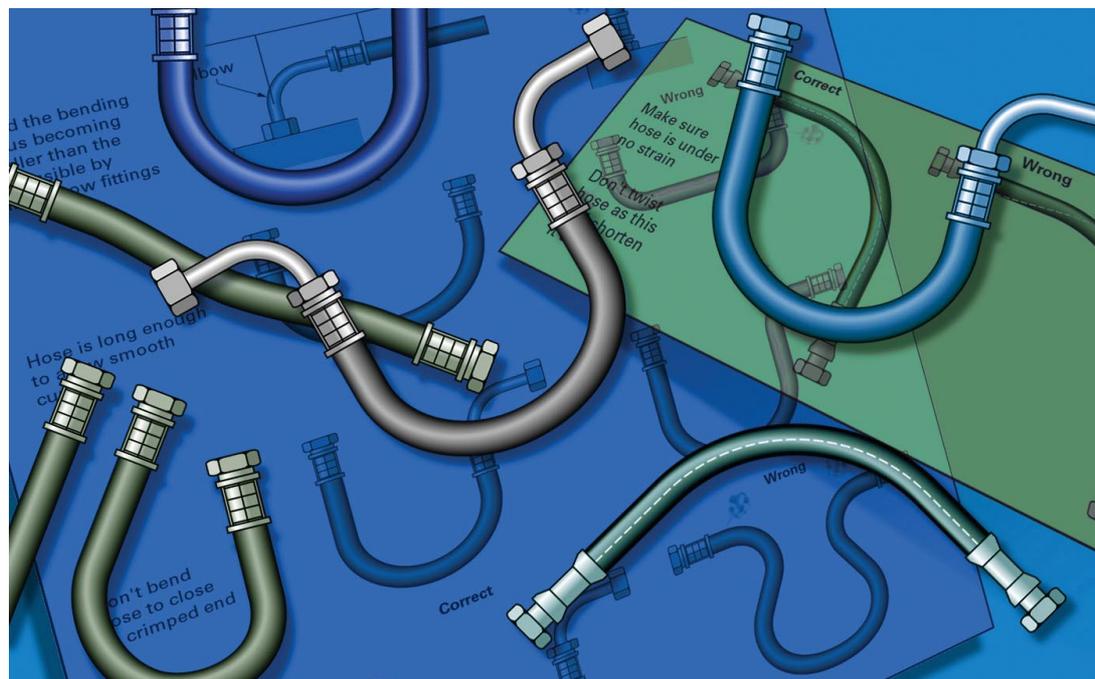


Flexible Hoses Standard



A Standard for manufacturers

Edited by Reginald Brown

Supported by



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This Flexible Hoses Standard has been prepared by BSRIA on behalf of the Hose Manufacturers and Suppliers Association (HMSA).

Reginald Brown contributed from BSRIA.

The author has sought to incorporate the views of the steering group, but final editorial control of this document rested with BSRIA.

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This Standard applies to hose assemblies up to 25 mm nominal bore, incorporating rubber, plastic or flexible metallic hose for the connection of closed-circuit heating and cooling equipment using water-based fluids.

Minimum operating requirements for the hose are:

- Pressures in the range 0 to 10 bar
- temperatures in the range -10°C to $+85^{\circ}\text{C}$ continuous (110°C peak).

The hose assemblies complying with this Standard are expected to have a minimum service life of 10 y in typical building services applications, provided that they are installed in the correct manner.

This Standard does not apply to hoses used for domestic hot and cold water services, nor to in-line pipework elements specifically designed for vibration isolation or for taking up thermal expansion.

2.1 HOSE ASSEMBLIES

A hose assembly shall consist of the hose and end fittings that connect directly to adjoining pipework or fittings.

All hose assemblies with screwed fittings shall be constructed with at least one fitting that allows free rotation during installation unless otherwise specified by the client.

An additional external cover may be applied for thermal insulation, abrasion resistance or UV protection against ultra-violet light.

2.2 HOSE SPECIFICATION

Rubber or plastic hose shall be reinforced with external stainless steel braid. This braid shall extend to the full length of the hose within the ferrule.

Stainless steel hose (braided or unbraided) shall be manufactured from suitable austenitic stainless steels such as 304L, 321 or 316L (*ISO 9328.5* types X2CrNi1810, X6CrNiTi1810, X2CrNiMo1712 respectively) according to *ISO 10380*.

2.3 FERRULES

End fittings of braided rubber or plastic hoses shall be permanently fixed to the hose with a swaged ferrule of austenitic stainless steel overlying the barbed hose-tail of the fitting.

2.4 END FITTINGS

End fittings may be male or female threaded, have push-fit connection, quick release couplings or be plain tube as specified by the customer. Cone seals are preferred to flat face-seals for parallel threaded fittings.

End fittings for rubber and plastics hoses shall be manufactured from a suitable corrosion-resistant material such as brass, plated brass or stainless steel.

The end fittings for stainless steel hoses may be manufactured from appropriate grades of non-stainless steel provided that the minimum thickness of material is sufficient to ensure long term reliability.

Stainless steel hose shall be welded or brazed to the end fittings.

3.1 HOSE DIAMETER AND WALL THICKNESS

Hoses should be classified according to the inside diameter. The client will specify the hose with this dimension and the supplier will provide information in the catalogue data about any diameter changes caused by the fittings. The minimum wall thickness of the hose shall be suitable for the application.

To aid the consistency of data presentation in manufacturers’ literature, Table 1 presents imperial and metric nominal bore together with the corresponding minimum internal diameter agreed by the Hose Manufacturers and Suppliers Association.

Table 1: Comparing imperial and metric bore.

Nominal bore		Minimum inside diameter
Inch	mm	mm
5/16	8	7.5
3/8	10	9.5
1/2	13	12.5
5/8	15	15
3/4	20	19
1	25	25

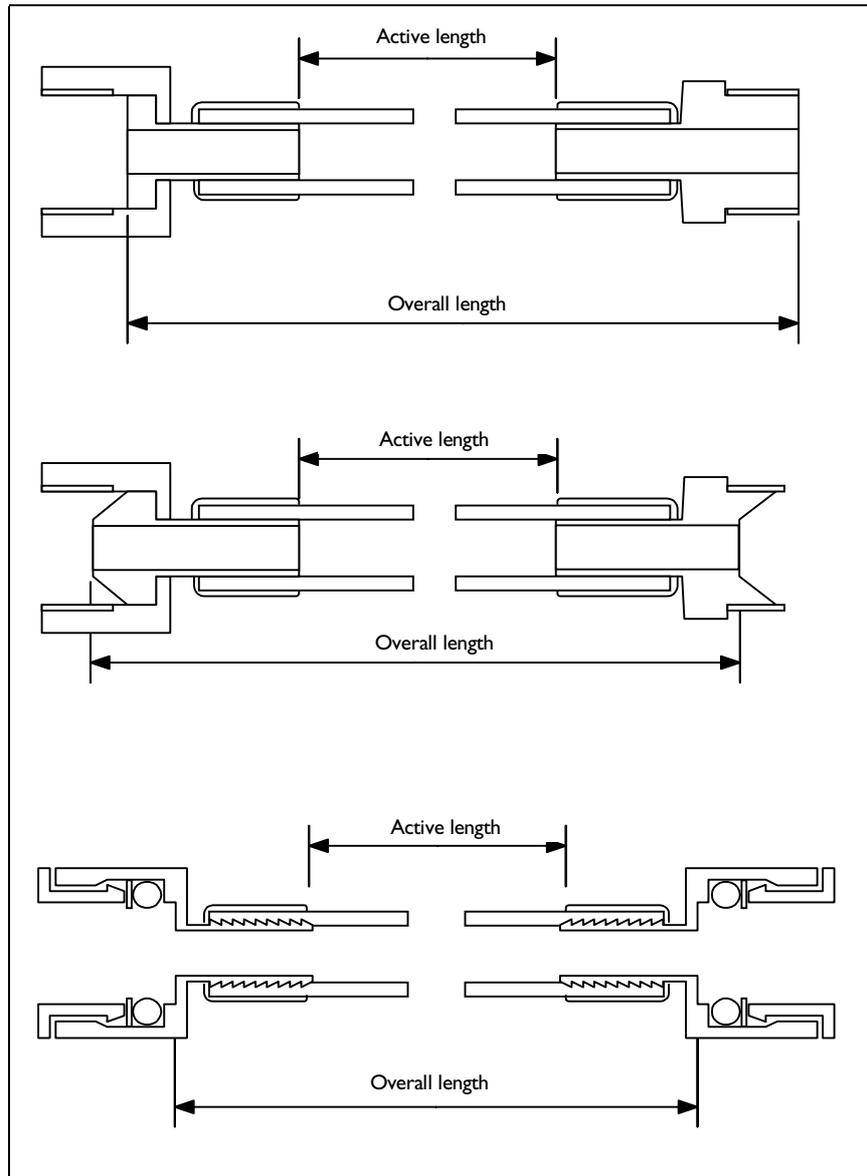
Length

The overall length of hoses shall be specified by the client. The allowable tolerances are:

- Up to 400 mm length: +10 mm, –0 mm
- Over 400 mm length: +20 mm, –0 mm

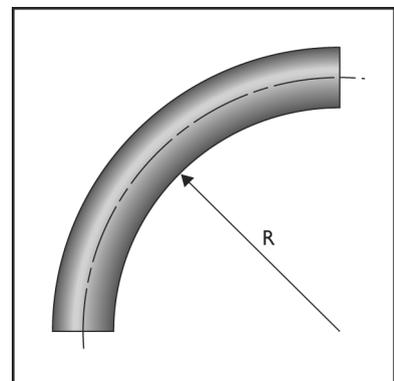
Catalogue data shall quote both the overall length between sealing faces (or equivalent) and the active length of the hose.

The active length of the hose is defined as the minimum length between the ferrules. Note that hose tail and ferrule may not end at the same point (hose tails tend to be longer). Some examples of active and overall lengths of a hose assembly are shown in Figure 1.

Figure 1: Hose assembly length measurement.

3.2 MINIMUM BEND RADIUS

The values of minimum bend radius (as defined in Figure 2) meeting the requirements of Section 4.4, vary according to the diameter and construction of the hose. The supplier shall declare the minimum bend radius in product information.

**Figure 2:** Bend radius.

The following sections describe the minimum performance requirements of a hose and hose assembly complying with this Standard and the tests to be carried out to verify the performance requirements are met.

All tests, except manufacturing proof pressure-tests, shall be carried out on a hose assembly with end fittings which are capable of sustaining a working pressure of 10 bar at 125°C.

4.1 PRESSURE AND TEMPERATURE RATING

The hose shall comply with the following minimum pressure requirements:

- Continuous rating: 10 bar at 85°C
- Short term high temperature rating: 10 bar at 110°C
- Proof pressure: 20 bar at 20°C ±5°C
- Tested burst pressure: 40 bar at 85°C -0°+2°C

Short term is defined as occasional operating conditions outside the continuous rating of the hose assembly.

The pressure rating of certain end fittings used with flexible hoses (including brass compression fittings to *BS EN 1057:1996*) may be less than 10 bar at 110°C. The declared working pressure of the hose assembly shall be the lowest pressure rating of any component of the assembly.

4.2 PRESSURE TESTING

Proof pressure

Proof pressure-testing shall be carried out for each batch of assemblies and with sufficient samples to comply with the quality assurance scheme operated by the manufacturer or supplier.

Note that proof testing may also be required to comply with client specifications.

Proof testing of hose assemblies shall be carried out at twice the declared maximum working pressure of the hose assembly at an ambient temperature (20°C ± 5°C).

There should be no visible leakage from any part of the hose assembly when held at proof test conditions for five minutes. The permanent change of length caused by proof testing shall be the than 4% of the active length, or 5 mm (whichever is least).

Burst pressure

The burst pressure of the hose shall exceed 40 bar at 85°C -0°+2°C. Burst pressure is attained when there is rupture of the hose or leakage from the end fitting.

4.3 PRESSURE LOSS

Where the flow coefficient (K_v) of the hose assembly is quoted in product literature, it shall be calculated from measurements of the pressure drop across the straight assembly at different flow rates, say 25%, 50%, 75% and 100% of the nominal flow rate (this corresponds to a fluid velocity of 1 ms^{-1}) according to the following equation:

$$K_v = \frac{Q}{\sqrt{(\Delta P_v)}}$$

Note that by undertaking the pressure loss test on several hoses of different length, it will be possible to extrapolate results to any length of hose and also to estimate the pressure loss of the end fittings.

4.4 MINIMUM BEND RADIUS

When bent to the minimum radius (measured in the inside of the bend, as shown in Figure 2), the internal diameter of the un-pressurised hose shall not reduce by more than 10%. This shall be confirmed by the free passage of a ball-bearing of diameter equal to $90\% \pm 1\%$ of the nominal internal diameter of the hose.

4.5 ACCELERATED AGEING

For the purpose of the mechanical tests described in the following sections, hose assemblies with rubber and plastic tubes shall be aged for 3000 h in a closed circuit of flowing clean water (without chemical additives) at 125°C . Note that this test shall be undertaken at 10 bar. There shall be no leakage during the test.

Ageing test

- The acceptable tolerance on the 10 bar pressure is +0 bar, -0.5 bar.
- The acceptable tolerance on the temperature of 125°C is $+0^\circ\text{C}$, -5°C .
- Water flow should be in the lower range of 0.7 to 3 m/s.
- The 3000 h should ideally be continuous. Unavoidable breaks up to 48 h are acceptable provided the total run-time of the test is 3000 h.

Note that this test represents 10 years of service with a 50% duty cycle.

4.6 FATIGUE TEST

Rubber and plastic hose assemblies shall be subjected to a mechanical fatigue and pressure test after a period of accelerated ageing as described in Section 4.5. Hoses shall be bent 10 times to the declared minimum bend radius (rotating 180° after each bend) then pressure tested. There shall be no visible leakage from any part of the hose assembly when held at 20 bar for five minutes.

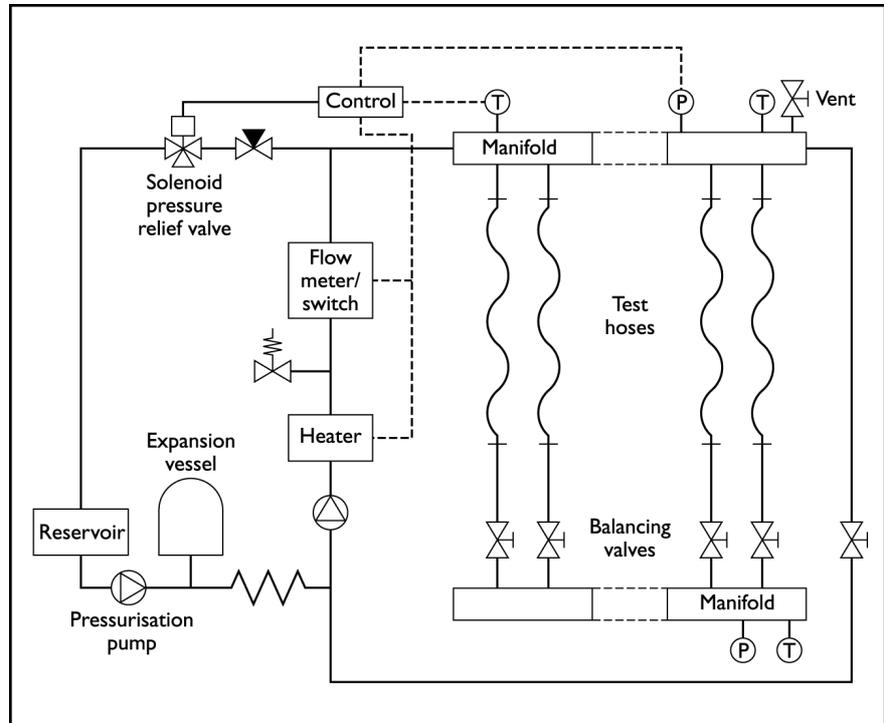
Metal hoses shall also be subjected to this fatigue test but they do not require a preliminary ageing process.

4.7 TEST RIG PREPARATION

Design

The outline design of the test rig is shown in Figure 3.

Figure 3: Test rig schematic.



The test rig should be constructed so that each linear string of hoses is divided into two lengths that are suspended from overhead flow and return manifolds.

The return bend of each string is formed from a 90° bend and a tee, allowing for a thermocouple to be inserted so that the temperature can be measured midway along the string (not shown).

The test rig is constructed from stainless-steel tube, with bronze commissioning valves to control the flow in each string. Circulation is induced by a cast-iron glandless circulating pump.

The water is heated by a specially constructed in-line electric heater and controlled by a digital temperature controller and thyristor switch. Pressure is controlled by a similar digital controller connected to a pressurisation pump and over-pressure relief valve.

Monitoring of temperature and pressure is by thermocouples and electronic pressure transducers connected to a data logger, from which data is periodically downloaded. Periodic readings should also be manually recorded from the digital controllers.

In view of the temperature and pressure conditions the test rig is fitted with various safety features:

- Robust enclosure
- minimum water volume

- safety pressure-relief valve
- door interlock so that the enclosure cannot be accessed when the rig is hot
- manual-only start for the circulation pump
- heating control circuit interlocked with a flow switch and heating safety thermostats.

4.8 CONSTRUCTION

Screwed joints can be used throughout and sealed where possible using a high performance jointing compound. Other joints can be made using use thick PTFE tape (gas tape). Ideally the manifolds should be of welded construction.

A number of key joints should be made using spherical unions so that sections of the rig can be easily removed. This includes the primary connections to the test strings.

Test rig sections should be pressure tested for leakage at 12 bar. A risk assessment and pressure testing is advisable in order for the rig to comply with the *Pressure Systems Safety Regulations 2000*.

To simplify construction, the manifolds can be suspended from a slotted angle frame (bolted to the enclosure) by flexible steel wire and Gripple cables.

The risers should be insulated with pre-formed foil-covered Rockwool sections and the heater section with a foil covered glass-fibre mat. The manifolds and hose strings should not be insulated.

4.9 COMMISSIONING

The test rig should be filled with tap water and commissioned with the hoses in place. This involves checking the operation of the safety provisions and adjusting the flows in each string while cold.

Heat is then applied, and should then be verified that the temperature and pressure control functions are working correctly.

4.10 OPERATING PRACTICE

Test rig

The specified temperature and pressure conditions and tolerances are detailed above.

With PID control, the temperature control function should achieve a flow manifold temperature normally within 0.2°C of the set point (125°C). The high/low pressure control function is generally set lower (9.6 bar) than the maximum pressure to prevent unnecessary operation of the solenoid relief valve which is set to 10 bar .

If the circulation pump body is of cast-iron it may suffer a high rate of corrosion. The accumulation of corrosion debris could lead to bearing failure. This problem can be reduced by means of a sacrificial anode.

Heater electrical connections should be soldered on rather than crimped.

The rig should be designed with vacuum relief to avoid negative pressure conditions developing in the case of unscheduled cooling where there is not a hose failure.

Overall, the 3000 h test should take 125 days if there are no failures or interruptions.

4.11 HOSE LEAKAGE

Steam leakage is noisy but invisible. Although leakage is easy to detect, it is not always possible to pinpoint where it is coming from while the rig is still active. Generally, it is easier to find the leak by allowing the rig to cool and then re-pressurising the pipework to find a liquid leak.

It is possible to detect steam leaks directly using an ultrasonic detector, but this requires suitable safe access ports to the rig enclosure.

If hoses fail, they should be returned to the supplier for investigation. A new hose of the same type should be fitted in the vacant position.

The best method of labelling hoses under test is cardboard luggage tags tied on with string.

Fibre-face seals may need regular replacement throughout the test.

4.12 BENDING AND PRESSURE TEST

Information on the minimum bend radius for the samples provided is essential for this test and before the ageing test is complete.

4.13 SUMMARY

The following table summarises the tests to be carried out in different stages of product development or manufacture. A full set of tests is necessary to comply with the Standard.

Table 2: Summary table of required tests.

Test	Compliance testing	Production testing		
		Batch testing	Quality assurance statistical sampling	Individual items
<i>Minimum bend radius</i>	✓	If there is a change of material		
<i>Proof pressure</i>		✓	✓	As specified by the client
<i>Burst pressure</i>	✓		✓	
<i>Thermal ageing and fatigue</i>	✓	If there is a change of material		

A supplier may claim conformity with the Standard provided that the requirements and tests described in this Standard are undertaken by themselves, or on their behalf by a recognised test organisation.

Manufacturers shall use an approved statistical method for production testing, including estimated confidence limits for dimensional tolerances and proof-pressure performance. Results shall be documented, preferably within the scope of an *ISO 9000* series quality scheme.

6.1 MARKING OF HOSE ASSEMBLIES

Hose assemblies shall be indelibly marked with the year of manufacture and identification of the manufacturer or supplier. This marking may be stamped, etched or engraved on the ferrule or end fitting, or on a permanently affixed identification band.

6.2 INSTALLATION INFORMATION

A simple leaflet illustrating good installation practice shall be enclosed within each box of hose assemblies (at least one leaflet per 100).

6.3 PACKAGING

Hoses shall be adequately protected from damage during shipping and from the ingress of foreign material into the hose.

ACTIVE LENGTH	Free length of hose between ferrules.
BURST	Leakage or rupture of any of the components of the hose assembly under pressure.
CLIENT	Person or organisation obtaining/purchasing the hose assembly from the manufacturer or distributor.
EPDM	Abbreviation for Ethylene Propylene Diene Monomer (a synthetic rubber compound).
FERRULE	A metal cap fixing the tube and the braid together by crimping.
FITTING	End element of a hose assembly. End fittings may be male or female threaded, use push-fit connections, quick release couplings or plain tube.
NOMINAL BORE	Minimum internal diameter of the hose.
OVERALL LENGTH	The distance between the mating faces of the fittings at each end of the hose.
PLASTIC(S)	A wide range of organic substances mostly produced synthetically. These consist of (or contain as an essential ingredient), a substance of high molecular weight. A suitable stage in manufacture, can be moulded, cast or otherwise shaped, employing heat and pressure.
RUBBER	Collective name for a number of elastomers which may be of vegetable or synthetic origin.