A detailed close-up photograph of industrial hydraulic equipment. The image shows several black, braided hydraulic hoses connected to yellow metal fittings and manifolds. Some hoses have white or yellow identification tags. The background is a bright yellow, suggesting the body of a piece of heavy machinery. The lighting is focused on the connections, highlighting the textures of the hoses and the metallic surfaces.

THE WHAT, WHERE & WHY OF TUBE FITTINGS AND ADAPTERS



BRENNAN



THE WHAT, WHERE & WHY OF TUBE FITTINGS AND ADAPTERS

The safety, reliability and service life of a system are only as good as its transfer lines and connections. Tube fittings and adapters are critical components in tubing and hose connections, valves, hydraulic systems, pumps and cylinders. The right connection of the fitting and tube or hose provides outstanding leak free service life, even at high temperatures, pressures, corrosive environments and steady vibration cycles.

There are two primary types of fitting connections, providing two principal functions:

- **METAL SEAL CONNECTIONS**
- **O-RING OR OTHER SOFT SEAL CONNECTIONS**

Simply put, fitting connections hold and seal system components under pressure via hoses, tubes, pipes, manifolds or other port connections.

JIC SAE J514 AND J1453 FITTINGS

The most widely used hydraulic tube fittings (metal seal connectors) are 37° flare and 24° bite type flareless. Just as important in many piping applications are O-ring fittings. The JIC 37° flare fitting has a tapered seating surface (aka AN 37° flare) which mates with a flared tube or hose end and is then tightened with a nut which is preset on the tube before flaring. A 24° bite type flareless (aka compression) fitting incorporates a nut that drives a ferrule (inner compression ring) into the tube as it is tightened, making a bite type connection on the tube. And fittings which incorporate an O-ring provide extra leak-tight connections in lower pressure piping applications. JIC fittings are widely used in fuel delivery and fluid power applications, and depending on the fitting style and material are sometimes designed to withstand high pressures of up to 10,000 PSI.

SELECTING THE RIGHT FITTING FOR THE APPLICATION

Fitting selection is critical to proper system operation, safety and service life. The acronym STAMP is an industry-wide term for what to consider when selecting fluid and gas components:

- **S**ize
- **T**emperature
- **A**pplication
- **M**edia
- **P**ressure

SIZE: Start with establishing the OD (outside diameter) and wall thickness of the tube based on required temperature, pressure, flow rate and other ambient conditions. In most applications flare fittings have a maximum tube wall thickness limitation, while flareless bite type fittings have minimum wall limitation. Select tube OD and wall thickness based on the system requirements and fitting specifications.

TEMPERATURE: Fitting material and type of seal (i.e. metal-to-metal or O-ring elastomer) is what establishes the allowable temperature range. Refer to the table below when selecting common fitting and seal materials with consideration to ambient and media transfer temperature:

Fitting Material	Operating Temperature Range	Seal Material	Operating Temperature Range
Aluminum	-40°→400°F (-40°→204°C)	EPDM (SAE J515, Type II)	-40°→ 400°F (-40°→204°C)
Brass	-40°→400°F (-40°→204°C)	Fluorocarbon (SAE J515, Type III)	-15°→400°F (-26°→204°C)
Stainless Steel	425°→1200°F (-254°→649°C)	Nitrile/Buna-N (SAE J515, Type I)	-30°→250°F (-34°→121°C)
Steel	-65°→500°F (-54°→260°C)		

APPLICATION: The application is what drives the entire selection of components. There is a big difference between delivering the flow of hazardous chemical pressurized steam versus hydraulic fluid or fuel. Even the delivery of fuel can vary from diesel to gasoline to CNG or LNG (compressed or liquid natural gas). Highly corrosive applications require stainless steel and sometimes other exotic alloys, such as Monel or Hastelloy. Even brass is sometimes a good choice in certain corrosive applications and steel fittings typically incorporate a corrosion resistant protective coating, but cannot deliver the corrosion resistance and measurably higher pressure rating of stainless steel and other exotic alloys. The many variables of system environment obviously influence fitting selection. Also consider the severity of the application, whether operating requirements are dynamic or static and the potential consequences of failure if selecting the wrong fitting.

MEDIA: The fluid or gas media to be transferred must be considered when selecting fitting and seal materials. It is important to identify the Chemical Compatibility of the fitting and tube selection material. Cole-Parmer®, a leader in laboratory and industrial fluid handling equipment provides an excellent [Chemical Compatibility Database](#).

PRESSURE: The pressure rating of a fitting must be equal to or exceed the required system pressure. The design of the connection must be established as a ratio of the required pressure and the rated strength of the fitting. To ensure safety and reliability in fluctuations of operating conditions, tube fittings are rated with a 4 to 1 design factor under normal operating circumstances.

This helps protect the system from most hydraulic and mechanical shock. The pressure capability in fitting selection depends on many factors, including tube wall thickness and tube or hose pressure rating, fitting type (i.e. flare vs. flareless), material, media and torque. The relationship between the pressure in-line and fitting torque is important. If a fitting is not torqued properly the system pressure can blow the connection. Be sure to refer to the manufacturer's pressure rating guidelines when selecting fitting type.

For instance, note the partial chart on the next page that illustrates the relationship of Suggested OEM Torque & Pressure Ratings for SAE J514 and J1453 Steel Fittings:

SUGGESTED OEM TORQUE & PRESSURE RATINGS

SAE J5 14 AND J1453 STEEL FITTINGS

Dash Size	Type	Wet Torque (ft-lb)	Variance	Flats Method for JIC Only	SAE Working Pressure 4:1
4	MAORB Jam Nut	23	+2 -2	N/A	4,000
4	MORB Straight Thread Port Connections	15	+2 -2	N/A	5,000
4	O-Ring Face Seal Treads	13	+2 -2	N/A	6,000
4	JIC 37* Flare and Swivel Nuts	13	+2 -2	1 1/2 -1 3/4	5,000/4,500
6	MAORB Jam Nut	32	+2 -2	N/A	4,000
6	MORB Straight Thread Port Connections	24	+2 -2	N/A	5,000
6	O-Ring Face Seal Treads	23	+2 -2	N/A	6,000
6	JIC 37* Flare and Swivel Nuts	23	+2 -2	1 - 1 1/2	5,000/4,500
8	MAORB Jam Nut	55	+3 -3	N/A	4,000
8	MORB Straight Thread Port Connections	40	+3 -3	N/A	4,500
8	O-Ring Face Seal Treads	40	+3 -3	N/A	6,000
8	JIC 37* Flare and Swivel Nuts	40	+3 -3	1 1/2 -1 3/4	4,500/4,000
10	MAORB Jam Nut	75	+5 -3	N/A	3,000
10	MORB Straight Thread Port Connections	60	+5 -3	N/A	3,500
10	O-Ring Face Seal Treads	60	+5 -3	N/A	6,000
10	JIC 37* Flare and Swivel Nuts	60	+5 -3	1 - 1 1/2	3,500/4,000
12	MAORB Jam Nut	115	+5 -3	N/A	3,000
12	MORB Straight Thread Port Connections	100	+5 -3	N/A	3,500

FITTING CONSTRUCTION

Straight fittings are machined from bar stock. Fittings that have an angle (such as tees, crosses, elbows, etc.) are usually one piece forgings. A one piece forged fitting has fewer leak paths than a multi-piece machined fitting. In addition, single piece forged materials allow for higher torque capacities, allowable working pressure and a longer service life. Consider the fact that a single piece of most anything is stronger than an item constructed of multiple parts.

FITTING TYPES & APPLICATIONS

The fitting connects to a tube, hose or a port. A port connection is part of a component, such as a manifold or pump. Fittings are made to industrial standards, the most common of which are:

- **DIN:** Deutsches Institut für Normung which is the German institute for Standardization
- **ISO:** International Organization for Standardization
- **JIC:** Joint Industry Council
- **MIL-STD:** Military; Department Of Defense Standard Practice
- **SAE:** Society of Automotive Engineers

WIDELY USED FITTINGS

SAE J514/J1453 37° FLARE, 24° FLARELESS (BITE TYPE) & O-RING FACE SEAL FITTINGS

Hydraulic tube fittings made to J514/MIL-DTL-18866 includes 37° flare seating face seal and 24° flareless type fittings. O-ring face seal (ORFS) fittings conform to SAE J1453 and ISO 8434-3. These specifications also cover adapter unions, plugs, pipe fittings and adapter unions. J514 fittings and adapters are frequently made of steel for applications ranging from 1,500 to 6,000 PSI. These leak-proof, full flow connection fittings are used in a wide variety of hydraulic system applications, such as fuel delivery and fluid power applications in industrial, construction, agricultural and testing equipment. SAE J514 fittings are also found in high pressure (up to 10,000 PSI) applications when constructed from stainless steel or other exotic alloys. Applications can include

- **37° FLARE FITTINGS:** This is the most popular flare fitting and available in the widest range of configurations, sizes and materials. To accommodate the fitting, the end of the mating tube is flared at a 37° angle and seats between the fitting nose and sleeve by properly torquing the mating nut. The tube typically has thin to medium wall thickness. The tube entry has a preset nut and sleeve behind a mating flare which seats onto the fitting, then properly torqued to make the seal.

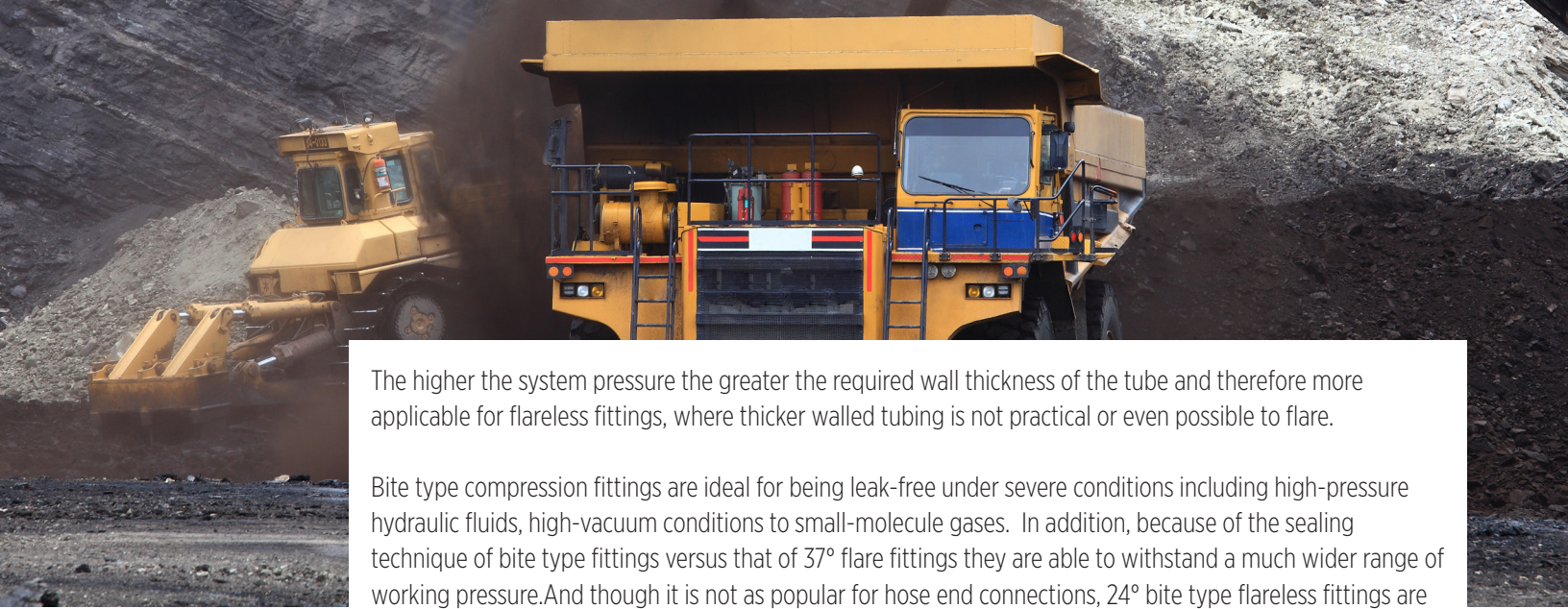
37° flare fittings are used in a wide range of applications of various temperatures and media. They are often used in applications requiring 3,000 PSI or less. Yet depending on material, size and configuration (i.e. straight vs. tee or elbow, etc.) they can be very suitable in working pressures up to 7,000 PSI.

Flared fittings provide significant design and performance characteristics as compared to pipe fittings and can be used with thin to medium wall tubing. In most hydraulic design applications, pipe fittings have long been replaced with flared fittings, particularly in military and aerospace equipment. In low to medium pressure applications, the most common connection type is a flared fitting. Single flare SAE 37° is the standard in most hydraulic systems. Be sure SAE standards for the maximum tube wall thickness are followed before flaring the tube to match the fitting connection.

- **AN (ARMY-NAVY) FLARED FITTINGS:** As with all flared fittings, the tubing is flared in preparation to installation to secure the seal. The flared tube fitting connection is made with a sleeve and a nut. With the nut fitted and tightened over the sleeve, it draws the sleeve and flared tubing securely to a cone shaped male fitting to create the seal. The cone on the male fitting is of the same angle as the inside of the flare. The sleeve will serve as a support to alleviate vibration at the flare, distributing the energy over a wider area. Male and female AN 37° flared fittings meet Class 3A/3B UNJ/UNJF allowing for tighter tolerances, enhanced exposure to fatigue and longer service life for aerospace and military applications. The tighter specifications of AN fittings also make them ideal for commercial and industrial applications where higher performance is desired.

- **SAE J514 24° FLARELESS COMPRESSION FITTINGS (BITE TYPE):** 24° bite type flareless compression fittings are second only to the 37° flare in popularity in the U.S., yet they are the most widely used fitting in Europe where they are often referred to as EO fittings. They are available in inch (SAE J514) and metric (DIN 3852) sizes. Like flare fittings this flareless style of fitting has a metal-to-metal seal. The fitting is made up of the body, nut and ferrule. This design incorporates a 24° tapered throat in the fitting body, and a nut that drives a ferrule into the tube as it is tightened. As the nut is tightened with the proper torque, the nut compresses the ferrule to the tube, thus providing a tight and leak-free seal.





The higher the system pressure the greater the required wall thickness of the tube and therefore more applicable for flareless fittings, where thicker walled tubing is not practical or even possible to flare.

Bite type compression fittings are ideal for being leak-free under severe conditions including high-pressure hydraulic fluids, high-vacuum conditions to small-molecule gases. In addition, because of the sealing technique of bite type fittings versus that of 37° flare fittings they are able to withstand a much wider range of working pressure. And though it is not as popular for hose end connections, 24° bite type flareless fittings are used in select applications.

- **MS FLARELESS FITTINGS:** MS (Military Standard) flareless fittings are used predominantly for higher pressure ($\geq 3,000$ PSI) hydraulic systems in areas that could experience rigorous vibration or inconsistent pressure. A MS type fitting replaces the need for flaring the tube and still provides a safe and dependable connection. Similar to standard compression fittings, MS fittings are made up of a body, a sleeve and a nut. The internal design of the body causes the sleeve to crimp into the OD of the tube as the body and nut are joined. There is a counter bore shoulder in the body of the fitting with a reverse angle of 15° designed to prevent the tubing from an inward collapse when tightening and serves as a sealing force against the body of the counter bore.

SAE J1453 O-RING FACE SEAL FITTINGS

The metal-to-metal seals of flare and flareless fittings are the best choice for many applications, yet they are not as reliable as O-ring seal fittings when it comes to maximum sealing in many lower pressure applications. O-rings are very popular among equipment designers because of their leak-tight connections, typically using a 90 durometer, Buna-N (Nitrile) O-ring.

- **SAE J1453 O-RING FACE SEAL:** O-ring face seal J1453 fittings comprise of a body, nut, O-ring and sleeve, and are used in assemblies for nominal tube or hose diameters of 0.25 inches (6.35 mm) to 1.5 inches (38.1 mm). They are most widely used in hydraulic systems and general applications where O-ring seals are acceptable to prevent leakage on industrial equipment and commercial products.

SAE J1453 also covers hose tail (hose barb) fittings and formed tube connections that incorporate O-rings. As with all connection designs, it is important to note that these connections do not exceed rated working pressure of the lowest rated component. For instance, if the required system working pressure for a ½ inch hose assembly needs to be 2,000 PSI, then:

- The hose could be ½ inch rated to 3,000 PSI
- The compatible hose tail fitting components may be rated at 2,000 PSI

Therefore the maximum working pressure for the assembly is the least of the two components; i.e. 2,000 PSI.

• **SAE J1926-1 (ISO 11296-1) STRAIGHT-THREAD O-RING BOSS FITTINGS:** These fittings incorporate a port connection as recommended by the National Fire Protection Association (N.F.P.A.) for leak prevention in medium and high pressure hydraulic systems. The male connection is a straight thread with an O-ring. The female port has a straight thread and a machined face to provide a smooth, flat, accurately located surface (minimum spotface), along with a chamfer where the O-ring seats. It seals when the O-ring is compressed into the chamfer when mating the male connection.

The O-ring in an O-ring boss fitting seats between the threads and wrench flats, and is positioned around the OD of the male end of the fitting. This allows for a leak-tight seal which is seated against the female port. O-ring boss fittings are either adjustable or non-adjustable. Adjustable O-ring boss fittings are typically elbows or tees that are installed in a fixed direction. Non-adjustable O-ring boss fittings are usually plugs and basic connectors that are fitted into a port without the need for alignment.

• **FACE SEAL OR FLAT-FACE O-RING (FFOR) FITTINGS:** Face seal and flat-face O-ring connections are considered the best for leak control. The male connector has a straight thread and an O-ring in the face. The female has a straight thread and a machined flat face. The seal takes place by compressing the O-ring onto the flat face of the female, similar to a split flange type fitting. The threads maintain the connection mechanically.

Choosing O-ring boss or FFOR fittings often depends on the location for wrench clearance. However, flange fittings are mostly used with applications calling for $\geq 7/8$ " OD tubing or extremely high pressures.

FITTING ADAPTERS

Fitting adaptors are used to modify the connection in a hydraulic system to achieve functions such as:

- Thread conversion for changing from one port thread type to another, typically for hose or tube fitting connections (i.e. JIC to NPT thread adaptors).
- Stainless-steel O-ring face seal and flange adaptors.
- Hose end adaptors to connect hose-to-hose or hose-to-port (port being a female threaded hole in a component).
- Thread size adaptors which are used to reduce or increase the existing thread connection.

There are many styles of fittings that serve as adaptors, including:

- Hose barb to male or female pipe, which can be straight, tees, elbows, MAORB (Male Adjustable O-ring Boss) and more.

The system should be designed with consideration of using complimentary hoses, couplings, fittings and adaptors to ensure safety, reliability and long service life.

WELD-ON FITTINGS

Hydraulic weld-on fittings (also known as socket weld fittings) have a pipe inserted into the open ID and joined to pipe or other fittings by arc welding fillet-type seals around the perimeter where the fitting flange extends over the pipe. Unlike butt weld fittings which are used for pipe connections up to 10 inches, weld-on fittings are typically used in smaller pipe diameters of up to 2 inches. In addition, performing butt welds has a higher installation cost over using weld-on fittings due to the labor cost and having to use a skilled welder.

Weld-on fittings are the best choice for smaller hydraulic system pipe welds where structural strength is important and/or to minimize the chance of leaks. Common applications for weld-on fittings include:

- All ASME pipe applications
- Hydraulic piping systems that are required to be permanent
- Hydraulic system lines transferring toxic, flammable or sensitive materials where the chance of leaking is prohibited
- Steam lines experiencing up to 600 PSI

CONCLUSION

The importance of selecting the right hydraulic fittings cannot be understated. If the hose is capable of handling high pressure, then the weakest link in the system is the connection points. In order to maintain the integrity of the line to ensure it can reach its full capacity the correct fitting must be selected. Otherwise, a leaking hydraulic line can cause a gradual decline in strength or a catastrophic failure of the system.

It is also very important to remember that not all fittings, hoses and other components are necessarily compatible or universal. Though interchangeability with components from different manufacturers is common, and when matched correctly is often safe, there can be differences in designs or specifications. Therefore, each component in the system must be properly selected to ensure a tight seal and system integrity.

ABOUT BRENNAN

In business for over 65 years, Brennan supplies customers worldwide with more than 50,000 standard and special hydraulic fittings, adapters and O-rings in sizes ranging from 1/16 to 3 inches. These include a wide choice of fitting and adapter types such as tube, O-ring face seal, instrumentation, metric bite type, push-to-connect, conversion and flareless bite type, as well as valves, clamps and swivels. Brennan products are stocked at strategically located, full-service distribution centers across North America, Europe and Asia.

SOURCES:

- Brennan Industries
- Hydraulics & Pneumatics
- IEEE GlobalSpec
- Machine Design 1
- Machine Design 2
- SAE International 1
- SAE International 2

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CORPORATE HEADQUARTERS

6701 Cochran Road
Solon, Ohio 44139 USA

US MANUFACTURING

26420 Century Corners Parkway
Cleveland, Ohio 44132 USA

PHONE: 440.248.1880

TOLL FREE: 888.331.1523

FAX: 440.248.7282

CANADIAN MANUFACTURING

290 Courtney Park Drive East
Mississauga, Ontario – L5T 2S5
Canada

brennaninc.com

