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NATIONAL RESEARCH COUNCIL
CANADA
DIVISION OF BUILDING RESEARCH

TRIAL OF SPECIFICATION TESTS
FOR FORESTRY FIRE HOSE

by

G. Williams-Leir and R. D. Stagg

ANALYZED

Internal Report No. 240
of the
Division of Building Research

OTTAWA

February 1962

PREFACE

The Division of Building Research has recently co-operated with the Canadian Government Specifications Board in a revision of its specification for unlined forestry fire hose and the preparation of a new one for lined hose. Certain measurements on lined hose were requested by the Board's Committee on Fire Hose to guide them in drafting the specification. Now that both specifications have been published, a series of tests on both types of hose has been completed.

All readily available brands of hose on the Canadian market were tested. Though none was found to comply with every requirement of the specifications, it should be borne in mind that these were hoses manufactured either to a different specification or to none at all. Now that manufacturers know the exacting requirements that their products should meet, it is confidently hoped that they will be able to produce hose that complies.

The authors are a research officer and a technician with the Fire Section of the Division.

Ottawa
February 1962

N. B. Hutcheon
Assistant Director

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by

G. Williams-Leir and R. D. Stagg

The Committee on Fire Hose of the Canadian Government Specifications Board has prepared Specifications 13-GP-1b for "Hose; Forestry, Unlined," and 13-GP-2 for "Hose; Forestry, Lined." These specifications differ considerably from their predecessors, and prior to the work described in this report, no tests had been made in exact accordance with them.

The objective of this work was to ascertain whether the specifications are sufficiently severe to distinguish between good and bad products, and to ensure that, in so doing, they do not disqualify all, or nearly all, hose in current production. The work was started while the specifications were still under discussion, and the early results on lined hose, presented in an interim report (1) were submitted to the committee before the final version of the lined hose specification had been approved.

Certain observations were made, and are here reported, beyond those which the current versions of the specifications require; some of these were called for in earlier drafts of the specifications and have since been discarded, and others have never been required.

Through the kindness of Mr. J. C. Macleod, Joint Secretary of the Associate Committee on Forest Fire Protection, specimens of hose, as listed below, were obtained. The 15 brands, A to I and P to U, are those to which the specifications apply. Six other brands to which they were not applicable were also included. Requirements of the specifications that are inappropriate to the type of hose have been indicated in the tabulation of results. The 21 brands have been coded; the code will be disclosed only to the Secretary of the Committee on Fire Hose of the Canadian Government Specifications Board.

<u>No. of Brands</u>	<u>Type</u>	<u>Nominal Diameter,</u> <u>in.</u>	<u>Code</u>
9	lined	$1\frac{1}{2}$	A-I
4	lined	1	J-M
2	lined,		
	plastic-coated	$1\frac{1}{2}$, $2\frac{1}{2}$	N-O
6	unlined	$1\frac{1}{2}$	P-U

(1) Stagg, R. D. and G. Williams-Leir. Trial of a proposed method of test for forestry fire hose. National Research Council, Division of Building Research, Technical Note 332. May 1961.

The specifications are frequently paraphrased or quoted in this report, but for the exact requirements the reader should refer to the originals.

NOTE ON TERMINOLOGY

Rupture means bursting of the hose.

Failure includes any deficiency in respect of the specification requirements, and is also used for rupture or coupling separation even when the specification requirements are met, i.e. when rupture etc. occurs above 600 psi.

In the tables, distinction is made between failures to meet the specification requirements and cases when a test could not be applied because of some earlier failure, e.g., it is not possible to measure leakage at 200 psi if a hose ruptures at 150 psi.

SECTION 1. PRESSURE AND LEAKAGE

1.1 Modes of Failure in Pressure and Leakage

The ways in which a hose can fail to meet the requirements relating to the bursting pressure and leakage test are as follows:

Rupture of weft fibres.

Rupture of warp fibres.

Small pinholes where it is not possible to detect which fibres, if any, have ruptured.
Excessive leakage.

In the use of lined hose, a small pinhole in the lining, which may show up as a "wet patch."

Slipping or tearing at a coupling. This indicates either that the coupling has been imperfectly attached to the hose, or that the hose has been weakened by compression between the coupling and the expansion ring.

In the tables that follow, the mode of failure of each hose is tabulated.

Unlined Hose Requirements

Four specimens are to be tested, two of which to be subjected to leaching in running water at 15°C for 7 days, followed by soil burial in loops totalling 4.0 ± 0.5 ft

for 14 days. After this they are subjected to a pressure test.

The pressure schedule for all four specimens was as follows. (All pressure increases were at the rate of 100 psi per min.)

Firstly, measure the length when dry.

At 0	min.	-	fill hose with water at 10 psi and measure the length.
1		-	raise pressure to 100 psi and hold.
17½		-	start to collect leakage.
27½		-	stop collecting leakage. Measure length, twist, etc.
28		-	raise pressure to 200 psi and hold.
29½		-	start collecting leakage.
39½		-	stop collecting leakage. Measure length, twist, etc.
40		-	raise pressure to 300 psi and hold.
41		-	measure length, twist, etc.
42		-	raise pressure to 600 psi and hold.
45½		-	start collecting leakage.
55½		-	stop collecting leakage. Measure length, twist, etc.
56		-	raise pressure to failure of specimen.

The requirements state that

leakage at 100 psi must not exceed 3.4 ml/ft of length/min.
leakage at 200 psi must not exceed 14.2 ml/ft of length/min.
leakage at 600 psi must not exceed 142.0 ml/ft of length/min.
the hose must withstand a pressure of 600 psi for 10 min.

Lined Hose Requirements

Three specimens are to be tested; all are to be subjected to leaching in running water at 15°C for 7 days. They are then to be placed in cold storage at -18 +2°C for 24 hours, followed by flexing. After soil burial in loops totalling 4.0 +0.5 ft for 14 days, the pressure schedule for all three specimens shall be as follows:

Firstly, measure the length when dry.

At 0	min.	-	fill hose with water, bleed off any air, raise pressure to 10 psi, hold, and measure length, twist, etc.
1		-	raise pressure to 300 psi and hold.
4		-	measure length, twist, etc.

- 5 - raise pressure to 600 psi and hold.
- 8 - measure length, twist, etc.
- 13 - raise pressure to failure of specimen.

The requirements are: no leakage or wet patches at any pressure up to and including 600 psi, and, 600 psi for 5 min $\pm$ 10 sec.

Test Results and Analysis

TABLE I
FAILING POINT* OF SPECIMENS

Brand	Pressure, psi							
	Test 1				Test 2			
A	300	300	300		425	500	425	
B	600	300	600		525	500	500	
C	300	220	325		150	100	-	
D	500	500	450		375	400	400	
E	925	950	950		-	-	-	
F	300	260	360		275	260	240	
G	750	750	725		600	750	600	
H	875	850	775		775	825	750	
I	575	575	500		600	600	-	
J	875	500	1080		-	-	-	
K	825	780	725		-	-	-	
L	400	450	600		-	-	-	
M	110	425	300		-	-	-	
N	520	470	520		-	-	-	
O	530	575	550		500	600	580	
P	600	600	700	850	860	200	200	200
Q	800	200	600	600	100	640	740	-
R	60	100	575	200	95	95	540	-
S	200	200	100	200	200	200	100	-
T	100	100	525	600	100	100	600	600
U	100	100	975	200	100	100	100	-

* The term "Failing Point" is used here to denote the first point at which the hose fails any one of the specification requirements for pressure or leakage. See the Note on Terminology above for the meaning given to "failure."

TABLE II
MODES OF PRIMARY FAILURE

	Brand	No. of specimens tested	Mode of failure at or below 600 psi								Above 600 psi				
			Rupture of weft fibres	Rupture of warp fibres	Wet patches	Pinholes	Leakage at 100	Leakage at 200	Leakage at 600	Couplings	Rupture of weft fibres	Rupture of warp fibres	Wet patches	Pinholes	Couplings
	A	6	2	-	3	1	-	-	-	-	-	-	-	-	-
	B	6	-	3	3	-	-	-	-	-	-	-	-	-	-
	C	5	-	4	-	1	-	-	-	-	-	-	-	-	-
	D	6	1	3	-	2	-	-	-	-	-	-	-	-	-
	E	3	-	-	-	-	-	-	-	-	1	2	-	-	-
	F	6	-	6	-	-	-	-	-	-	-	-	-	-	-
	G	6	-	-	2	-	-	-	-	-	1	2	-	-	1
	H	6	-	-	-	-	-	-	-	-	1	-	-	-	5
	I	5	5	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal	9	49	8	16	8	4	-	-	-	-	3	4	-	-	6
	J	3	-	-	-	-	-	-	-	1	1	-	-	-	1
	K	3	-	-	-	-	-	-	-	-	1	-	-	-	2
	L	3	3	-	-	-	-	-	-	-	-	-	-	-	-
	M	3	1	1	-	1	-	-	-	-	-	-	-	-	-
Subtotal	4	12	4	1	-	1	-	-	-	1	2	-	-	-	3
	N	3	2	-	-	-	-	-	-	1	-	-	-	-	-
	O	6	5	-	-	1	-	-	-	-	-	-	-	-	-
Subtotal	2	9	7	-	-	1	-	-	-	1	-	-	-	-	-
	P	8	2	-	-	-	-	3	-	-	3	-	-	-	-
	Q	7	2	-	-	-	1	1	-	-	3	-	-	-	-
	R	7	6	-	-	-	1	-	-	-	-	-	-	-	-
	S	7	-	-	-	-	2	5	-	-	-	-	-	-	-
	T	8	3	-	-	-	4	-	-	1	-	-	-	-	-
	U	7	-	-	-	-	5	1	-	-	-	-	-	-	1
Subtotal	6	44	13	-	-	-	13	10	-	1	6	-	-	-	1
TOTAL	21	114	32	17	8	6	13	10	-	3	11	4	-	-	10

TABLE III

MODE OF SECONDARY FAILURE OF THOSE SPECIMENS
FOR WHICH THE PRESSURE TEST COULD BE CONTINUED
AFTER PRIMARY FAILURE

Brand	No. of specimens	At or below 600 psi						Above 600 psi			
		Weft fibres	Warp fibres	Pinholes	Leakage 200	Leakage 600	Couplings	Weft fibres	Warp fibres	Pinholes	Couplings
A	3	1	1	-	-	-	-	1	-	-	-
B	3	-	2	-	-	-	-	-	-	-	-
G	2	-	-	-	-	-	-	1	-	-	1
P	3	-	-	-	-	-	-	2	-	-	1
Q	2	1	-	-	1	-	-	-	-	-	-
R	1	-	-	-	1	-	-	-	-	-	-
S	1	-	-	3	2	-	-	-	-	-	1
T	7	1	-	-	4	-	-	-	-	-	-
U	4	-	-	-	3	-	-	2	-	-	1
TOTAL	31	3	3	3	11	-	-	6	-	1	4

TABLE IV

MODE OF TERTIARY FAILURE OF THOSE HOSES
FOR WHICH THE PRESSURE TEST COULD BE CONTINUED
AFTER SECONDARY FAILURE

Brand	No. of specimens	At or below 600 psi		Above 600 psi		
		Weft fibres	Couplings	Weft fibres	Pinholes	Couplings
Q	1	-	1	-	-	-
R	1	1	-	-	-	-
S	2	-	2	-	-	-
T	4	4	-	1	1	1
U	3	-	-	-	-	-
TOTAL	11	5	3	1	1	1

1.2 Cause of "Final" Failure of Hose

The manner in which each specimen first failed to comply with specification requirements in the pressure test has been presented in Table II. Such defects as excessive leakage do not bring the test to an end. Whenever the first failure was of such a nature as to permit it, the test was continued and a secondary and often a tertiary failure occurred, as given in Tables III and IV.

In nearly every case the final failure was rupture or separation of couplings. By presenting again the mode of final failure it will be possible to bring out information on the effectiveness of mildew-proofing as applied to these hose specimens.

As already mentioned, both specifications require that before the pressure test a portion of the sample submitted for testing be buried in soil of prescribed microbiological activity, in loops, so that a part of each specimen is covered and part not. If the specimen ultimately ruptured, it was generally possible to determine whether the point of rupture lay in the buried part or in the remainder. The final failure is tabulated in Tables V and VI according to where the rupture lay.

Where rupture occurred in the unburied part, the mildew-proofing must have been adequate. Such ruptures, if they occur below 600 psi, are evidence of inadequate strength. This deficiency can also cause ruptures in the buried part; for an accurate comparison of the frequency of mildew-proofing failures with strength failures, the latter should be doubled at the expense of the former. This reasoning assumes strength failures to be uniformly distributed, though the number of samples is such that the probability of chance variation influencing the conclusions is not negligible. There were several cases where it was uncertain whether the rupture occurred in the buried or the unburied part; these are shown in an intermediate column in the tables.

Results show that failures below 600 psi are more often due to poor mildew-proofing than to inadequate strength or poor coupling. To pass 600 psi all three conditions must be met; once this level is passed, however, the most common weak point has been the coupling. In most cases, the couplings, all of them new, were carefully put on at the Division of Building Research. It is thought that the currently standard method of attaching couplings with a soft brass expander ring 7/8 in. by 0.04 in. is not strong enough for pressures much in excess of 600 psi. If couplings were required to stand higher pressures, some improvement of the method would become necessary, for instance, the use of a thicker expander ring or of a ring material having a higher elastic limit.

TABLE V

MODE OF FINAL FAILURE OF LINED HOSE

Brand	Failure at or below 600 psi				Failure above 600 psi			
	In * S.B. part	?	Not in S.B. part	Coupling	In S.B. part	?	Not in S.B. part	Coupling
A	6	-	-	-	-	-	-	-
B	5	1	-	-	-	-	-	-
C	5	-	-	-	-	-	-	-
D	6	-	-	-	-	-	-	-
E	-	-	-	-	1	-	2	-
F	6	-	-	-	-	-	-	-
G	-	-	-	-	3	-	-	3
H	-	-	-	-	1	-	-	5
I	3	2	-	-	-	-	-	-
Subtotal	31	3	-	-	5	-	2	8
J	-	-	-	1	-	1	-	1
K	-	-	-	-	-	1	-	2
L	1	2	-	-	-	-	-	-
M	2	1	-	-	-	-	-	-
Subtotal	3	3	-	1	-	2	-	3
N	1	-	1	1	-	-	-	-
O	1	4	1	-	-	-	-	-
Subtotal	2	4	2	1	-	-	-	-
TOTAL	36	10	2	2	5	2	2	11

* S.B. - Soil buried.

TABLE VI

MODE OF FINAL FAILURE OF UNLINED HOSE

TWO SPECIMENS PER TEST ARE SOIL BURIED:

Brand	Failure at or below 600 psi				Failure above 600 psi			
	In S.B. part	?	Not in S.B. part	Coupling	In S.B. part	?	Not in S.B. part	Coupling
P	2	-	-	-	-	1	1	-
Q	-	1	-	-	2	1	-	-
R	3	1	-	-	-	-	-	-
S	-	4	-	-	-	-	-	-
T	4	-	-	-	-	-	-	-
U	-	-	-	-	1	1	-	2
TOTAL	9	6	-	-	3	3	1	2

TWO SPECIMENS PER TEST ARE NOT SOIL BURIED:

Brand	Failure at or below 600 psi		Failure above 600 psi	
	Hose	Coupling	Hose	Coupling
P	-	-	4	-
Q	2	-	1	-
R	3	-	-	-
S	-	2	-	1
T	3	-	-	1
U	-	-	2	1
TOTAL	8	2	7	3

1.3 Leakage Measurements

The upper limits of acceptable leakage for unlined hose are:

3.4 ml/ft of length/min at 100 psi
14.2 ml/ft of length/min at 200 psi
142 ml/ft of length/min at 600 psi

In Table VII the specimens have been put into two groups with summary columns showing the number of failures to meet the specification.

From Table VII, it may be seen that soil burial appears to increase the leakage from an unlined hose.

TABLE VII
LEAKAGE (ml/ft/min)

Brand	(1) Specimens not buried				(2) Buried specimens				No. of failures by excessive leakage	
									(1)	(2)
P	0.60	0.56	1.00	2.20	1.15	1.10	1.67	1.76	-	-
Q	0.28	0.12	0.36	-	1.05	1.08	<u>3.54</u>	1.65	-	1
R	0.35	4.20	0.43	-	-	-	-	-	1	-
S	<u>5.20</u>	<u>0.35</u>	<u>5.00</u>	-	2.25	2.75	3.30	2.65	2	-
T	<u>0.96</u>	1.65	<u>2.40</u>	2.90	<u>4.25</u>	<u>9.00</u>	<u>5.90</u>	<u>6.40</u>	-	4
U	1.10	1.55	<u>5.35</u>	-	<u>5.70</u>	<u>4.10</u>	<u>6.60</u>	<u>8.70</u>	<u>1</u>	<u>4</u>
									4	9
200 psi										
P	8.90	12.6	<u>18.8</u>	<u>30.2</u>	9.70	13.7	10.2	21.0	2	1
Q	11.7	5.60	<u>4.90</u>	-	13.0	<u>22.5</u>	<u>23.5</u>	<u>11.6</u>	-	2
R	5.50	55.0	4.00	-	-	-	-	-	1	-
S	<u>43.5</u>	<u>14.7</u>	39.0	-	27.8	34.5	80.1	38.3	3	4
T	<u>5.60</u>	<u>11.5</u>	<u>7.90</u>	9.40	<u>24.0</u>	<u>31.5</u>	<u>24.3</u>	<u>20.4</u>	-	4
U	12.5	<u>18.8</u>	14.2	-	<u>13.5</u>	<u>18.3</u>	<u>33.0</u>	<u>51.8</u>	<u>1</u>	<u>3</u>
									7	14
600 psi										
P	46.5	46.5	64.8	55.0	15.6	3.75	19.4	46.0	-	-
Q	-	56.4	54.0	-	27.0	-	37.8	55.0	-	-
R	-	-	-	-	-	-	-	-	-	-
S	-	105.	-	-	-	-	-	-	-	-
T	-	-	-	-	-	-	-	-	-	-
U	19.5	31.5	21.5	-	11.3	15.3	60.0	90.0	-	-
									0	0

Note: The underlined leakage figures are those that exceed the acceptable.

1.4 Twist, Rise and Warp

The specifications do not impose limits upon twist, rise or warp. In the case of twist, the direction if specified as "the twist shall be in a direction that would tend to tighten the couplings."

Table VIII presents the average results of all tests for each brand. The lowest pressure at which rise or warp occurred, and its extent, is also given. For example, $\pm 1 \times 300$ means ± 1 -in. warp at 300 psi. The correct direction of twist is recorded as positive.

TABLE VIII

Brand	Revolutions of twist					Rise	Warp	No. of specimens showing rise or warp
	Pressure, psi							
	10	100	200	300	600			
A	0	-	-	+1	+1	-	<u>+1</u> x300	2
B	0	-	-	+1	+1	-	<u>+1</u> 1/2x600	1
C	0	-	-	+1/2	-	-	-	-
D	0	-	-	+1 1/8	-	-	-	-
E	0	-	-	+1	+1	-	<u>+1</u> x600	2
F	0	-	-	-	-	-	-	-
G	0	-	-	+1 1/8	+1 1/2	+1x600	<u>+1</u> x600	2
H	0	-	-	+1	+1 1/4	+1x300	<u>+1</u> x300	4
I	0	-	-	+7/8	-	-	-	-
J	0	-	-	+1 3/4	+2 1/2	-	-	-
K	0	-	-	+1 1/4	+1 3/4	+1x600	<u>+1</u> x300	3
L	0	-	-	+1 1/2	+2	+1x300	<u>+2</u> x300	3
M	0	-	-	+1 1/2	-	-	-	-
N	0	-	-	0	-	-	-	-
O	0	-	-	+1	-	-	-	-
P	0	+3/8	+3/4	+7/8	+1 1/8	-	<u>+1</u> x600	7
Q	0	0	-1/8	-1/4	-1/2	-	-	-
R	0	+1/4	+3/4	+7/8	-	-	<u>+1</u> x200	1
S	0	0	0	0	-	-	-	-
T	0	+3/8	+3/4	+7/8	-	-	<u>+1</u> x300	3
U	0	+1/2	+3/4	+7/8	+1 1/8	+1x600	<u>+1</u> x600	7

1.5 Elongation

The limits of acceptable change of length with pressure are:

Unlined hose - 5 per cent shrinkage between 0 and 10 psi

10 per cent elongation between 10 and 300 psi.

Lined hose - 0 per cent shrinkage between 0 and 10 psi

15 per cent elongation between 10 and 300 psi.

TABLE IX

Brand	% Elongation (*)				
	Pressure, psi				
	0 to 10	10 to 100	10 to 200	10 to 300	10 to 600
A	+1	No measurement for these brands.		+5	(+7)
B	0			+6	(+10)
C	+1			(+7)	-
D	+1			+7	-
E	+2			+6	+8
F	0			(+3)	-
G	+1			+9	+13
H	+1			+8	+16
I	+1			+8	(+10)
J	+1			+7	+11
K	+1			+5	+9
L	+2			+5	(+6)
M	0			(+5)	-
N	+1			+11	-
O	+1			+3	-
P	-2	+3	+5	+7	+11
Q	+1	+2	+2	+4	+5
R	-1	-1	-1	(-2)	-
S	0	+2	+3	+4	(+4)
T	(-2)	+2	+3	+5	(+11)
U	-1	+3	+5	+6	+9

* Figures shown in brackets are the results of only one or two specimens reaching the appropriate pressure.

Time Change of Length

Some of the unlined specimens showed a small change in length with time, during those parts of the pressure schedule in which a constant pressure was maintained.

TABLE X

At pressure, psi after time in min	100		200	600
	10	25	10	10
Brand	Elongation %			
P	0	0	+1	+1
Q	(-1)	(-1)	+1	+1
R	-	-	-	-
S	0	0	(+1)	-
T	(-1)	0	(+1)	-
U	0	0	+1	+1

Note: Figures shown in brackets are the results of only one or two specimens reaching the appropriate pressure.

SECTION 2. HOSE CONSTRUCTION

2.1 Jacket Materials Used

The unlined hoses all had linen warp and weft. The lined and plastic-coated hoses were woven from the following fibres:

TABLE XI

Warp fibres	Weft fibres	No. of brands
Linen	Linen	3
Cotton	Nylon	2
Cotton and polyester	Nylon	2
Cotton	Polyester	6
Ramie	Polyester	1
Polyvinyl alcohol	Polyester	<u>1</u>
		15

The specifications have the following stipulations regarding the construction of hose:

"The hose shall be woven from first quality yards suitable for the purpose, which shall be practically free from knots, shives and other imperfections. The fabric shall be of uniformly even and firm texture and shall be free from all defects that might affect its serviceability.... The warp yarns shall lie in a direction parallel to the length of the hose and shall cover the weft yarns sufficiently to protect them from abrasion."

2.2 Diameter

The rate of flow for a given pressure should be regulated by any performance specification for fire hose. This has not been done directly in the specifications under review; they control it by regulating the inside diameter, surface roughness, and leakage, on which the rate of flow must depend.* A limit on the outside diameter is also necessary to ensure that the hose can be attached to a standard coupling.

The internal diameter of the hose, as received, is required to be not less than 1-33/64 (1.52) in. for lined hose, or 1-17/32 (1.53) in. for unlined hose. The outside diameter of either hose must be such that a standard coupling as specified in CSA Standard B89-1954, having a lip and bowl diameter of 1-11/16 (1.69) in., can be attached to the hose by the purchaser using regular equipment and expansion rings 1.500 $\pm$ 0.003 in. in outside diameter.

To measure the internal diameter, a fresh cut is made across the hose, approximately 6 in. from the end of the specimen. A tapered plug-gauge, with a taper of 3/8 in. per ft and marked to indicate variations in diameter of 1/64 in., is then inserted until a close fit is obtained. The diameter, as shown on the gauge, is then averaged with a second such measurement for each specimen.

* Williams-Leir, G. Water flows and pressures obtainable with forestry pumps and hose. National Research Council, Division of Building Research, Internal Report No. 179. February 1960. 14p.

TABLE XII

Brand	I.D., in.	O.D.
A	1 35/64(1.55)	acceptable
B	1 35/64(1.55)	"
C	1 33/64(1.52)	"
D	1 37/64(1.58)	"
E	1 31/64(1.48)	not acceptable
F	1 1/2 (1.50)	acceptable
G	1 35/64(1.55)	"
H	1 9/16(1.56)	"
I	1 33/64(1.52)	"
J	1 7/64(1.11)	"
K	1 7/64(1.11)	"
L	1 1/8 (1.13)	"
M	1 1/32(1.09)	"
N	N/M*	N/M
O	N/M	N/M
P	1 39/64(1.61)	acceptable
Q	1 19/32(1.59)	"
R	1 19/32(1.59)	"
S	1 37/64(1.58)	"
T	1 9/16(1.56)	"
U	1 19/32(1.59)	"

* N/M = No measurement recorded.

2.3 Weight and Flexibility

Since this type of hose is intended for forestry purposes it is especially desirable that it should be as light as possible while satisfying the other requirements. The hose should also be capable of being handled with ease under all conditions. It is possible that hose acquired for forestry fighting purposes might be used in the winter for fire fighting in buildings. Consequently, it has been thought fit to impose a requirement that the hose shall not be so stiff at low temperatures that flexure would cause damage.

The maximum acceptable weight for lined hose, when in equilibrium at 21 +1°C and 65 +2 per cent relative humidity, is 18.0 lb per 100 ft, exclusive of fittings. The maximum acceptable weight for unlined hose, when dried to constant weight at 100-105°C, is 14.0 lb per 100 ft, exclusive of fittings.

Each of the three 10-ft lengths of lined hose which has been leached and dried at room temperature, is to be placed, tightly coiled, in a cold box at $-18 \pm 2^{\circ}\text{C}$ for 24 hours. Upon removal, the hose is to be rapidly uncoiled, and then immediately recoiled in the reverse direction. This is done before soil burial and the pressure test so that any damage resulting from cold flexure will influence the result. An assessment of the flexibility of the hose was made and is shown as "FAIR" or "POOR" in Table XIII; no specimen was rated better than "FAIR".

TABLE XIII
WEIGHT AND FLEXIBILITY

Brand	Weight, lb/100 ft	Flexibility
A	17.35	FAIR
B	15.85	"
C	18.5	"
D	14.9	"
E	20.7	POOR
F	21.45	FAIR
G	14.2	"
H	12.5	"
I	17.25	POOR
J	8.8	FAIR
K	10.3	"
L	13.2	POOR
M	7.8	FAIR
N	N/M*	POOR
O	N/M	"
P	13.0	N/A**
Q	12.4	"
R	12.6	"
S	11.8	"
T	13.4	"
U	12.8	"

* N/M = No measurement reported.

** N/A = Requirement not applicable to this type of hose.

2.4 Bonding of Lining

The following statements in quotation marks are from CGSB Specification No. 13-GP-2; "3.2 The lining shall adhere

to the jacket over the entire surface." Any visible separation of the liner from the jacket is to be considered a failure.

"6.9 Examination for Bonding of Lining. Hose that has been subjected to leaching, cold flexing, soil burial, the pressure test and the heat resistance test shall be cut into lengths of at least 6 inches and examined visually for bonding of the lining, while being flexed manually. Twelve ends taken equally from all the original lengths shall be examined. Not more than one defect shall be permitted where a single separation showing on the two ends resulting from one cut is defined as one defect. Pieces cut from the hose in the area where the hot block was placed shall be discarded."

TABLE XIV

Brand	Number of ends	Remarks
A	36	meets
B	36	"
C	30	"
D	36	"
E	18	"
F	36	"
G	36	"
H	36	"
I	30	"
J	18	"
K	18	FAILS
L	18	meets
M	18	"
N	18	"
O	36	"

SECTION 3. OTHER REQUIREMENTS

3.1 Heat Resistance

After the pressure test, the hose is subjected to a heat resistance test. A block of steel 12 by 3 by 3 in. is to be heated to $260 \pm 5^{\circ}\text{C}$ throughout for lined hose, and $400 \pm 5^{\circ}\text{C}$ for unlined hose, and then placed transversely on a portion of the specimen. Water is to be pumped through at 1 gal per min and a pressure of 50 ± 10 psi maintained. After $2 \text{ min} \pm 10 \text{ sec}$ the block is removed, the flow stopped and the pressure raised, at 100 psi per min to 300 psi and held for 5 min. One specimen from each of the 10-ft lengths is tested. No specimens of any sample should fail at 300 psi.

There is at present no specification for the plastic-coated type hose. In this series of tests, therefore, the plastic-coated hose was treated as a lined hose, and was tested to the 260 $\pm 5^{\circ}\text{C}$ temperature requirement.

TABLE XV

Brand	Number of specimens tested	Number of specimens passing
A	6	6
B	6	6
C	5	5
D	6	6
E	3	3
F	6	2*
G	6	6
H	6	6
I	5	5
J	3	-**
K	3	3
L	3	3
M	2	-**
N	3	0
O	6	6
P	8	8
Q	7	7
R	7	3*
S	7	7
T	8	8
U	7	7

* This hose was severely affected by soil burial and would not withstand a pressure of 100 psi, although it appeared to be little damaged by the hot block at 50 psi.

** These hoses, because of couplings not holding, would not pass 200 psi although they appeared to be little damaged by the hot block at 50 psi.

3.2 Aging of Hose Lining

Accelerated aging of lining. The lining is required to pass an accelerated aging test, which in the case of natural rubber linings is as given in CGSB Specification 13-GP-2,

TABLE XVI

Brand	Thickness		Tensile strength		Per cent elongation		Remarks
	Unaged	Aged	Unaged	Aged	Unaged	Aged	
A	.028 to .046 .036	.031 to .039 .035	530 to 1540 1095	65 to 765 330	650 to 740 700	110 to 800 425	fails
B	.010 to .011 .010	.010 to .011 .011	1905 to 2875 2370	1525 to 2325 1735	780 to 900 830	810 to 910 870	meets
C	.022 to .047 .029	.022 to .041 .028	1280 to 1540 1430	1230 to 1550 1420	200 to 310 250	210 to 290 250	fails
D	.029 to .031 .030	.025 to .031 .029	2055 to 3125 2480	1450 to 2230 1870	670 to 730 700	620 to 720 650	meets
E	.012 to .013 .013	.012 to .013 .013	1825 to 2305 2045	1595 to 1935 1795	840 to 880 860	880 to 950 910	meets
F	.033 to .051 .041	.038 to .049 .045	1210 to 1335 1230	1135 to 1290 1195	440 to 490 465	350 to 400 370	fails
G	Lining too thin to be tested						
H	.026 to .035 .030	.030 to .037 .033	1130 to 1960 1520	915 to 1290 1020	740 to 830 790	650 to 800 735	fails
I	.029 to .034 .031	.030 to .034 .032	1000 to 1140 1080	775 to 1420 1190	710 to 760 735	650 to 780 720	fails
J	Lining too thin to be tested						
K	.0105 - .0105	.0105 to .010 .010	1980 to 2170 2080	1905 to 2160 2020	860 to 870 870	870 to 880 880	meets
L	.038 to .046 .042	.042 to .051 .046	1345 to 1800 1645	70 to 140 95	150 to 800 785	150 to 450 295	fails
M	.022 to .029 .025	.022 to .029 .025	2705 to 3740 3090	1960 to 2700 2320	700 to 730 710	620 to 650 640	meets

Note: The first row of figures is the range of figures reported for one brand; the second row is the average of the figures reported for that brand.

paragraph 4.8.1, provided the lining thickness is adequate for this test.

"4.8.1 After air-oven aging, the tensile strength and ultimate elongation of natural rubber lining from unleached hose shall be not less than 60 per cent of the strength and elongation of unaged specimens. The tensile strength and ultimate elongation of unaged lining shall be not less than 1800 psi and 700 per cent respectively."

"6.10 Accelerated aging of lining. Specimens of natural rubber lining, taken from the specimen supplied without couplings, shall be oven-aged in accordance with ASTM Method D573 at 80 $\pm$ 1°C for 96 hours and tested for tensile strength and elongation by ASTM Method D412 using die C."

3.3 Acidity

Method of test. Approximately 5 gm of yarn unravelled from the hose was boiled for 1 hr, with 100 ml of distilled water with a pH of not less than 6.0 and not greater than 7.5. The water extract was then cooled to room temperature and made up to 100 ml with distilled water, after which its pH value was determined by a glass electrode.

TABLE XVII

Brand	Test 1	Test 2
A	5.4	5.9
B	7.6	8.6
C	6.7	7.4
D	6.3	7.0
E	7.6	-
F	7.2	7.7
G	5.9	6.3
H	6.6	6.7
I	6.5	6.6
J	6.8	-
K	8.3	-
L	6.0	-
M	7.1	-
N	6.3	-
O	7.8	8.0
P	5.3	7.5
Q	8.0	8.0
R	5.4	5.3
S	7.2	7.2
T	8.6	8.5
U	5.7	5.6

SECTION 4. SUMMARY

The results given for unlined hose are summarized in Tables XVIII and XIX, and for lined hose in Tables XX and XXI.

Specification 13-GP-1b, 1½" Unlined Hose

For each test 5 specimens are required, one of which is used for the tests on hose construction (Section 2) and acidity (Section 3). For this program of work, there were generally nine specimens available, two which were used for the tests on hose construction and acidity, and four which comprised the "first test." The remainder were used for a partial "second test." Whatever the results of testing a fourth specimen might be, they could not cause a group to pass the second test, if the other three specimens did not pass. Thus the possible results are: 1 meets, 1 uncertain; 1 meets, 1 fails; and 2 fail. For two brands only, ten specimens were available, and for these, "2 meet" is another possibility.

Specification 13-GP-2, 1½" Lined Hose

In each test four specimens are required. For some brands only seven specimens were available so that the remarks in the preceding paragraph again apply; for one brand, only four were available so that only one test was done.

Hose Types Not Covered by the Specifications

For this series of tests, the types of hose (1 in. lined and 1½ in., 2½ in. plastic-coated) were tested against Specification 13-GP-2, in so far as it was applicable.

CONCLUSION

No single hose met all the requirements of the current specifications. However, each requirement was met by more than one hose. None of the hoses tested had been manufactured with these particular specifications in view, since the specimens were procured before the specifications were promulgated. It is reasonable to expect that more than one manufacturer will be able to produce hose to meet the new specifications.

TABLE XVIII

UNLINED 1½-IN. HOSE SPECIMENS MEETING REQUIREMENTS

Brand	No. of specimens tested (a)	4.1 Weight	4.2 Dia.	4.4 Elong.	4.5 Twist	4.6.1 Leakage 100	4.6.2 Leakage 200	4.7 Leakage 600	4.7 Rupture	4.11 H.R.
P	2 + 8	2	2	8	8	8	5	6(2N)	6	8
Q	2 + 7	2	2	7	0	6	5	4(3N)	4	7
R	2 + 7	2	2	(b)	3	2(4N)*	2(4N)	0(4N)	0	3(4N)
S	2 + 7	2	2	7	5	5	0	0(7N)	1	7
T	2 + 8	2	2	8	8	4	4	0(8N)	0	8
U	2 + 7	2	2	7	7	2	3	7	7	7

Notes: * N indicates the number of specimens to which a test could not be applied because of failure at an earlier stage of the pressure schedule.

(a) For columns 4.1 and 4.2, only two specimens were required.

(b) All elongation measurements above 10 psi were negative (specification has no allowance for such a case).

H.R. = Heat resistance.

TABLE XIX

UNLINED 1½-IN. HOSE GROUPS MEETING REQUIREMENTS

Brand	4.1 Weight	4.2 Dia.	4.4 Elong.	4.5 Twist	4.6.1 Leakage 100	4.6.2 Leakage 200	4.7 Leakage 600	4.7 Rupture	4.11 H.R.
P	2M*	2M	2M	2M	2M	1M 1F	1M 1U	1M 1F	2M
Q	2M	2M	1M 1U*	2F	1M 1F	2F	2U	1F 1U	1M 1U
R	2M	2M	2U(a)	1M 1U	1F 1N*	1F 1N	2N	2F	2N
S	2M	2M	1M 1U	1F* 1U	2F	2F	2N	2F	1M 1U
T	2M	2M	2M	2M	2F	2F	2N	2F	2M
U	2M	2M	1M 1U	1M 1U	2F	2F	1M 1U	1M 1U	1M 1U

Notes: * M = meets; U = uncertain, i.e., a set of four specimens was not completed, but those that were tested complied: F = fails.
 N indicates that a set of tests on four specimens was not complete, since at least one of the four failed at an earlier stage of the pressure schedule.

- (a) All elongation measurements above 10 psi are negative, a case which is not covered by the specification.

TABLE XX

LINED 1½-IN. HOSE SPECIMENS MEETING REQUIREMENTS

Brand	No. of specimens tested (e)	3.2 Lining bonding	4.1 Weight	4.2 Dia.	4.4 Elong.	4.5 Twist	4.7 Wet patches	4.7 Coupling	4.7 Rupture	4.8 H.R.	4.9 Lining aging
A	2 + 6	6	2	2	6	6	0(2N)	0(6N)	0	6	0
B	2 + 6	6	2	2	6	6	0(3N)	0(6N)	0	6	2
C	2 + 5	5	0	2	2(3N)	5	0(4N)	0(5N)	0	4(1N)	2
D	2 + 6	6	2	2	6	6	0(4N)	0(6N)	0	6	2
E	1 + 3	3	0	0	3	3	3	3	3	3	1
F	2 + 6	6	0	0	1(5N)	6	0(6N)	0(6N)	0	3(3N)	0
G	2 + 6	6	2	2	6	6	4	6	6	6	(c)
H	2 + 6	6	2	2	6	6	6	6	6	6	0
I	2 + 5	5	2	2	5	5	0(5N)	0(2N)	0	5	0
J	1 + 3	3	(b)	(b)	3	3	2	2	2	0(3N)	(c)
K	1 + 3	1	(b)	(b)	3	3	3	3	3	3	1
L	1 + 3	3	(b)	(b)	3	3	0(3N)	0(3N)	0	3	0
M	1 + 3	3	(b)	(b)	1(2N)	3	0(2N)	0(3N)	0	1(2N)	1
N	1 + 3	3	(b)	(b)	3	3	0(3N)	0(2N)	0	0	(d)
O	2 + 6	6	(b)	(b)	6	6	0(5N)	0(6N)	0	6	(d)

(a) N indicates the number of specimens to which a test could not be applied because of failure at an earlier stage of the pressure schedule.

(b) Specification does not apply to this size or type of hose.

(c) Lining too thin to be tested; refer to Section 3.2 of this report.

(d) No measurement made.

(e) For columns 4.1, 4.2, 4.9, only two specimens were required, except as noted for particular brands.

TABLE XXI

LINED 1½-IN. HOSE GROUPS MEETING REQUIREMENTS

Brand	3.2 Lining bonding	4.1 Weight	4.2 Dia.	4.4 Elong.	4.5 Twist	4.7 Wet patches	4.7 Coupling	4.7 Rupture	4.8 H.R.	4.9 Lining aging
A	2M	2M	2M	2M	2M	2F	2N	2F	2M	2F
B	2M	2M	2M	2M	2M	1F 1N	2N	2F	2M	2M
C	1M 1U	2F	2M	2N	1M 1U	1F 1N	2N	2F	1M 1N	2M
D	2M	2M	2M	2M	2M	2F	2N	2F	2M	2M
E	1M	1F	1F	1M	1M	1M	1M	1M	1M	1M
F	2M	2F	2F	2N	2M	2N	2N	2F	2N	2F
G	2M	2M	2M	2M	2M	1M 1F	2M	2M	2M	(c)
H	2M	2M	2M	2M	2M	2M	2M	2M	2M	2F
I	1M 1U	2M	2M	1M 1U	1M 1U	2N	1F 1N	2F	1M 1U	2F
J	1M	(b)	(b)	1M	1M	1F	1F	1F	1N	(c)
K	1F	(b)	(b)	1M	1M	1M	1M	1M	1M	1M
L	1M	(b)	(b)	1M	1M	1N	1N	1F	1M	1F
M	1M	(b)	(b)	1N	1M	1N	1N	1F	1N	1M
N	1M	(b)	(b)	1M	1M	1N	1N	1F	1F	(d)
O	2M	(b)	(b)	2M	2M	2N	2N	2F	2M	(d)

- (a) M = meets, F = fails, U = uncertain, i.e. a set of three specimens was not completed, but these that were tested complied. N indicates that a set of tests on three specimens was not complete since at least one of the three failed at an earlier stage of the pressure schedule.
- (b) Specification does not apply to this type or size of hose.
- (c) Lining too thin to be tested, refer to Section 3.2 of this report.
- (d) No measurement made.

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