Metal hose assemblies —

Part 1: Guidance on the construction and use of corrugated hose assemblies

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Foreword

This Part of BS 6501-1 has been prepared by Technical Committee PSE/12. It supersedes BS 6501-1:1991 which is withdrawn. This edition has been produced to compliment BS EN ISO 10380 and its contents are topics that are not covered by BS EN ISO 10380 but were in the 1991 version of BS 6501-1. BS EN ISO 10380 specifies requirements for the design, manufacture and testing of corrugated metal hose assemblies for general purposes.

This revision of BS 6501-1 gives guidance on the installation and selection of corrugated metal hose assemblies.

A high temperature resistance test for hose assemblies is also included.

BS 6501-2 covers strip-wound hose assemblies.

Corrugated metal hoses assemblies, as part of pipework systems, are used to convey liquids and gases under various pressure and temperature conditions in applications where, because of the need to accept displacement during operation, the use of standard piping materials is precluded. Corrugated hose assemblies may be used also as pipelines for connecting fixed and movable installations during loading/discharge operations.

On account of the materials of its construction, a corrugated hose is electrically conductive and is more suitable for certain duties than a non-metallic hose, particularly where resistance to extremes of temperature, crushing or fire and flame is involved. Corrugated hose assemblies are suitable also for applications involving vacuum or high pressure.

The piping services in which corrugated metal hose assemblies may be used include those for hazardous applications such as high pressure steam, chemicals and gases as well as non-hazardous applications.

Assessed capability. Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.

A British Standard does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 25 and a back cover.

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1 Scope

This part of BS 6501 gives guidance on the installation of corrugated metal hose assemblies and on the selection of the method of construction, the flexibility type and the material used for the hose.

This part of BS 6501 is complementary to BS EN ISO 10380.

NOTE 1 Corrugated hose assemblies generally are not suitable for applications involving axial compression or extension.

NOTE 2 Guidance on the selection and application of metal hose assemblies is given in Annex A and Annex B.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the reference cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN ISO 7369, *Metal hoses and hose assemblies — Vocabulary.*

BS EN ISO 10380:2003, *Corrugated metal hoses and hose assemblies.*

3 Terms and definitions

For the purposes of this part of BS 6501, the terms and definitions given in BS EN ISO 7369 apply.

4 Guidance on the selection of corrugated hose assemblies

4.1 Materials

Due consideration should be given to the selection of suitable materials for the hose, braid if fitted, and the end fittings. Materials for the manufacture of corrugated metal hose assemblies should be selected on the basis of their suitability for fabrication, e.g. cold forming, welding, as appropriate, and according to the conditions under which they will operate.

NOTE 1 Because of the wide variety that exists in such conditions and the choice of materials available, this standard does not make the choice of materials the subject of compliance by specifying a comprehensive list of materials. BS EN ISO 10380:2003, Table 1, however, lists those materials that are preferred.

Table 1 should be used in conjunction with the requirements of BS EN ISO 10380:2003, **4.2**e).

NOTE 2 Further guidance on the selection of materials is given in **A.3.1**.

4.2 Hose construction

Where concerns exist regarding the environment (see BS EN ISO 10380:2003, **4.1**a)) or the product conveyed (see BS EN ISO 10380:2003, **4.2**c)) being a potential source of crevice corrosion, construction type X as given in BS EN ISO 10380:2003, **5.5** should be used.

4.3 Temperature related corrosion resistance

The effect of temperature on the corrosion resistance of the assembly should be considered and reference should be made to BS EN ISO 10380:2003, **4.1**a), **4.1**g) and **4.2**c).

NOTE Further guidance on the effect of temperature on corrosion resistance is given in **A.3.2**.

4.4 Pressure

The effect of pressure variations should be considered.

NOTE Guidance on this topic is given in **A.3.3**.

4.5 Product velocity

High product velocities should be avoided.

NOTE Limits on product velocities and corrective action are given in **A.3.4**.

4.6 High temperature resistance

Hose assemblies with welded end fittings may be subjected to the test described in Annex C. At no time during the test may the sample show any signs of leakage.

NOTE The flame test simulates a 1 000 °C flame.

4.7 Flexibility

The requirements given in BS EN ISO 10380:2003, **4.1**c) should be used as the basis for the selection of the hose flexibility requirement.

NOTE Further details on flexibility are given in **A.2**.

Annex A (informative) Selection and installation of corrugated metal hose assemblies

A.1 General

A.1.1 This annex is provided in order to assist the purchaser in the selection of a hose assembly for a specific application, taking into account pressure, temperature and other considerations and to give guidance on hose installation and handling.

A.1.2 A hose assembly has the following four basic uses:

a) it facilitates movement, e.g. that associated with thermal expansion in piping or with connection to moving components;

b) it facilitates random motion, e.g. that which occurs in plant transfer hose;

c) it facilitates ease of connection between non-moving parts and compensates for misalignment, e.g. in gas meter installations;

d) it greatly reduces the transmission of vibration, e.g. local to pump connections.

A.1.3 The following points should be considered when selecting a hose assembly:

a) the movement required;

b) the cyclic life required;

c) the product to be conveyed by the hose assembly;

d) the design pressure (see BS EN ISO 10380:2003, **5.3.1**);

e) the design temperature range (see BS EN ISO 10380:2003, **5.3.2**);

f) the handling and installation requirements e.g. minimum bend radius and maximum unsupported length;

g) the environmental conditions;

h) any special conditions such as pressure fluctuations due to pump surge, valve opening or closing, high product velocity, etc. (see **A.3.4**).

A.2 Hose assembly types

A.2.1 *General*

Three types of hose flexibility are specified in BS EN ISO 10380:2003. When selecting the cyclic life, it should be borne in mind that the service life of the assembly will be dependent also upon the other parameters listed in **A.1.3**.

A.2.2 *Type 1 hose assemblies*

BS EN ISO 10380 Type 1 hose is a highly flexible hose designed for demanding applications. However, its test requirements are less demanding than those of BS 6501-1:1991, Type C. A comparison between the requirements of BS 6501-1:1991, Type C and those of BS EN ISO 10380:2003, Type 1 is shown in Table A.1. Where a purchaser requires Type C flexibility, the manufacturer should be consulted.

A.2.3 *Type 2 hose assemblies*

BS EN ISO 10380:2003 Type 2 hose is a flexible hose designed for typical applications.

A.2.4 *Type 3 hose assemblies*

BS EN ISO 10380:2003 Type 3 hose is a bendable hose designed for use in static installations in order to overcome problems of misalignment or offset and to facilitate connection.

Type 3 assemblies should be used only for applications where pliability, as opposed to flexibility, is required.

Table A.1 — Comparison between the flexibility requirements of BS 6501-1:1991, Type C and BS EN ISO 10380:2003, Type 1

DN	BS 6501-1, Flexibility Type C		BS EN ISO 10380, Flexibility Type 1	
	Bend radius	Life	Bend radius	Life
4	—	40 000/50 000	100	8 000/10 000
6	100	40 000/50 000	110	8 000/10 000
8	—	40 000/50 000	130	8 000/10 000
10	150	40 000/50 000	150	8 000/10 000
12	200	40 000/50 000	165	8 000/10 000
15	200	40 000/50 000	195	8 000/10 000
20	200	40 000/50 000	225	8 000/10 000
25	200	40 000/50 000	260	8 000/10 000
32	250	40 000/50 000	300	8 000/10 000
40	250	40 000/50 000	340	8 000/10 000
50	350	40 000/50 000	390	8 000/10 000
65	410	40 000/50 000	460	8 000/10 000
80	450	40 000/50 000	660	8 000/10 000
100	560	40 000/50 000	750	8 000/10 000
125	660	40 000/50 000	1 000	8 000/10 000
150	815	40 000/50 000	1 250	8 000/10 000
200	1 015	40 000/50 000	1 600	8 000/10 000
250	1 220	40 000/50 000	2 000	8 000/10 000
300	1 420	40 000/50 000	2 400	8 000/10 000

A.3 Selection of hose assemblies

A.3.1 *Materials*

It is essential to select a material that has adequate resistance to both product and environment. Where resistance to the environment is the determining factor, the use of an outer sleeve or jacket might be preferable to the selection of more expensive materials for the hose.

Details of internal and external plant cleaning routines should be considered where appropriate.

Guidance on the corrosion resistance of commonly used hose assembly materials is given in BS 6501-1, Table A.2. This table should be read in conjunction with BS EN ISO 10380:2003, Table 1, but not all hose materials and products conveyed are included in the table. The manufacturer should be consulted before materials are selected.

A.3.2 *Temperature*

Where a hose is required for use at temperatures in excess of 50 °C and in the presence of certain corrosive agents, notably halogens, the possibility of stress corrosion should be considered and a suitable material resistant to this type of failure should be selected. In some applications high temperatures can alternate with lower temperatures with the attendant risk of condensation and corrosion. Details of temperature de-rating factors based on a creep life of 100 000 h are given in BS EN ISO 10380: 2003, Table 3.

A.3.3 *Pressure*

When selecting the nominal pressure of a hose assembly to be used, consideration should be given to the nature of the pressure to be applied. Where shock or pulsating pressure are likely to occur, the manufacturer should be consulted.

A.3.4 *Product velocity*

Liquid velocities in excess of 5 m/s and gas velocities in excess of 60 m/s can force the corrugations into resonant vibration resulting in premature failure. Such failure may be prevented by the use of flexible liners. The manufacturer should be consulted in these cases.

A.3.5 *Coverings and coatings*

It is strongly recommended that synthetic covers and protective coatings should not contain chlorine or sulfur, examples include neoprene, PVC, marking inks and paint.

End fittings that have been galvanized and paints containing zinc should not be used. Other non-ferrous metals, e.g. lead and tin, can cause damage similar to that caused by zinc.

NOTE At temperatures over 450 °C, either under working conditions or as a result of a plant fire, zinc can rapidly penetrate and embrittle austenitic stainless steel and high nickel alloys. For further information, see Guidance Note PM13, from the Health and Safety Executive, *Zinc embrittlement of austenitic stainless steel 3* [1].

A.3.6 ***Guidance on the choice of materials***

A.3.6.1 *General*

Operating temperature can affect the choice of hose materials from the point of view of resistance to corrosion. Data on fluid compatibility are given in Table A.2. Most service requirements in industry can be met by selecting from the materials listed in Table A.2.

A.3.6.2 *Hose materials*

A.3.6.2.1 *Austenitic stainless steels*

A.3.6.2.1.1 *ISO 9328-5 type X6CrNiTi 18 10*

This material is commonly used where good corrosion resistance and satisfactory mechanical properties over a wide temperature range are required. The material is stabilized and, therefore, is resistant to corrosion problems associated with welding.

A.3.6.2.1.2 *ISO 9328-5 type X2CrNiMo 17 12*

This material offers improved resistance to pitting corrosion but, since it is a non-stabilized alloy, carbon precipitation can be a problem where carbon steel end fittings are used.

A.3.6.2.1.3 *ISO 9328-5 type X2CrNi 18 10*

This material is commonly used where good corrosion resistance is required.

A.3.6.2.2 *Nickel-based alloys*

A.3.6.2.2.1 *ISO 6208 number NW 8825*

A high nickel alloy resistant to stress corrosion cracking and having good resistance to sulfuric and phosphoric acids.

A.3.6.2.2.2 *ISO 6208 number NW 8800*

A high nickel alloy resistant to stress corrosion cracking and having very good general corrosion resistance.

A.3.6.2.2.3 *ISO 6208 number NW 6600*

The alloys included under this designation are immune to stress corrosion cracking and exhibit a good resistance to high temperature oxidation and corrosion.

A.3.6.2.2.4 *ISO 6208 number NW 4400*

A nickel copper alloy widely used in marine and chemical processing applications and also in applications involving contact with chlorine.

A.3.6.2.3 *Copper-based alloys*

Copper-based alloys are used mainly in areas where sparking can be a danger and for applications involving contact with sea water flowing at a rate of less than 1m/s. Copper based alloys should not be used where there is a risk of flame impingement.

A.3.6.3 *End fitting materials*

A.3.6.3.1 *End fittings attached by welding*

The use of carbon steel end fittings is an acceptable practice but such construction is not advisable for applications where shock or high flexing are involved. Carbon steel end fittings are not suitable for low temperature applications nor for applications where corrosion resistance is required.

A.3.6.3.2 *End fittings attached by brazing*

It is essential that the joining material selected is compatible with the product to be conveyed and that it has adequate strength at the design temperature.

Table A.2 — Guidance on the corrosion resistance of materials (see Note)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Acetic acid							
5 % to 20 % agitated or aerated	1	1	1	3	2	3	3
50 %, 20 °C	1	1	1	3	3	3	3
50 % to 80 %, boiling	3	2	3	3	3	3	3
80 %, 20 °C	1	1	1	3	1	3	3
100 %, 20 °C	1	1	1	3	1	3	3
100 %, boiling	3	2	3	3	2	3	3
Acetic anhydride	1	1	1	3	2	3	3
Acetone, boiling	1	1	1	1	1	3	1
Acetyl chloride, boiling	2	2	2	2	1	3	2
Acetylene							
concentrated	1	1	1	3	1	1	3
commercially pure	1	1	1	3	1	1	3
Acid salt mixture	1	1	1	3	3	3	3
Air	1	1	1	1	1	1	1
Aluminium acetate, saturated	1	1	1	3	1	3	3
Aluminium chloride							
10 %, quiescent	3	3	3	3	2	3	3
25 %, quiescent	1	1	1	3	2	3	3
Aluminium hydroxide, saturated	1	1	1	1	1	1	1
Aluminium sulfate							
5 %	1	1	1	3	1	3	3
10 %, 20 °C	1	1	1	3	1	3	3
10 %, boiling	2	1	2	3	1	3	3
saturated, 20 °C	1	1	1	3	1	3	3
saturated, boiling	2	1	2	3	1	3	3
Aluminium potassium sulfate (alum)							
2 % to 1 %, 20 °C	1	1	1	2	2	3	2
10 %, boiling	2	1	2	3	2	3	3
saturated	3	2	3	3	2	3	3
Ammonia (anhydrous)							
All concentrations	1	1	1	1	1	1	1
hot gas	3	3	3	3	3	3	3
Ammonia liquor							
20 °C	1	1	1	3	3	3	3
boiling	1	1	1	3	3	3	3
Ammonium bromide	2	1	2	3	2	3	3
Ammonium carbonate, 1 % and 5 %	1	1	1	3	3	1	3

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Ammonium chloride							
1 %	1	1	1	3	1	2	3
10 %	1	1	1	3	2	3	3
28 %	2	1	2	3	2	3	3
50 %	2	1	2	3	2	3	3
Ammonium dihydrogen orthophosphate							
(Ammonium phosphate), 5 %	1	1	1	3	3	2	3
Ammonium hydrogen carbonate							
(Ammonium bicarbonate), hot	1	1	1	3	2	3	3
Ammonium monophosphate	1	1	1	3	2	2	3
Ammonium oxalate, 5 %	1	1	1	3	3	2	3
Ammonium perchlorate, 10 %, boiling	1	1	1	3	3	2	3
Ammonium peroxodisulfate	1	1	1	3	3	3	3
(Ammonium persulfate), 5 %							
Ammonium solution (Ammonium hydroxide)							
all concentrations	1	1	1	3	3	2	3
Ammonium sulfate							
1 %, aerated or agitated	1	1	1	3	2	3	3
5 %, aerated and agitated	1	1	1	3	2	3	3
10 %, saturated	2	1	2	3	2	3	3
Ammonium sulfite, 20 °C, boiling	1	1	1	3	3	3	3
Amyl acetate, concentrate	1	1	1	1	1	2	1
Amyl chloride	1	1	1	2	2	3	2
Aniline							
3 %	1	1	1	3	2	2	3
concentrated crude	1	1	1	3	2	1	3
Argon (refrigerated liquid)	1	1	1	1	1	3	1
Barium carbonate	1	1	1	1	2	2	1
Barium chloride, 5 %, saturated	1	1	1	2	2	3	2
Barium hydroxide, aqueous solution, hot	1	1	1	1	2	2	1
Barium nitrate, aqueous solution, hot	1	1	1	1	2	2	1
Barium sulfate (Barytes-blanc fixe)	1	1	1	1	2	3	1
Barium sulfide, saturated solution	1	1	1	3	3	3	3
Benzene (Benzol) 20 °C or hot	1	1	1	1	2	2	1

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Benzoic acid	1	1	1	1	3	1	1
Bitumen	1	1	1	1	1	1	1
Butane							
–50 °C	1	1	1	1	1	3	1
20 °C	1	1	1	1	1	2	1
Butyl acid							
5 %	1	1	1	2	2	3	2
aqueous solution, dilution of 0.964 g/l	1	1	1	3	2	3	3
Calcium carbonate	1	1	1	3	1	1	3
Calcium chlorate, dilute solution	1	1	1	3	2	2	3
Calcium chlorite, dilute or concentrate solution	2	1	2	2	3	3	2
Calcium hypochlorite, 2 %	2	1	2	2	3	3	2
Calcium hydroxide, 10 % to 20 %	1	1	1	1	1	3	1
Calcium sulfate, saturated	1	1	1	1	2	3	1
Carbonated water	1	1	1	2	3	3	2
Carbonic acid, saturated solution	1	1	1	1	3	3	3
Carbon dioxide							
dry	1	1	1	1	1	1	3
moist	1	1	1	3	1	2	3
Carbon disulfide (Carbon bisulfide)	1	1	1	2	2	2	1
Carbon tetrachloride							
CP	1	1	1	1	1	2	1
dry CP	1	1	1	1	2	2	1
commercial + 1 % water	3	3	3	2	2	3	2
Cellulose	1	1	1	3	1	3	3
Chloracetic acid	3	3	3	2	2	3	2
Chlorbenzol, concentrated, pure, dry	1	1	1	2	2	2	2
Chlorine gas							
dry	3	3	3	2	2	2	2
moist	3	3	3	3	3	3	3
Chlorinated water, saturated	1	1	1	1	1	1	1
Chloroform	1	1	1	1	1	1	1
Chromium (VI) oxide (Chromic acid)							
5 % CP	1	1	1	3	3	3	3
10 %	3	2	3	3	3	3	3
Chromium plating bath	1	1	1	3	3	2	3

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
1-chloro-2,4-dinitrobenzene (Dinitrochlorobenzene)							
melted and solidified	1	1	1	3	3	3	3
Chloroethane (Ethyl chloride)	1	1	1	2	1	2	2
Citric acid							
5 %, still	1	1	1	1	2	3	2
15 %, still, 20 °C	1	1	1	2	2	3	3
15 % boiling	2	1	2	2	3	3	3
Copper (II) acetate, saturated solution	1	1	1	3	2	3	3
Copper (III) carbonate, saturated solution in 50 % NH_4OH	1	1	1	3	3	3	3
Copper (II) cyanide, saturated solution	1	1	1	3	2	3	3
Copper (II) nitrate							
1 % still, agitated and aerated	1	1	1	3	3	3	3
5 % still, agitated and aerated	1	1	1	3	3	3	3
50 % aqueous solution	1	1	1	3	3	3	3
Copper (II) sulfate							
5 % agitated still or aerated	1	1	1	2	3	3	2
saturated solution	1	1	1	2	3	3	2
Creosote (coal tar)	1	1	1	1	2	2	1
Creosote oil	1	1	1	2	2	2	2
Cyanogen gas	1	1	1	3	3	3	3
Developing solutions	1	1	1	3	3	3	3
1,2-Dichloroethylene (Dichloroethane) dry	1	1	1	3	2	3	3
Diethyl ether (Ether)	1	1	1	1	2	2	1
Disodium tetraborate (Borax), 5 %	1	1	1	1	2	2	1
Distillery wort	1	1	1	3	3	3	3
Dyewood liquor	1	1	1	3	2	3	3
Ethanediol (Ethylene glycol)	1	1	1	1	1	2	1
Ethanol (Ethyl alcohol) 20 °C and boiling	1	1	1	1	1	1	1
Ethyl acetate, concentrated solution	1	1	1	1	2	2	1
Ethylene chloride	1	1	1	2	1	2	2
Fluorine (gas) moist	3	3	3	3	3	3	3
Fluorosilicic (Hydrofluosilicid acid)	3	3	3	2	2	3	2
Formaldehyde, 40 % solution	1	1	1	1	1	2	1
Formic acid							
5 %, still, 20 °C							
5 %, still, 66 °C							

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:
— Category 1: recommended;
— Category 2: partially resistant;
— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Fuel oil	1	1	1	1	2	2	1
containing sulfuric acid	3	2	3	3	2	3	3
2-Furaldehyde (Furfural)	1	1	1	1	2	2	1
Gelatin	1	1	1	1	1	3	1
Glue							
dry	1	1	1	2	2	1	2
solution, acid	2	1	2	3	2	2	3
Glycerol (Glycerine)	1	1	1	1	1	2	1
Hydrochloric acid, all concentrations	3	3	3	3	3	3	3
Hydrocyanic acid	1	1	1	3	2	3	3
Hydrofluoric acid	3	3	3	3	1	3	3
Hydrogen peroxide							
20 °C	2	1	2	3	2	3	3
boiling	2	1	2	3	2	3	3
Hydrogen sulfide							
dry	1	1	1	1	3	2	1
wet	2	1	2	3	3	3	3
Ink	2	1	2	3	1	3	3
Iodoform	1	1	1	3	2	3	3
Iron (II) chloride							
(Ferrous chloride) saturated solution	3	1	3	2	3	3	2
Iron (III) chloride (Ferric chloride)							
1 % solution, 20 °C	2	1	2	3	3	3	3
1 % solution, boiling	3	3	3	3	3	3	3
5 % solution agitated, aerated	3	3	3	3	3	3	3
Iron (II) hydroxide							
(Ferric hydroxide) (hydrated iron oxide)	1	1	1	3	2	3	3
Iron (III) nitrate (Ferric nitrate)							
1 % to 5 % quiescent or agitated	1	1	1	3	3	3	3
1 % to 5 % aerated	1	1	1	3	3	3	3
Iron (II) sulfate (Ferrous sulfate) dilute solution	1	1	1	2	3	3	2
Iron (III) sulfate (Ferric sulfate)							
1 % to 5 % quiescent or agitated	1	1	1	3	3	3	3
1 % to 5 % aerated	1	1	1	3	3	3	3
10 %	1	1	1	3	3	3	3
Kerosene	1	1	1	1	2	2	1

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Lactic acid							
1 %, 20 °C	1	1	1	2	2	3	2
1 %, boiling	1	1	1	3	2	3	3
5 %, 20 °C	1	1	1	2	2	3	2
5 %, boiling	2	1	2	3	2	3	3
10 %, 20 °C	2	1	2	3	2	3	2
10 %, boiling	3	2	3	3	2	3	3
concentrated, 20 °C	2	1	2	2	2	3	2
concentrated, boiling	3	2	3	3	2	3	3
Lead diacetate (Lead acetate) 5 %	1	1	1	3	2	3	3
Linseed oil	1	1	1	2	1	2	2
Magnesium chloride							
1 % quiescent, 20 °C	1	1	1	2	1	3	2
1 % quiescent, hot	3	2	3	2	1	3	2
5 % quiescent, 20 °C	1	1	1	2	1	3	2
5 % quiescent, hot	3	2	3	2	1	3	2
Magnesium sulfate	1	1	1	1	1	3	1
Malice acid	2	1	2	3	2	3	3
Mash	1	1	1	3	2	3	3
Mercury	1	1	1	3	3	1	3
Methane (refrigerated liquid)	1	1	1	1	1	3	1
Methanol (Methyl alcohol) boiling	3	2	3	1	1	3	1
Mixed acids, 53 % H_2SO_4 + 45 % HNO_3	1	1	1	3	3	3	3
Molasses	1	1	1	1	1	2	2
Mustard	1	1	1	3	2	3	3
Naphtha							
crude	1	1	1	2	1	2	2
pure	1	1	1	2	1	2	2
Naphthalene sulfonic acid	1	1	1	3	1	3	3
Nickel chloride solution	1	1	1	2	2	3	3
Nickel sulfate	1	1	1	1	1	3	3
Nitre cake	2	1	2	3	2	3	3
Nitric acid							
5 %, 50 %, 70 %, boiling	1	1	1	3	3	3	3
65 %, 20 °C	1	1	1	3	3	3	3
65 %, boiling	2	2	2	3	3	3	3
concentrated, 20 °C	1	1	1	3	3	3	3
concentrated, boiling	3	3	3	3	3	3	3
fuming concentrated, 43 °C	1	1	1	3	3	3	3
fuming concentrated, boiling	3	3	3	3	3	3	3

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Nitrogen (refrigerated liquid)	1	1	1	1	1	3	1
Nitrous acid, 5 %	1	1	1	3	3	3	3
Oils, crude	1	1	1	2	1	3	2
Oils, vegetable, mineral	1	1	1	2	1	3	2
Oleic acid	1	1	1	2	2	2	2
Orthoboric acid (Boric acid)							
5 % solution, 20 °C	1	1	1	1	2	3	1
5 % solution, boiling	1	1	1	1	2	3	2
saturated solution, 20 °C	1	1	1	2	2	3	3
saturated solution, boiling	1	1	1	3	2	3	3
Orthophosphoric acid (Phosphoric acid)							
1 %, 20 °C	1	1	1	3	2	3	3
1 %, boiling	1	1	1	3	2	3	3
1 % 3, 1 bar, 140 °C	1	1	1	3	2	3	3
5 % quiescent, or agitated	1	1	1	3	2	3	3
5 % aerated	1	1	1	3	2	3	3
10 % quiescent	3	1	3	3	2	3	3
10 % agitated or aerated	3	2	3	3	2	3	3
10 %, 50 %, boiling	1	1	1	3	3	3	3
80 %, 20 °C	3	3	3	3	2	3	3
80 %, 110 °C	3	3	3	3	3	3	3
85 %, boiling	3	3	3	3	3	3	3
Oxalic acid							
5 %, 10 %, 20 °C	1	1	1	2	2	3	3
10 %, boiling	3	3	3	2	2	3	3
25 %, 50 %, boiling	3	3	3	2	1	3	3
Oxygen (refrigerated liquid)	1	1	1	1	1	3	1
Paraffin, hot	1	1	1	1	1	2	1
Petrol	1	1	1	1	1	2	1
Petroleum ether	1	1	1	3	2	2	3
Phenol	1	1	1	3	2	2	1
Picric acid	1	1	1	3	3	3	3
Potassium bromide	2	1	2	2	2	3	2
Potassium carbonate							
1 %, 20 °C	1	1	1	2	1	2	2
hot	1	1	1	3	1	2	3

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Potassium chlorate saturated at 100 °C	1	1	1	3	3	2	3
Potassium chloride							
1 % quiescent	1	1	1	2	1	3	3
1 % agitated or aerated	1	1	1	2	1	3	3
5 % quiescent	1	1	1	2	1	3	3
5 % agitated or aerated	1	1	1	2	1	3	3
5 %, boiling	1	1	1	2	1	3	3
Potassium chromium sulfate							
5 %	1	1	1	2	3	3	3
dilution of 1.6 g/l	3	3	3	3	3	3	3
Potassium cyanide	1	1	1	3	2	2	3
Potassium dichromate (Potassium bichromate)							
25 %, 20 °C	1	1	1	3	2	3	3
25 %, boiling	1	1	1	3	2	3	3
Potassium hexacyanoferrate (III) (Potassium ferricyanide)							
5 %, 25 %, 20 °C	1	1	1	3	2	3	3
25 %, boiling	1	1	1	3	2	3	3
Potassium hexacyanoferrate (II) (Potassium ferrocyanide)							
5 %	1	1	1	3	2	3	3
Potassium hydrogen oxalate (Potassium oxalate)							
5 %	1	1	1	2	1	2	3
27 %	1	1	1	2	1	2	3
50 %	2	1	2	2	1	3	3
Potassium hypochlorite	2	2	2	3	3	3	3
Potassium nitrate							
1 %, 5 % still or agitated	1	1	1	2	1	3	2
1 %, 5 % aerated	1	1	1	2	1	3	2
50 %, 20 °C	1	1	1	2	1	3	2
50 %, boiling	1	1	1	2	1	3	2
molten	1	1	1	3	3	3	3
Potassium permanganate, 5 %	1	1	1	3	3	2	3
Potassium sulfate							
1 %, 5 % still or agitated	1	1	1	1	2	2	2
1 %, 5 % aerated, 20 °C	1	1	1	1	2	2	2
hot	1	1	1	1	2	3	2

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Potassium sulfite (salt)	1	1	1	3	3	3	3
Propane							
–50 °C	1	1	1	1	1	3	1
20 °C	1	1	1	1	1	2	1
Pyrogallol (Pyrogallic acid)	1	1	1	3	3	2	3
Quinine bisulfate, dry	2	1	2	3	3	3	3
Quinine sulfate, dry	1	1	1	2	2	3	2
Resin	1	1	1	1	1	3	1
Sea water	3	2	3	2	2	3	2
Silver bromide	2	1	2	3	3	3	3
Silver nitrate	1	1	1	3	3	3	3
Soap	1	1	1	1	1	2	1
Sodium acetate, moist	1	1	1	3	2	3	3
Sodium carbonate							
5 %, 66 °C	1	1	1	2	1	2	2
5 %, 50 %, boiling	1	1	1	2	1	2	2
molten	3	3	3	3	1	3	3
Sodium chloride							
5 % still	1	1	1	2	1	3	3
20 % aerated	1	1	1	2	1	3	3
saturated, 20 °C	1	1	1	2	1	3	3
saturated, boiling	2	1	2	2	1	3	3
Sodium cyanide	1	1	1	3	3	2	3
Sodium fluoride, 5 % solution	2	1	2	1	1	3	1
Sodium hydrogen carbonate (Sodium bicarbonate)							
all concentrations, 20 °C	1	1	1	2	1	3	2
5 % still, 66 °C	1	1	1	2	1	3	2
Sodium hydrogen sulfate (Sodium bisulfate)							
solution	1	1	1	2	2	3	3
saturated solution	3	3	3	2	2	3	3
Sodium hydroxide	1	1	1	2	1	2	3
Sodium hypochlorite	3	3	3	3	3	3	3

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Sodium nitrate	1	1	1	1	2	2	1
Sodium perchlorate, 10 %	1	1	1	3	3	3	3
Sodium phosphate	1	1	1	2	2	2	2
Sodium sulfate							
5 % still	1	1	1	1	1	3	1
all concentrations	1	1	1	1	1	3	1
disodium sulfide, saturated	2	1	2	3	2	3	3
Sodium sulfite							
5 %	1	1	1	2	2	3	3
10 %	1	1	1	2	2	3	3
Sodium thiosulfate							
saturated solution	1	1	1	3	1	3	3
acid fixing bath (hypo)	1	1	1	3	2	3	3
25 % solution	1	1	1	3	2	3	3
Sodium thiosulfite (Sodium hyposulfite)							
Steam	1	1	1	1	1	3	2
Stearic acid	1	1	1	2	2	3	3
Starch, aqueous solution	1	1	1	3	2	3	3
Strontium hydroxide	1	1	1	3	3	3	3
Strontium nitrate solution	1	1	1	3	2	3	3
Sulfur							
moist	2	1	2	3	2	3	3
molten	1	1	1	3	1	3	3
Sulfur chloride, dry	3	3	3	1	2	3	1
Sulfur dioxide gas							
moist	2	1	2	2	3	3	2
dry	1	1	1	1	2	3	1
Sulfuric acid							
5 %, 10 %	3	2	3	2	3	3	3
50 %	3	3	3	3	3	3	3
concentrated, 20 °C	1	1	1	2	3	3	3
concentrated, boiling	3	3	3	2	3	3	3
Sulfurous acid							
saturated	3	2	3	2	3	3	3
saturated, 4 bar pressure	3	2	3	2	3	3	3
saturated, 8 bar pressure	3	2	3	2	3	3	3
10 bar pressure	3	2	3	2	3	3	3

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

Table A.2 — Guidance on the corrosion resistance of materials (see Note) (*continued*)

Service condition	Hose and end fittings					End fitting	
	Austenitic steels			Phosphor bronze	Nickel alloy NW 4400	Carbon steels	Copper-based alloys
	X2CrNi 18 10	X2CrNi Mo 17 12	X6CrNi Ti 18 10				
Tannic acid							
20 °C	1	1	1	1	3	3	2
66 °C	1	1	1	1	3	3	2
Tanning liquor	1	1	1	3	1	3	3
Tar	1	1	1	1	3	2	1
Tartaric acid							
10 %, 20 °C	1	1	1	1	2	3	2
10 %, 50 %, boiling	2	1	2	1	2	3	2
Tin (IV) chloride (Stannic chloride solution)							
(dilution of 1.21 g/l)	3	3	3	3	3	3	3
Tin (II) chloride (Stannous chloride)							
saturated	3	1	3	3	3	3	3
Trichloroacetic acid	3	3	3	2	3	3	3
Trichloroethylene							
dry	1	1	1	1	1	3	1
moist	3	3	3	2	3	3	2
3,4,5-Trihydroxybenzoic acid (Gallic acid)							
5 %	1	1	1	3	2	3	3
saturated	1	1	1	3	2	3	3
Varnish	1	1	1	1	1	2	1
Vegetable juices	1	1	1	2	2	2	3
Vinegar fumes	2	1	2	2	3	3	3
Vinegar, still, agitated or aerated	1	1	1	2	3	3	3
Water, potable	1	1	1	1	1	2	1
Whisky	1	1	1	1	1	3	2
Wine, all phases of processing and storing	1	1	1	3	2	3	3
Yeast	1	1	1	3	1	3	3
Zinc chloride							
5 % still	1	1	1	3	2	3	3
20 °C boiling	2	2	2	3	2	3	3
Zinc cyanide, moist	1	1	1	3	3	3	3
Zinc nitrate, solution	1	1	1	3	3	3	3
Zinc sulfate							
4 %	1	1	1	2	2	3	3
25 %	1	1	1	2	2	3	3
saturated	1	1	1	2	2	3	3

NOTE The figures quoted in this table present the following categories of resistance to corrosion. Unless otherwise stated, resistance is quoted as ambient temperature:

— Category 1: recommended;

— Category 2: partially resistant;

— Category 3: not recommended.

A.4 Hose assembly installation

A.4.1 *General*

Annex B gives examples of correct and incorrect hose assembly installation. Annex B also gives equations for the calculation of hose length together with worked examples.

The hose centre-line bend radius is an important factor in installation. In actual installations, bend radii can vary from the values theoretically required and hence hose cyclic life can be affected.

A.4.2 *Torsional loading*

Hose assemblies should not be installed in such a manner that a torque loading is imposed. Twisting of the hose develops a shear stress in the metal that can produce premature hose failure. Torsion develops when the applied movement is not in the same bending plane as the hose.

Care should be taken to ensure that torque is not applied when tightening fittings. Where torque is likely to be applied, the manufacturer should be consulted (see Annex B).

A.4.3 *Minimum bend radius*

Where a hose assembly is used in an application requiring either repetitive or random motion, bending on both sides of the centre-line or bending to a tighter radius than that recommended by the manufacturer will cause premature failure.

A.4.4 *Braid damage*

The prime function of the braid is to prevent the hose from elongating and thus to give the hose assembly its ability to withstand pressure. Any hose assembly found to have braid damage should be removed from service as a safety precaution since the integrity of the assembly will have been impaired.

A.5 Cleaning and handling

A.5.1 *Precautions needed during storage of hose assemblies*

Corrugated hose assemblies should not be allowed to come into contact with substances that can cause their deterioration.

A.5.2 *Special cleaning and packaging*

Special cleaning and packaging is a necessity for certain applications, e.g. oxygen service and nuclear power. Such requirements should be agreed between the purchaser and the manufacturer at the time of quotation. In addition, special precautions should be taken by the purchaser after assemblies are received to ensure that they remain clean.

A.5.3 *Site cleaning*

Where the system in which the hose is installed is cleaned, care should be taken to ensure that any fluid used is free from halogenated solvents such as trichloroethylene unless the hose is removed during the cleaning operation. Wherever practicable, hoses should be removed during all system cleaning operations.

Annex B (informative) Hose assembly lengths and installation configurations

B.1 Application

The following information is provided as guidance in the determination of the minimum overall length of hose assemblies possible for the conditions shown.

The overall length of a hose assembly is the length between the insides of the ferrules added to the length of the end fittings.

Lengths calculated using these equations might require alteration in order to ensure that the hose assembly is capable of giving the required service life (see **A.2**). Further guidance may be obtained from the manufacturer. The minimum centre-line bend radii for hose assemblies are given in BS EN ISO 10380:2003, Table 3.

B.2 Notation

The following symbols are used in **B.3**, **B.4** and **B.5**:

c is the minimum height of a vertical loop subject to horizontal travel (in mm);

l is the minimum length between inside of ferrules (in mm);

r is the bend radius (in mm);

t is the total travel (in mm).

B.3 Vertical loop for maximum vertical travel

See Figure B.1.

$l = 4r + 0.5t$

EXAMPLE Using DN10 hose:

$r = 150$ mm

Assume $t = 400$ mm

then $l = (4 \times 150) + (0.5 \times 400) = 800$ mm

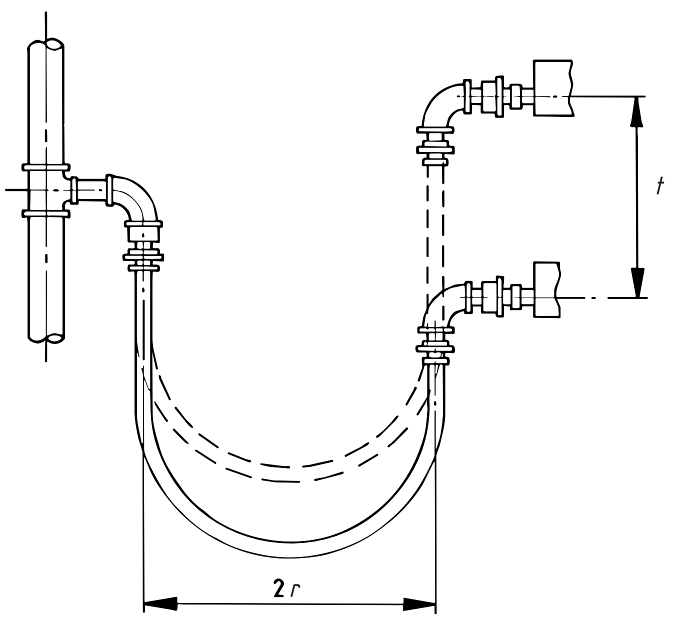


Figure B.1 — Vertical loop (maximum vertical travel about fixed point)

B.4 Vertical loop for short horizontal travel

See Figure B.2.

$l = 4(r + 0.5t)$

$c = 0.5(1 - 4r) + r$

EXAMPLE *r*, *t* and *l* as in **B.3**:

$l = 4(150 + 0.5 \times 400) = 1\ 400$ mm

and

$c = 0.5(1\ 400 - 4 \times 150) + 150 = 550$ mm.

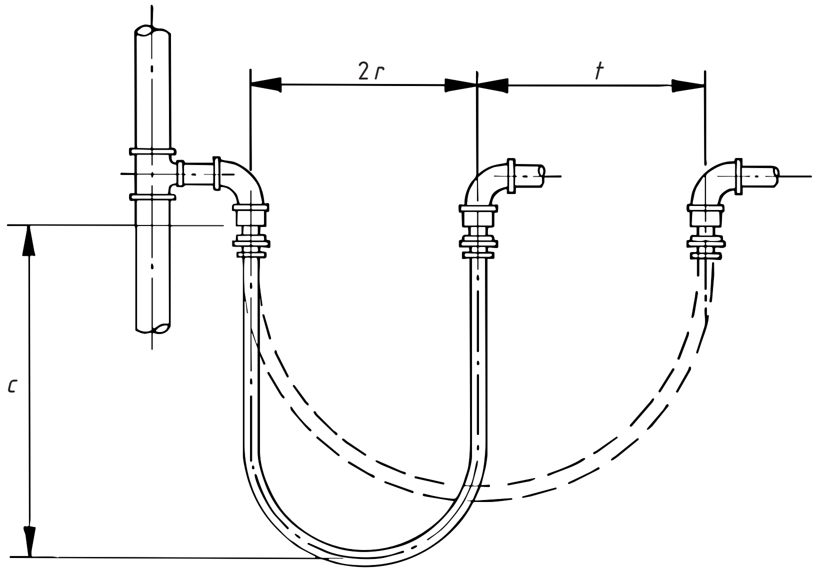


Figure B.2 — Vertical loop (short horizontal travel)

B.5 Horizontal loop for maximum horizontal travel

See Figure B.3.

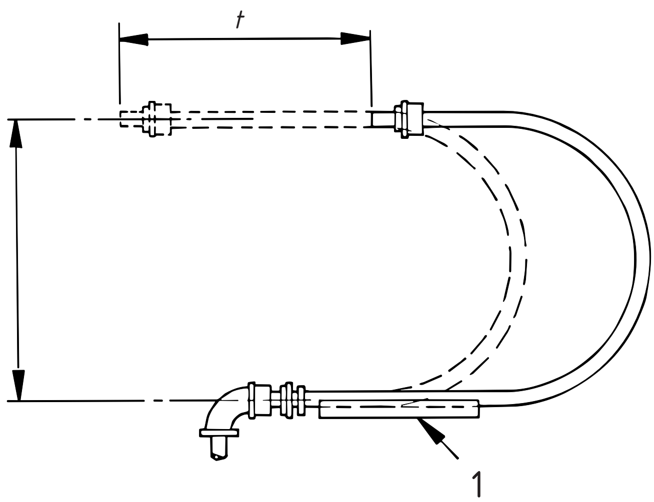
$l = 4r + 0.5t$

EXAMPLE Travel = 800 mm:

r =150 mm

t = 800 mm

then $l = (4 \times 150) + (0.5 \times 800) = 1\ 000$ mm



Key

1 Support for hose

Figure B.3 — Horizontal loop (maximum horizontal travel about fixed point)

B.6 Installation of corrugated metal hose assemblies

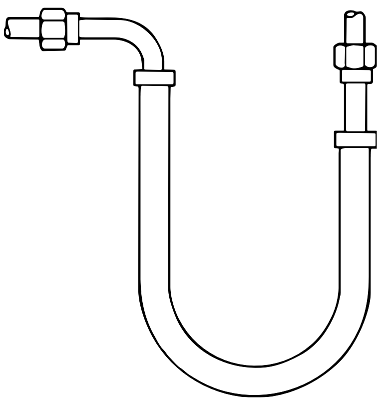
See Figure B.4.

There are three fundamental points to remember when installing corrugated flexible metal hose assemblies. These points are as follows.

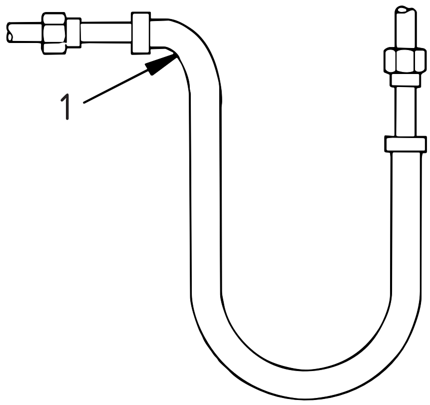
a) The hose should not be bent below the minimum recommended bend radius.

b) Always install without twist; twist is torsional strain that is harmful to the hose.

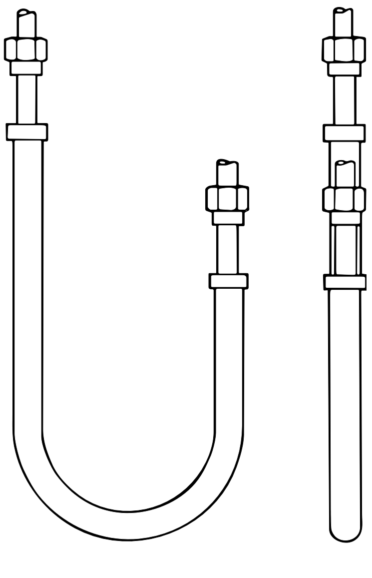
c) Always install so that movement takes place in one plane.



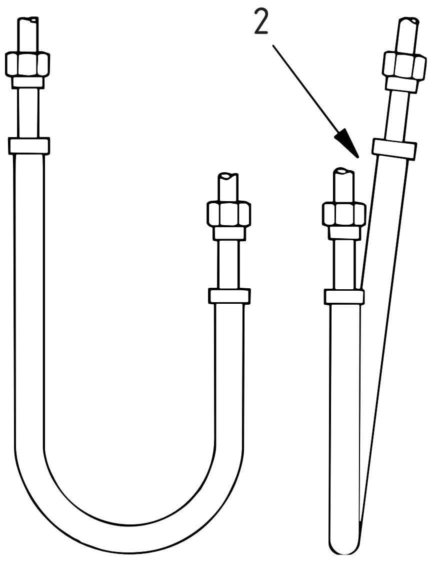
a) **Correct.** The drawing illustrates the correct way to install a hose assembly in loop form. Note the free bend of the hose and that there are no sharp bends near either of the fittings.



b) **Incorrect.** An installation of this type is incorrect because there is a sharp bend near the upper fitting. If a hose assembly is installed in this manner, fatigue failure can result near the fitting.



c) **Correct.** The drawing demonstrates the manner of installing a hose assembly so that the hose during all movement will be in one plane. Note also that there are no sharp bends near either fitting.



d) **Incorrect.** A hose assembly should not be installed like this when it will be required to move. Note that the fittings are not in line and that the hose is in torsion. When installed in this manner, the twist in the hose can cause permanent fatigue failure.

Key

1 Bend too sharp

2 Avoid this twist

Figure B.4 — Correct installation of hose assemblies

Annex C (informative) Flame test

C.1 Test conditions

C.1.1 Test one sample hose assembly in a draught-proof cabinet at room temperature under the standard conditions given in **C.1.2** to **C.1.8**.

C.1.2 Use a butane gas torch, incorporating a gas injector 1), the essential details of which are shown in Figure C.1. Procure and assemble the steel burner tube, gauze filter and any remaining parts of the torch as shown in Figure C.1.

C.1.3 It will be found that the jet assembly is fitted with one inner and one outer red fibre washer. Remove these washers and replace by aluminium alloy washers of the same size. Bed carefully the smaller (inner) of the two alloy washers on both sides of the mating faces to form a gas-tight joint. Check the jet to ensure that it is of the correct size, and that it is clean and firmly tightened in its holder. A jet-key is supplied for this purpose by the injector manufacturer. Clean the torch parts and assemble and couple to the butane gas installation.

C.1.4 Place the butane gas cylinder where it is not subjected to heat and in a position that is well ventilated, particularly at ground level where, in the event of leakage, the relatively heavy gas tends to collect. Take special care to ensure gas-tight joints in the pipeline.

C.1.5 Make a mercury column pressure gauge connection at the point where the flexible tubing to the torch is coupled to the gas pipeline. Use 6.3 mm bore tubing suitable for use with LPG vapour. A suitable arrangement is shown in Figure C.2.

C.1.6 After testing the pipeline for leaks at a pressure slightly higher than the working pressure, ignite the torch and set the gas pressure at 240 mbar. Set the air adjustment to give a clearly defined blue cone in the flame almost level with the end of the burner tube. This is done by screwing the throat nearer to or further from the jet. Failure to obtain a satisfactory flame may be caused by a partially choked jet or filter or by a leak at the inner washer of the jet holder or between the jet and its seating in the holder. The latter condition is usually indicated by a smell of gas, by flashing back or by a weak discoloured flame.

C.1.7 When the torch is satisfactorily adjusted, lock the air adjustment. Allow the flame to burn steadily for at least five minutes prior to the commencement of a test.

C.1.8 Set the hose assembly at its minimum dynamic bend radius. Fill the hose assembly with test fluid and subject it to a hydrostatic pressure equal to the nominal working pressure and maintain it at this pressure during the test.

C.2 Procedure

C.2.1 *General*

Subject the sample to the hose test and to the end fitting test. Examine for any signs of leakage.

Ensure that precautions are taken to avoid a fire in the event of hose failure.

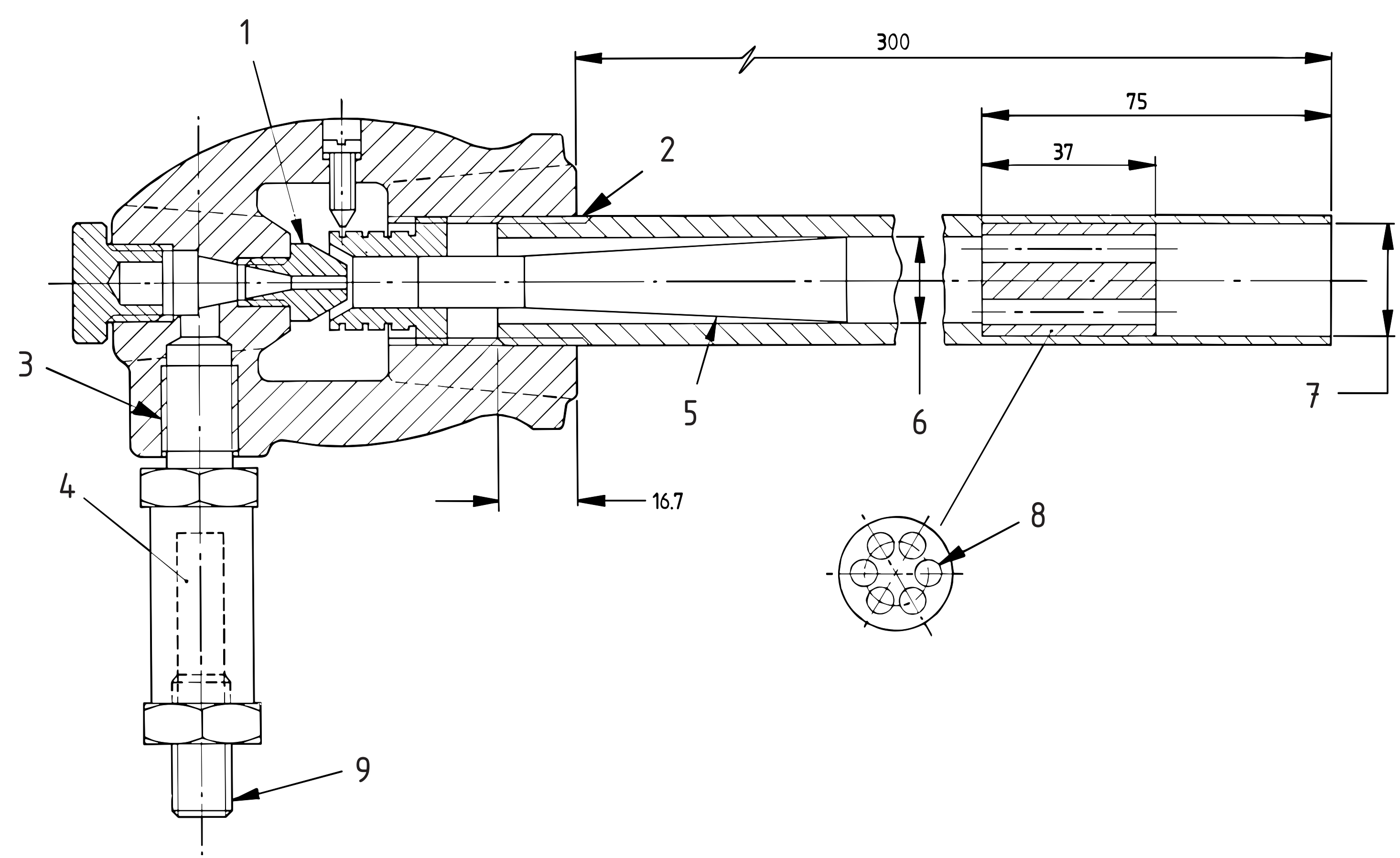
C.2.2 *Hose test*

With the nozzle of the torch 50 mm from the surface of the hose, direct the flame radially on to the outer periphery of the hose at the bend for 15 min.

C.2.3 *End fitting test*

With the nozzle of the torch 50 mm from the surface of the hose, direct the flame radially on to the junction between the hose and the end fitting for 15 min.

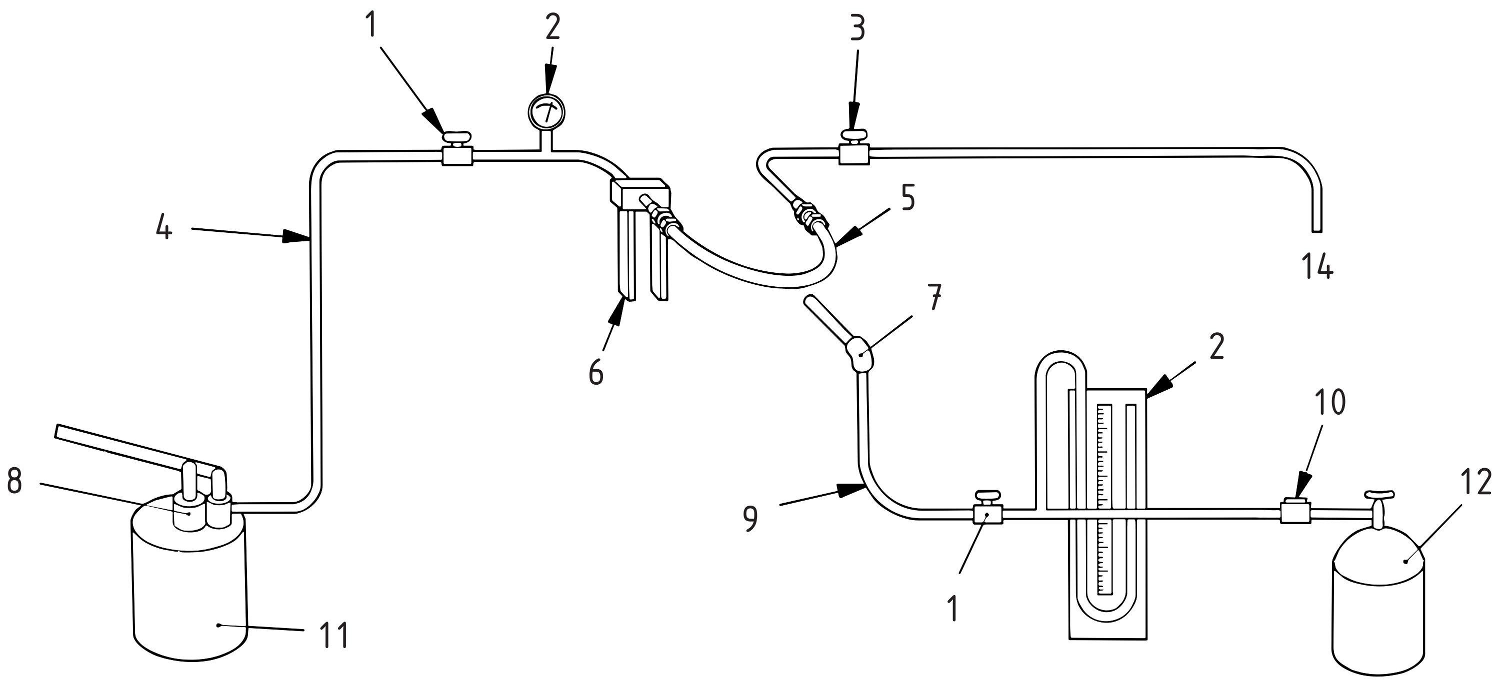
Dimensions in millimetres



Key

1 Gas injector 25 cm²
2 ¾ BSP
3 Inlet ⅜ BSP
4 Copper gauge filter ∅ 95 × 28 long 3 per mm mesh
5 Venturi
6 Bore ∅ 39 steel tune
7 Bore ∅ 22
8 6 holes ∅ 5.56 on 135 PCD
9 ¼ BSP

Figure C.1 — Butane gas torch for standard flame test



Key

1	Stop cock	7	Butane gas torch
2	Pressure gauge	8	Hydraulic pump
3	Bleed cock	9	900 length of 6.3 mm bore flexible tubing
4	DN6 rigid tubing	10	Pressure regulator
5	Sample corrugated metal hose assembly under test	11	Reservoir
6	Fixed support	12	Butane gas cylinder

Figure C.2 — Typical flame test rig

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