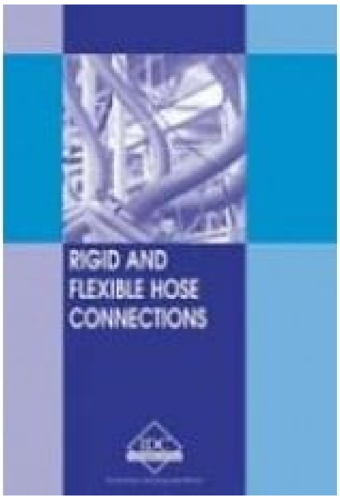
HS-E - Rigid and Flexible Hose Connections



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Short Description

Hose design and construction is a very technical and precise science. Proper selection and sizing of hoses and allied fittings is critical to ensuring the efficiency of a hydraulic system. Good installation and routing practices not only enhance system performance and efficiency but also provide sufficient safeguards under conditions of extreme pressure and temperature. Proper material selection is vital to ensuring long service life of the hose and also goes a long way in minimizing the possibility of premature hose failures. It is also important to strictly adhere to safety considerations, while deciding on the type of hose to be used in a particular application. Hose condition in general can be effectively monitored through the implementation of timely maintenance practices. In the event that any failure symptoms are identified, remedial measures must be undertaken well in time, if catastrophic failures are to be prevented.

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This manual covers: Basic aspects related to hose design and construction. Various hose types from the design as well as application point of view. Sizing and selection of the right type of hose for a particular application. Different materials of construction and the use of reinforced material. Other hose selection criteria based on parameters such as pressure and temperature, shelf life and useful life of hoses in general. Common hose fittings, adaptors, couplings and clamps and also other miscellaneous fittings. Various hose standards and testing procedures. Standard installation practices and hose routing. Maintenance and safety practices related to hoses. Various aspects related to hose failures in general and common troubleshooting techniques.

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First Chapter

Rigid and Flexible Hose Connections - What Constitiutes a Good Hose?

1 What Constitutes a Good Hose?

Hoses are one of the most important conductors used in a hydraulic or pneumatic system and basically used in applications where the lines must bend or flex or in other words, when hydraulic/pneumatic components such as actuators are subjected to movement. Examples of this are found in hydraulically powered machine tools, mobile equipment and portable power units. Although hoses can last a long time, they are not as permanent as metal conductors because the rubber tends to deteriorate over a period of time due to contact with various substances such as solvents, sunlight, heat and water.

A good hose must provide a cost-effective, reliable and efficient means of conveying a given medium. Most importantly, it must fully be compatible with the fluid carried. While it is difficult to predict the actual service life of a hose assembly, an understanding of some of the key operating parameters such as size, application, pressure and temperature is quite essential in ensuring long life and better performance. Following are some of the characteristics of a good hose.

Mechanical

- High strength, rupture and superior flex-fatigue life.
- Good dampening properties, high resistance to abrasion, vibration and flexing.
- Ability to withstand stresses and contain end loads.
- Low coefficient of friction.
- Ability to resist pressure surges and fluctuations.

Chemical

- Compatibility with fluid.
- Resistant to the action of acids, alkalis, solvents, chemicals and sunlight.
- Resist oxidation, surface fouling and discoloration.
- Resistant to permeation by gas and lower moisture absorption capacity.

Thermal

- Ability to withstand a wide temperature range.
- Flame/fire proof, heat resistant
- Favorable thermal expansion characteristics.

Electrical

- Good dielectric properties

These characteristics must be backed by an effective maintenance regime, in order to obtain prolonged hose life and satisfactory performance. The maintenance and replacement intervals must be based on previous service life and in tune with government and industry guidelines and includes simple tasks such as maintaining fluid cleanliness and visually inspecting the hose from time to time for any visible signs of damage due to heat, abrasion etc.

1.2 Hose Design Principles

Hoses are fabricated in layers of elastomer (synthetic rubber) and braided fabric or braided wire, which permit operation at high pressure. Normally, hoses are rated by a safety factor between 1and 4. The various types of coatings and reinforcements used, determine the specific pressure ratings. The volume and velocity of the fluid flow determines the hose size and unlike pipes and tubing, hoses are designated by the inside diameter. The construction of a typical flexible hose is illustrated in Figure 1.1.

Figure 1.1

Construction of a flexible hose

The outer layer is normally made of synthetic rubber and serves to protect the braid layer. The hose can have as few as three layers (one being the braid). When multiple layers are used, they may alternate with synthetic rubber layers or the wire layers may be directly placed over one another.

The design of a hose for a particular application depends on a lot of factors such as length, diameter, minimum bend radius, size, installation and routing practices, compatibility with fluid etc. Let us discuss these in detail.

Installation and Handling

Hose assembly installations must comply with standard hose routing procedures and recommended practices. As the hose and couplings are designed together for the best interface, it is also important to choose the right coupling. Also, intermixing of hose, fittings or assemblies must never be carried out without knowing if they are compatible.

Proper care must also be exercised when handling hose assemblies. Any twisting, pulling, crushing, kinking and adradation of the hose must never be permitted, if longer hose life is to be ensured.

Fluid Compatibility

The entire hydraulic assembly consisting of the tube, cover, reinforcement and couplings must be fluid compatible. It is important to ensure that the correct hose is used. Although many of the hoses are compatible with one or the other, not all the fluids are so.

Hose Size

The hose inner diameter must be capable of handling the required flow volume. If the inner diameter for a given flow volume is too small, excessive fluid pressure that builds up, can lead to tube damage.

Hose Length

When choosing the hose length, factors such as change in length under pressure, machine vibration and motion and hose assembly routing have to be taken into account.

Minimum Bend Radius

The bending or flexing of the hose must conform to the minimum recommended value. Care must also be taken to ensure that the hose is not subjected to any torque or tension as this may result in excessive stress on the reinforcement, while also drastically reducing the ability of the hose to withstand pressure. The table below illustrates the typical minimum bend radii for elastomeric hoses.

Nominal Bore		Low Pressure Fabric Braid				Medium Pressure Single Wire Braid				High Pressure Doubl		
inch	mm	Static		Flexing		Static		Flexing		Static		Flexing
		Inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
1/8	3	2.25	57	4.5	115	2	50	4	100			
¼	6	2.5	64	5	125	2.5	64	5	125	2.5	64	5
3/8	10	2.75	70	5.5	140	3.5	90	7	180	4	100	8

½	12.5	3	75	6	150	4	100	8	200	5	125	10
5/8	16	3.25	82	6.5	165	5	125	10	250	6	150	12
¾	19	3.5	90	7	180	6	150	12	300	7	180	14
1	25	4.5	115	9	230	8	200	16	400	10	250	20
1 1/4	32	5.75	150	10.5	270	10	250	20	500	11	280	22
1 1/2	38	8	200	16	400	12	300	24	600	12	300	24
2	50	15	380	30	760	16	400	32	800	18	460	36

Table 1.1

Typical Minimum Bend Radii for Elastomeric Hoses

Note: The figures given above are only typical values. Practical minimum bend radius depends on the actual construction and materials used and therefore manufacturer recommendations must always be adhered to.

Hose Routing

It is important to use guide clamps wherever necessary in order to minimize the risk of damage due to excessive flexing, whipping and contact with other moving parts. The correct configuration must be used in order that the hose assembly is protected from abrasion and kinking and leak-resistant connections provided.

Applications

The most suitable hose must be selected for a particular application. Particular attention must be paid to applications suction, special fluids and high temperature capabilities.

1.2 Common Hose Types

Hoses are normally employed in fluid circuits where movement has to be accommodated and to provide ease of coupling. They may also be considered in circuits where the use of rigid lines would result in installation or operational problems and in sections, to provide noise or vibration damping or to function as shock absorbers. The three main types of flexible hoses are:

1. Elastomeric tubes reinforced by braided coverings.
2. Metallic flexible hose.
3. Reinforced nylon tubes.

Let us discuss the above three types in detail.

Elastomeric tubes reinforced by braided coverings

As the name suggests, these hoses consist of rubber tubes reinforced by braided coverings. The construction may vary according to the type of application the hose is subjected to. Hoses used in low pressure applications may consist of an oil-resistant seamless inner tube of rubber compound, with an inner reinforcing layer of cotton and an outer cotton braid cover impregnated with a synthetic compound. An additional outer cover in the form of synthetic rubber may or may not be provided.

Figure 1.2

Elastomeric Hoses (courtesy Weatherflex)

In the case of hoses employed in medium pressure applications, the inner tube is normally reinforced with a single wire braid together with fabric braid layers, with the outer braid layer being impregnated. As with low-pressure hoses, a synthetic rubber outer cover may or may not be provided. For hoses used in high-pressure applications, the construction is somewhat similar except that the reinforcement may consist of a double wire braid or even multiple wire braids.

The choice of inner lining material for all these hose types is largely dependent on the fluid to be carried and its service temperature. The impregnation of the outer braid or the synthetic rubber type used as outer cover is also usually selected, based on their compatibility with the fluid used.

Metallic Flexible Hoses

They are normally in the form of a convoluted metallic tube and close braided with steel wire, as illustrated in the figure below. The braid layer or layers, while measuring the strength and protecting the outer surfaces of the convoluted tube, also function as vibration and resonance dampeners when containing the end loads imposed by internal pressure. The depth and pitch of the convolutions and braid tension are critical factors since these govern the change in length of the tubing under pressure and the degree of fretting that is likely on the convolution crests.

Figure 1.3

Convoluted stainless steel hose (courtesy Palmaflex)

One of the principal advantages of using these hose types is their ability to work under high temperature conditions. Although pressure ratings also tend to be high, these hoses normally experience a decrease in their ratings, with increasing bore size. Also, the convoluted inner form in these hoses, results in higher frictional resistance. But this can be reduced by incorporating a flexible smooth bore lining, although this tends to reduce the service temperature of the composite hose to that of the liner material.

Other alternative forms of this type include:

Titeflex all-metal hose

Figure 1.4

All-Metal hose (Titeflex)

This is heavier in construction and permits multiple braiding. Here, the convolutions are formed from helically wound brass strip, seamed, soldered and finally reinforced with single or double layers of tinned cadmium copper wire braid.

3-ply convoluted steel hose

FIGURE 1.5

Three-ply convoluted steel hose (Avica)

This is more suitable for high-pressure applications. Here, the convolutions are in 3-ply stainless steel tube, with an outer stainless steel braid. The outer braids are designed to withstand extreme pressure load ends. Hoses of this type retain the high operating temperature characteristics of conventional convoluted stainless steel pipes (around 500°C) and pressures of up to 6000 psi (42 mPa), depending on the size of the bore.

This is a semi-metallic hose comprising alternate layers of PTFE tube and steel wire braid. These hoses in addition to being substantially flameproof, also permit pressure ratings of up to 4000 psi (28 mPa). A single wire braid and double wire braid PTFE hose are illustrated in the figures below.

PTFE and wire braid hose

Figure 1.6

PTFE single braid wire hose

Figure 1.7

PTFE double braid wire hose

Reinforced Nylon tubes

These are basically nylon tubing with braided outer fabric reinforcement and are more correctly referred to as flexible tubing or nylon hose. Nylon offers a specific advantage in that it is essentially free from fatigue characteristics, while also undergoing relatively little creep or cold flow at elevated temperatures. On the other hand, the strength is markedly temperature-dependent and decreases rapidly with increase in temperature. Coiled tubes in nylon hose are being increasingly used in applications where axial movements have to be accommodated.

1.3 Rigid and Flexible Applications

Rigid or static operation of hoses involves a non-moving application. Here the hose assembly is attached to a stationary object. Although there is no flexing in this type of application, care should be taken to allow enough slack in the assembly, to account for changes in length under surge pressure.

A Flexible or dynamic operation on the other hand, allows for random or intermittent flexing. In this case the hose assembly is attached to a moving object and flexing of the same occurs. As compared to a static operation, a dynamic application requires a larger bend radius, with the increase being dependent on the total angle of flexing. Also, care must be taken to ensure non-stretching of the hose at maximum extension and that the possibility of chaffing is eliminated or provided protection against. The table given below can be used to obtain the bend factor “B” and the appropriate minimum bend radius increased accordingly.

Total Flexing Range	**Bend Factor “B”**
30°	1.08
60°	1.17
90°	1.25
120°	1.33
180°	1.50

The installation and routing procedures for both static and dynamic applications will be discussed in detail, in the discussions to follow.