LOW PRESSURE FLEXIBLES

by

D. H. CAMERON, C.ENG., F.I.MAR.E., M.I.MECH.E., R.C.N.C.
(*Ship Department*)

A low pressure flexible is an assembly of rubber hose or bellows complete with end fittings, designed for use in systems operating within the pressure range of 958 mbar (vacuum) to 10 bar. The definition of a hose is a flexible rubber tube complete with reinforcement but excluding end fittings, whereas that of a bellows is a preformed reinforced hose with either a single or multiple corrugation.

For years flexible tubes and pipes were made by folding over thin pliable leather which was then secured by copper rivets along the seam. Such leather flexibles were used in many areas of engineering, two examples being the flexible connection from the water tower to the water tender of a steam railway engine and, in ships, the bilge pump flexible suction hose complete with elephant's foot.

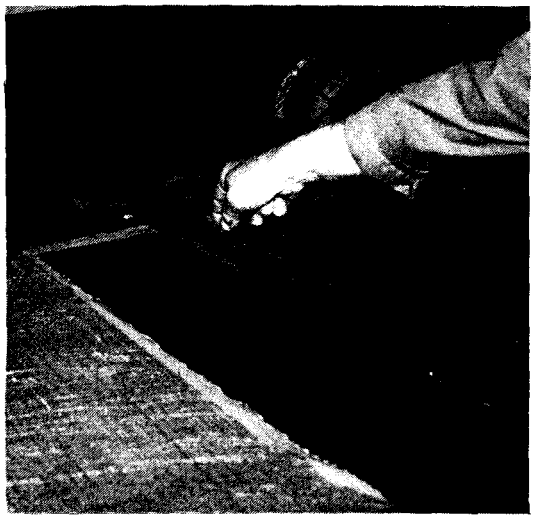

FIG. 1A—PREPARING MATERIALS FOR BUILDING HOSE

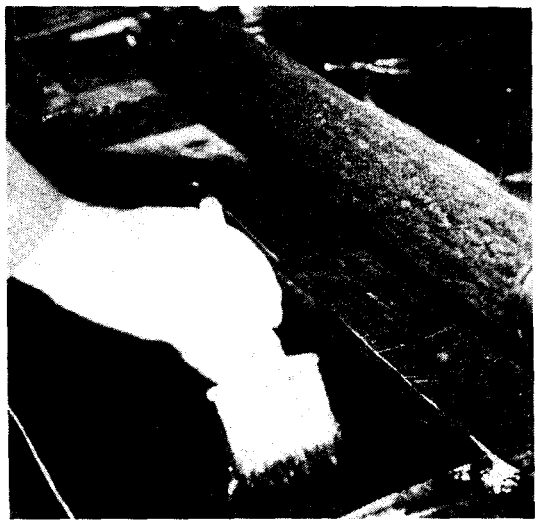

FIG. 1B—STRAIGHT HOSE IN EARLY STAGE OF CONSTRUCTION

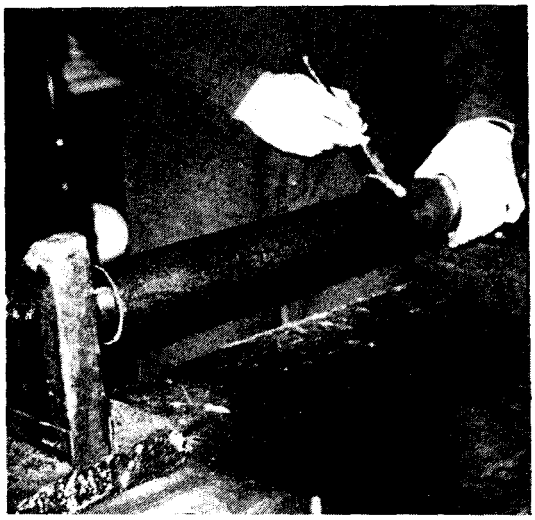

FIG. 1C—STRAIGHT HOSE IN EARLY STAGE OF CONSTRUCTION

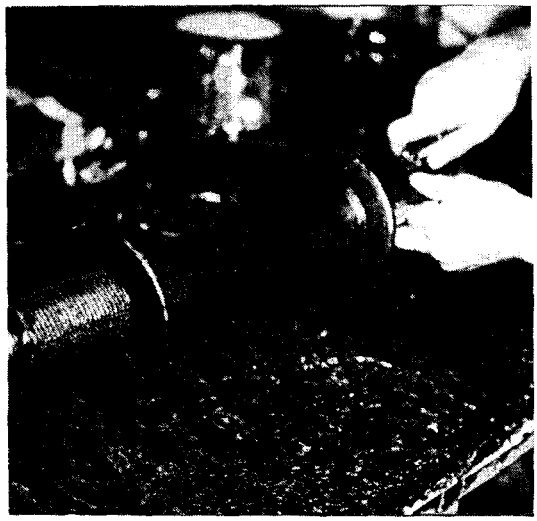

FIG. 1D—BUILDING THE SPECIAL 'BUILT-IN' FLANGE ON A STRAIGHT HOSE

Following the discovery and use of vulcanization in the nineteenth century, rubber and, more recently, synthetic rubber gradually replaced leather and, in order to make pipes more robust and pressure resistant, reinforcing materials were added to the composite. In this area, progress has been dependent upon the development and growth of synthetic fibres, whilst manufacturing techniques have depended upon the actual type and application.

Low pressure rubber flexibles (50 mm and above) are usually hand made and have a helical wire embedded in them to prevent collapse when used under suction conditions. Such flexibles are usually provided with metallic backing plates to provide hard facings and so prevent nuts becoming embedded in the rubber flanges. Detailed procurement specifications for such flexibles are given in D.G. Ships Procurement Specifications Nos. 1055 and 1056.

Basically the manufacturing process for hand-made flexibles consists of taking a steel mandrel on to which the lining is applied (FIGS. 1a, b, c, and d). This is braided, adhesives are applied, and it is then covered with an extruder. The whole is then cloth wrapped and vulcanized (See FIGS. 2a, b, c, and d). After vulcanizing (curing)(FIG. 3), the cloth is removed, the mandrel is extracted, and the whole length of the flexible is pressure tested (FIGS. 4a and 4b).

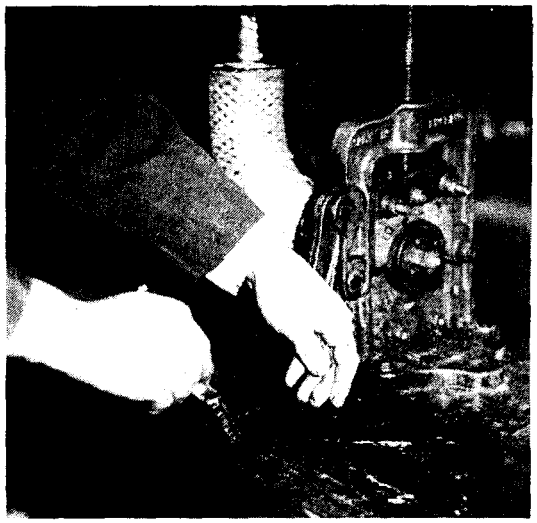

FIG. 2A—PREPARING MATERIALS USED IN THE CONSTRUCTION OF AN ELBOW

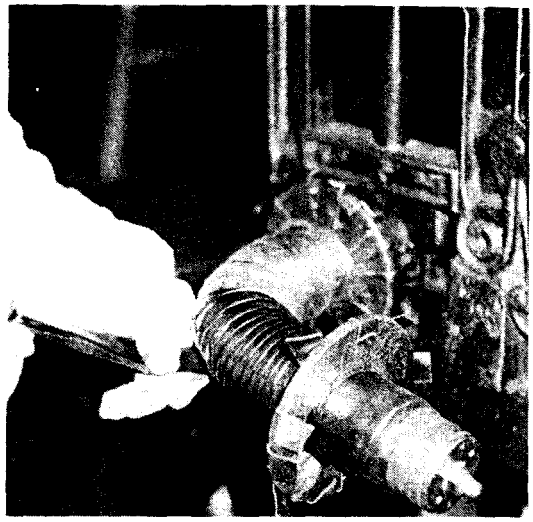

FIG. 2B—CONSTRUCTION OF AN ELBOW

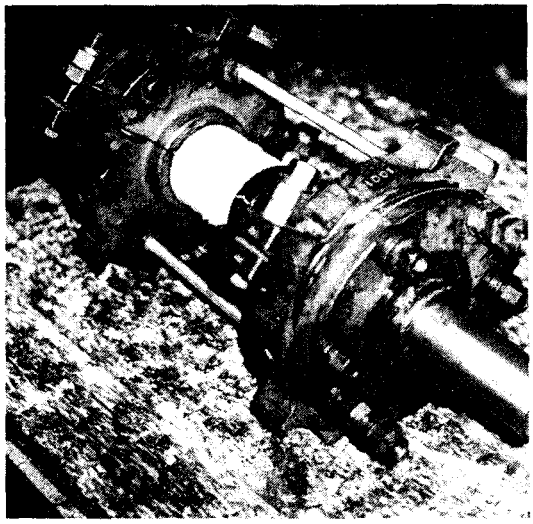

FIG. 2C—HOSE LOCKED IN MOULD READY FOR CURING IN STEAM OVEN

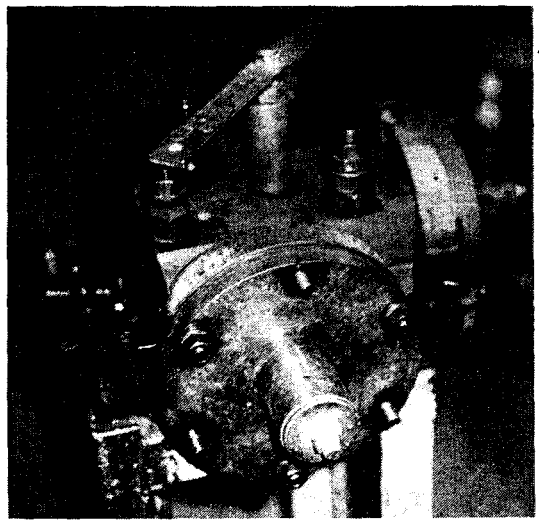

FIG. 2d—COMPLETED ELBOW LOCKED IN MOULD READY FOR CURING IN STEAM OVEN

Of paramount importance in hose design is the angle of application of the textile reinforcement together with the ultimate bursting pressures achieved. The designer aims at the so-called neutral angle—this is calculated to be 54° 44′. At this angle there is no movement of the hose under pressure either in length or diameter assuming no elongation of the reinforcement (FIG. 5).

If the angle of application is greater than neutral, then the hose will increase in length and the diameter will decrease; if the angle is less than neutral, the reverse will occur.

Installation

Why are flexibles used in various systems? Flexibles are fitted for many reasons such as to accommodate movement caused by vibration and shock, to absorb expansion or structural movement, to act as noise isolaters, or where space is inadequate for conventional piping arrangement. They are not, however, intended to be used as closing lengths to take up misalignment of piping.

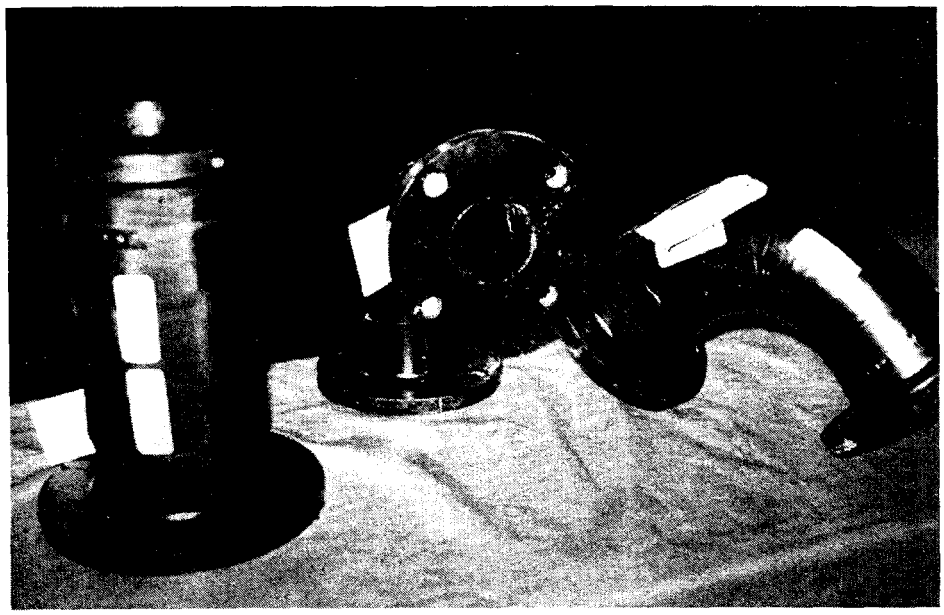

FIG. 3—SELECTION OF FLEXIBLES AFTER FINAL CURE

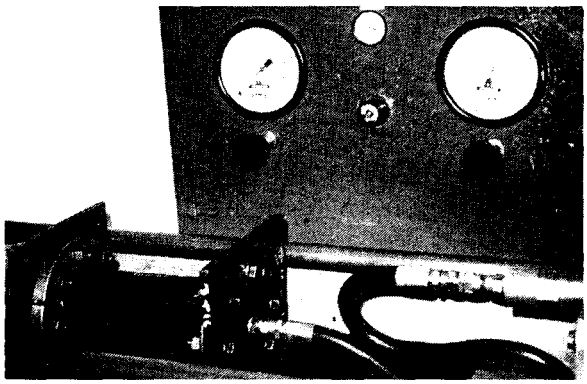

FIG. 4A—FINISHED HOSE BEING PRESSURE TESTED

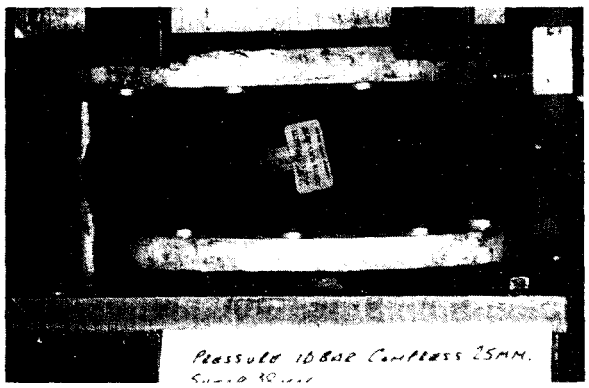

FIG. 4B—EXPERIMENTAL BELLOWS DURING SHEAR TEST

Flexibles should be installed in a relaxed position with no twist or tensile loading; a longitudinal line known as the *lay line* is normally marked on the cover of the flexible hose to assist in correct installation (FIG. 6). Flexibility in pipe systems is normally provided by the use of bends, loops, and offsets into the piping, but flexibles may be used when space is inadequate. Care must, however, be taken to ensure that specified minimum bend radii are not reduced by incorrect layout as illustrated in FIG. 7.

Pipework should be correctly aligned and supported as close to the flexible as possible; it is essential that the mating flanges are parallel and the correct distance apart. To ensure this rigidity, dummy pieces must be fitted before the installation of flanged flexibles (FIGS. 8a and b). These dummies should be painted a distinctive colour to ensure their ultimate replacement; they should, however, be retained as late as possible in the construction programme to limit damage and abuse to the flexible. Undrilled flanges of the flexible should be marked off from the finished pipework. Rubber flanges do not require gaskets but backing plates should be used behind the flanges. Flexibles fitted in vulnerable positions must be protected against damage in service by external guards or other means; for fire protection this may already have been

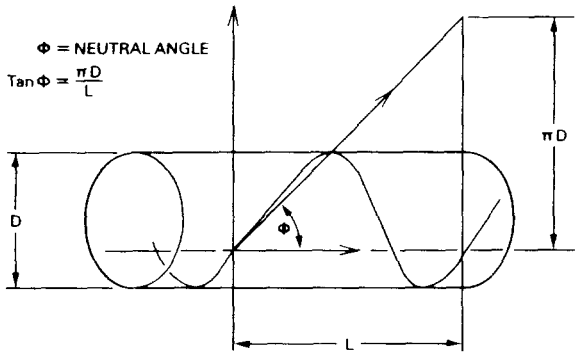

FIG. 5—ANGLE OF APPLICATION OF TEXTILE REINFORCEMENT

covered in the construction of the flexibles, e.g. Messrs. Oldham include a fire-resistant lining. Flexible pipes and bellows must never be painted and, furthermore, all flexible pipe assemblies and hoses over 20 mm bore should whenever possible be installed in a vertical plane.

Selection

When selecting flexibles it is essential to note:

(*a*) System fluid pressure—steady or pulsating?

(*b*) Compatibility of the system fluid with that of the flexible lining.

(*c*) Temperature of the fluid and the environment. The life of the elastomer is related to temperature and care must be taken to ensure that such temperature is applicable at system pressure.

(*d*) End connections are compatible with the conveyed fluid and external conditions.

(*e*) The outer cover must be resistant to oil, abrasion and, when required, fire.

(*f*) Selection should be made from the standard range of flexibles already in service. For LP fluids, flexibles up to 100 mm (4″) bore should be selected to D.G. Ships Specification 1056 and bellows over 100 mm (4″) bore should be selected from D.G. Ships Specification 1055. Smaller size bellows may only be fitted where either space dictates or where small movements are required. Reference should also be made to BR 3001 regarding details of standard assembly, backing ring details, etc.

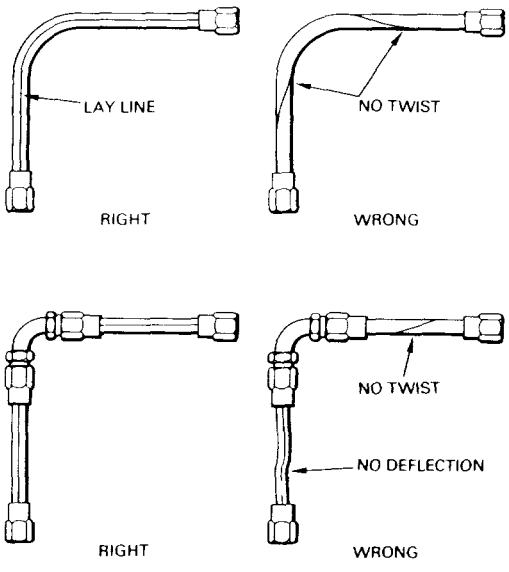

FIG. 6—RIGHT AND WRONG METHOD OF HOSE INSTALLATION—PRESSURE APPLIED TO A TWISTED OR DEFLECTED HOSE WILL CAUSE PREMATURE FAILURE

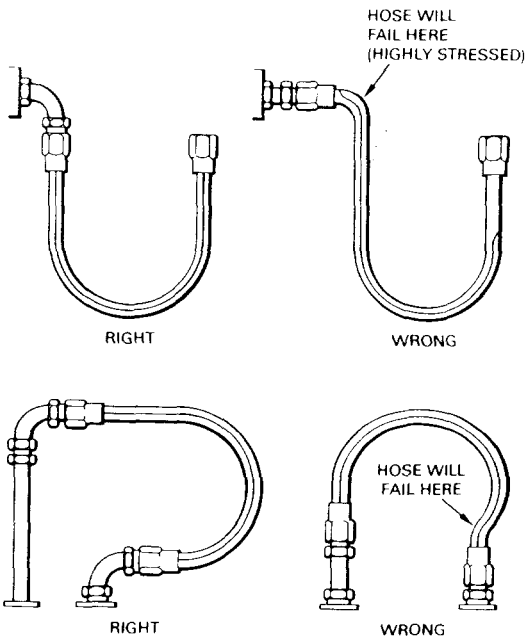

FIG. 7—RIGHT AND WRONG METHOD OF HOSE INSTALLATION—PRESSURE APPLIED TO HIGHLY STRESSED HOSE WILL CAUSE PREMATURE FAILURE

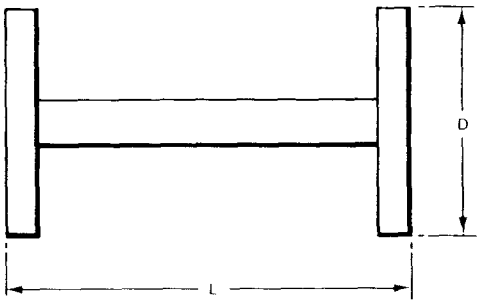

FIG. 8A—DUMMY ALIGNMENT PIECES FOR RUBBER BELLOWS

FIG. 8a—Dimensions in millimetres

Nom. Size	Length L	Flange Dia. D	Bolting		
			PCD	Hole Dia.	No. of Holes
32	90	140	100	18	4
40	90	150	110	18	4
50	90	165	125	18	4
65	134	185	145	18	4
80	156	200	160	18	8
100	178	220	180	18	8
125	178	250	210	18	8
150	152	285	240	22	8
175	152	315	270	22	8
200	178	340	295	22	12
250	184	405	355	26	12

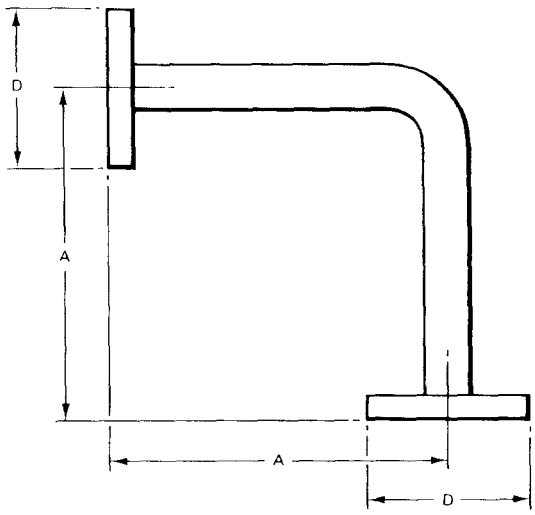

FIG. 8B—DUMMY ALIGNMENT PIECES FOR FLEXIBLE PIPE ASSEMBLIES

FIG. 8b—Dimensions in millimetres

Nom. Size	Dimension A	Flange Dia. D	Bolting		
			PCD	Hole Dia.	No. of Holes
50	484	165	125	18	4
65	486	185	145	18	4
80	486	200	160	18	8
100	500	220	180	18	8

To obtain the best performance from a flexible, it is essential that it is of the correct type and attached in the correct manner. However, with the extensive use of hose for an ever-widening range of applications, there has developed a very large number of non-standard flexibles using an extremely large range of couplings. This proliferation of couplings has partly been created by the fact that there are very few hose manufacturers in the United Kingdom but there is a very large number of suppliers who offer completed hoses to which they have added connections and made them specials. Fortunately, large bore flexibles 100 mm (4″) and above tend to have flange type connections and so avoid this lack of standardization problem. By having flange type connections, the problem of the fluid being transferred becoming exposed to the hose coupling is also avoided. Smaller bore hose connections are generally made of steel or brass although some of aluminium or monel are used when low weight or resistance to a particular type of corrosion is involved. Some non-metallic connections may also be used.

Lifing and Working Conditions

The total life of a flexible is expected to be ten years from the date of cure, and they should be replaced at the end of this period of life. Since 1974, all flexibles should have been marked with the date of manufacture, i.e. the date of cure. Before 1974, some were supplied undated. As a general guide, flexibles with less than five years of life remaining should not be used in new construction ships but may be used in emergency as replacements.

Flexible hoses may be installed in systems carrying sea water, fresh water, lubricating oils, fuels, and air to meet the following working conditions:

(*a*) Ambient temperature range −10°C to 55°C

(*b*) Maximum fluid velocity 3 metres/second.

(*c*) Minimum fluid temperature −2°C

(*d*) Nominal working pressure 958 mbar (vacuum) to 10 bar

(*e*) Maximum fluid temperature:

(*i*) Sea water 30°C

(*ii*) Fresh water 80°C

(*iii*) Dieso/Avcat 30°C

(*iv*) Lub. oil/Hydraulic fluid 80°C

To ensure trouble free life and satisfactory performance, the following points must be observed:

(*a*) Flexibles must be installed correctly and this includes the drilling of flanges.

(*b*) Flexibles must be protected from damage by abrasion and heat.

(*c*) Flexibles should never be painted.

(*d*) The date of manufacture should be checked before installation to ensure that adequate life remains.

Acknowledgements

The author would like to acknowledge the assistance given by Mr. J. Oldham of Oldhams Seals Ltd. and their permission to reproduce the photographs.