



Flexible Connectors: The Shock Absorbers in UST Piping Systems

The principal role of flexible connectors in underground storage tank piping systems is to absorb hydraulic shock created when a submersible pump turns on and off and when a fueling nozzle is clicked on and off by customers topping off their tanks. Without flexible connectors, the hydraulic shock and other forces would cause premature failure of the piping system.

The principal role of flexible connectors in underground storage tank (UST) piping systems is to absorb hydraulic shock created when a submersible pump turns on and off and when a fueling nozzle is clicked on and off by customers topping off their tanks. Such connectors also dampen the effects of ground movement caused by vehicles, ground settlement and frost heave. Without flexible connectors, the hydraulic shock and other forces would cause premature failure of the piping system.

Used in both rigid (fiberglass reinforced plastic or FRP) and flexible piping systems, flexible connectors also make installation easier and more adaptable to different situations. And, while the role of flexible connectors remains basically the same, new designs have been developed to make installation easier and the systems safer and longer lasting. As piping system design continues to change, the versatile flexible connector becomes even more essential.

Exactly what is a flexible connector? What are its components? What materials is it constructed from? How does it work to absorb shock and other forces? How is it installed? Where in the piping system is it located? These and other important questions about the technology of flexible connectors are answered below.

Anatomy of a connector

A flexible connector consists of a length of flexible hose with a fitting on each end. The hose's flexibility allows it to bend and flex to absorb line shock and other movement. The hose is made of Teflon™ or stainless steel. The Teflon™ connector consists of Teflon™ corrugated hose with stainless steel braid. The end fittings are typically crimped.

Stainless steel connectors consist of a stainless steel corrugated hose with a stainless steel braid. The hose is formed either mechanically or hydraulically and the end fittings are attached by welding. Mechanically formed hose tends to fail sooner due to the work hardening and stress that is put into the hose during the manufacturing process. Hydraulically formed hose is more forgiving and flexible

in shorter lengths because the process of hydroforming (hydraulically forming) produces less stress on the steel during manufacturing.

Stainless steel connectors were introduced to UST systems as the fire code regulators became more stringent about environmental concerns at fueling sites. Both Teflon and stainless steel connectors are UL listed for fuel compatibility (petroleum products, alcohol and alcohol-gasoline mixtures). However, stainless steel connectors are also fire rated, which means the connector has been tested in a fire condition, UL 842, and survived.

Connector hose sizes range from 1/2-inch through 3-inches ID and in lengths from 12-inches through 8-feet. Connectors are available with the following fittings: hex males and females, swivel males and females, 45° and 90° elbows, tees and swivel adapters.

The purpose of the swivel fittings is to connect the flexible hose to the pipe or other system component. The swivel design eliminates stress and torque of the connector during installation. Swivel fittings can be either adapters or “live” swivels. Male and female adapters are loose fittings that thread onto rigid male or female connector fittings. The adapter provides a temporary swivel to facilitate installation.

As the connector fitting engages the adapter threads, the swivel will rotate until the threads lock and a metal to metal seal is formed, creating a rigid fitting (this is similar to a connection between a male pipe and female pipe union connection).

Live swivels provide a continuous rotating swivel and typically consist of a two piece design with an internal seal. The two pieces are either flared or pinned together. The seal material used is the key to the life of a live swivel. Because of its compatibility with fuels, a swivel with a Teflon™ seal provides the longest life. Swivels with a rubber seal can be susceptible to premature failure depending on the type of elastomer used.

Where do you put them?

Flexible connectors are used at the beginning and at the end of primary liquid carrying piping runs. A piping run usually begins at the submersible pump and ends at the dispenser. However, at larger facilities, there may be intermittent points (such as transition sumps) that need to be equipped with flexible connectors. Flexible connectors are also used on vapor and vent lines, both at the dispenser and on piping runs back to the storage tank.

Choosing the right design

Several factors are important in selecting the specific type of flexible connector for a piping system, including the length and diameter of the flexible hose and the types of end fittings.

The proper length of the flexible hose depends on the amount of “offset” or movement needed to accommodate line shock and other movement in the system. Underwriters Laboratories determines the minimum length required for a connector to achieve a 90° bend. This information is typically printed on the installation instructions.

Different configurations of flexible connectors are used in various places within the piping system, as discussed below.

<div>Installation Instructions</div> <div>Hose Masters's Flexible Connectors for Underground Petroleum Systems</div> <div>Caution: Follow instructions carefully</div> <div>Do not twist connector: Twisting the connector during installation or service must be avoided. Torque will lead to the premature failure an assembly.</div> <div>Do not put wrenches on hose: Wrenches must only be used on the hex of the fitting.</div> <div>Do not overbend the connector: The installed radius of the connector must be larger than the minimum bend radius defined in the table below.</div> <div>Do not abuse connector: Avoid placing the connector in contact with other components service.</div> <table><tr><th colspan="2">TEFCON - PTFE CONNECTORS</th><th>minimum</th><th>min.length</th></tr><tr><th>Hose Dia.</th><th>Bend Radius</th><th></th><th>for 90° Bend</th></tr><tr><td>1.50"</td><td>4.5"</td><td></td><td>20"</td></tr><tr><td>2.00"</td><td>6.0"</td><td></td><td>24"</td></tr><tr><td colspan="4">150 p.s.i. maximum working pressure</td></tr></table> <div>The prefix TC on a connector denotes TEFCON</div> <div>Important: Installation should be made in accordance with standard piping practices recommended by API and PEI. For more information, contact Hose Master Inc.'s Technical Sales Department.</div>				TEFCON - PTFE CONNECTORS		minimum	min.length	Hose Dia.	Bend Radius		for 90° Bend	1.50"	4.5"		20"	2.00"	6.0"		24"	150 p.s.i. maximum working pressure				<div>Installation Instructions</div> <div>Hose Masters's Flexible Connectors for Aboveground and Underground Petroleum Systems</div> <div>Caution: Follow instructions carefully</div> <div>Do not twist connector: Twisting the connector during installation or service must be avoided. Torque will lead to the premature failure an assembly.</div> <div>Do not put wrenches on hose: Wrenches must only be used on the hex of the fitting.</div> <div>Do not overbend the connector: The installed radius of the connector must be larger than the minimum bend radius defined in the table below.</div> <div>Do not abuse connector: Avoid placing the connector in contact with other components service.</div> <table><tr><th colspan="2">TEFCON - PTFE CONNECTORS</th><th>minimum</th><th>min.length</th></tr><tr><th>Hose Dia.</th><th>Bend Radius</th><th></th><th>for 90° Bend</th></tr><tr><td>1.50"</td><td>4.5"</td><td></td><td>20"</td></tr><tr><td>2.00"</td><td>6.0"</td><td></td><td>24"</td></tr><tr><td colspan="4">150 p.s.i. maximum working pressure</td></tr></table> <div>The prefix FS on a connector denotes FIRESHIELD</div> <div>Important: Installation should be made in accordance with standard piping practices recommended by API and PEI. For more information, contact Hose Master Inc.'s Technical Sales Department.</div>				TEFCON - PTFE CONNECTORS		minimum	min.length	Hose Dia.	Bend Radius		for 90° Bend	1.50"	4.5"		20"	2.00"	6.0"		24"	150 p.s.i. maximum working pressure			
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Dispenser connectors

FRP systems will typically require a 24-inch long flexible connector with a 1 1/2-inch diameter under the dispenser and 24-inch long connector with a 2-inch diameter at the submersible pump. The end fitting configuration most used under the dispenser is a 1 1/2-inch male swivel on one end and a 2-inch female on the other. The 1 1/2-inch end is threaded into the shear valve. The connector’s bend angle is typically 45º - 90º. The bend angle is a variable that depends upon the piping run or penetration fitting. The 2-inch female swivel fitting is threaded onto a 2-inch fiberglass bell by male pipe adapter. Flexible connectors are also available with a 1 1/2-inch male swivel on one end and either a 1 1/2-inch or 2-inch male on the other to facilitate connecting to a fiberglass bell by female adapter.

Because of limited space in small, shallow dispenser sumps, some piping connections require a 45º or 90º fiberglass elbow. For these applications, stainless steel custom design connectors are available in a 1 1/2-inch male swivel by a 2-inch 90º female swivel or a 2-inch female swivel by 1 1/2-inch 45º male swivel. This simplifies piping systems and creates a safer installation by reducing the number of fittings, glue joints and threads. This connector requires only two threaded connections: the 1 1/2-inch male swivel threads into the shear valve and a 2-inch female swivel threads onto a fiberglass bell by male pipe. (See Diagram 2).

The benefits of these connectors are:

- Fewer threads due to welded fitting construction (Stainless steel connectors always have welded end fittings.)
- Swivel fittings to facilitate installation or removal of the connector
- Short, compact length facilitates installations within small, shallow sumps
- 45º or 90º elbows reduce potential stress on pipe and connector
- Easy installation reduces expensive time and labor costs

Submersible pump connectors

If the submersible pump has a bottom or side discharge, piping connections at the submersible pump can be made in several ways. Flexible connectors should be used between the primary piping and the submersible pump to eliminate the potential damage caused by “hydraulic hammer” or line shock

created when the pump turns on and off. Although the typical UST system operating pressure is about 35 psi, the system may spike as high as 150 psi when the pump is turned on. This pressure shock creates vibration and movement in the piping system. The best way to reduce this shock and dampen its effects is to use flexible connectors.



Diagram 1: Flexible connector in a pump sump.
Courtesy of Hose Master, Inc.



Diagram 2: Flexible connector in a dispenser sump. Courtesy of Hose Master, Inc.

A combination of the following components may be found connecting a submersible pump to a single primary pipe:

- 2-inch close nipples (2)
- 2-inch female union
- 2-inch street elbow
- 2-inch ball valve
- 24-inch long flexible connector with a 2-inch hose and 2-inch male fittings

Other fittings may be used, depending on the number of primary piping lines running off the pump or mainframe filter system. In any case, we are talking about a large number of threaded connections that add up to a lot of time, labor and potential leaks. The alternative is a flexible connector that comes complete with the above mentioned fittings.

For a side discharge pump, a 24-inch connector would be installed vertically with a 90° bend to connect to the primary pipe. For a bottom discharge pump, the connector would run horizontally to the primary pipe (see Diagram 1). Male and female end fittings are available to accept FRP or flexible pipe threads. The benefits include:

- Reduces line shock and vibration
- Swivel takes the place of a union
- Available in various lengths
- Fitting sizes and type may be mixed and matched

Changes in elevation

Other issues that call for the use of a flexible connector at a job site include changes in ground elevation and maintaining piping slope. More and more we are seeing the typical fueling site footprint consisting of a “starting gate” type approach where the fuel islands line up in a row. With these situations, a continuous piping run from the tank sump to the dispenser sump requires at least a 1/8-inch pipe slope. A connector that can accommodate both vertical and horizontal changes in piping runs is ideal for these applications. Adjustable length connectors are available that can be adjusted, lengthwise, by up to 4 inches (see Photo). The length of a 1 1/2-inch diameter adjustable connector

can be set in the field and appropriate vertical and horizontal adjustments can be made between the shear valve and the primary pipe fittings.

Adjustable length connectors can be used with both flexible and fiberglass pipe. The typical fittings are 1 1/2-inch male threaded into the shear valve and a 1 1/2-inch male threaded into the top of a fiberglass tee or elbow. Adjustable connectors are also available with welded tees, elbows and rigid or swivel male and female threads. The benefits include:

- Reduces the need to stock connectors of various lengths
- Allows for the proper hose length for any installation
- Eliminates the need to add additional fittings to make a connection
- Reduces line shock better than rigid pipe
- Easier to install than rigid pipe or standard connectors

Vapor lines and vents

Flexible connectors may be used in the dispenser sump to connect the vapor recovery pipe. Typically, a 24-inch long connector with a 1 1/2-inch male swivel and a 2-inch female fitting is used. The 1 1/2-inch male swivel is threaded into the vapor shear valve and the 2-inch female accepts a 2-inch bell by male fiberglass adapter. Again, the use of flexible connectors would facilitate shallow dispenser sump connections.

Flexible connectors in 1/2-inch and 1-inch diameters are available for connections from the top of the vapor shear valve to the dispenser. Vapor lines running back to the tank have 2-inch and 3-inch flexible connectors.

Vent lines with a 2-inch inside diameter have flexible connectors that run horizontally between the 90° elbows and the pipe back to the tank or as 90° connections between the vertical and horizontal pipes. Here again, a flexible connector would reduce threaded connections and labor. The vertical vent pipe adapter may be threaded into the 90° female swivel and, with the connector in a horizontal position, the vent pipe adapter may be threaded into the 2-inch male swivel. Considerations when selecting one of today's new flexible connector designs are:

- End fittings may be mixed and matched
- Lengths range from 12-inches up to 8-feet for most connectors
- New designs have been proven to reduce labor costs
- Used properly, flexible connectors provide safety to UST piping systems

Traditional installation

Recent environmental regulations and more sophisticated engineering specifications have made the use of dispenser sumps the norm rather than the exception. However, because they vary in dimension, plumbing some sumps at the job site can be challenging.

Typical on-site plumbing of primary piping under the dispenser sump involves a dispenser sump, shear valve, flexible connector, primary pipe and pipe penetration fittings. Additional fittings may be

needed should the pipe connections require field modification.

After the dispenser sump is set into the ground, the installer places a shear valve in a vice and threads a flexible connector into the bottom. The shear valve/ flexible connector assembly is then lowered into the dispenser sump and the shear valve is loosely threaded onto the stabilizer bar. Sump penetrations may be drilled at this point and the penetration fittings are installed.

Fiberglass or flexible pipe enters the bottom of the sump through the penetration; then, pipe and fitting connections are made. Again, connections vary based on the type of primary pipe being used. Fiberglass and flexible pipe may require the use of tees or elbows. After all threaded connections are made, a line pressure test is conducted. Next, the dispenser is mounted to the top of the dispenser sump island. The dispenser-to-shear valve connection and appropriate vertical adjustments to the shear valve are made before it is tightened down to the dispenser sump stabilizer bar.

Pre-plumbed sumps

Independent installers, oil company engineers and others are now using the concept of pre-plumbed dispenser pumps. The motivation behind this change from traditional on-site plumbing was to reduce time, labor and the number of fitting connections. Also, assembling the sumps in mass production has some cost saving benefits.

Using this concept, dispenser sump piping and components are assembled, pressure tested in a controlled environment and then delivered to the site for installation. As this concept has evolved, flexible connectors have been introduced to reduce labor time and minimize threaded connections at the job site. Flexible connectors are available with various welded fittings for use with fiberglass and flexible pipe threads, to reduce potential leak points. Some benefits of installing pre-plumbed dispenser sumps are as follows:

- Pre-plumbed sumps may be mass produced to lower costs
- Independent installers also realize the cost savings of mass production when done in house
- Fewer threaded connections
- Constant repeatable performance
- Easy installation at the job site



**Adjustable length flexible connector between
dispenser shear valve and primary piping.
Courtesy of Hose Master, Inc.**

Fire codes and flexible connectors

The National Fire Protection Association recently adopted new language in NFPA 30A, Automotive and Marine Service Station Code, regarding the use of components made of low melting point materials in dispenser sumps. This change allows low melting point materials to be used in tank and piping connection sumps, provided that the sump has a fitted cover, is monitored to detect leaks and is made of components that are either resistant to or shielded from damage by fire exposure.

The components in a containment sump under a dispenser are:

- Shear valve
- Flexible connector
- Penetration fittings
- Primary and secondary pipe fittings
- Primary and secondary piping

The shear valve and the fire rated flexible connector are the only components made of steel and have passed a fire test at Underwriters Laboratories (UL 842). This means that at least 50 percent of the components in the containment sump are fire rated. No additional protection or shielding from damage by fire is required of these components. Additionally, this accounts for the area of the containment sump closest to the surface of the pump island, minimizing potential damage and injury in the event of a fire due to a dispenser knock down. Conversely, Teflon™ connectors are not UL 842 fire tested. These connectors are required to be shielded from damage by fire exposure. Fire rated, all steel, flexible connectors are the most cost effective way to maintain fire code compliance and safety at a fueling site.

Buying guidance

Selecting the correct flexible connectors for the job at hand is essential for a safe, long lasting and cost effective piping system. Following are several important flexible connector characteristics to keep in mind when deciding on which ones to install:

- Flexibility of the connector
- UL listing
- Fire rating
- Factory testing the connector
- Use of swivel fitting
- Acceptance of containment boot or cathodic protection
- Hex wrench pads
- Proper length

Also, it usually is wise to get your piping components from manufacturers who are recognized as having good research, development, production and testing capabilities, as well as the capability and commitment to provide timely services.

Joe Valenti was Product Manager for Hose Master Inc., a PEI manufacturer of UL/ULC listed flexible connectors located in Cleveland, Ohio.