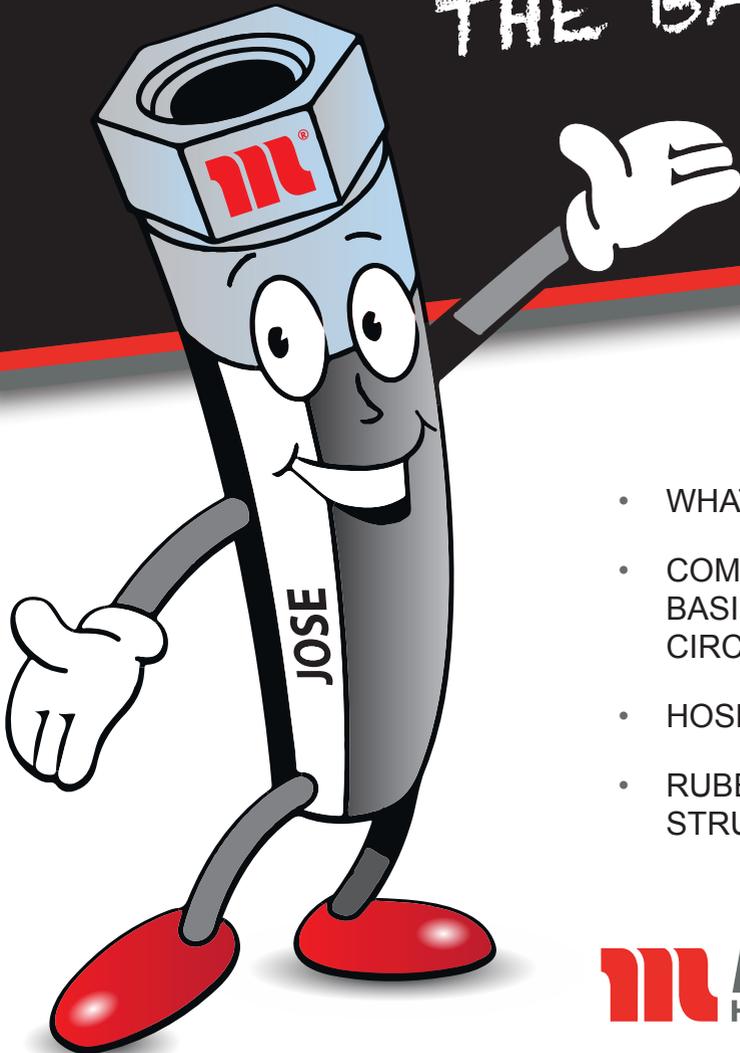


HYDRAULICS THE BASICS



- WHAT IS HYDRAULICS?
- COMPONENTS OF A BASIC HYDRAULIC CIRCUIT
- HOSE ASSEMBLIES
- RUBBER HOSE STRUCTURE

HYDRAULICS - THE BASICS

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WHAT IS HYDRAULICS?



At its most basic level, hydraulics is the generation, control and transmission of power by the use of pressurised liquids.

A hydraulic circuit is a system to supply energy by means of a liquid under pressure.

COMPONENTS OF A BASIC HYDRAULIC CIRCUIT

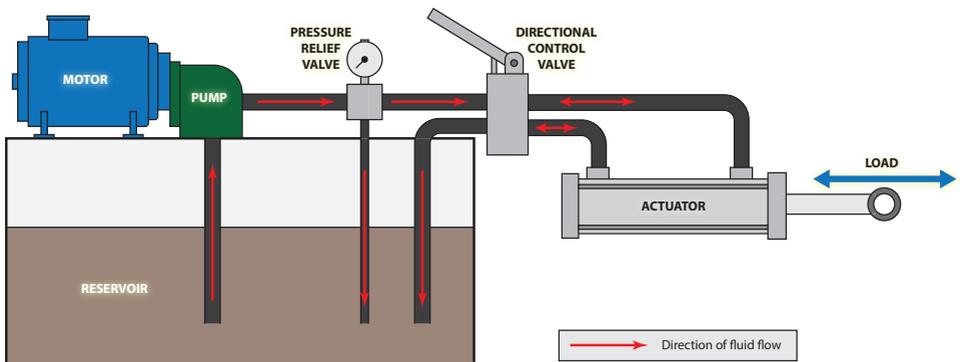


Fig. 1 - A simple hydraulic circuit

MOTOR

Sometimes referred to as a “prime mover”, this is an externally powered device (usually electrical) the purpose of which is to drive the pump.

PUMP

Converts the mechanical energy of the motor into fluid power, by drawing the hydraulic fluid out of the reservoir and sending it into the circuit.

PRESSURE RELIEF VALVE

This is a fundamental safety device which allows fluid to drain back into the reservoir if the pressure in the system exceeds a predetermined value.

DIRECTIONAL CONTROL VALVE

Allows the fluid from one or more sources to flow along different paths in order to control elements within the hydraulic circuit. Directional control valves come in various types with varying numbers of ports depending on the control requirements.

ACTUATOR

Hydraulic actuators convert the transmitted hydraulic power back into useful mechanical energy to move the load. The most common form of actuator used in hydraulic systems is a cylinder or linear actuator. The other common actuator type is a hydraulic motor.

RESERVOIR

This is the tank from which the hydraulic fluid is drawn, and to which it returns after being transmitted through the circuit.

HYDRAULIC POWER

One of the most fundamental equations relating to hydraulics is the calculation of hydraulic power (P)

Hydraulic power is calculated using the following equation:

$$\text{Power (kW)} = \frac{\text{Pressure (bar)} \times \text{Flow Rate (L/min)}}{600}$$

$$P = \frac{p \times Q}{600}$$



The pressure (p) in a hydraulic circuit is created by the load not by the pump.

The pump causes the hydraulic fluid to flow at a rate (Q) in the circuit.

So increasing the load or flow rate will result in increased power in the system.

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HOSE ASSEMBLIES



The flexible conduit used to transfer fluid from one point to another in a hydraulic system is referred to as a hose assembly.

Variation in the overall size and design of hoses assemblies is more or less infinite, but they do all share certain features.

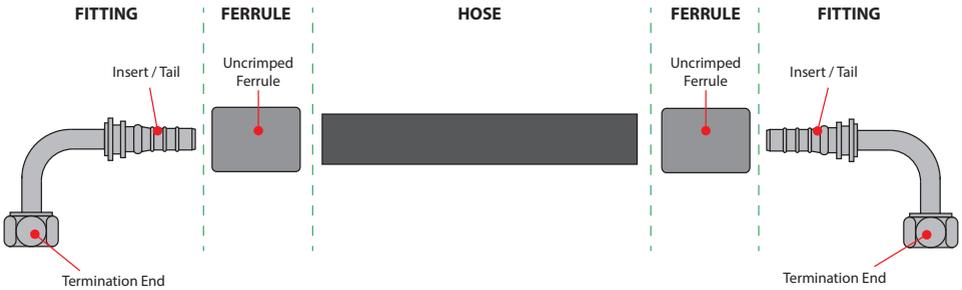


Fig. 2 - Individual components of a hydraulic hose assembly



Fig. 3 - Complete hydraulic hose assembly



An incorrectly made hose assembly can be lethal - only suitably trained people should be allowed to assemble them.

A basic hose assembly is made up of the following components:

HYDRAULIC HOSE

The hydraulic hose is the flexible connection which joins two parts of the hydraulic circuit. Hydraulic hoses come in different diameters, pressure ratings, reinforcement types and cover types. These variations in hydraulic hose types are covered in more detail later in this booklet.

FITTINGS

Each assembly will have a fitting attached to each of the two ends of the hose. These fittings come in a variety of shapes, sizes, thread types etc. A hydraulic fitting typically comprises of:

Termination End - this connects the end of the hose assembly to one of the ports on a system component

Insert (sometimes called a *Tail*) - this is the part of the fitting that is inserted into the end of the hose

FERRULE

This is a metal sleeve which fits over the end of the hose when the fitting is inserted. The ferrule is then mechanically crimped to provide a safe, secure seal and to prevent the fitting from being forcibly ejected from the hose when pressure is applied.

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RUBBER HOSE STRUCTURE



The structure of hydraulic hoses comes in a variety of forms, but the overall composition will almost always conform to the following arrangement:

Tube → Reinforcement → Cover

TUBE

The innermost layer of the hose, the tube's function is to convey the hydraulic fluid and provide full containment of the hydraulic fluid.

The material used for the tube is usually a synthetic rubber chosen specifically for its ability to resist chemical degradation by the intended hydraulic fluid(s).

Typical tube materials and their uses are shown in the below table:



Tube Material	Properties
NBR (Nitrile Butadyene Rubber)	High resistance to mineral and biodegradable oils and fuels
CR (Chloroprene)	Mineral oil resistant
Polyamide	Resistant to a wide range of fluids
PTFE	High temperature, oil, fuel and chemical resistant
EPDM (Ethylene Propylene Diene Rubbers)	Used for phosphate ester based fluids

Table 1 – Typical tube materials and their properties

REINFORCEMENT

Due to the high pressures encountered in hydraulic systems, the internal rubber tube would not survive long on its own. For this reason, the next element of a hydraulic hose's structure is the reinforcement.

The reinforcement provides the hose with the structural strength and integrity to withstand the internal pressure of the hydraulic fluid on the hose during operation.

The type and amount of hose reinforcement required depends on the intended working pressure of the hose.

Hose reinforcement comes in two basic forms and is used to classify the hose into one of the following two families:

Braided Hose



Fig. 4 - Typical wire braided hose structures

Hoses with braided reinforcement use a woven material to contain the pressures on the internal rubber tube.

The woven material can be a textile (eg: Nylon, Aramide or Polyester) for low pressure applications up to 100 bar, or a metal wire weave for higher pressure applications.

Wire braided hoses usually have either one or two layers of reinforcement, but in some cases may have as many as three.

When multiple braided layers are present, they are separated by a layer of adhesive rubber which prevents the layers from rubbing against each other and causing wear.

Spiral Hose

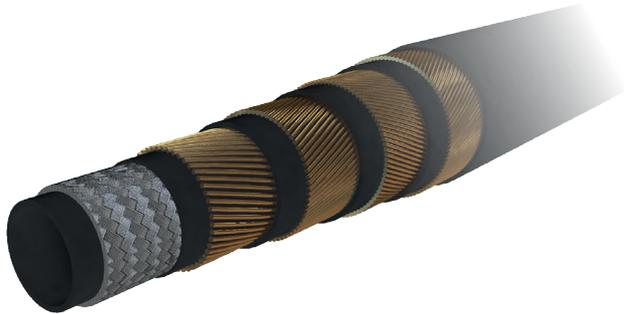


Fig. 4 - Typical wire spiral hose structure

When a higher level of pressure resistance is required, the reinforcement is provided by layers of steel wire spirals.

Wire spirals are usually present in either four or six layers, but in some extreme cases there may be as many as ten layers.

Each layer of wire spiral is wound in the opposite direction to the previous one, and there will only ever be an even number of layers in order to balance the forces within the structure.

As with braided hoses, the individual spiral layers are separated by adhesive rubber layers to prevent wear.

It is also possible to have hoses constructed with a combination of both reinforcement types depending on the required performance of the hose.

Typically, the pressure application of a hose can be judged by the reinforcement type as shown below:



Pressure Application	Pressure Rating	Reinforcement Type
Low Pressure Applications	< 100 bar	Textile Braided Hose
Medium / High Pressure Applications	100 – 300 bar	Wire Braided Hose
High / Very High Pressure Applications	> 200 bar	Wire Spiral Hose

Table 2 – Typical pressure applications based on hose reinforcement type

COVER

The outer cover of a hydraulic hose is its interface with the external world. Hose cover materials are many and varied, selected for a variety of reasons ranging from simple factors such as economy of manufacture and colour, to more safety critical factors such as fire, abrasion and temperature resistance.

The main categories of cover type are as follows:

Smooth Rubber Cover

The outer rubber cover is vulcanized in direct contact with steam at high temperatures or with external plastic mould.

Wrapped Rubber Cover

The outer rubber cover is wrapped in a wet nylon tape during vulcanization, allowing for tighter tolerances and a reduced chance of cover defects. When the nylon tape is removed the hose will retain its imprint, making it easily distinguishable.

Fabric Braided Cover

A woven fabric (often impregnated with rubber adhesive) cover may be used in situations where minimal weight and heat dissipation are required. Due to its relatively low strength, this type of cover is usually only used in low / medium pressure hoses.

Coverless

This option is usually only used in situations where a stainless steel wire braid is used, often on PTFE hoses.

ENVIRONMENTAL FACTORS AFFECTING HOSE COVERS

Hydraulic systems are used in a huge variety of applications, many of which take place in locations and environments that are less than ideal for the materials used in hydraulic hose construction.

The cover of a hose is its first and best line of defence against these harsh conditions.

Choosing the wrong type of cover can become a potential time-bomb for the system as a whole.

The biggest environmental threats to hoses are:

- Temperature
- Ozone
- UV Rays
- Abrasion
- Fire
- Dirt



Each of the above conditions has its own detrimental effect on hose cover compounds, and in many cases they will act in combination to attack the hose - although none of them may be present to a particular extreme.

In these instances a high-quality cover compound will be enough to see the hose through the rigours of day-to-day use.



Manuli offers several high-quality, general-use cover options which are suitable for these types of environments.

However, in some applications there is one environmental factor which is overwhelmingly more significant than all the others combined.

In these situations a specialist cover compound may be required.

These specialist compounds will usually have a particularly high resistance to one or more of the environmental factors which will attack the hose cover in the specific application.

For example, in forestry, hoses are subject to a particularly high degree of abrasion as well as extremes of cold temperature.

In these conditions a general use hose would not survive long and would need replacing more often than is cost effective.

Selecting a specialist hose with enhanced abrasion and cold resistance would be the better choice. The specialist hose may be more expensive piece-for-piece, but the extended life and superior performance of the hose would make it a worthwhile investment.



Manuli has an extensive range of hoses which have been specifically designed to meet the needs of these specialist applications.

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Manuli's specialist cover compounds are typically designed to meet and greatly exceed the requirements of the relevant international standards.

For example, the Manuli high abrasion and ozone resistant covers (TUFF, SHARC and ShieldMaster) perform as shown below:

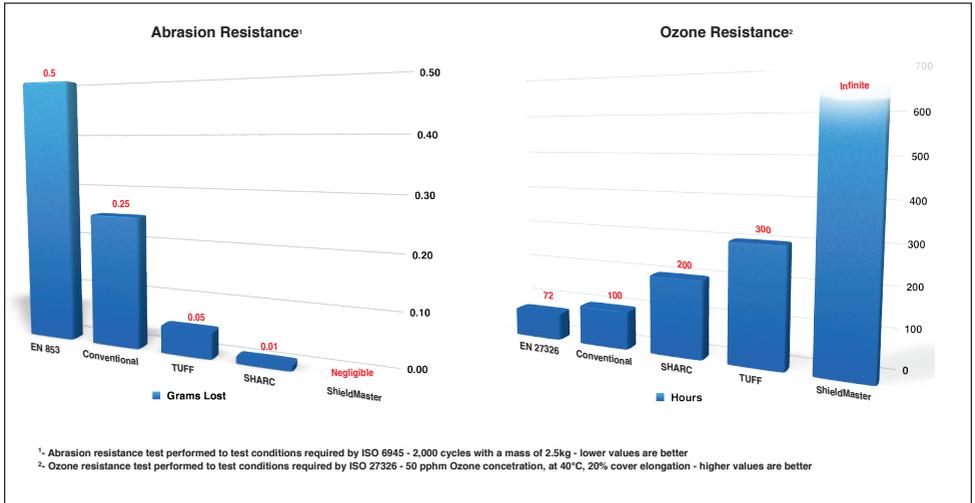


Fig. 5 - Abrasion and ozone resistance performance of Manuli cover compounds

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