CONFIDENTIAL

F.R. Note No. 49/1953
Research Programme
Objective G.1

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH AND FIRE OFFICES' COMMITTEE
JOINT FIRE RESEARCH ORGANIZATION

THE EFFECTS OF BURNETTIZING, ALKALI-SOLUBLE CONTENT AND SPECIFICATION ON SOME PROPERTIES OF UNLINED CANVAS FIRE HOSE

by

J. F. Fry,
J. A. Gordon,
P. H. Thomas.

Summary

Experiments have been made with $2\frac{3}{4}$ in. diameter, unlined canvas delivery hose obtained from three manufacturers. Each manufacturer supplied both burnettized and unburnettized samples made to each of two Ministry of Works Specifications, one for Fire Brigade hose and one for Service Department hose; the Fire Brigade hose was made from two differently-finished yarns, the alkali-soluble content of one being 5 per cent and that of the other 10 per cent.

Neither burnettizing nor reduction of the alkali-soluble content of the yarn had any appreciable effect on the rate at which the strength of the hose was reduced by mildew attack. Both treatments increased the flexibility of the hose, but also caused an increase by a factor of two or three in the rate of percolation.

Comparison between hoses made to the two specifications showed the Service Department hose to be more flexible and more water absorbent than Fire Brigade hose. Other differences between the two types of hose were not marked.

June, 1953.

File No. F.1061/1/25

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I. Introduction

During and immediately after the war fairly extensive examinations of fire delivery hose were made, and the results of this work have been summarized elsewhere (1). Many of the tests were performed with hose obtained from only one manufacturer or made to only one specification, so that the results do not always provide sufficient information for the purposes of general comparison.

Tests on the mildew-resistance of hose treated with sodium pentachlorate, and on the effect of the rot-proofing process on other properties of hose, were made in 1945 (2) when it was shown that the treatment improved mildew-resistance but that percolation losses were greater with treated than with untreated hose. In these tests the mildewing was accomplished by the soil-burial method to which there is the objection that little control of the fungus is possible; hence, while the method may be satisfactory for making direct comparisons, the conditions are not always repeatable at different times or in different places.

For the present programme, hose was obtained from three manufacturers, each of whom supplied both burnettized and unburnettized samples made to each of two Ministry of Works Specifications. The Specification for Fire Brigade hose is given in Appendix I and that for Service Department hose in Appendix II. Each manufacturer supplied hose made to the Fire Brigade Specification from each of two differently-treated yarns, the alkali-soluble contents of which were 5 per cent and 10 per cent; this was done to permit an examination of the suggestion that the alkali-soluble materials in hose fabric serve as food for mildew growths or in some other way assist fungal attack.

The principal tests made were to determine:-

(a) bursting pressure

(b) percolation

(c) water absorption by the hose fabric

(d) flexibility

(e) resistance to abrasion

(f) tensile strengths of yarn and of fabric

(g) resistance to mildew.

II Methods and procedure of testing hose

The results of all the hose tests are given in Table 1, but to show more clearly the differences in any one property between the several types of hose, the results for each test (with the exception of the disc bursting strength and certain of the tensile tests) are given separately in the succeeding tables (Tables 2 - 16). The value of σ, the standard deviation, is that calculated for the quoted property based on a sample of six or three specimens.

Descriptions of the various tests are given below.

(a) Bursting pressure

The bursting pressures of the hose were measured in two ways. In the first method three 3 ft. long specimens of each type of hose were attached in turn to a pressure head connected to a hydraulic accumulator. Each specimen was allowed to soak at a pressure of 100 lb./sq.in. for 30 minutes and the pressure was then increased at the rate of 100 lb./sq.in. per minute until failure occurred. The results of these tests are given in Table 2.

For the second method discs of fabric, $3\frac{3}{4}$ in. in diameter, were cut from the hose and clamped to the pressure head between plates having a central orifice $1\frac{3}{4}$ in. in diameter. The pressure was increased in the manner described above until the specimen burst. Six discs from each hose were burst in this manner for each test.

(b) Percolation

For the percolation tests three specimens, each 3 ft. long, of each type of hose were conditioned in an atmosphere of relative humidity 60 per cent and temperature 105°F until their weights remained constant over a period of 24 hours. The specimens were then filled with water and the pressure was gradually increased to a value of 100 lb./sq.in. at the end of a period of 2 minutes. The quantity of water which had percolated through the hose was measured at the ends of further periods of 5, 10, 15, 30 and 60 minutes, the pressure being maintained at 100 lb./sq.in. throughout the test. The results of these tests are given in Tables 3 and 4.

(c) Absorption of water

The quantity of water absorbed by the fabric of each specimen during the percolation test was measured directly by observing the difference in the weights of the specimen immediately before and after the test. The results are given in Table 5.

(d) Flexibility

Three 1 ft. lengths of each hose were soaked with water at a pressure of 100 lb./sq.in. for 1 hour. Each specimen was then emptied of water, flattened, and supported on a fixed $3\frac{1}{2}$ in. diameter roller (A). A load was applied through two $\frac{1}{2}$ in. diameter rollers (B and C) $5\frac{1}{8}$ in. apart and fixed to a balanced lever as shown in Fig. 1. The load applied at the end of the lever was steadily increased at the rate of 4 lb./min. The results in Table 6 give the loads required to produce a deflexion of 1 in. This, being a direct measure of stiffness, is an inverse measure of flexibility.

(e) Abrasion

Ten specimens, each 12 in. long and 1 in. wide, were cut longitudinally from each type of hose and the warp threads were subjected to abrasion on a machine, which is fully described elsewhere (4) and consists of a power-driven knurled steel roller onto which a mixture of graded sand and water is poured. The specimen being tested was held against the roller and subjected to a tensile load of 50 lb., and its resistance to abrasion was measured by the number of revolutions of the roller necessary to cause failure. The results are given in Table 7.

(f) Tensile strength

Specimens 1 in. wide were cut from each type of hose both in the direction of the warp and that of the weft; some of the weft strength specimens being arranged to include the fold of the hose and others excluding it. Tensile strength measurements were made on six dry specimens and on six which had been immersed in water for 24 hours. The results of these tests are given in Tables 8 and 9.

Tensile strength tests were also made on the weft yarns, 10 specimens being tested dry and 10 wet. The results are given in Table 10.

(g) Mildew resistance

The resistance to mildew attack of each type of hose was assessed from the loss of tensile and disc-bursting strengths of specimens exposed for various periods to a culture of Chaetomium Globosum. Preparation of the culture and exposure of the specimens were carried out by the Mycology Section of the Forest Products Research Laboratory of the Department of Scientific and Industrial Research and the method used was based upon that described by Abrams (5).

A number of the strips used for tensile strength tests and the discs used for bursting strength tests were leached for 6 hours in an inclined tray in which the water was changed completely approximately once per minute. After drying, both leached and unleached specimens were exposed to fungal attack, the ends of the tensile strength specimens being dipped in wax to restrict the attack to the central portion.

The specimens were sprayed with spores from an atomizer spray and placed so that the central portions made contact with a culture of spores growing on 2 in. squares of filter paper. This culture had been allowed to grow for 3 days at 30°C in a carbohydrate-free inorganic agar of pH 6·8. The incubation period for the leached tensile strength specimens (weft and warp) was 4 days and that for the leached discs was 8 days. Two incubation periods were allowed for the unleached specimens - 4 and 8 days for the tensile test strips (weft and warp), and 8 and 16 days for the discs. All specimens were dried after the appropriate incubation period, and later soaked in water for the 24 hours prior to the strength tests.

The mean values of the tensile strengths of mildewed and un-mildewed hose are given in Tables 11A, 12A, 13A, 14A, 15A and 16A, and the reductions in strength due to the mildew attack are given in Tables 11B, 12B, 13B, 14B, 15B and 16B. There was practically no strength in the warp after 8 days. The effects of leaching may be seen from the mean values given in Table 1. There was found to be no practical difference between the leached and unleached specimens but since no data was obtained for leached specimens mildewed for 8 days, the values given in Tables 14, 15, and 16, are for the unleached specimens only.

The results of the tests on the bursting strength of discs were too variable to be of value in assessing the effects of the different factors (burnettizing, alkali-solubility etc.) on mildew-resistance and they have not been tabulated separately, although mean values have been included in Table 1.

III Discussion

The results of the experiments described above have been subjected to statistical analysis by the standard techniques used for analysis of variance, in order to assess the effects of the various factors such as burnettizing. The level of significance has been taken at 95 per cent.

In many of the analyses the variance corresponding to the highest order of interaction was significantly greater than the variance due to repeated measurements on six specimens and it would therefore appear that the actual experimental error and variations within a length of hose, were in some cases, much less than the random variations between hoses. That is, they were less than those variations in the value of a property which were not attributable to any particular factor or group of factors. This could indicate a random variation due to manufacturing variations.

The effects of the various factors on each of the properties examined are discussed below.

(a) Bursting pressure

Neither burnettizing nor alkali-soluble content was found to have any overall effect on the bursting pressure of the hose, and the major differences between bursting strengths were those between the three different makes.

Fire Brigade hose was markedly superior to Service Department hose only in the case of make "A" in which the difference was attributable to the method of weaving. The only significant differences between bursting strengths were due to differences between flat and circular weaving.

(b) Percolation

From the figures given in Table 4a it appears that percolation in the first 5 minutes was increased 2 to 4 times either by burnettizing or by reducing the alkali-soluble content from 10 per cent to 5 per cent. There were no significant differences in this respect between Service Department and Fire Brigade hose.

(c) Absorption of water

The results given in Table 5 show that reducing the alkali-soluble content of hose from 10 per cent to 5 per cent had the effect of increasing the amount of water absorbed by the fabric when wetted, although the differences may be over-shadowed by the differences between makes of hose. For example, except in the case of burnettized hose of make "C", all hose with a 10 per cent alkali-soluble content absorbed less water than the corresponding hose with a 5 per cent alkali-soluble content, but the 10 per cent alkali-soluble hose of makes "B" and "C" absorbed more than the 5 per cent hose of make "A".

In general, Fire Brigade hose was less water-absorbent than Service Department hose of the same make, but here again differences between makes may be greater than differences between the two types of hose of one make.

(d) Flexibility

The results of the flexibility tests given in Table 6 show that hose of 5 per cent alkali-soluble content was more flexible than hose of 10 per cent alkali-soluble content, and that burnettized hose was more flexible than that which was not burnettized. They also show that burnettizing not only increased flexibility of itself, but increased the difference in flexibility between hoses of 5 and 10 per cent alkali-soluble content.

All the Service Department hose examined was more flexible than the Fire Brigade hose.

(e) Abrasion

From Table 7, in which the results of the abrasion tests are summarised, it may be seen that hose of 10 per cent alkali-soluble content was more resistant to abrasion than that of 5 per cent alkali-soluble content in the case of makes "A" and "B", but that no difference is apparent in the case of make "C".

The difference between Service Department and Fire Brigade hose was significant only for make "A", in which the Service Department hose was found to be superior to the Fire Brigade hose.

Burnettizing was not found to have any clearly-defined effect upon abrasion resistance.

(f) Tensile strength

(i) Warp strength of fabric.

The results of the warp strength tests are given in Table 8. From these it is seen that, except for the burnettized sample of make "B", the warp strength of hose of 5 per cent alkali-soluble content was greater than that of hose of 10 per cent alkali-soluble content, but that the differences could be outweighed by differences between makes. Only in the case of make "A" was the Service Department hose practically different from the Fire Brigade hose and here the strength of the Service Department hose was the greater.

(ii) Weft strength of fabric.

The results of the tensile strength tests of fabric in the direction of the weft are summarized in Table 9. It appears that the weft strength of hose of 5 per cent alkali-soluble content was reduced by burnettizing, but no similar effect was observed with hose of 10 per cent alkali-soluble content.

The weft strengths of the Service Department hose tested were lower than those of the Fire Brigade hose.

(iii) Strength of weft yarn.

The weft yarn strengths are given in Table 10.

The differences observed in the yarn strengths do not appear to be attributable to any particular factor or group of factors.

(g) Mildew resistance

There was considerable variation within the results of the disc bursting-strength tests, and the very large interaction between the various factors made satisfactory analysis of these results impossible. This method of assessing the effects of mildew was therefore considered unsuitable and no detailed analysis was made. Analysis of the results of the tensile tests showed that the random variation after 8 days mildew exposure was greater than that after 4 days exposure. This increase in variation may explain the failure of the disc bursting-pressure tests. For the tensile tests in which the warp strength of the fabric was the criterion of mildew resistance, it was found that this strength was reduced practically to nothing at the end of the 8-day period. The weft, on the other hand, was protected by the warp and retained a considerable fraction of its strength after the fabric had been exposed to mildew attack for 8 days.

(i) Leaching

Statistical analysis of the effects of leaching the specimens before exposing them to the mildew culture showed no significant difference between the warp strengths of leached and unleached specimens after 4 days exposure. In the weft strengths there was some difference, but since this was of borderline significance (i.e. about 95 per cent) and in the direction of reduced attack after leaching it was rejected.

Recent tests by Rose and Bayley [5] showed that a long period of leaching could cause a reduction in the effectiveness of a rot-proofer. In terms of complete changes of water their tests involved leaching periods $\frac{1}{2}$, $7\frac{1}{2}$ and 30 times as long as the period used for the tests described here. Several rot-proofing materials were tested, but only those containing copper were found to be effective.

The strength of the unmildewed control fell by 35 per cent after the longest period of leaching, and it was suggested that this may have been due to contamination of the tap water by cellulose-destroying organisms. Unfortunately this means that the effect of leaching itself remained undetermined, but the importance of proper controls and the use of long periods of leaching was demonstrated.

(ii) Burnettizing and alkali-soluble content.

To determine the effects of the two factors, burnettizing and alkali-soluble content, on the mildew resistance of the hose, both the initial strength and the strength after mildewing were considered. By this means it was possible to make corrections for differences which were present both before and after mildewing. For example, differences between 5 per cent and 10 per cent alkali-soluble fabrics which were present both before and after mildewing need to be excluded from the assessment of differences in mildew resistance. The estimate of the effect, for example, of the alkali-soluble content on the loss of strength through the action of mildew was measured in the analysis of variance by the variance of interaction between the alkali-soluble content and the loss of strength during mildewing. Analyses were made of the warp and weft strength after 4 days mildewing and of the weft strength after 8 days mildewing.

The results in Tables 11B, 12B and 13B show that, except in the case of burnettized hose of make B, mildew attack caused a greater reduction in the warp strength of a 5 per cent alkali-soluble hose than in that of a 10 per cent alkali-soluble hose of the same make. The magnitude of the difference, however, varied so much between makes of hose that a hose of make A with a 5 per cent alkali-soluble content was superior to one of make B with a 10 per cent alkali-soluble content. Burnettizing appeared to have had no significant overall effect on the resistance of the warp to mildew attack.

On the other hand, the results of the tests on the weft, given in Tables 14-16, show that burnettizing reduced the loss of strength both after 4 days and after 8 days exposure to mildew action. The alkali-soluble content of the hose had no appreciable over-all effect, although the slight difference that did exist indicated, as with the warps, that hose of 10 per cent alkali-soluble content tended to be better than hose of 5 per cent alkali-soluble content. The effect of burnettizing on the Service Department hose was not marked except for make A, and indeed for make B burnettizing appears to have reduced the mildew resistance of the weft.

From the foregoing it would appear that neither burnettizing nor reducing the alkali-soluble content from 10 to 5 per cent makes any appreciable difference to the mildew resistance of the hose.

(iii) Specification

There was no evidence of any difference in mildew resistance, common to all three of the makes examined, between Service Department hose and Fire Brigade hose.

IV Conclusions

The main conclusions to be drawn from this investigation are:-

(1) That burnettizing produces little or no improvement in the resistance of hose to attack by the fungus Chaetomium Globosum.

(2) That burnettizing hose increases its flexibility, but also causes the percolation to increase by a factor of 2 to 4 without affecting the water absorption.

(3) That reducing the alkali-soluble content of hose produces no improvement in its mildew resistance and may, in fact, decrease it.

(4) That reducing the alkali-soluble content greatly increases percolation and slightly increases the water absorption of the hose. It also increases the flexibility and possibly reduces the abrasion resistance.

(5) That Service Department hose is more flexible and more water absorbent than Fire Brigade hose, and has a slightly lower weft strength.

(6) That, in view of (2) and (4) above, absorption and percolation are not directly related.

(7) That the magnitude of some of the effects described above is not appreciably greater than the difference between hose of different makes so that, in any tests of general properties of hose, several makes should be used for the experiments.

Acknowledgement

Thanks are due to the Director of the Forest Products Laboratory of the Department of Scientific and Industrial Research and to Dr. W. P. K. Findlay and Mr. J. G. Savory, members of his staff, for their assistance with the mildewing of hose specimens; and also to Mr. D. W. Fittes of the Joint Fire Research Organization who performed most of the actual tests and assisted with statistical computations.

References

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(2) A. Bailey & P. Wright. "Investigations of a method of rot-proofing canvas delivery hose". D.S.I.R. & F.O.C., J.F.R.O. F.P.E. Note 16/1949.

(3) E. Abrams. "Microbiological deterioration of organic materials - its prevention and methods of test". U.S. Dept. of Commerce Nat. Bur. of Standards. Publ. No. 188, 1948.

(4) J. F. Fry & J. A. Gordon. "An abrasion machine for comparing the wear resistances of fire hose". D.S.I.R. & F.O.C., J.F.R.O. F.P.E. Note 71/1951.

(5) S. F. R. Rose & C. H. Bayley. "Stability to water leaching of various rot-proofers on unlined linen Forestry Fire Hose". Nat. Res. Council of Canada. N.R.C. No. 2730, 1952.

Table 2

Bursting pressure of 3 ft lengths - lb. sq. in.

Make A				Make B				Make C				Specification
Burnettized		Not Burnettized		Burnettized		Not Burnettized		Burnettized		Not Burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
665	695	680	645	655	485	645	715	425	475	415	445	F.B.
/	435	/	395	/	635	/	575	/	485	/	445	S.D.

σ = 57·5

95% limits on a difference ± 170

Make A	Make B	Make C	Specification
670 Circular weave	625 Circular weave	440 Flat weave	F.B.
415 Flat weave	605 Circular weave	465 Flat weave	S.D.

The figures quoted are mean values for the various sub-groups shown.

Table 1

Average results of tests of unlined hose

Make	Weave (1)	Burnst-itizing (2)	Alkali-solubility (%)	Speci-fication (3)	Bursting (lb./sq.in.)	Percol-ation (gall./5 min)	Absorp-tion (gm)	Abrasion (min)	Flexi-bility (lb.)	Tensile (load lb.)								Mildew tensile (load lb.)(4) fabric (wet)						Disc bursting (lb./sq.in.)	Mildew disc bursting (lb./sq.in.)(4)		
										Fabric						Yarn		Warp			Weft						
										Weft fold		Weft flat		Warp		Weft											
										Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	4U	4L	8U	4U	4L	8U		8U	8L	16U
A	F	Bz	10	SD	435	0·65	132	38·0	14·5	688	582	1071	745	955	735	83	54	298	467	170	965	1198	819	1875	808	1283	367
A	F	NBz	10	SD	395	0·21	128	35·1	19·1	1065	594	1414	904	916	668	101	62	258	298	-	855	1001	755	1713	1246	938	1217
B	C	Bz	10	SD	635	2.09	146	24·9	15·3	1458	693	1390	757	808	605	98	67	253	318	70	-	786	-	1746	646	1096	353
B	C	NBz	10	SD	575	0·22	125	25·5	15·2	1150	553	1226	635	864	603	103	66	434	396	93	933	958	717	1483	1225	1021	604
C	F	Bz	10	SD	485	5·44	159	27·5	13·6	1213	658	1417	842	822	583	118	71	223	228	-	985	952	694	1904	946	488	746
C	F	NBz	10	SD	445	0·39	165	21·3	17·6	1167	623	1500	736	872	538	110	77	198	231	-	939	1024	571	1692	1184	743	446
A	C	Bz	5	FB	665	4·53	120	21·7	12·9	1447	821	1462	822	817	551	116	71	268	248	-	1100	1178	953	1725	1308	1458	1053
A	C	NBz	5	FB	680	2·51	129	21·3	18·7	1560	840	1617	872	793	528	118	70	190	244	-	1180	1128	692	1533	450	1450	-
A	C	Bz	10	FB	625	1·90	116	27·0	21·4	1430	759	1500	853	754	544	120	70	321	304	99	1132	1225	897	1704	1479	1238	1354
A	C	NBz	10	FB	645	0·86	114	25·1	24·1	1338	841	1455	855	723	476	112	74	254	263	-	1160	1070	903	1550	438	1517	-
B	C	Bz	5	FB	655	5·34	156	18·9	14·0	1443	715	1368	757	867	597	121	78	155	180	-	1084	1074	889	1679	1221	854	925
B	C	NBz	5	FB	645	0·35	137	27·1	17·5	1560	745	1481	768	938	598	115	70	220	189	-	995	1007	775	1633	1538	1371	733
B	C	Bz	10	FB	485	0·71	156	28·7	18·6	1377	747	1460	741	919	606	113	64	228	233	63	1155	1083	792	1683	613	875	-
B	C	NBz	10	FB	715	0·31	129	27·8	19·4	1399	744	1497	784	904	623	113	68	185	233	-	1007	997	738	1663	1325	1221	1125
C	F	Bz	5	FB	425	4·18	145	22·2	15·4	1218	582	1572	764	978	671	111	57	323	298	-	1351	1354	1128	1879	1038	833	521
C	F	NBz	5	FB	415	0·69	146	23·0	17·7	1169	616	1629	821	1001	658	119	68	305	296	-	1092	1083	1000	1554	746	575	-
C	F	Bz	10	FB	475	1·68	145	22·3	18·9	1093	627	1558	871	842	630	121	66	333	320	263	1312	1553	1297	1646	854	883	-
C	F	NBz	10	FB	445	0·58	136	23·7	18·4	1227	647	1578	876	829	606	122	78	290	275	114	1214	1182	987	1679	673	1067	501

(1) F - flat, C - circular woven. (2) Bz - burnettized, NBz - not burnettized. (3) SD - Service Department, FB - Fire Brigade. (4) U - not leached, L - leached.

serious defects. Pinholes due to broken warp threads which are easily repairable by darning should not be taken as grounds for rejection. Generally weft thread breakages should be regarded as serious defects, but a breakage of a weft thread in a length may be regarded as repairable if so agreed between the purchaser and the maker.

In such a case, before effecting a repair, the note clause below shall be brought into effect, in order to ensure that the defect is not general throughout the batch, and the repair to the first length only agreed if the subsequent two samples are free of this defect.

These tests shall be carried out on a basis of 1 in every 50 lengths.

(NOTE. In the event of a sample or length failing on any of the above tests, two further samples should be selected and similarly tested. If both pass, the consignment should be accepted subject to fulfilment of other requirements, but if either of these samples also fails, the consignment should be rejected. If however the maker so desires he may submit the remaining lengths to the test in question and those which pass should be accepted subject to fulfilment of other requirements).

(d) Construction test. Every hose length, without pre-wetting, must be subjected to a pressure of 175 lb./sq.in. built up during 2 minutes and maintained for a period of one minute. During this test the hose must not shew defects due to faulty manufacture, but any length shewing minor defects may, by mutual agreement between the maker and the purchaser, be repaired by the maker and re-submitted to a second "construction" test.

PC.

APPENDIX II

Second issue

Specification for S.D. Quality Canvas Hose $2\frac{3}{4}$ in. diameter

PRELIMINARY

This specification includes for the supply and delivery of unlined canvas hose for Fire Services Generally. The hose shall be seamless and shall be suitable for use on couplings with serrated tails of $2\frac{3}{4}$ in. external diameter.

The yarn shall be dry spun flax long line, finished to not more than 10 per cent Alkaline Solubility. All hose is to be shrunk and burnettized and shall be examined for smoothness before being coiled. The lengths to which the hose shall be cut, after shrinkage, will be as specified in the delivery instructions.

The schedule of guarantees and particulars shall be filled in by tenderers, and a 6 ft. sample length shall be supplied when tendering.

CONSTRUCTION, WEIGHT, PERCOLATION AND BURSTING PRESSURE

The construction of the hose shall be such as to produce a good pliable and hard wearing hose, free from pinholing or other defects. In the case of flat woven hose the weft shall be correctly tensioned to give an even edge with the weft reasonably covered.

The weight of the hose shall be not less than 13 ozs. per yard and should preferably be not more than 14 ozs. per yard.

The percolation and bursting pressure shall be such as to conform to the tests given below.

TESTING

(a) Percolation. From every warp, subsequent to burnettizing, one full length of hose shall be cut in the presence of the Testing Officer and percolation measured over any 12 ft. shall not exceed the following:-

During first seven minutes from dry 14 gallons.

During 31st to 35th minutes inclusive 6 pints.

The pressure must be applied to the dry hose and be built up steadily over a period of 2 minutes to 100 lb. per sq. in. which must be maintained throughout the rest of the test.

(b) Pressure test. A 3 ft. length or lengths as may be determined by the Testing Officer shall be cut from every warp and tested, and must withstand a minimum bursting pressure of 400 lb. per sq. in.

(c) Proof test. This test should be carried out on a full length test which has undergone the percolation test and in consequence is thoroughly soaked. The pressure must be built up at a rate not exceeding 100 lb. per sq. in. per minute to 225 lb. per sq. in., which must be maintained for 5 minutes. During this test the hose must not show signs of serious defect. Pinholes shown up at this pressure and not at 150 lb. per sq. in. should not be regarded as

TESTING

(a) Bursting test. A 3 ft. length or lengths from every warp as may be determined by the testing officer shall be tested and must withstand the minimum bursting pressure as specified.

(b) Percolation. From every warp, subsequent to burnettizing, one full length of hose shall be cut in the presence of the testing officer, and percolation measured over any 12 ft. shall not exceed the limits specified.

(c) Proof test. The proof test must meet the conditions specified, and will be applied to one full length in 50. During this test the hose must show no signs of serious defects. Generally, broken weft threads should be regarded as a serious defect, but one broken weft thread in a length of hose may be regarded as repairable if so agreed between the purchaser and the maker. In such a case, before effecting a repair, the note clause as specified shall be brought into operation, in order to ensure that the defect is not general throughout the batch, and the repair to the first length only agreed if the subsequent two samples are free of this defect.

(d) Change in diameter and length. These requirements must meet the conditions as specified, and will be checked on a basis of one length in every 50 or consignment of less than 50.

(e) Construction test. The construction test on every hose length shall be as specified, and any length showing minor defects may be repaired and re-submitted to a second test, subject to agreement with the testing officer.

The above tests must be carried out on a basis of one length in every 50 or consignment of less than 50; the length used for test (d) not necessarily being the same as that used for tests (b) and (c).

(NOTE: In the event of a sample or length failing on any of the above tests two further samples should be selected and similarly tested. If both pass, the consignment should be accepted subject to fulfillment of other requirements, but if either of these samples also fails the consignment should be rejected. If however the maker so desires he may submit the remaining lengths to the test in question and those which pass should be accepted subject to fulfillment of other requirements).

(e) Construction test on every hose-length. Every hose-length without pre-wetting must be subjected to a pressure of 175 lb./sq.in., built up during two minutes and maintained for a period of one minute. During this test the hose must not show defects due to faulty manufacture, but any length showing minor defects may, by mutual agreement between the Maker and the Purchaser be repaired by the Maker and re-submitted to a second 'construction' test.

2¾ in. Unlined Delivery Hose for Fire Brigade Use
M.O.W. Supplementary Specification No. 1

GENERAL

This specification includes for the supply and delivery of 2¾ in. unlined delivery hose for fire services generally, and as specified in the requirement specification, a copy of which is attached. The hose shall be seamless and shall be suitable for use on couplings with serrated tails of the same nominal external diameter.

All hose is to be shrunk and burnettized and shall be examined for smoothness before being coiled. The lengths to which the hose shall be cut, after shrinking, will be as specified in the delivery instructions. It shall consist entirely of British dry spun flax long line yarns, such yarns to be finished so that the alkaline solubility shall not be more than 5 per cent.

CONSTRUCTION, WEIGHT, PERCOLATION AND BURSTING PRESSURE

It shall be such as to produce a good, pliable, and hard wearing hose, free from pinholing or other defects. In the case of flat woven hose the weft shall be correctly tensioned to give an even edge with the weft reasonably covered. The weight must not exceed 16 ozs. and preferably should be not more than 14 ozs. The weights apply to hose which, subsequent to thorough drying, has been allowed to stand for 2/3 days in an atmosphere with a relative humidity of approximately 75 per cent.

The amount of percolation shall not exceed the limits as specified.

The bursting pressure should not be less than 450 lb. per sq.in. under the conditions specified for a 3 ft. length, but the Contractor should state the actual bursting pressure he is prepared to guarantee.

The internal surface of the hose shall be as smooth as possible to reduce friction loss to a minimum. A sample 75 ft. length shall be submitted when required for testing purposes, for which the Department will bear the cost.

(g) Mildew. The material from which the hose is made should be as resistant as possible to mildew, and may be given special treatment for this purpose, providing it does not affect adversely the hose in any way.

(h) Repair. The hose must be easily repairable, either by existing or other simple methods.

4. ACCEPTANCE TESTS

The following acceptance tests are intended to be made at the Maker's works, the Fire Brigade or elsewhere as may be agreed between the Purchaser and the Maker:-

(a) Bursting test on 3 ft. samples cut from any length selected by the Purchaser

The pressure must be built up steadily at a rate approximating to, but not exceeding 100 lb./sq.in. per minute, after the sample has previously been soaked for 30 minutes at a pressure of 100 lb./sq.in. The hose must not burst at a pressure less than 450 lb./sq.in.

(b) Percolation test. A hose length selected by the Purchaser, must be subjected to a test for Percolation which will be measured over any 12 ft. The pressure must be applied to the dry hose and be built up steadily over a period of 2 minutes to 100 lb./sq.in. which must be maintained throughout the rest of the test. Under normal humidity conditions the percolation must not exceed the following quantities:-

Diameter	During first seven minutes from dry	During 31st to 35th minute inclusive
in.	Gallons	Pints
$1\frac{3}{4}$	8	2
$2\frac{3}{4}$	13	4
$3\frac{1}{2}$	19	5

(c) Proof test. This test should be carried out on a full length hose which has undergone the percolation test and in consequence is thoroughly soaked. The pressure must be built up at a rate not exceeding 100 lb./sq.in. per minute, to 300 lb./sq.in., which must be maintained for 5 minutes. During this test the hose must not show signs of serious defects. Pinholes shown up at this pressure and not at 175 lb. per square inch should not generally be regarded as serious defects. Pinholes due to broken warp threads which are easily repairable by darning should not be taken as grounds for rejection. Generally weft thread breakages should be regarded as a serious defect, but a breakage of a weft thread in a length may be regarded as repairable if so agreed between the Purchaser and the Maker. In such a case, before effecting a repair the note clause below should be brought into operation, in order to ensure that the defect is not general throughout the batch, and the repair to the first length only agreed if the subsequent two samples are free of this defect.

(d) Change in diameter and length. The stipulated requirements (see paragraph 3-d) must be verified on any length undergoing the construction test (e) below, measurements being taken: (i) when dry before pressure is applied, (ii) at 100 lb./sq.in. and (iii) at 175 lb./sq.in.

(c) Friction loss. The internal surface of the hose should be as smooth as possible reducing friction loss to a minimum. The maximum permissible friction loss figures through 100 ft. of hose with a pressure of 100 lb./sq.in. at inlet are as follows:-

(1) Diameter in.	(2) Flow gallons per minute	(3) Loss in pressure lb. per sq. in.
1¾	60	24
2¾	200	27
3½	400	33

It is intended that the manufacturer will either supply a certificate that the friction loss of the construction of hose he submits is within the required limits, or the Purchaser may make arrangements for the friction loss to be checked.

(d) Change in size. The construction of the hose must be such that in use the diameter does not increase unduly, nor the length contract or extend excessively as pressure is built up. The following figures must not be exceeded, the pressure being built up steadily to 175 lb./sq.in. in 2 minutes.:

Length	Contraction between 'dry' (i.e. without pre-wetting) and 10 lb./sq.in.	2%
	Increase between 10 lb./sq.in. and 175 lb./sq.in.	6%
Diameter Increase between 10 lb./sq.in. and 175 lb./sq.in.		1/16 in.

(e) Flexibility. When dry the hose must be capable of being laid into 6 ft. flakes without kinking. After being subjected to 100 lb./sq.in. pressure for 30 minutes, it must be capable of being rolled into a smooth roll (i.e. without 'flats').

(f) Durability. The standard of durability should be as high as possible, laboratory tests are being devised to give comparative figures for resistance to abrasion and ageing, and this clause will be subjected to revision when the tests are established. Meanwhile durability is to be safeguarded in the case of hose of normal construction by prescribed warp weights. For hose woven from flax the weight of the warp yarn shall not be less than 60 per cent of the total weight of the hose nor less than the figures given in the table below:-

Diameter	Weight of warp per yard of hose
in.	oz.
1¾	5
2¾	8
3½	13

APPENDIX I

Ministry of Works hose specifications

The relevant parts of the Fire Brigade and Service Department Specifications are as follows:-

Requirement Specification for 1¾ in., 2¾ in., and 3½ in. unlined DELIVERY HOSE for Fire Brigade Use

NOTE:- The requirements of this specification are to be regarded as minima (or maxima as the case may be) and nothing herein is to be construed as tending to prevent a Purchaser from specifying stricter requirements in any direction to meet special circumstances.

1. GENERAL

This specification, which is not intended to cover any particular or special method of construction, refers to Unlined Delivery Hose for use by Fire Brigades.

Under working conditions the hose may be required to be used at pressures up to 150 lb./sq.in., and to ensure that the hose remains in condition to withstandthis pressure, it will be subjected periodically to a test pressure of 175 lb./sq.in. (maintained for one minute). The hose is also subject in service to shock loads in excess of this figure.

2. SIZES

The nominal internal diameters of the sizes of hose covered by this specification are 1¾ in., 2¾ in., and 3½ in., and, in order to ensure fitting on to coupling tailpieces, the manufactured diameters must be the nominal diameters plus 3/64 in., with a tolerance not exceeding ± 1/64 in.

The lengths in which the hose is required will be specified by the Purchaser. (Normally not more than 100 ft.).

3. PROPERTIES

(a) Weight. The weight of the hose should be as light as reasonably possible, but it is essential that durability is not sacrificed thereby. The weights per yard should preferably not exceed those shown in Column 2 and must not exceed those shown in Column 3 of the following Table.

(1)	(2) (3) Weights per yard	
Diameter	Preferred maximum	Maximum
in.	oz. per yard	oz. per yard
1¾	9	11
2¾	14	16
3½	21	24

(b) Percolation. It is important that percolation is as low as possible to minimise wastage of water and water-damage. (See Percolation test 4-b).

WEFT - unleached hose.

MAKE C

Table 16A

Weft strength before and after mildewing 4 and 8 days - lb. per in.

Specification	Burnettized				Not burnettized				Period (days)
	5% A.S.		10% A.S.		5% A.S.		10% A.S.		
	Before	After	Before	After	Before	After	Before	After	
FB	1572	1351	1558	1312	1629	1092	1578	1214	4
		1128		1297		1000		987	8
SD			1417	985			1500	939	4
				694				571	8
95% 4 days = 47.5 8 days (F.B. only) = 81									

Table 16B

Loss of strength - lb. per in.

Specification	Burnettized		Not burnettized		Period (days)
	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
FB	221	246	537	364	4
	444	261	629	591	8
SD		432		561	4
		723		929	8
95% confidence limits on loss of strength = $\pm$ 132.					

WEFT - unleached hose. MAKE B

Table 15A

Weft strength before and after mildewing 4 and 8 days - lb. per in.

Specification	Burnettized				Not burnettized				Period (days)
	5% A.S.		10% A.S.		5% A.S.		10% A.S.		
	Before	After	Before	After	Before	After	Before	After	
FB	1368	1084	1460	1185	1481	995	1497	1007	4
		889		792		779		738	8
SD			1390	1000*			1226	933	4
				600*				717	8
σ 4 days = 47.5 σ 8 days (F.B. only) = 81									

*Data incomplete for unleached hose.

Table 15B

Loss of strength - lb. per in.

Specification	Burnettized		Not burnettized		Period (days)
	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
FB	284	305	486	490	4
	479	668	702	759	8
SD		390		293	4
		790		509	8
95% confidence limits on loss of strength = $\pm$ 132					

WEFT - unleached hose. MAKE A

Table 14A

Weft strength before and after mildewing 4 and 8 days - lb. per in.

Specification	Burnettized				Not burnettized				Period (days)
	5% A.S.		10% A.S.		5% A.S.		10% A.S.		
	Before	After	Before	After	Before	After	Before	After	
FB	1462	1100	1508	1132	1617	1180	1455	1168	4
		953		897		692		903	8
SD			1071	965			1414	855	4
				819				753	8

σ 4 days = 47.5

σ 8 days (F.B. only) = 81

Table 14B

Loss of strength - lb. per in.

Specification	Burnettized		Not burnettized		Period (days)
	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
FB	362	376	437	287	4
	509	611	925	552	8
SD		106		559	4
		252		661	8

95% confidence limits on loss of strength = $\pm$ 132.

WARP - leached hose. MAKE C

Table 13A

Warp strength before and after mildewing 4 days - lb. per in.

Specification	Burnettized				Not burnettized			
	5% A.S.		10% A.S.		5% A.S.		10% A.S.	
	Before	After	Before	After	Before	After	Before	After
FB	978	298	842	320	1001	286	829	275
SD			822	228			872	231
σ = 18								

Table 13B

Loss of strength in 4 days - lb. per in.

Specification	Burnettized		Not burnettized	
	5% A.S.	10% A.S.	5% A.S.	10% A.S.
FB	680	522	715	554
SD		594		641
95% confidence limits on loss of strength = $\pm$ 50				

WARP - leached hose.

MAKE B

Table 12A

Warp strength before and after mildewing 4 days - lb. per in.

Specification	Burnettized				Not burnettized			
	5% A.S.		10% A.S.		5% A.S.		10% A.S.	
	Before	After	Before	After	Before	After	Before	After
FB	867	180	919	233	938	189	904	233
SD			808	318			864	396
σ = 18								

Table 12B

Loss of strength in 4 days - lb. per in.

Specification	Burnettized		Not burnettized	
	5% A.S.	10% A.S.	5% A.S.	10% A.S.
FB	687	686	749	671
SD		490		468
95% confidence limits on loss of strength = $\pm$ 50				

WARP - leached hose.

MAKE A

Table 11A

Warp strength before and after mildewing 4 days - lb. per in.

Specification	Burnettized				Not burnettized			
	5% A.S.		10% A.S.		5% A.S.		10% A.S.	
	Before	After	Before	After	Before	After	Before	After
FB	817	248	754	304	798	244	723	263
SD			955	467			916	298
σ = 18								

Table 11B

Loss of strength in 4 days - lb. per in.

Specification	Burnettized		Not burnettized	
	5% A.S.	10% A.S.	5% A.S.	10% A.S.
FB	569	450	554	460
SD		488		618
95% confidence limits on loss of strength = $\pm$ 50				

Table 9

Weft strength (wet) - lb. per in.

Make A				Make B				Make C				Specification
Burnettized		Not burnettized		Burnettized		Not burnettized		Burnettized		Not burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
1462	1508	1617	1455	1368	1460	1481	1497	1572	1558	1629	1578	FD
/	1071	/	1414	/	1390	/	1226	/	1417	/	1500	SD
σ (F.B. hose) = 30 σ (10% hose) = 49				95% limits on a difference ± 85 (F.B. hose) ± 140 (10% hose)								

The figures quoted are mean values for the various sub-groups shown.

Table 10

Yarn strength (dry) - lb.

Make A				Make B				Make C				Specification
Burnettized		Not burnettized		Burnettized		Not burnettized		Burnettized		Not burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
71	70	70	64	78	64	70	68	57	68	66	78.1	FB
/	54	/	62	/	67	/	66	/	71	/	77	SD
σ = 0.76				95% confidence limits ± 2.2 on a difference								

The figures quoted are mean values for the various sub-groups shown.

Table 7

Abrasion resistance in number of revolutions.

Make A				Make B				Make C				Specification
Burnettized		Not burnettised		Burnettized		Not burnettized		Burnettized		Not burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
21.7	27.0	21.3	25.1	18.9	28.7	27.1	27.8	22.2	22.3	23.0	23.7	FB
/	38.0	/	35.1	/	14.9	/	25.5	/	27.5	/	21.3	SD

σ (F.B. hose) = 1.49
σ (10% hose) = 2.18

95% limits on a difference $\pm$ 4.16 (F.B. hose)
$\pm$ 6.08 (10% hose)

The figures quoted are mean values for the various sub-groups shown.

Table 8

Warp strength (wet) - lb. per in.

Make A				Make B				Make C				Specification
Burnettized		Not burnettized		Burnettized		Not burnettized		Burnettized		Not burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
817	754	798	723	867	919	938	904	978	842	1001	829	FB
/	955	/	916	/	808	/	864	/	822	/	872	SD

σ (F.B. hose) = 18
σ (10% hose) = 30

95% limits on a difference $\pm$ 51 (F.B. hose)
$\pm$ 85 (10% hose)

The figures quoted are mean values for the various sub-groups shown.

Table 5

Absorption of water; gm per 3 ft length

Make A				Make B				Make C				Specification
Burnettized		Not burnettized		Burnettized		Not burnettised		Burnettized		Not burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
120	116	129	114	156	136	137	129	145	148	14[illegible]	136	FB
/	132	/	128	/	146	/	125	/	159	/	165	SD
σ = 4.05								95% limits on a difference ± 11.8				

The figures quoted are mean values for the various sub-groups shown.

Table 6

Flexibility: measured inversely by load for given deflection

Make A				Make B				Make C				Specification
Burnettized		Not burnettized		Burnettized		Not burnettized		Burnettized		Not burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
14.9	21.4	18.7	24.1	14.0	18.6	17.9	19.4	15.4	18.9	17.7	18.4	FB
/	14.5	/	19.1	/	15.3	/	15.2	/	13.6	/	17.6	SD
σ = 0.66								95% limits on a difference ± 1.90				

Burnettized		Not burnettized		Specification
5% A.S.	10% A.S.	5% A.S.	10% A.S.	
14.7	19.6	18.1	20.6	FB
/	14.4	/	17.3	SD

The figures quoted are mean values for the various sub-groups shown.

Table 4

Percolation in 1st 5 minutes of tests on 3 ft lengths (gal)

Make A				Make B				Make C				Specification
Burnettized		Not Burnettized		Burnettized		Not Burnettized		Burnettized		Not Burnettized		
5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	5% A.S.	10% A.S.	
4.53	1.90	2.51	0.86	5.34	0.71	0.35	0.31	4.18	1.68	0.69	0.58	F.B.
	0.65		0.21		2.09		0.22		5.44		0.89	S.D.

σ (10% hose only) = 0.17

σ (5% hose only) = 0.76

95% confidence limits on a difference
= ± 0.50 (10% hose only)
= ± 2.2 (5% hose only)
= ± 2.3 (5% and 10%)

Table 4A

Burnettized		Not Burnettized		Specification
5% A.S.	10% A.S.	5% A.S.	10% A.S.	
4.63	1.43	1.18	0.58	F.B.
	2.73		0.44	S.D.

The figures quoted mean values for the various sub-groups.

Table 3

Percolation at intervals up to 1 hour

Make	Burnettizing	Alkali solubility (%)	Specification	Percolation in gall. at end of				
				5 min	10 min	15 min	30 min	60 min
A	Bz	10	SD	0.65	0.95	1.14	1.50	2.14
A	NBz	10		0.21	0.31	0.38	0.52	0.68
B	Bz	10	SD	2.09	3.39	4.40	6.73	10.22
B	NBz	10		0.22	0.31	0.36	0.46	0.59
C	Bz	10	SD	5.44	8.96	11.74	17.14	-
C	NBz	10		0.89	1.43	1.86	2.29	4.44
A	Bz	5		4.53	7.06	9.01	13.16	-
A	NBz	5	FB	2.51	3.89	5.02	7.42	10.52
A	Bz	10		1.90	2.87	3.56	4.97	6.56
A	NBz	10		0.86	1.43	1.90	3.04	4.76
B	Bz	5		5.34	8.85	11.76	-	-
B	NBz	5	FB	0.35	0.47	0.56	0.75	1.00
B	Bz	10		0.71	1.08	1.38	2.02	2.93
B	NBz	10		0.31	0.44	0.53	0.71	0.94
C	Bz	5		4.18	7.25	9.81	15.97	-
C	NBz	5	FB	0.69	1.13	1.49	2.53	3.67
C	Bz	10		1.68	2.83	3.81	6.31	10.22
C	NBz	10		0.58	0.97	1.31	2.17	3.59

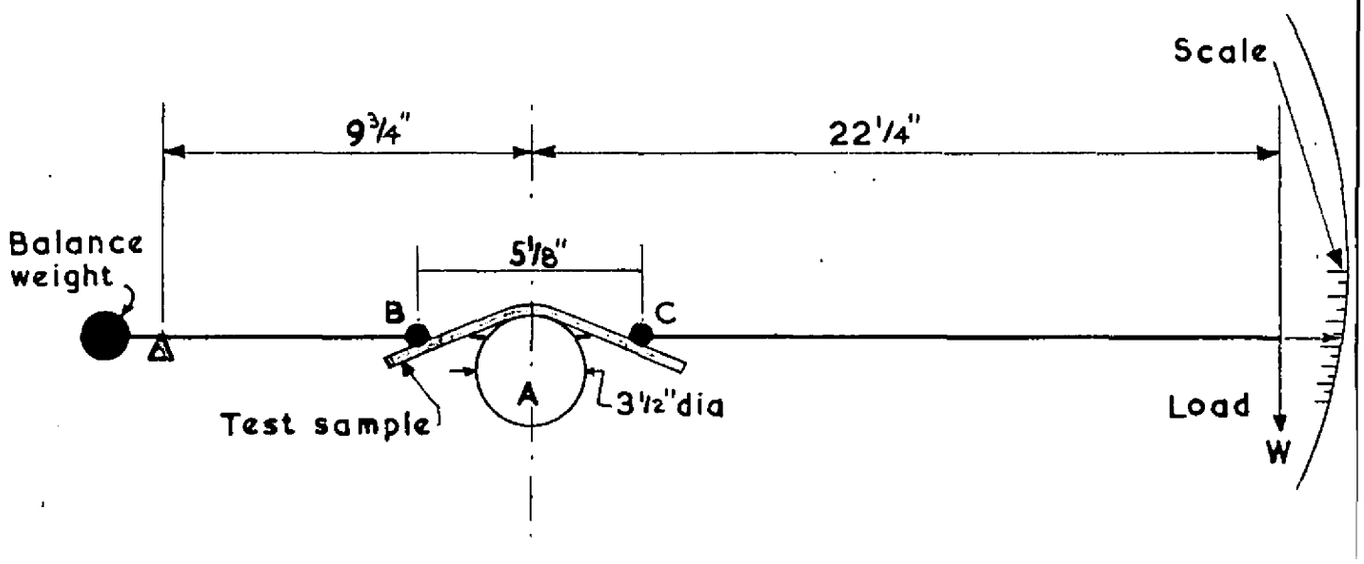

FIG.I. DIAGRAM OF FLEXIBILITY APPARATUS