

HYDRAULIC HOSE: Strength under **pressure**



Modern hydraulic hoses vary widely in terms of pressure ratings, temperature ranges, and materials, but all consist of three basic components: tube, reinforcement, and cover.

The inner tube, made from synthetic-rubber compounds and composites, must be chemically compatible with a wide range of petroleum-based and biodegradable fluids. Special compounds may be required to handle fire-resistant fluids. The tube must also resist corrosion and deterioration and the effects of high or low temperatures.

Reinforcement allows the hose to handle fluid pressures and pressure spikes, and prevents premature hose bursts when properly used. It determines the working pressure of the hose. Hoses with low working pressures normally use textile-fiber reinforcement, while those handling higher pressures generally use high-strength steel wire.

Steel-reinforced hoses, in turn, fall into two categories: braid and spiral. Wire-braided hose handles working

Today's hydraulic hose is engineered for ruggedness and long life despite high operating pressures, pressure spikes, and harsh environments. Better flexibility also makes it easier to route and install.

A wide range of standard and proprietary hoses have evolved to meet most every industrial and mobile-equipment need.



Braided hose
Braided reinforcement can be of wire or textile, and can have one or more layers. It is lightweight and flexible for low to medium-pressure applications.

Spiral hose
Spiraled reinforcement is typically wire and has four or six layers. It handles severe applications with long impulse-service life.

Helical construction
Helical reinforcement has one or more plies of woven or braided textile fibers with a spiral of body wire. It's typically used for low pressure and suction lines.

pressures to 6,000 psi, depending on size, with one or two braid layers. Spiral hose, which generally handles high pressures in larger diameters, has wire spiraled around the tube on a bias, with successive layers laid at opposing angles. There are typically four or six layers of steel reinforcement. In braid and spiral hose, rubber layers separate layers of steel wrap to ensure good adhesion throughout the hose wall.

The cover protects the tube and reinforcement from heat, abrasion, and corrosion, as well as environmental deterioration from heat, cold, UV light, and ozone. Covers are made from synthetic rubber, fiber braids, or a fabric wrap, depending on the application.

Selection considerations

When specifying hydraulic hose, experts agree it's important to understand the relationship between reinforcement and pressure ratings across different classes of hose.

Very-high and extremely high-pressure hose is used in off-highway equipment and heavy-duty machinery subject to extreme impulse or pressure surges. These hoses are reinforced with spiraled, high-tensile steel wire wound over the tube in alternating, even-numbered layers to balance pressure and containment forces. The hoses are often called "four-wire" for high pressure and "six-wire" for extremely high-pressure hose, though the actual number of spiral-wire layers varies with hose ID. Most spiral hose with an ID of 1 in. or

less has four layers.

Spiral reinforcement is particularly suited to high-pressure impulse applications because individual wires in each layer are parallel, and thin rubber-adhesion layers separate adjacent reinforcement layers and keep the wires from cutting one another.

Spiral construction packs the reinforcement tighter around the tube than does braid reinforcement and, therefore, provides more support. Individual ends or strands can be bound tightly together as opposed to the over-under gaps with braiding. However, braided hose is generally more flexible than spiral hose.

High-pressure hoses are mainly "two-wire" braid hose because it generally has this type of high-tensile-strength steel reinforcement. It is frequently used on construction equipment and similar applications. Operating pressures range from 6,000 psi for a $3/16$ -in. ID to 1,825 psi for 2-in. ID. Some proprietary hoses, such as **Gates M3K** and **M4K**, have the same pressure rating for all sizes.

Medium-pressure hoses handle hydraulic applications requiring operating pressures of 300 to 3,000 psi. They may have one-wire steel-braid reinforcement or multiple wire and/or textile-braid construction.

In addition to medium-pressure hydraulic equipment, these hoses are often used in heavy-duty truck and fleet applications. In the early 1940s, there were no flexible hoses

Authored by:

Dennis Kemper

Fluid Power Consultant
Aurora, Colo.

Edited by **Kenneth J. Korane**
ken.korane@penton.com

Key points:

- SAE J517 Standard remains the benchmark for hydraulic hose dimensions and performance.
- Many proprietary hoses offer higher pressure ratings, longer life, and more flexibility than standard hoses of the same size.

Resources:

Gates Corp., www.gates.com/hydraulics

For information on MXP hose,
www.gates.com/mxp

For information on SAE J517 hose standards, www.sae.org

SAE J517 ratings

SAE HOSE TYPE	TEMPERATURE RANGE, °F	HOSE DASH SIZE AND MAXIMUM WORKING PRESSURE, PSI														
		-3	-4	-5	-6	-8	-10	-12	-16	-20	-24	-32	-40	-48	-56	-64
100R1	-40 to 212	3,625	3,275	3,125	2,600	2,325	1,900	1,525	1,275	925	725	600				
100R2	-40 to 212	6,000	5,800		4,800	4,000	3,625	3,100	2,400	1,825	1,300	1,175				
100R3	-40 to 212		1,250		1,125	1,000	875	750	565	375						
100R4	-40 to 212							300	250	200	150	100	62	56	45	35
100R5	-40 to 212		3,000			1,750	1,500		625*		500*	350*				
100R6	-40 to 212	500	400	400	400	400	350	300								
100R7	-40 to 200		2,750		2,250	2,000	1,500	1,250	1,000							
100R8	-40 to 200		5,000		4,000	3,500	2,750	2,250	2,000							
100R12	-40 to 250				4,000	4,000	4,000	4,000	4,000	3,000	2,500	2,500				
100R13	-40 to 250				5,000	5,000	5,000	5,000	5,000	5,000						
100R14	-54 to 400		1,500		1,500	800	800	800	800							
100R15	-40 to 250				6,000	6,000	6,000	6,000	6,000	6,000						
100R16	-40 to 212		5,000		4,000	3,500	2,750	2,250	2,000							
100R17	-40 to 212		3,000	3,000	3,000	3,000	3,000	3,000	3,000							
100R18	-40 to 200	3,000	2,750	2,500	2,250	2,000		1,250	1,000							
100R19	-40 to 212		4,000		4,000	4,000	4,000	4,000								

* Pressures shown are for SAE 100R5 sizes 1.12, 1.38, and 1.81-in. ID, respectively.

Though many proprietary products now exceed the performance of similar SAE-rated hose, the J517 Standard remains the benchmark for hydraulic-hose dimensions and performance.

on the market specifically for fleet users. Truck mechanics turned to aircraft hydraulic hose and applied it to fleet applications. Soon the hose replaced rigid copper tubing originally used on trucks. This truck hose is often called flexline, TWT (textile-wire-textile), or C5 hose, after the Society of Automotive Engineers (SAE) standard designation of 100R5.

Low-pressure hydraulic hoses withstand operating pressures up to 300 psi. Reinforcement is usually textile. They are found on low-pressure hydraulic applications and transmit petroleum-based fluids, diesel fuel, hot lubricating oil, air, glycol antifreeze, and water. Some, such as Global MegaVac (GMV), are also rated for suction applications.

Specialty hydraulic hoses do not fit well into a particular pressure category. For example, specialty hose might be used in applications such as conveying refrigerant, environmentally friendly hydraulic fluids, or LPG gas, operating at extremely high or low temperature, or requiring electrical nonconductivity. They may be specified where weight is a concern or long continuous lengths are required. Reinforcement is generally nonmetallic — usually a rubber-impregnated fabric.

SAE hose constructions

To bring a measure of uniformity to hydraulic-hose manufacturing, minimum standards for construction, dimensions, and performance have long been established in North America by SAE.

In other parts of the world, organizations such as the European Norm/Standard (EN), Deutsche Industrie Norm (DIN), and the International Standards Organization (ISO) also set standards, which may differ from those of SAE. Governmental agencies also set standards. Among them are the Mine Safety & Health Administration (MSHA) and the Department of Transportation's Federal Motor Vehicle Safety Standards.

SAE Standard J517 provides general, dimensional, and performance specs for the 100R hose series, which are the most common hoses used in hydraulic systems. Here's an overview of SAE 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 PVC. 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 ISN.

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. This hose type has been removed from the SAE standard.

SAE 100R10. This hose type has been removed from the SAE standard.

SAE 100R11. This hose type has 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 4,000 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.

Exceeding SAE specs

Some manufacturers have developed hoses that far exceed the performance and construction requirements of SAE specifications. Benefits to users include higher pressure and temperature capabilities, greater flexibility, and a bend radius as little as one-half that of the SAE standard.

One such product is Gates M-XP hydraulic hose, which combines the flexibility of wire-braid construction with the strength and performance of spiral-wire reinforcement. The result is an economical, two-braid wire hose that handles 4,000-psi high-impulse duty in all sizes.

M-XP hose is rated for 1,000,000 impulse cycles (at 100°C), which exceeds the SAE standard of 200,000 impulse cycles and the Gates minimum requirement of 600,000 impulse cycles for typical wire-braid hoses. A high cycle rating equates to longer service life and makes the hose suited for out-of-sight and hard-to-reach applications such as boom arms and scissor lifts on mobile and construction equipment.

The hose also has half the minimum bend radius of equivalent SAE-rated hose. This means it tolerates tighter bends without compromising performance or life. In some installations, this can reduce the required hose length by nearly 50%. Greater flexibility also makes it easier to install in confined spaces.

Another advantage is that rather than needing expensive spiral-wire couplings, M-XP hose can use less-costly, one-piece MegaCrimp couplings that are also rated for ≥1,000,000 impulse test cycles. The assemblies meet MSHA flame-resistance requirements. **MD**