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## TESTS ON FLAMMABLE SWEATERS

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Requested by

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for  
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District of Columbia



# U. S. DEPARTMENT OF COMMERCE NATIONAL BUREAU OF STANDARDS

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## TESTS ON FLAMMABLE SWEATERS

### 1. INTRODUCTION

The Fire Marshal of the District of Columbia has requested that certain sweaters, which have caused current widespread public concern because of extreme flammability, be inspected and tested to determine their burning characteristics and flammability as compared with other materials commonly used in clothing.

### 2. TEST MATERIAL

For test purposes, the Fire Marshal submitted a sweater set consisting of a sleeveless, slip-over style sweater and a long-sleeved jacket sweater with front button closure. Both sweaters were made of a maroon tricot knit rayon with brushed outer surface, and were trimmed by front and neck bands of the same material in gray. The long-sleeved sweater bore a label inscribed "Designed for Comfort, Genuine Embassy Sportswear". No further identification appeared on the sweaters or the box in which they were received.

### 3. TESTS AND RESULTS

#### 3.1 Composition of the Fabric

Investigation by the Testing and Specifications Section of the Bureau determined that the fabric in the sweaters had been knit entirely of delustered viscose rayon. The delustering process is a common treatment and leaves a small amount of the delustering agent (frequently titanium dioxide) in the fibers, but there was no evidence of other special finishing materials present in the cloth. The outer surface of the fabric had been brushed to a soft, fuzzy texture similar to that of a woolen blanket while the inner surface had been left with the smooth finish of the knitted threads.



### 3.2 Flammability Tests

Samples of the material were subjected to three different flammability tests, an inclined test developed by the American Association of Textile Chemists and Colorists, a horizontal test developed by the National Bureau of Standards, and a vertical test developed by the office of the California State Fire Marshal. No one of these tests has yet been accepted as an established standard, though both the inclined test and the horizontal test were included as criteria in Federal legislation proposed in 1949. However, since the inclined test, which is fully described in the 1951 Yearbook of the A.A.T.C.C., has had the widest usage among textile interests, the major part of the present testing was done by that method. The horizontal test equipment and procedure are described in National Bureau of Standards Circular C455 on "Flameproofing of Textiles", and mimeographed material describing the vertical test is available from the office of the California State Fire Marshal.

#### (a) Inclined Test

A 2 by 6 in. sample of the material is clamped in a specimen holder which leaves a 1 by 6 in. strip of the fabric exposed, and is conditioned at 105° C. After cooling in a desiccator over anhydrous calcium chloride, the mounted sample is supported at an angle of 45 degrees in the test cabinet, and the flame from a microburner is applied for one second to the surface of the fabric near the lower end of the sample. The time required for the flame to progress upward over a five inch length of the sample is recorded by an automatically operated stopwatch. It is suggested by the A.A.T.C.C. that a fabric for which the recorded time of flame spread, based on an average of five samples, is less than four seconds should be considered dangerously flammable.

Tests were made on the brushed surface of the sweater material, both in its original condition and after being subjected to normal dry cleaning in perchlorethylene at the National Institute of Cleaning and Dyeing, Silver Spring, Md. The average flame spread times obtained were 1.2 seconds and 1.1 seconds respectively, indicating that the dry cleaning had no appreciable effect on the flammability,





though it had somewhat altered the hand of the fabric. In every test the body of the fabric was ignited from the surface flames and burning continued until the entire material was destroyed.

This extremely rapid spread of flames over the fabric closely paralleled previous experience with heavily napped or fleeced fabrics both of rayon and of cotton. Tests have been made on fabrics with a long, fine rayon pile (such as the material in the cowboy suit chaps which caused a number of fatal accidents), on brushed rayons, on highly fleeced cottons, and on tufted cottons, which burned in a manner similar to that of the present sweater material, and gave average flame spread times ranging from 1.1 to 2.0 seconds in the inclined test. The evidence strongly indicates that the type of fabrication is a more decisive factor in producing unusual flammability than the particular combustible fiber used, and that fabrics of any cellulosic fiber may become unusually hazardous if the pile is made especially long and fine or the surface is very heavily fleeced or napped. On such surfaces the myriad fine fibers, raised so that there is free access of air among them, present ideal conditions for instant ignition and rapid spread of flame.

Further evidence of the importance of surface condition in relation to flammability was provided by an additional test, made on the sweater material with the fabric reversed so that the igniting flame was applied to the smooth back or inner surface. In this position, a four second application of the microflame was necessary to ignite the fabric, and the time of flame spread over the five inch length was 22 seconds. Since the fabric was knit of the same rayon fibers throughout, the difference was apparently in the surface condition.

#### (b) Horizontal Test

A 4 by 12 1/2 in. sample of the material, after conditioning at 60° C, is placed in a specimen holder which leaves a 2 by 12 1/2 in. strip of the fabric exposed, and the holder is supported in a horizontal position in the test cabinet. The exposed edge of one end of the sample is ignited by a low gas flame or match flame and, after 1 1/2 inches of the sample have burned, the time required for the flames to progress over the next ten inches



is recorded with a manually operated stopwatch. From the recorded time, the rate of flame travel in inches per minute is calculated. The proposed Federal legislation which referred to this test, defined as highly flammable a fabric which shows a rate of flame spread greater than 60 inches per minute, based on the average of five tests.

Two samples of the sweater material in its original condition were tested, and an average rate of flame spread of 270 inches per minute was obtained. This value also compared closely with flame spread rates previously determined by the same method on other highly flammable fabrics.

### (c) Vertical Test

A 6 by 8 in. sample of the material is clamped between two vertically mounted, convexly curved metal plates which have a 2 by 7 in. spiral opening or window cut diagonally across the center. Thus, the exposed test area of the vertically held sample is 2 by 7 inches and spirals upward at an angle of about 45 degrees. The fabric is ignited by a microflame applied to the surface at the lower end of the test area, and the time required for the flames to progress over a designated five inch length is recorded by an automatically operated stopwatch. Performance requirements which might suitably define a highly flammable fabric have not been suggested, but, since most fabrics appear to burn somewhat more rapidly in this test than in the inclined test, a time limit slightly lower than the four seconds proposed for the inclined test would perhaps be reasonable.

Four samples of the sweater material, in its original condition, were tested and showed an average flame spread time of 0.7 second. Though our experience with this test has not been as extensive as with the other two, it has included some heavily fleeced cottons which had flame spread times comparable to the value obtained for the sweater fabric.

### 3.3 Ignition by Cigarettes

Six attempts to ignite the sweater material by pressing a lighted cigarette into the brushed surface, failed to

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produce flames or continuing glow in any instance. Glow usually appeared around the edges of the hole burned by the cigarette, but was always self-extinguished in a few seconds.

In a further test, a burning cigarette was buried within a deep fold of the fabric and left undisturbed until all smoke and evidence of burning had ceased. Examination of the fabric after the cigarette had burned out, showed that the char did not extend beyond the area in contact with the cigarette.

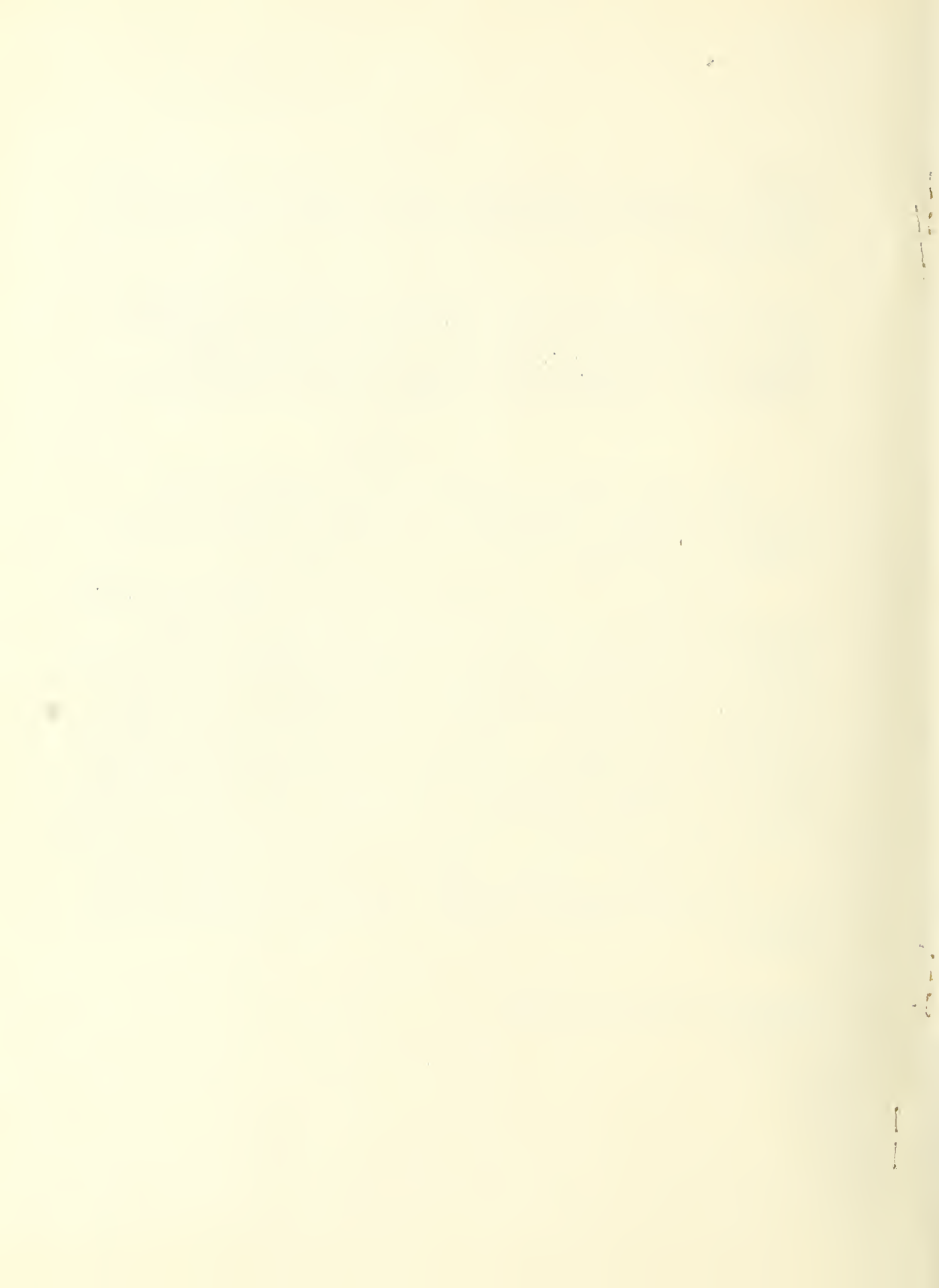
#### 4. SUMMARY

The fabric used in the sweaters was knit of de-lustered viscose rayon, with the inner surface left smooth and the outer surface brushed to a soft, fuzzy texture resembling that of a woolen blanket.

In flammability tests the material compared closely, in both manner and rate of flame spread, with highly flammable napped and pile fabrics previously tested. These have included cottons as well as rayons and there is strong evidence that the type of fabrication of a cellulosic material, particularly of the surface, is a more decisive factor in producing extreme flammability than is its fiber composition. Specific evidence that the high flammability shown by the sweater material resulted primarily from the brushing of the outer surface was provided by a test which demonstrated that the smooth back of the fabric did not ignite or spread flame with unusual rapidity.

The sweater material was not ignited by application of a burning cigarette, either on a single thickness of the fabric or within a pocket formed by deep folds of the cloth.

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