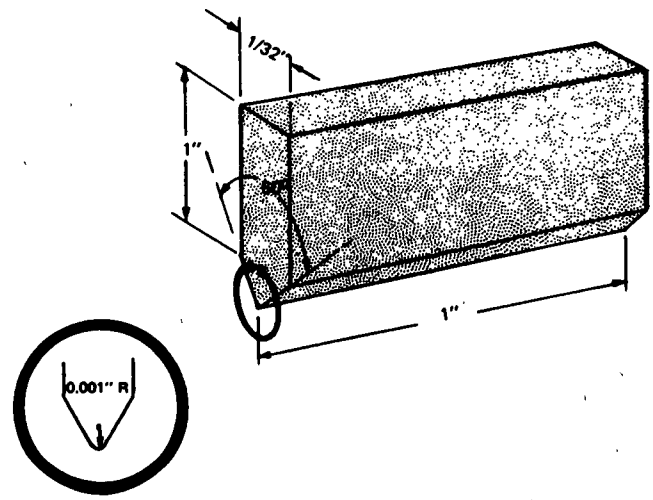
5-3.1.1* The sharpness, or geometry, of the blade edge shall be closely monitored and controlled to prevent changes in cutting characteristics to ensure a consistent baseline for interpreting the cut data. A test blade shall be either replaced or resharpened when the sharpness, or geometry, of the blade edge changes.

5-3.2 Protective footwear shall be tested after preconditioning in accordance with 5-1.1 of this Chapter.

5-3.3 Specimens shall be taken from the vamp; quarter; gusset, if present; and shaft. If different types of thicknesses of materials are utilized for other areas of the upper, these areas shall also be tested.

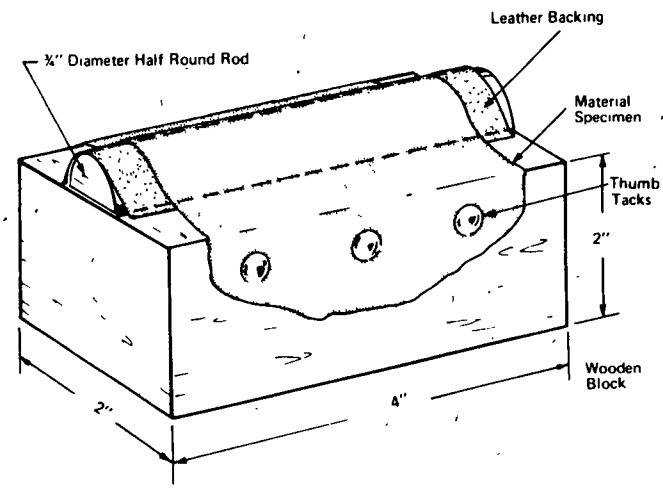
Specimens shall be 2.0 x 4.5 in. (5.1 x 11.4 cm).

5-3.4 The specimen shall be oriented so that the normal outer surface is the first to be contacted by the edge of the blade. The material specimen shall be draped over the leather strip covering the rod and block and tacked tightly in place, but not stretched, as shown in Figure 5-3.1(d). The support assembly shall be positioned on the base of the L-frame, as shown in Figure 5-3.1(a). The blade shall be inserted in the holder and the pivoted arm lowered to bring the blade edge into contact with the specimen surface.



Test Blade.

Figure 5-3.1(c)



Material Specimen Support.

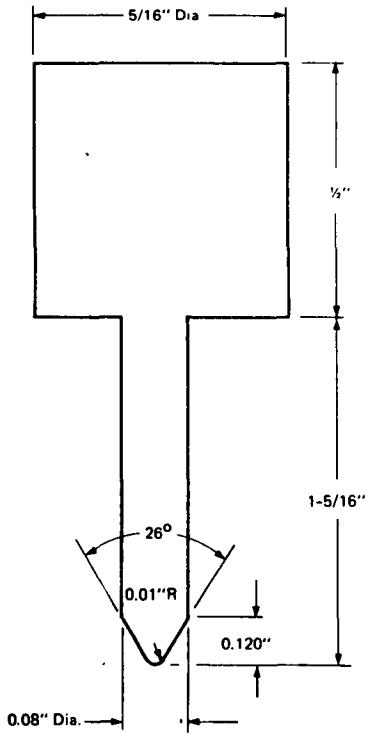
Figure 5-3.1(d)

The specimen-edge contact shall be made 0.125 in. (0.3 cm) from the leading end of the blade. The specimen support assembly shall be drawn smoothly under the weighted blade at 20.0 in./minute (50 cm/min) parallel to the blade edge. The support assembly shall be stopped when the specimen edge contact reaches 0.125 in. (0.3 cm) from the trailing end of the blade. The pivoted arm shall be lifted to remove the blade edge from the specimen and the locking mechanism engaged to secure the pivoted arm.

5-3.5 The specimen shall be inspected as to whether the lining was cut through to determine pass/fail.

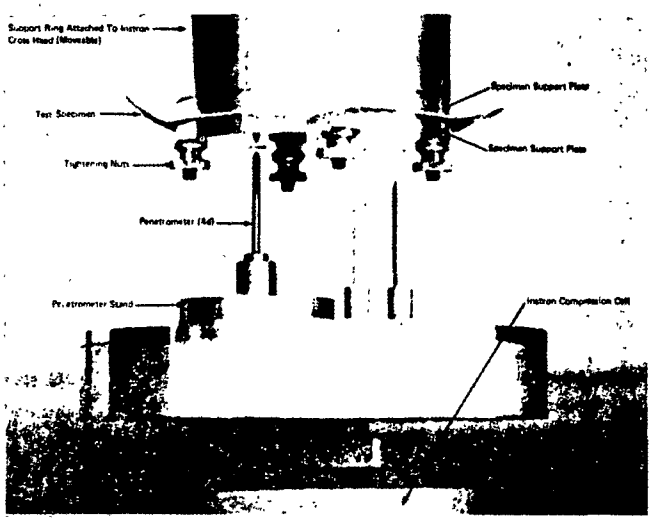
5-4 Upper Penetration Resistance Test.

5-4.1 The apparatus shall consist of a tensile testing machine, such as an Instron or equivalent, that challenges a specimen with a pointed penetrometer. Force shall be detected by a compression cell and shall be indicated by a recorder able to indicate the load at puncture specimen to ±1 percent. A penetrometer having the size and dimensions shown in Figure 5-4.1(a) shall be mounted on the test apparatus and attached to the compression cell of the machine as shown in Figure 5-4.1(b). The specimen support assembly shall consist of two flat metal plates that clamp together so the specimen is held tightly between, as shown in Figure 5-4.1(c). Each plate shall have three 0.25 in. (0.6 cm) diameter holes as shown in Figure 5-4.1(d). The specimen support plates shall be connected to a metal support ring that mounts on the movable arm of the test apparatus, as shown in Figure 5-4.1(b).



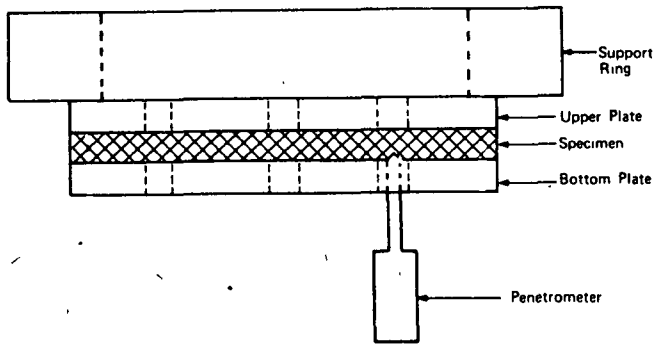
Cross Section of 4d Penetrometer.

Figure 5-4.1(a)



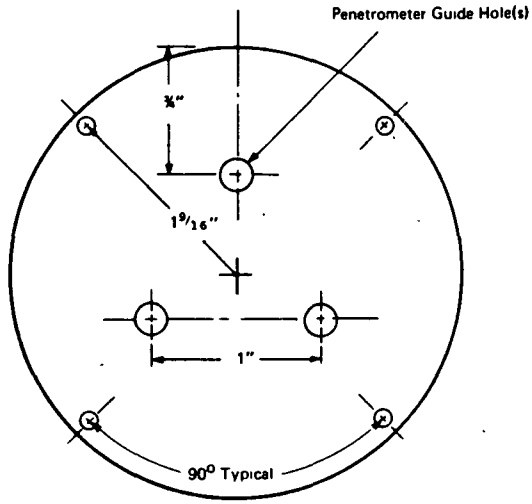
Static Puncture Test Apparatus.

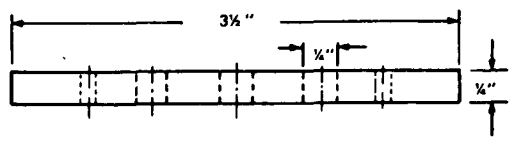
Figure 5-4.1(b)



Side View of Specimen Support Assembly.

Figure 5-4.1(c)





Support Plate (Two Required).

Figure 5-4.1(d)

5-4.2 Protective footwear shall be tested after preconditioning in accordance with 5-1.1 of this chapter.

5-4.3 Specimens shall be taken from the vamp; quarter; gusset, if present; and shaft. If different types or thicknesses of materials are utilized for other areas of the upper, these areas shall also be tested. Specimens shall be at least 3.5 in. (8.7 cm) in diameter.

5-4.4 Specimens shall be mounted in the support assembly shown in Figure 5-4.1(c). The specimen shall be oriented so that the normal outer surface is the first to be contacted by the penetrometer. The support assembly shall be attached to the movable arm of the test apparatus. The penetrometer shall be positioned on the compression cell of the test apparatus as shown in Figure 5-4.1(b). The apparatus shall be operated with a uniform velocity of 20.0 in./minute (50.0 cm/min) until the penetrometer has been driven through the specimen. The penetrometer shall be repositioned under each of the other guide holes and the test repeated until three punctures have been made.

5-4.5 The average penetration force for each specimen shall be calculated to determine pass/fail.

5-5 Conductive Heat Resistance Test.

5-5.1 The apparatus shall consist of a thermocouple connected to a meter and a 1 x 6 x 18 in. (2.5 x 15 x 45 cm) iron plate.

5-5.2 Testing shall be done after preconditioning in accordance with 5-1.1 of this chapter and after preconditioning in accordance with 5-1.2 of this chapter.

5-5.3 The thermocouple shall be affixed to the insole surface next to the foot, directly above the ball of the foot. The plate shall be heated to a uniform temperature of 932°F (500°C). The sample shall be placed on the plate in the upright position for 30.0 seconds.

5-5.4 The thermocouple temperature shall be recorded at 30.0 seconds of exposure to determine pass/fail.

5-6 Radiant Heat Resistance Test.

5-6.1 The apparatus shall consist of a radiometer with a special response flat within ±3.0 percent of not less than 1.10 to 10.0 microns with an accuracy of ±5.0 percent; a radiant panel with an effective radiating surface of not less than 6.0 x 6.0 in. (15 x 15 cm) and an emittance approximating that of a black body of 1000°K ±200°K; a thermocouple with meter; and a test chamber that prevents interference from air movement.

5-6.2 Testing shall be done after preconditioning in accordance with 5-1.1 of this chapter and after preconditioning in accordance with 5-1.2 of this chapter.

5-6.3 Tests shall be done on the toe; vamp; quarter; gusset, if present; and shaft. If different types or thicknesses of materials are utilized for other areas of the upper, these areas shall also be tested.

5-6.4 The radiant panel shall be placed in front of the radiometer, parallel to the plane tangent to the radiometer. The radiant panel shall be adjusted to obtain a stable, uniform irradiance of 1.0 ±.01 watt/cm^2 over at least a 3.0 in. (7.5 cm) diameter circle located on the above plane and centered at the center of test area. Calibration shall be achieved when the irradiance changes by less than 10 percent during a 3.0 minute period.

5-6.5 The thermocouple shall be affixed to the inside surface of the lining next to the foot, in the center of the test area. The radiometer shall be replaced with the protective footwear with the test area oriented parallel to the plane tangent to the heat source, at the same distance. The area shall be exposed for 1.0 minute.

5-6.6 The thermocouple temperature shall be recorded at 1.0 minute of exposure to determine pass/fail.

5-7 Ladder Shank Bend Resistance Test.

5-7.1 The apparatus shall consist of a tensile testing machine, such as an Instron or equivalent, that challenges a specimen with a simulated ladder rung. A 1.25 in. diameter x 2.0 in. long (3.25 x 5 cm) noncompressible probe shall be mounted on the movable arm. The specimen support assembly shall consist of two 2.0 x 1.0 x 1.0 (5 x 2.5 x 2.5 cm) noncompressible blocks placed 2.0 in. (5 cm) apart as shown in Figure 5-7.1.

(SEE Figure 5-7.1 TOP, RIGHT)

5-7.2 The ladder shank shall be preconditioned for 1 hour +5/-0 minutes at 70°F ±5° (21°C ± 2°C).

5-7.3 The ladder shank shall be placed on mounting blocks as it would be oriented toward the ladder when affixed into the protective footwear and subjected to force on its center with the test probe operated at 2.0 in./minute (5 cm/min).

5-7.4 Deflection at 400.0 lbs (182.0 kg) shall be recorded to determine pass/fail.

5-8 Corrosion Resistance Test.

5-8.1 Specimens shall be tested in accordance with ASTM B 117, *Standard Method of Salt Spray (Fog) Testing.* Salt spray shall be 5 percent saline solution and test exposure shall be for 20 hr.

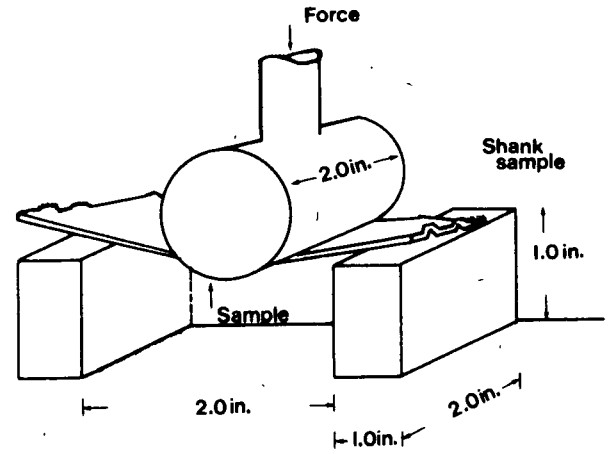


Figure 5-7.1 Ladder Shank Bend Test Set-up.

5-8.2 Immediately following the test exposure and prior to examination, specimens shall be rinsed under warm, running tap water and dried with compressed air.

5-8.3 Specimens shall then be examined visually with the unaided eye to determine pass/fail.

5-9 Puncture Resistance Test.

5-9.1 Protective footwear sole area and heel area shall be tested to not less than 272.0 lbs (123.4 kg) in accordance with Section 5.3 of CSA Z195, *Standard for Protective Footwear, Occupational Health and Safety.*

5-10 Electrical Resistance Test.

5-10.1 Protective footwear shall be tested to 14,000 volts (RMS) in accordance with Section 5.1.1 of ASTM F 1116, *Standard Test Method for Determining Dielectric Strength of Overshoe Footwear.*

5-10.2 Appropriate milliampere readings shall be taken to determine pass/fail.

5-11 Flame Resistance Test.

5-11.1 Protective footwear sole with heel and upper shall be tested in accordance with Method 5903.1, Flame Resistance of Cloth; Vertical, of Federal Test Method Standard 191A, Textile Test Methods, with the modification that the protective footwear shall be suspended such that burner flame impinges on the surface to be tested at a 90 degree angle to the flame.

5-11.2 The test shall be done on the sole with heel under the ball of the foot and on the upper at the toe; vamp; quarter; gusset, if present; and shaft. If different types of thicknesses of materials are utilized for other areas of the footwear, these areas shall also be tested.

5-11.3 Test specimens shall be observed to determine pass/fail.

5-12 Flex Test.

5-12.1 Protective footwear shall be tested in accordance with Footwear Industries of America Standard 1209, *Whole Shoe Flex.*

5-12.2 The test shall consist of 100,000 flexes.

5-12.3 After flexing, protective footwear shall be blotted dry on the exterior and filled with tap water to not less than 1.0 in. (2.5 cm) from the lowest point of the throat.

5-12.4 After 2.0 hours, protective footwear shall be examined for water seepage to determine pass/fail.

Chapter 6 Referenced Publications

6-1 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 shall be the current edition as of the date of the NFPA issuance of this document.

6-1.1* ANSI Publications.

ANSI Z41, *Standard for Safety-Toe Footwear*, 1983

6-1.2* ASTM Publications.

ASTM B 117, *Standard Method of Salt Spray (Fog) Testing*, 1985
ASTM D 4966, *Standard Test Method for Abrasion Resistance of Textile Fabrics*, 1989.
ASTM F 1116-88, *Standard Test Method for Determining Dielectric Strength of Overshoe Footwear*, 1988.

6-1.3* GSA Publications.

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

6-1.4* FIA Publications.

Footwear Industries of America, *Shoe Size Conversion, Research Results and Recommendations.*

Footwear Industries of America, Standard 1209, *Whole Shoe Flex*

Footwear Industries of America Standard 301, *NBS Abrasion.*

6-1.5* CSA Publications.

Canadian Standards Association, Standard Z195-M, Protective Footwear Occupational Health and Safety, 1984 Edition.

Appendix A

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

A-1-2.3 Users are cautioned that if unusual conditions prevail, such as higher or lower extremes of temperature than described herein, or if there are signs of abuse or mutilation of the footwear or any component thereof, or modifications or replacements made without permission of the manufacturer, the margin of protection may be reduced.

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, procedure 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" agencies 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 Listed. The means for 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-2-2.1 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-2-2.5 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-2-6.1 For information relative to the prevention and transmission of communicable diseases and carcinogens from contaminated protective footwear consult Centers for Disease Control, local board of public health, or the American Medical Association.

A-2-6.2 Footwear materials resistance to deterioration by chemicals should be assessed by the following methods. As a minimum, chemical resistance information should be provided for the liquid chemicals listed in ASTM F 1001, *Standard Guide for Test Materials to Evaluate Protective Clothing Materials.* Chemical resistance information should be provided for additional materials.

Boot Upper Material chemical resistance should be determined by using one or both of the following test procedures:

(a) Permeation Resistance. The boot upper material should be tested in accordance with ASTM F 739, *Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids Gases*, using the following modifications:

(i) The minimum detectable permeation rate for the permeation test apparatus should be measured for each chemical tested. The minimum detectable permeation rate should be less than or equal to 0.14 mg/cm^2/min for all permeation resistance tests. When using closed loop systems, the testing should assume one hour accumulated permeation.

(ii) All tests should be conducted at 77°F ±5°F (25°C ±3°C).

(iii) The following information and results should be reported:

Material Type
Chemical Name
Permeation breakthrough time calculated at a system detectable rate of 0.14 mg/cm^2/min
Maximum permeation rate mg/cm^2/min
Minimum detectable permeation rate for test system (mg/cm^2/min)
Detection Method
Date of Testing
Laboratory

(iv) The manufacturer should report all three measured breakthrough times.

(v) The manufacturer should report all three observed permeation rates in the technical data package.

(b) Penetration Resistance. The boot upper material should be tested in accordance with ASTM F 903, *Test Method for Resistance to Penetration by Liquids, Procedure C.* The manufacturer should report the pass/fail result for each of the three test specimens tested. All tests should be conducted at 77°F ±5°F (25°C ±3°C).

Boot sole, shank, and heel materials shall be testing in accordance with ASTM D 471, Standard Test Method for Rubber Property — Effect of Liquids, using the procedures contained in Section 9, Procedure for Change in Mass.

A-4-1.3 Steel test pins may be obtained from the Label Sales Department of the Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Canada M9W 1R3.

A-4-1.4 WARNING Fire department personnel should be advised that the electrical hazard resistant protective properties in new unworn structural fire fighters boots as required by this standard will diminish or be eliminated as the boot, soles/heels wear or if they are punctured or cut.

A-5-3.1.1 A practical easy-to-use technique for achieving this control utilizes a reference material with known cut resistance. For example, the following vinyl tapes manufactured by the 3M Company, or their equivalents, should be used:

Tape Identification	Minimum Weight for Cut
No. 470 White Vinyl	Tape 10 lb (4.5 kg)
No. 472 Black Vinyl	Tape 12 lb (5.4 kg)

A-6-1.1 ANSI publications can be obtained from the American National Standards Institute, 1450 Broadway, New York, NY 10018.
A-6-1.2 ASTM publications can be obtained from American Society for Testing Materials, 1916 Race Street, Philadelphia, PA 19103.

A-6-1.3 Military Specifications and Federal Standards may be obtained from the Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

A-6-1.4 FIA publications can be obtained from the Footwear Industries of America, 1420 K Street, N.W., Suite 600, Washington, DC 20005.

A-6-1.5 C.S.A publications can be obtained from the Canadian Standards Association, 178 Rexdale Boulevard, Toronto, Canada M9W 1R3.

Appendix B Referenced Publications

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

B-1 ASTM publications can be obtained from American Society for Testing Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM F 739, *Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids and Gases*, 1985

ASTM F 903, *Test Method for Resistance of Protective Clothing Materials to Penetration Liquids*

ASTM F 1001, *Guide for Test Chemicals To Evaluate Protective Clothing Materials*, 1989

PART III

(Log # 1)

1976-1 - (Entire Document): Reject
SUBMITTER: Frank D. Harrisson, Philadelphia, PA
RECOMMENDATION: Add new text as follows:
3.1 Fire fighters and emergency response people working on or adjacent to maritime waters that obtain temperatures of 60°F or below shall be properly attired with a combination coverall that provides maximum radiant heat and flame protection, built-in flotation FR foam that does not break down under heat PFD, and provides maximized hypothermia protection in cold water environments.

3.2 In particularly rough waters or climate conditions, in conjunction with the Type V coverall/suit, an inflatable vest with CO_2 cartridge that would enhance floatability in the water to a Type II or Type I configuration. This ensemble would maximize sea action protection and visibility for the rescue party.

3.3 The marine fire fighting coverall and vest shall be trimmed out with reflective tape sewn on the international orange exterior nomex fabric.

3.4 Fire fighters shall carry ready available in the breast pocket or arm pocket of the ensemble, a whistle with lanyard and either two cold flares or a strobe signal light.

3.5 The fire fighter when working on deck of a fire marine unit or on board ship shall wear insullated leather high top work boots for ease of maneuvering and safety on board ship.
SUBSTANTIATION: 4.1 We all know it's no joke to face a fire without the proper turn-out gear, it is equally no joke to fall or get blown into cold water where you have only maybe 10 or 20 minutes to live depending on the temperature of the PFD with standard turn-out gear just does not work and wearing fire boots on ships ladders and companionways is a sure hazard for slips and falls.

4.2 The U.S. Coast Guard and the U.S. Public Health Service had performed a major study and had documented a comprehensive report addressing hypothermia and survival in cold water environs and made recommendations toward the use of protective gear.

4.3 As an active firefighter for the past 40 years, the last 18 years as a marine firefighter, 15 years of which were as chief fire marshal for the Lavino Shipping Company. I strongly recommend the use of the aforementioned protective gear such as the Mustang MAC 10 Aviation Coverall with the in flatable vest in waters lower than 60°F.

4.4 Please refer to NFPA 1987 Annual Meeting TCD, entry 1500-1, Log 967, page 62 (Cincinnati, Ohio 18/12 May 87).

NOTE: "Supporting material is available for review at NFPA Headquarters".

COMMITTEE ACTION: Reject.
COMMITTEE STATEMENT: This document is a minimum standard. Nothing in the document prohibits the user from specifying additional requirements such as those recommended by the submitter.

1976-2 - (Entire Document): Accept
SUBMITTER: Technical Committee on Fire Service Protective Clothing and Equipment
RECOMMENDATION: Adopt the new document NFPA 1976, Standard on Protective Clothing for Proximity Fire Fighting, 1992 Edition.
SUBSTANTIATION: This new document provides design, performance criteria, and test methods for protective coats and protective trousers utilized in fires involving high levels of radiant heat including, but not limited to, aircraft fires, bulk flammable liquid fires, and bulk flammable gas fires.
This document follows the performance criteria for NFPA 1971 and incorporates additional performance criteria for radiant heat. THe principle reflective requirements can be found in 3-1.3, 4-3.1, 4-3.5, 4-3.6, 4-3.7, 4-3.8, Section 5-3, Section 5-7, Section 5-8, Section 5-13, and Section 5-14.
The performance criteria included in this document meets or exceeds the FAA advisory bulletin on protective clothing for aircraft rescue and fire fighting.
The document includes requirements for third party certification including labeling, listing, and manufacturers quality assurance in Chapter 2.
COMMITTEE ACTION: Accept.

NFPA 1976

Standard on Protective Clothing for Proximity Fire Fighting

1992 Edition

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

Information on referenced publications can be found in Chapter 6.

Chapter 1 ADMINISTRATION

1-1 Scope.

1-1.1* This standard specifies minimum design and performance criteria and test methods for protective clothing designed to provide limb/torso protection for fire fighters against adverse environmental effects encountered during proximity fire fighting operations.

1-1.2 This standard specifies criteria for protection from convective and conductive heat that is equivalent to such requirements in NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*, and, in addition, specifies criteria for protection from high levels of radiant heat for limited exposures.

1-1.3* Proximity protective garments meeting the requirements of this standard are intended to provide equivalent levels of protection to those specified in NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting* with the exception of trim requirements. Criteria for the use of proximity protective clothing in structural fire fighting applications are specified in NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.*

1-1.4* This standard does not address specialized protective clothing for fire entry, hazardous materials emergencies, or wildland fire fighting, and does not provide criteria for protection from chemical, biological, or radiological agents.

1-1.5* This standard is not intended to be utilized as a detailed manufacturing or purchase specification, but shall be permitted to be referenced in purchase specifications as minimum requirements.

1-2 Purpose.

1-2.1* The purpose of this standard is to provide minimum performance requirements for proximity protective clothing worn by fire fighters primarily responsible for aircraft fire fighting, bulk flammable liquids fire fighting, flammable gas fire fighting, and similar situations releasing high levels of radiant heat.

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

1-2.3 Nothing herein is intended to restrict any jurisdiction or manufacturer from exceeding these minimum requirements.

1-3 Definitions.

Aircraft Rescue and Fire Fighting. The fire fighting actions taken to rescue persons, and to control or extinguish fire involving or adjacent to aircraft on the ground. Such rescue and fire fighting actions are performed both inside and outside of aircraft.

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

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

Cargo Pockets. Pockets located on the proximity protective garment exterior.

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 compliance 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.

Collar Lining. That part of collar fabric composite that is next to the skin when the collar is closed in the raised position.

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

Composite. The layer or layers that provide the protection required of the outer shell, moisture barrier and thermal barrier.

Drip. To run or fall in drops or blobs.

Entry Clothing. Protective clothing that is designed to provide protection from conductive, convective, and radiant heat and permit entry into flames.

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 products listed that are being produced by the manufacturer to the requirements of this standard.

Garment Label. A label affixed to the proximity protective clothing by the manufacturer containing general information, warnings, care, maintenance, or similar data. This garment label is not a certification organization label or identifying mark.

Hardware. Non-fabric components of proximity protective clothing including those made of metal or plastic material.

Hazardous Materials Emergencies. Incidents involving the release or potential release of hazardous chemicals into the environment that can cause loss of life, personnel injury, or damage to property and the environment.

Interface Area. An area of the body not protected by a proximity protective garment, helmet, gloves, footwear, or SCBA facepiece; the area where the proximity protective garments and the helmet, gloves, footwear, or SCBA facepiece meet, i.e. the proximity protective coat/helmet/SCBA facepiece area, the proximity protective coat/glove area, and the proximity protective trouser/footwear area.

Interface Component. Item(s) designed to provide limited protection to interface areas.

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.

Major A Seams. See Seams.

Major B Seams. See Seams.

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

Minor Seams. See Seams.

Moisture Barrier*. That portion of the composite designed to prevent the transfer of liquid water from the environment to the thermal barrier.

Outer Shell. That outside facing portion of the composite with the exception of trim, hardware and reinforcing material.

Protective Wristlet. The interface component that provides limited protection to the proximity protective coat/glove interface area.

Proximity Fire Fighting. The activities of rescue, fire suppression, and property conservation at situations involving high levels of radiant heat including, but not limited to, aircraft fires, bulk flammable liquid fires, and bulk flammable gas fires.

Proximity Head Protection. A radiant reflective protective item which includes, or is used in conjunction with, head impact protection and is designed to provide protection to the head, face, and neck areas against radiant, convective, and conductive heat.

Proximity Protective Clothing. Radiant reflective protective garments configured as a coat and trousers, or as a coverall, and interface components that are designed to provide protection for the fire fighter's body from conductive, convective, and radiant heat.

Proximity Protective Coat. Proximity protective garment designed and configured to provide protection to upper torso and arms, excluding the hands and head.

Proximity Protective Coverall. Proximity protective garment designed and configured to provide protection to the torso, arms, and legs, excluding the head, hands, and feet.

Proximity Protective Garment. Proximity protective coat, proximity protective trouser, or proximity protective coverall.

Proximity Protective Trouser. Proximity protective garment designed to provide protection for the lower torso and legs, excluding the feet.

Seams.
Major A Seams. Those outer shell seam assemblies where rupture could reduce the protection of the garment by exposing the moisture barrier, thermal barrier, the wearer's station/work uniform, other clothing, or skin.
Major B Seams. Those moisture barrier or thermal barrier seam assemblies were rupture could reduce the protection of the garment by exposing the next layer of the garment, the wearer's station/work uniform, other clothing, or skin.
Minor Seams. Those remaining seam assemblies that are not classified as Major A or Major B seams.

Shall. Indicates a mandatory requirement.

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

Structural Fire Fighting. The activities of rescue, fire suppression, and property conservation in buildings, enclosed structures, vehicles, vessels, or like properties that are involved in a fire or emergency situation.

Thermal Barrier. That portion of the composite designed to provide thermal protection.

Trim. Retroreflective and fluorescent material permanently attached to the outer shell for visibility enhancement. Retroreflective materials enhance night time visibility and florescent materials improve day time visibility.

Winter Liner. An optional component layer designed to provide added insulation against cold.

Chapter 2 Certification

2-1 General.

2-1.1 Proximity protective garments that are labeled as being

compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 All certification shall be performed by an approved certification organization.

2-1.3 Compliant proximity protective garments shall be labeled and listed. Such proximity protective garments shall also have a garment label that meets the requirements specified in Section 2-5 of this Chapter.

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 on 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 that meets the requirements of Section 2-4 of this Chapter.

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 continual 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 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified as being compliant with the standard are compliant.

2-3.2 Inspection for determining compliance with the design requirements specified in Chapter 3 of this standard shall be performed on a completed garment.

2-3.3 Testing for determining material and component compliance with the requirements specified in Chapter 4 of this standard shall be performed on samples representative of materials and components used in the actual construction of the proximity protective clothing. The certification organization shall be permitted to also use sample material cut from a representative proximity protective clothing.

-4 Manufacturer's Quality Assurance.

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 product conformance to this standard.

2-4.2 The characteristics to be inspected, or tested, or both, shall be classified according to the potential effect of such defects and grouped into the following classes:

(a) Major A —— a defect that will reduce protection and is not readily detectable by the user;

(b) Major B —— a defect, other than Major A, that is likely to result in reduced protection, and is detectable by the user; and

(c) Minor —— a defect that is not likely to materially reduce the usability of the device for its intended purpose .

2-4.2.1 The acceptable quality level shall be as defined by Military Standard MIL-STD 105D, *Sampling Procedures and Tables for Inspection by Attributes*, Inspection Level II.

2-4.2.2 The acceptable quality level for all garment defects shall be as follows: (a) Major A —— 1.0, (b) Major B —— 2.5, and (c) Minor —— 4.0.

2-4.3 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe inspection and test of materials, work in process, and completed articles. In addition, criteria for acceptance and rejection of product shall be included in the instructions.

2-4.4 The manufacturer shall maintain records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, and the quantities accepted or rejected.

2-4.5 The manufacturer shall take action to correct discrepant conditions which have resulted, or could result, in products which do not conform to the requirements of this Standard. The nature of the discrepancy and the corrective action taken shall be documented.

2-4.6 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.

2-4.7 Subcontracted or purchased supplies shall be subjected to inspection after receipt, as necessary, to assure conformance of the end item to the requirements of this standard. When manufacturers rely upon the supplier to provide data to demonstrate material conformance to this standard, or when the supplier is individually certified, that data shall become a part of the manufacturer's inspection records. The use of a supplier's test data or certification shall not relieve the manufacturer of their responsibility to furnish an end item which complies with all the requirements of this standard.

2-4.8 When the manufacturer conducts quality assurance testing, the 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.

2-4.8.1 The manufacturer, at their option, shall be permitted to utilize an outside test facility to conduct the quality assurance tests. When this option is selected, the outside test facility shall meet the requirements of 2-4.8 of this Section:

2-4.8.2 The test facility shall provide a written report to the manufacturer that describes the tests performed and the results. This report shall become a part of the manufacturer's inspection records.

2-4.9 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in-process, and finished goods.

2-4.10 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.

2-5 Garment Labeling.

2-5.1* The outer shell and each separable layer of each proximity protective garment shall have a garment label permanently and conspicuously attached to each layer upon which at least the following warning and information are printed in at least 1/16 inch (1.5 mm) high letters. At least one garment label shall be conspicuously located inside the garment in all possible configurations of garment utilization.

"THIS PROXIMITY PROTECTIVE GARMENT MEETS THE REQUIREMENTS OF NFPA 1976, *STANDARD ON PROTECTIVE CLOTHING FOR PROXIMITY FIRE FIGHTING*, 1992 EDITION.

WARNING

FOR PROXIMITY FIRE FIGHTING OPERATIONS, BOTH PROXIMITY PROTECTIVE COAT AND PROXIMITY PROTECTIVE TROUSERS MUST BE WORN FOR LIMB/TORSO PROTECTION. OUTER SHELL, MOISTURE BARRIER, AND THERMAL BARRIER MEETING ALL REQUIREMENTS OF NFPA 1976 MUST BE UTILIZED AND ALL GARMENT CLOSURES MUST BE FASTENED WHEN IN USE. DO NOT USE PROXIMITY PROTECTIVE COAT AND PROXIMITY PROTECTIVE TROUSERS ALONE FOR PROXIMITY FIRE FIGHTING OPERATIONS; OTHER PROTECTIVE EQUIPMENT—HEAD PROTECTION, SCBA, GLOVES, FOOTWEAR, PASS——IS REQUIRED FOR PROTECTION. DO NOT KEEP THIS GARMENT IN DIRECT CONTACT WITH FLAMES. THIS GARMENT ALONE MAY NOT PROVIDE PROTECTION FOR FIRE ENTRY APPLICATIONS OR FOR PROTECTION FROM CHEMICAL, BIOLOGICAL, OR RADIOLOGICAL AGENTS. KEEP THIS GARMENT CLEAN AS SOILING WILL REDUCE PROTECTIVE QUALITIES.

——DO NOT USE CHLORINE BLEACH——

CHLORINE BLEACH WILL SIGNIFICANTLY COMPROMISE THE PROTECTION AFFORDED BY THE TEXTILE MATERIALS UTILIZED IN THE CONSTRUCTION OF THIS GARMENT. USERS MUST CLEAN, MAINTAIN, AND ALTER ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. DO NOT STORE IN DIRECT SUNLIGHT. NO PROTECTIVE CLOTHING CAN PROVIDE COMPLETE PROTECTION FROM ALL CONDITIONS. USE EXTREME CARE FOR ALL EMERGENCY OPERATIONS. FAILURE TO COMPLY WITH THESE WARNINGS MAY RESULT IN SERIOUS INJURY OR DEATH".
Manufacturer's name
Manufacturer's address
Country of manufacture
Manufacturer's garment identification number
Date of manufacture

Size
Cleaning and drying instructions
Garment material(s)

"DO NOT REMOVE THIS LABEL"

2-5.2 All portions of the required label shall be printed at least in English.

2-5.3 All labels shall be clearly legible to the eye both before and after being subjected to the procedure specified in Section 5-1 of this standard. Labels not meeting specimen size requirements for the procedure listed above shall be sewn to a support fabric of required size.

2-6* User Information.

2-6.1 Proximity protective clothing manufacturers shall provide the following instructions and information with each garment:

(a) Cleaning instructions,
(b) Maintenance criteria,
(c) Methods of repair,
(d) Warranty information,
(e) Retirement considerations.

2-6.2* Proximity protective clothing manufacturers shall furnish training materials that address, but are not limited to:

(a) Safety considerations,
(b) Storage conditions,
(c) Decontamination procedure.

Chapter 3 Design Requirements

3-1* Proximity Protective Garment Requirements.

3-1.1* A sample garment shall have at least the applicable design requirements specified in this chapter when inspected as specified in Chapter 2 of this standard.

3-1.2* Proximity protective garments shall consist of a composite of an outer shell, moisture barrier, and thermal barrier. This composite shall be permitted to be configured as a single layer or multiple layers.

3-1.3* Proximity protective garments shall NOT have non-radiant reflective material, including but not limited to trim, lettering, patches, name or number stencils, emblems, paint, or other marking mediums affixed to the outer shell reflective surfaces. In addition, proximity protective garments shall NOT have non-radiant reflective leather or other reinforcements affixed to the outer shell reflective surfaces other than when used as reinforcement of the sleeve and trouser leg cuffs only. Such reinforcements shall not exceed more than 1 in. (25 mm) over the reflective outer surface from the end of the cuff.

3-1.4* Proximity protective garments shall have a means of securing the moisture barrier and thermal barrier to the outer shell.

3-1.5 Proximity protective garments, including the front closure, shall be constructed in a manner that provides secure and complete moisture and thermal protection. If non-positive fasteners such as snaps or hook and pile tapes are utilized in the garment closure, a positive locking fastener, such as hooks and dees or a zipper shall be utilized.

3-1.6 Snaps shall meet the requirements of MS 27980E, Fastener, Snap.

3-1.7* Fastener tape shall meet the requirements of MIL-F-21840G, Fastener Tapes, Hook and Pile, Synthetic, excluding Class 2.

3-1.8 Zippers shall meet minimum requirements of FED-V-F-106F, Fastener, Slide, Interlocking. The minimum crosswise breaking strength of the zipper shall be size M of FED-V-F-106F.

3-1.9 Hooks and dees shall be non-ferrous and shall conform to the design of Figure 3-1.9.

(SEE Figure 3-1.9 Next page)

3-1.10* Moisture barriers and thermal barriers shall extend to within 3 in. (76.2 mm) of the outer shell at the cuffs and hems of proximity protective garments. At the neck, the coat moisture barrier and thermal barrier shall extend to neckline seam. At the waist, the trouser moisture barrier and thermal barrier shall extend, as a minimum, to the waistline.

3-1.11* Cargo pockets where provided shall have a means of drainage of water, and shall have flaps with a means of fastening them in the closed position.

3-2 Additional Requirements for Proximity Protective Coats.

3-2.1* Proximity protective coats shall provide protection as specified to the upper torso, neck, arms, and wrists, excluding the hands and head.

3-2.2 Proximity protective coat hardware shall not penetrate through the outer shell, moisture barrier, and thermal barrier to contact the wearer's body when the coat is worn with closures fastened, unless the hardware is completely covered by external closure flaps.

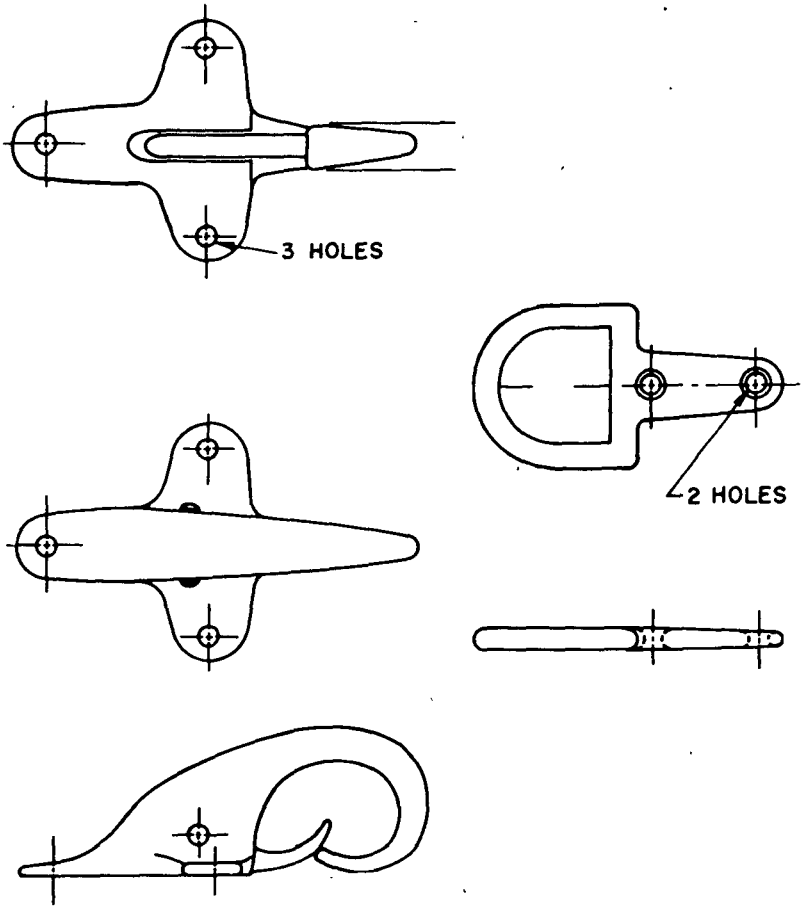
3-2.3* Each proximity protective coat sleeve shall have a protective wristlet meeting requirements as specified in Section 6-2 of NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting.*

3-2.4 Proximity protective coats shall have a composite collar not less than 4.0 in. (101.6 mm) in height at any point with a closure system. The collar lining material shall not be reflective material. Collar and closure system shall consist of an outer shell, moisture barrier, and thermal barrier that meet all performance requirements as specified in Chapter 4 of this standard.

3-3 Additional Requirements for Proximity Protective Trousers.

3-3.1* Proximity protective trousers shall provide protection as

Figure 3-1.9 Hook and Dee Ring (Inward Facing) Not to Scale



specified to the lower torso and legs, excluding the ankles and feet.

3-3.2 Proximity protective trouser hardware shall not penetrate through the outer shell, moisture barrier, and thermal barrier to contact the wearer's body when trouser is worn with closures fastened, unless the hardware is located on the waistband or hardware is completely covered by external closure flaps.

3-4 Additional Requirements for Proximity Protective Coverall.

3-4.1 That portion of the proximity protective coverall that corresponds to the proximity protective coat shall meet all requirements of Section 3-2 of this Chapter.

3-4.2 That portion of the proximity protective coverall that corresponds to the proximity protective trouser shall meet all requirements of Section 3-3 of this Chapter.

Chapter 4 Performance Requirements

4-1 Proximity Protective Garment Requirements.

4-1.1 The proximity protective garment fabric composite consisting of outer shell, moisture barrier, and thermal barrier shall have an average thermal protective performance (TPP) of not less then 35 when tested as specified in Section 5-2 of this standard.

4-1.2 All seam assemblies shall be tested for breaking strength and shall demonstrate a sewn seam strength equal to or greater than 150 lbs (675 N) force for Major A seams, 75 lbs (337.5 N) for Major B seams, and 40 lbs (180 N) force for Minor seams when tested as specified in Section 5-9 of this standard.

4-1.2.1 Seam breaking strength shall be considered acceptable when the fabric strength is less than the required seam strength specified in 4-1.2 of this Section, provided the fabric fails without failure of the seam below the applicable forces specified in 4-1.2.

4-2 Textiles.

4-2.1 Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric shall be individually tested for flame resistance and shall have an average char length of not more than 4.0 in. (101.6 mm), an average after flame of not more than 2.0 seconds, and shall not melt or drip when tested as specified in Section 5-10 of this standard.

4-2.2 Outer shell moisture barrier, thermal barrier, collar linings and winter liner fabric shall be individually tested for thermal shrinkage resistance and shall not shrink more than 10.0 percent in any direction when tested as specified in Section 5-4 of this standard.

4-2.3 Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric and other materials used in construction —— including but not limited to padding, reinforcement, garment labels, interfacing, binding, hanger loops, and emblems, but excluding hook and pile fasteners when not placed in direct contact with the body —— shall be individually tested for heat resistance and shall not melt, separate, or ignite when tested as specified in Section 5-5 of this standard.

4-2.3.1 Moisture barrier seam seal materials shall be tested for heat resistance and shall not drip or ignite when tested as specified in Section 5-5 of this standard.

4-2.4 Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric shall be individually tested for cleaning shrinkage resistance and shall not shrink more than 5.0 percent in any direction when tested as specified in Section 5-11 of this standard.

4-3 Outer Shell Requirements.

4-3.1 The outer shell shall have a 100 percent radiant reflective value of 20 when tested as specified in Section 5-3 of this standard.

4-3.2 Outer shell and collar lining fabrics shall be tested for tear resistance and shall have a tear strength of not less than 22 lb (99 N) when tested as specified in Section 5-6 of this standard.

4-3.3 Outer shell and collar lining fabric shall be tested for char resistance and shall not char when tested as specified in Section 5-5 of this standard.

4-3.4 Outer shell and collar lining fabrics shall be tested for water absorption resistance and shall have no more then 30 percent water absorption when tested as specified in Section 5-12 of this standard.

4-3.5 The outer shell shall show no signs of cracking on the face or delamination if the base fabric is a laminate when tested for wet flex as specified in Section 5-7 of this standard.

4-3.6 The outer shell shall show no evidence of separation of the coating or laminate from the base cloth, when tested for adhesion after wet flex as specified in Section 5-8 of this standard.

4-3.7 The outer shell shall show no evidence of breaking, shattering, or cracking of the coating, laminate or fabric when tested for flex at low temperature as specified in Section 5-13 of this standard.

4-3.8 The outer shell shall show no blocking, with a blocking rating of 1, when tested for resistance to high temperature blocking as specified in Section 5-14 of this standard.

4-4 Moisture Barrier Requirements.

4-4.1 Moisture barrier shall be tested for tear resistance and shall have a tear strength of not less than 5.0 lb (22.5 N) when tested as specified in Section 5-6 of this standard.

4-4.2 The moisture barrier fabric shall be tested for water penetration resistance and shall have a minimum water penetration resistance of 25 psi (1.76 kg/cm2) when tested as specified in 5-15.2 of this standard and 1 psi (0.07 kg/cm2) when tested as specified in 5-15.4 of this standard. Appearance of water drops shall constitute failure.

4-4.3 Moisture barrier seams shall be tested for water penetration resistance and shall have a minimum water penetration resistance of not less then 1 psi (0.07 kg/cm2) when tested as specified in 5-15.4 of this standard.

4-5 Thermal Barrier Requirements.

4-5.1 Thermal barrier shall be tested for tear resistance and shall have a tear strength of not less than 5.0 lb (22.5 N) when tested as specified in Section 5-6 of this standard.

4-6 Winter Liner Requirements.

4-6.1 When provided, the winter liner shall be tested for tear strength resistance and shall have a tear strength of not less than 5.0 lb (22.5 N) when tested as specified in Section 5-6 of this standard.

4-7 Thread Requirements.

4-7.1 All thread utilized in the construction of the garments shall be tested for heat resistance and shall not ignite, melt, or char when tested as specified in Section 5-16 of this standard.

4-8 Hardware Requirements.

4-8.1 All hardware finish shall be free of rough spots, burrs, or sharp edges.

4-8.2 All metal hardware and hardware that includes metal parts shall be tested for corrosion resistance as specified in Section 5-17 of this standard. Metals inherently resistant to corrosion, including but not limited to stainless steel, brass, copper, aluminum, and zinc shall show no more than light surface corrosion or oxidation. Ferrous metals shall show no corrosion of the base metal.

4-8.3 All hardware shall be tested for heat resistance and shall not ignite and shall remain functional when tested as specified in Section 5-5 of this standard.

Chapter 5* Test Methods

5-1 Washing and Drying Procedure.

5-1.1 Specimens shall be subjected to 5 cycles of washing and drying in accordance with the procedure specified in Machine Cycle 1, Wash Temperature V, Drying Procedure Ai, of AATCC 135, Dimensional Change in Automatic Home Laundry of Woven and Knit Fabrics. A laundry bag shall not be used.

5-2* Thermal Protective Performance Test.

5-2.1 Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this Chapter.

5-2.2 All specimens to be tested shall be preconditioned by placement in a circulating air oven for not less then 4 hours at 120°F ±5°F (49°C ±2°C) and then conditioned in accordance with Section 4, Atmospheric Conditions for Testing, of Federal Test Method Standard 191A, Textile Test Methods, with a relative humidity of 65 percent, ±5 percent. Specimens shall be tested not more than 5 minutes after removal from conditioning.

5-2.3 Thermal protective performance (TPP) testing shall be performed in accordance with ASTM D 4108, Thermal Protective Performance of Materials for Clothing, Open Flame Method, with the following modifications:

5-2.3.1 Specimens shall consist of proximity protective clothing composites measuring 6 x 6 in. +1/2/- 0 in. (152.4 x 152.4 mm +12.7/-0 mm) consisting of outer shell, moisture barrier, and thermal barrier. Collar lining fabric shall be permitted to be included in the proximity protective garment collar fabric composite specimen. Winter liners shall not be included in the test composite.

5-2.3.2 Apparatus shall consist of specimen holder assembly, specimen holder assembly support, thermal flux source, protective shutter, sensor assembly, and recorder.

5-2.3.3 Specimen holder assembly shall consist of upper and lower mounting plates. Specimen holder mounting plates shall be 8 x 8 in. ±1/16 in. x 1/4 in. ±1/32 in. (203.2 x 203.2 mm ±1.6 mm x 6.4 mm ±0.8 mm). The lower specimen mounting plate shall have centered a 4 x 4 in. ±1/16 in. (101.6 x 101.6 mm ±1.6 mm) hole. The upper specimen mounting plate shall have centered a 5 1/8 x 5 1/8 in. ±1/16 in. (130.2 x 130.2 mm ±1.6 mm) hole. The lower specimen mounting plate shall have a 1 in. ±1/16 in high x 1/8 in. ±1/32 in. (25.4 mm ±1.6 mm x 3.2 mm ±0.8 mm) thick steel post welded to each corner 1/4 in. ±1/16 in. (6.4 mm ±1.6 mm) from each side and perpendicular to the plane of the plate. The upper sample mounting plate shall have a corresponding hole in each corner so that the upper specimen mounting plate fits over the lower specimen mounting plate.

5-2.3.4 Specimen holder assembly support shall consist of a steel frame that rigidly holds and positions in a reproducible manner the specimen holder assembly and specimen relative to the thermal flux. Specimen holder assembly support shall be securely clamped at the edges such that specimen shrinkage is prevented. Sensor assembly shall consist of 5 1/4 x 5 1/4 x 1/2 in. (133.3 x 133.3 x 12.8 mm) heat-resistant block that fits without binding into hole of upper specimen mounting plate and shall be uniformly weighted such that complete sensor assembly, including copper calorimeter, weighs 1000 grams ±10 grams (2.2 lb ±0.022 lb).

5-2.3.5 Thermal flux source shall consist of a convective thermal flux source and a radiant thermal flux source. The convective thermal flux source shall consist of two Meeker or Fisher burners affixed beneath the specimen holder assembly opening, and subtended at a nominal 45 degree angle from the vertical so that the flames converge at a point immediately beneath the specimen. The radiant thermal flux source shall consist of nine quartz infrared tubes affixed beneath and centered between the burners.

5-2.3.6 A protective shutter shall be placed between the thermal flux source and the specimen. The protective shutter shall be capable of completely dissipating thermal load from thermal flux source for the time periods before and after specimen exposure. The protective shutter shall be controlled by means of an automatic timer with a resolution of not less than 0.10 second.

5-2.3.7 Specimens shall be exposed to a thermal flux of 2.0 cal/cm²/sec ±0.1 cal/cm2/sec exposure condition. The total heat flux shall be calculated directly from the temperature response of the copper calorimeter and calorimeter constants. Other heat-sensing devices shall not be used to reference or adjust the heat flux read by the copper calorimeter. The 2.0 cal/cm²/sec shall be determined directly and only from the voltage output of the thermocouples, using the measured temperature rise of the copper calorimeter, the area and mass of the calorimeter, and the heat capacity of copper to calibrate the incoming heat flux. The radiant load shall be set on 1.0 cal/cm²/sec as measured using a calibrated commercial radiometer.

5-2.3.8 The sensor assembly shall be fitted into the opening in the top plate of the specimen holder and be in contact with the surface of the thermal barrier normally facing the wearer.

5-2.3.9 If the individual test results vary more than ±8 percent from the average result, the result shall be discarded and another set of specimens shall be tested.

5-2.3.10 The individual test results of each specimen shall be reported. The average value for each sample and the pass/fail result shall be calculated and reported.

5-3* Radiant Reflective Test.

5-3.1 All samples shall be preconditioned in accordance with Section 4, Atmospheric Conditions for Testing, of Federal Test Method Standard 191A, Textile Test Methods, at a relative humidity of 65 percent ±5 percent. All samples shall be conditioned by means of abrading the sample before removing it from the conditioned atmosphere. Samples shall be tested for radiant heat not more than five minutes after removal from conditioning.

5-3.2 The outer shell material test samples shall be 3 x 10 in. (7.6 x 25.4 cm) with the long dimension in the warp or wale direction.

5-3.3 All samples shall be conditioned on an oscillating drum abrasion apparatus as specified in Method 5304, Abrasion Resistance of Cloth; Oscillatory Method (Wyzenbeek) Method, of Federal Test Method Standard 191A, Textile Test Methods. The samples shall be mounted on the oscillating drum of the apparatus. The abradant shall be No. 6 hard textured cotton duck conforming to Type I of Federal Specification CCC-C-419, Cloth, Duck, Unbleached, Plied-Yarn; Army and Numbered, and shall be cut into strips 1 7/8 in. (4.7 cm) wide by 9 in. (22.9 cm) long with the long dimension in the warp or wale direction. The abradant shall be mounted in the specimen holding clamps under a tension of 3 lbs. (13.5 N) and a head load of 3 lbs. (1.36 kg). A new abradant shall be used for each test and the contact area of the abradant shall be free of slubs, knots, or other weave imperfections. The test samples shall be subjected to 300 abrasion cycles.

5-3.4* Apparatus shall consist of a vertically oriented radiant heat source, specimen holder assembly, protective shutter, sensor assembly, and recorder. The sensor block shall consist of a 5 1/4 x 5 1/4 x 1/2 in. (133.3 x 133.3 x 12.8 mm) heat resistant material, that fits without binding into the bracket or rear plate. The sensor shall be in accordance with paragraph 6.5, the recorder shall be in accordance with paragraph 6.6, and the chart overlay shall be in accordance with all paragraphs of ASTM D 4108, Thermal Protective Performance for Clothing, Open Flame Method.

5-3.5 The radiant apparatus, as shown in Figure 5-3.5, shall consist of a bank of five, 500 watt, infrared, tubular, translucent quartz lamps having a 5 in. (12.7 cm) lighted length and a mean overall length of 8 13/16 in. (22.4 cm). The lamps shall be mounted so that the lamp's surfaces are approximately 0.015 in. (0.381 mm) apart. The bank or array shall be mounted and centered behind a 2 1/4 x 5 1/2 in. (5.7 x 14.0 cm) cutout on 1/2 in. (1.3 cm) transite board. A specimen holder and holder plate with a 2 1/2 by 6 in. (6.5 by 15.2 cm) center cut out shall be positioned so that the distance from the nearest lamp surface to the test specimen is exactly 1.0 in. (2.5 cm). The holder plate shall include a bracket to hold the copper calorimeter sensor assembly which will cover the complete cutout section. The quartz lamp shall be heated electrically and the power input controlled by means of a variac having a capacity of at least 25 amperes.

(SEE FIGURE 5-3.5 NEXT 6 PAGES)

5-3.6* A protective shutter shall be placed between the radiant source and the specimen. The protective shutter shall be capable of completely reflecting radiant load for the time period before specimen exposure.

5-3.7 The sensor face shall be wiped immediately after each run, while hot, to remove any decomposition products which condense and could be a source of error. If a deposit collects and appears to be thicker than a thin layer of paint, or is irregular, the sensor surface shall be reconditioned. The cooled sensor shall be carefully cleaned with cleaning solution, making certain there is no ignition source nearby. If bare copper is showing, the surface shall be repainted with a thin layer of flat black spray paint. At least one calibration run shall be conducted before using the repainted sensor in a test run. The sensor shall be recalibrated after every sample run of five specimens. The sensor shall always approximate body temperature by contact with the hand prior to placing on the apparatus.

5-3.8 Specimens shall be exposed to a thermal flux of 2.0 cal/cm^2, ±0.1 cal/cm^2 as measured with copper calorimeter. The copper calorimeter shall be the only heat sensor used in setting the 2.0 cal/cm^2/sec. exposure condition. The total heat flux shall be calculated directly from the temperature response of the copper calorimeter constants. Other heat sensing devices shall not be used to reference or adjust the heat flux read by the copper calorimeter. The 2.0 cal/cm^2/sec. exposure shall be determined directly and only from the voltage output of the thermocouple, using the measured temperature rise of the copper calorimeter, the area and mass of the calorimeter, and the heat capacity of copper to calibrate the incoming heat flux.

5-3.9 The abraded specimens shall then be placed in the specimen holder so that the abraded area will be centered in the opening of the specimen holder. The sensing device shall be placed in contact with the back of the specimen holder and then both shall be placed in front of the heat source so that the distance from the specimen to the nearest edge of the lamp surface is exactly one inch (2.54 cm). A hand or mechanical operated shutter device shall be placed between the specimen holder containing the test specimen and the lamps to completely block the heat from reaching the specimen when lamps are first turned on. The lamps shall be turned on for a 60 second warm up period. With the lamps still turned on, the shutter shall be removed from the front of the test specimen, and the recorder started. The specimen shall be exposed to the heat for 25 seconds and then the current shall be turned off.

5-3.10* The radiant reflective value shall be graphically determined from the recorder chart of the sensor response and the overlay prepared in 5-3.4 of this Section. The overlay shall be positioned on the recorder chart, matching the zero of the overlay with the start of the exposure. The horizontal axis shall be placed in line with the initial trace of the pen. While keeping the overlay square with the recorder chart, the time in seconds shall be read from the overlay chart where the sensor response curve and the overlay curve intersect. The time in seconds shall be called the radiant reflective value for the test specimen.

5-3.11 Five specimens shall be run and the radiant reflective value determined. The average value of the five specimens shall be calculated and reported to determine pass/fail.

5-4* Thermal Shrinkage Resistance Test.

5-4.1 Thermal Shrinkage Resistance testing shall be conducted on three specimens of each fabric, and each fabric shall be tested separately.

5-4.2 Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this Chapter.

5-4.3 Specimens to be tested shall be preconditioned in accordance with Section 4, Atmospheric Conditions for Testing, of Federal Test Method Standard 191A, Textile Test Methods, at a relative humidity of 65 percent ±5 percent. Specimens shall be tested not more than five minutes after removal from conditioning.

5-4.4 Each specimen shall be 15 x 15 in. ±0.5 in. (381 x 381 mm ±13 mm) and shall be cut from the fabric lot to be utilized in the construction of the garment.

5-4.5 Specimen marking and measurements shall be conducted in accordance with the procedure specified in AATCC Test Method 135, Dimensional Changes in Automatic Home Laundering of Woven and Knit fabrics.

5-4.6 The forced circulating air oven shall achieve and maintain an air temperature of 500°F +10°/-0°F (260°C +3°/-0°C) for a period of not less than five minutes. Oven recovery time after door is closed shall not exceed one minute.

1	CAST ALUMINUM APPARATUS BODY
2	TOGGLE SWITCH - DPST
3	TRANSITE - SMOOTH SURFACES
4	5 QUARTZ LAMPS - 500T3 115-125V
5	SCREW -10-24 3/4"
6	LEGS FOR HORIZONTAL TEST POSITION
7	TAPPED 10-24
8	1/2" D IMBEDDED MAGNET
	CENTER SCREW FASTENING
9	HOLDER-20 GAGE COLD ROLLED STEEL
10	BOLT - 3/16" D 1/2" BRAZED FLUSH
11	TEST SAMPLE
12	HOLDER PLATE - 20 GAGE
	COLD ROLLED STEEL
13	DRILLED HOLES - 3/8" D

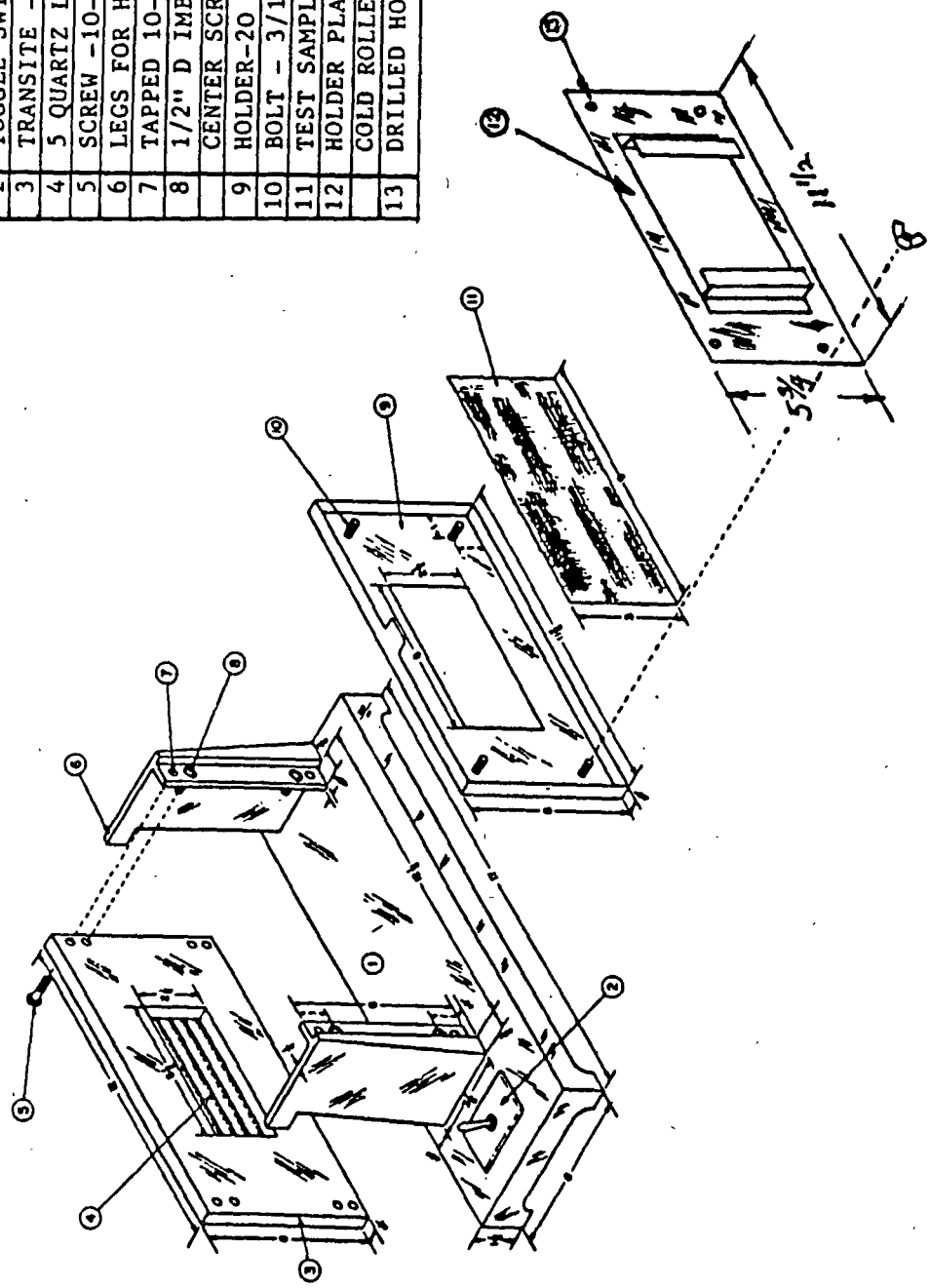


Figure 5-3.5

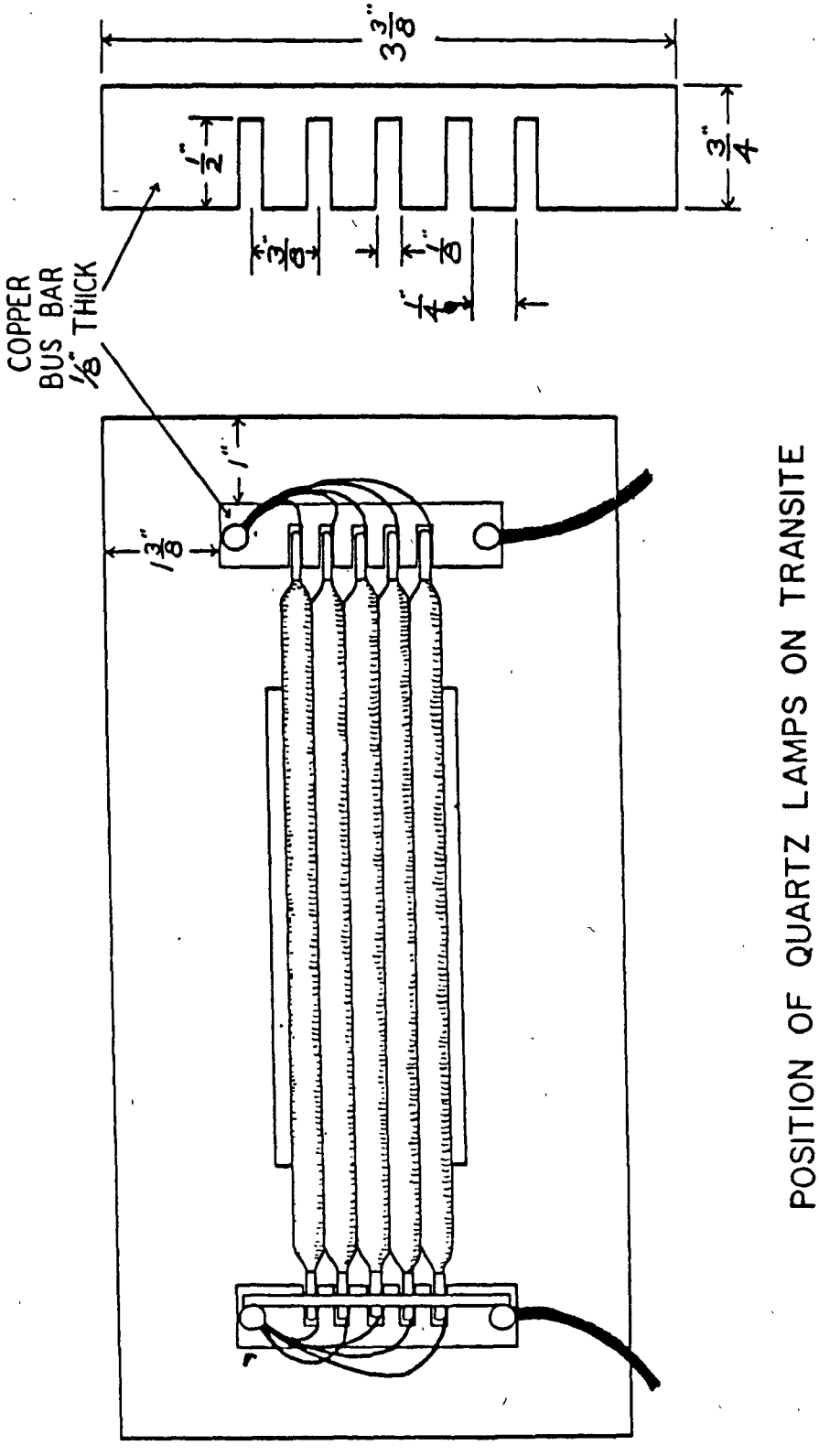
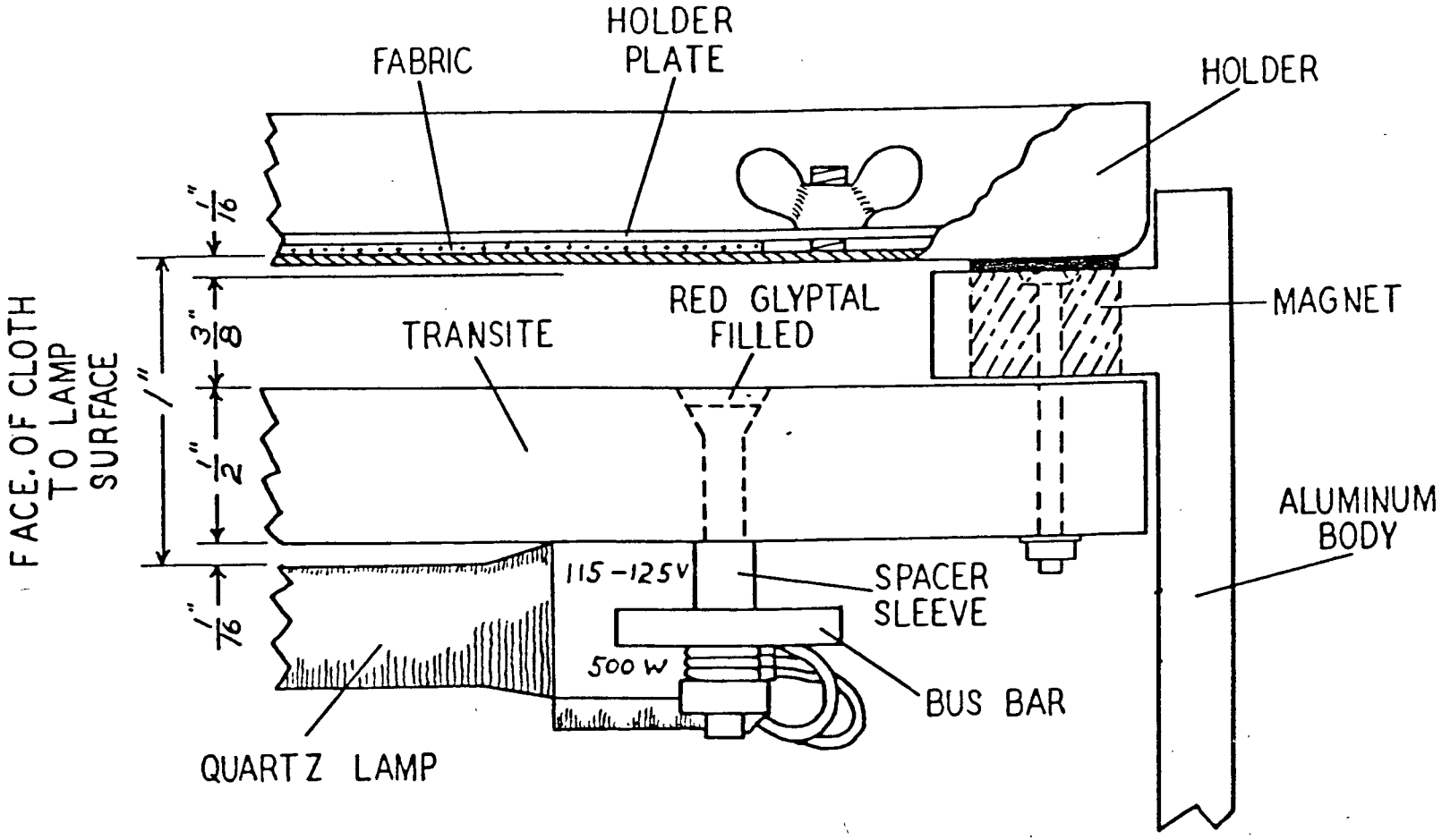
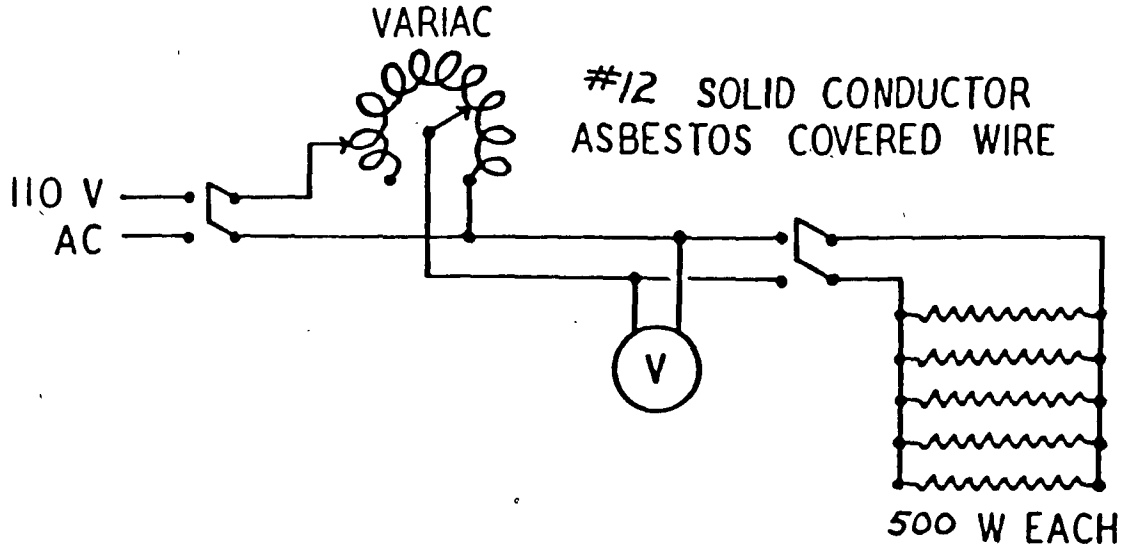


Figure 5-3.5 (continued)



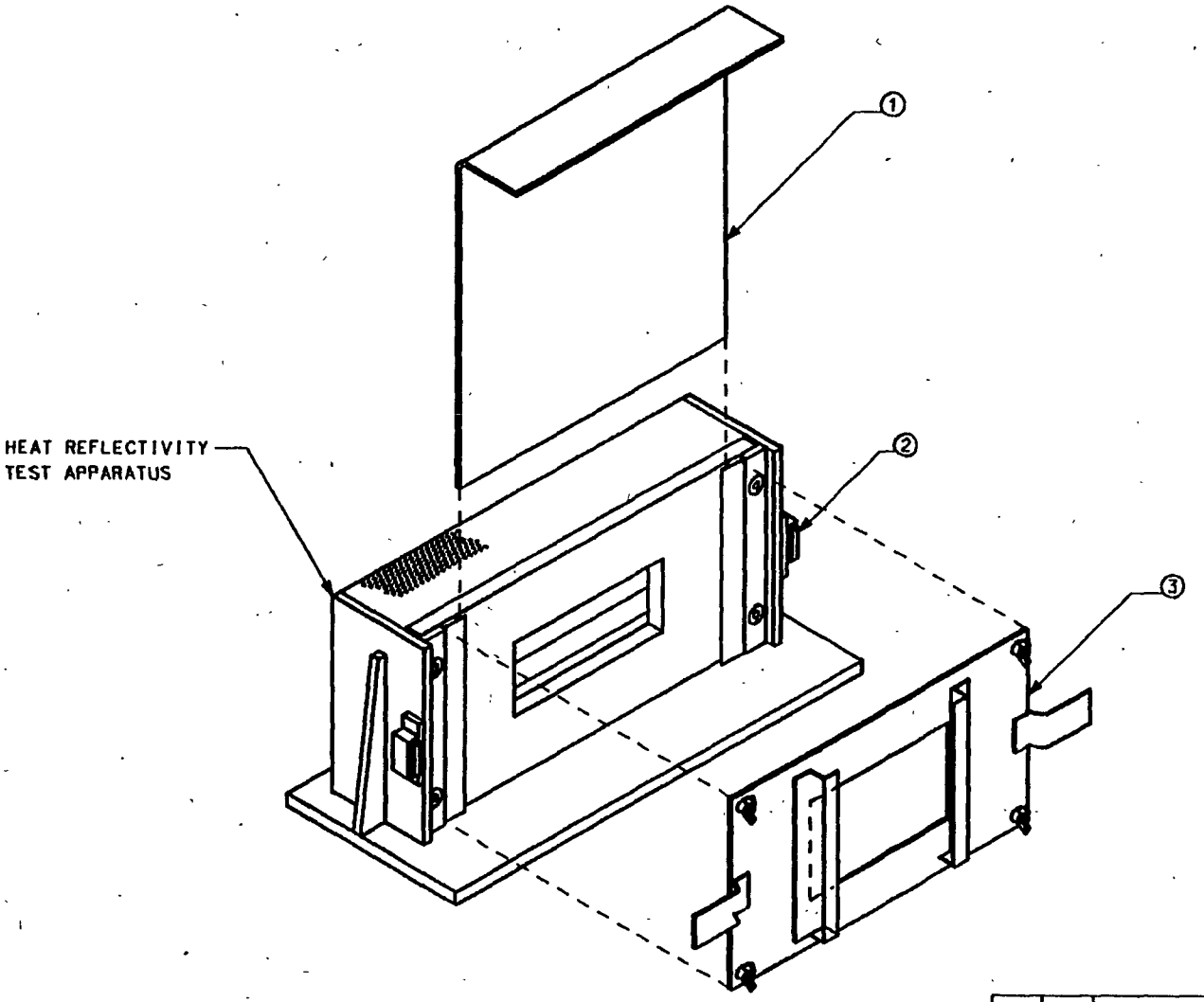
SAMPLE POSITION TOP VIEW ENLARGEMENT

Figure 5-3.5 (continued)



SCHEMATIC OF ELECTRICAL CIRCUIT

Figure 5-3.5 (continued)



ITEM	REQ'D	DRAWING NUMBER	DESCRIPTION	MATERIAL	REMARKS
03	01	DL-36S-E127	SAMPLE HOLDER		
02	02	DL-36S-C126	McMASTER-CARR PART# 1674A11		
01	01	DL-36S-E127	SHUTTER PLATE		

THIRD ANGLE PROJECTION

HOECHST CELANESE CORPORATION

DRAWER NO.
MICROFILM NO.
LOCATION RP TYPE NO

TITLE: MODIFICATION TO HEAT REFLECTIVITY TEST APPARATUS

DRAWN BY RADIAL	DATE 10/10/96	APPVD.	DATE	FLOOR 2 NO.
CHECKED BY	DATE	APPVD.	DATE	BLDG./ALLEN
APPROVED	SCALE 1:2	DWG. NO. DL-36S-C126	SHT. 1 OF 1	REV. 01

Figure 5-3.5 (continued)

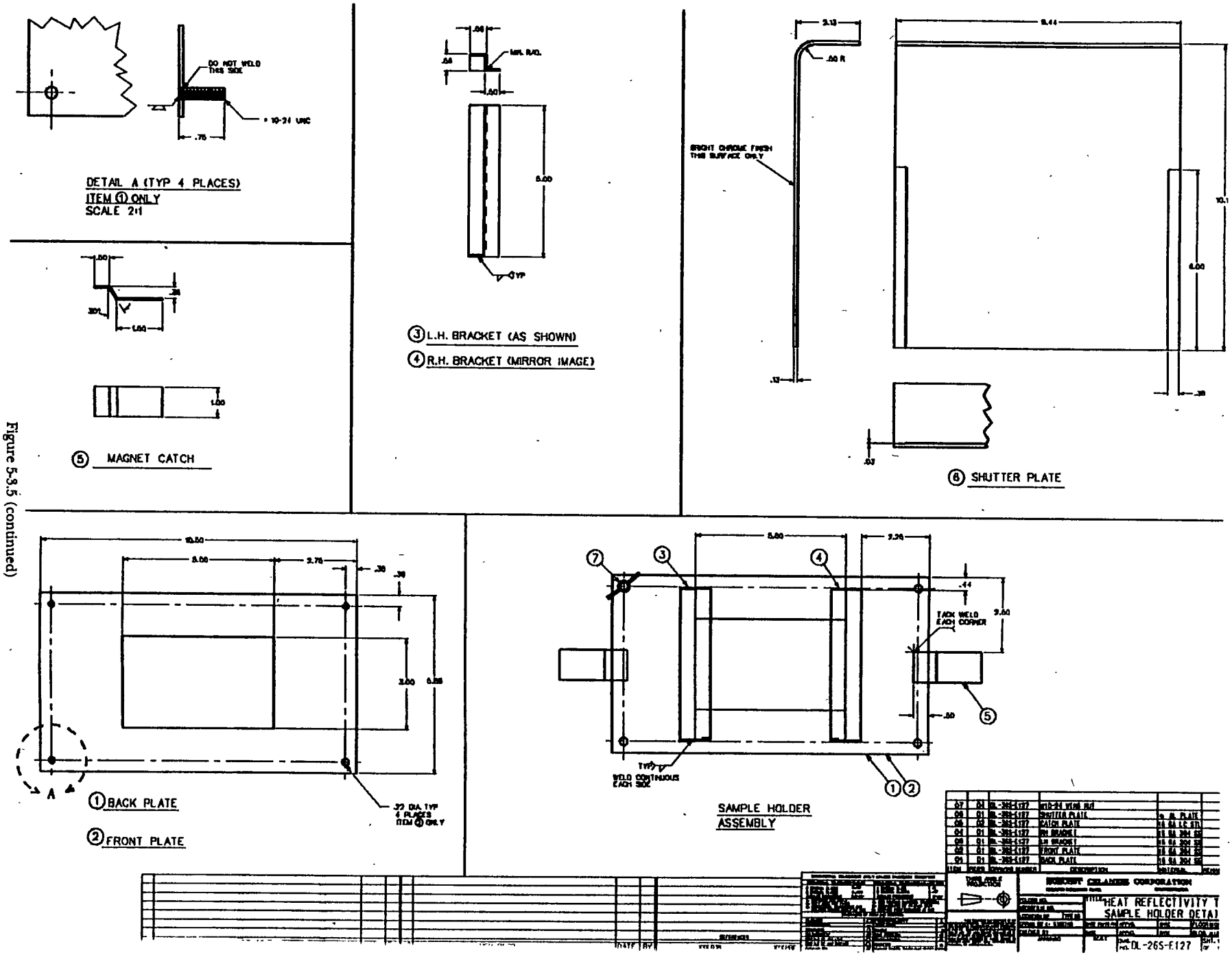


Figure 5-3.5 (continued)

5-4.7 The specimen shall be suspended by two metal hooks near each top corner with a 12 ±0.5 in. (305 mm ±12.7 mm) separation between hooks. The entire specimen shall be exposed to the circulating air so that it is not less than 2 in. (50.8 mm) from any oven surface or other specimen, and airflow is parallel to the plane of the material.

5-4.8 Specimens mounted as specified in 5-2.6 of this Section, shall be placed in the circulating air oven for 5 minutes +0.15/-0 minutes. Specimen exposure time shall begin when oven has recovered to an air temperature of 500°F +10°/-0°F (260°C +3/-0°C).
5-4.9 After removal from the oven, knit fabric shall be allowed to relax for 1 minute prior to measurement to determine pass/fail.

5-4.10 Results shall be reported as the average of all three specimens.

5-5* Heat, Char, and Ignition Resistance Test.

5-5.1 Fabric specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this Chapter.

5-5.2 The fabric specimen to be tested shall be preconditioned in accordance with Section 4, Atmospheric conditions for Testing, of Federal Test Method Standard 191A, Textile Test Methods, at a relative humidity of 65 percent ± 5 percent. Specimens shall be tested not more than five minutes after removal from conditioning.

5-5.3 Specimen length shall be 6 in. (152.4 mm), except for textiles utilized in the garment in length less than 6 in. (152.4 mm), where length shall be the same as utilized in garment. Specimen width shall be 6 in. (152.4 mm), except for textiles utilized in the garment in widths less then 6 in. (152.4 mm), where width shall be the same utilized in garment. Specimen shall be suspended in oven utilizing metal clips.

5-5.3.1 Oven testing of seam seal materials shall be done on a specimen consisting of two 3 x 6 in. (76.2 x 152.4 mm) pieces of moisture barrier fabric utilized in garment, sewn together and with seam sealing material applied.

5-5.4 The forced circulating air oven shall achieve and maintain an air temperature of 500°F +10°/-0°F (260°C +3°/-0°C) for a period of not less than five minutes. Oven recovery time after door is closed shall not exceed one minute.

5-5.5 The fabric specimen shall be suspended by metal hook(s) at the top and centered in the oven so that the entire specimen is not less than 2 in. (50.8 mm) from any oven surface or other specimen, and airflow is parallel to the plane of the material.

5-5.6 Hardware and accessory material specimens shall be supported or freely suspended in the center of the oven so that they are not less than 2 in. (50.8 mm) from any oven surface or other specimen and are exposed to the circulating air.

5-5.7 Specimens, mounted as specified in 5-5.5 of this Section, shall be placed in the circulating air oven for 5 minutes +0.15/-0 minutes. Specimen exposure time shall begin when oven has recovered to an air temperature of 500°F +10°/-0°F (260°C +3/-0°C).

5-5.8 Results shall be reported as pass or fail.

5-6 Tear Resistance Testing.

5-6.1 The specimen shall be a 3 x 6 in. (76.2 x 152.4 mm) rectangle. The long dimension shall be parallel to the warp or wale for warp and parallel to the filling or corse for the filling tests. No two specimens for warp or wale tests shall contain the same warp yarns, nor shall any two specimens for filling or corse tests contain the same filling yarns. The specimen shall be taken no nearer the selvage than one-tenth of the width of the cloth. An isosceles trapezoid having an altitude of 3 in. (76.2 mm) and bases of 1 and 4 in. (25.4 and 101.6 mm) in length, respectively, shall be marked on each specimen, with the aid of a template. A cut 3/8 in. (9.5 mm) in length shall then be made in the center of a line perpendicular to the 1-in. (25.4-mm) edge.

5-6.2 Apparatus shall consist of a straining mechanism, two clamps for holding specimens, and load and elongation recording mechanisms, wherein the specimen is held between two clamps and strained by a uniform movement of the pulling clamp. The test machine shall be operated at a rate of 12 in./min. (304.8 mm/min).

5-6.2.1 Straining mechanism shall be of such capacity that the maximum load required to break the specimen shall be not greater than 85 percent or less than 15 percent of the manufacturer's rated capacity.

5-6.2.2 Clamps shall be designed such that the 6 ounces (170 g) of weight are distributed evenly across the complete width of the sample. The clamps shall have two jaws on each clamp. The design of the clamps shall be such that one gripping surface or jaw may be an integral part of the rigid frame of the clamp or be fastened to allow a slight verticle movement, while the other gripping surface or jaw shall be completely movable. The dimensions of the immovable jaw of each clamp parallel to the application of the load shall measure 1 in. (25.4 mm), and the dimension of the jaw perpendicular to this direction shall measure 3 in (76.2 mm) or more. The face of the movable jaw of each clamp shall measure 1 x 3 in. (25.4 x 76.2 mm). Each jaw face shall have a flat, smooth gripping surface. All edges that might cause a cutting action shall be rounded to a radius of not more than 1/64 in. (0.4 mm). In cases where a cloth tends to slip when being tested, the jaws shall be faced with rubber or other material to prevent slippage. The distance between the jaws shall be 1 in. (25.4 mm) at the start of the test.

5-6.2.3 Recorder shall consist of calibrated dial, scale, or chart used to indicate applied load and elongation. Error shall not exceed 2 percent up to and including a 50-lb (22.7 kg) load at any reading within its loading range. All machine attachments for determining maximum loads shall be disengaged during test.

5-6.3 The specimen shall be clamped along the non-parallel sides of the trapezoid so that these sides lie along the lower edge of the upper clamp and the upper edge of the lower clamp with the cut halfway between the clamps. The short trapezoid base shall be held taut and the long trapezoid base shall lie in the folds. The strain mechanism shall be started and the force necessary to tear the cloth shall be observed by means of the recording device. Five specimens in each of the warp/wale and filling/corse directions shall be tested from each sample unit. If a specimen slips between the jaws, breaks in or at the edges of the jaws, or, if for any reason attributable to faulty technique, an individual measurement falls markedly below the average test results for the sample unit, such result shall be discarded and another specimen shall be tested.

5-6.4 The tear strength shall be the average of the five highest peak loads of resistance registered. The tear strength shall be reported to the nearest 0.1 lb (45.4 g).

5-7 Wet Flex.

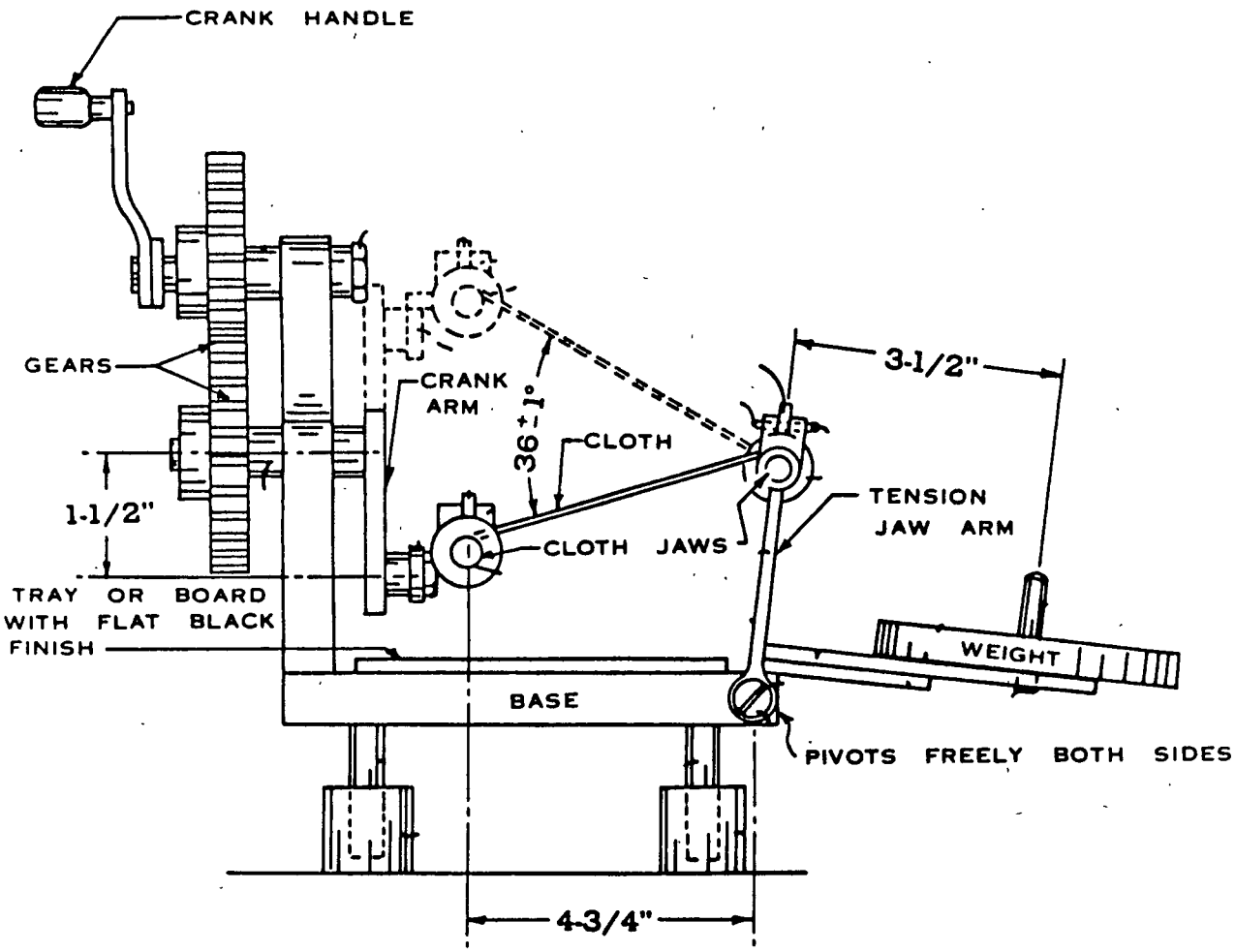
5-7.1 All samples shall be preconditioned in accordance with Section 4, Atmospheric Conditions for Testing, of Federal Test Method Standard 191A, Textile Test Methods, at a relative humidity of 65 percent ±5 percent.

5-7.2 Test specimens shall be 4 in. (10.2 cm) wide by 8 in. (20.3 cm) long dimension parallel to the warp or wale direction and shall be from the fabric lot utilized in the construction of the proximity protective garment. Five (5) specimens from each sample unit shall be tested with no two specimens containing the same yarns.

5-7.3 The test specimen shall be immersed in water at 140°F ±5°F (60°C ±2.8°C) for 15 minutes. Upon removal from the water it shall be placed on 2 layers of absorbent type blotters and covered by 2 additional layers. After placing the wet specimens between the blotters a 10 lb (4.5 kg) weight, a steel rod 3 in. (7.6 cm) in diameter and 5 in. (12.7 cm) long, shall be rolled over the test specimen for 4 complete cycles, 8 passes. The specimen shall be removed from between the blotters and placed in the flexing device as shown in Figure 5-7.3 The blotting paper shall conform to requirements detailed in Method 5500, Water Resistance of Cloth; Dynamic Absorption Method, of Federal Test Method Standard 191A, Textile Test Methods.

(SEE FIGURE 5-7.3 NEXT 2 PAGES)

5-7.4 The flexing device as shown in the Figure 5-7.3 shall be used. This device shall have a suitable weight on the weight arm to produce a 3 to 3.5 lb (13.5 N to 15.75 N) tension on the specimen during flexing. The tensioning jaw or clamp shall be so located that, with tension jaw arm vertical, any point on the tensioning jaw would be the apex of a cone of motion generated between that point and the corresponding point of the moving jaw. The crank arms shall be equal in effective length and in angular phase so that the moving jaw connecting the two arms remains parallel to the tension jaw throughout a complete revolution of the arms. The specimen shall be placed in the device with the moving jaw at bottom dead center, the tension jaw arm vertical, and the face of the cloth down. Each jaw shall clamp the specimen across the entire width. The crank handle shall be turned at a rate of 50 revolutions ±10 revolutions per minute



FLEXING DEVICE — END VIEW

Figure 5-7.3

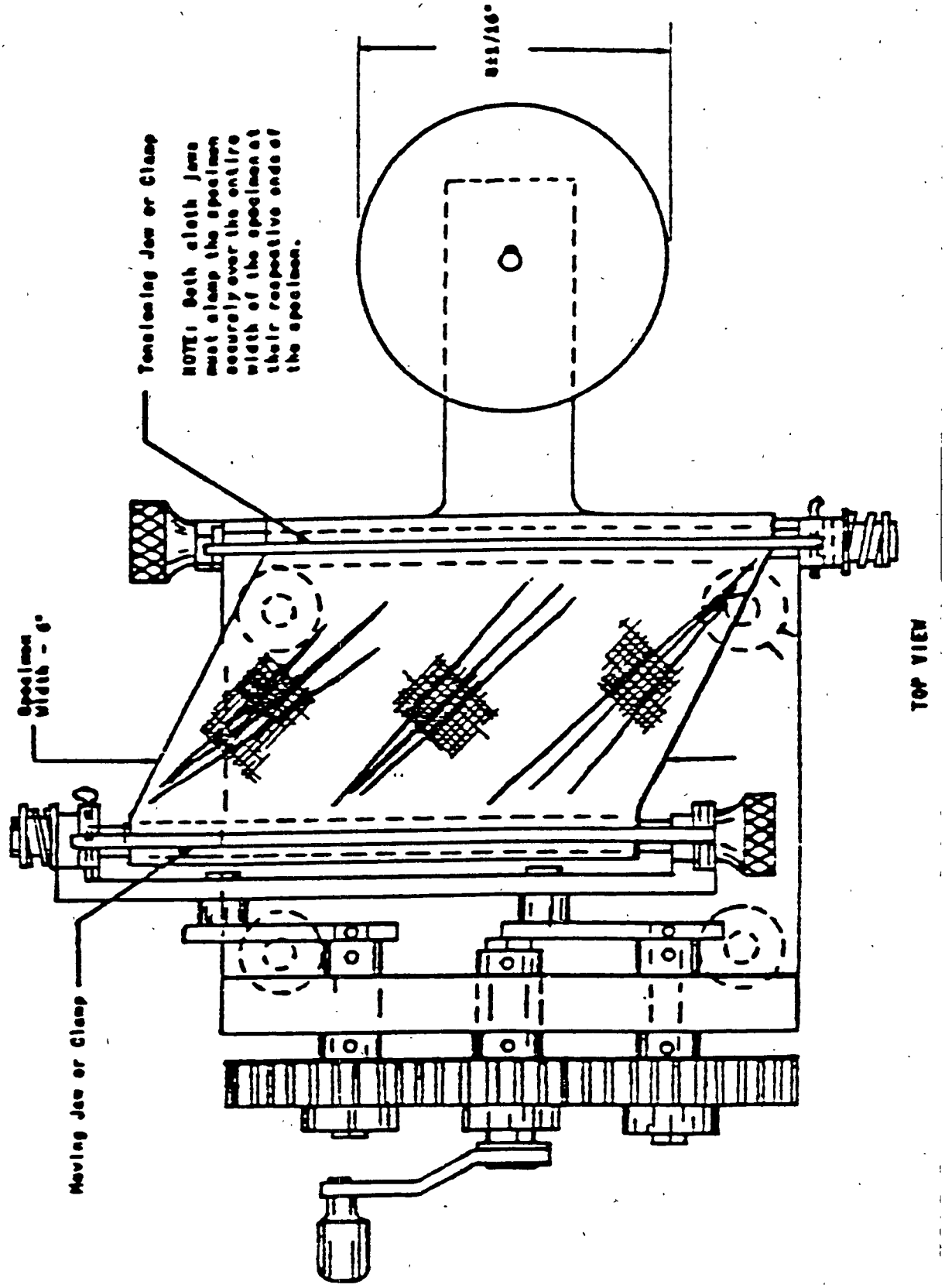


Figure 5-7.3 (continued)

of the crank arms and moving jaw during the test. A tray or board, flat black in color and sufficiently large to catch any particles that are removed from the fabric, shall be cleaned before each test and examined for material particles after each test. A motor driven apparatus shall be permitted to be used in lieu of the manual device specified.

5-7.5 The specimens shall be taken directly from the blotter paper and laced in the flexing device with the warp or wale direction perpendicular to the jaw line. The distance between jaw lines shall be 5.25 in. (13.3 cm). The specimen shall be flexed for 1000 cycles and then removed from the apparatus and shall be visually inspected to determine pass/fail.

5-7.6 Any cracking or delamination closer than 7/8 in. (22.4 mm) from either jaw line shall not be considered. Failure of any one specimen shall constitute failure of sample unit of product.

5-8 Adhesion After Wet Flex — Tape Method.

5-8.1 Immediately after each of the 5 specimens has completed the wet flex test in Section 5-7 of this Chapter, the specimens shall be tested and evaluated for adhesion. This test shall be performed only on coated or laminated materials.

5-8.2 A razor cut design shall be symmetrically centered within the 4 x 8 in. (10.2 x 20.3 cm) specimen. Two "X" cuts and three horizontal cuts shall be made as shown in Figure 5-8.2 with a sharp razor blade through the coating or laminate and adhesive layers, but not through the base cloth.

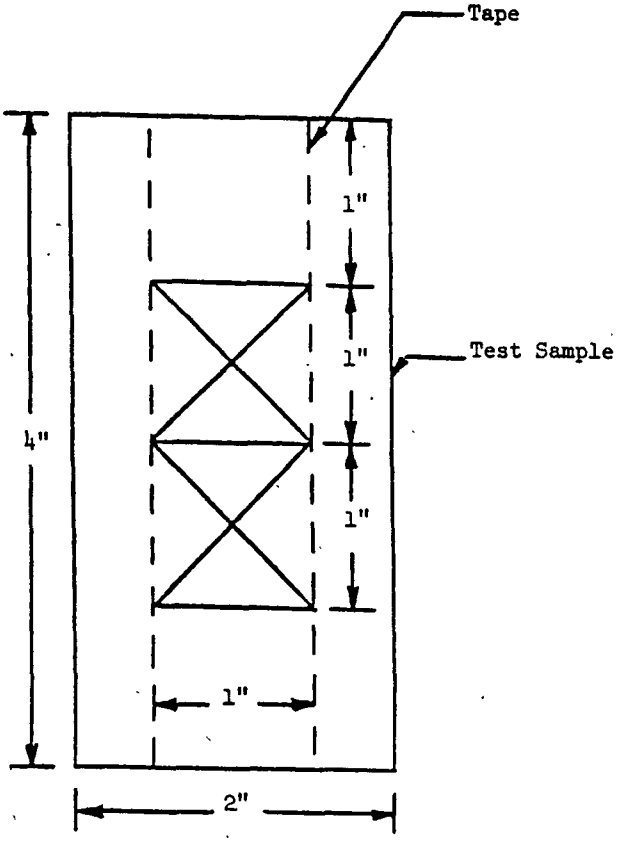


Figure - Showing "x" and horizontal cuts for adhesion of coating test

NOTE: Solid lines indicate cut lines

Figure 5-8.2

5-8.3 The pressure sensitive tape used for testing the adhesion of the coating or the laminate shall have an adhesion value of not less than 2.75 pounds per inch (1.150 N/cm) width or more than 3.50 pounds per inch (0.191 N/cm) width. Five 1 x 8 in. (2.5 x 20.3 cm) specimens of the tape shall be tested using:

(a) A tensile testing machine as described in Method 5100, Strength and Elongation, Breaking of Woven Cloth; Grab Method, of Federal Test Method Standard 191A, Textile Test Methods with the modification that all machine attachments for determining maximum load shall be disengaged and speed of the pulling clamp shall be 20 in. (50.8 cm) per minute.

(b) Five 2 x 4 in. (5.1 x 10.2 cm) steel plates conforming to Class 301 of Federal Specification QQ-S-766, Steel Plate, Sheet, and Strip-Corrosion Resisting, which have been polished to a No. 4 finish.

(c) A 1.5 inch (3.8 cm) wide steel roller weighing 10 pounds ±2 ounces (4.53 kg ±0.06 kg).

5-8.3.1 Before each test, the steel plates shall be thoroughly cleaned with diacetone alcohol, methyl alcohol, or methyl ethyl ketone, using a clean piece of lintless wiping tissue. The tape shall be applied to the clean surface of the plate so that it covers the entire length of the plate and extends 4 in. (10.2 cm) beyond one end of the plate.

5-8.3.2 The tape shall be pressed down by passing the roller over it 6 times, 3 times in each direction. The free end of the tape shall be doubled back and 1 in. (2.5 cm) of the tape peeled off the plate. The plate shall be inserted and clamped in the bottom jaw of the tensile testing machine with the free end of the tape downward. The free end of the tape shall be looped upward and inserted and clamped in the upper jaw so as to peel the tape from the plate when the jaw motion is started. The minimum tension required to remove the remainder of the tape, except for the final 1 in. (2.5 cm), shall be the adhesion value and shall be determined by means of the autographic recording device.

5-8.4 Five 1 x 8 in. (2.5 x 20.3 cm) specimens of similar tape, taken from a lot of material which has passed the test as specified in Section 5-6 of this Chapter, shall be used for testing the adhesion of the coating or laminate.

5-8.4.1 The apparatus and procedure shall be as specified in 5-8.3 of this Section, but instead of the steel plates specified in 5-8.3 (b), the test specimens used in Section 5-6 of this Chapter shall be used for this test.

5-8.5 A moderate amount of specks on the tape of coating shall not constitute failure; however exposure of adhesive beneath a laminate shall constitute failure. The failure of one specimen shall constitute failure of the unit of product.

5-9 Seam Breaking Strength.

5-9.1 All seams shall be tested in accordance with ASTM D 1683, Standard Test Method for Failure in Sewn Seams of Woven Fabric.

5-9.2 The test machine shall be operated at a rate of 12 in./min (304.8 mm/min).

5-10 Flame Resistance.

5-10.1 Specimens shall be tested before and after being subjected to the procedure specified in Section 5-1 of this Chapter.

5-10.2 Specimens shall be tested in accordance with Method 5903.1, Flame Resistance of Cloth; Vertical, of Federal Test Method Standard 191A, Textile Test Methods.

5-11 Shrinkage Resistance.

5-11.1 Specimens to be tested shall be subjected to the procedure as specified in Section 5-1 of this Chapter.

5-11.2 Knit fabric specimens shall be pulled to original dimensions, released, and shall be allowed to relax for 1 minute prior to measurement.

5-11.3 Specimens shall then be measured to determine pass/fail.

5-12 Water Absorption Test.

5-12.1 Specimens shall be tested before and after being subjected to the procedure specified in Section 5-1 of this chapter.

5-12.2 Specimens shall be tested with the outer surface of the composite face up as oriented in the proximity protective garment in accordance with Method 5504, Water Resistance of Coated Cloth;

Spray Absorption Method, of Federal Test Method Standard 191A, Textile Test Methods.

5-13 Flex at Low Temperature.

5-13.1 The test samples shall be 5 specimens, 1 x 4 inches (2.5 x 10.2 cm) with the long dimension in the warp or wale direction and shall be from the fabric lot utilized in the construction of the garment.

5-13.2 All samples shall be preconditioned in accordance with Section 4, Atmospheric Conditions for Testing, of Federal Test Method Standard 191A, Textile Test Methods, at a relative humidity of 65 percent ±5 percent. Specimens shall begin conditioning not more then 5 minutes after removal from preconditioning.

5-13.3 The test samples and jig as shown in Figure 5-13.3 shall be conditioned for 4 hours at a temperature of -25°F (-31.7°C).

(SEE FIGURE 5-13.3 BELOW)

5-13.4 At the end of the conditioning period, with the jig and the test specimens still in the test atmosphere, the sample shall be placed in the open jig with the rod in the center of the fabric. The face of the fabric shall be positioned away from the rod. The jig shall be closed in less than 3 seconds so that the specimen is bent face out around the rod until the back of the specimen touches itself. The tested fabric shall be examined without magnification.

5-13.5 Failure of any one specimen shall constitute failure of sample unit of production.

5-14 Resistance to High Temperature Blocking.

5-14.1 All samples shall be preconditioned in accordance with Section 4, Atmospheric Conditions for Testing, of Federal Test Method Standard 191A, Textile Test Methods, at a relative humidity of 65 percent ±5 percent.

5-14.2 Blocking test procedure shall be as stated in Method 5872, Temperature, High, Effect on Cloth Blocking, of Federal Test Method Standard 191A, Textile Test Methods.

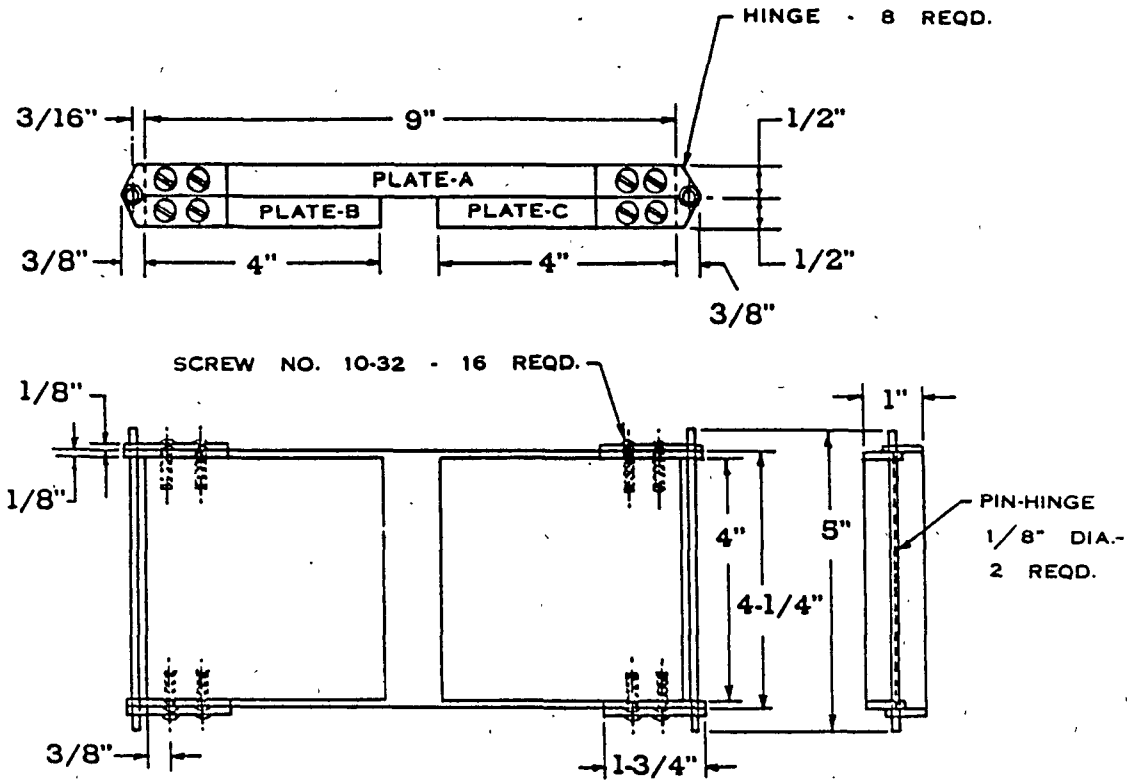
5-14.3 The test specimen shall be examined to determine pass/fail. Failure to any one specimen shall constitute failure of the unit of product.

5-15 Water Penetration Resistance.

5-15.1 Specimens shall be tested both before and after being subjected to the procedure specified in Section 5-1 of this Chapter.

5-15.2 Specimens shall be tested at 25 psi (1.76 kg/cm^2) in accordance with Method 5512, Water Resistance of Coated Cloth; High Range, Hydrostatic Pressure Method, of Federal Test Method Standard 191A, Textile Test Methods.

Figure 5-13.3



JIG ASSEMBLY—RESISTANCE TO LOW TEMPERATURE TEST

5-15.3 The specimen shall be examined to determine pass/fail.

5-15.4 Specimens shall be tested at 1 psi (0.07 kg/cm^2) for 5 minutes when tested in accordance with Method 5516, Water Resistance of Cloth; Water Permeability; Hydrostatic Pressure Method, of Federal Test Method Standard 191A, Textile Test Methods.

5-15.5 The specimen shall be examined to determine pass/fail.

5-16 Thread Heat Resistance.

5-16.1 Specimens shall be tested to a temperature of 500°F (260°C) in accordance with Method 1534, Melting Point of Synthetic Fibers, of Federal Test Method Standard 191A, Textile Test Methods.

5-16.2 Specimens shall be examined to determine pass/fail.

5-17 Corrosion Resistance.

5-17.1 Specimens shall be tested in accordance with ASTM B 117, Standard Method of Salt Spray (Fog) Testing. Salt spray shall be 5 percent saline solution and test exposure shall be for 20 hr.

5-17.2 Immediately following the test exposure and prior to examination, specimens shall be rinsed under warm, running tap water and dried with compressed air.

5-17.3 Specimens shall then be examined visually with the unaided eye to determine pass/fail.

Chapter 6 Referenced Publications

6-1 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.

6-1.1* NFPA Publications.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1992 edition.

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

6-1.2* AATCC Publications.

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

6-1.3* ASTM Publications.

ASTM B 117, Standard Method of Salt Spray (Fog) Testing, 1985

ASTM D 1683, Standard Test Method for Failure in Sewn Seams of Woven Fabrics, 1990.

ASTM D 4108, Standard Method of Thermal Protective Performance of Materials for Clothing by Open-Flame Method, 1987

6-1.4* GSA Publications.

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

Federal Specification FED-V-F-106F, Fasteners, Interlocking, Slide; 23 June 1987.

Federal Specification CCC-C-419, Cloth, Duck, Unbleached, Plied-yarns, Army and Numbered, 15 December 1989.

Federal Specification QQ-S-766, Steel Plate, Sheet, and Strip-Corrosion Resisting, 15 December 1966.

6-1.5* U.S. Navy Publications.

MS 27980E, Fastener, Snap, 30 November 1984

MIL-F-21840G, Fastener Tapes, Hook and Pile, Synthetic, 16 December 1987.

Appendix A

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

A-1-1.1 Research and testing that was available to the Committee was insufficient for development of specific proximity protection requirements for footwear and gloves at this time. Until further data is produced and test criteria developed and validated so that specific proximity protective requirements can be incorporated for footwear and gloves, it is recommended that purchasers consider referencing in written purchase specifications as a minimum the appropriate NFPA standard for the respective item (NFPA 1973 for gloves and NFPA 1974 for footwear) and additional radiant reflective criteria that is considered suitable for the expected exposures where the item will be used.

Also, sufficient research and testing data was not available for development of specific proximity protection requirements for head protection and for self-contained breathing apparatus (SCBA) protection.

It is recommended that purchasers include, in written purchase specifications for proximity head protection, sufficient head protection requirements as are considered suitable for the expected exposures where the item will be used.

Purchasers should also consider including, in written purchase specifications, proximity protection criteria for the SCBA. This might be accomplished by designing proximity protective coats that can be worn over the SCBA while still providing means for access to SCBA operating knobs, switches, and valves; or providing a radiant heat covering for the SCBA.

See also A-2-4.1.

A-1-1.3 Trim is specifically excluded from proximity protective garments as described in this standard. The use of trim on proximity protective clothing can substantially reduce or eliminate the ability of the garment to reflect radiant heat. Trim acts as a heat sinc which accelerates heat transfer through the garment and increases the risk of burn injury to the fire fighter. Some of the materials that act as a heat sinc are: trim, leather or other non-radiant reflective reinforcements, lettering, patches, name or number stencils, emblems, paint, or other marking mediums.

A-1-1.4 Organizations responsible for specialized functions including wildland fire fighting and hazardous materials response should use protective clothing and equipment specifically designed for those activities.

A-1-1.5 This standard is not designed to be utilized as a purchase specification. It is prepared as far as practical in terms of required performance, avoiding restrictive design of garments. Purchasers should specify departmental requirements for closures, pockets, etc. Tests specified in this standard should not be deemed as defining or establishing performance levels for protection from all proximity fire fighting environments.

A-1-2.1 "Primarily responsible for" refers to the principal responsibility in a given jurisdiction. This encompasses fire fighting situations that are most probable to occur within the responding area of the responsible agency. Proximity fire fighting situations include, but are not limited to, the hazards associated with aircraft fire fighting, bulk flammable gas and bulk flammable liquid fire fighting, and similar situations involving high levels of radiant heat.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires protective clothing to be appropriate for the intended application. It is not the intention of this standard to provide a protective garment to be used by fire fighters who are primarily responsible for structural fire fighting. Users who are primarily responsible for structural fire fighting should use protective clothing meeting all of the requirements of NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*. When using protective garments meeting the requirements of this standard for structural fire fighting, it must be realized that the lack of trim can reduce the ability to see or visually locate fire fighters.

A-1-3 Approved. The National Fire Protection Association does not approve, inspect or certify any installation, 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, procedure 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 quote "approval" agencies 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 marshall, 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 installation, the commanding officer or departmental officer may be "the authority having jurisdiction".

A-1-3 Listed. The means for 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-1-3 Moisture Barrier. The term "vapor barrier" that was utilized in past editions of NFPA 1971 was changed to "moisture barrier" in the 1986 Edition to represent more accurately the test methods 5512 and 5516 of Federal Standard Test Method 191A. Purchasers wishing to specify additional requirements for vapor resistance should contact fabric suppliers for assistance with establishing specifications. Moisture barriers might not prevent the passage of chemical, biological, or radiological agents through the garment; such incidents should be handled with appropriate chemical protective clothing and procedures.

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 current 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 an 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 by the agency before any major testing is undertaken.

A-2-2.7 Such factory 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-2-5.1 See A-3-1.10 for protective ensemble information.

It is recommended that purchasers consider referencing in written purchase specifications as a minimum the appropriate NFPA standard for the respective item (NFPA 1973 for gloves and NFPA 1974 for footwear) and additional radiant reflective criteria that is considered suitable for the expected exposures where the item will be used.

Some proximity head protection utilizes a hard hat within the hood for impact head protection. Users are cautioned that hard hats may not provide adequate head protection for all situations where proximity protective clothing is needed.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, requires that helmets meeting the requirements of NFPA 1972, *Standard on Helmets for Structural Fire Fighting*, be worn while engaged in structural fire fighting operations. The use of self-contained breathing apparatus (SCBA) is required by NFPA 1500 whenever fire fighters are exposed or may be exposed to the products of combustion, oxygen deficient, or toxic atmospheres. Since this would cover most if not all proximity fire fighting situations, SCBA will be used with proximity protective clothing.

There are no specific proximity protection requirements for SCBA in this document. Persons wearing SCBA in conjunction with proximity protective clothing are cautioned to use EXTREME CARE. An SCBA worn over or outside of the proximity garments will be exposed to the high radiant levels of the situation and failure of the SCBA is possible. Users should consider the purchase of proximity protective coats that are designed to be worn over the SCBA, or provide a protective covering for radiant heat protection of the SCBA. See also A-1.1.1.

Purchasers might wish to include a requirement in purchase specifications for an additional label containing certain information such as date of manufacture, manufacture's names, garment identification number, etc., to be located in a protected location in the garment to reduce the chance of label degradation and as a backup source of information to aid garment tracking or an investigation.

A-2-6 Some components of these garments are inherently flame resistant but lose their physical integrity on exposure to chlorine bleach. Other components will actually lose their flame resistant properties and thermal insulation on exposure to chlorine bleach. In either case, the protection provided by the garment will be compromised.

Clean protective clothing reduces health and safety risks; it is recommended that clothing be cleaned frequently to reduce the level of and bodily contact with contaminates. User agencies should establish guidelines for frequency and situations for garment cleaning. For gross contamination with products of combustion, fire debris or body fluids removal of contaminants by flushing water as soon as practical is necessary, followed by appropriate cleaning.

Decontamination may not be possible when protective clothing is contaminated with chemical, radiological, or biological agents. When decontamination is not possible garments should be discarded in accordance with local, state, and federal regulations.

There are industrial cleaning products and facilities available for protective clothing that the user may wish to investigate. Contact your protective clothing manufacturer for additional information. Where not explicitly outlined by the manufacturer, the following procedures are recommended for cleaning protective clothing.

Cleaning of Outer Shells - The outer shells of this ensemble contain a highly reflective surface, in order that it may reflect high levels of radiant heat. It is extremely important to keep this surface clean so that it may perform at peak efficiency.

One common reflective surface is an aluminized film laminated to a base fabric. This material cannot be machine washed without losing reflective qualities of the garment. Cleaning of this type of garment can be accomplished in the following manner:

1. Clean by gently rubbing surface with a cloth or sponge using mild soap, 1.1.1 trichlorethylene, or isopropanol.

2. Rinse the garment with clear water to assure that all cleaning compounds have been removed from the garment.

3. Dry the garment by hanging it in a shaded area that receives good cross ventilation or hang the garment on a line and use a fan to circulate the air.

4. Do not store garment until it has been completely dried.

When cleaning with 1.1.1 trichlorethylene or isopropanol, ensure that work is performed in an area with adequate ventilation and that proper gloves and eye protection are utilized.

Cleaning compounds that contain ammonia should not be used at any time, since the ammonia will react with the aluminum surface and diminish its reflectivity.

Aluminized surfaces can be damaged by contact with the dry powder fire extinguishing agent potassium bicarbonate powder (PKP). Before storing a garment with PKP residue present, the following is recommended:

1. Dry powder should be removed with dry brush or vacuum.

2. Wet powder should be removed by thoroughly flushing with water and wiping surface down with a clean soft cloth.

3. Damp or wet garments should be hung to dry in a shaded area that receives a good cross ventilation or should be hung on a line and use a fan to circulate the air.

4. Do not store garment until it has been completely dried.

Cleaning of Liners —— Liners may be washed in an automatic washing machine. Protective clothing should be washed separately from other garments. Snaps and other metal fasteners may damage the tub of the washer so the liner should be placed in a large laundry bag that can be tied shut to avoid damage to the wash tub. A stainless steel tub should be used if available.

These instructions can be used for cleaning any of the following wash loads in a large capacity (16 gallon) top loading or front loading machine.

(a) one protective coat liner and one protective trouser liner
(b) two protective coat liners
(c) two protective trouser liners

1. While the washing machine is filling with hot water [temperature between 120°F (54.5° C) and 130°F (49° C)], add 1/2 cup (118.3 ml) of liquid oxygenated bleach (do not use chlorine bleach) and 1 cup (237.6 ml) of liquid detergent. These products are readily available in supermarkets around the country.

2. Fill the washing machine to the highest water level.

3. Add garments to be washed.

4. Set washing machine for normal cycle, cotton/white, or similar setting.

5. Machine should be programmed for double rinse. If the machine will not automatically double rinse, a complete second cycle can be run without adding detergent or oxygenated bleach. Double rinsing helps remove any residual dirt and ensures detergent removal.

6. Remove garments from washing machine and hang to dry in a shaded area that receives a good cross ventilation or hang the garment on a line and use a fan to circulate the air. A water extractor may be utilized.

Purchaser should maintain protective clothing only in accordance with manufacturer's instructions. Maintenance should include regular inspection, proper repair,and retirement when appropriate. Protective clothing that is retired should be destroyed.

A-3-1 Purchasers of protective clothing should realize that fire fighters must wear many items of protective clothing and equipment. Any interference by one item of another's use might result in inefficient operation or unsafe situations. Chest, girth, sleeve length, and coat length should be required for protective coats; waist girth, inseam length, and crotch rise should be required for protective trousers; chest girth, sleeve length, waist girth, outseam length from underarm to pant cuff, and trunk length from base of neck to crotch fold should be required for protective coveralls. Since manufacturer's patterns vary to assure proper fit, measurement for sizing should be done by manufacturer's representative or a person familiar with sizing in accordance with manufacturer's instructions.

A-3-1.1 See A-3-1.10 for ensemble information.

A-3-1.2 Purchasers might wish to specify additional reinforcement or padding in high-wear or load-bearing areas, such as pockets, cuffs, knees, elbows, and shoulders. Padding could include additional thermal barrier material meeting requirements as specified herein. Reinforcement material could include outer shell material or other material that meets the outer shell requirements. Purchasers are cautioned that additional weight caused by excessive reinforcement or padding could lead to fatigue or result in injury.

A-3-1.3 See A-1-1.3

A-3-1.4 Fastener system should be specified by the purchaser. Fastener system methods can include (but are not limited to) stitching the thermal barrier and moisture barrier into the coat at the neck, or into the trouser at the waist area, with snap or hook and pile fasteners securing the remainder; entirely stitching the thermal barrier and moisture barrier to the outer shell; entirely securing the thermal barrier and moisture barrier to a component part of the outer shell with snap fasteners or fastener tape; or zipping the thermal barrier and moisture barrier to the outer shell.

A-3-1.7 Purchasers should consider including in purchase specifications requirements for hook and pile fastener service life for dry and wet operation and thermal stability including shrinkage, melt, char, and drip requirements when tested in accordance with 5-2.2 and Section 5-3 of the text of this standard.

A-3-1.10 Protective ensemble consisting of both protective coat and protective trouser is required to be utilized for both proximity and structural fire fighting in order to assure better protection for the fire fighter's torso and limbs by NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program.* An overlap of no less them 2 in. (203.2 mm) of all layers of the proximity protective coat and of the proximity protective trouser is also required by NFPA 1500 so there is no gaping of the total thermal protection when the protective garments are worn. The minimum overlap is determined by measuring the garments on the wearer, without SCBA, with the wearer in the most stretched position, hands together reaching overhead as high as possible.

A-3-1.11 Purchasers should specify pocket placement to allow for access to the pockets while wearing SCBA. Specifying ballooned pockets will increase capacity, but could interfere with maneuverability. Divided pockets could be desired, as well as pockets for specific items, such as SCBA facepieces and radios.

A-3-2.1 A protective ensemble consisting of both protective coat and protective trousers is required to be utilized for both proximity and structural fire fighting in order to assure better protection for the fire fighter's torso and limbs by NFPA 1500, *Standard on Fire Department Safety and Health Program.* An overlap of coat and trousers is also required. See A-3-1.10 for further details.

A-3-2.3 Purchasers should consider specifying wristlets with a thumb hole or bartack creating a thumb hole for wearer's thumb in order to assure protection when arms are in raised position.

A-3-3.1 A protective ensemble consisting of both protective coat and protective trousers is required to be utilized for both proximity and structural fire fighting in order to assure better protection for the fire fighter's torso and limbs by NFPA 1500, *Standard on Fire Department Safety and Health Program.* An overlap of coat and trousers is also required. See A-3-1.10 for further details. Purchasers might wish to specify for the proximity protective trouser an anklet that is part of the outer shell. The anklet is set in similar to a wristlet of a coat and will come down over the boot. The anklet could be manufactured from the moisture barrier material and be elasticized at the bottom.

A-5 Proper laboratory procedures should be followed when performing any flammability or oven testing. The tests should be performed in a hooded or vented area to carry away combustion products, smoke and fumes. If air currents disturb the flames, shield the apparatus or turn off the hood while running the test; turn the hood on to clear fumes. Exercise care in handling burners with open flames. Maintain adequate separation between flame and combustible materials. Protective gloves should be used when handling hot objects. When performing radiant heat tests protective goggles should be worn.

A-5-2 The requirements in Sections 5-2, 5-3, 5-4, and 5-5 are not intended to establish the limiting working environment for fire fighting but are for establishing material performance requirements. However, fire fighters should understand that when they feel a continual increase of heat, the protective garments may be nearing their maximum capacity and injury may be imminent.

A-5-3 See A-5-2.

A-5-3.4 Radiant heat source, specimen, and sensor are mounted vertically to allow convective heat to escape from the test apparatus. If tested in a horizontal position, convective heat significantly effects the test results.

A-5-3.6 An example of a protective shutter that can completely reflect radiant heat would be a chrome plated aluminum shutter.

A-5-3.10 The graphical data described in paragraph 5-3.10 can be digitized for computer analysis applications.

A-5-4 See A-5-2.

A-5-5 See A-5-2.

A-6-1.1 NFPA publications can be obtained from National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, Ma. 02269-9101

A-6-1.2 ASTM publications can be obtained from American Society for Testing Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

A-6-1.3 GSA publications can be obtained from General Services Administration, Specifications Activity; Printed Materials Supply Division; Building 197, Naval Weapons Plant, Washington, DC 20407. Single copies are generally available without charge at the General Services Administration Business Centers in cities throughout the U.S.

A-6-1.4 Navy publications can be obtained from Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

Appendix B

B-1 The following documents or portions thereof are referenced within Appendix A for informational purposes only and thus are not 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.

B-1.1 **NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101. Quincy, Ma 02269-9101.

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1992 edition.

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

NFPA 1972, *Standard on Helmets for Structural Fire Fighting*, 1992 edition.

NFPA 1973, *Standard on Gloves for Structural Fire Fighting*, 1988 Edition.

NFPA 1974, *Standard on Protective Footwear for Structural Fire Fighting*, 1992 edition.

B-1.2 Other Publications.

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

ASTM publications can be obtained from American Society for Testing Materials (ASTM), 1916 Race Street, Philadelphia, Pa 19103

The Federal Test Method Standard can be obtained from General Service Administration, Specifications Activity; Printed Material Supply Division; Building 197, Naval Weapons Plant, Washington, DC 20407. Single copies are generally available without charge at the General Service Administration Business Centers in cities throughout the U.S.

PART IV

(Log # 1)

1981- 1 - (Entire Standard): Accept in Principle
SUBMITTER: Robert W. Tyree, International Safety Instruments, Inc.
RECOMMENDATION: Paragraph 2 reads:
"This document is being completely revised. . . and to add a series of seven performance tests that are designed to simulate various environmental conditions that fire fighters' self-contained breathing apparatus may be exposed to during use and storage."
SUBSTANTIATION: In my opinion, the tests as designed do not simulate environmental conditions that fire fighters might actually encounter. There is no substantial reason for the soak time of the temperature excursion tests to be so long, nor are the continuous three-hour vibration tests representative. In addition, flame and heat resistance tests will be made on selected components of the S.C.B.A. In my opinion, all components of the S.C.B.A. should be subjected to the same flame and heat resistance tests. At no time will different components be exposed to different flame or temperature conditions.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See new Heat and Flame test in Sections 3-11 and 4-11 of this TCR.

(Log # 2A)

1981- 2 - (3-5): Accept in Principle
SUBMITTER: Manfred Rotmann, Toronto, Canada
RECOMMENDATION: Delete "Flame Resistance Performance and Test." Test not relevant to SCBA primary functions.
SUBSTANTIATION: There is no purpose indicated for the test nor background on what is to be tested. Presumably, the harness material might be the tested objects. However, whether a fabric does or does not pass is not the question. The question is whether the harness has sufficient strength after exposure. This requires a separate test.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See new Heat and Flame test in Sections 3-11 and 4-11 of this TCR.

(Log # 3)

1981- 3 - (3-6): Accept in Principle
SUBMITTER: Manfred Rotmann, Toronto, Canada
RECOMMENDATION: Delete "Heat Resistance Performance." Test not relevant to SCBA primary functions.
SUBSTANTIATION: There is no purpose nor background on test application as for 3-5 and 4-4.
If it is the intention to ensure harness performance in case of heat or flame exposure it is necessary to go further than just the material test. It is necessary to have a functional test for the harness.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See new Heat and Flame test in Sections 3-11 and 4-11 of this TCR.

(Log # 4)

1981- 4 - (3-7): Accept in Principle
SUBMITTER: Manfred Rotmann, Toronto, Canada
RECOMMENDATION: Delete "Thread Heat Resistance Performance." Test not relevant to SCBA primary function.
SUBSTANTIATION: There is no purpose nor background given for this test. Even if the thread passes the test it does not ensure passing of the main requirement assumed to be harness integrity after flame exposure.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See new Heat and Flame test in Sections 3-11 and 4-11 of this TCR.

(Log # 5)

1981- 5 - (4-4): Accept in Principle
SUBMITTER: Robert W. Tyree, International Safety Instruments, Inc.
RECOMMENDATION: General question: Why is only the harness material on the S.C.B.A. subjected to the high temperature flame resistance tests?
SUBSTANTIATION: Either all components on the S.C.B.A. which will be subjected to a high temperature flame should be tested in the same manner, or the harness material on the S.C.B.A. should only be tested to the maximum temperature that the remainder of the S.C.B.A. is subjected to (in this case as I read the specification, plus 160°F is the maximum temperature to which the S.C.B.A. facemask, regulators, breathing hoses, etc. are subjected.)
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See new Heat and Flame test in Sections 3-11 and 4-11 of this TCR.

(Log # 2B)

1981- 6 - (4-4): Accept in Principle
SUBMITTER: Manfred Rotmann, Toronto, Canada
RECOMMENDATION: Delete "Flame Resistance Performance and Test." Test not relevant to SCBA primary functions.
SUBSTANTIATION: There is no purpose indicated for the test nor background on what is to be tested. Presumably, the harness material might be the tested objects. However, whether a fabric does or does not pass is not the question. The question is whether the harness has sufficient strength after exposure. This requires a separate test.
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See new Heat and Flame test in Sections 3-11 and 4-11 of this TCR.

(Log # 6)

1981- 7 - (4-5): Accept in Principle
SUBMITTER: Robert W. Tyree, International Safety Instruments, Inc.
RECOMMENDATION: General question: Why is only the harness material on the S.C.B.A. subjected to the high temperature flame resistance tests?
SUBSTANTIATION: Either all components on the S.C.B.A. which will be subjected to a high temperature flame should be tested in the same manner, or the harness material on the S.C.B.A. should only be tested to the maximum temperature that the remainder of the S.C.B.A. is subjected to (in this case as I read the specification, plus 160°F is the maximum temperature to which the S.C.B.A. facemask, regulators, breathing hoses, etc. are subjected.)
COMMITTEE ACTION: Accept in Principle.
COMMITTEE STATEMENT: See new Heat and Flame test in Sections 3-11 and 4-11 of this TCR.

1981- 8 - (Entire Document): Accept
SUBMITTER: Technical Committee on Fire Service Protective Clothing and Equipment
RECOMMENDATION: Completely revise NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighting, 1987 Edition.
SUBSTANTIATION: This complete revision of the 1987 edition incorporates two major additions to the standard and 2 significant changes to existing test methods.
In new Chapter 2 (in the TCR text), the requirements of a third party testing and certification program appear. This program includes labeling, listing, and the certification test series criteria, as well as product labeling criteria.
In new Sections 3-11 and 4-11 (in the TCR text), the requirements of the heat and flame test appear. This new performance requirement and test method exposes a functioning SCBA to an oven heat soak, and then exposes the entire SCBA to a high temperature flame exposure while the SCBA is being "breathed" at a 100 liters per minute rate.
The facepiece lens abrasion test method in Section 4-9 (TCR text) was changed to make the method a more reproductible test. The communications test was also revised in Section 4-10 (TCR text) in an attempt to improve on the past test method.
In general, editorial clean-up has occurred throughout the document.
COMMITTEE ACTION: Accept.

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 exceeds 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.

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 as 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 which 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 facepieve, 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 the positive pressure or pressure demand type.

Pink Noise. Noise which 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 affixed to the SCBA by the manufacturer containing general information, warnings, care, maintenance, or similar data. This product label is not a certification organization label or identifying mark.

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 Appendix A, 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 pounds.

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 2-4 of this Chapter.

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 two 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, "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.

(SEE TABLE 2-3.1 NEXT PAGE)

2-3.2 SCBA shall be initially tested and shall meet the performance requirements of three separate test series of Category 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 of this Section. 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 of this Section 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 3-4				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 Product Labeling.

2-4.1 In addition to the NIOSH/MSHA certification label and the certification organizations 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 MANUFACTURERS 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. 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"

2-4.2 The major components listed by the manufacturer in 2-4.1 of this Section shall be labeled with the lot number or serial number, or the year and the month of manufacture.

2-4.3 All portions of the required product labels shall be printed at least in English.

2-5 User Information.

2-5.1 The SCBA manufacturer shall provide, with each SCBA, instructions and information for maintenance, cleaning, disinfecting, storage, and inspection.

2-5.2 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) of water column nor greater than 3.50 in. (88.9 mm) of 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 Test 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), 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 Test 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 Communications Test specified in Section 4-10 of this standard, the average calculated value shall not be 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) of water column nor greater than 3.50 in. (88.9 mm) of 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 4-11.21 of this standard, the facepiece lens shall not obscure vision below the 20/100 vision criterion.

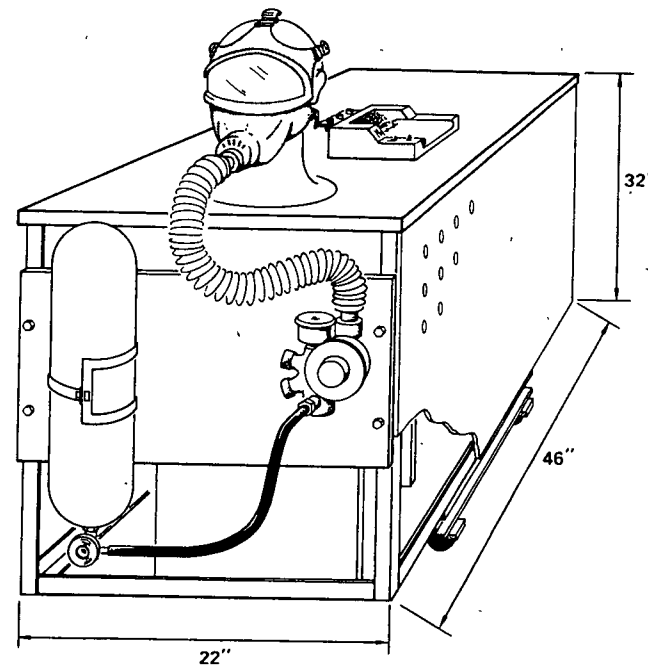
Chapter 4 Test Methods

4-1 Air Flow Performance Test.

4-1.1* The facepiece of the SCBA being tested shall be secured to Scott Aviation Model Nos. 803608-01 or 8-3608-02 test headform or equivalent. The facepiece shall be secured to the headform to assure that an initial pressure of 1.0 in. ±0.1 in. (25.4 mm ±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.

Figure 4-1.2 Typical Apparatus Configuration for Airflow Performance Test



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 holes, each 0.062 in. ±0.005 in. (1.6 mm ±0.1 mm), and positioned 0.250 in. ±0.02 in. (6.4 mm ±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: ±0.5% Full Scale (FS) best straight line
Line Pressure Effect: Less than 1% FS zero shift/1000 psig
Output: ±2.5 Vdc for ±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°F (55.6°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 .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 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.

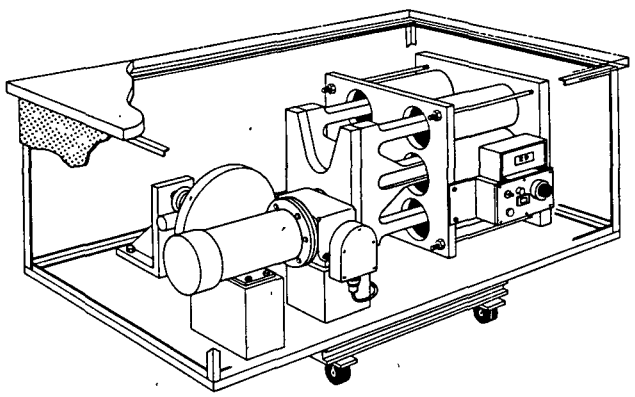
4-1.12* A Model 327-6 Breathing Machine as shown in Figures 4-1.12(a), (b), and (c) shall be used. The breathing machine shall be set to the following characteristics:

(SEE TABLE AT BOTTOM)

(SEE FIGURE 4-1.12(a) NEXT PAGE)

(SEE FIGURE 4-1.12(b) AFTER NEXT PAGE)

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



4-1.13 The test conditions shall be as follows:
Ambient temperature: 72°F ±5°F (22°C ±3°C)
Relative humidity: 50 percent ± 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 G7.1, 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 gauge. The pressure shall be measured using an incline manometer or equivalent with a scale measuring in increments of ±0.02 in. (±0.5 mm) of 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-life 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 ±5°F (22°C ±3°C) with a relative humidity of 50 percent ±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 ±2°F (-32°C ±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 ±10°F (-32°C ±5°C).

4-2.5 The SCBA shall be hot soaked at 160°F ±2°F (71°C ±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 ±10°F (71°C ±5°C).

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

VENTILATION RATE (liters/min)	RESPIRATORY FREQUENCY (breaths/min)	TIDAL VOLUME (liters)
103 ± 3	30 ± 1	3.4 Nominal

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

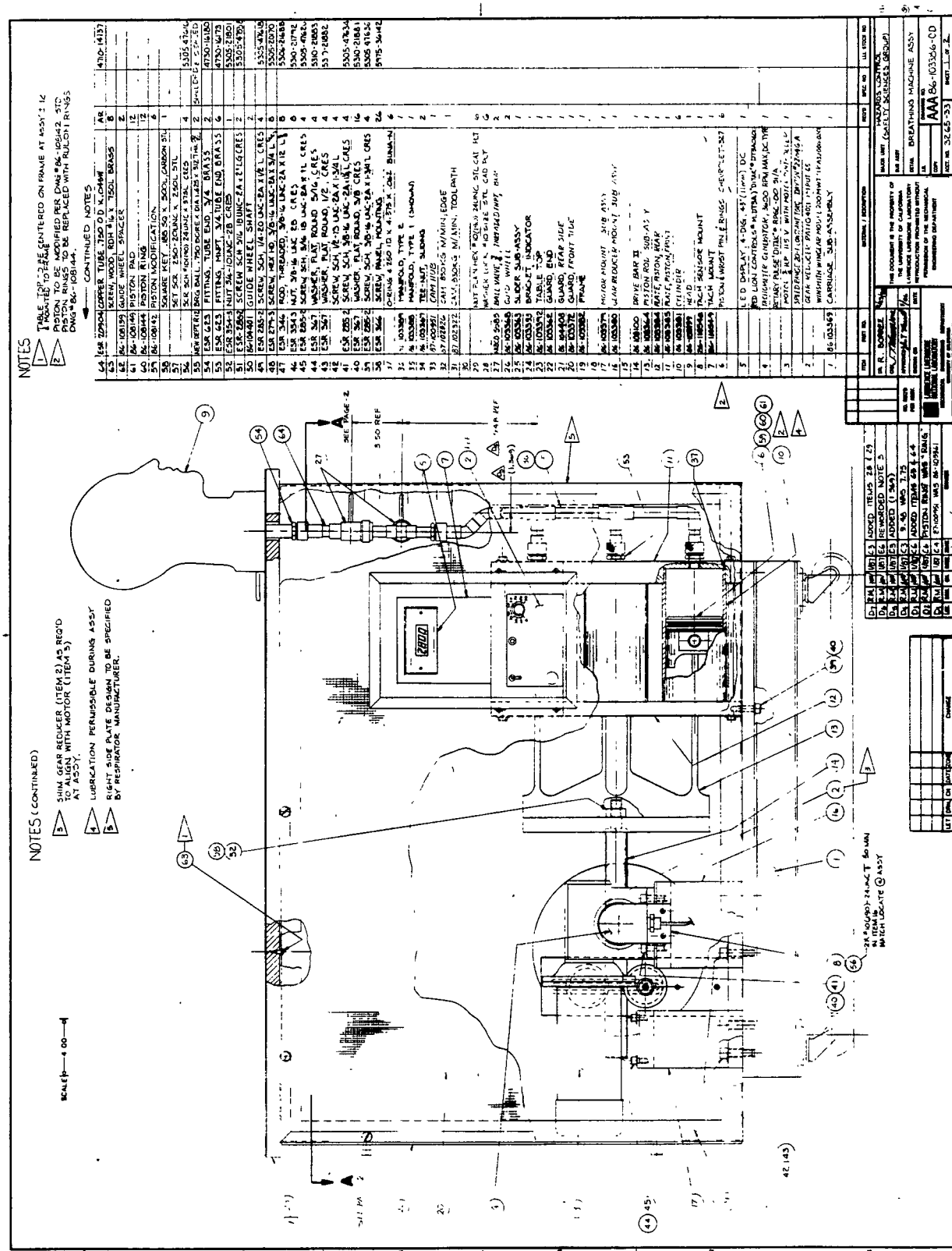
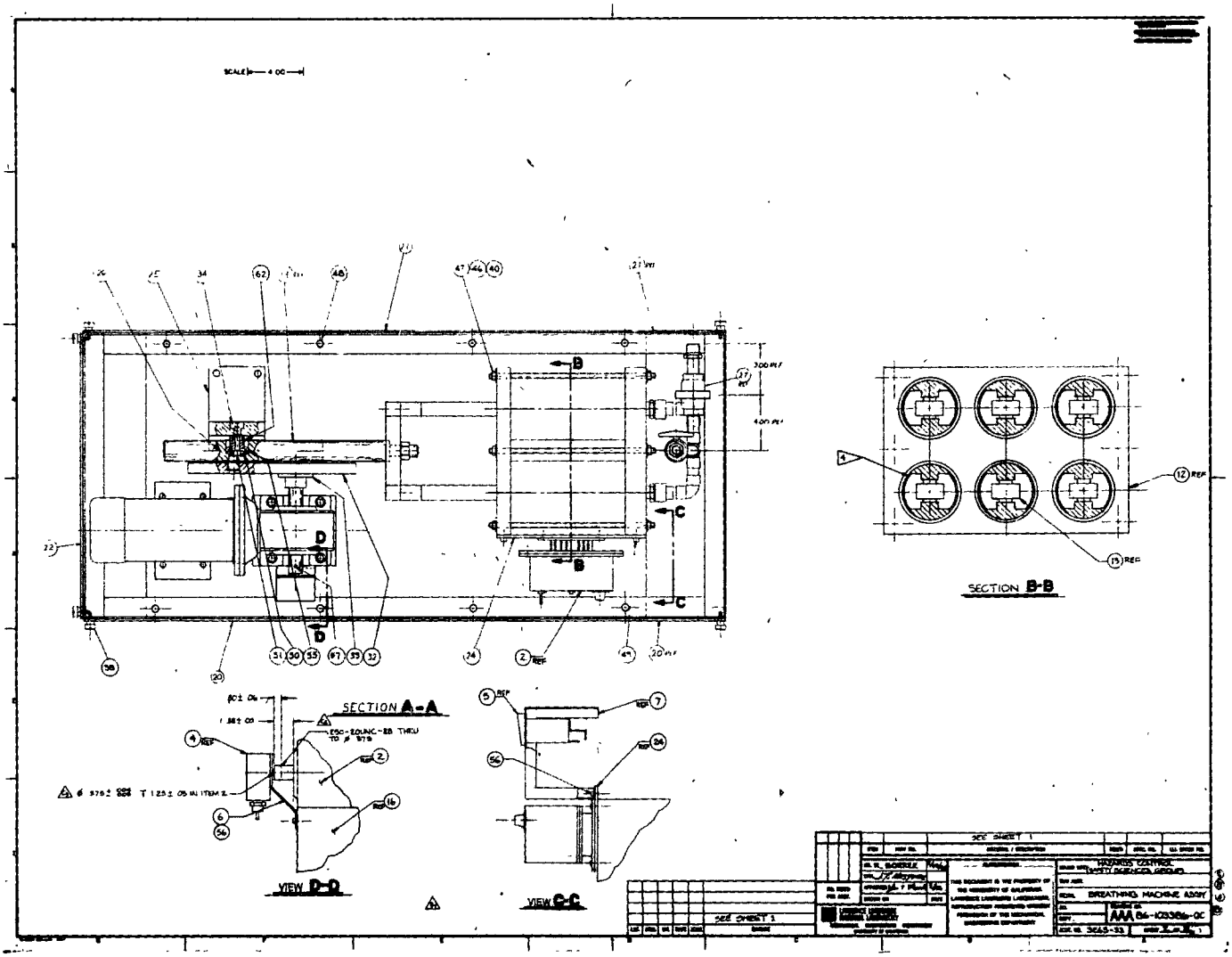


Figure 4-1.12 (b)



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

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.

(SEE FIGURE 4-3.2 NEXT PAGE< TOP)

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 A holding box shall be constructed with one-inch plywood to accommodate the complete SCBA, less facepiece, and those components that attach directly to the facepiece. The total travel distance between the SCBA and the sideboards of the vibration box shall be 2.0 ±0.5 in., 1.0 ±0.25 in./side (5.08 ±1.3 cm, 2.54 ±0.64 cm/side).

4-3.4.1 A separate plywood holding box shall be constructed with one inch plywood to accommodate the facepiece and those components that attach directly to the facepiece. The total travel distance between the SCBA components and the side boards of the vibration box shall be 2.0 ±0.5 in., 1.0 ±0.25 in.side (5.08 ±1.3 cm, 2.54 ±0:64 cm/side).

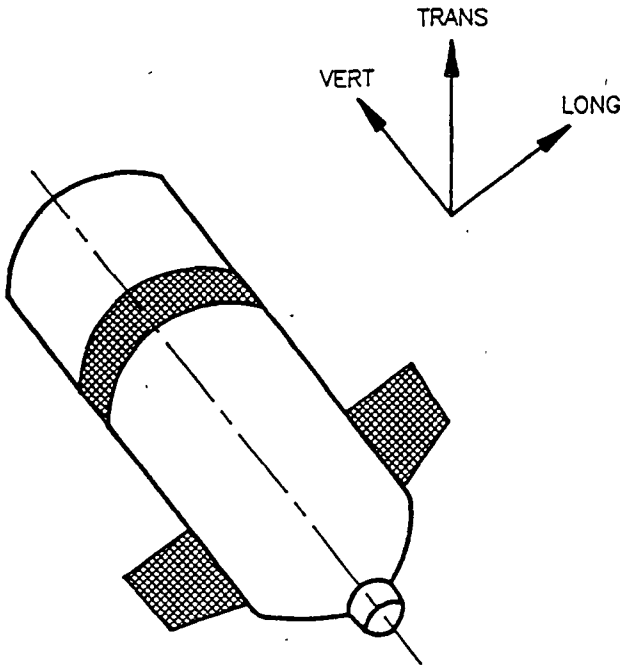


FIGURE 4-3.2 Test Specimen Axis Definition

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 four positions shown in Figures 4-3.6(a), 4-3.6(b), 4-3.6(c), and 4-3.6(d) of this standard. The total test duration shall be three hours, consisting of four 45-minute periods: one period for each position.

(SEE Figures 4-3.6a, b, c & d BELOW)

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.

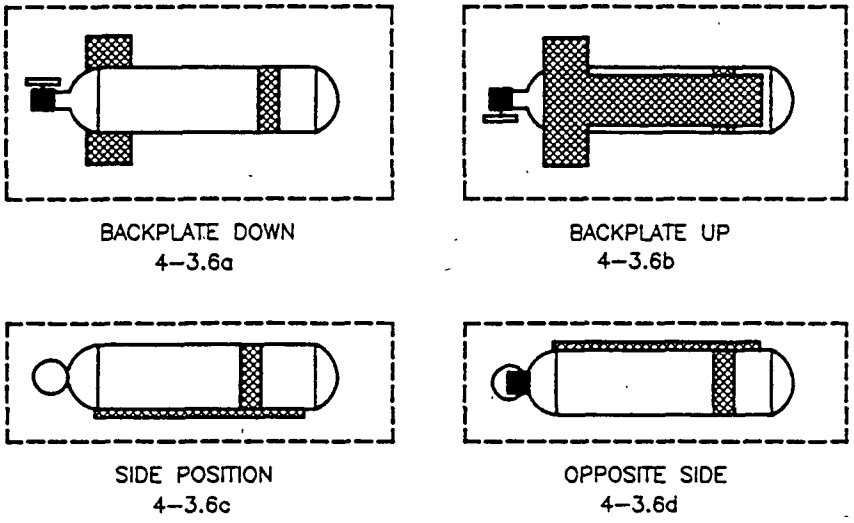
4-5 Fabric Heat Tests.

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 x 15 in. ±0.5 in. (381 x 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.



Figures 4-3.6a, b, c & d Test Specimen Orientation (Top View)

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% ±5% 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, 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° 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° 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.

(SEE FIGURE 4-9.1 NEXT TWO PAGES)

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 x 2 in. (51 x 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 1 1/2 inches (38 mm) of the 2 x 2 in. (51 x 51 mm) square shall be taken from the left side of the center line of the lens.
(d) The 2 x 2 in. (51 x 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 x 2 in. (51 x 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 1 1/2 inches (38 mm) of the 2 x 2 in. (51 x 51 mm) square shall be taken from the right side of the center line of the lens.
(d) The 2 x 2 in. (51 x 51 mm) square shall be cut at approximately eye level.

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 de-ionized 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, Test Methods for Haze and Luminous Transmittance of Transparent Platics, and recorded with the following additions:
(a) The haze shall be measured in the middle of the sample ±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, Test Methods for Haze and Luminous Transmissance 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 ±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.

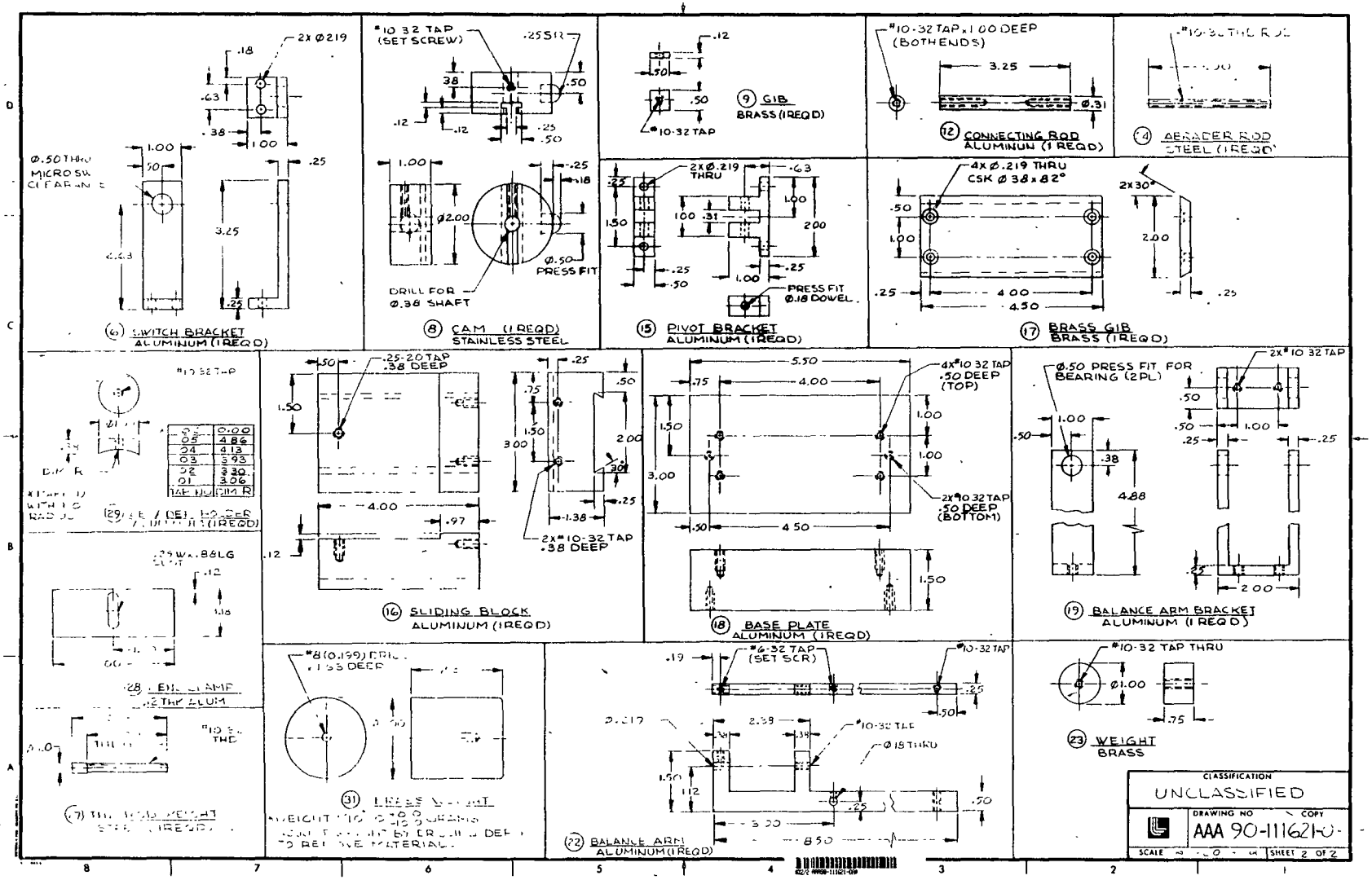
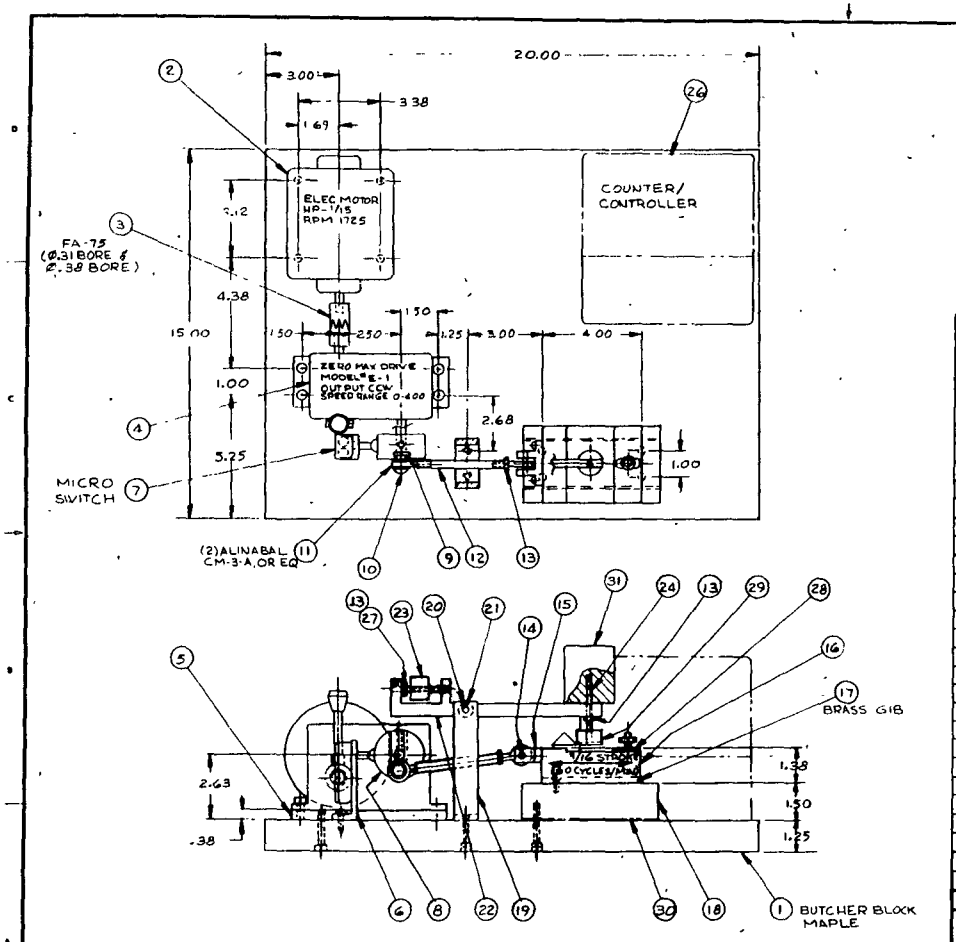


Figure 4-9.1 Lens Abrasion Tester

Figure 4.9.1 (continued)



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-403-1512.

NO REQD		PART / LENL STK NO	DESCRIPTION / MATERIAL	SPEC NO	ITEM
1			BRASS WEIGHT Ø2.00 x 2.32L BRASS		31
1			RUBBER CUSHION .032THK x 3.00W x 5.50L		30
1			ABRADER HOLDER Ø1.00 x 6.3L AL		29
1			LENS CLAMP .12THK x 1.18W x 3.00L AL		28
1			THD ROD WEIGHT STL		27
1	COMMERICAL		COUNTER / CONTROLLER		26
					25
1			ABRADER ROD #10-32 x 3.00L STL		24
1			WEIGHT Ø1.00 x .75 L BRASS		23
1			BALANCE ARM .25THK x .50W x 8.50L AL		22
2	COMMERICAL		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	COMMERICAL		DOWEL Ø.18 x 1.00L STL		14
3	COMMERICAL		LOCK NUT #10-32		13
1			CONNECTING ROD Ø.31 x 3.25L AL		12
2	COMMERICAL		BALL JOINT ROD END #10-32 STL		11
1	COMMERICAL		PIVOT SCREW & WASHER #10-32 x .38 STL		10
1			GIB .12THK x .50 SQ BRASS		9
1			CAM Ø 2.00 x 1.00L SST		8
1	COMMERICAL		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	COMMERICAL		VARIABLE SPEEDDRIVE ZERO-MAX "E" SERIES 0-400 RPM		4
1	COMMERICAL		COUPLING FA 75 Ø.31 BORE x Ø.38 BORE	EQ	3
1	COMMERICAL		MOTOR HP 1/15 RPM 1725	EQ	2
1			BASE BUTCHER BLOCK MAPLE 1.25THK x 15W x 20L		1

	LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE
A	A	BG	BG	BG	7/31	BG	WAS 7/16 STROKE

DWN DAN CILLEY 11/29/90
CHK O Beason 12/1/90
APVD O Beason 12/1/90
CLASSIFYING BY: TITLE DATE

LAWRENCE LIVERMORE NATIONAL LABORATORY MECHANICAL ENGINEERING DEPT UNIVERSITY OF CALIFORNIA

CLASSIFICATION

MATERIAL FOR UNIT
SUBASSY
DETAIL N.F.P.A. LENS ABRASION TEST APPARATUS
SHOWN ON AAA DRAWING NO AAA 90-111621-0A
ACCT NO 666885
SCALE NO — 4.0 — SHEET 1 OF 2

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 gram ±5 gram 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. with (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 ±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 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 have no 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 mask, 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 form 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 ±2 dB at each listener's head position, without listerers 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 ≥ 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:

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

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 x 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:

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

where 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 x 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 as 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.

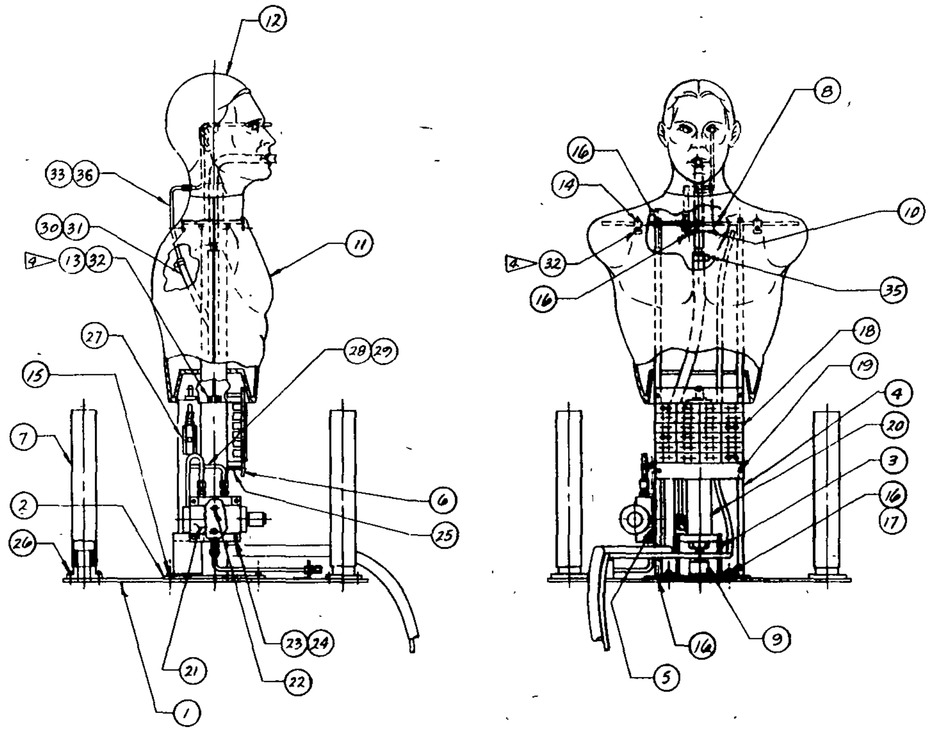
4-11 Heat and Flame Test.

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

(SEE FIGURE NEXT PAGE)

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. 4X $\phi.194^{+.010}_{-.002}$ THRU ITEM 11, MATCH DRILL FROM ITEMS 13 & 14 FOR ITEM 32



NO REQD	PART / LLNL STK NO	DESCRIPTION / MATERIAL		SPEC NO	ITEM
A/R		TUBE, S/STL, 1/4 O.D.			36
1		CLAMP, AEROSEAL, φ1/2			35
1	SWAGELOK -400-6	UNION, 1/4 TUBE	CRES		33
12		SCR, #8-32 UNC-2A RD HD X 3/8 LG	CRES		32
1		CLAMP, AEROSEAL, φ1/2	CRES		31
A/R		TUBE, PVC REINFORCED 1/4 I.D		9330-51405	30
5	SWAGELOK -600-1-2	MALE CONNECTOR, 3/8 TUBE X 1/8 NPT	CRES		29
A/R		TUBE, φ 375 X 035 W	CRES	4710-14193	28
1	ARO CORP	SNUBBER			27
12		SCR, 1/4-20 UNC-2A SOC HD X 1.00 LG	STL		26
4		STANDOFF, #6-32 THD, X 1.00 LG	ALUM	5975-53447	25
4		NUT, HEX, #10-32 UNF-2B STD	STL		24
4		SCR, #10-32 UNF-2A SOC HD X 1.50 LG	STL		23
4		SCR, #10-32 UNF-2A FLT HD X 1.00 LG	STL		22
1	ARO CORP MODEL K213SS120A	VALVE			21
1	ARO CORP 0418-1003-080	CYLINDER, AIR, 1 1/8 BORE			20
4		SCR, #6-32 UNC-2A RD HD X 1 1/2 LG	STL		19
4	MARLIN CORP 1032-6	CONNECTOR, T.C, 6 JACK, 2 HOLE, TYPE K		5935-58196	18
		NUT, HEX, 1/4-20 UNC-2B STD	STL		17
12		SCR, 1/4-20 UNC-2A FLT HD X .75 LG	STL		16
4		SCR, 1/4-20 UNC-2A SOC HD X .50 LG	STL		15
4	90-101459	BRACKET			14
2	90-101473 (A)	TIE STRAP			13
1	90-101456	HEAD			12
1	90-101461 OR 90-101458	TORSO I OR TORSO II			11
1	89-113884	COLLAR - MOUNT			10
1	89-113883	SHAFT END			9
1	89-111724	MOUNT PLATE, MANIKAN			8
4	89-113882	GUIDE VERTICAL			7
1	89-113881	TC PANEL			6
1	89-113880	VALVE PLATE			5
2	89-113878	FRAME BAR			4
1	89-113877	MOUNT - AIR CYL			3
1	89-113876	BASE MOUNT			2
1	89-113879	LIFT PLATE			1

LTR	DWN	CHK	APVD	DATE	ZONE	CHANGE
A				9/90		ITEM 13 WAS 90-101457

DWN G. Ferris 12/89
CHK Jan G Valha 9/5/90
APVD D. Beason 5/90
CLASSIFIED BY:
TITLE
DATE

LAWRENCE LIVERMORE NATIONAL LABORATORY
MECHANICAL ENGINEERING DEPT
UNIVERSITY OF CALIFORNIA

CLASSIFICATION

MAJOR UNIT: HAZARD CONTROL (SAFETY SCIENCE GROUP)
SUBASSY: NFPA HEAT & FLAME TEST APPARATUS
DETAIL: MANIKIN ASSY
ACCT NO: 3265-30
DRAWING NO: AAA 90-101453-OA
SCALE: 8.00
SHEET 1 OF 1

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.

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 x 34 in. sleeve (118 mm x 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 4-1.2(a), (b) and (c), with the modification that 0.75 in. ID 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 Strucutral 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 specified in Figure 4-11.9.

(SEE FIGURE NEXT TWO PAGES)

4-11.10 The test oven shall be a vertical 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 x 36 in. width x 48 in. height. (91 x 91 x 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 de-ionized 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 airflow 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 airflow 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 airflow 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 airflow 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 pre-heated 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.

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.

Figure 4-11.9

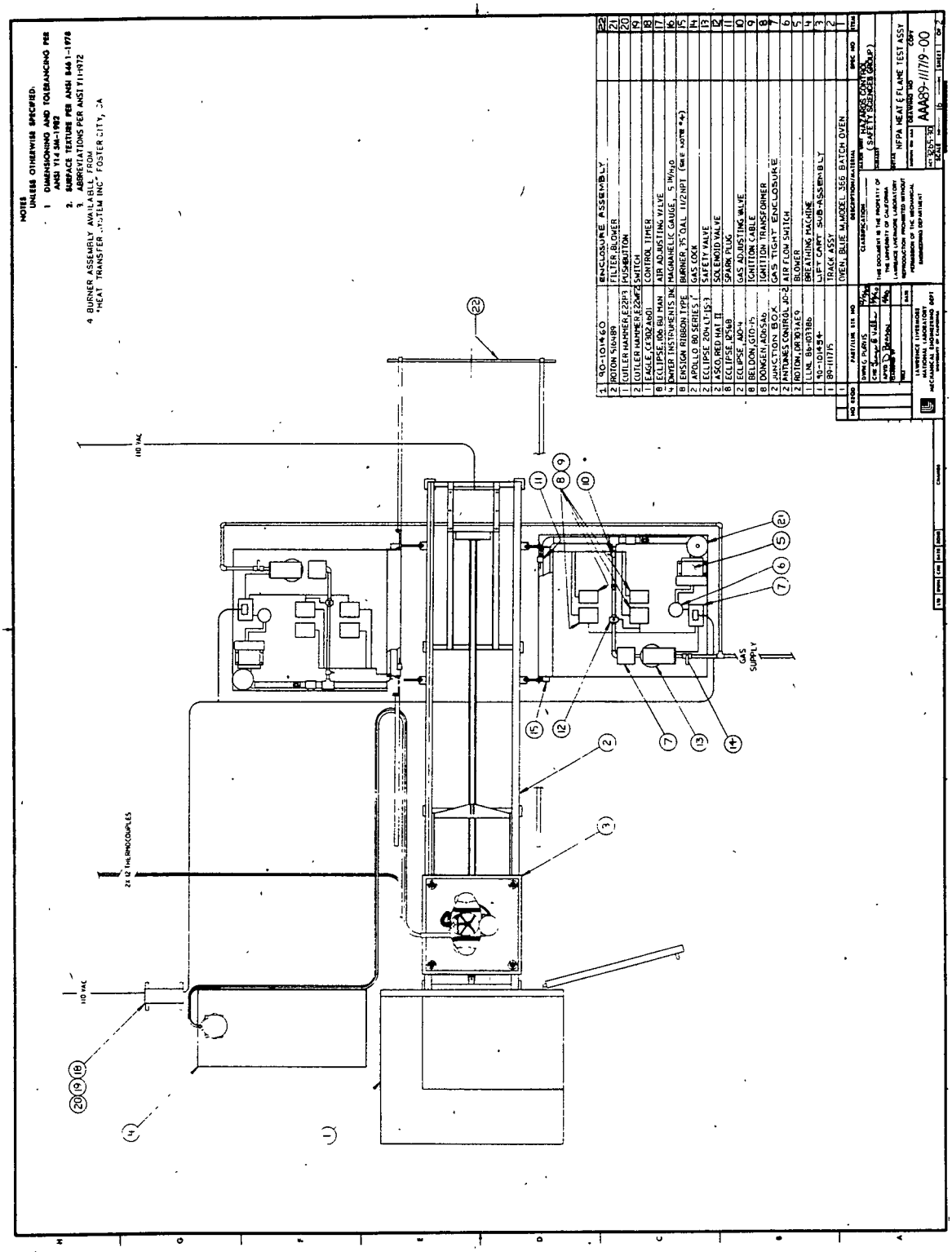
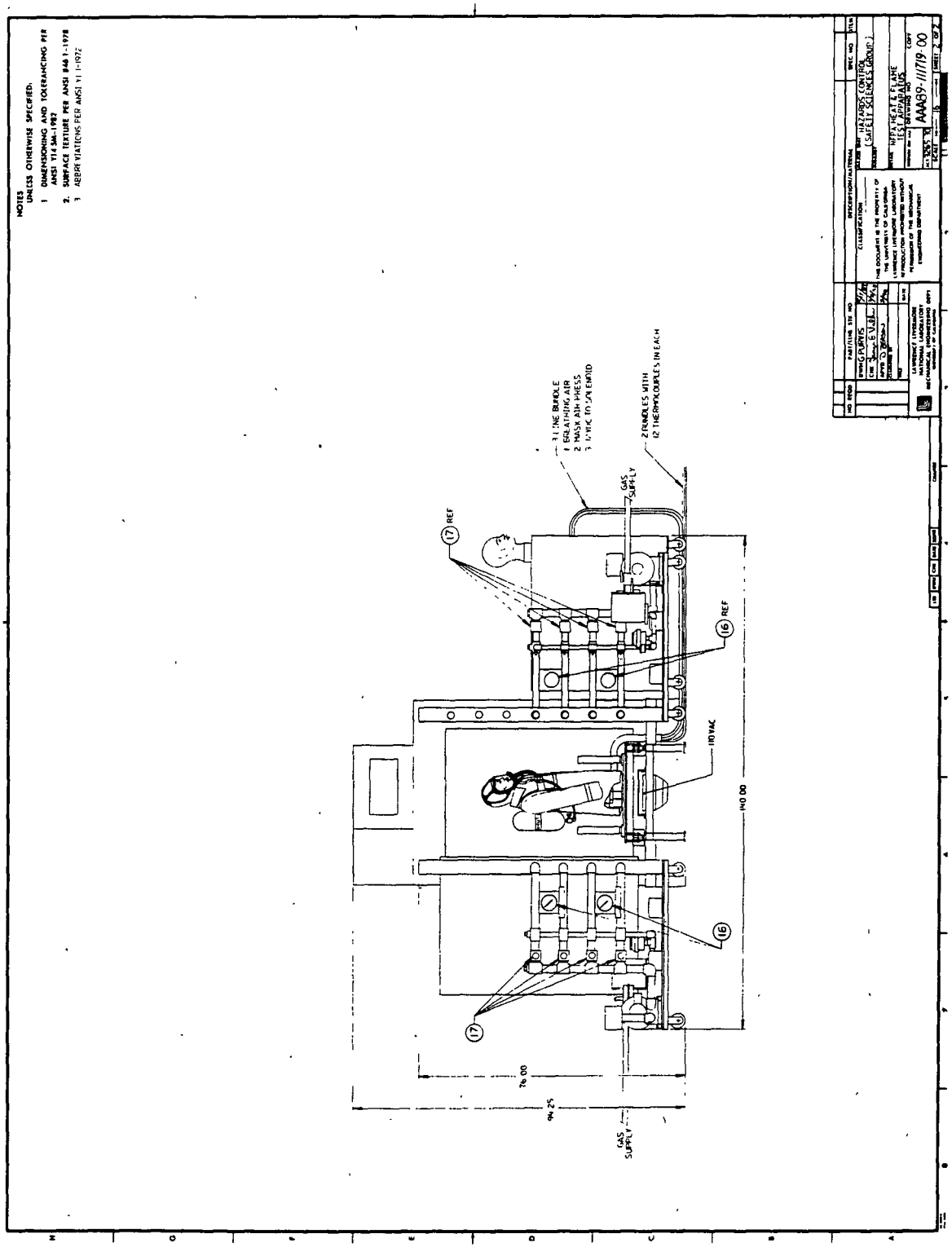

NOTES
UNLESS OTHERWISE SPECIFIED:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M-1982
2. SURFACE TEXTURE PER ANSI B46.1-1978
3. ABBREVIATIONS PER ANSI Y1.1-1972
4 BURNER ASSEMBLY AVAILABLE FROM "HEAT TRANSFER SYSTEM INC" FOSTER CITY, CA
ENCLOSURE ASSEMBLY
FILTER,BLOWER
PUSHBUTTON
SWITCH
CONTROL TIMER
AIR ADJUSTING VALVE
MAGNAHELIC GAUGE, 5 IWG
BURNER, 3" DIA. 1 1/2 NPT (SEE NOTE #4)
GAS COCK
SAFETY VALVE
SOLENOID VALVE
SPARK PLUG
GAS ADJUSTING VALVE
IGNITION CABLE
IGNITION TRANSFORMER
GAS TIGHT ENCLOSURE
AIR FLOW SWITCH
BLOWER
BREATHING MACHINE
LIFT CART SUB-ASSEMBLY
TRACK ASSY
OVEN, BLUE M MODEL 366 BATCH OVEN
DESCRIPTION/MATERIAL
NFPA HEAT & FLAME TEST ASSY
AAA89-11119-00
GAS SUPPLY
110 VAC
110 VAC
2 1/2" THERMOCOUPLES

Figure 4-11.9 (continued)



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 (65.8 m) eye chart with normal lighting of 100-150 ft-candles at the chart and with the test subject positioned at a distance of 20 ft (65.8 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 document and shall be considered part of the requirements of this document. The edition indicated for each reference shall be the current edition as of the date of the NFPA issuance of this document.

5-1.1* AATCC Publication.

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

5-1.2* ANSI Publications.

ANSI S3.2,

5-1.3* ASTM Publication.

ASTM D 1003, Test Methods for Haze and Luminous Transmittance of Transparent Plastics, 1988.

5-1.4* GSA Publication.

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

5-1.5* Navy Publication.

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

5-1.6* Superintendent of Documents 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 which 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 liters per minute to 100 liters per minute. The 100 liters per minute ventilation rate was derived from a review of several studies indicating that a ventilation rate of 100 standard liters per minute encompass 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.

A-1-2.1 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" agencies 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. There are requirements in many standards and regulations covering the quality of air to be used in open-circuit SCBA, and it is not the function of this Committee to reference all the established requirements. However, the Committee believes it is most important to remind the user that the quality and water content of the air in the cylinder are of great concern. ANSI/ CGA G7.1, Commodity Specification for Air, specifies air quality and dewpoint for SCBA. As a minimum, open-circuit SCBA manufacturers recommend and NIOSH requires the use of Grade D air. Open-circuit SCBA manufacturers also recommend that the air used to fill cylinders shall have a water vapor content of 25 ppm or less. Further, NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* in 5-3.6, requires that breathing air for SCBA be at least Grade D with a water vapor content of 25 ppm or less.

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 identifying 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 lbs (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 liters per minute. NIOSH uses this 40 liter per minute 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 liter per minute test, the typical SCBA cylinder must contain 1200 liters or more of compressed breathable air. A 45-cubic foot cylinder has a capacity of 1273.5 liters, based on 28.3 liters per cubic foot. Because actual work performed by a fire fighter often results in a ventilation rate that exceeds 40 liters per minute, 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 CO_2 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 CO_2 in the inhalation air leads to increased ventilation and, consequently, shorter service time for a given air supply. Means to reduce CO_2 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-3-1.1 The current NIOSH certification test method, 30 CFR 11, uses a ventilation rate of 40 liters per minute, while NFPA 1981 requires an airflow test based on a ventilation rate of 100 liters per minute. A ventilation rate of 100 standard liters per minute encompasses the 98th percentile of all fire fighters studied. The ability of the SCBA to supply the 100 liters per minute of breathing air is measured in this airflow 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 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 an appropriate method to do this.

The Student t-distribution quantile 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.

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 1.)

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 Figure 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 Figure 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 RPMs 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 Figure 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.

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 Figure 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,

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

4. Determine the tidal volume (TV),

$$TV = \frac{V_{SIPD}}{NE}$$

5. Determine the Minute Volume, V_M.

$V_M = TV \times RPM$

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.

(SEE Figure A-4-1.14 NEXT PAGE)

The total distance is the length that the 30 exhalations take on the strip chart recording. Each positive pressure peak indicates an exhalation stroke.

(SEE Calibration Log AFTER NEXT PAGE)

A-4-9.7 The Blue Streak M3-6M wool felt polishing pad can be obtained from J.I. Morris Co., 394 Elm Street, Southbridge, MA.

A-4-9.8 The 3M, 7415 Wood Finishing Pad is an abrasive sheet that has markings on one side. The pad can be obtained from 3M Corp. Box 33053, St. Paul, MN 55133.

A-4-11.2 The protective covering has been selected solely for the purpose of protecting the Flame and Heat Test mannequin and providing a reproducible exterior configuration to support the SCBA being tested. The intention of this standard is to test the SCBA and not the protective covering.

A-5-1.1 AATCC publications can be obtained from the American Association of Textile Chemists and Colorists, Post Office Box 12215, Research Triangle Park, NC 27709.

A-5-1.2 ANSI publications can be obtained from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

A-5-1.3 ASTM publications can be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

A-5-1.4 GSA publications can be obtained from the General Services Administration, Specifications Activities, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington, DC 20407.

A-5-1.5 Navy publications can be obtained from the Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

A-5-1.6 Superintendent of Documents publications can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Appendix B

B-1 The following documents or portions thereof are referenced within this document for informational purposes only and thus should not be considered part of the requirements of this document. The edition indicated for each reference should be the current edition as of the date of the NFPA issuance of this document.

B-1-1 Other Publications.

American National Standards Institute, 1430 Broadway, New York, NY 10018.

ANSI Z88.2, Practices for Respiratory Protection, 1982

ANSI Z88.6, Standard for Respiratory Protection — Respirator Use Physical Qualifications for Personnel, 1984.

ANSI/CGA G7.1, Method for Measuring the Intelligibility of Speech Over Communication Systems, 1989.

Figure A-4-1.14

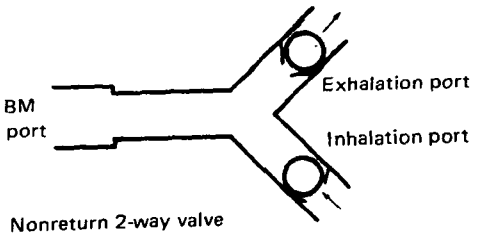
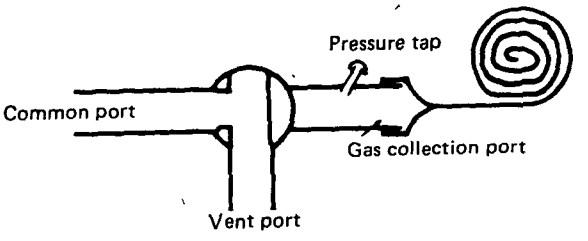
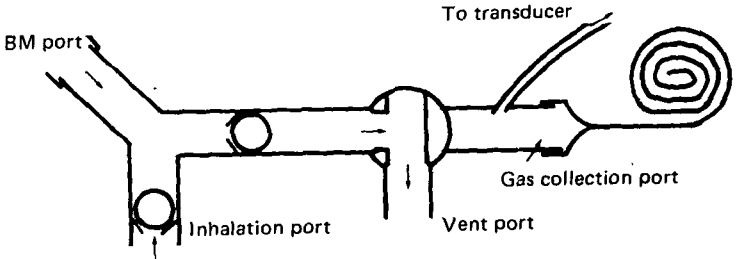


Figure 1



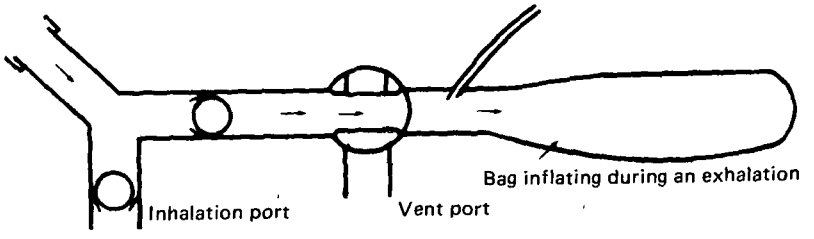
3-way valve with gas collection bag

Figure 2



3-way valve connected to nonreturn 2-way valve

Figure 3



System in gas collecting mode

Figure 4

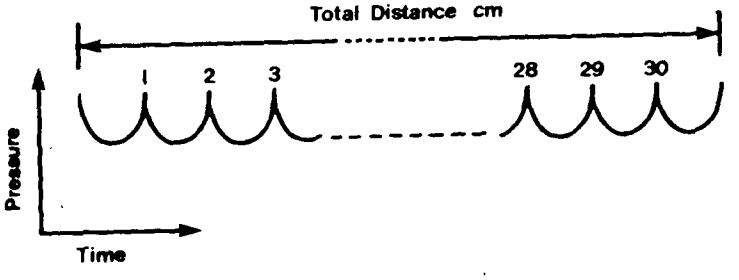


Figure A-4-1.14

Calibration Log
for Model 327-6 Breathing Machine

1.	2.	3.	4.	5.	6.	7.	8.	9.
Date	T (°R)	Pb (mm Hg)	V_m	NE	RPM	TV (liters) $\left[\frac{V_{STPD}}{NE}\right]$	MV (liters) [IV = RPM]	OPR Initials

PART V

1999- 1 - (Entire Document): Accept
SUBMITTER: Technical Committee on Fire Service Protective Clothing and Equipment
RECOMMENDATION: Adopt the new document NFPA 1999, Standard on Protective Clothing for Medical Emergency Operations, 1992 Edition.
SUBSTANTIATION: This new standard covers protective garments, gloves, and facewear designed to protect emergency medical service personnel against exposure to liquid borne pathogens during emergency medical operations. Each type of clothing must resist penetration to blood-borne pathogens as determined by performance tests to determine "fluid-proof" performance of materials. Garments are also required to meet requirements for overall lquid-tight integrity, material strength and physical hazard resistance, seam strength, and closure strength. Gloves must demonstrate minimum performance for tensile and elongation properties, in an "as received" condition as well as following heat aging and isopropyl alocohol immersion. Gloves also must meet requirements for minimum sizing, liquid tight integrity, puncture resistance, and dexterity. Facewear is tested for and must meet minimum requirements with respect to water-tight integrity for intended areas of penetration. The selectiron of test methods and performance requirements was based on surveys of EMS personal and a technical study supported by the U.S. Fire Administration.
COMMITTEE ACTION: Accept.

NFPA 1999

Standard on

Protective Clothing for Emergency Medical Operations

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 6.

Chapter 1 Administration

1-1 Scope.

1-1.1* This standard specifies minimum documentation, design criteria, performance criteria and test methods for emergency medical clothing, including garments, gloves, and face protection devices.

1-1.2* This standard does not apply to protective clothing for any fire fighting application.

1-1.3* This standard does not provide criteria for protection from radiological or cryogenic agents, hazardous chemicals, or flammable or explosive atmospheres.

1-1.4* This standard is not intended to be utilized as a detailed manufacturing or purchase specification, but can be referenced in purchase specifications as minimum requirements.

1-2 Purpose.

1-2.1 The purpose of this standard is to provide minimum requirements for emergency medical garments, gloves, and face protection devices designed to minimize skin exposure to liquid-borne pathogens under the various conditions that might exist at the scene of an emergency.

1-2.2* It is not the purpose of this standard to provide criteria for protection from biological agents that are not liquid borne.

1-2.3 Controlled laboratory tests used to determine compliance with the performance requirements of this standard shall not be deemed as establishing performance levels for any situations to which personnel may be exposed.

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.

Biological Agents. Biological materials that are capable of causing a disease or long term damage to the human body.

Body Fluids. Fluids that the body makes including, but not limited to, blood, semen, mucus, feces, urine, vaginal secretions, breast milk, amniotic fluid, cerebrospinal fluid, synovial fluid, and pericardial fluid.

Boot. A protective clothing item designed to protect the wearer's feet.

Bootie. A sock-like extension of the garment leg designed to protect the wearer's feet when worn in conjunction with an outer boot.

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 the 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 compliance 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.

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

Cryogenic Agents. Low temperature materials that are capable of causing acute or long term freeze burn damage to the human body.

Emergency Medical Clothing. A single garment or an assembly of multiple garments constructed of protective clothing material, designed and configured to cover any part of the wearer's skin that meets all applicable requirements of NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations.*

Emergency Medical Face Protection Device. A face protection device which meets all applicable requirements of NFPA 1999, *Standard on Protective Clothing for Emergency Medical Operations.*

Emergency Medical Glove. A glove constructed of protective clothing materials designed and configured to cover the wearers hand to at least the wrist and meets all applicable requirements of NFPA 1999, *Standard on Protective Clothing of Emergency Medical Operations.*

Emergency Medical Operations. Delivery of emergency patient care and transportation prior to arrival at a hospital or other health care facility.

Emergency Patient Care. The provision of treatment to patients, including first aid, cardiopulmonary resuscitation, basic life support (EMT level), advanced life support (Paramedic level), and other medical procedures that occur prior to arrival at a hospital or other health care facility.

Exposure. Contact with an infectious agent, such as body fluids, through inhalation, percutaneous inoculation, or contact with an open wound, nonintact skin, or mucous membrane.

Face Protection Devices. Devices constructed of protective clothing materials designed and configured to cover part or all of the wearer's entire face or head. Face protection devices may include splash resistant eyewear, hooded visors, or respirators.

Face Protection Device Product Label. A label affixed to or imprinted on the face protection device by the manufacturer indicating compliance with this standard. This product device label is not a certification organization label or identifying make.

Flammable or Explosive Atmospheres. Atmospheres containing substances or gases at concentrations that will burn or explode if ignited.

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 labeled and listed products that are being produced by the manufacturer to the requirements of this standard.

Garment. An item of clothing that covers any part of the wearer's skin except accessory items like gloves or face protection devices.

Garment Closure. The garment component designed and configured to allow the wearer to enter (don) and exit (doff) the emergency medical garment.

Garment Closure Assembly. The combination of the garment closure and the seam attaching the garment closure to the garment, excluding any protective flap or cover.

Garment Product Label. A label affixed to the garment by the manufacturer containing general information, warnings, care, maintenance, or similar data. This product label is not a certification organization's label or identifying mark.

Garment Material. The primary protective clothing material(s) used in the construction of Emergency Medical Garments.

Glove. A protective clothing item designed to protect the wearer's hands.

Glove Product Label. A label affixed to or imprinted on the glove by the manufacturer indicating compliance with this standard. This product label is not a certification organization's label or identifying mark.

Glove Material. The primary protective clothing material(s) used in the construction of Emergency Medical Gloves.

Hazardous Chemical. Any solid, liquid, gas or mixture thereof that can potentially cause harm to the human body through respiration, ingestion, skin absorption, or contact.

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.

Liquid Borne Pathogen. An infectious bacteria or virus carried in human, animal or clinical body fluids, organs or tissues.

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.

Package. The wrapping or enclosure directly containing the emergency medical glove or face protection device.

Protective Clothing Material. Any material or combination of materials used in garments, gloves, or face protection devices for the purpose of isolating parts of the wearer's body from contact with liquid borne pathogens or physical hazards.

Radiological Agents. Radiation associated with x-rays, alpha, and gamma emissions from radioactive isotopes or other material in excess of normal radiation background levels.

Seam. Any permanent attachment of two or more garment or glove materials, excluding external fittings, gaskets, and garment closure assemblies, in a line formed by joining the separate material pieces.

Shall. This term indicates a mandatory requirement.

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

Splash Resistant Eyewear. Safety glasses, prescription eyewear, goggles, or chin-length face shields that when properly worn provide limited protection against splashes, spray, spatters, droplets, or aerosols of body fluids or other potentially infectious material.

Trace Number. A code that can be used to retrieve the production history of a product, for example a lot or serial number.

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 Emergency medical garments, gloves, and face protection devices that are labeled as being compliant with this standard shall meet or exceed all applicable requirements specified in this standard and shall be certified.

2-1.2 All certifications shall be performed by an approved certification organization.

2-1.3 Compliant emergency medical garments shall be labeled and listed. Such garments shall also have a garment product label that meets the requirements specified in Section 2-5 of this Chapter.

2-1.4 Compliant emergency medical gloves shall be labeled and listed. Such gloves shall also have product labels that meets the requirements specified in Section 2-6 of this Chapter.

2-1.5 Compliant emergency medical face protection devices shall be labeled and listed. Such face protection devices shall also have product labels that meet the requirements specified on Section 2-7 of this Chapter.

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 applicable requirements of this standard.

2-2.3* The contractual provisions between the certification organization and the manufacturer shall specify that certification is contingent on compliance with all applicable requirements of this standard. There shall be no conditional, temporary, or partial certifications.

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 that meets the requirements of Section 2-4 of this Chapter.

2-2.6 The manufacturer 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 Sampling levels for testing and inspection shall be established by the certification organization and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified to this standard are compliant. This information shall be included in the manufacturers technical data package.

2-3.2 Testing for determining material and component compliance with the requirements specified in Chapter 4 of this standard shall be performed on samples representative of materials and components used in the actual construction of the emergency medical garments, gloves, or face protection devices. The certification organization shall also be permitted to use sample materials cut from representative emergency medical clothing.

2-3.3 Any combination of materials used in emergency medical clothing that is needed to meet any of the performance requirements specified in Chapter 4 of this standard, shall also be required to meet all of the requirements for that particular segment of the emergency medical clothing.

2-4 Manufacturer's Quality Assurance.

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 product conformance to this standard.

2-4.2 The characteristics to be inspected, or tested, or both shall be classified according to the potential effect of such defects and grouped into the following classes:

(a) Major A — a defect that will reduce protection and is not readily detectable by the user;

(b) Major B — a defect, other than Major A, that is likely to result in reduced protection, and is detectable by the user; and

(c) Minor — a defect that is not likely to materially reduce the usability of the device for its intended purpose .

2-4.2.1 The acceptable quality level shall be as defined by Military Standard MIL-STD 105D, *Sampling Procedures and Tables for Inspection by Attributes*, Inspection Level II.

2-4.2.2 The acceptable quality level for all garment defects shall be as follows: (a) Major A — 1.0, (b) Major B — 2.5, and (c) Minor — 4.0.

2-4.3 The manufacturer shall maintain written inspection and testing instructions. The instructions shall prescribe inspection and test of materials, work in process, and completed articles. In addition, criteria for acceptance and rejection of product shall be included in the instructions.

2-4.4 The manufacturer shall maintain records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found and the quantities accepted or rejected.

2-4.5 The manufacturer shall take action to correct discrepant conditions which have resulted, or could result, in products which do not conform to the requirements of this Standard. The nature of the discrepancy and the corrective action taken shall be documented.

2-4.6 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.

2-4.7 Subcontracted or purchased supplies shall be subjected to inspection after receipt, as necessary, to assure conformance of the end item to the requirements of this standard. When manufacturers rely upon the supplier to provide data to demonstrate material conformance to this standard, or when the supplier is individually certified, that data shall become a part of the manufacturer's inspection records. The use of a supplier's test data or certification shall not relieve the manufacturer of their responsibility to furnish an end item which complies with all the requirements of this standard.

2-4.8 When the manufacturer conducts quality assurance testing, the 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.

2-4.8.1 The manufacturer, at their option, shall be permitted to utilize an outside test facility to conduct the quality assurance tests. When this option is selected, the outside test facility shall meet the requirements of 2-4.8 of this Section.

2-4.8.2 The test facility shall provide a written report to the manufacturer that describes the tests performed and the results. This report shall become a part of the manufacturer's inspection records.

2-4.9 The manufacturer shall maintain a system for identifying the appropriate inspection status of component materials, work in-process, and finished goods.

2-4.10 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.

2-5 Garment Product Labeling.

2-5.1 The emergency medical garment shall have a garment product label permanently and conspicuously attached to the inside of the garment upon which at least, the following warnings and information are printed in at least 1/16 in (1.5 mm) high letters.

THIS EMERGENCY MEDICAL GARMENT MEETS THE REQUIREMENTS OF
NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 1992 EDITION.

WARNING

THIS GARMENT MAY BURN. IT HAS NOT BEEN REQUIRED TO MEET A FLAMMABLE PERFORMANCE TEST. USE THIS GARMENT FOR EMERGENCY MEDICAL RESPONSE ONLY. DO NOT USE FOR PROTECTION FROM ANY HAZARDOUS CHEMICAL EMERGENCIES, FIRE FIGHTING APPLICATIONS, CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CONTAMINATION OF THIS GARMENT MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE GARMENT CAN PROVIDE PROTECTION FROM ALL CONDITIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Garment model and style
Trace number
Date of manufacture
Size

"DO NOT REMOVE LABEL"

2-5.2 All portions of this required garment product label shall be printed at least in English. The label shall be clearly legible to the eye.

2-6 Glove Product Labeling.

2-6.1 The emergency medical glove shall have at least a glove product label on the outside of the gauntlet that includes the following statement printed in at least 1/4 inch (6.0 mm) high letters:

"MEETS NFPA 1999 (1992 EDITION)"

2-6.2 Each package containing one or more emergency medical gloves shall have a package product label permanently and conspicuously attached to the outside or printed on the package upon which at least the following warnings and information are printed in at least 1/16 in (1.5 mm) high letters.

"THIS EMERGENCY MEDICAL GLOVE MEETS THE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 1992 EDITION.

WARNING

THIS GLOVE MAY BURN. IT HAS NOT BEEN REQUIRED TO MEET A FLAMMABLE PERFORMANCE TEST. USE THIS GLOVE FOR EMERGENCY MEDICAL OPERATIONS ONLY. DO NOT USE FOR PROTECTION FROM ANY HAZARDOUS CHEMICAL EMERGENCIES, FIRE FIGHTING APPLICATIONS, CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CONTAMINATION OF THIS GLOVE MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE CLOTHING CAN PROVIDE PROTECTION FROM ALL CONDITIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Glove model and style
Trace number
Date of manufacture
Size

"DO NOT REMOVE LABEL"

2-6.3 All portions of the required glove and package product labels shall be printed in at least English. All labels shall be clearly legible to the eye.

2-7 Face Protection Device Product Labeling.

2-7.1 The emergency medical face protection device shall have a face protection device product label in a conspicuous location not interfering with vision that includes the following statement printed in at least 1/4 (6.0 mm) high letters:

"MEETS NFPA 1999 (1992 EDITION)".

2-7.2 Each package containing one or more emergency medical face protection devices shall have a package product label permanently and conspicuously attached to the outside of the package upon which at least the following warnings and information are printed in at least 1/16 in (1.5 mm) high letters.

"THIS EMERGENCY MEDICAL FACE PROTECTION DEVICE MEETS THE REQUIREMENTS OF NFPA 1999, STANDARD ON PROTECTIVE CLOTHING FOR EMERGENCY MEDICAL OPERATIONS, 1992 EDITION.

WARNING

THIS FACE PROTECTION DEVICE MAY BURN. IT HAS NOT BEEN REQUIRED TO MEET A FLAMMABLE PERFORMANCE TEST. USE THIS FACE PROTECTION DEVICE FOR EMERGENCY MEDICAL OPERATIONS ONLY. DO NOT USE FOR PROTECTION FROM ANY HAZARDOUS CHEMICAL EMERGENCIES, FIRE FIGHTING APPLICATIONS, CRYOGENIC AGENTS, OR IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES. CONTAMINATION OF THIS FACE PROTECTION DEVICE MAY WARRANT ITS DISPOSAL. MAINTAIN ONLY IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. NO PROTECTIVE DEVICE CAN PROVIDE PROTECTION FROM ALL CONDITIONS. FAILURE TO COMPLY WITH THESE INSTRUCTIONS MAY RESULT IN SERIOUS INJURY OR DEATH."

Manufacturer's name
Manufacturer's address
Country of manufacture
Device model and style
Trace number
Date of manufacture
Size

"DO NOT REMOVE LABEL"

2-7.3 All portions of the required face protection device and package product labels shall be printed in at least English. All labels shall be clearly legible to the eye.

2-8 Garment User Information.

2-8.1 The manufacturer of emergency medical garments certified as being compliant with this standard shall provide the following instructions and information with each garment:

(a) Cleaning instructions;
(b) Marking and storage instructions;
(c) Frequency and details of inspections;
(d) Maintenance criteria;
(e) How to use test equipment, where applicable;
(f) Method of repair, if recommended by manufacturer;
(g) Warranty information.

2-8.2 The manufacturer of emergency medical garments shall also furnish training materials that address, but are not limited to:
(a) Donning procedures;
(b) Doffing procedures;
(c) Safety considerations;
(d) Optimum storage conditions;
(e) Recommended storage life;
(f) Decontamination recommendations and considerations;
(g) Retirement considerations;
(h) Disposal considerations;and
(i) Closure lubricants, if applicable.

2-9 Glove User Information.

2-9.1 The manufacturer of emergency medical gloves certified as being compliant with this standard shall provide the following instructions and information with each package of gloves:
(a) Donning procedures;
(b) Doffing procedures;
(c) Safety considerations;
(d) Optimum storage conditions;
(e) Recommended storage life;
(f) Decontamination recommendations and considerations;
(g) Retirement considerations;and
(h) Disposal considerations.

2-10 Face Protection Device User Information.

2-10.1 The manufacturer of emergency medical face protection certified as being compliant with this standard shall provide the following instructions and information with each package of face protection devices:

(a) Donning procedures;
(b) Doffing procedures;
(c) Safety considerations;
(d) Optimum storage conditions;
(e) Recommended storage life;
(f) Decontamination recommendations and considerations;
(g) Retirement considerations;
(h) Disposal considerations;and
(i) Visor/faceshield antifog agents or procedures, if applicable.

Chapter 3 Documentation Requirements

3-1 Technical Data Package.

3-1.1* Upon the request of the purchaser or end user, the manufacturer shall furnish a technical data package with each type of clothing.

3-1.2 The technical data package shall contain all documentation required by this standard and the data showing compliance with this standard.

3-2 Emergency Medical Garment Information.

3-2.1 In the technical data package, the manufacturer shall describe the emergency medical garment in terms of manufacturer trade name and model number, manufacturer replaceable components and available options, accessories such as repair kits and sizes.

3-2.2 The manufacturer shall provide, in the technical package, the list and descriptions of the following garment materials and components, if applicable:

(a) Garment material;
(b) Boot or bootie material;
(c) Zipper/closure type and materials;
(d) Material seam types and composition;
(e) External fitting types and material(s);
(f) External gasket types and material(s).

3-2.2.1 All descriptions of material composition shall specify either the generic material names or trade names if the composition of the material is proprietary.

3-2.2.2 Descriptions of respective suit materials and components shall include the following information, if applicable:

(a) Boots or Booties

1. Type of linings or surface treatments;
2. Type of soles or special toe reinforcements.
3. Available boot sizes.

(b) Garment Zipper or Closure

1. The material(s) of construction for the closure (including chain, slide, pull and tape for zippers);
2. The location and the length of the completed closure assembly.
3. A description of any protective covers or flaps.

3-2.3 The manufacturer shall describe, in the technical data package, the type of seams or methods of attachment for the following garment material and component combinations; if applicable:

(a) Garment material-garment material;
(b) Garment material-visor;
(c) Garment material-glove;
(d) Garment material-boot; and
(e) Garment material-garment closure.

3-2.4* The manufacturer shall document, in the technical data package, the flame resistance of the garment material when tested as specified in Section 5-1 of this standard.

3-2.5* This manufacturer shall document, in the technical data package, penetration resistance after abrasion to liquid borne pathogens of the garment material for one hour, when tested as specified in Section 5-2 of this standard.

3-2.6* The manufacturer shall document, in the technical data package, penetration resistance after flexing to liquid-borne pathogens of the garment material for one hour, when tested as specified in Section 5-3 of this standard.

3-3 Emergency Medical Glove Information.

3-3.1 In the technical data package, the manufacturer shall provide the following information, if applicable:

(a) Name or designation of manufacturer,
(b) Model, name number or design,
(c) Material composition,
(d) Description of material seams,
(e) Type of linings or surface treatments, and
(f) Available glove sizes.

3-3.2 Description of the material composition shall specify either the generic material name or tradename if the composition of the material is proprietary.

3-4 Emergency Medical Face Protection Device Information.

3-4.1 In the technical data package, the manufacturer shall provide the following information, if applicable:

(a) Name or designation of manufacturer,
(b) Model, name, number or design,
(c) Material composition,
(d) Description of any hardware,
(e) Replaceable items, and
(f) Available sizes.

3-4.2 Description of the material composition shall specify either the generic material name or tradename if the composition of the material is proprietary.

Chapter 4 Design and Performance Requirements

4-1* Emergency Medical Garment Requirements.

4-1.1 All external fittings including, but not limited to, zippers, snaps, or other fasteners, shall be free of rough spots, burrs, or sharp edges that could tear the garment or glove materials.

4-1.2 Sample garments shall be tested for water-tight integrity and allow no water penetration when tested as specified by Section 5-4 of this standard.

4-1.3 Garment material samples shall exhibit no penetration of Phi-X-174 Bacteriophage for at least one hour when tested as specified by Section 5-5 of this standard.

4-1.4 Garment material samples shall be tested for tensile strength and have a tensile strength of not less than 30 lbs (13.6 kg) when tested in accordance with Section 9 of ASTM D 751, *Methods of Testing Coated Fabrics, Breaking Strength, A - Grab Method.*

4-1.5 Garment material samples shall be tested for bursting strength and have a bursting strength of not less than 50 psi (3.5 kg/cm^2) in accordance with Section 15.3 of ASTM D 751, *Methods for Testing Coated Fabrics, Bursting Strength, using the Diaphragm Bursting Testing.*

4-1.6 Garment material samples shall be tested for puncture resistance and shall have a puncture resistance of not less than 5.5 lbs (2.5 kg) when tested in accordance with ASTM D 2582, *Standard Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting.*

4-1.7 Garment material samples shall be tested for tear strength and have a tear strength of not less than 8.0 lbs when tested as specified in Section 5-6 of this standard.

4-1.8 All garment seams shall possess a breaking strength of not less than 15 lbf/2in. (66.7N/5.0 cm) when tested in accordance with Section 50-55 of ASTM D 751, of *Testing Coated Fabrics, Seam Strength.*

4-1.9* The garment closure assembly shall possess a breaking strength of not less than 15 lbf/2 in. (6.77N/5.0 cm) when tested in accordance with Section 50-55 of ASTM D 751, *Methods of Testing Coated Fabrics, Seam Strength.*

4-2* Emergency Medical Glove Requirements.

4-2.1 Sample gloves and related hardware shall be free of rough spots, burrs, or sharp edges which could tear the garment or glove material.

4-2.2 Sample gloves shall be tested for water tight integrity and meet the "pass" requirements when tested in accordance with ASTM D 5151, *Test Method for Detection of Holes in Medical Gloves.*

4-2.3 Sample gloves shall be measured for physical dimensions and meet the length and width dimension requirements when tested in accordance with ASTM D 3577, *Standard Specification for Rubber Surgical Gloves.*

4-2.4 Glove material samples shall exhibit no penetration of Phi-X-174 Bacteriophage for at least one hour when tested as specified in Section 5-7 of this standard.

4-2.5 Glove material samples shall have an ultimate tensile strength elongation of not less 2000 lbs/in^2 (13.7 MPa) and a 300% modulus of not more than 300 lbs/in^2 (2.07 MPa) when tested in accordance with ASTM D 412, *Standard Test Methods for Rubber Properties in Tension, Method A, Dumbbell Specimens.*

4-2.6 Glove material samples shall be tested for ultimate elongation following whole glove immersion in isopropanol, and have an ultimate elongation of not less than 500 percent when tested as specified in Section 5-8 of this standard.

4-2.7 Glove material samples shall be tested for ultimate elongation following heat aging, and have an ultimate elongation of not less than 500% when tested as specified in Section 5-9 of this standard.

4-2.8 Glove material samples shall be tested for puncture resistance and have a puncture resistance of not less than 1.0 lb (0.45 kg) when tested as specified in Section 5-10 of this standard.

4-2.9 Sample gloves shall be tested for dexterity and have a dexterity test timing not greater than 120 percent of the baseline time when tested as specified in Section 5-11 of this standard.

4-3* Emergency Medical Face Protection Device Requirements.

4-3.1 Sample face protection devices and related hardware shall be free of rough spots, burrs, or sharp edges which could tear garment or glove materials.

4-3.2 Visor or faceshield material samples shall be tested for total visible luminous transmittance and percentage haze as specified in Section 5-12 of this standard. Visor material samples shall transmit not less than 95 percent of the incident visible radiation. The percentage haze of visor material samples shall not exceed 3 percent.

4-3.3 Sample face protection devices shall be tested for water tight integrity and shall allow no water penetration when tested as specified in Section 5-4 of this standard.

4-3.4 Samples representing protective clothing materials used in construction of the face protection device shall exhibit no penetration of Phi-X-174 Bacteriophage for at least one hour when tested as specified by Section 5-5 of this standard.

Chapter 5 Test Methods

5-1 Flame Resistance Test.

5-1.1 All samples to be tested shall be conditioned for not less than four hours in standard atmospheric conditions at a relative humidity of 65 percent ±2 percent and a temperature of 70°F ±2°F (21°C ±1°C). Samples shall be tested not more than five minutes after removal from conditioning.

5-1.2 Vertical flammability testing shall be performed in accordance with Method 5903.1; *Flame Resistance of Cloth; Vertical*, of Federal Test Method Standard 191A, Textile Test Methods, with the following modifications:

5-1.2.1 Specimens shall consist of at least ten protective clothing material samples measuring 3 x 16 in. ±1/16 in. (76 x 203 mm ±1.6 mm). If the material is anisotropic, specimens shall be cut in both the machine and transverse directions.

5-1.2.2 Specimens shall be folded such that the folded edge is exposed in the apparatus holder. The fold shall be produced by placing a 1/4 in (6.4 mm) rod at the bend of the material. The rod shall then be removed after the material is clamped in the holder prior to flame contact. The folded edge of the specimen shall protrude 1/4 in (6.4 mm) below the lower horizontal end of the mental specimen clamp.

5-1.2.3 A stopwatch or other time device reading in seconds shall be started. The tip of the flame shall be applied to the end of the specimen until it is ignited, but no longer than 3 seconds. The operator shall observe whether or not the specimen ignites and supports self-sustaining burning after removal of the flame from the specimen.

5-1.2.4 If the specimen fails to ignite in 3 seconds, the time shall be restarted and the flame shall be reapplied to the end of the specimen for an additional 12 seconds. If the specimen ignites, the timer shall be stopped when the flame is extinguished.

5-1.2.5 The vertical distance, measured from the horizontal edge of the specimen to which the ignition flame is applied, to the farthest point on the specimen visibly charred or melted by the burning process, shall be recorded. This measurement shall be made on the specimen after exposure. The apparent cause of extinguishment, such as melting or dripping, shall be noted.

5-1.3 The ignition propensity shall be noted as those specimens igniting within the 3-second exposure period, specimens igniting within the 12-second exposure period, and specimens not igniting at all.

5-1.4 Burning time shall be the time, reported in seconds, from the moment that the operator removes the flame from the sample until burning is extinguished.

5-1.5 The distance of burn shall be the distance, reported in inches (cm), from the ignited edge of the sample to the farthest vertical point on the sample that is burned in the test.

5-1.6 The burning behavior of the specimen shall be noted and characterized for the samples that ignite, are self-extinguishing, or as otherwise observed. The specimen shall be considered self-extinguishing if the distance of burning is less than 4.0 inches (10.24 cm) and the burning time is less than 10 seconds. The appearance of decomposition by melting or dripping shall be noted.

5-1.7 Report items shall be summarized as:

(a) Test specimens igniting in 3 seconds or less;
(b) Test specimens igniting in 12 seconds or less;
(c) Test specimens not igniting in the test;
(d) Test specimens with an ignition time exceeding 3 seconds but supporting burning for 10 seconds or more;
(e) Test specimens with an ignition time exceeding 3 seconds but having a burn distance exceeding 4 inches (10.24 cm);
(f) Notation of specimen dripping.

5-2 Abrasion Resistance Test.

5-2.1* Abrasion resistance testing shall be conducted in accordance with ASTM D 4157, *Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)* with the following conditions:

(a) A 5 lb (2.27 kg) tension weight shall be used.
(b) A 3 1/2 lb (1.6 kg) head weight shall be used.
(c) An 80 grit abradant trimite D-weight open coat #1A4180, or equivalent, shall be used.
(d) The specimen shall be abraded for 25 continuous cycles.
(e) Penetration resistance to Bacteriophage Phi-X-174 testing as specified in Section 5-5 of this chapter shall be substituted for abrasion to rupture and percentage loss in breaking load for interpreting abrasion resistance test results.

5-2.2 Only one specimen for bacteriophage penetration resistance testing shall be taken from each sample subjected to abrasion. The test specimen shall be taken from the exact center of the abraded sample so that the center of the bacteriophage exposure test and the center of the abraded sample coincide.

5-2.3 The average number plaque forming units per ml shall be reported.

5-2.4 Any visual observations, such as sample rupture, loss of luster, or deformation of the outside coating of tested specimens shall be reported.

5-3 Flexural Fatigue Test.

5-3.1 Flexural fatigue testing shall be conducted in accordance with ASTM F 392, *Test Method for Flex Durability of Flexible Barrier Materials*, with the following modifications:

(a) In lieu of Flexing Conditions A, B, C, D, or E, test specimens shall have a flex period of 100 cycles at 45 cycles per minute. A cycle shall be full flex and twisting action.
(b) Penetration resistance to Bacteriophage Phi-X-174 testing as specified in Section 5-5 of this Chapter shall be substituted for pinhole counting.
(c) Anisotropic materials shall be tested in both machine and transverse directions.

5-3.2 Only one specimen for bacteriophage penetration testing shall be taken from each sample subjected to flexing conditions. The test specimen shall be taken from the exact center of the flexed sample so that the center of the bacteriophage exposure and the center of the flexed sample shall coincide.

5-3.3 The average number of plaque forming units per ml shall be reported.

5-3.4 Any unusual observations for test specimens, such as delamination or tears, shall be reported.

5-4 Overall Clothing Water Penetration Test.

5-4.1 Sample emergency medical clothing shall be selected for overall garment water penetration testing as specified in Section 2-3 of this standard.

5-4.2 A human form mannequin shall be selected that is of appropriate size for the suit to be tested. The mannequin shall be water resistant. During the test the mannequin arms shall be placed by the sides of the mannequin torso and the mannequin legs shall not be bent.

5-4.3* Portions of the mannequin not covered by the emergency medical clothing or face protection device shall be covered by accessory items or their equivalent.

5-4.4* An inner garment shall cover all areas of the mannequin as an aid to observe water penetration. The inner garment shall be constructed from a fabric that is easily watermarked.

5-4.5 Five nozzles shall be oriented with respect to the mannequin as specified in Figure 5-4.5.

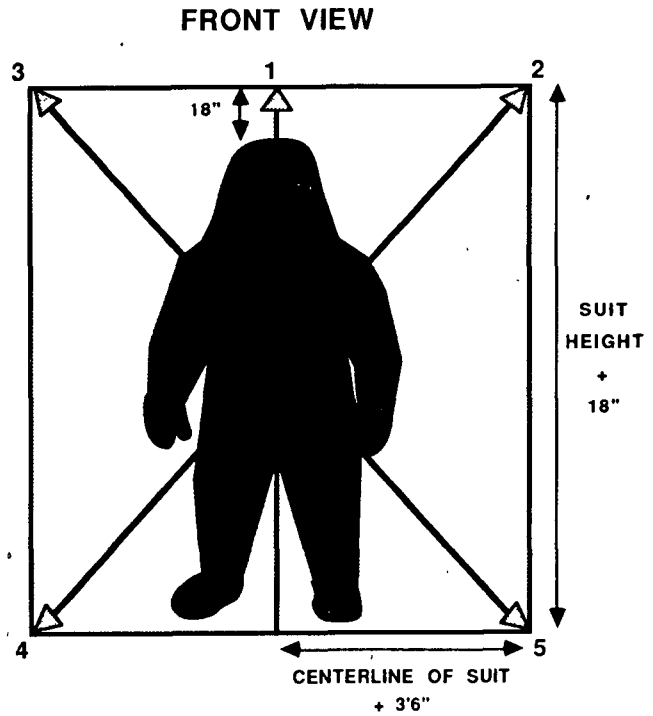


Figure 5-4.5 - Positions of Shower Nozzles.

5-4.6* The nozzles shall conform to the specifications in Figure 5-4.6.

(SEE FIGURE 5-4.6 NEXT PAGE)

5-4.7 The water distribution system shall deliver a minimum of 3 l/ min. through each nozzle.

5-4.8* Water used for overall clothing penetration testing shall contain a non-foaming surfactant that lowers the surface tension to less than 34 dynes/cm.

5-4.9 The inner garment and emergency medical clothing to be tested shall be inspected for total dryness before they are donned on the mannequin. The inner garment shall be donned on the mannequin underneath the emergency medical garment to be tested. The emergency medical garment shall be donned on the mannequin in accordance with manufacturer instructions.

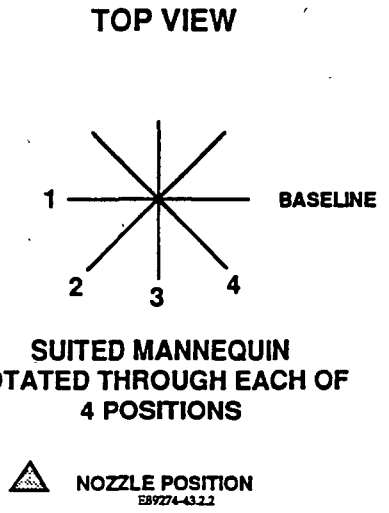
5-4.10 Water shall be sprayed at the suited mannequin for duration of 5 minutes for each of the suit orientations specified in Figure 5-4.10. Note: Mannequin or test subject torso shall be oriented such that the front faces parallel to the indicated orientation.

(SEE Figure 5-4.10 RIGHT, TOP)

5-4.11 Water penetration shall be determined by removing the protective suit and any other protective clothing components or equipment from the mannequin and examining the inner garment, garment liners, and garment interior for signs of wetness. Any evidence of water penetration shall constitute failure of the protective clothing for this test.

5-5 Bacteriophage Penetration Test.

5-5.1 A Thickness Gauge, suitable for measuring thickness to the nearest 0.001 in. (0.01 mm), as specified in Method 5030.2 of Federal Test Method Standard 191A, *Textile Test Methods*, shall be used to determine the thickness of each protective clothing material specimen tested.



Note: Mannequin or test subject torso shall be oriented such that the front faces parallel to the indicated orientation

Figure 5-4.10 - Orientation of Suited Mannequin (or Test Subject) Exposure.

5-5.2 A test cell shall be used to restrain the specimen during contact with the pressurized test liquid. It shall consist of a chamber which will contain approximately 60mL (2.0 oz) of the challenge liquid in contact with the specimen's normal outside surface and a restraining ring with a viewing port which will allow observation of the specimen's normal inside surface during the test. The test cell shall be as specified in ASTM F 903, *Test Method for Resistance of Protective Clothing Materials to Penetration.*

5-5.3 The following other equipment shall be used in this test:

(a) Air pressure source.

(b) Cell incubator capable of 35°- 37°C (95°- 99°F).

(c) Waterbath capable of 45°C ±2°C (113°F ±4°F).

(d) Analytical balance capable of 0.001 g.

(e) Vortex mixer.

(f) Refrigerator capable of 2°- 8°C (36°- 46°F).

(g) Autoclave capable of 121°C (250°F); 15 lbs (66.7 N) pressure.

(h) Electronic timer.

(i) Orbital shaker.

(j) pH meter sensitive to 0.1 pH units.

5-5.4* The following supplies shall be used in this test:

(a) Sterile petri dishes, 15 x 100 mm.

(b) Sterile 1, 5, 10 mL pipettes.

(c) 13 x 100 mm test tubes.

(d) Stainless steel test tube rack.

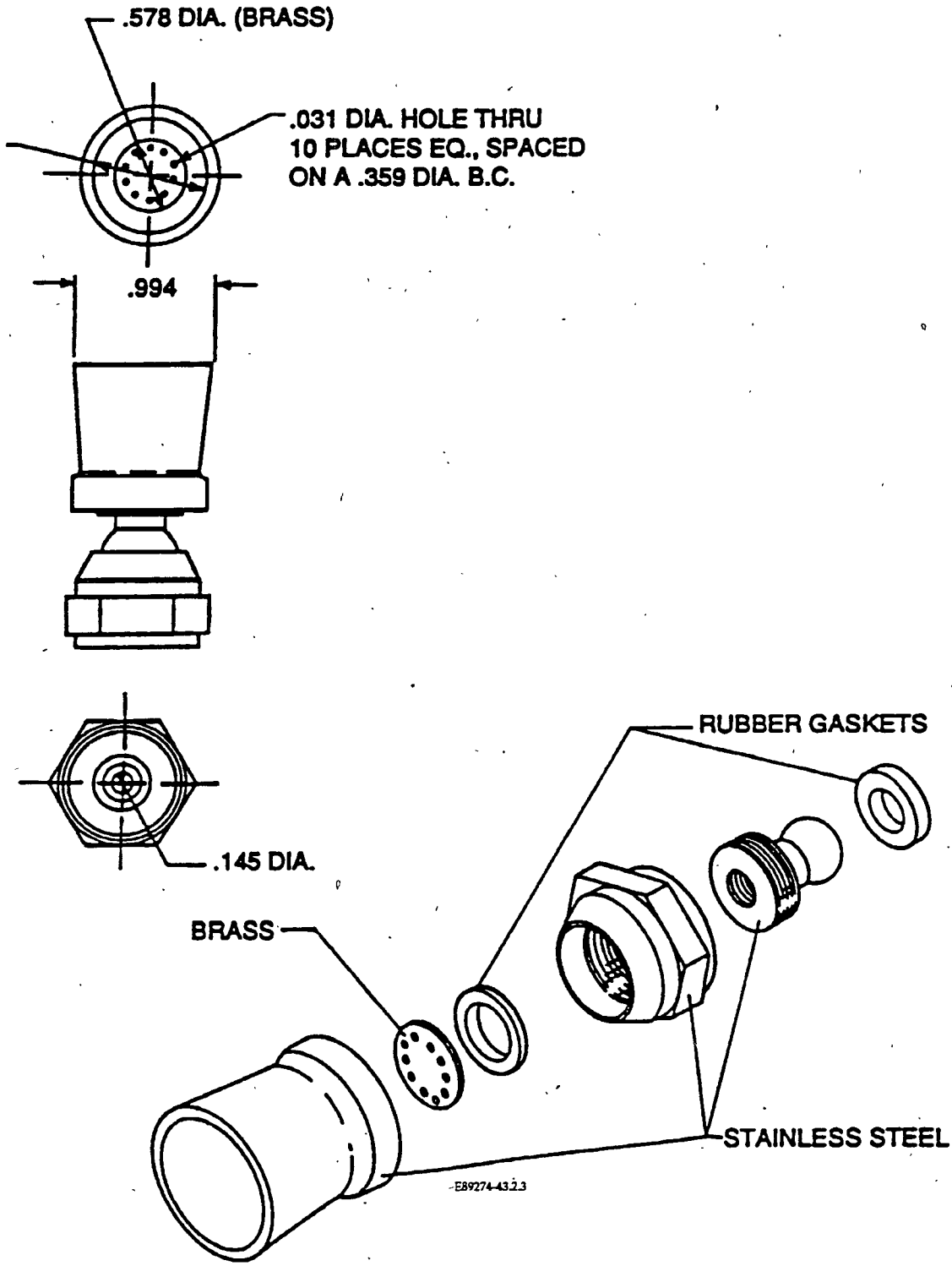
(e) 0.45 um sterile membrane filters.

(f) 0.22 um sterile membrane filters.

(g) Sterile glass bottles, 100 mL - 500 mL.

(h) Phi-X-174 ATCC 13706-B1.

(i) E. coli ATCC 13706.



NOTE: All dimensions are in inches (1 inch = 25.44 mm)
Figure 5-4.6 - Shower Nozzle Specifications.

5-5.5 The following reagents shall be used in this test:

(a) Tween 80. Sterilize by filtering through sterile 0.22 um membrane filter.

5-5.6 Test media shall be prepared as follows:

(a) Bacteriophage Tryptone broth (Phi-X):

Bacto-Tryptone 10.0g
Potassium Chloride 5.0 g
Calcium Chloride 0.15 g
Purified Water Q.S. to 1000 mL
Adjust pH to 7.3 with 2.5 N Sodium Hydroxide; sterile filter.

(b) Bottom Agar (Phi-X):

Bacto-Agar 10.0 g
Tryptone 13.0 g
NaCL 8.0 g
Glucose 1.3 g
Sodium Citrate 2.0 g
Purified water, Q.S. to1000 mL
Adjust pH to 7.2 - 7.4; Sterilize by Autoclaving

(c) Top Agar (Phi-X):

Agar 6.5 g
Tryptone 13.0 g
NaCL 8.0 g
Glucose 3.0 g
Sodium Citrate 2.0 g
Purified Water, Q.S. to1000 mL
Adjust pH to 7.2 - 7.4; Sterilize by Autoclaving

5-5.7* Test specimens shall have a minimum dimension of 2.5 in (64 mm). A minimum of three random specimens shall be tested for each material.

5-5.8 The bacteriophage shall be prepared as follows:

(a) Inoculate 100 mL of tryptone broth with E. coli and incubate overnight at 35°- 37°C (95°-99°F) with shaking at 200 rpm.

(b) Prepare a 1:100 dilution of the culture and incubate for approximately 90 minutes.

(c) Inoculate the 90 minute culture with 0.5 mL of the Phi-X-174 phage stock.

(d) Incubate the culture with rapid shaking for 2 hours ±0.25 hours. Complete lysis of the host bacteria shall be noted when the broth is clear.

(e) Filter through a sterile 0.22 micron microporous membrane filter to remove the host cell debris.

(f) Refrigerate the phage stock at 5°C ±3°C.

(g) Make sterile 0.1 percent Tween 80 in tryptone broth and dilute it 1 volume to 9 volumes of the phage suspension.

(h) Adjust the titer of the phage suspension to $\geq 1.0 \times 10^8$.

5-5.9 The test cell shall be prepared as follows:

(a) The penetration test cell shall be autoclaved.

(b) The sterile sample shall be aseptically inserted in the cell with the liner side oriented away from the challenge.

(c) The bolts in the test cell shall be torqued to 120 inch pounds (13 Joules) each.

(d) The cell shall be assembled in test apparatus but not connected the air line to the cell.

(e) The drain valve shall be is closed.

(f) The chamber shall be carefully filled with the cell in a vertical orientation with approximately 60 mL of challenge.

(g) The chamber shall be observed for five minutes.

(h) The air line shall be connected to the cell.

(i) The cell valve shall be opened to the pressure source. The pressure shall be slowly raised to 2 psig (0.14 kg/cm^2) at a rate no faster than 0.5 psig/s (0.035 kg/cm^2).

(j) The psig shall be held constant for one minute and the surface of the sample shall be monitored for the appearance of liquid. If liquid appears, the test shall be terminated.

(k) The cell valve shall be turned to the vent position.

(l) The chamber shall be observed for 54 minutes.

(m) The drain valve shall be opened and the cell drained of challenge.

(n) The cell shall be disassembled from the apparatus.

(o) With the cell in a horizontal position, 2 mL sterile tryptone broth with 0.01 percent Tween shall be slowsly added onto the inner surface of the sample. The tryptone broth shall be removed as soon as possible.

(p) With a sterile swab prewetted with sterile media to prevent bacteriophage absorption, the sample surface shall be gently wiped to release any penetrated Phi-X-174 into the media. The media shall be pipetted off and transfered to a sterile container.

(q) The assay fluid shall be refrigerated until the sample can be tittered.

(r) The sample shall be removed from the cell.

(s) The apparatus shall be disassembled.

5-5.10 The assay fluid shall be quantified as follows:

(a) 2.5 mL of sterile molten top agar shall be dispensed into sterile test tubes and the top agar shall be held at 45°C ±2°C (113°F ±4°F).

(b) 0.5 mL of the assay media shall be added to three top agar tubes.

(c) 1-2 drops of an overnight culture of E coli C shall be added to each of the inoculate tubes.

(d) The tubes shall be mixed well and poured over the surface of the bottom agar plates.

(e) The agar shall be allowed to solidify and incubate at 35°-37°C (95°- 99°F) for 4 to 18 hours. The length of time shall depend on having the plaques large enough to count but not merging.

(f) The plaques shall be counted and the phage titer shall be calculated.

(g) If necessary, serial 1 to 10 dilutions shall be prepared in Tryptone broth of the assay media and assay for phage as above.

5-5.11 All tests shall be run with a "blank" that uses deionized water, which shall be tested and titered using the procedure established in 5-5.10 of this Section.

5-5.12 Background aerosol/airborne counts for the Phi X-174 shall be made utilizing settling plates. Background counts shall be made during the entire procedure to enable the operator to distinguish false positive results from true failures and allow the operator to subtract background counts from actual penetration counts. Settling plates shall be placed in strategic locations during the aseptic test sample insertion, filling, testing, draining, and assay operations.

5-5.13 Negative test sample controls shall be selected at random and introduced into the test program. Mylar film shall be used as the test sample controls.

5-5.14 Positive test sample controls shall be selected at random and introduced in the test program. A hydrophilic porous membrane material with a pore sizes larger than 0.03 microns shall be used as the positive test sample controls.

5-5.15 A statistical analysis of settle plate counts shall be made and compared to the results for all test samples to rule out false positives. Background counts shall be subtracted from all failing test sample data. Sample data shall be calculated by using the formula: Failed Sample PFU/mL- Mean = 3 X Standard Deviation of Background Count PFU/mL.

5-5.16* All failed sample data shall be normalized to a challenge concentration of 1.0 x 10E8 PFU/mL Phi X-174.

5-6 Tear Resistance Testing.

5-6.1 The specimen shall be a 3 x 6 in . (76.2 x 152.4 mm) rectangle. The long dimension shall be parallel to the warp for the warp tests and parallel to the filling for filling tests. No two specimens for warp tests shall contain the same warp yarns, nor shall any two specimens for filling tests contain the same filling yarns. The specimen shall be taken no nearer to salvage than one-tenth of the width of the cloth. An isosceles trapezoid having an altitude of 3 in. (76.2 mm) and bases of 1 and 4 in. (25.4 and 101.6 mm) in length, respectively, shall be marked on each specimen, with the aid of a template. A cut 3/8 in. (9.5 mm) in length shall then be made in the center of a line perpendicular to the 1 in. (25.4 mm) edge.

5-6.2 Apparatus shall consist of a straining mechanism, two clamps for holding specimens, and load and elongation recording mechanisms, wherein the specimen is held between two clamps and strained by a uniform movement of the pulling clamp.

5-6.2.1 Straining mechanism shall be of such capacity that the maximum load required to break the specimen shall be not greater than 85 percent or less than 15 percent of the manufacturer's rated capacity.

5-6.2.2 Clamps shall be designed such that the six ounces (170 g) of weight are distributed evenly across the complete width of the sample. The clamps shall have two jaws on each clamp. The design of the clamps shall be such that one gripping surface or jaw shall be permitted to be an integral part of the rigid frame of the clamp or be fastened to allow a slight vertical movement, while the other gripping surface or jaw shall be completely moveable.

The dimensions of the immovable jaw of each clamp parallel to the application of the load shall measure 1 in. (25.4 mm) and the dimension of the jaw perpendicular to this direction shall measure 3 in. (76.2 mm) or more. The face of the moveable jaw of each clamp shall measure 1 in. x 3 in. (25.4 x 76.2 mm). Each jaw face shall have a flat, smooth gripping surface. All edges that might cause a cutting action shall be rounded to a radius of not more than 1/64 in. (0.4 mm).

In cases where a cloth tends to slip when being tested, the jaws shall be faced with rubber or other material to prevent slippage. The distance between the jaws shall be in 1 in. (25.4 mm) at the start of the test.

5-6.2.3 Recorder shall consist of calibrated dial, scale, or chart used to indicate applied load and elongation. Error shall not exceed 2 percent up to and including a 50 pound (22.7 kg) load and 1 percent over a 50 pound (22.7 kg) load at any reading within its loading range. All machine attachments for determining maximum loads shall be disengaged during test.

5-6.3 The specimen shall be clamped along the non-parallel sides of the trapezoid so that these sides lie along the lower edge of the upper clamp and the upper edge of the lower clamp with the cut halfway between the clamps. The short trapezoid base shall be held taut and the long trapezoid base shall lie in the folds.

The strain mechanism shall be started and the force necessary to tear the clothing shall be observed by means of the recording device. Five specimens in each of the warp and filling directions shall be tested from each sample unit. If a specimen individual measurement falls markedly below the average test results for the sample unit, such result shall be discarded and another specimen shall be tested.

5-6.4 The tear strength shall be the average of the five highest peak loads of resistance registered for inches of separation of the tear. The tear strength shall be reported to the nearest 0.1 lb (45.4 g)

5-7 Overall Glove Bacteriophage Penetration Test.

5-7.1 The procedures outlined in Section 5-5 of this Chapter shall be used to test whole emergency medical gloves with the following modifications:

(a) Gloves to be tested shall be turned inside-out so that the normal exposure surface of the gloves face inward.

(b) A sterile 250 ml Erlenmeyer flask shall be used in place of the test cell. Gloves shall be placed in the flask, fingers first with the cuff portion of the glove turned over the lip of the flask to minimize the chance of contamination.

(c) 100 ml of phage suspension shall be poured into each test glove. The cuff portion of the glove shall be clamped to prevent spillage and contamination of the flask.

(d) 100 ml of deionized water shall be used as a "blank" for determining background contamination.

(e) 10 ml of media shall be used to wash the exposed glove surfaced (originally the glove intern).

(f) The test flasks interval surface shall be maintained at 35°-37°C (95°-99°F) for one hour.

(g) The test flasks shall be swiveled carefully to thoroughly wash all exposure surfaces of the glove.

(h) The assay liquid shall be removed by holding the top portion of the glove to one side and transferring from the flask to a sterile sample vial using a sterile glass pipet.

5-7.2 The assay fluid shall be quantified using the procedures established in Section 5-5 of this Chapter.

5-8 Isopropanol Degradation Test.

5-8.1 Isopropanol degradation shall be measured in accordance with ASTM D 412, *Standard Test Methods for Rubber Properties in Tension, Method A, Dumbbell Specimen*, with the following modifications:

(a) Test specimens shall be conditioned by total immersion in 100 percent isopropanol at room temperature for a period of 2 hours.

(b) The test specimens shall be blotted dry and tested within 5 minutes following removal from the isopropanol.

5-8.2 Ultimate elongation (percentage) shall be measured and reported.

5-9 Heat Aging Degradation Test.

5-9.1 Specimen degradation shall be measured in accordance with ASTM D 412, *Standard Test Methods for Rubbers in Tension, Method A, Dumbbell Specimen* following heat aging conducted in accordance with ASTM D 573, *Test Method for Rubber - Deterioration in an Air Oven.*

5-9.2 Specimens shall be subjected to a temperature of 100°C ±2°C (212°F ±4°F) for 22 hours ±0.3 hours.

5-9.3 Ultimate elongation (percentage) shall be measured and reported.

5-10 Puncture Resistance Testing For Gloves.

5-10.1 Each sample specimen to be tested shall be a rectangle at least 3.5 in. (8.9 cm) on a side. Multiple puncture tests shall be permitted to be made on each sample specimen.

5-10.2 Each sample specimen shall consist of either a single layer or composite used in actual glove construction with all layers arranged in proper order. In each test, the sample specimen's normal outer surface shall be the first contacted by the point of the penetrometer.

5-10.3 Three sample specimens shall be tested for each material with one puncture made on each sample specimen.

5-10.4 The static puncture test apparatus shall be a testing machine, such as an Instron or its equivalent, that challenges a sample specimen with a uniformly moving pointed penetrometer.

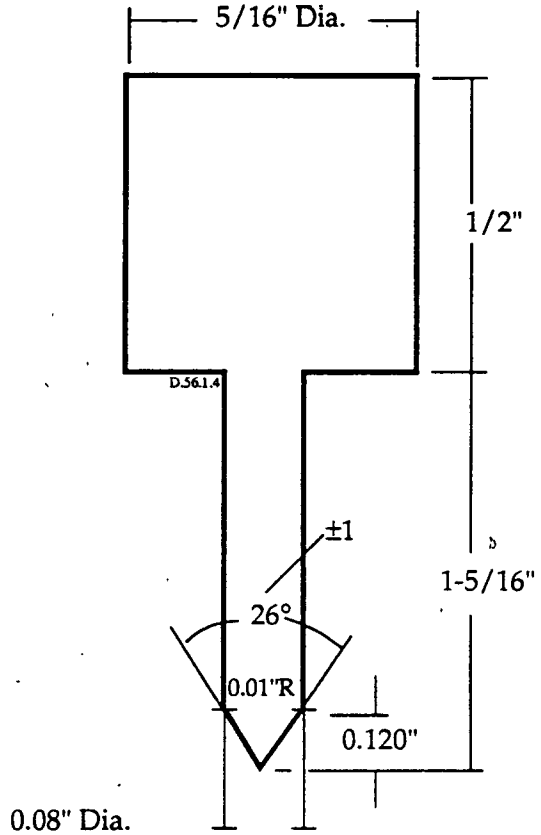
5-10.4.1 The penetrometer shall have a velocity of 20 in/min (50.8 cm/min) under load conditions and shall be uniform at all times.

5-10.4.2 The force applied to the sample specimen shall be accurate to ±1 percent up to and including a force of 50 lb (23 kg). The force shall be detected by a compression cell and shall be indicated by a dial, scale or automatic recorder.

5-10.4.3 The apparatus shall be able to record or indicate the maximum load at puncture of a sample specimen.

5-10-4.4 The travel of the penetrometer shall be capable of being stopped once the tip has passed beyond the sample specimen to prevent damage by impact on the underlying supports assembly. This may be accomplished by a mechanical or an electrical stop on the test apparatus. For the support assembly specified in 5-10.6 of this section, the stop shall be set in 1 in (2.5 cm) beyond the sample specimen surface.

5-10.5 A penetrometer having the size and dimensions shown in Figure 5-10.5 shall be mounted on the apparatus and shall be attached to the compression cell of the machine as shown in Figure 5-10.6.

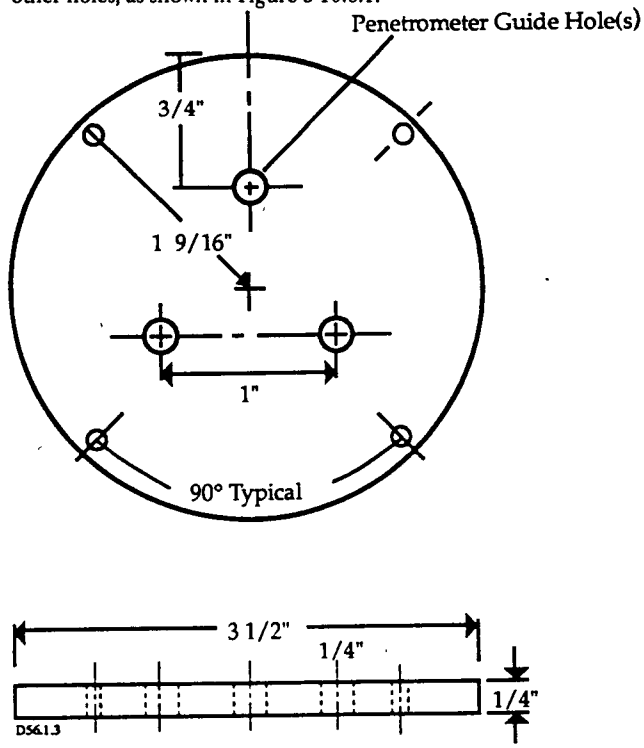


NOTE: All dimensions are in inches (1 inch - 2.54 cm)

Figure 5-10.5 - Cross-Section of Puncture Probe.

5-10.6 The specimen support assembly shall consist of two flat metal plates that clamp together so the sample specimen is held tightly between them, as shown in Figure 5-10.6.

5-10.6.1 Each plate shall have one or more 1/4 in. (0.6 cm) diameter holes. For efficiency in testing, three holes spaced at the points for a 60-degree equilateral triangle having 1 in (2.5 cm) legs centered within the plate may be used. Each hole shall be located 3/4 in. (1.9 cm) from the plate edge and 1 in (2.5 cm) from each of the other holes, as shown in Figure 5-10.6.1.



NOTE: All dimensions are given in inches (1 inch - 2.54 cm)

Figure 5-10.6.1 - Support Plate (Two Required).

5-10.6.2 The specimen support plates shall be connected to a metal support ring that mounts on the movable arm of the test apparatus.

5-10.7 A template shall be used to locate the holes for specimen mounting the support assembly, as shown in Figure 5-10.7.

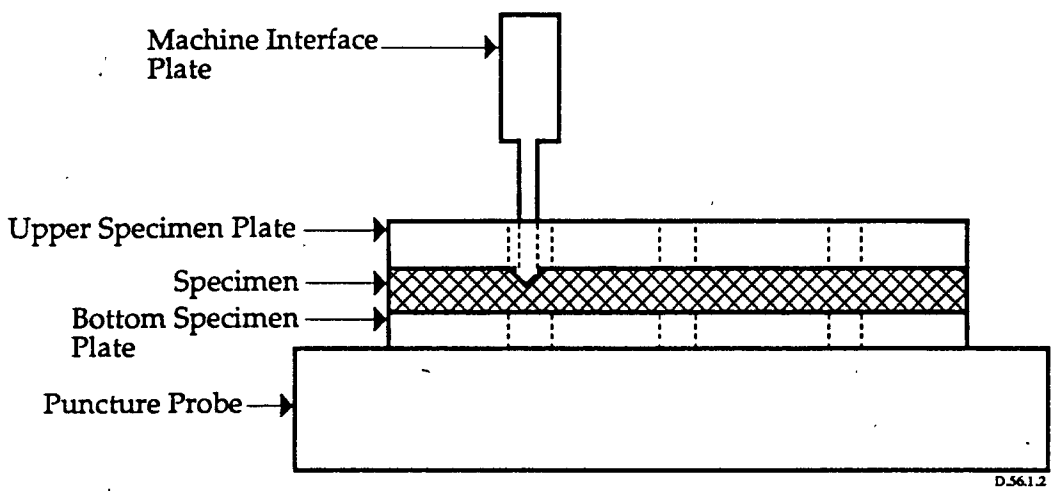
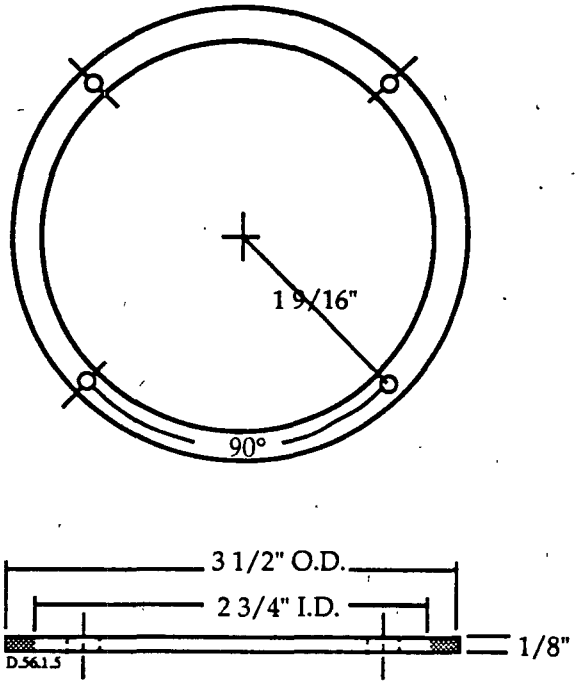


Figure 5-10.6 - Side View of Specimen Support Assembly.



NOTE: All dimensions are given in inches (1 inch - 2.54 cm)
Figure 5-10.7 - Template.

5-10.8 A leather punch ball shall be used to cut the four holes in each sample specimen as located by the template.

5-10-9 The first sample specimen to be tested shall be mounted in the support assembly as shown in Figure 5-10.6. The two plates shall be marked and care shall be taken that the holes are aligned prior to testing to avoid damaging the penetrometer and plates.

5-10.10 The support assembly shall be attached to the moveable arm of the test apparatus.

5-10.11 The pentrometer shall be positioned on the compression cell of the test apparatus.

5-10.12 The apparatus shall be set in operation, but stopped when the pentrometer has been driven through the sample specimen.

5-10.13 The maximum force resisted by the indicating device shall be recorded to the nearest 0.1 lb (nearest 50 g) for each determination.

5-10.14 If the sample specimen has not been penetrated, a maximum force of 50 lb (23 kg) shall be recorded.

5-10.15 After the first test has been run, the penetrometer shall be repositioned under each of the other guide holes and the test repeated until three punctures have been made.

5-10.16 Additional sample specimens shall be tested until the requirement of 5-10.3 of this section is met.

5-10.17 The force required for each puncture shall be reported to the nearest 0.1 lb (nearest 50 g) for each sample specimen. The average force for each sample specimen shall then be calculated and reported.

5-11 Dexterity Testing.

5-11.1* Dexterity shall be evaluated using the Crawford Small Parts Dexterity Test, Screws Technique.

5-11.2 Each sample glove shall be tested as a complete glove in new, as distributed, condition. The size most comfortably fitting the test subject shall be selected.

5-11.3 Sample gloves shall not receive special softening treatments prior to tests.

5-11.4 For each glove style or type to be certified the test shall be repeated three times using three separate test subjects and glove specimens for each material and construction combination.

5-11.5 Each test subject shall practice without wearing any glove until the baseline times of that person's last three repetitions vary no more than 6 percent.

5-11.6 Each test subject's first time wearing gloves shall be compared with the average time from the three last practice trials to determine percentage of baseline test time required to perform the exercise while wearing gloves.

5-12 Luminous (Visible) Transmittance Testing.

5-12.1 Luminous (visible) transmittance shall be measured in accordance with ASTM D 1003, *Test Method for Haze and Luminous Transmittance of Transparent Plastics,* Method A, with the following modifications:

(a) The standard source of radiant energy used in the measurement of luminous transmittance of filter lenses shall be a projection-type lamp T-8, or other high-powered, gas-filled, tungsten-filament incandescent lamp, operated at the color temperature corresponding to Commission Internationale de l'Eclairage (CIE) Source A.

(b) Luminous transmittance shall be determined by measuring the spectral transmittance and calculating the luminous transmittance through the use of published data on the special radiant energy of CIE Source A and the relative luminous efficiency of the average eye. The standards of luminous transmittance maintained by the National Bureau of Standards shall be tested.

Chapter 6 Referenced Publications

6-1 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 the date of the NFPA issuance of this document.

6-1.1* ASTM Publications.

ASTM D 412, *Test Methods for Rubber Properties in Tension,* 1987

ASTM D 573, *Test Method for Rubber-Deterioration in an Air Oven,* 1988

ASTM D 751, *Method of Testing Coated Fabrics,* 1979

ASTM D 1003, *Test Method for Haze and Luminous Transmittance of Transparent Plastics,* 1977

ASTM D 2582, *Test Method for Puncture Propagation Tear Resistance of Plastic Film and Thin Sheeting,* 1984

ASTM D 3577, *Specification for Rubber Surgical Gloves*, 1991

ASTM D 4157, *Test Method for Abrasion Resistance of Textile Fabrics (oscillatory cylinder method)*, 1982

ASTM D 5151, *Test Method for Detection of Holes in Medical Glove*, 1991

ASTM F 392, *Test Method for Flex Durability of Flexible Barrier Materials*, 1987

ASTM F 903, *Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids and Gases*, 1990

Military Standard MIL-STD-105D, *Sampling Procedures and Tables for Inspection by Attributes*, 29 April 1983

6-1.2* GSA Publication.
Federal Test Method Standard 191A, *Textile Test Methods*, 20 July 1978.

6-1.3* Psychological Corporation Publication, San Antonio, Texas. *Crawford Small Parts Dexterity Test*, 1981.

Appendix A

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

A-1.1.1 Use of emergency medical clothing is addressed in NFPA 1581, *Standard on Fire Department Infection Control Program.* Particularly relevant sections are:

2-2 Training and Education

2-5 Exposures

4-2 Infection Control Garments and Equipment

5-1 Skin Washing

5-2 Disinfectants

5-3 Emergency Medical Equipment

5-4 Clothing

A-1.1.2 Organizations responsible for fire fighting applications should use protective clothing and equipment specifically deigned for those activities.

A-1.1.3 Organizations responsible for chemical response functions and other hazard protection including radiological, cryogenic or hazardous chemical should use protective clothing and equipment specifically designed for those activities. Criteria for protection from hazardous chemicals are provided in the following standards:

(a) NFPA 1991, *Standard on Vapor Protective Suits for Hazardous Chemical Emergencies*

(b) NFPA 1992, *Standard on Liquid Splash-Protective Suits for Hazards Chemical Emergencies*

(c) NFPA 1993, *Standard on Support Function Protective Garments for Hazardous Chemical Operations*

A-1.1.4 Purchasers should specify desired features that are not in conflict with the design requirements of this standard. It is recommenced that purchasers of emergency medical garments should consider the following:

(a) Personnel may be wearing many items of protective clothing and equipment. Any interference by one item of another's use might result in inefficient operations or unsafe situations.

(b) Different breathing apparatus, communications systems, cooling devices, and other protective equipment may not be accommodated by the emergency medical garments equally.

(c) Specifications of additional reinforcement in high-wear or load-bearing areas such as the knees, elbows, shoulders, and back may be necessary. Reinforcing materials should be the same as the garment material. Purchasers are cautioned that additional weight caused by excessive reinforcement could lead to fatigue or injury.

A-1-2.2 Biological agents may also be transmitted via aerosols.

A-1-3 Approved. The National Fire Protection Association does not approve, inspect or certify an 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 consider on compliance with NFPA or other appropriate standards.

In the absence of such standards, such authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labelling 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" agencies 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 Listed. The means for 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-1-4.1 English units are used throughout Chapter 4 with metric equivalents provided in parentheses. This practice is also follows in Chapter 5 with the exception of Sections 5-5 and 5-7 where metric units are exclusively used for units of volume.

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 program 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 the 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 meaning full 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 main laboratory for countercheck testing. With other products, it may be desirable to purchase samples in the open market for test purposes.

A-3-1.1 Purchasers should use the technical data package to compare garment or glove performance data in purchasing emergency medical garments or gloves. The purchaser should determine the relative ranking of performance data to aid this selection process.

A-3-2.4 This documentation requirement provides information to the end user about the flame resistance of the garment material. Material flame resistance is measured using a modified version Method 5903.1 of FTMS 191A, where a folded edge of the material is suspended over a flame. The test involves two flame exposures: an initial 3 second exposure and subsequent 12 second exposure.

Ignition of the material is noted after each exposure. Ignition of the material is noted after each exposure period, with measurement of both burn distance and burn time for each material specimen tested, if the specimen ignites. These measurements provide an assessment for the ease of material ignition, if the material does ignite, and whether the material is self-extinguishing.

A-3-2.5 This documentation requirement provides information to the end user about the abrasion resistance of the garment material. Material abrasion resistance is measured by subject material specimens to a standard abrasion technique designed to simulate wear on an asphalt-like surface. These material specimens are then tested for penetration resistance to bacteriophage (described in A-4-1). End users should assess the abrasion resistance of the garment material by comparing the material bacteriophage penetration before abrasion (as required in 4-1.3 of this standard) and after abrasion.

A-3-2.6 This documentation requirement provides information to the end user about the flexing resistance of the garment material. Material abrasion resistance is measured by subject material specimens to a standard flexing technique designed to simulate wear from repeated material bending, twisting, and compression. These material specimens are then tested for penetration resistance to bacteriophage (described in A-4-1). End users should assess the flexing resistance of the garment material by comparing the material bacteriophage penetration before flexing (as required in 4-1.3 of this standard) and after flexing.

A-4-1 There are one design and eight performance requirements for emergency medical garments. The basis and rationale for each given below:

(a) Fittings Quality (4-1.1). This design requirement prevents fittings being used in the construction of garments which could potentially snag or test protective clothing materials.

(b) Overall Water-Tight Integrity (4-1.2). This performance requirement entails testing of the complete garment in a "shower-like" test which is designed to assess how well garment materials, seams, and closures and interfaces resist penetration from liquid splashes. The test is not intended to simulate exposure from liquid splashes. This requirement is similar to that required in NFPA 1993, *Standard on Support Function Protective Garments in Hazardous Chemical Operations.*

(c) Bacteriophage Penetration Resistance (4-1.3). This test is intended to determine how well garment materials prevent penetration or biological agents (liquid-borne pathogens). The resistance of protective clothing materials to penetration by blood-borne pathogens is determined using a modified form of ASTM F 903, *Standard Test Method for Resistance of Protective Clothing Materials to Penetration by Liquids.* Procedure C form F903 is used for this test. The protective clothing materials are challenged with a Phi-X174 Bacteriophage suspension for 5 minutes at atmospheric pressure, 1 minute at 2.0 PSI, and 54 minutes at atmospheric pressure, or until liquid penetration. Then the reverse side of the test material is rinsed and assayed for the Phi-X174. Bacteriophage Phi-X174 best approximates Hepatitis C virus but also simulates Hepatitis B virus and the Human Immunodeficiency Virus (HIV). It was chosen as the most appropriate blood-borne pathogen model because of its non-human infectivity, high assay sensitivity, rapid growth, and high titer (available in large concentrations.)

All remaining performance requirements are identical to those provided in NFPA 1993, *Standard on Support Function Protective Garments for Hazardous Chemical Operations.* The same requirements were adopted since the subcommittee believed the working environment for Emergency Medical Clothing to be the same as for Support Function Protective Clothing.

(d) Tensile Strength (4-1.4). This requirement was designed to ensure materials provide adequate strength when pulled or stretched.

(e) Burst Strength (4-1.5). This requirement was designed to simulate material bursting from protruding objects with the emergency medical garment.

(f) Puncture Propagation Tear Resistance (4-1.6). This requirement is designed to simulate material snagging and subsequent tearing from sharp objects, such as walking past a protruding rail.

(g) Tear Resistance (4-1.7). This requirement is designed to simulate how the material tears when pulled apart.

(h) Seam Strength (4-1.8). This requirement is based on documentation of adequate strength from field performance data.

(i) Closure Strength (4-1.9). Garment closure assemblies are required to meet the same minimum tensile strength requirements as garment seams.

A-4-2 There are one design and eight performance requirements for emergency medical gloves. The basis and rational for each are given below:

(a) Hardware Quality (4-2.1). This requirement prevents any glove hardware from being used in the construction of the glove which could potentially snag or tear protective clothing materials.

(b) Water Tight Integrity (4-2.2). This requirement assesses the overall integrity of the gloves in a procedure developed by ASTM in which water is poured into a glove, with the glove checked for leakage after 2 minutes.

(c) Sizing (4-2.3). This requirement addresses dimensional requirements of gloves. ASTM D 3578, *Standard Specification for Rubber Surgical Gloves* specifies width and length requirements for 8 different glove sizes.

(d) Bacteriophage Penetration Resistance (4-2.4). This requirement is analogous to the Bacteriophage Penetration Resistance test described in A-4-1(c). The test is conducted differently in that entire gloves are evaluated as opposed to material specimens. Gloves are turned inside out and placed in a flask. The "new" inside surface of the glove is filled with media containing the Phi-X-174 Bacteriophage. The "new" outside surface of the glove is rinsed and assayed for bacteriophage penetration after one hour contact with the bacteriophage. The analysis of the assay media is evaluated in the same manner as done for garment material specimens.

(e) Tensile Strength Elongation and 300 Percent Modulus (4-2.5). This requirement is designed to simulate the failure mode of gloves which occurs from pulling the glove onto the hand with its subsequent breaking and tearing.

(f) Isopropanol Degradation Resistance (4-2.6). In this requirement, the degradation resistance of the glove is measured following a 2 hour immersion in isopropanol with measurement of glove elongation. The inability of the glove to elongate 500 percent is cause for failure. Isopropanol is a common medical solvent which when in contact with glove materials may remove plasticizer or other additives necessary for adequate glove function.

(g) Heat Aging Degradation Resistance (4-2.7). Analogous to Isopropanol Degradation Resistance, the heat aging degradation resistance is measured by subjecting sample gloves to an accelerated heat aging at 100°C for 22 hours. This protocol was adopted from ASTM D 3577, specification for *Rubber Surgical Gloves* and is designed to simulate the effects of long term storage of gloves at elevated temperature and subsequent glove degradation through loss of plasticizers or other additives necessary for adequate glove function. Glove degradation resistance is measured using glove elongation.

(h) Puncture Resistance (4-2.8). This requirement is designated to simulate the puncture of gloves by sharp (nail-like) object. It is not designed to simulate needle-pricks or similar medical instrument punctures.

(i) Dexterity (4-2.9). The overall glove performance is assessed through a standard glove dexterity test in which test subjects ability to manipulate fine objects is determined. Test subject performance is compared with and without gloves.

A-4-3 There are one design and three performance requirements for emergency medical face protection devices. The basis and rationale for each requirement are given below:

(a) Hardware Quality (4-3.1). This design requirement prevents hardware on face protective devices being used which could potentially snag or tear protective clothing materials.

(b) Light Transmission (4-3.2). This requirement ensures emergency medical devices provide clear and undistorted visor through the visor or eye piece portions of the device. Although similar, this requirement is not the same as that established on ANSI Z87.1 for protective visors.

(c) Water-Tight Integrity (4-3.3). This requirement is analogous to the test performed on emergency medical garments described in A-4-1(b). Water-tight integrity is assessed on a standard mannequin head form.

(d) Bacteriophage Penetration Resistance (4-3.4). This requirement is analogous to the requirement for medical emergency garments described in A-4-1(c). It applies only to those portions of the face protection device intended to provide protection to the face or head.

A-5-2.1 A source for the equipment required to perform ASTM D 4157, *Standard Test Method for Abrasion Resistance of Textile Fabrics*, is J.K. Industries, P.O. Box 6, Villa Park, Il 60181.

A-5-4.3 Examples of accessory items are gloves, boots, hoods, and breathing apparatus.

A-5-4.4 An example of an inner garment fabric is a light weight, tight woven (e.g. 2.2 oz/yd, 92 x 88), medium or dark colored, 100 percent polyester fabric without surface treatment.

A-5-4.6 Type #SSW1C nozzles can be obtained from Whedon Products, Inc., West Hartford, CT.

A-5-5.4 Phi-X-174 ATCC 13706 B1 Bacteriophage and E. Coli ATCC 13706 are available from American Type Culture Collection, 12301 Parklawn Drive, Rockville, MD 2-852.

A-5-5.7 A 2.8-in. (70 mm) square is convenient.

A-5-5.16 Example:

1.0 X 10E8 (Normal Challenge) = X (Normal Failure)
2.9 X 10E8 (Actual Challenge) = 115230 (Actual Failure)
X = 39734

A-5-11.1 The Crawford Small Parts Dextrity Test is available from the Psychological Corporation, 555 Academic Court, San Antonio, TX 78204.

A-6-1.1 ASTM publications can be obtained form American Society for Testing and materials (ASTM), 1916 Race Street, Philadelphia, PA 19130.

A-6.1.2 GSA publications can be obtained from General Services Administration Specifications Activity; Printed Materials Supply Division; Building 197, Naval Weapons Plant, Washington, DC 20407. Single copies are generally available without charge at the General Service Administration Business Centers in cities throughout the U.S. Federal Test Method standards are available form the U.S. Government Printing Office, Washington, DC 20402.

A-6-1.3 This publication is available form The Psychological Corporation, 555 Academic Court, San Antonio, TX 78204

Appendix B

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

"NOTICE TO THE READER"

The following test method is given so that persons who are interested in evaluating and comparing the heat transfer qualities of fabrics can do so to an established method.

This test method is NOT a requirement of this document and nothing contained herein can be construed to be a part of the mandatory requirements of this document. The use of the term "shall" in this test method is to emphasize critical procedures that are part of the test and not to indicate a mandatory requirement of this document. A simple criterion — the watts/m^2 of heat transferred through the composite by the combined dry and avaporative heat exchnages from 95°F (35°C), fully sweating test plate surface in a 77°F (25°C), 65 percent RH environment — provides a single number for comparing each fabric.

Total Heat Loss Test.

NOTE: Practitioners of this method should be intimately familiar with ASTM D 1518, although this Total Heat Loss Test contains significant differences.

1. The test plate and guard ring shall have a wettable surface.

NOTE: One useful sweating hot plate, apparatus is available form Holometrix, Inc., 99 Erie Street, Cambridge, MA 02139; (telephone 617-868-8050). An environmental chamber with air temperature, humidity and air velocity control is also required.

2. The test plate shall have a temperature of 35°C, ± 0.5°C (95°F, ± 1°F). The guard ring and bottom plate shall be controlled to eliminate lateral and downward heat from the test plate.

3. The local environmental climate shall be 25°C, ± 0.5°C (77°F, ± 1°F) and 65% RH, ± 4% RH. The air velocity shall be the same for all calibrations and tests. These conditions shall be measured continuously in the free flow air stream uninfluenced by the boundary of the test plate. Apparatus used to measure temperature shall be accurate to within ± 0.25°C. Apparatus used to measure humidity shall be accurate to within ± 4% RH.

4. The average bare plate thermal resistance, including the air layer and any apparatus contribution (Rcbp), shall be an average of at least 3 measurements with nothing mounted on the test plate.

5. The average intrinsic thermal resistance of the sample along (Rcf) shall be determined by subtracting the average bare plate resistance (Rcbp) form the average of the total thermal resistance (Rct) of the specimens tested.

6. The total thermal resistance (Rct) of the specimen shall be calculated form the following equation:

$$Rct = \frac{(Ts - Ta)\,A}{H}$$

where

Rct = total thermal resistance of the specimen and surface air layer ($°cm^2/w$)

T_s = temperature at the place surface (°C)

T_a = temperature in the local environment (°C)

A = area of the test plate (m^2)

B = power input (watts)

7. Data shall be collected when equilibrium is reached. Data shall be collected every 5 minutes. Equilibrium shall be a rate of change of less than 3 percent per hour of calculated thermal resistance over a period not less than 30 minutes. The standard deviation of the calculated thermal resistance shall be less than 1 percent.

8. The specimens shall be mounted on the test plate in the orientation its has in the finished garment from the skin surface (plate surface) to the outside.

9. The apparatus shall be calibrated to meet the following constraints:

(a) A graph of total thermal resistance versus number of layers of 7.5 oz./yd^2 Nomex duck shall be linear for the bare plate value, one, two, three, and four layers.

(b) The slope of the linear regression shall be 0.0206°Cm^2/W±10%.

(c) No individual data measurement shall be outside + 10% of the value predicted by the linear regression.

(d) The intrinsic thermal resistance of four layers of 7.5 oz Nomex duck shall be 0.082°cm^2/W±10%.

NOTE: The standard sample of 7.5 oz/yd^2 Nomex duck should be obtained form Office of Standard Reference Materials, National Institute of Standards and Technologies, Gaithersburg, Maryland 20899; 301-957-6776.

10. The average intrinsic thermal resistance of the specimens shall be determined by averaging all values obtained over the equilibrium period (minimum of 6). The average intrinsic thermal resistance of the sample shall be determined by averaging the values for all specimens. If the results for any of the 3 individual specimens vary more than ±10% from the average of all 3, then the test shall be repeated on the specimen(s) lying outside the ±10% limit. If the retest produces a value(s) within the ±10% limit, then the new value(s) shall be used instead. If the retest remains outside the ±10% limit, then an additional 3 specimens shall be tested, and all original

and retest results shall be reported along with the average and standard deviation for intrinsic thermal resistance, and a statement identifying this sample as having a high variability.

11. Water shall be fed to the test plate and guard ring so that water uniformly wets the test plate and guard ring surface.

12. The test plate and guard ring shall be covered with a liquid barrier that prevents wetting of the test specimen by the liquid water. The permeability index of the bare plate with the liquid barrier in place be greater than 0.7.

NOTE: The permeability index of the bare plate should be calculated from the following equation:

$i_m = 061 \times Rcbp/Rebp$

where

i_m = permeability index

Rcbp = average bare plate thermal resistance (without liquid barrier) described in paragraph 4 ($°cm^2/W$)

Rebp = average bare plate evaporative resistance (with liquid barrier in place) described in paragraph 14 (kPa_m2/W)

NOTE: One source for uncoated cellophane that will meet this Olin, Ecusta Paper and Film Group, NC 28768.

13. The average bare plate evaporative resistance, including the air layer, the liquid barrier, and any apparatus contribution, (Rebp) shall be an average of at least 3 measurements with only the liquid barrier mounted on the plate. The local environmental climate may be increased above 25°C (77°F) if necessary to maintain test plate temperature at 35°C (95°F).

14. The apparent total evaporative resistance (ARet) of the specimen shall be calculated from the following equation:

$$ARet = \frac{(P_s - P^a)A}{H - \frac{(T_s - T^a)A}{Rct}}$$

where

ARet = apparent total evaporative resistance of the specimen and surface air layer ($kPam^2/W$)

P_s = water vapor pressure at the plate surface (kPa)

P^a = water vapor pressure in the local environment (kPa)

A = area of the test plate (m^2)

H = power input (watts)

T_s = temperature at the plate surface (°C)

T_a = temperature in the local environment (°C)

Rct = total thermal resistance of the specimen and surface air layer ($°C\ m^2/W$)

NOTE: The term "apparent" is used as a modifier for evaporative resistance to reflect the fact that condensation may occur within the specimen.

15. Data shall be collected when equilibrium is reached. Data shall be collected every 5 minutes. Equilibrium shall be a rate of change of less than 3 percent per hour of calculated apparent evaporative resistance over a period not less than 30 minutes. The standard deviation of the calculated apparent evaporative resistance shall be less than 1 percent.

If data collection cannot be completed within 4 hr after mounting the specimen on the test plate, the specimen shall be removed form the test plate and allowed to dry at least 24 hr at 60-80°F (16° - 25°C) before retesting. Subsequent data reporting shall state that drying was required. If the retest of the specimen still cannot meet these constraints, then it shall be reported that the specimen cannot be tested by this method.

16. The average apparent intrinsic evaporative resistance of the sample alone (ARef) shall be the apparent total evaporative resistance (ARet) minus the average bare plate evaporative resistance (Rebp).

17. The apparatus shall be calibrated to meet the following constraints:

(a) A graph of apparent total evaporative resistance versus number of layers of 7.5 $oz./yd^2$ Nomex duck shall be linear for the bare plate value, one, two, three and four layers.

(b) The slope of the linear regression shall be .005 kPa m^2/W.

(c) No individual data measurement shall be outside ± 10% of the value predicted by the linear.

(d) The apparent intrinsic evaporative resistance of four layers of 7.5 oz/yd^2 Nomex duck shall be .020 kPa m^2/W, ± 10%.

18. The average apparent intrinsic evaporative resistance of the specimen shall be determined by averaging all values obtained over the equilibrium period (minimum of 6). The average apparent intrinsic evaporative resistance of the sample shall be determined by averaging the values of all specimens. If the results for any of the 3 individual specimens vary more than ± 10% from the average of all 3, then the test shall be repeated on the specimens(s) lying outside the ± 10% limit. If the retest produces a value(s) shall be used instead. If the retest remains outside the ± 10% limit, then an additional 3 specimens shall be tested an all original and retest results shall be reported along with the average and standard deviation for apparent intrinsic evaporative resistance, and a statement identifying this sample as having a high variability.

19. The average total heat loss of the sample shall be determined and reported, subject of the reporting requirements in paragraphs 11, 16, and 19. The total heat loss of the sample shall be calculated from the following equation:

$$Q^* = \frac{10°C}{Rcf + .04} + \frac{3.57kPa}{ARef + .0035}$$

where

Q^* = total heat loss (W/m^2)

Rcf = average intrinsic thermal resistance of the sample determined in paragraph 5 ($°C\ m^2/W$)

ARef = average apparent intrinsic evaporative resistance of the sample determined in paragraph 17 (kPa m^2/W)

* These values are appropriate for a surface air layer at an air temperature of 25°C, a relative humidity of 65 percent, a skin temperature of 35°C, and a nominal effective air velocity of 2 m/s.

NOTE: This calculation is based on the temperature and vapor pressure differences between and the test plate and local environmental climate specified in this procedure. Other environmental conditions may alter the performance measured.

Using the total heat calculated under the conditions used here to extrapolate to other environmental temperatures and other environmental humidities may also produce inaccurate results because of possible condensation within a composite that would not be accounted for. The permeability index of the specimen and its associated air layer may also be calculated using the following equation:

$i_m = .06 \times Rct/ARet$

where

i_m = permeability index

Rct = total thermal resistance described in paragraph 6($°C\ m^2/W$)

ARet = apparent total evaporative resistance described in paragraph 15 (kPa m^2/W)

I_m is the measure of the efficiency of evaporative heat transport in a clothing system. An i^m of 0 indicates that the clothing system allows no evaporative heat transfer. An i_m of 1 indicates that the clothing

system achieves the theoretical maximum evaporative heat transfer allowed by its insulation. Casual dress clothing typically has values for i_m of 0.3 to 0.5. Protective clothing typically has values of i_m of 0.1 to 0.3

Appendix C

C-1 The following documents or portions hereof are referenced within this standard for informational purposes only and thus are not considered part of the requirement of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

C-1.1 NFPA Publications, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101

NFPA 1581, *Standard on Fire Department Infection Control Program*, 1991 edition

NFPA 1991, *Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies*, 1990 edition

NFPA 1992, *Standard on Liquid Splash Protective Suits for Hazardous Chemical Emergencies*, 1990 edition

NFPA 1993, *Standard on Support Function Garments for Hazardous Chemical Operations*, 1990 edition