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## THE PROTECTION AGAINST FIRE AFFORDED BY CERTAIN UNDERWEAR MATERIALS

by

D. L. Simms and P..L. Hinkley

### Summary

Tests have been carried out on the protection afforded against flames by certain underwear materials by themselves and in combination with different serges. Their flammabilities have also been tested.

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Fire Research Station,  
Boreham Wood,  
Herts.

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Special investigation for the Ministry of Supply on the protection against  
fire afforded by certain underwear materials

1) Application for test

Letters from Ministry of Supply dated 6th May, 1954. Reference 7/cttee/833/9 and 2nd November, 1954. Reference 7/Tex/144.

2) Purpose of tests

To determine the protection against flames provided by various types of underwear in combination with outer garments of serge. These serges had been previously tested for flammability. (1)(2)

3) Materials to be tested

Five types of knitted underwear material were submitted. These were of similar construction but of different composition. The Joint Fire Research Organization's reference number, the Ministry of Supply's reference number, the composition, and the weight per unit area of each material are given in Table 1.

Table 1

Details of materials supplied

Joint Fire Research Organization Reference Number	Ministry of Supply Reference number	Wool per cent	Nylon per cent	Viscose per cent	Weight per unit area	
					oz yd <sup>-2</sup>	gm cm <sup>-2</sup> x 10 <sup>-2</sup>
R 94	1	100	-	-	8.2	2.78
R 95	2	50	50	-	9.2	3.12
R 96	3	50	-	50	8.1	2.75
R 97	4	50	17	33	8.4	2.85
R 98	8	50	33	17	8.3	2.82

4) Description of tests and experimental results

The materials were tested for protection from flames and for flammability.

(i) Protection against flames

In this test, which is described in detail elsewhere (3), one surface of a clothing assembly is exposed to flames from a petrol fire and horsemeat is placed in contact with the other surface to simulate human flesh. The time taken for the surface of the meat to rise 25°C is an indication of the protection afforded by the material against flames.

A diagram of the apparatus used in these tests is shown in Fig. 1. The board A had a hole in which a square frame B fitted holding a specimen 2½ in. square in position flush with the surface. The board was placed

in position over a metal tray containing enough petrol to burn uniformly for about ten minutes. The unexposed face was protected from the flames by an asbestos board C. The temperature rise at the underwear - skin interface was measured by a 36 s.w.g. copper-constantan thermocouple soldered to a ½ in. diameter copper disk. The petrol was then ignited and allowed to burn until the temperature of the disk had risen by 25°C. The fire was then extinguished and any further rise in temperature recorded.

Tests were made on the underwear samples in combination with the serges. For comparison, tests were also made on the serges alone and on the underwear alone. The results of these tests are given in Table 2.

Table 2

Results of tests on protection against flames

Underwear Ministry of Supply Reference No.	Serge Ministry of Supply Reference No.	Time for 25°C rise sec.	Further time to reach maximum temperature	Maximum Temperature rise °C
1	} Underwear alone	12 *	1.5 *	27.5 *
2		9 *	3 *	30 *
3		10 *	1.5 *	29 *
4		7 *	1.5 *	28.5 *
8		10 *	2 *	28 *
Outer garment alone	100 p.c. wool	11.5	2	29
-	N.N./22	13	2	28
-	W.K./22	17	2½	29
-	N.N./20	15.5	2	27.5
1	N.N./20	13	6.5	30
2	N.N./20	16.5	3.5	29
3	N.N./20	18.5	8.5	32
4	N.N./20	16	6	31
8	N.N./20	17	5.5	30
3	N.N./22	13	3.5	30
3	W.K./22	18.5	-	25

\* mean of two tests

(ii) Flammability

1) B.S. 1547 test

The test is described in detail in a previous report<sup>(1)</sup>. Since the weft and warp were different strips cut at right angles were tested. The samples of underwear were ignited and their behaviour noted.

Table 3

Results of B.S. 1547 test.

Ministry of Supply Reference No.	Behaviour	Passed P Failed F
1	Direction A B Burnt 6 in. in 40 secs. Burnt completely 12 in. in 60 secs.	F F
2	A B Burnt 3 in. in 25 secs. Burnt 9 in. in 52 secs.	F F
3	A B Burnt 12 in. in 60 secs. Burnt 12 in. in 56.2 secs	F F
4	A B Burnt 12 in. in 59.5 secs. Burnt 12 in. in 62.7 secs.	F F
8	A B Does not continue to burn Burn 1 in. in 12 secs.	P F

As all these materials failed this test they were then examined on the semi-circular test (2).

2) Semi-circular test

The test is described in the previous report (1).

Table 4

Results of Semi-Circular test

Ministry of Supply Reference No.	Distance of flame spread in.	Time of flame spread sec.
1	6.3	42.6
2	6.4	62.7
3	3.1	17.8
4	7.2	44.8
8	3.1	23

The above results are the mean of six tests.

5) Conclusions

(i) Protection afforded against flames

The results of the tests on the individual materials show that there is no significant difference either between the various types of underwear or between the various types of serge.

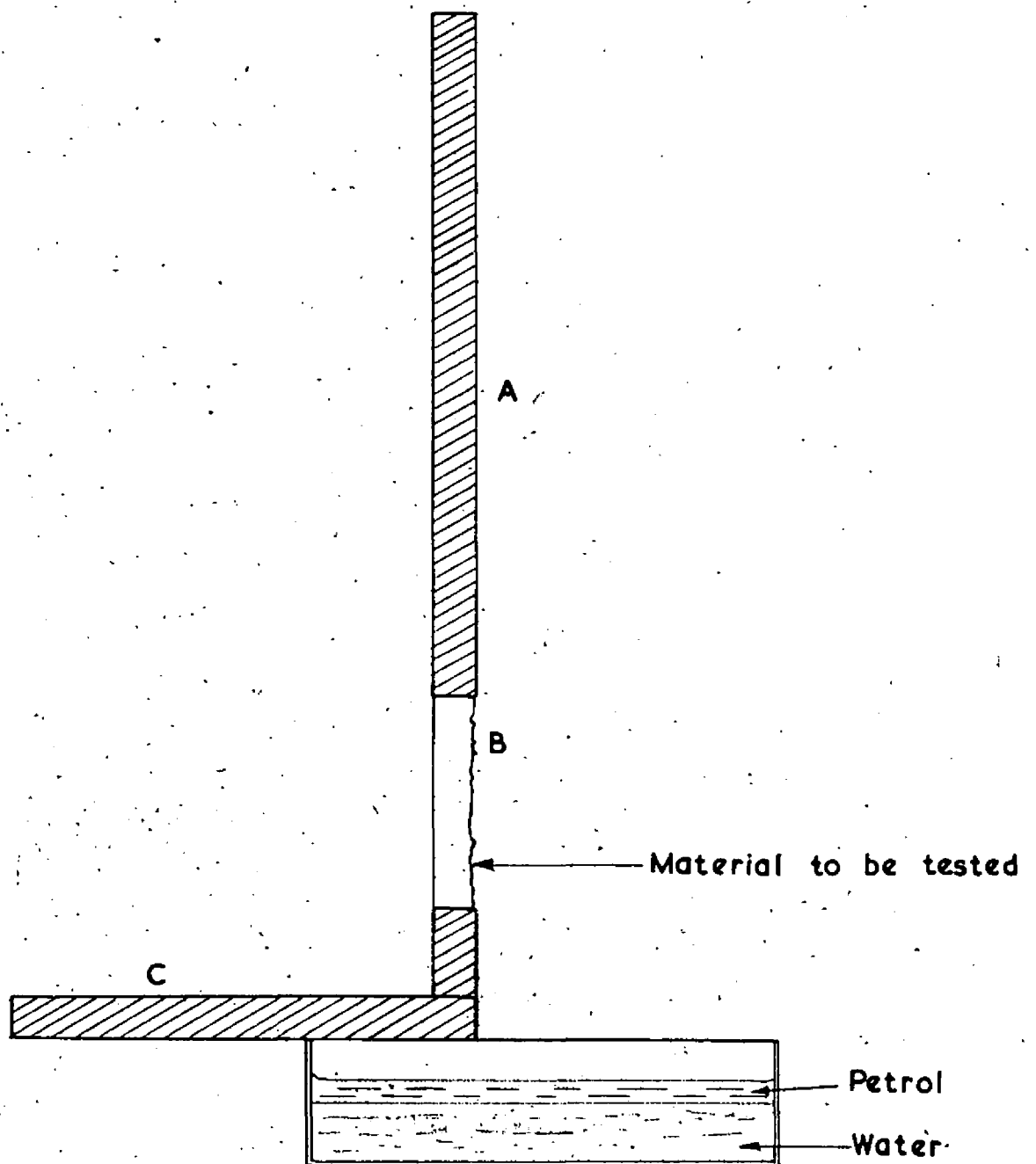
The protection afforded by underwear in combination with serge is only slightly better than that provided by serge alone. There is no significant difference between the 5 materials in this respect.

(ii) Flammability tests

The results of the semi circular test show that the vertical flame speed of the fabrics is 3 cm/sec or less. The tests using B.S. 1547/1949 show that the fabric containing 33 p.c. nylon is slightly less flammable than the others. Even so, the fire hazard of a combination of outer and under garment is, in no case, significantly different from that of a serge outer garment alone.

References

- (1) F.R.O.S.I. No. 503, Part I.
- (2) LAWSON, D. I., WEBSTER, C. T., and GREGSTEN, M. J. The flammability of fabrics. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization. F.R. Note No. 107/1954.
- (3) PICKARD, R. W., and SIMMS, D. L. Materials suitable for clothing aircraft crash rescue teams. Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization. Part I. F.R. Note No. 153/1955.



Scale - half size

FIG. 1. APPARATUS USED IN TESTS TO DETERMINE THE PROTECTION AFFORDED BY MATERIALS AGAINST FLAMES