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NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

No.

332

TECHNICAL NOTE

NOT FOR PUBLICATION

FOR INTERNAL USE

PREPARED BY R. D. Stagg and
G. Williams-Leir

CHECKED BY GWS

APPROVED BY NBH

DATE May 1961

PREPARED FOR The Committee on Specifications for Fire Hose

SUBJECT TRIAL OF A PROPOSED METHOD OF TEST FOR FORESTRY FIRE HOSE

The Committee on Fire Hose of the Canadian Government Specifications Board has prepared draft specifications: 13-GP-1P for "Hose; Forestry, Unlined", and 13-GP-2P for "Hose; Forestry, Lined". These drafts differ considerably from their predecessors and to date no tests had been made in exact accordance with them. Consequently the Committee asked (see minutes, January 19, 1961, p. 8) that the procedures of specification 13-GP-2P be tried out before adoption of the draft, the implied objectives being to discover whether any of the hoses in current production can meet the new specification, and whether the specification is severe enough to ensure that the poorer products are rejected; further the tests should provide information on which decisions can be based if it appears desirable to the Committee to raise or lower any of the various acceptance levels.

Through the good offices of Mr. J.C. Macleod, Joint Secretary of the Committee, specimens of hose as listed below were obtained. Nine brands of lined hose from several manufacturers comprise the program proper, but to gain additional information other specimens to which the specification does not apply are included. In addition, six brands of unlined hose were obtained for a similar trial of the draft specification applicable to unlined hose, 13-GP-1P. A total of 21 brands have been coded and the code will be disclosed only to the Joint Secretary.

<u>No. of Brands</u>	<u>Type</u>	<u>Nominal Diameter In.</u>	<u>Coded</u>
9	lined	1½	A-I
4	lined	1	J-M
2	lined, plastic-coated	1½ and 2½	N-O
6	unlined	1½	P-U

The present report deals only with that part of the investigation that it was possible to complete in time for discussion at a meeting planned for May, that is to say, the first two items in the listing above. Certain specimens were received too late for observations on them to be included. Another version of the report will be brought out at a later date to include these.

Test Result Tables:

<u>Table Number</u>	<u>Item</u>	<u>Applicable Paragraphs in Specification</u>	<u>Page</u>
1	Bonding of Lining	3.2, 6.9	2-3
2	Weight	4.1	3
3	Diameter	4.2, 6.2.1, 6.2.2	4
4	Per cent Elongation	4.4, 6.7	5
5	Twist	4.5, 6.7	7
6	Flexibility	4.6, 6.5	8
7	Pressure	4.7, 6.7	9
8	Soil Burial	6.6	10
9	Heat Resistance	4.8, 6.8	12
10	Lining Aging	4.9, 6.10	13
11	pH	4.10, 6.11	15
12	Summary	-	16

GENERAL REQUIREMENTS

3.2 Lining ... The lining shall adhere to the jacket over the entire surface. Any visible separation of the liner from the jacket shall 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 short lengths and examined visually, while flexing manually for bonding of the lining. At least 12 ends taken equally from all the original lengths shall be examined. Pieces cut from the hose in the vicinity where the hot block was placed shall be discarded.

TABLE 1

<u>Brand</u>	<u>Number of Ends</u>	<u>Remarks</u>
A	36	meets
B	36	meets
C	30	meets
D	36	meets
E	18	meets
F	36	meets
G	36	meets
H	36	meets
I	30	meets
J	18	meets
K	18	FAILS
L	18	meets
M	18	meets

DETAIL REQUIREMENTS

4.1 Weight The hose shall have a weight, when in equilibrium at $21 \pm 2^{\circ}\text{C}$ and 65 ± 2 per cent relative humidity, not greater than 18.0 pounds per 100 feet, exclusive of fittings.

TABLE 2

<u>Brand</u>	<u>Weight</u>	<u>Remarks</u>
A	17.35	meets
B	15.85	meets
C	18.5	FAILS
D	14.9	meets
E	20.7	FAILS
F	21.45	FAILS
G	14.2	meets
H	12.5	meets
I	17.25	meets
J	8.8	*
K	10.3	*
L	13.2	*
M	7.8	*

* The Specification does not apply to this size of hose.

4.2 Diameter The internal diameter of the hose, as received, shall be not less than 1-33/64 inches. The outside diameter of the hose shall be such that a standard coupling as specified in CSA Standard B89-1954, having a lip and bowl diameter of 1-11/16 inches, can be attached to the hose by the purchaser using regular equipment and expansion rings 1.500 $\pm$ 0.003 inches in outside diameter.

6.2 Diameter

6.2.1 Apparatus The diameter shall be measured using a tapered plug gage having a taper of 3/8 inch per foot, marked to indicate variations of 1/64 inch in diameter.

6.2.2 Method Cut off and discard at least 6 inches from the uncoupled sample length. Insert the tapered plug gage in the freshly cut end until a close fit is obtained without forcing. The diameter of the gage at the end of the sample shall be reported as the actual internal diameter of the hose.

TABLE 3

<u>Brand</u>	<u>I.D. (in.)</u>	<u>O.D.</u>	<u>Remarks</u>
A	1 35/64 (1.55)	acceptable	meets
B	1 35/64 (1.55)	acceptable	meets
C	1 33/64 (1.52)	acceptable	meets
D	1 37/64 (1.58)	acceptable	meets
E	1 31/64 (1.48)	not acceptable	FAILS
F	1 1/2 (1.50)	acceptable	meets
G	1 35/64 (1.55)	acceptable	meets
H	1 9/16 (1.56)	acceptable	meets
I	1 33/64 (1.52)	acceptable	meets
J	1 7/64 (1.11)	acceptable	*
K	1 7/64 (1.11)	acceptable	*
L	1 1/8 (1.13)	acceptable	*
M	1 3/32 (1.09)	acceptable	*

* The Specification does not apply to this size of hose.

4.4 Elongation When the internal pressure is increased from 10 to 300 psi the hose shall not change in length by more than + 15 per cent of the length at 10 psi. There shall be no shrinkage.

6.7 Elongation, Twist and Pressure Test Each 10-foot length of hose which has been subjected to leaching (para. 6.4), cold flexing (para. 6.5) and soil burial (para. 6.6) shall be connected to a pump capable of developing a steady pressure of 600 psi. After bleeding off air, the pressure shall be raised at a rate of 100 psi per minute, pausing 1 minute at 10 psi and 300 psi to allow measurement of the lengths in a straight line between coupling shoulders, ... until 600 psi is reached or the hose fails.....

TABLE 4A

<u>Brand</u>	<u>Number of Specimens</u>	<u>Elongation 10 to 300 psi</u>	<u>Remarks</u>
A	6	5%	meets
B	6	5%	meets
C	5	7%	meets*
D	6	7%	meets
E	3	5%	meets
F	6	3%	meets**
G	6	9%	meets
H	6	8%	meets
I	5	8%	meets
J	3	7%	meets
K	3	5%	meets
L	3	4%	meets
M	3	5%	meets**

* Only two specimens reached 300 psi.
 ** Only one specimen reached 300 psi.

TABLE 4B

ADDITIONAL DATA

<u>Brand</u>	<u>Number of Specimens</u>	<u>Elongation 0 to 10 psi</u>	<u>Number of Specimens</u>	<u>Elongation 10 to 600 psi</u>
A	6	1%	2	7%
B	6	1%	2	10%
C	5	1%	0	-
D	6	1%	0	-
E	3	2%	3	7%
F	6	0%	0	-
G	6	1%	6	13%
H	6	0%	6	16%
I	5	1%	2	10%
J	3	1%	3	10%
K	3	1%	3	8%
L	3	2%	1	6%
M	3	0%	0	-

4.5 Twist The twist, if any, of the hose shall be in a direction that would tend to tighten couplings with a standard thread.

6.7 Elongation, Twist and Pressure Test ... and to note the direction of the twist

TABLE 5A

<u>Brand</u>	<u>Number of Specimens</u>	<u>Direction of Twist</u>	<u>Remarks</u>
A	6	correct	meets
B	6	correct	meets
C	5	correct	meets
D	6	correct	meets
E	3	correct	meets
F	6	*	*
G	6	correct	meets
H	6	correct	meets
I	5	correct	meets
J	3	correct	meets
K	3	correct	meets
L	3	correct	meets
M	3	correct	meets

* This brand of hose failed at such a low pressure that it was not possible to make a twist measurement.

TABLE 5B

ADDITIONAL DATA

Brand	Revolutions of Twist at:			Pressure in PSI at Which Rise or Warp Occurred: **	
	10 psi	300 psi	600 psi	Rise	Warp
A	0	1	1	-	300
B	0	1	1	-	600
C	0	$\frac{1}{4}$	-	-	-
D	0	$1\frac{1}{2}$	-	-	-
E	0	1	1	-	600
F	0	-	-	-	-
G	0	1	$1\frac{1}{2}$	600	600
H	0	1	$1\frac{1}{4}$	300	300
I	0	1	-	-	-
J	0	2	$2\frac{1}{2}$	-	-
K	0	$1\frac{1}{4}$	$1\frac{3}{4}$	600	600
L	0	$1\frac{1}{2}$	2	300	300
M	0	$1\frac{3}{4}$	-	-	-

** The term "warp" refers to departures in the horizontal plane from straightness, and "rise" to similar departures in the vertical plane. One end of the hose was secured, the other free to move.

4.6 Flexibility Dry hose that has been leached in accordance with paragraph 6.4, then dried and stored at temperatures as low as -18°C (0°F), shall be capable of being unrolled and unfolded without damage, and of being handled with ease.

6.5 Cold Flexing Each of the three 10-foot lengths of hose which have been leached (para. 6.4) and then dried at room temperature, shall be tightly coiled and placed in a cold box at $-18 \pm 2^{\circ}\text{C}$ for 24 hours, removed, uncoiled rapidly and immediately recoiled in the reverse direction.

TABLE 6

EASE OF HANDLING *

Brand	Specimen					
	1	2	3	4	5	6
A	Fair	Fair	Fair	Fair	Fair	Fair
B	Fair	Fair	Fair	Fair	Fair	Fair
C	Fair	Fair	Fair	Fair	Fair	-
D	Fair	Fair	Fair	Fair	Fair	Fair
E	POOR	POOR	POOR	-	-	-
F	Fair	Fair	Fair	Fair	Fair	Fair
G	Fair	Fair	Fair	Fair	Fair	Fair
H	Fair	Fair	Fair	Fair	Fair	Fair
I	POOR	POOR	POOR	Fair	Fair	-
J	Fair	Fair	Fair	-	-	-
K	Fair	Fair	Fair	-	-	-
L	POOR	POOR	POOR	-	-	-
M	Fair	Fair	Fair	-	-	-

* It was considered that the specification requirement was not sufficiently precise to fail these hoses on, although the observer reported the flexibility as no better than "fair" or "poor" for any specimen.

4.7 Pressure Test After being subjected to leaching, cold flexing and soil burial by the procedures described in paragraphs 6.4, 6.5 and 6.6, the hose, including connections to the couplings, shall not fail; i.e., it shall not leak or burst at pressures up to and including 600 psi. Wet patches on the hose during the test shall be considered failures. Leaks at couplings that drip but do not run shall not be considered failures. The hose shall be conditioned to equilibrium at 65 ± 2 per cent relative humidity at $70 \pm 2^\circ\text{F}$ before testing.

6.7 Elongation, Twist and Pressure Test ... If the hose reaches 600 psi, this pressure shall be maintained for 5 min $\pm$ 10 sec and the test piece examined for leaks. The pressure shall then be increased to failure. Three 10-foot lengths shall be tested; none shall fail at 600 psi.

TABLE 7

Brand	Test 1			Test 2			Remarks
	1	2	3	1	2	3	
A	300	300	300	425	500	425	2 FAIL
B	600	300	600	525	500	525	2 FAIL
C	300	220	325	150	100	-	2 FAIL *
D	500	500	450	375	400	400	2 FAIL
E	925	950	950	-	-	-	1 meets
F	300	260	360	275	260	240	2 FAIL
G	750	750	725	600	750	600	1 meets 1 FAILS
H	875	850	775	775	825	750	2 meet
I	575	575	500	600	600	-	2 FAIL *
J	875	800	1080	-	-	-	1 meets
K	825	780	725	-	-	-	1 meets
L	400	450	600	-	-	-	1 FAILS
M	110	425	300	-	-	-	1 FAILS

* To meet the specification, three specimens passing the test are required. In these two cases, only five specimens were available but whatever the results of a pressure test on a sixth specimen, and however the six results were grouped, these hoses would have each twice failed to meet the specification requirements.

6.6 Soil Burial Each of the three 10-foot lengths of hose, leached (para. 6.4) and cold flexed (para. 6.5) shall be subjected to burial as follows: portions to a total length of 4 feet + 6 inches of each 10-foot length shall be filled with soil and buried in the form of two loops for 14 days. Conditions of burial shall be in accordance with Method 28.3 of CGSB 4-GP-2.

TABLE 8A

MODE OF FAILURE IN PRESSURE TEST

<u>Brand</u>	<u>No. of Specimens</u>	<u>Wet Patches</u>	<u>Coupling Failure</u>	<u>Rupture</u>
A	6	4	-	2
B	6	3	-	3
C	5	1	-	4
D	6	2	-	4
E	3	-	-	-
F	6	-	-	6
G	6	2	-	-
H	6	-	-	-
I	5	-	-	5
J	3	-	-	-
K	3	-	-	-
L	3	-	-	3
M	3	1	-	2

TABLE 8B

LOCATION OF WET PATCHES

<u>Brand</u>	<u>In Area Buried</u>	<u>Not in Area Buried</u>	<u>Questionable</u>
A	4	-	-
B	2	-	1
C	1	-	-
D	2	-	-
E	-	-	-
F	-	-	-
G	1	-	1
H	1	-	-
I	-	-	-
J	-	-	1
K	-	-	-
L	-	-	-
M	-	-	1

TABLE 8C

Brand	LOCATION OF RUPTURE *				TYPE OF RUPTURE	
	In Area Buried	Not in Area Buried	Question-able	At coup-ling **	Weft	Warp
A	2	-	-	-	2	-
B	3	-	-	-	-	3
C	4	-	-	-	-	4
D	4	-	-	-	1	3
E	1	2	-	-	1	2
F	6	-	-	-	-	6
G	2	-	-	2	1	2
H	1	-	-	5	1	-
I	-	-	2	3	5	-
J	-	-	1	1	1	-
K	-	-	1	2	1	-
L	1	-	2	-	3	-
M	2	-	-	-	1	-

* Not all "ruptures" are failures to meet this specification, since when a hose met the requirements the pressure test was continued to rupture.

** The couplings were not buried in the soil.

4.8 Heat Resistance After being subjected to the pressure test detailed in paragraph 4.7, the hose shall not fail in the heat resistance test.

6.8 Heat Resistance A block of steel 12 by 3 by 3 inches shall be heated to $260 \pm 5^{\circ}\text{C}$ throughout, and placed crossways on a portion of a length of hose that has been subject to leaching (para. 6.4), cold flexing (para. 6.5), soil burial (para. 6.6) and the pressure test (para. 6.7). The hose shall be at a pressure of 50 ± 10 psi with a flow of 1 gallon per minute. After 2 minutes ± 10 seconds the block shall be removed, the flow stopped and the pressure raised, at 100 psi per minute, to 300 psi and held for 5 minutes. Three specimens, one from each of the lengths tested in paragraph 6.7, shall be tested; none shall fail at 300 psi.

TABLE 9

Brand	Number of Specimens Tested	Number of Specimens Passing	Remarks
A	6	6	meets
B	6	6	meets
C	5	5	meets
D	6	6	meets
E	3	3	meets
F	6	2	*
G	6	6	meets
H	6	6	meets
I	5	5	meets
J	3	-	**
K	3	3	meets
L	3	3	meets
M	2	-	**

* This hose because of soil burial would not pass 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.

4.9 Accelerated Aging of Lining The lining shall pass an accelerated test acceptable to the purchaser. For natural rubber lining the accelerated test shall be as given in 4.9.1

4.9.1 After air-oven aging in accordance with paragraph 6.10, 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 $80 \pm 1^\circ\text{C}$ for 96 hours and tested for tensile strength and elongation by ASTM Method D412 using die C.

TABLE 10

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, while the second row is the average of the figures reported for that brand.

4.10 pH of Yarn The water extract of yarn taken from the sample of the hose as received shall show a pH of 7.0 ± 1.0 .

6.11 pH of Yarn Approximately 5 grams of yarn unravelled from the hose shall be boiled for 1 hour with 100 ml of distilled water with a pH of not less than 6.0 and not greater than 7.5. The water extract shall then be cooled to room temperature and made up to 100 ml with distilled water, after which its pH value is determined by a glass electrode.

TABLE 11

<u>Brand</u>	<u>Test 1</u>	<u>Test 2</u>	<u>Remarks</u>
A	5.4	5.9	FAILS
B	7.6	8.6	1M 1F
C	6.7	7.4	meets
D	6.3	7.0	meets
E	7.6	-	1M
F	7.2	7.7	meets
G	5.9	6.3	1F 1M
H	6.6	6.7	meets
I	6.5	6.6	meets
J	6.8	-	meets
K	8.3	-	FAILS
L	6.0	-	meets
M	7.1	-	meets

TABLE 12

SUMMARY

Brand	3.2 Lining Bonding	4.1 Weight	4.2 Dia.	4.4 % Elong- ation	4.5 Twist	4.7 Wet Patches	4.7 Coup- ling	4.7 Rup- ture	4.8 Heat Re- sistance	4.9 Lining Aging	4.10 pH
A	meets	meets	meets	meets	meets	<u>fails</u>	meets	<u>fails</u>	meets	<u>fails</u>	<u>fails</u>
B	meets	meets	meets	meets	meets	1M <u>1F</u>	meets	1M <u>1F</u>	meets	meets	1M <u>1F</u>
C	meets	<u>fails</u>	meets	meets	meets	1M <u>1F</u>	meets	<u>fails</u>	meets	<u>fails</u>	meets
D	meets	meets	meets	meets	meets	<u>fails</u>	meets	<u>fails</u>	meets	meets	meets
E	meets	<u>1F</u>	<u>1F</u>	1M	1M	1M	1M	1M	1M	1M	1M
F	meets	<u>fails</u>	<u>fails</u>	(3)	(3)	meets	meets	<u>fails</u>	(5)	<u>fails</u>	meets
G	meets	meets	meets	meets	meets	1M <u>1F</u>	meets	meets	meets	(4)	<u>1F</u> 1M
H	meets	meets	meets	meets	meets	meets	meets	meets	meets	<u>fails</u>	meets
I	meets	meets	meets	meets	meets	meets	meets	<u>fails</u>	meets	<u>fails</u>	meets
J	meets	(1)	(1)	1M	1M	1M	1M	1M	(5)	(4)	1M
K	<u>fails</u>	(1)	(1)	1M	1M	1M	1M	1M	meets	1M	<u>1F</u>
L	meets	(1)	(1)	1M	1M	1M	1M	<u>1F</u>	meets	<u>1F</u>	1M
M	meets	(1)	(1)	1M	1M	<u>1F</u>	1M	<u>1F</u>	(5)	1M	1M

✕ Low temperature flexibility is not considered here, for reasons stated in footnote to Table 6.

- NOTE: (1) Specification does not apply to this size of hose.
 (2) "Meets" means 2 tests meet requirements: "Fails" means 2 tests fail requirements.
 "1M" means 1 test meets requirement: "1F" means 1 test fails requirement.
 (3) Measurement not made because of low bursting pressure (see Tables 4 and 5).
 (4) These brands had too thin a lining to be tested (see Table 10).
 (5) These hoses, for reasons noted in Table 9, would not pass 200 psi although they appeared to be little damaged by the hot block at 50 psi.