A Tomkins Company

WHITE PAPER

Assortment of hoses, couplings, industry standards requires hydraulic systems approach

Among the basic components of every hydraulic system is a series of hoses and couplings that transport fluid under pressure from a pump to an actuating mechanism that converts the fluid into motion or force.

In a way, hoses and couplings are a critical sub-system of the larger hydraulic circuit that includes the fluid, reservoir, hydraulic pump, hydraulic valves and the actuator.

Match hoses, couplings, crimpers

Suppliers offer hundreds of different types and styles of hydraulic hoses, and thousands of different couplings and fittings. When selecting an OE hydraulic hose and coupling system or fabricating an aftermarket assembly, the first step must be to match hoses and couplings from the same manufacturer.

Gates Corporation and the Society of Automotive Engineers (SAE) recommend against using couplings from one manufacturer and hoses from a different manufacturer interchangeably. Although most American-made hydraulic hoses, and many imported hoses, are built to confirm to SAE specifications, SAE allows a wide range of materials to be used.

Different manufacturers use different materials that can result in a variety of hose styles. They design their hose and coupling components to fit their own tolerances. Hoses from various manufacturers may have similar dimensions and constructions, but different rubber compounds and reinforcement materials. Couplings are individually designed and tested to handle the hose manufacturer’s unique product. Also, the proliferation of thread ends from around the world in recent years has dramatically increased the possibility of mismatching threads and seats on various couplings.

To complete the hydraulic assembly system process it’s important that hose fabricators follow the assembly recommendations, and use the crimping equipment of the hose and coupling manufacturer. An improperly matched or coupled hose will likely fail, causing downtime and possible personal injury.

Pressure drop also affects heat gain and the Reynolds Number. A high pressure drop, increases heat, which equates to horsepower loss. The Reynolds Number relates to flow:

Reynolds No. <= 2,000 = Laminar Flow
Reynolds No. > 2,000 and < 3,000 = Transient Flow
Reynolds No. >= 3,000 = Turbulent Flow

When designing a hydraulic hose and coupling system that requires a specified pressure (psi) of output for equipment to run efficiently, it is important to allow for pressure drop. If the system pressure is 4,000 psi and the pressure drop is 150 psi, for example, the system output pressure that will provide work will be at 3,850 psi. Help in determining pressure drop is available from representatives of hose and coupling manufacturers. Be prepared to describe the type of application, fluid type and viscosity, fluid and ambient temperature, fluid flow rate, hose size and length, routing requirements, required government and industry standards and the number and type of fittings.

Tube, cover stocks

Hose selection must assure compatibility of the hose tube, cover, couplings and O-rings with the fluid used. The characteristics shown in Table 1 are for the normal or usual range of specific hose stocks. Also, consult the hose manufacturer’s chemical resistance tables to determine hose compatibility.

Most hydraulic fluids are petroleum-based. Others include water-based, water glycols, and synthetic-based fluids such as phosphate esters. In the past, hydraulic-fluid leaks have sometimes contaminated soil and fouled water supplies. As a result, the industry is moving toward more environmentally friendly fluids.

“Green” fluids are typically synthetic (primarily ester-based) or vegetable-based. Vegetable oils are gaining popularity because they cost less and are more biodegradable than synthetics. They also have excellent lubricity and a high viscosity index. The downside is their limited temperature range and rapid oxidation at elevated temperatures. And although the base fluid may be biodegradable and non-toxic, the additives may not be.

Biodegradable fluids might be great for the environment, but they’re tough on hoses. They permeate ordinary hose tubes, causing cover blisters and sweating/wetness on the cover of the hose. The result is premature and expensive hose failure.

Most manufacturers utilize a nitrile tube for environmentally safe hydraulic fluids. Nitrile is tough enough to handle aggressive biodegradable fluids like synthetic esters, polyglycols, and vegetable oils at operating temperatures to 250ºF. Plus, nitrile permits significantly less permeation than neoprene tubes when used with petroleum-based oils. (Permeation, or effusion, is seepage through the tube and hose, resulting in fluid loss.)

Because permeation may expose the entire hose assembly to fluid, check compatibility not only with the tube, but with the reinforcement, cover, fittings, and seals. The same holds for assemblies that convey special oils or chemicals.

Exercise additional caution selecting hose for gaseous applications subject to permeation. Some fluids that raise concerns include: liquid and gas fuels, refrigerants, helium, fuel oil, and natural gas. If gas permeates through the tube, consider pin-perforated covers to prevent gas build-up. Don't neglect the potentially hazardous effects of permeation, such as explosions, fires, and toxicity. Refer to applicable standards for specific precautions involving fuels and refrigerants.

Hybrid Hose stocks

Tube and cover stocks may be upgraded to enhance performance. The hybridization of rubber and synthetic thermoplastic compounds into abrasion-resistant hydraulic hose offers a number of enhancements over traditional hose materials such as neoprene and nitrile.

A primary cause of hose failure on fluid power equipment is cover abrasions (pictured) resulting from cuts, friction caused by other moving parts or from mechanical impacts. On stationary equipment, for example, hoses can change in length while hydraulic mechanisms are in operation, causing a buffeting action to occur and exposing the hose reinforcement. Exposed hose reinforcement is susceptible to rust and accelerated damage leading to failure.

Hybridized covers made of thermoplastics have a very slick surface with a coefficient of friction just under that of Teflon™. The result is a cleaner appearing cover that resists dirt and oil residues.

Abrasion-resistant hose covers have been tested and found to last up to 300 times longer than standard rubber covers. This feature increases service life, lowers maintenance and eliminates the need for costly hose protectors such as guards, sleeves and bundling.

Also under development are elastomeric tubing compounds that are more readily compatible with a new generation of environmentally friendly hydraulic fluids and additives.

As stated earlier, avoid using couplings and hoses from different manufacturers interchangeably. Different manufacturers use different materials, which can result in a variety of tube styles. SAE allows a whole range of materials. An improperly matched or coupled hose will likely fail causing downtime and possible personal injury. So it's important to follow only the crimp and assembly recommendations of the manufacturer of the products being used.

Temperature Considerations

Fluid temperature and ambient temperature must be considered when selecting both hose and couplings. The hose and couplings must be capable of withstanding the minimum and maximum temperature of the system.

Hoses are rated with a maximum working temperature that can range from 200°F to 400°F (93°C to 204°C). This depends on both the hose materials and the fluid temperature. Using a hydraulic hose at a temperature of 18°F above maximum rated temperature of the hose will decrease the hose life at least in half. Failure to use hydraulic oil with the proper viscosity to hold up under high temperatures can accelerate this problem.

Always follow the manufacturer's temperature recommendations. Depending on materials used, hose temperatures may range from -65°F (Hytrel and winterized rubber compounds) to +400°F (Teflon®).

When hoses are exposed to high external and internal temperatures concurrently, there will be a considerable reduction in hose service life. Insulating sleeves can help protect hose from hot equipment parts and other high temperature sources that are potentially hazardous. In these situations, an additional barrier is usually required to shield fluid from a possible source of ignition.

Minimum Bend Radius

Subjecting a hose to a bend radius smaller than the minimum recommendation places excessive stress on the reinforcement, opens larger gaps between strands of reinforcement and severely reduces the ability of the hose to withstand pressure, thereby reducing hose assembly life. Also, hose bends immediately behind the couplings result in undue stress at the couplings. This is a very common cause of hose failures.

Gates suggests that if the bend must be sharper than the minimum radius, adapters or angle fittings should be used. The hose manufacturer's specifications should be checked to determine the straight hose section, between the couplings, needed for a particular ID As a rule of thumb, a 1/4-inch ID hose requires a five-inch minimum straight section, a 3/4-inch ID hose needs seven inches, and a two-inch ID hose must have at least 11 inches of hose length between the couplings.

SAE Hose Constructions

Here's an overview of SAE J517 specifications. Unless otherwise noted, each hose has an oil-resistant, synthetic-rubber inner tube compatible with petroleum and water-based hydraulic fluids, an oil and weather-resistant synthetic rubber cover, and an operating temperature range from –40 to 100°C.

SAE 100R1: Type A hose has one braid of high-tensile-strength wire around an oil resistant tube (commonly nitrile), and an oil, weather, UV, and ozone-resistant cover commonly made of NBR or NBR/PVC blend. Type AT has the same construction as Type A, except the cover does not need to be removed to assemble with fittings. Type S has the same construction as Type AT and working pressures of ISO 436-1, Type 1SN.
SAE 100R2: hose has two braids of steel-wire reinforcement. A ply or braid of suitable material may be used over the inner tube and/or wire reinforcement to anchor the rubber to the wire. Type A requires skiving (removing) a portion of the cover to assemble with fittings. Type AT has the same construction as Type A, except the cover does not need to be removed to assemble with fittings. Type S has the same construction as Type AT and working pressures of ISO 1436-1, Type 2SN.
SAE 100R3: hose has two braids of textile yarn. It is generally used in low-pressure applications with petroleum oils, antifreeze, or water.
SAE 100R4: hose has one or more plies of woven or braided textile fibers with a spiral of body wire. It's typically used for return and suction lines.
SAE 100R5: hose is reinforced with two textile braids separated by a high-tensile-strength steel-wire braid. All of the braids are impregnated with an oil and mildew-resistant synthetic rubber compound.
SAE 100R6: hose includes one braided or spiral ply of textile yarn. It's for general-purpose, low-pressure applications.
SAE 100R7: thermoplastic hose should be used with synthetic, petroleum, and water-based hydraulic fluids at temperatures from –40 to 93°C. It consists of a thermoplastic inner tube resistant to hydraulic fluids with synthetic-fiber reinforcement and a hydraulic fluid and weather-resistant thermoplastic cover. Nonconductive 100R7 is identified with an orange cover and appropriate layline. Pressure capacity is similar to that of 100R1.
SAE 100R8: high-pressure thermoplastic hose should be used with synthetic, petroleum, and water-based hydraulic fluids within a temperature range from –40 to 93°C. It has a thermoplastic inner tube resistant to hydraulic fluids, synthetic-fiber reinforcement, and a hydraulic fluid and weather-resistant thermoplastic cover. Nonconductive 100R8 is identified with an orange cover and appropriate layline. Pressure capacity is similar to that of 100R2.
SAE 100R9, SAE 100R10, and **SAE 100R11** hoses types have been removed from the SAE standard.
SAE 100R12: hose should be used with petroleum and water-based hydraulic fluids within a temperature range from –40 to 121°C. It has four spiral plies of heavy wire wrapped in alternating directions. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.
SAE 100R13: hose is for petroleum and water-based hydraulic fluids within a temperature range from –40 to 121°C. Multiple spiral plies of heavy wire wrapped in alternating directions cover the inner tube. It's for high-pressure applications subject to surges or flexing.
SAE 100R14: hose handles petroleum, synthetic, and water-based hydraulic fluids within a temperature range from –54 to 204°C. Type A consists of an inner tube of polytetrafluorethylene (PTFE) reinforced with a single braid of stainless steel. Type B has the same construction as Type A, but with the additional feature of an electrically conductive inner surface to prevent buildup of electrostatic charge.
SAE 100R15: hose should only be used with petroleum-based hydraulic fluids within a temperature range from –40 to 121°C. It has multiple spiral plies of heavy wire wrapped in alternating directions. A ply or braid of suitable material may be used over or within the inner tube and/or over the wire reinforcement to anchor the rubber to the wire.
SAE 100R16: hose has one or two braids of steel-wire reinforcement. It's for high-pressure hydraulic applications requiring tight bends and high flexibility.
SAE 100R17: hose, with one or two braids of steel-wire reinforcement, has a constant working pressure rating of 3,000 psi.
SAE 100R18: thermoplastic hose should be used for synthetic, petroleum, and water-based hydraulic fluids in a temperature range from –40 to 93°C. It has a thermoplastic inner tube that resists hydraulic fluids, synthetic-fiber reinforcement, and a hydraulic fluid and weather-resistant thermoplastic cover. Nonconductive 100R18 is identified with an orange cover and appropriate layline. Working pressure rating is 3,000 psi for all sizes.
SAE 100R19: hose has a constant working pressure rating of 4000 psi in all sizes. It has one or two braids of steel-wire reinforcement. A ply or braid of suitable material may be used over the inner tube and/or wire reinforcement to anchor the rubber to the wire.

Table 1
Characteristics of Hose Stock Types

Chemiacl Name	Neoprene	Nitrile	Butyl	Hypalon	EPDM	CPE
Chemical Name ASTM-SE Designation SAE J14 & SAE J200	SC BC	SB BG	R AA	TB CE	R AA	None None
Flame Resistance	Very Good	Poor	Poor	Good	Poor	Good
Petroleum Base Oils	Good	Excellent	Poor	Good	Poor	Very Good
Diesel Fuel	Good to Excellent	Excellent	Poor	Poor	Poor	Very Good
Gas Permeation Resistance	Good	Good	Outstanding	Good to Excellent	Fair to Good	Good
Weather	Good to Excellent	Poor	Excellent	Very Good	Excellent	Good
Ozone	Good to Excellent	Poor for Tube, Good for Cover	Excellent	Very Good	Outstanding	Good
Heat	Good	Good	Excellent	Very Good	Excellent	Excellent
Low Temperature	Fair to Good	Poor to Fair	Very Good	Poor	Good to Excellent	Good
Water-Oil Emulsions	Excellent	Excellent	Good	Good	Poor	Excellent
Water-Glycol Emulsions	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Diesters	Poor	Poor	Excellent	Fair	Excellent	Very Good
Phosphate Esters	Fair for Cover	Poor	Good	Fair	Very Good	Very Good
Phosphate Ester Base Emulsions	Fair for Cover	Poor	Good	Fair	Very Good	Very Good