NBSIR 75-702

Design Criteria for Firefighters' Turnout Coats

J. W. Eisele

Center for Fire Research
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

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Final Report

Prepared for
National Fire Prevention and Control Administration
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U.S. DEPARTMENT OF COMMERCE, Rogers C.B. Morton, *Secretary*
James A. Baker, III, *Under Secretary*
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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

CONTENTS

CONTENTS (cont'd)

LIST OF FIGURES

LIST OF TABLES

DESIGN CRITERIA FOR FIREFIGHTERS' TURNOUT COATS

J. W. Eisele

These design criteria cover requirements for the sizing, construction, outer shell, inner linings, weight and thickness for firefighters' turnout coats as well as test methods, labeling requirements and design considerations. Included also is a list of options and other items of concern to potential users of the criteria and a sample purchase specification to be used in conjunction with the criteria.

Key words: Firefighters; firefighters' turnout coats; protective clothing.

1. INTRODUCTION

Early in the program on turnout coats, a series of studies were made directed toward determining what was needed by the Fire Services in the way of turnout coats, and for investigating the most practical means for meeting these needs as soon as possible. The studies concentrated on evaluating what was available in the marketplace. Based on these studies and the needs and desires of the Fire Department of Prince Georges County, Maryland, a purchase specification was developed which was used by that County to purchase a number of coats. A coat manufacturer was able to meet the specification at a reasonable price and the Fire Department has found the coat satisfactory.

Based upon the Prince Georges County experience, upon additional research (conducted by the National Bureau of Standards and many others) and upon comments from Fire Service personnel, proposed guidelines were prepared and circulated nationally to leaders of the International Association of Fire Chiefs, including the entire Metropolitan Committee, to each Director of State Fire Service Training, to representatives of the International Association of Fire Fighters, and to other interested parties. To obtain the views of manufacturers, the proposal was sent to all known manufacturers of turnout coats, and to manufacturers of the base fabrics and trim materials.

The comments were analyzed and used as the basis for proposed changes to the draft. The proposed changes were discussed at a series of the seminars arranged by Fire Service groups. They include the International Association of Fire Chiefs, International Association of Fire Fighters, International Fire Service Training Association, National Fire Protection Association, the University of Maryland Extension Service and the Federal Fire Council. The proposals contained in this report represent the results of this consensus process.

The publication of these guidelines and their general acceptance by the Fire Services does not lay to rest the problem of obtaining acceptable turnout coats, however. First, the guidelines leave many items to local option and each fire department must make its own selection from these options. Appendix B of this report is included to help in defining these local options.

Second, design concepts should be continually updated and upgraded; these guidelines are no exception. New technology pertinent to the product will continually become available and field experience with coats meeting these criteria will uncover needed improvements.

Included in this report as appendix B is a list of options and other items of concern to potential users of the report. Those referencing the criteria in a purchase specification could limit their attention to the items covered in appendix B. Appendix C contains a summary of requirements for additional information that the manufacturer must supply. A sample purchase specification for using the criteria is contained in appendix D.

2. DESIGN CRITERIA FOR FIREFIGHTERS' TURNOUT COATS

2.1. Purpose

The purpose is to improve the protection afforded firefighters by their turnout coats and to insure the durability of the coats. The criteria will serve as a guide for fire officers and others responsible for purchasing protective clothing for firefighting. This document may be referenced completely or in part in purchase specifications. If referenced in its entirety, care should be taken to specify the particular options desired; for example, the type of closures and the size and location of pockets. This document is not intended to serve as a detailed manufacturing specification. It has been prepared, as far as practicable, in terms of required performance, avoiding specifications of materials or designs so phrased as to preclude obtaining the desired results by other means. It is not the intention of this document to bar from consideration materials of improved quality or special designs if they meet the performance requirements.

2.2. Scope

A turnout coat is an outer garment worn to protect the upper portion of the firefighter's body, excluding the head and hands, while he is engaged in structural firefighting. This document covers coats designed for protection against extremes of temperature, sharp objects, steam, hot water, hot particles, and other hazards encountered during fire and emergencies. The report presents requirements that are applicable to both water-permeable and impermeable outer shells. Additional requirements applicable only to impermeable coats, which should be included in the purchase specification are: brittleness at low temperature, coating thickness, and coating adhesion; these are not treated here but should be considered where impermeable coats are purchased.

2.3. General

Requirement - The coat shall consist of an outer shell, vapor barrier, and insulation. (The outer shell may serve as the vapor barrier.) The vapor barrier shall have a minimum water penetration of 25 psi when tested using method 5512 of Federal Test Method Standard No. 191, "Textile Test Methods," [1][1] and shall be insulated from the body for protection from trapped steam. Later issues of all referenced publications shall be used provided the requirements are applicable and consistent with the issue designated. In those instances where specific requirements are not provided in this report nor in the purchase specification, the coat shall be made in accordance with good commercial practice.

Comment - Design considerations for air circulation and impact resistance are given in appendix A, as are guidelines on padding, color selection, water repellency and pocket selection. Items of equal performance and safety should be allowed as substitutes for those specified provided that adequate technical evidence is given and that the substitute is approved by a technically qualified representative of the purchaser (when applicable), the senior officer of the Fire Department and by the purchasing agent. High quality (durability) requirements have been set for the outer shell and the inner most liner by setting relatively high tear strength requirements for these items. The tear strength requirement for the outer shell material is based on the results of actual tests conducted by those associated with the fire services at seminars held during the development of the standard. A department having relatively high fire-fighting demands, or other such reasons, may wish to save money by purchasing a less durable coat. Since the tear strength test is the one most related to durability, a less durable coat can be obtained by specifying a lower level on the tear strength test than the level stated in table 1.

2.3.1. Sizing

Comment - Proper sizing is an important safety characteristic and custom ordering of coats or ordering by traditional coat sizes (e.g. 34, 36, 38 etc., short, medium, and long) are good methods of selection. In selecting a coat length, consideration should be given to the protection afforded the leg and buttocks area by boots and pants. While the coats shall be made to allow room for air circulation, in cities with very cold winters it may be desirable to order coats slightly larger than needed to allow room for sweaters or vests, or to specify that an additional liner be added. This additional liner is not considered an insulation liner for the purpose of the labeling requirement in 2.3.3.11. [4]

[1]Numbers in brackets refer to the literature references listed in appendix E.

Table 1. Outer Shell Requirements

Characteristics and Test Methods*	Requirements**
Tearing Strength, lb (min) ASTM Method D 2263, "Automotive Fabrics Testing," Trapezoid Tearing Load of Woven fabrics method, except that the tearing strength of the specimen shall be the average of the five highest peak loads of resistance, disregarding the first high peak, registered for 3 inches of separation of the tear. [2]	22.0***
Color fastness (minimum) To light, method 5660 To laundering, method 5605 without bleach To crocking, method 5651	 Good Good Good
Shrinkage in laundering AATCC method 96 - Test IV E [3] Max. change in length Max. change in width Max. difference between length and width	 ±3% ±3% 3%
Water absorption, method 5500 (see appendix A5 for information on water repellency.)	28% maximum
Flame resistance (including trim) Method 5903 Char length (inches), (max.) After flame (seconds), (max.)	 4.0 2.0

*Unless otherwise indicated, the test method references pertain to Federal Test Method Standard No. 191, "Textile Test Methods."

**All requirements above are also applicable after five cycles of laundering and drying in accordance with American Association of Textile Chemists and Colorists (AATCC) Method 96 Test IV-E.

***Information - Material meeting this strength (durability) requirement and all other requirements specified is available. However, a Fire Department may wish to use a lower performance level for tear strength because their light firefighting demands permit the use of a less durable and less expensive coat. (see section 2.3.)

2.3.2. Stitching

Requirement - Each load-bearing seam, including pockets, their dividers, and the storm flap, shall possess a breaking strength of at least 80 pounds or 80 percent of the outer shell material when tested in accordance with ASTM D 1683-68, "Standard Method of Test for Seam Breaking Strength (Load) of Woven Textile Fabrics" (with the machine operated at a rate of 12 $\pm$ 1/2 in/min). [5] The fiber stitching shall be compatible with the shell material and shall not carbonize at a temperature below 700 °F (351 °C).

2.3.3. Outer Shell

General - For those fire departments which consider the purchase of an impermeable outer shell necessary for the reasons indicated in appendix A5., such a coat should be considered in compliance with this report provided the variations from this report for the outer shell are approved by the purchasing fire department and specified in the purchase document. It should be noted that it will be difficult, if not impossible, for existing impermeable coats to meet the combination of requirements for the outer shell in this report. When the manufacture of impermeable coats meeting all the requirements of this report becomes practicable, this exception should be considered terminated.

2.3.3.1. Material

Requirement - The outer shell shall be fabricated of material meeting the requirements specified in table 1. All requirements are also applicable after five cycles of laundering and drying in accordance with American Association of Textile Chemists and Colorists (AATCC) Method 96-Test-IV-E. (This is a commercial laundering and drying cycle which provides a 203° to 212 °F (95° - 100 °C) exposure in a water environment for the material.) This provides a steam-like exposure for the coat. The manufacturer must also provide the purchaser with the following information prior to purchase; exact performance levels to be set by local options:

1. Evidence or a guarantee of the durability of the coat. (While the tear strength requirement should provide an indication of the durability of the outer shell, some supporting evidence of the coat's overall durability is needed.)

2. Evidence of the satisfactory stability of the fabric at high temperature, including temperature/shrinkage curves and the temperature at which a fabric will char, separate, and melt. All results shall show the effects of temperature exposures in a forced air oven for 10 minutes.

3. Evidence of the fabric's resistance to caustic substances.

Comment - Requirements for durability, high-temperature performance and resistance to caustic substances are left to local option for two reasons: (1) different levels of performance will be required by different departments, depending on their size, geographical location, and the kinds of fires they are most likely to encounter; and (2) single test methods are not capable of measuring the appropriate performance characteristics over a range wide enough to accommodate all local requirements.

In setting performance levels for these characteristics, the local fire department should consider the frequency with which the coats will be used and the likelihood that they will be exposed to severe thermal or chemical conditions.

2.3.3.2. Visibility

Requirement - The coat shall have a minimum lightness in color or shall be trimmed with fluorescent tape. If a minimum color visibility is selected as the alternative, it shall be not less than Munsell Value 7/(43.06%) for CIE source "C" (6774K) when tested in accordance with either American Society for Testing and Materials (ASTM) Method D 1535-68, "Standard Method of Specifying Color by The Munsell System" [6] or ASTM E 308-66, "Standard Recommended Practice for Spectrophotometry and Description of Color in CIE 1931 System." [7]

Comment - The color requirement establishes a minimum acceptable level of visibility. It will include most whites and yellows. Of the non-white colors, yellow and yellow green have been found to be highly visible. The visibility of the coat in the day time can be further increased by the use of fluorescent materials. Visibility at night can be increased by the use of retro-reflective materials (see 2.3.3.9.). To continue the benefits of a visible coat, the outer coat should be periodically cleaned. A label with washing instructions is required on the inside of the coat (see 2.3.3.11.).

Requirement - The coat shall contain at a minimum, reflectorized trim, and when specified, fluorescent trim, as follows (all tape shall be at least 2 inches wide):

1. circumference band on each sleeve just above cuff line,

2. circumference band around bottom of coat, and

3. additional striping on the front and back of the upper portion of the coat as selected by the purchaser.

Comment - A possible configuration for reflectorized trim would be:

1. Back:

   ° Two 15-inch vertical stripes (separation between vertical stripes 15 inches)

2. Front:

° One 30-inch vertical stripe

° Two 17-inch vertical side stripes

° (separation between vertical stripes approximately 3 inches)

2.3.3.3. Collar

Requirement - The collar shall be snug fitting and comfortable and shall completely cover the neck and throat when in the raised position. A throat strap of at least 3 inches in width shall be sewn to the underside of the collar on the left side and shall be closed by means of hook and pile fastener tape or by a snap fastener. It shall be held in the stowed position by a portion of tape or by a snap fastener. When used, tape shall conform to the requirements of section 2.3.8. No snaps shall directly contact the skin when the collar is in the closed position. The collar shall provide water penetration protection at least equal to the vapor barrier (see section 2.3.).

Comment - If the material in the outer shell is rough, the purchaser may wish to specify that a liner material be used. Such a material could be preshrunk cotton corduroy (10 wales per inch minimum), moleskin, or other soft material meeting the requirements in table 2 (fabric weight requirement applicable to corduroy only.) The cotton corduroy specified is soft and if charred, the charred portion can be brushed away if not extensively burned and the coat can be continued in use with little or no irritation to the firefighter's neck. Based upon a number of comments received during the development of this standard, a better covering for the back of the neck would be desirable (that is, one that would better keep out embers, etc.). Such a covering should be in conformance with these criteria if its material and construction are consistent with the requirements of this report. If the use of such a covering would cover ears that would otherwise be exposed, the loss of the ears as a heat sensor and interference with hearing should be considered in deciding upon the use of such an item.

2.3.3.4. Sleeves

Requirement - The sleeves shall be attached to the coat so that there is no restriction and the wrist remains covered when the arms are raised above the head.

Comment - Outer shell material meeting the requirements of these criteria should provide significant wear resistance for the entire sleeve. (See section 2.3.3.1. on obtaining wearability data from the manufacturer.) An optional reinforcement for the lower part of the sleeve, which must be specified, could be leather meeting the requirements of 2.3.6. or any materials which meet the requirements of table 1.

Table 2. Requirements for Corduroy Used in Collar

Characteristics and Test Methods*	Requirements**
Fabric Weight Method 5041	9 oz/yd^2 minimum
Breaking strength Method 5100	35 lb minimum in warp and fill
Flame resistance Method 5903	Char length - 4.0 inch maximum After flame time - 2.0 second maximum
Colorfastness to perspiration AATCC Method No. 15	
Color change	Class 3.5 or better
Staining	Class 3.5 or better
Shrinkage in laundering AATCC Method No. 96 - Test IV-E	Results to be reported after 5 laundering cycles
Maximum change in length	$\pm$5%
Maximum change in width	$\pm$5%
Maximum difference between length and width	5%

*Unless otherwise indicated, the test method references pertain to Federal Test Method Standard No. 191, "Textile Test Methods."

**All requirements above are also applicable after five cycles of laundering and drying in accordance with American Association of Textile Chemists and Colorists (AATCC) Method 96 - Test IV-E.

2.3.3.5. Wristlets

Requirement - Each sleeve shall have a suitable and durable wristlet which meets the flammability requirements for trim (see table 1). The wristlet ensemble will be of a configuration such that the material will form a well to collect water below the wristlet when the arm is in the raised position.

2.3.3.6. Shoulder and Backyoke

Requirement - The shoulder and backyoke shall be reinforced from a point on the front of the coat at least 4 1/2 inches from the crown of the shoulder to a point on the back of the coat at least 6 inches from the bottom of the collar by a double thickness of material meeting the requirements for the outer shell.

2.3.3.7. Storm Flap and Closures

Requirement - The front of the coat shall close in a manner which provides secure protection from steam and water when the coat is worn and shall allow freedom for leg movement. Conventional coat designs utilize a storm flap to provide this protection. When a storm flap is used, acceptable inside closures shall be hook and pile fastener tape at least 1-inch wide conforming to the requirements of section 2.3.8. (snaps or other mechanisms shall be provided for aligning the tape); 4 sets of hook and dee rings conforming to the requirements of 2.3.7.1., spaced approximately 7 inches apart, or snap fasterners conforming to the requirements of section 2.3.7.3. spaced approximately 7 inches apart. If the inside closure is hooks and dee rings, the outside closure shall be hook and pile fastener tape at least 2-inches wide conforming to the requirements of section 2.3.8., or snap fasteners conforming to the requirements of 2.3.7.3. If the inside closures are snaps or hook and pile fastener tape, the outside closure shall be hook and dee rings conforming to the requirements of 2.3.7.1. or hook and pile fastener tape at least 2-inches wide conforming to the requirements of 2.3.7.3.

Comment - Any combination that does not include hook and dee rings should be specified by the purchaser and approved by his technically qualified representative and by the senior officer of the Fire Department, based in part on a demonstration by the manufacturer of the ability of the closure to provide an acceptable closure when flexed and strained as in use.

Requirement - Each rivet hole for both snaps and dees shall be supported or reinforced on the inside with appropriate material, such as a patch of leather of any type, but having the same minimum thickness as the leather specified in 2.3.6.

2.3.3.8. Pockets

Requirement - The location, size and number of pockets shall be as agreed upon between buyer and seller. (See appendix A6. for guidelines on pocket selection.) They shall be reinforced in all four corners and at flap corners with a series of stitches forming a bar. Each rivet shall be reinforced with appropriate material such as a patch of leather complying with the requirements of 2.3.6. Each outside pocket shall have a flap of at least 3 inches in depth. On the outside, the lower 5 inches of the pocket shall be reinforced with a material meeting the requirements of table 1. An optional reinforcement could be leather meeting the requirements of 2.3.6. The pocket shall also have two holes at the bottom, providing a means of drainage for water.

2.3.3.9. Retro-reflective Material Use

Requirement - The retro-reflectorized fabric shall be as described in 2.3.9. and shall be sewn to the coat.

2.3.3.10. Attachment of Linings

Requirement - Lining shall be securely attached to the outer shell in the neck, front face and wristlet areas by snap fasteners or by stitching except that in the neck area hook and pile fastener tape may be used. If snap fasteners are used, two shall be positioned on each sleeve, just above the wristlets. The metal of these fasteners shall not extend from the outside surface of the coat to the inside surface as worn. Fastener tape shall conform to the requirements of 2.3.8.

2.3.3.11. Labels

Requirement - Each outer shell shall have sewn to the inside in a location not covered by the lining (e.g., inside front flap), one or more permanent labels stating the following:

1. Fiber content of the outer shell fabric, to conform with the "Rules and Regulations under the Textile Fiber Products Identification Act,"
2. Size of coat for which the outer shell is designed (see 2.3.1.),
3. Care instructions, including minimum instructions for washing or cleaning. These instructions shall include instructions for home machine laundering and a cautionary statement if this washing can remove the water repellent treatment.
4. A warning that for effective firefighting protection, the coat must be fully assembled to include the vapor barrier(s) and all insulation layers. (This label is not required if all linings are sewn to the outer shell.)

5. A warning that the coat is not a proximity or entry suit and should not be kept in direct contact with flames.

2.3.3.12. Hangar Loops

Requirement - Unless otherwise specified, a fabric hangar loop shall be provided inside the neck. It shall be sewn in so that it shall not tear or separate from the coat when the coat is hung up by the hangar loop, loaded evenly with a weight of 100 pounds, and allowed to hang for one minute.

2.3.4. Linings

(Linings provide insulation, limited padding, and in many cases the vapor barrier.)

2.3.4.1. Material

Requirement - The linings shall be fabricated of material meeting the requirements specified in table 3. The requirements contained therein are also applicable after five cycles of laundering and drying in accordance with AATCC Method 96 Test III-E except that for those linings next to the body which do not have the vapor barrier integral to them, the laundering requirement will be in accordance with the washing instructions on the label. The manufacturer must also provide information on the high temperature stability of the fabric prior to purchase, to include temperature/shrinkage curves, and an indication of the temperature at which a fabric will char, separate and melt, with all results showing the effects of temperature exposures in a forced air oven for 10 minutes.

Comment - As in the case for the outer shell, requirements for high-temperature performance will vary depending upon the firefighting conditions to be encountered. Requirements are therefore left to local option.

2.3.4.2. General Configuration and Measurements

Requirement - The linings shall have the general configuration indicated in figure 1 and shall extend to within 3 inches of the hem of the coat. Their sizing shall be compatible with that of the outer shell so they do not buckle, pull, or otherwise restrict body motion, even when the arms are raised directly overhead.

Table 3. Requirements for Linings

Characteristics and Test Methods*	Requirements**
Tear strength, ASTM Method D2263, "Trapezoid Tearing Load of Woven Fabrics Method," except that the tearing strength of the specimen shall be the average of the five highest peak loads of resistance, disregarding the first high peak, registered for 3 inches of separation of the tear.	Lining type Single layer & multiple layer (lining next to body) *** Warp - 15 lb, minimum Fill - 10 lb, minimum Multiple layer (lining next to shell, i.e., vapor barrier.) Warp - 4 lbs, minimum Fill - 3 lbs, minimum
Water absorption, Method 5500	40% maximum
Shrinkage in laundering AATCC Method 96-Test III E, except that for those linings next to the body which do not have the vapor barrier integral to them, the laundering requirement will be in accordance with the washing instructions on the label. (5 cycles)	Lining type Single layer and multiple layer (lining next to body)- Max. change in length ±3% Max. change in width ±3% Max. difference between length & width - 3% Multiple layer (lining next to shell, i.e., vapor barrier) - Max. change in length ±5% Max. change in width ±5% Max. difference between length and width - 5%
Flame resistance, Method 5903 Char length, maximum (inches) After flame, maximum (seconds)	 6.0 2.0

*Unless otherwise indicated, the test method references pertain to Federal Test Method Standard No. 191, "Textile Test Methods."

**All Requirements above are also applicable after five cycles of laundering and drying in accordance with American Association of Textile Chemists and Colorists (AATCC) Method 96-Test III-E unless otherwise indicated.

***Information - Purchase of a less durable material may be acceptable under the standard provided the purchaser agrees to a decrease in the quality and strength received (see 2.3.).

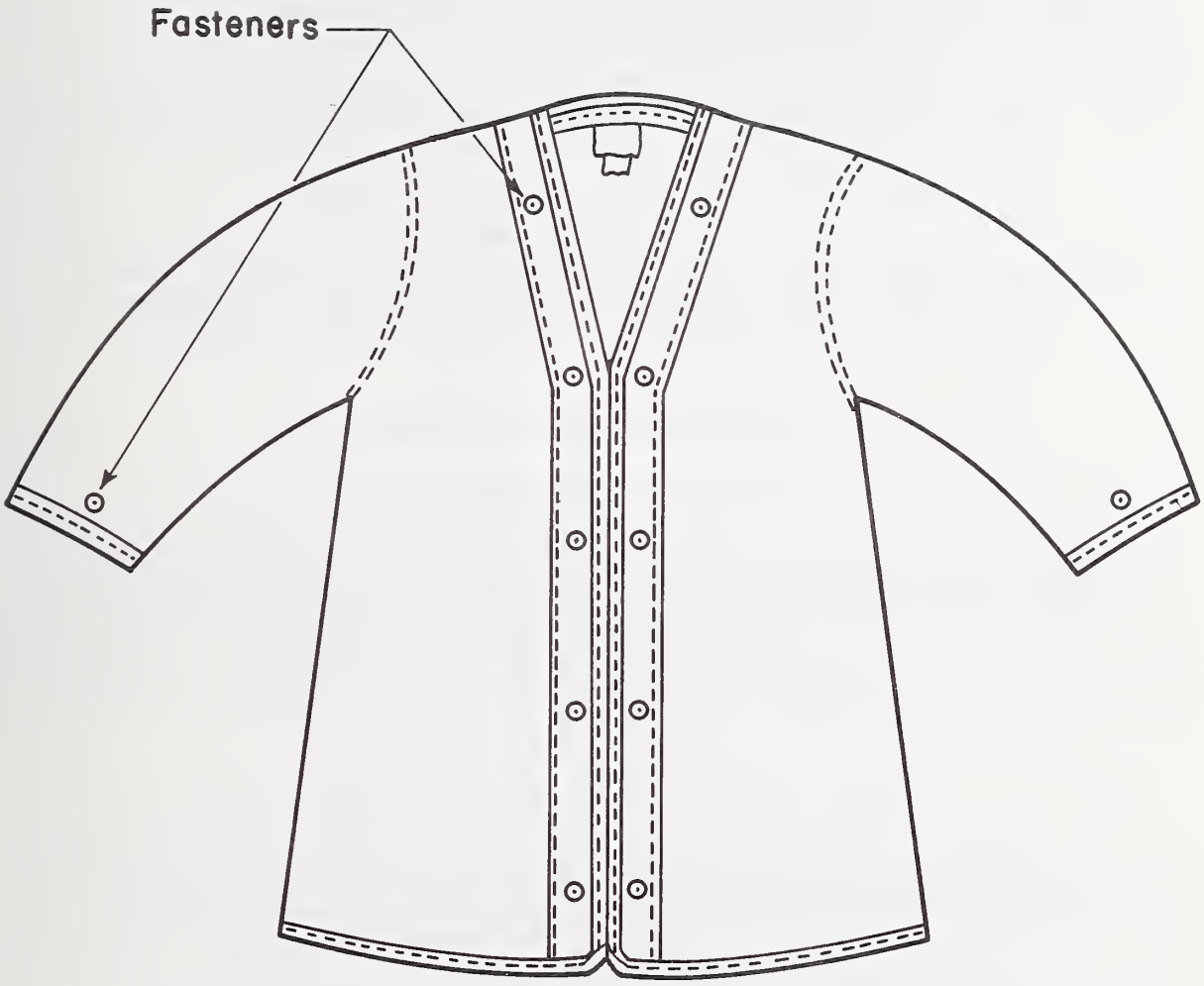


Figure 1. General configuration of linings showing snap fastener locations.

2.3.4.3. Attachment to Outer Shell and Other Linings

Requirement - Attachment shall be in accordance with 2.3.3.10.

2.3.4.4. Labels

Requirement - Each lining shall have sewn visibly to the inside, near the neck, one or more permanent labels stating the following:

1. fiber content of the lining fabric, to conform with the "Rules and Regulations under the Textile Fiber Products Identification Act,"
2. size of the coat for which the lining is designed, (see 2.3.1.), and
3. care instructions, including minimum instructions for cleaning or washing. These instructions shall include home machine laundering instructions.

2.3.5. Requirements for the Assembled Coat

2.3.5.1. Total Weight

Requirement - The total weight of a size 40 (40-inch back length -- back length from collar base to coat bottom) coat shall not exceed 6.0 pounds when weighed on a scale with an accuracy of $\pm$ 0.1 pound. Other sizes shall vary in weight in proportion to the variation in fabric area required. The coat shall be conditioned and weighed at Standard Atmospheric conditions in accordance with Section 4 of Fed. 191.

2.3.5.2. Thickness (Insulation Provision)

Requirement - The minimum thickness of the assembled coat shall be 0.175 inch when tested using a compressometer with a 3-inch diameter presser foot set at 0.05 psi, following the procedure outlined in American Society for Testing and Materials (ASTM) Method D1777-64 (70), "Thickness of Textile Materials, Measuring," [8] allowing 5 seconds to lapse between the application of the load and the thickness reading.

Comment - This requirement is a minimum thickness based on what appears practicable at this time. It can be expected that increased insulation from the heat of the fire can be obtained up to 0.250 inches thickness, however, and thicker composites should therefore be obtained when possible.

Requirement - The manufacturer shall supply information on the thickness of the coat prior to sale.

2.3.6. Leather

Requirement - When used to reinforce cuffs and pockets, leather shall be a flesh split cattlehide, suede natural finish, conforming to Type III, Class 2 of Federal Specification KK-L-162, "Leather, Cattlehide, Chrome Tanned for Gloves, Garments and Equipment," [9] except that the shrinkage temperature shall not be less than 230 °F (110 °C) and the requirements for chloroform extract, ash content, chrome oxide, and acidity (pH) shall not apply. The thickness of the leather shall be not less than 2 1/2 ounces nor more than 4 1/2 ounces when tested in accordance with Method 1011 of Federal Test Method Standard No. 311, "Leather, Methods of Sampling and Testing." The water resistance shall be 50 taps when tested in accordance with Method 8121 of Fed. 311. [10]

2.3.7. Hardware

Requirement - All outer surfaces on metal parts shall be nonferrous to avoid sparking and shall be rust resistant.

2.3.7.1. Hooks and Dees

Requirement - The hooks and dees shall be aluminum and shall conform in general to the design and dimensions shown in figure 2 (4 vs 3 stays are allowed). The top hook may be outward facing. The casting shall be sound, smooth, and free from fracture and repair such as impregnations, peening and weld. The commercial finish of the hooks and dees shall be free of any rough spots, burrs, and sharp or rough edges.

2.3.7.2. Rivets

Requirement - The rivets for attaching hooks and dees shall be 9/64 inch nominal size and shall conform to Type XII, Class 3, Grade B of Federal Specification FF-R-556C, "Rivet, Solid, Small; Rivet, Split, Small; Rivet, Tubular, Small; Bur and Cups, Rivet; General Purpose" except that the inside of the rivet shank may be chamfered. [11]

2.3.7.3. Snap Fasteners

Requirement - The snap fasteners for attachment of the outer shell and innerlinings to each other shall conform to style 2 of Military Specification MIL-F-10884D, "Fasteners, Snaps." [12]

2.3.8. Fastener Tape

Requirement - Fastener tape, hook and pile, used for pockets, collar, and storm flap closures shall conform to Type II, Class 4, of MIL-F-21840D, "Fastener Tapes, Hook and Pile, Synthetic." [13] Other fastener tape may

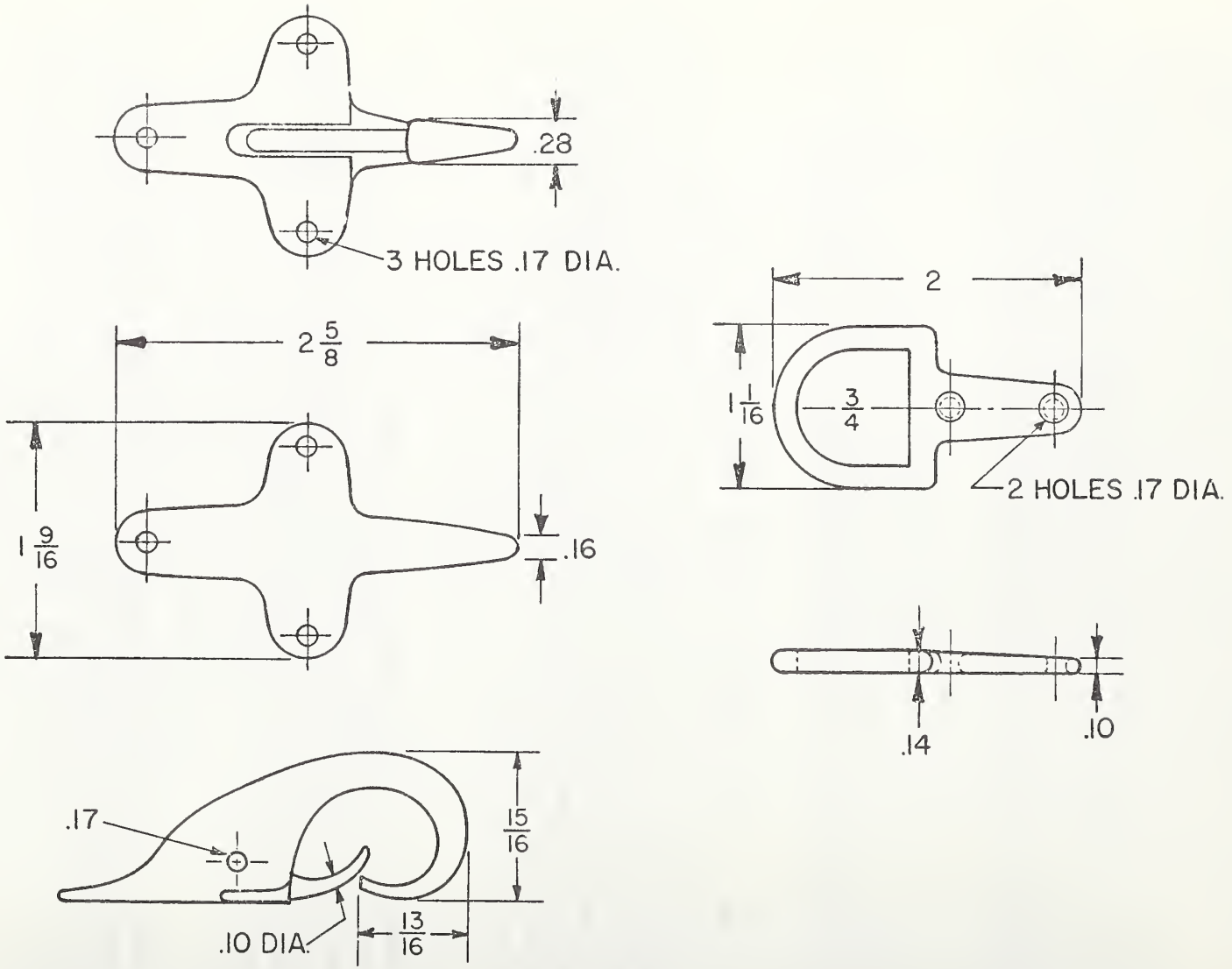


Figure 2. "Hook and dee ring (inward facing)" (all dimensions in inches).

used provided it meets or exceeds the performance of that specified.

Comment - This tape at present does not meet the flammability requirements provided for trim. Use of the tape should be allowed however, provided the manufacturer supplies information on the flammability of the material prior to sale and provided the variations from the report are approved by the purchasing fire department and specified in the purchase document. When the manufacture of hook and pile fastener tape meeting all the requirements of this report becomes practicable, the provision of this exception should be considered terminated.

Requirement - The manufacturer shall also provide information to the purchaser, prior to sale, on the high temperature stability of the tape, to include an indication of the temperature at which the tape will char, melt, or shrink, with all results showing the effects of temperature exposures in a forced air oven for 10 minutes.

2.3.9. Retro-reflective Material Properties

Requirement - The manufacturer must in all cases provide information to the purchaser, prior to sale, on the high temperature stability of the fabric, to include temperature/shrinkage curves and an indication of the temperature at which a fabric will char and melt, with all results showing the effects of temperature exposures in a forced air oven for 10 minutes.

Comment - While use of retro-reflective trim material is an important safety feature for firefighters' outer wear, no national standard exists setting minimum performance requirements for this material for use on firefighters' coats. Users should therefore give consideration to the performance of those materials which have been used in the past. While some retro-reflective material may meet the flammability requirements for trim provided in this report, these materials have not been field tested. For this reason, retro-reflective material that does not meet the flammability requirements in the report can be used provided variations from the report are approved by the purchasing fire department and specified in the purchase document.

APPENDIX A. DESIGN CONSIDERATIONS

A1. Air Circulation

Air circulation within the coat is desirable for cooling. Designs which could promote this characteristic would be the use of spacers within the coat, billowing designs at the bottom of the coat, air inlets under the flap in the shoulder area and air inlets under the arms. The effect of air inlets under the arms however, appears to be small. Billow designs should not be such as to allow easy entry of flames to the linings of the coat. Belts, it should be noted, serve to increase the heat storage level.

A2. Impact Resistance

Striking and being struck by objects are the most frequent causes of injury at a fire, and of these, injuries to the upper extremities are the most numerous. Incorporation of impact protection in the coat by means of padding should be considered highly desirable, provided the weight of the coat is not increased beyond the specified weight requirements, thereby increasing the danger of fatigue and heat strain, the most severe of the various types of injuries.

A3. Padding

Consideration should be given by the purchaser to specifying elbow protection for wear resistance and heat protection when crawling.

A4. Color

The following information is offered for guidance in the selection of color:

1. Light colors assist visibility;
2. For thermal comfort in sunlight, color has a strong effect on solar heating load, and light colors, as expected, tend to be best. However, when the coat is soiled, this effect is reduced;
3. For radiant heat protection from fires, color has only a small effect on reducing the radiative heating load and soiled or wet clothing may negate any color effect entirely;
4. Only special aluminized fabric constructions or reflective pigments offer a distinct improvement in reducing the radiative heat load from fires and these only when used on the outer shell.

A5. Water Repellency

A high degree of water repellency can be obtained by specifying that a water repellent treatment be placed on materials that are not inherently water repellent. This treatment is susceptible to removal after several home washings however, and must then be renewed. While the flammability requirements of this report apply to the coat after it has been treated for water repellency, care must be taken in the selection of subsequent treatments to insure that the flammability of the coat is not increased. A permeable coat, even with a water repellent treatment, can absorb considerable water and hold it for evaporation and cooling of the wearer, although this will add additional weight. The value of this factor has also been questioned by some persons commenting. Water on an impermeable outer shell runs off quickly and there is little water present at any instant for evaporative cooling. This characteristic may be offset in the selection of coats by departments however, by the ability of impermeable outer shells to reduce ice formation on the coats in freezing conditions and by their ability to dry faster. A material which is available, and which increases the water repellency of the coat is back-coated flame resistant fabric. This type fabric might also provide the vapor barrier. A method which can be used to test the water resistance of the coats is Method 5526, "Water Resistance of Cloth with Hydrophobic Finish; Spray Method," of Fed. 191. A description of this test follows.

A6. Pocket Selection

Care should be taken to specify pockets large enough to carry those tools and items normally carried by the intended users. Placement should allow for access to the pockets while wearing breathing apparatus. Specifying ballooned pockets will increase capacity, but may interfere with maneuverability. Ballooning only the back edges may serve to minimize the maneuverability problem. Divided pockets may be desired, as well as pockets for specific items, such as masks and radios. Fastening mechanisms for the mask on the outside of the coat in the area of the left shoulder might also be considered.

A7. FEDERAL TEST METHOD STANDARD NO. 191

METHOD 5526
31 December 1968

WATER RESISTANCE OF CLOTH WITH HYDROPHOBIC FINISH;

SPRAY METHOD

1. SCOPE

1.1 This method is intended for determining the hydrophobic effectiveness of water-repellent finishes applied to cloth by measuring the amount of water absorbed.

2. TEST SPECIMEN

2.1 The specimen shall be a square of cloth 8 inches by 8 inches.

3. APPARATUS (Fig. 5526A)

3.1 Six-inch glass laboratory funnel held by a laboratory ring support.

3.2 Spray nozzle of 1-7/16 inch outside diameter having a convex face with a 1-1/4 inch radius and connected to the funnel with a piece of 3/8 inch rubber tubing.

3.2.1 The nozzle shall be provided with 19 holes, 0.035 inch in diameter (No. 65 drill), having 1 hole in the center, 6 evenly spaced holes on a 25/64 inch diameter circle concentric with the outside circumference of the nozzle.

3.2.2 The distance from the top of the funnel to the bottom of the nozzle shall be 7-1/2 inches.

3.3 Metal embroidery hoops 6 to 7 inches in diameter for mounting the specimen.

3.4 Block of wood for supporting the mounted specimen so that the plane of the specimen makes an angle of 45° with the horizontal.

3.5 The distance from the bottom of the nozzle to the center of the hoop-mounted specimen shall be 6 inches.

METHOD 5526

4. PROCEDURE

4.1 Unless otherwise specified in the material specification, the specimen shall be securely mounted, finished side up, in the embroidery hoops with sufficient tension to insure a uniformly smooth surface.

4.2 Unless otherwise specified in the material specification, the direction of the flow of water down the specimen shall coincide witht he warpwise direction of the specimen as placed on the stand.

4.3 The mounted specimen shall be placed on the block with the center of the specimen directly beneath the center of the nozzle and the plane of the surface of the specimen at a 45° angle with the horizontal.

4.4 A 250-ml volume of distilled water at a temperature of 26.7° $\pm$ 1.0 °C (80° $\pm$ 1.8 °F) shall be poured quickly into the funnel and allowed to spray onto the specimen which should take approximately 25 to 30 seconds.

4.5 Upon completion of the spraying period, the hoop shall be grasped at one edge and the opposite edge tapped downward against a solid object, the wet side of the specimen being face down during tapping. The hoop shall then be turned 180°, grasped at the opposite edge, and similarly tapped at the point previously held.

4.6 After tapping, the finished side of the cloth shall be compared with the standard figure 5526B and the wetted and/or spotted pattern on the specimen assigned a rating corresponding to the nearest standard rating.

4.6.1 No attempt shall be made to assign to the cloth an intermediate rating.

4.6.2 In rating light porous cloth, passage of water through the open construction of the cloth shall be disregarded.

5. REPORT

5.1 Unless otherwise specified in the material specification, three specimens shall be tested from each sample unit.

5.2 Spray rating shall be reported for each specimen tested.

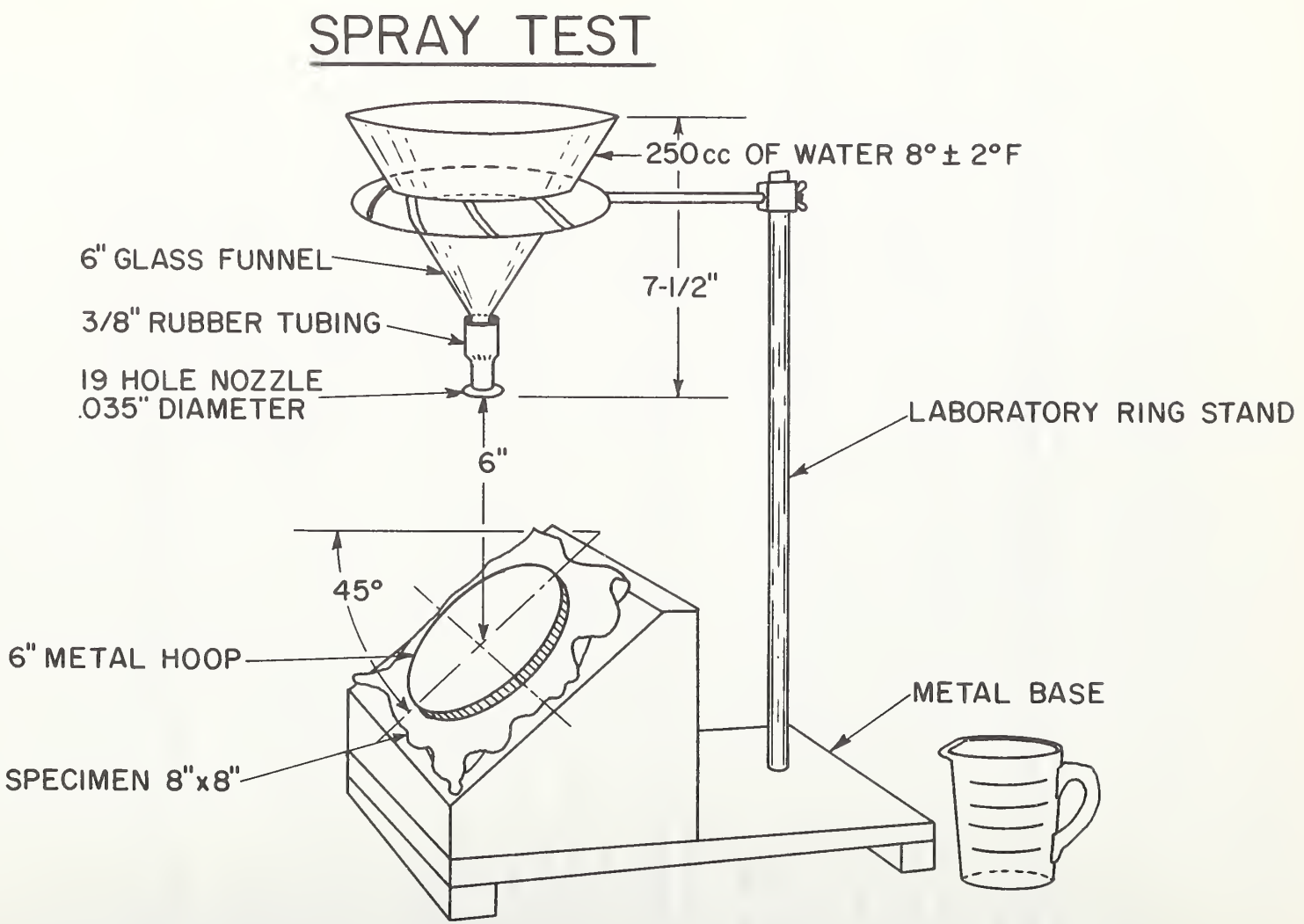
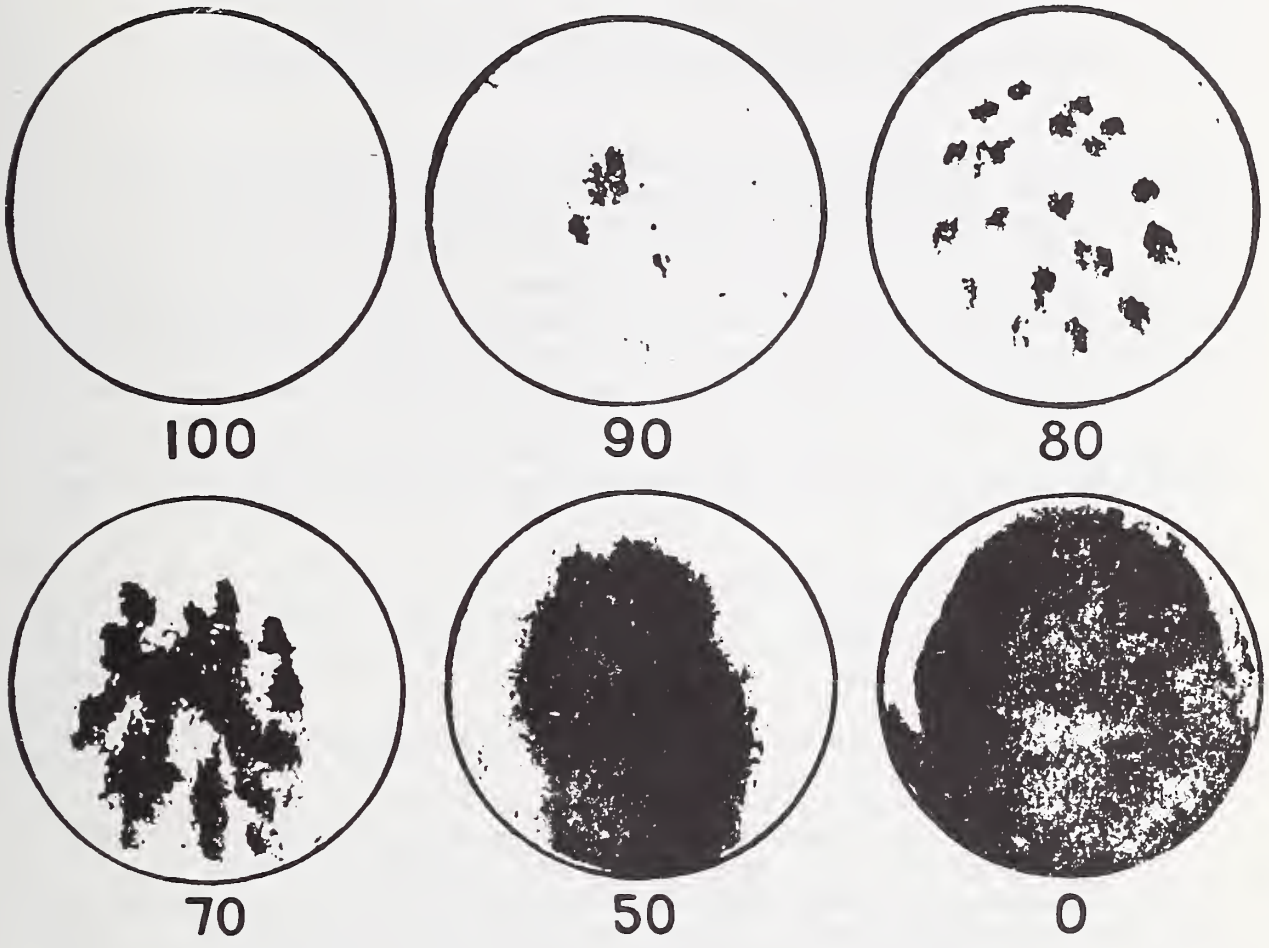


Figure A1. Spray Test, Federal Test Method Standard No. 191, Method 5526



100- NO STICKING OR WETTING OF UPPER SURFACE.
90- SLIGHT RANDOM STICKING OR WETTING OF UPPER SURFACE.
80- WETTING OF UPPER SURFACE AT SPRAY POINTS.
70- PARTIAL WETTING OF WHOLE UPPER SURFACE.
50- COMPLETE WETTING OF WHOLE OF UPPER SURFACE.
0- COMPLETE WETTING OF WHOLE OF UPPER AND LOWER SURFACES.

—— COLORED WATER USED FOR PHOTOGRAPHIC EFFECT ——

Figure A2. Standard Spray Test Ratings, Federal Test Method Standard No. 191, Method 5526

APPENDIX B. OPTIONS AND OTHER ITEMS OF CONCERN TO POTENTIAL USERS OF THIS CRITERIA

This summary provides a listing of acceptable alternatives under the criteria in the report. Those referencing the report in a purchase specification could limit their attention to the items covered in this summary.

(Sections Correspond to Numbered Headings in Section 2)

Purpose (2.1.) The report is not intended to serve as a detailed manufacturers' specification. It was prepared, as far as practicable, in terms of required performance, avoiding specifications of materials or designs so phrased as to preclude obtaining the desired results by other means. It is not the intention of the report to bar from consideration materials of improved quality or special designs if they satisfactorily meet the performance requirements. Consideration must be given to specifying the items listed herein when preparing the purchase specification.

Scope (2.2.) If an impermeable shell coat is to be purchased, additional requirements not provided in this report, but which should be included in the purchase specification when ordering are:

1. Brittleness at low temperature
2. Coating thickness
3. Coating adhesion

General (2.3.) Some general requirements that pertain to options are as follows:

A. Items of equal performance and safety should be allowed as substitutes for those specified in these criteria provided that adequate technical evidence of their acceptability is supplied and provided that the substitute is approved by a technically qualified representative of the purchaser (when applicable), the senior officer of the Fire Department, and by the purchasing agent. Purchase of a less durable material might be considered provided the purchaser agrees to a decrease in the quality and strength received. (See 2.3. and table 1)

B. General design options for liners which the purchaser will want to address are as follows:

   1. Number of liners
   2. Position of vapor barrier (must be insulated from the body)
   3. Material for liners may be specified.

Sizing (2.3.1.) Proper sizing is an important safety characteristic. Coats may be custom ordered or ordered by traditional coat sizes. The following must be considered:

1. Number of coats by size must be specified (see 2.3.1. for sizing guidelines.)

2. In selecting a coat length, consideration should be given to the protection afforded the leg and buttocks areas by the boots and pants.

3. In cities with very cold winters it may be desirable to order coats slightly larger than needed to allow room for sweaters or vests, or to specify that an additional liner be added.

Outer shell (2.3.3.) For those fire departments who consider purchase of an impermeable outer shell necessary for the reasons indicated in appendix A5 in the design considerations, such a coat should be considered in compliance with this report provided the variations from this report for the outer shell are approved by the purchasing fire department and specified in the purchase document. When the manufacture of impermeable coats meeting all the requirements of this report becomes practicable this provision should be considered terminated.

Note: A material which is available and which increases the water repellency of the coat but which has not been field tested to our knowledge, is back-coated fabric. This type fabric might also provide the vapor barrier.

The following must also be considered:

1. Specific materials meeting the requirements of the standard may be specified by the purchaser.

2. While the tear strength requirement should provide an indication of the durability of the outer shell, some supporting evidence or guarantee of the overall durability of the coats must be provided by the manufacturer prior to purchase.

3. An indication of the satisfactory high temperature stability of the fabric must be provided by the manufacturer prior to purchase This shall include temperature/shrinkage curves and an indication of the temperature at which the fabric will char, separate and melt, with all results showing the effects of temperature exposures in a forced air oven for 10 minutes.

4. The manufacturer must supply an indication of the resistance of the fabrics to caustic substances.

Visibility (2.3.3.2.) The purchaser must specify a color meeting the visibility requirements criteria or may select as an alternative that the coat be trimmed with fluorescent tape. With regard to color, of the non-white colors, yellow and yellow-green have been found to be highly visible, and the visibility of the coat in the day time can be further increased by the use of fluorescent materials. Visibility at night can be increased by the use of retro-reflective materials. Guidelines on the placement of tape are given in 2.3.3.2.

Collar (2.3.3.3.) If the material of the outer shell is rough, the purchaser has the option of specifying corduroy, moleskin, or other soft material meeting the requirements in section 2.3.3.3. as a collar lining material. The cotton corduroy specified is soft and can be brushed away if not extensively charred and the coat can be continued in use with little or no irritation to the fireman's neck.

Note: Based upon a number of comments received during the development of the report, a better (that is one that would better keep out embers etc.) covering for the back of the neck would be desirable. If the use of such a covering would cover ears that would otherwise be exposed, the loss of the ears as a heat sensor and the interference with hearing should be considered in deciding upon the use of such an item.

Sleeves (2.3.3.4.) While the outer shell material meeting the requirements of this report should provide significant wear resistance for the entire sleeve, an optional reinforcement for the lower part of the sleeve could be leather meeting the requirements of 2.3.6. or any materials which meet the requirements of table 1. (See 2.3.3.1. on obtaining wearability data from the manufacturer.)

Storm Flaps and Closures (2.3.3.7.) Any of the following meeting the requirements of the report are an option:

1. Hooks and dee rings on inside, hook and pile fastener tape on outside.
2. Hooks and dee rings on inside, snaps on outside.
3. Hook and pile fastener tape on the inside, hook and dee rings on the outside.
4. Hook and pile fastener tape on the inside and the outside.
5. Snaps on inside, hook and dee rings on outside.
6. Snaps on inside, hook and pile tape on outside.

See 2.3.3.7. and 2.3.8. for responsibility of the manufacturer if hook and pile fastener closures are specified. Minimum width requirements are specified for the tape, but wider tapes would allow for greater adjustment.

Note: When one of the combinations that does not use hook and dee rings is used, the manufacturer should demonstrate the ability of the closure to provide an acceptable closure when flexed and strained as in use. Whenever used, the manufacturer must supply information on the flame-resistance and high temperature stability of the hook and pile fastener tape in accordance with section 2.3.8. of the report.

Pockets (2.3.3.8.) Number, size and placement of pockets are to be specified based on the recommendations in appendix A6. Optional reinforcement for the lower 5 inches can be leather meeting the requirement of 2.3.6.

Retro-reflective Material Use (2.3.3.9.) See the sample purchase specification in appendix D for a suggested placement. The following can be specified if desired as additional marking: F. D. emblem, F. D. name, firefighters' name, company name and/or number, job speciality symbol.

Attachment of Linings (2.3.3.10.) It may be specified that they be attached by snap fasteners, stitching, or in the neck area by hook and pile closures. Sewn in liners insure that the protection afforded by the coat will be available at all times.

Linings (2.3.4.) It may be desirable that the lining be of a style which would permit being used as an outer garment when the outer shell is removed for tasks such as overhauling. (This option would however, prevent the option of receiving the insured protection of a sewn in liner.)

Lining Material (2.3.4.1.) Specific materials meeting the requirements of the report may be specified by the purchaser. Purchase of a less durable material for the liner next to the body is acceptable under the report provided the purchaser agrees to a decrease in the quality and strength received (see 2.3. and table 3 in the standard). The manufacturer must provide information on the high temperature stability of the liner material.

Thickness (Insulation Provision) (2.3.5.2.) The report provides a minimum thickness based on what appears practicable at this time. It can be expected that increased insulation from the heat of the fire can be obtained up to 0.250 inches thickness, however, and thicker composites should therefore be obtained when possible. The manufacturer shall supply information on the thickness of the coat prior to sale.

Fastener Tape (2.3.8.) Information on the high temperature stability of the tape must be supplied by the seller.

Retro-reflective Material Properties (2.3.9.) A specific color for the retro-reflective fabric should be selected within the provisions of 2.3.9. Information on the high temperature stability of the fabric must be supplied by the seller.

Design Considerations - Design considerations are provided for the following in appendix A, and should be considered prior to selecting a coat:

1. Air circulation
2. Impact resistance
3. Padding on elbows
4. Color
5. Water repellency
6. Pocket selection

Extra Materials - If practicable, provisions should be made with supplier that he make available the materials necessary to repair coats that become damaged.

APPENDIX C. REQUIREMENTS FOR ADDITIONAL INFORMATION THAT THE MANUFACTURER MUST SUPPLY

This section summarizes that information which the manufacturer must supply to the purchaser at the time of bid submission.

(Sections below Correspond to Numbered Headings in section 2.)

Scope (2.2.) If an impermeable shell coat is purchased, information on the following must be supplied; in addition to other information as specified:

1. Brittleness at low temperature,
2. Coating thickness, and
3. Coating adhesion

General (2.3.) Items of equal performance and safety should be allowed as substitutes for those specified in the report provided that adequate technical evidence of their acceptability is supplied the purchaser and provided that the substitute is approved by a technically qualified representative of the purchaser (when applicable), the senior officer of the Fire Department, and by the purchasing agent.

Outer Shell Material (2.3.3.1.)

1. Some supporting evidence or a guarantee of the durability of the coats must be provided.
2. An indication of the satisfactory high temperature stability of the fabric must be provided. This shall include temperature/shrinkage curves and an indication of the temperature at which the fabric will char, separate and melt, with all results showing the effects of temperature exposures in a forced air oven for 10 minutes.
3. The manufacturer must supply an indication of the resistance of the fabric to corrosive substances.

Storm Flaps and Closures and Fastener Tape (2.3.3.7. and 2.3.8.) When hook and dee rings are not used as part of the closure for the storm flap, the manufacturer should demonstrate the ability of the closure to provide an acceptable closure when flexed and strained as in use. Whenever hook and pile fastener tape is used, the manufacturer must supply information on the flame-resistance and high temperature stability of the tape to include an indication of the temperature at which the fabric will char, melt or shrink, with all results showing the effects of temperature exposures in a forced air oven for 10 minutes.

Lining Material (2.3.4.1.) The manufacturer must supply information on the high temperature stability of the fabric prior to purchase, to include temperature shrinkage curves, and an indication of the temperature at which the fabric will char, separate and melt, with all results showing the effects of temperature exposures in a forced air oven for 10 minutes.

Thickness (2.3.5.2.) The manufacturer shall supply information on the thickness of the coat prior to sale.

Fastener Tape (2.3.8.) The manufacturer must supply information to the purchaser, prior to sale, on the high temperature stability of the fabric, to include an indication of the temperature at which the fabric will char, melt, or shrink.

Retro-reflective Fabric (2.3.9.) The manufacturer must supply information on the flammability of the material prior to sale, and information on the high temperature stability of the fabric, to include temperature shrinkage curves and an indication of the temperature at which the fabric will char or melt.

APPENDIX D. SAMPLE PURCHASE SPECIFICATION

This report describes features and performance measures that an acceptable turnout coat should contain and meet. However, there are a number of features that are left for local option. These items should be described in a purchase specification. Appendix B describes and discusses these options. In this section, we provide a portion of a sample purchase specification. Its purpose is to help clarify what type of information should be in that part of the purchase specification that further defines the desired coat. Specific requirements given in this section are given for example only. Trade names are omitted and a solid line is provided instead.

1) All coats supplied in response to the bid shall meet all of the requirements of the report titled "Design Criteria for Firefighters' Turnout Coats. The bid may include features required or permitted by published amendments to the criteria.

2) This bid is for 20 yellow coats sized to fit a 38-inch chest, and 25 to fit a 41-inch chest. All coats are to be custom tailored for the chest dimensions indicated and the following sleeve lengths:

38-inch chest	*41-inch chest*
ten 32-inch sleeves	*twelve 32-inch sleeves*
ten 34-inch sleeves	*thirteen 34-inch sleeves*

Each coat must be identified for chest and sleeve measurement.

Note: Chest measurements made well up under the arms, across the shoulder blades of the individual with his normal station uniform on. Back length determined from the collar base to the coat botton, sleeve length measured from the center of the back around a bent elbow to the tip of the sleeve, with the hand held in a horizontal plane in front of the face. The length of all coats shall be 40 inches.

3) The outer shell shall be made of _____.
and the inner liners shall be made of _____.

4) There shall be two liners, one containing the vapor barrier and one for insulation from the heat of the fire. The latter shall be the innermost liner.

5) The storm flap shall have hooks and dees on the outside and hook and pile fastener tape on the inside. The flammability of the trim may differ from that required in the referenced design criteria in that it may be 5.0 inches char length (max.) and 5.0 seconds after flame (max.)

6) *The pockets shall be as follows: Two pockets, 11 inches wide by 12 inches high, placed at the hem of the coat.*

7) *The retro-reflective tape shall be as follows: All tape shall be 3-inches wide positioned as follows:*

A. *Back:*

Two 15-inch vertical stripes
Two 15-inch horizontal stripes
(Outside measurements 15 inches by 21 inches)

B. *Front:*

One 30-inch vertical stripe
Two 17-inch vertical side stripes
(Separations between vertical stripes approximately 3 inches)

C. *Circumference band on each sleeve just above cuff line*

D. *Circumference band around bottom of coat*

E. *Shoulder patch (minimum 3-inches square)*

Elements that can be added for more information on coat; F.D. emblem, F.D. name, firefighter's name, company name and/or numbers, job specialty symbol.

8) *The water resistance of the coat shall be at least 90 percent when tested in accordance with method 5526 of Fed. 191.*

Note: Thorough consideration should be given to the design considerations mentioned throughout the report and in appendix A when preparing specifications or evaluating bids. If practicable, provisions should be made with supplier that he make available the materials necessary to repair coats that become damaged.

APPENDIX E. REFERENCES

The following publications are referenced in this report and may be obtained from the organizations indicated. Later issues of all publications referenced shall be used provided the requirements are applicable and consistent with the issue designated.

[1] Textile Test Methods, Federal Test Method Standard No. 191, General Services Administration, Specifications Activity, Printed Materials Supply Division, Building 197, Naval Weapons Plant, Washington, D.C. 20407.

[2] Automatice Fabrics, Testing, ASTM Method D 2263-68, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa 19103.

[3] Dimensional Changes in Laundering of Woven and Knitted Textiles Except Wool, AATCC Method 96, American Association of Textile Chemists and Colorists, P.O. Box 12215, Research Triangle Park, North Carolina 27709.

[4] Textile Fiber Products Identification Act, Division of Public Records, Federal Trade Commission, Washington, D.C. 20580.

[5] Standard Method of Test for Seam Breaking Strength (Load) of Woven Textile Fabrics, ASTM Method D 1683-68, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

[6] Standard Method of Specifying Color by the Munsell System, ASTM Method D 1535-68, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

[7] Standard Recommended Practice for Spectrophotmetry and Description of Color in CIE 1931 System, ASTM Method E 308-66, American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

[8] Thickness of Textile Materials, Measuring, ASTM Method D 1777-64 (70), American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103.

[9] Leather, Cattlehide, Chrome Tanned for Gloves, Garments and Equipment, Federal Specification KK-L-162, General Services Administration, Specification Activity, Printed Materials Supply Division, Bldg 197, Naval Weapons Plant, Washington, D.C. 20407.

[10] Leather, Methods of Sampling and Testing, Federal Test Method Standard No. 311, General Services Administration, Specifications Activity, Printed Materials Supply Division, Bldg 197, Naval Weapons Plant, Washington, D.C. 20407.

[11] Rivet, Solid, Small; Rivet, Split, Small; Rivet, Tubular, Small; Bur, and Cups, Rivet; General Purpose, Federal Specification FF-R-556C, General Services Administration, Specifications Activity, Printed Materials Supply Division, Bldg. 197, Naval Weapons Plant, Washington, D.C. 20407.

[12] Fasteners, Snaps, Military Specification MIL-F-10884D, The Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pa. 19120.

[13] Fastener Tapes, Hook and Pile, Synthetic, Military Specification MIL-F-21840D, The Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pa. 19120.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

These design criteria cover requirements for the sizing, construction, outer shell, inner linings, weight and thickness for firefighters' turnout coats as well as test methods, labeling requirements and design considerations. Included also is a list of options and other items of concern to potential users of the criteria and a sample purchase specification to be used in conjunction with the criteria.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

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