Hydraulic hose

Hydraulic hose provides a basic means for transporting fluid from one component to another, and at the same time it supplies an inherent versatility to designers.

To say that hose is an important part of a hydraulic system is a huge understatement. The flexibility of hose enables components to be positioned in the most efficient or convenient places, because the hose has the ability to bend around corners, through tight spaces, or across long distances.

Yet these days, there seems to be as many different *types* of hose as there are telephone long-distance carriers. How does a designer tell one from the other? Isn't there an easy way to choose or compare hoses?

The SAE standards

SAE answers those questions with its J517 hydraulic hose standard. This hose standard serves as the most popular benchmark in the realm of industrial hydraulics today. More specifically, J517 is a set of guidelines that applies to the current SAE 100R series of hoses. Currently, 16 such hose styles exist, and they are designated as 100R1 through 100R16 (see descriptions, pages A105 and 106). Each of the styles must meet a set of dimensional and performance characteristics as set forth by SAE. However, SAE issues no approval source lists, certification, or letters of approval—conformance to these standards by manufacturers is strictly voluntary. In short, the standards only assure a *similarity* of products among different manufacturers.

Hydraulic hose construction

Modern hydraulic hose typically consists of at least three parts: an inner tube that carries the fluid, a reinforcement layer, and a protective outer layer.

The inner tube must have some flexibility and needs to be compatible with the type of fluid it will carry. Commonly used compounds include synthetic rubber, thermoplastics, and PTFE, sometimes called Teflon. The reinforcement layer consists of one or more sheaths of braided wire, spiral-wound wire, or textile yarn. The outer layer is often weather-, oil-, or abrasion-resistant, depending upon the type of environment the hose is designed for.

Not surprisingly, hydraulic hoses have a finite life. Proper sizing and use of the correct type of hose will certainly extend the life of a hose assembly, but there are many different factors that affect a hose's lifespan. SAE identifies some of the worst offenses as:

- flexing the hose to less than the specified minimum bend radius
- twisting, pulling, kinking, crushing, or abrading the hose
- operating the hydraulic system above maximum or below minimum temperature
- exposing the hose to rapid or transient rises (surges) in pressure above the maximum operating pressure, and
- intermixing hose, fittings, or assembly equipment not recommended as compatible by the manufacturer or not following the manufacturer's instructions for fabricating hose assemblies.

For more info . . .
Manufacturers' recommendations on proper hose installation and routing techniques appear on pages A/99-101.

Selecting the proper hose

Here are seven recommended steps the system designer should follow during the hose and coupling selection process. To help determine the proper hose for an application, use the acronym *STAMPED* — from *S*ize, *T*emperature, *A*pplication, *M*aterials, *P*ressure, *E*nds, and *D*elivery. Here is what to consider in each area:

Size — In order to select the proper hose size for replacement, it is important to measure the inside and outside hose diameters exactly using a precision-engineered caliper, as well as the length of the hose. Hose OD is particularly impor-

	Type of fluid				Pressure range			
SAE#	Petroleum oil	Synthetic oil	High-water content	Temp.*	psi	ID, in.	psi	ID, in.
100R1	x		x	1	3000	3/16	375	2
100R2	x		x	1	5000	3/16	1000	2 1/2
100R3	x		x	1	1500	3/16	375	1 1/4
100R4	x		x	1	300	3/4	35	4
100R5	x		x	1	3000	3/16	200	3
100R6	x		x	1	500	3/16	300	3/4
100R7	x	x	x	2	3000	3/16	1000	1
100R8	x	x	x	2	5000	3/16	2000	1
100R9	x		x	1	4500	3/8,	2000	2
100R10	x		x	1	10,000	3/16	2500	2
100R11	x		x	1	12,500	3/16	2500	2 1/2
100R12	x		x	3	4000	3/8	2500	2
100R13	x		x	3	5000	3/4	5000	2
100R14	x	x	x	4	1500	1/8	600	1 1/8
100R15	x			3	6000	3/8	6000	1 1/2
100R16	x		x	1	5000	1/4	1625	1 1/4

*Temperatures...
1 = -40° to 100° C 2 = -40° to 93° C 3 = -40° to 121° C 4 = -54° to 204° C

tant when hose-support clamps are used or when hoses are routed through bulkheads. Check individual hose specification tables for ODs in suppliers' catalogs. When replacing a hose assembly, always cut the new hose the same length as the one being removed. Moving components of the equipment may pinch or even sever too long a hose. If the replacement hose is too short, pressure may cause the hose to contract and be stretched, leading to reduced service life.

Changes in hose length when pressurized range between +2% to –4% while hydraulic mechanisms are in operation. Allow for possible shortening of the hose during operation by making the hose lengths slightly longer than the actual distance between the two connections.

Temperature —All hoses are rated with a maximum working temperature ranging from 200° to 300° F based on the fluid temperature. Exposure to continuous high temperatures can lead to hoses losing their flexibility. Failure to use hydraulic oil with the proper viscosity to hold up under high temperatures can accelerate this problem. Always follow the hose manufacturer's recommendations.

Exceeding these temperature recommendations can reduce hose life by as much as 80%. Depending on materials used, acceptable temperatures may range from –65° F (Hytrel and winterized rubber compounds) to 400° F (PTFE). External temperatures become a factor when hoses are exposed to a turbo manifold or some other heat source.

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 hydraulic fluid from a potential source of ignition.

Application — Will the selected hose meet bend radius requirements? This refers to the minimum bend radius (usually in inches) that a hydraulic hose must meet. Exceeding this bend radius (using a radius smaller than recommended) is likely to injure the hose reinforcement and reduce hose life.

Route high-pressure hydraulic lines parallel to machine contours whenever possible. This practice can help save money by reducing line lengths and minimizing the number of hard-angle, flow-restricting bends. Such routing also can protect lines from external damage and promote easier servicing.

Materials — It is mandatory to consult a compatibility chart to check that the tube compound is compatible with the fluid used in the system. Elevated temperature, fluid contamination, and concentration will affect the chemical compatibility of the tube and fluid. Most hydraulic hoses are compatible with petroleum-based oils. Note that new readily biodegradeable or *green* fluids may present a problem for some hoses.

Pressure capabilities — Hose working pressure must always be chosen so that it is greater than or equal to the *maximum* system pressure, including pressure spikes. Pressure spikes greater than the published working pressure will significantly shorten hose life.

Hose ends — The coupling-to-hose mechanical interface must be compatible with the hose selected. The proper mating thread end must be chosen so that connection of the mating components will result in leak-free sealing.

There are two general categories of couplings to connect most types of hose: the permanent type (used primarily by equipment manufacturers, large-scale rebuilders, and maintenance shops) and the field-attachable type.

Permanently attached couplings are cold-formed onto the hose with powered machinery. They are available for most rubber and thermoplastic hoses and offer a wide range of dependable connections at low cost. Assemblies made in the field with portable machines are relatively simple; these machines are economical and easy to operate. In most cases, it is not necessary to skive the cover. These couplings are less complicated to install than other types.

Field-attachable couplings are classified as screw-together and clamp-type. The screw-together coupling attaches to the hose by turning the outer coupling shell over the outside diameter of the hose. The coupling insert is then screwed into the coupling shell. A clamp-type coupling has a 2-piece outer shell that clamps onto the hose OD with either two or four bolts and nuts.

In either case, the coupling has limited potential for reuse because the threads distort during attachment.

To ensure the correct-size coupling is used when replacing an assembly, the number of threads per inch and thread diameter of the original coupling must be determined. Thread pitch gages are available for identifying the number of threads per inch. A caliper can measure both inside and outside dimensions of the threads. ODs are measured on male couplings, while IDs are measured on female couplings.

In most situations, the only differences between an SAE coupling and an imported coupling are the thread configuration and the seat angle. International thread ends can be metric, measured in mm, but also include BSP (British Standard Pipe) threads, which are measured in inches. Knowing the country of origin provides a clue as to what type of thread end is used. DIN (Deutsche Industrial Norme) fittings began in Germany and now are found throughout Europe, while BSP is found on British equipment. Japanese Komatsu machinery uses Komatsu fittings with metric threads, while other Japanese equipment most likely uses JIS (Japanese Industrial Standard–BSP threads), or, in some cases, BSP with straight or tapered threads.

Three determinations are required to identify these couplings correctly:

- type of seat — inverted (BSPP & DIN), regular (JIS & Komatsu) or flat (flange, flat-face)
- seat angle — 30° (JIS, BSP, DIN and Komatsu) or 12° (DIN), and
- type of threads — metric (DIN or Komatsu), BSP (BSPP, BSPT or JIS), or tapered (BSPT or JIS Tapered)

SAE standards relating to hydraulic/pneumatic fittings and assemblies specifically designed to eliminate leakage include:

- J514 — straight thread ports/fittings
- J518c — 4-bolt flange ports/fittings, and
- XJ1453 — the number provisionally assigned to O-ring face seal fittings.

Delivery — How available is the product? Is it unique? How soon can it be delivered to the distributor or end user? It may be preferable to consider several options to maximize flexibility and avoid the delays that can result from relying on components that are

SAE hose standards — description and construction

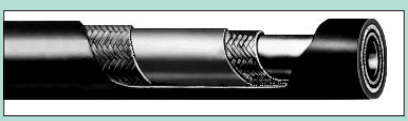
SAE 100R1

This hose should be used with petroleum- and water-based hydraulic fluids, within a temperature range from – 40° to 100° C.

Type A—Consists of an inner tube of oil-resistant synthetic rubber, a single wire braid reinforcement, and an oil- and weather-resistant synthetic rubber cover. A ply, or braid, of suitable material may be used over the inner tube or over the wire reinforcement (or both) to anchor the synthetic rubber to the wire.

Type AT—Same construction as Type A, except it has a cover designed to assemble with fittings which do not require removal of the cover or any portion of it.

SAE 100R2



This hose should be used with petroleum- and water-based hydraulic fluids, within a temperature range from – 40° to 100° C.

It consists of an inner tube of oil-resistant synthetic rubber, steel-wire reinforcement according to hose type, as detailed below, and an oil- and weather-resistant synthetic rubber cover. 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.

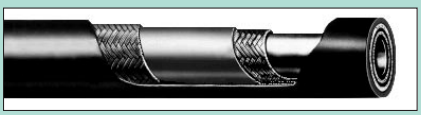
Type A — This type has two braids of wire reinforcement

Type B — This type has two spiral plies and one braid of reinforcement

Type AT — This type is the same as Type A, but has a cover designed to assemble with fittings which do not require removal of the cover or any portion of it.

Type BT — This type is the same as Type B, but has a cover designed to assemble with fittings which do not require removal of the cover or any portion of it.

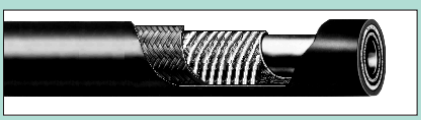
SAE 100R3



This hose should be used with petroleum- and water-based hydraulic fluids, within a temperature range from – 40° to 100° C.

It is constructed with an inner tube of oil-resistant synthetic rubber, two braids of suitable textile yarn, and an oil- and weather-resistant synthetic rubber cover.

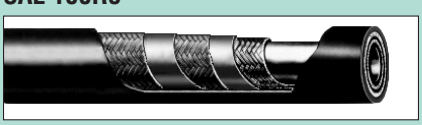
SAE 100R4



This hose should be used in low pressure and vacuum applications, with petroleum- and water-based hydraulic fluids, within a temperature range from – 40° to 100° C.

It is constructed with an inner tube of oil-resistant synthetic rubber, a reinforcement consisting of a ply, or plies, of woven or braided textile fibers with a suitable spiral of body wire, and an oil- and weather-resistant synthetic rubber cover.

SAE 100R5



This hose should be used with petroleum- and water-based hydraulic fluids, within a temperature range from – 40° to 100° C.

It is constructed with an inner tube of oil-resistant synthetic rubber 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

This hose should be used with petroleum- and water-based hydraulic fluids within a temperature range from – 40° to 100° C.

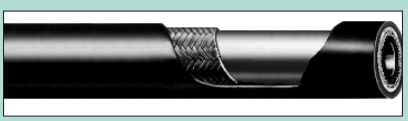
It consists of an inner tube of oil-resistant synthetic rubber, one braided ply of suitable textile yarn, and an oil- and weather-resistant synthetic rubber cover.

SAE 100R7

This thermoplastic hose should be used for synthetic, petroleum-, and water-based hydraulic fluids in a temperature range from – 40° to 93° C.

It consists of a thermoplastic inner tube resistant to hydraulic fluids with suitable synthetic-fiber reinforcement and a hydraulic fluid- and weather-resistant thermoplastic cover. Nonconductive 100R7 is identified with an orange cover and appropriate lay line. Its pressure capacity is similar to that of 100R1.

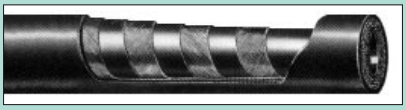
SAE 100R8



This 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 consists of a thermoplastic inner tube resistant to hydraulic fluids with suitable synthetic-fiber reinforcement and a hydraulic fluid- and weather-resistant thermoplastic cover. Nonconductive 100R8 is identified with an orange cover and appropriate lay line. Its pressure capacity is similar to that of 100R2.

SAE 100R9



This hose should be used with petroleum- and water-based hydraulic fluids within a temperature range from −40° to 100° C.

Type A—This type consists of an inner tube of oil-resistant synthetic rubber, four spiral plies of wire wrapped in alternating directions, and an oil- and weather-resistant synthetic rubber cover. 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.

Type AT—This type is the same construction as Type A, but has a cover designed to assemble with fittings which do not require removal of the cover or any portion of it.

SAE 100R10

This hose should be used with petroleum- and water-based hydraulic fluids within a temperature range from −40° to 100° C.

Type A—This type consists of an inner tube of oil-resistant synthetic rubber, four spiral plies of heavy wire wrapped in alternating directions, and an oil- and weather-resistant synthetic rubber cover. 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.

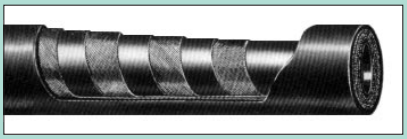
Type AT—This type has the same construction as Type A, but its cover is designed to assemble with fittings which do not require removal of the cover or any portion of it.

SAE 100R11

This hose should be used with petroleum- and water-based hydraulic fluids within a temperature range from −40° to 100° C.

It consists of an inner tube of oil-resistant synthetic rubber, six spiral plies of heavy wire wrapped in alternating directions, and an oil- and weather-resistant synthetic rubber cover. 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.

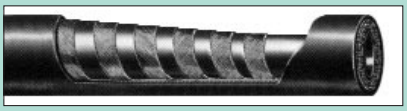
SAE 100R12



This hose should be used with petroleum- and water-based hydraulic fluids, within a temperature range from −40° to 121° C.

It consists of an inner tube of oil-resistant synthetic rubber, four spiral plies of heavy wire wrapped in alternating directions, and an oil- and weather-resistant synthetic rubber cover. 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.

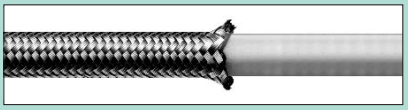
SAE 100R13



This hose should be used with petroleum- and water-based hydraulic fluids, within a temperature range from −40° to 121° C.

It is constructed with an inner tube of oil-resistant synthetic rubber, followed by multiple spiral plies of heavy wire wrapped in alternating directions, and concluding with an oil- and weather-resistant synthetic rubber cover. 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 100R14



This hose should be used with petroleum-, synthetic-, and water-based hydraulic fluids within a temperature range from −54° to 204° C.

Type A—This type consists of an inner tube of polytetrafluorethylene (PTFE) reinforced with a single braid of type 303XX stainless steel.

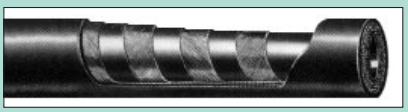
Type B—This type has the same construction as Type A, but has the additional feature of an electrically-conductive inner surface to prevent buildup of an electrostatic charge.

SAE 100R15

This hose should be used with petroleum-based hydraulic fluids within a temperature range from −40° to 121° C.

It consists of an inner tube of oil-resistant synthetic rubber, multiple spiral plies of heavy wire wrapped in alternating directions, and an oil- and weather-resistant rubber cover. 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 synthetic rubber to the wire.

SAE 100R16



This hose should be used with petroleum- and water-based hydraulic fluids, within a temperature range from −40° to 100° C.

It consists of an inner tube of oil-resistant synthetic rubber, steel wire reinforcement of one or two braids, and an oil-and weather-resistant synthetic rubber cover. 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.