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Indian Standard

SPECIFICATION FOR AUTOMOTIVE HYDRAULIC BRAKE HOSE

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(*Continued on page 2*)

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0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 18 July 1973, after the draft finalized by the Rubber Products Sectional Committee had been approved by the Chemical Division Council.

0.2 In the preparation of this standard, considerable assistance has been taken from the following documents:

ASTM Designation: D 571-55 Standard method of testing automotive hydraulic brake hose. American Society for Testing and Materials.

SAE J 1401 Hydraulic brake hose. Society of Automotive Engineers, USA.

0.3 This standard contains clauses **3.4.1**, **3.4.2** and **4.2** which call for agreement between the purchaser and the supplier.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard prescribes the requirements, methods of sampling and test for 3·25, 4·85 and 6·40 mm hydraulic brake hoses used in automotive industry.

1.2 This standard does not cover specifications for the end fittings.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in **2** of IS : 443-1963† shall apply.

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*Rules for rounding off numerical values (*revised*).
†Methods of sampling and test for rubber hoses (*revised*).

3. REQUIREMENTS

3.1 Material

3.1.1 *Lining* — The lining shall consist of a suitable oil-resistant rubber compound.

3.1.2 *Reinforcement* — The textile reinforcement shall consist of cotton, viscose rayon, polyester fibre or other suitable synthetic fibre or a combination of these.

3.1.3 *Cover* — The cover shall consist of suitable synthetic rubber compound based substantially on polychloroprene.

3.2 Construction

3.2.1 *Lining* — The lining shall be reasonably uniform in thickness, concentric and free from air blisters, porosity and other visible defects. It shall be seamless and as smooth in the bore as is consistent with good manufacturing practice.

3.2.2 *Reinforcement* — The textile reinforcement shall be firmly and evenly braided over the lining. The plies of reinforcement shall be impregnated with a suitable rubber compound.

3.2.3 *Cover* — The cover shall be reasonably uniform in thickness, concentric and free from air blisters, porosity and splits. The cover of the hose shall be smooth, fluted, cloth-marked or with a pattern finish.

3.3 Dimensions and Tolerances

3.3.1 *Diameter and Reinforcement Plies* — The bore size, when measured according to the method prescribed in **9.2** of IS : 443-1963*, and the number of reinforcement plies shall be as given in Table 1.

3.3.2 *Lining and Cover Thickness* — The thickness of the lining shall be not less than 0·75 mm and that of the cover not less than 0·6 mm when measured according to the method prescribed in **8** of IS : 443-1963*.

TABLE 1 BORE SIZE, TOLERANCE AND MINIMUM NUMBER OF REINFORCEMENT PLIES

(*Clause* 3.3.1)

Nominal Bore Size	Tolerance	Minimum No. of Plies
(1)	(2)	(3)
mm	mm	
3·25 4·85 6·40	+ 0 − 0·3	2

*Methods of sampling and test for rubber hoses (*revised*).

3.4 Requirements of Physical Tests

3.4.1 *Tensile Strength and Elongation at Break of Lining and Cover* — The tensile strength and elongation at break of the rubber used for lining and cover of the hose, when tested according to the method given in **4** of IS:443-1963*, shall be as specified in Table 2. For carrying out these tests, the manufacturers shall supply the requisite test slabs, if required by the purchaser.

TABLE 2 TENSILE STRENGTH AND ELONGATION AT BREAK OF LINING AND COVER

Characteristic	Requirements for	
	Lining	Cover
(1)	(2)	(3)
Tensile strength, kgf/cm², *Min*	140	85
Elongation at break, percent, *Min*	200	250

3.4.2 *Accelerated Ageing Test* — After ageing at 70 ± 1°C for a period of 72 hours in accordance with the method prescribed in **7** of IS:443-1963*, the tensile strength and elongation at break of the rubber used for lining of hose shall not vary by more than ± 15 percent of the corresponding values obtained before ageing. Further, after ageing at 100 ± 1°C for 72 hours, the rubber used for the cover of the hose shall not vary by more than ± 25 percent for tensile strength, and $^{+10}_{-45}$ percent for elongation at break of the corresponding values obtained before ageing when tested according to **4** of IS:443-1963*. For carrying out these tests, the manufacturers shall supply the requisite test slabs, if required by the purchaser.

3.4.3 *Swelling Test* — The increase in volume of the lining after immersion in a mixture of equal volumes of commercial grade of castor oil and purified diacetone alcohol at 70 ± 1°C for 72 hours, shall not exceed by 12 percent of the original volume when tested according to **13** of IS:443-1963*. The increase in the case of the cover of the hose after immersion in the above test liquid shall not exceed by 100 percent.

3.5 Tests on Assembled Hose

3.5.1 Exposed steel end connections of the hose assembly shall be plated with zinc, tin or cadmium for protection against rust or corrosion.

3.5.2 *Constriction Test* — The constriction of the hose assemblies shall be measured with gauge plug as given in Appendix A. The time required for the gauge plug to drop its own weight a distance of 75 mm into the hose assembly shall not exceed 5 seconds.

*Methods of sampling and test for rubber hoses (*revised*).

3.5.3 *Expansion Test* — The maximum volumetric expansion of any of the hose assemblies when subjected to an internal hydraulic pressure of 70 kgf/cm² and 105 kgf/cm² and tested according to the method prescribed in Appendix B, shall not exceed values given in Table 3.

TABLE 3 MAXIMUM VOLUMETRIC EXPANSION OF DIFFERENT FREE LENGTHS UNDER HYDRAULIC PRESSURE

Free Length, mm		Maximum Expansion, ml					
		3·25-mm Bore		4·85-mm Bore		6·40-mm Bore	
Above	Up to	70 kgf/cm²	105 kgf/cm²	70 kgf/cm²	105 kgf/cm²	70 kgf/cm²	105 kgf/cm²
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
—	200	0·48	0·60	0·59	0·71	0·71	0·89
200	225	0·51	0·60	0·66	0·79	0·79	0·99
225	250	0·56	0·67	0·73	0·79	0·87	1·09
250	275	0·61	0·73	0·80	0·95	0·95	1·20
275	300	0·66	0·79	0·86	1·02	1·04	1·30
300	325	0·72	0·85	0·93	1·10	1·12	1·40
325	350	0·77	0·91	1·00	1·18	1·20	1·50
350	375	0·82	0·97	1·07	1·26	1·28	1·60
375	400	0·87	1·04	1·13	1·34	1·36	1·70
400	425	0·92	1·10	1·20	1·42	1·45	1·80
425	450	0·98	1·16	1·27	1·50	1·53	1·91
450	475	1·03	1·22	1·34	1·58	1·61	2·01
475	500	1·08	1·29	1·40	1·65	1·69	2·11

3.5.4 *Bursting Strength* — When tested under hydraulic pressure in accordance with method given in Appendix C, each sample of hose and hose assembly shall withstand the specified pressure given in Table 4 for 2 minutes. The pressure shall then be increased at the rate of 1 750 ± 700 kgf/cm² per minute until burst occurs. The minimum bursting pressure shall also be as given in Table 4.

TABLE 4 MINIMUM BURSTING STRENGTH

(*Clauses* 3.5.4 *and* C-2.1)

Bore Size	Retention Pressure	Bursting Pressure, *Min*
(1)	(2)	(3)
mm	kgf/cm²	kgf/cm²
3·25	280	350
4·85	210	315
6·40	210	315

3.5.5 *Whip Test* — The minimum life of any one of the sample hose assemblies when tested in accordance with Appendix D with free length ranging from 200 to 500 mm for 3·25 mm bore and 200 to 400 mm for 4·85 mm and 6·40 mm bore hoses, run continuously on the flexing machine, shall be 35 hours.

3.5.6 *Tensile Test* — The hose assembly is fixed in the testing machine and pulled at a speed of approximately 25 mm/min. All hose assemblies so tested shall withstand a pull of 150 kg without the end fittings pulling off or rupture of the hose. Any tensile testing machine capable of recording up to 500 kg of tension may be used.

3.5.7 *Water Absorption Test* — Remove 12·5 to 16 mm of cover from either side of the centre (total 25 to 32 mm) of the assembled and coupled hose so that the outer braid is exposed. Care must be taken during removal of the cover so that the outer yarn is not injured, nor shall the hose be elongated during the removal. The assembly with the portion of cover removed shall be immersed in water at room temperature for a period of 70 to 72 hours. Carry out expansion, burst and tensile test on this hose within 10 minutes of removal from the water and whip test immediately after that. The hose shall pass all these tests as mentioned earlier.

3.5.8 *Cold Test* — The hose assembly shall be conditioned in a cold box in straight position at — 40°C for 72 hours. After conditioning and without removal from the cold box, the hose shall be bent around a mandrel of diameter 75 mm for 3·25 mm bore size, and 87·5 mm for 4·85 mm and 6·40 mm bore sizes. The hose shall not crack or break.

3.5.9 *Salt Spray Test* — The hose assembly and end connections shall be capable of withstanding 24 hours of exposure to salt spray without evidence of rust or corrosion when tested in accordance with Appendix E.

3.5.10 *Pressure Test* — Before despatch by the supplier, each complete hose assembly shall be given a pressure test using air or water as the medium. The test pressure shall be 105 kgf/cm² for air and 210 kgf/cm² for water. The pressure shall be held for not less than 10 seconds nor more than 25 seconds. Hose assembly showing leaks under this test shall be rejected and destroyed.

NOTE — Special care shall be taken if air is used, as under the pressure specified, air is explosive in case a failure occurs in the hose or hose assembly.

4. PACKING AND MARKING

4.1 Packing — Packing of the hoses shall be done as agreed to between the purchaser and the supplier.

4.2 Marking — Each length of the hose shall be marked with the manufacturer's name or recognized trade-mark; hose denomination and, if required by the purchaser, with the month and year of manufacture.

4.2.1 Each length may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

5. SAMPLING

5.1 Scale of Sampling

5.1.1 *Lot* — In any consignment, all the lengths of assembled brake hose of the same type, size and diameter, having the same number of plies, produced under essentially similar conditions of manufacture (such as those from single batch of raw materials or from components obtained from a single source or from a single production method or undergoing a single curing process) shall be separated into groups and each such group shall constitute a lot.

5.1.2 Tests for the determination of the conformity of a lot to the requirements of this specification on assembled brake hoses shall be carried out for each lot separately. The number of lengths of assembled hoses to be selected for this purpose shall be in accordance with col 1 and 2 of Table 5.

5.1.3 The required number of lengths of assembled hoses shall be selected at random from the lot. For this purpose, a suitable number of bundles in the lot, shall be chosen first and from each of the bundles so chosen not more than 5 lengths shall be taken out at random so as to obtain the desired numbers indicated in col 2 of Table 5.

TABLE 5 SCALE OF SAMPLING

(*Clauses* 5.1.2, 5.1.3 *and* 5.2.1.1)

LOT SIZE (IN LENGTHS)	SAMPLE SIZE (IN LENGTHS)	PERMISSIBLE NUMBER OF DEFECTIVE LENGTHS
(1)	(2)	(3)
Up to 1 000	25	1
1 001 to 1 500	35	1
1 501 and above	50	2

5.2 Tests for Characteristics Requiring Non-destructive Testing

5.2.1 The lengths of hoses selected according to **5.1.3** shall be inspected visually for defects like air blisters, porosity and other surface defects and for constructional details like number of reinforcement plies. The lengths shall also be subjected to constriction measurement (*see* **3.5.2**) and dimensional measurement of internal diameter, external diameter and length which does not require cutting up of hoses. Any length found to be unsatisfactory with regard to one or more of these characteristics shall be considered as a defective length.

5.2.1.1 If the number of defective lengths found is not greater than the corresponding number of defectives given in col 3 of Table 5, the lot shall be declared as conforming to the requirements of these characteristics. Only such lots shall be further examined for characteristics requiring destructive testing as given in **5.3**.

5.3 Tests for Characteristics Requiring Destructive Testing

5.3.1 *Burst Test, Whip Test and Tensile Test* — From each of the lots which are found to be satisfactory according to **5.2.1.1**, one length of assembled brake hose for each lot containing 1 500 lengths or less and two lengths of assembled brake hoses for each lot containing more than 1500 lengths, shall be chosen at random from those already selected (*see* **5.1.3**) for carrying out each of these tests.

5.3.1.1 The lot shall be declared as conforming to the requirements of the specification if the test results for the determination of different characteristics are all found satisfactory. In case test results for any characteristic fail to meet the relevant requirement of the specification, two more tests for each lot containing 1 500 lengths or less and four more tests for each lot containing more than 1 500 lengths, shall be conducted for that characteristic and only on finding all these tests satisfactory, the lot shall be considered as conforming to the requirements of that characteristic; otherwise not.

5.3.2 *Cold Test and Salt Spray Test* — One length of assembled brake hose shall be selected at random from lots already selected (*see* **5.1.3**) and found satisfactory (*see* **5.2.1.1**) for carrying out either of the tests.

5.3.2.1 The lot shall be declared as conforming to the requirements of the specification if both test results are found satisfactory. In case the test results for either of the characteristics fail to meet the relevant requirements of the specification, two more tests shall be conducted for that characteristic on two different lengths of hoses chosen from the lot and only on finding these two tests satisfactory, the lot shall be considered as conforming to the requirements of that characteristic; otherwise not.

5.3.3 *Accelerated Ageing Test, Swelling Test and Tests for Determining Tensile Strength and Elongation at Break* — If it is not possible to carry out any of these tests from the hose, the preparation of a suitable test specimen according to **4**, **7** and **13** of IS:443-1963* may be permitted for the purpose.

APPENDIX A

(*Clause* 3.5.2)

METHOD FOR CONSTRICTION TEST

A-1. PROCEDURE

A-1.1 Constriction of bore of the hose ends before swaging shall be measured with a gauge plug as shown in Fig. 1. The mass of the gauge plug shall be 57 ± 3 g.

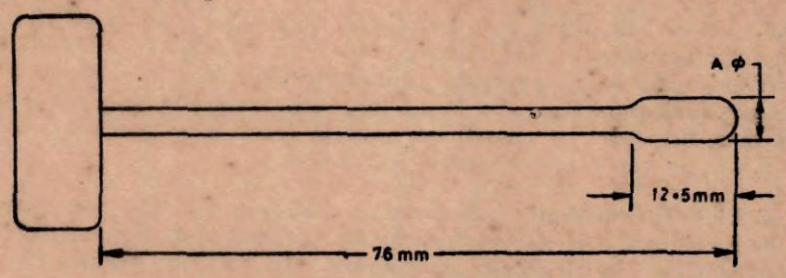

FIG. 1 GAUGE PLUG FOR TESTING CONSTRICTION OF BORE OF HOSE

A-1.2 The hose ends shall be held in a vertical position and the *A* dia portion inserted into the threaded end. The gauge shall be permitted to drop of its own weight at a distance of 75 mm through the hose end. The time required to drop 75 mm shall not exceed 5 seconds. The diameter of the plug at *A* for various bore sizes shall be as follows:

Bore Size	*Diameter of Plug*
mm	mm
3·25	2·03
4·85	3·05
6·40	4·20

*Methods of sampling and test for rubber hoses (*revised*).

APPENDIX B
(*Clauses* 3.5.3 *and* C-1.1)

METHOD FOR EXPANSION TEST

B-0. GENERAL

B-0.1 This expansion test is designed to measure, by fluid displacement, the volumetric expansion of the free length of assembled hydraulic brake hose when subjected to specified internal pressures.

B-1. APPARATUS

B-1.1 The test apparatus shall consist essentially of a suitable source for required fluid pressures, pressure gauges, piping, valves, fittings in which the hose assembly may be mounted in a vertical position for application of pressure under controlled conditions, and a graduated burette for measuring the volume of liquid corresponding to the expansion of the hose under pressure. All piping and connections shall be smooth bore without recesses or offsets, so that all air may be freely removed from the system before running each test. The valves shall be of such design as to open and close with minimum displacement of liquid. The apparatus shall be capable of applying the pressure at a rate of increase of 1 750 ± 700 kgf/cm² per minute. A suitable apparatus is illustrated in Fig. 2.

B-1.2 Calibration of Apparatus — The apparatus shall be tested prior to use to determine its calibration correction factor. For this purpose, 6·35 mm diameter soft seamless steel tubing or its equivalent shall be used in place of the hose assembly. Calibration correction factors shall be established at pressures of 105 kgf/cm² and these shall be substracted from the expansion readings obtained on the test specimen. The maximum permissible calibration correction factor shall be 0·08 ml at 105 kgf/cm².

B-2. PROCEDURE

B-2.1 Carefully thread the test specimen into position on the apparatus in such a way as to provide a leakproof seal, taking care to avoid twisting and to maintain the hose in a vertical position without tension while under pressure. Fill the tank *C* with distilled water, taking care that it is free of air or dissolved gases. Open valve *B* and turn crank *D* to the left to allow the maximum amount of water to flow into the master cylinder. Next open valves *E*, *F*, and *G*, allowing the water to run from tank *C* through burette *K* until no air bubbles are seen in the burette. Removal of air bubbles may be facilitated by moving the hose back and forth. Close valves *B* and *F* and raise the pressure in the hose to 105 kgf/cm² for not more than 10 seconds. After inspecting for leaks at the connections, release the pressure in the hose completely by opening valve. Close this valve before proceeding with the next step. Adjust the water level

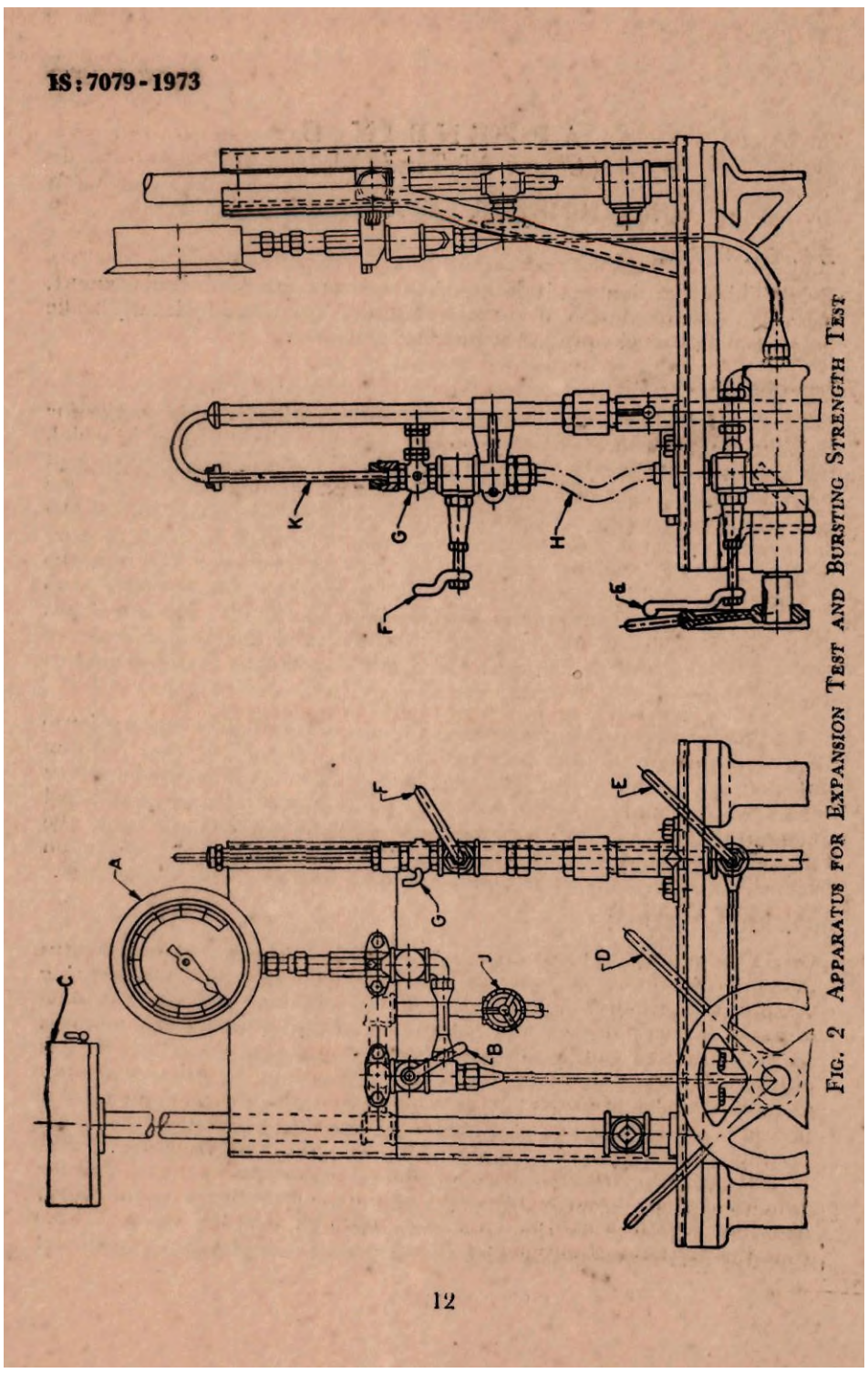

FIG. 2 APPARATUS FOR EXPANSION TEST AND BURSTING STRENGTH TEST

in burette *K* to zero by means of valve *G*. Turn crank *D* to the right until gauge *A* shows a pressure of 70 kgf/cm². Seal this pressure in the hose by closing valve *E*, after which measure the expansion immediately by opening value *F* and allowing the water in the expanded hose to rise in the burette. As soon as the liquid level is constant, close valve *F* and take the reading on burette *K*. Repeat this operation so that the final reading taken on burette *K* will be the total of three expansions. Consider one-third this reading minus the calibration factor, as the final volumetric expansion of the hose at 70 kgf/cm². Readjust the water level in the burette to zero as above and repeat the procedure to obtain the expansion at a pressure of 105 kgf/cm². If the pressure in the hose should inadvertently be raised just prior to the expansion reading to a value above that specified, do not take a reading, but instead completely release the pressure and repeat the procedure.

APPENDIX C

(*Clause* 3.5.4)

METHOD FOR BURSTING STRENGTH TEST

C-0. GENERAL

C-0.1 This bursting strength test consists of subjecting the specimen of hydraulic brake hose to the action of internal hydrostatic pressure under specified condition.

C-1. APPARATUS

C-1.1 The apparatus shall consist of a suitable pressure system in which the hose is so connected that controlled and measured fluid pressure may be applied internally. The pressure shall be obtained by means of a hand or power driven pump or an accumulator system and shall be measured with a calibrated gauge. Provision shall be made for filling the hose with distilled water and allowing all air to escape through a relief valve prior to application of pressure. This is important as a safety measure. The pressures shall be applied at a rate of increase of 1 750 ± 700 kgf/cm² per minute. Since the type of hose withstands a minimum bursting pressure of 350 kgf/cm², care shall be taken that all piping, valves, and fittings are sufficiently rugged and adapted to high-pressure work. The apparatus described for the expansion test (*see* Appendix B) may be used when conforms to these requirements.

C-2. PROCEDURE

C-2.1 Connect the specimen to the pressure system and fill completely with water allowing all air to escape. Removal of air bubbles may be facilitated by moving the hose back and forth. Close the relief valve and apply the pressure at the rate specified in **C-1.1** until it reaches the retention pressure prescribed in Table 4. Hold this pressure for 2 minutes. At the expiration of this 'hold' period, increase the pressure until the specimen bursts. Consider the maximum pressure noted on the calibrated gauge as the bursting strength of the specimen.

APPENDIX D

(Clause 3.5.5)

METHOD FOR WHIP TEST

D-0. GENERAL

D-0.1 The whip test is designed to measure the fatigue life of the brake hose assembly. The flexing motion imparted by the test apparatus, while different from that to which the assembly is subjected in service, provides a highly accelerated method of measuring the resistance of a hose to dynamic fatigue.

D-1. APPARATUS

D-1.1 The essential features of the apparatus are a movable header consisting of a horizontal bar mounted at each end on vertically rotating disk through ball bearings with centres placed 10 cm from the disk centres, and an adjustable stationary header parallel to the movable header in the same horizontal plane as the centres of the disks. The headers are each provided with four standard end connections equally spaced, approximately 9 cm on centres in which the hose assemblies are mounted in parallel. The disks are revolved at a speed of 800 ± 10 rpm, whereby the hose ends fastened to the moving header are rotated at this speed through a circle 20 cm in diameter while the opposite hose ends remain stationary. The end connections on the movable header are tightly capped, while those on the stationary header are open to a manifold through which water pressure is supplied by means of a weight operated plunger in a pressure cylinder. The hose assemblies are thereby subjected during test to a constant water pressure which shall be maintained between 16 kgf/cm² and 17·5 kgf/cm² as shown by a gauge installed so as to read pressure in the manifold. A limit switch operated by the plunger weight shall be used to stop the machine when the water pressure drops, as in the case of failure of the hose, since it is essential that the machine stops if the pressure drops or a specimen fails. A suitable revolution counter and elapsed time indicator shall be provided.

D-1.2 Alternatively, machine capable of testing one hose at a time may also be used provided other conditions of test are maintained.

D-2. PROCEDURE

D-2.1 Equip the non-rotating header to permit attachment of each hose assembly with individual adjustment for length. When mounted in the whip test machine, the projected length of the hose assembly shall be less than the straight length by the amount indicated as slack in Table 6. Determine, the fatigue life on specimens 200 to 600 mm for 3·25 mm hose and 200 to 400 mm for 4·85 and 6·40 mm hose made from the same lot of hose. Since the whip test results are very sensitive to errors in setting this length, take measurements carefully. The reduction from straight length to projected length on the machine shall be within the limits specified. Take the projected length parallel to the axis of the rotating head. Install the test specimen assemblies in the apparatus in their natural 'lay', that is, without any twist. Apply the water pressure and bleed all hose and passages to eliminate air pockets or bubbles. Start the meter rotating the movable head and note the duration of the test. Failure of the specimen by water leakage through a rupture, and consequent loss of pressure terminates the test. When a minimum time requirement is specified, run the machine continuously during this period.

TABLE 6 HOSE LENGTHS

Straight Length (Free Length Between Fittings)	Slack in mm	
	3·25 mm Hose	4·85 mm and 6·40 mm Hoses
(1)	(2)	(3)
Above 200 up to 400	44·45 ± 0·04	2·54 ± 0·04
,, 400 ,, 480	31·75 ± 0·04	—
,, 480 ,, 600	19·06 ± 0·04	—

APPENDIX E

(*Clause* 3.5.9)

METHOD FOR SALT SPRAY TEST

E-1. APPARATUS

E-1.1 The apparatus required for salt spray testing consists of a fog chamber, a salt solution reservoir, a supply of suitably conditioned compressed air, one or more atomizing nozzles, specimen supports, provision for heating the chamber, and necessary means of control. The size and detailed construction of the apparatus are optional provided the conditions obtained meet the requirement of this method.

E-1.2 Drops of solution which accumulate on the ceiling or cover of the chamber shall not be permitted to fall on the specimens under testing.

E-1.3 Drops of solution which fall from the specimens shall not be returned to the solution reservoir for respraying.

E-1.4 Material of construction shall be such that it does not affect the corrosiveness of the fog.

E-2. PREPARATION AND POSITIONING OF TEST SPECIMENS

E-2.1 Metallic and metal-coated fittings shall be suitably cleaned. The cleaning method shall be optional depending on the nature of the surface and the contaminants, except that it shall not include the use of abrasives other than paste of pure magnesium oxide nor of solvents which are corrosive or will deposit corrosive or protective films. The use of a nitric acid solution for the chemical cleaning, or passivation, of stainless steel specimens is permissible when agreed upon by the buyer and the seller. Care shall be taken that specimens are not recontaminated after cleaning by excessive or careless handling.

E-2.2 The position of the hose assembly in the salt spray chamber during the test shall be such that the conditions given in **E-2.2.1** to **E-2.2.4** are met.

E-2.2.1 Unless otherwise specified, the hose assembly shall be supported or suspended between 15° and 30° from the vertical, preferably parallel to the principal direction of horizontal flow of fog through the chamber, depending upon the dominant surface being tested.

E-2.2.2 The hose assemblies shall not touch each other or any metallic material or any material capable of acting as a wick.

E-2.2.3 Each specimen shall be so placed as to permit free settling of fog on all specimens.

E-2.2.4 Salt solution from one specimen shall not drip on any other specimen.

NOTE — Suitable materials for the construction or coating of racks and supports are glass, rubber, plastic, or suitably coated wood. Bare metal shall not be used. Specimens shall preferably be supported from the bottom or the side. Slotted wooden strips are suitable for the support of flat panels. Suspension from glass hooks or waxed string may be used as long as the specified position of the specimens is obtained, if necessary by means of secondary support at the bottom of the specimens.

E-3. SALT SOLUTION

E-3.1 The salt solution shall be prepared by dissolving 5 parts by mass of salt in 95 parts of distilled water or water containing not more than 200 ppm of total solids. The salt used shall be sodium chloride substantially free of nickel and copper and containing on the dry basis not

more than 0·1 percent of sodium iodide and not more than 0·3 percent of total impurities. The *p*H of the salt solution shall be such that when atomized at 35°C, the collected solution shall be in the *p*H range of 6·5 to 7·2 (*see* Note 1). Before the solution is atomized, it shall be free of suspended solids (*see* Note 2). The *p*H measurement shall be made electrometrically at 27°C using a glass electrode with a saturated potassium chloride bridge; or colorimetrically using bromothymol blue as indicator (*see* Note 3).

NOTE 1 — Temperature affects the *p*H of a salt solution prepared from water saturated with carbon dioxide at room temperature and *p*H adjustment may be made by any one of the following three methods:

i) When the *p*H of a salt solution is adjusted at room temperature, and atomized at 35°C, the *p*H of the collected solution will be higher than the original solution due to the loss of carbon dioxide at the higher temperature. When the *p*H of the salt solution is adjusted at room temperature, it is necessary to adjust it below 6·5 so that the collected solution after atomizing at 35°C will meet the *p*H limits of 6·5 to 7·2. Take about a 50 ml sample of the salt solution as prepared at room temperature, boil gently for 30 seconds, cool and determine the *p*H. When the *p*H of the salt solution is adjusted to 6·5 to 7·2 by this procedure, the *p*H of the atomized and collected solution at 35°C will come within this range.

ii) Heating the salt solution to boiling and cooling to 35°C or maintaining it at 35°C for approximately 48 hours before adjusting the *p*H produces a solution, the *p*H of which does not materially change when atomized at 35°C.

iii) Heating the water from which the salt solution is prepared to 35°C or above, to expel carbon dioxide, and adjusting the *p*H of the salt solution within the limits of 6·5 to 7·2 produces a solution the *p*H of which does not materially change when atomized at 35°C.

NOTE 2 — The freshly prepared salt solution may be filtered or decanted before it is placed in the reservoir, or the end of the tube leading from the solution to the atomizer may be covered with a double layer of cheese cloth to prevent plugging of the nozzle.

NOTE 3 — The *p*H can be adjusted by additions of dilute hydrochloric acid or sodium hydroxide solutions.

E-4. AIR SUPPLY

E-4.1 The compressed air supply to the nozzle or nozzles for atomizing the salt solution shall be free of oil and dirt (*see* Note 1) and maintained between 0·7 and 1·75 kgf/cm² (*see* Note 2).

NOTE 1 — The air supply may be freed from oil and dirt by passing it through a water scrubber or at least 60 cm of suitable cleaning material, such as asbestos, sheep's wool, excelsior, slag wool, or activated alumina.

NOTE 2 — Atomizing nozzles may have a critical pressure at which an abnormal increase in the corrosiveness of the salt fog occurs. If the critical pressure of a nozzle has not been established with certainty, control of fluctuation in the air pressure within ± 0·007 kgf/cm², by installation of a suitable pressure regulator valve, minimizes the possibility that the nozzle will be operated at its critical pressure.

E-5. CONDITIONS IN THE SALT SPRAY CHAMBER

E-5.1 Temperature — The exposure to zone of the salt spray chamber shall be maintained at $35 \pm \frac{1}{1{\cdot}5}$ °C. The temperature within the exposure zone of the closed cabinet shall be recorded at least twice a day at least 7 hours apart.

NOTE — A suitable method to record the temperature is by a continuous recording device or by a thermometer which can be read from outside the closed cabinet. The recorded temperature must be obtained with the salt spray chamber closed to avoid a false low reading because of wet bulb effect when the chamber is open.

E-5.2 Atomization and Quantity of Fog — At least two clean fog collectors shall be so placed within the exposure zone that no drops of solution from the test specimens or any other source shall be collected. The collectors shall be placed in the proximity of the test specimens, one nearest to any nozzle and the other farthest from all nozzles. The fog shall be such that for each 80 cm² of horizontal collecting area there will be collected in each collector from 1·0 to 2·0 ml of solution per hour based on an average run of at least 16 hours (*see* Note 1). The sodium chloride concentration of the collected solution shall be 5 ± 1 percent by mass (*see* Note 2). The *p*H of the collected solution shall be 6·5 to 7·2. The *p*H measurement shall be made electrometrically or colorimetrically using bromothymol blue as the indicator.

NOTE 1 — Suitable collecting devices are glass funnels with the stems inserted through stoppers into graduated cylinders, or crystallizing dishes. Funnels and dishes with a diameter of 10 cm have an area of about 80 cm².

NOTE 2 — A solution having a specific gravity of 1·025 5 to 1·040 0 at 27°C will meet the concentration requirement. The concentration may also be determined as follows:

Dilute 5 ml of the collected solution to 100 ml with distilled water and mix thoroughly; put a 10 ml aliquot into an evaporating dish; add 40 ml of distilled water and 1 ml of 1 percent potassium chromate (chloride free) and titrate with 0·1 N silver nitrate to the first appearance of a permanent red colouration. A solution, which requires between 3·4 and 5·1 ml of 0·1 N silver nitrate will meet the concentration requirements.

E-5.3 The nozzle or nozzles shall be so directed or baffled that none of the spray can impinge directly on the test specimens.

E-6. CLEANING OF TESTED SPECIMENS

E-6.1 After carefully removing the specimens at the end of the test, these shall be treated as follows:

Specimens may be gently washed or dipped in clean running water not warmer than 40°C to remove salt deposits from their surface, and then immediately dried. If required, corrosion products may be removed by light brushing to observe any corrosion of the underlying metal substratum.