FUELING CONTAINMENT SYSTEMS

The FlexWorks Loop System™

Introduction

OPW-FCS is a leading worldwide manufacturer of retail and commercial fueling station equipment located in Smithfield, NC. We offer the industry's broadest line of environmentally safe fuel delivery and containment systems and associated service station equipment.

The components we manufacture are designed to work in unison as a completely integrated underground fuel delivery system known as "FlexWorks™". FlexWorks™ systems are designed for ease of installation and long term performance, and to provide the ultimate in environmental protection. A complete FlexWorks™ System includes all of the components that make up the underground fuel delivery system, the containment sump system, and other ancillary equipment.

The secondarily contained underground fuel delivery systems for fueling stations developed and produced by OPW have dramatically reduced the likelihood of fuel leaks escaping into the environment. These systems include double wall flexible piping having all piping connections contained within grade accessible containment sumps.

Our extensive experience with handling fuel in the underground environment has enabled us to identify potential problem areas, understand the root causes of field problems, and ultimately address problems through superior product design. Our 100 years of industry experience and interaction with fuel retailers, installing contractors, environmental regulators, and testing companies has provided us with the unparalleled experience necessary to know what works, and equally importantly, what doesn't.

The following information explores the current state of underground fuel delivery systems, traditional problem areas regarding underground fuel delivery systems, the costs associated with fuel system problems, and new solutions now available to minimize future problems, provide a higher level of environmental protection, and lower the cost of fuel delivery ownership.

Regulatory Environment

Underground storage and delivery of hazardous liquids, such as motor fuels, are regulated by federal, state and local governments. In 1988 Congress passed the Clean Water Act that required all fueling facilities to meet specified environmental safety standards. In August of 2005 Congress passed the Energy Policy Act which triggered a nationwide requirement for double wall fuel tanks and piping or that certain financial responsibility requirements be met by equipment manufacturers and installing contractors. The impact of this legislation will be that most fueling facility owners will now be installing monitored double wall tanks and piping systems.

Also in recent years, environmental regulators have urged testing laboratories like Underwriters Laboratories (UL) to create tougher testing standards for underground piping products to address issues with previous generations of some manufacturer's products. While more stringent standards may address product problems of the past, they do not provide any guarantee of eliminating issues going forward. While certainly offering some level of assurance of product performance, no testing regimen can fully account for installation workmanship or guarantee the performance of products after long term exposure in actual field conditions. Our goal at OPW-FCS is to not to simply meet the required minimum standard, but to use our considerable experience and expertise to design products that promote quality installations as well as account for the long term rigors of the harsh underground fueling environment.

Improved Systems

Underground piping systems installed over the last decade are safer for the environment than those systems installed previously. Specifically, the introduction of double wall piping systems and sealed containment sumps represented a quantum leap, environmentally speaking, over multi-jointed single wall pipe systems having no containment sumps. Today there are substantially fewer fuel leaks escaping into the environment than ever before, but there are still many areas that can be improved with respect to installation integrity, system performance, and leak prevention and detection.

Opportunities for Further System Improvements

Number of Pipe Joints: Some piping systems have more than five (5) times the number of connection joints than others. All of these joints must be field fabricated by qualified technicians using specialized tools under favorable weather and temperature conditions to insure that a joint that will not leak over the life of piping system. Since the vast majority of all piping leaks originate at piping joints, the potential of having a fuel leak can increase by a factor of five (5) with these type of piping systems.

Inaccessibility of Piping Joints: Some piping systems dictate that the piping joints be buried and therefore not accessible from above ground for routine inspections. Having a large number of inaccessible joints restricts the ability to observe the existence or the source of a leak. As a result, a leak can remain undetected, and thus unreported.

Field Assembly of Deep Dispenser Sumps: Deep dispenser containment sumps can be labor intensive to install, maintain, and inspect. Their fabrication, assembly, and connections in the field represent a significant portion of the labor involved in installing a complete underground piping system. Most deep dispenser sumps require height adjustability, accurate location and installation of pipe entry boots, field measurement and fabrication of steel riser pipes, assembly of flex connectors, stabilizer bars, shear valves, and other components. Deep Dispenser Sumps require a lot of skilled labor for proper field fabrication, installation, and assembly. Their considerable depth (30 to 36 inches) can make them difficult to inspect and to work in, and exposes them to greater ground forces.

Entry Boot Design and Installation: Entry boots designs adopted from other applications have not proven sufficiently robust to provide a secure long term seal to sump walls in the underground environment. Flexibility and the ability to seal on surfaces that are not entirely flat are minimum requirements for successful entry fittings. The seal on non-flexible or rigid pipe entry fittings has to be able to accommodate movement of the pipe in relation to the sump wall due to tank and ground movement. Material selection is also of the utmost importance to ensure resistance to degradation from fuels, additives, ozone, and the underground environment. Finally, improperly locating the entry fitting on the sump wall results in misalignment and imparts excess stresses on the boots, pipes, and sumps.

Leak Detection and System Maintenance

Many issues encountered with secondarily contained fuel delivery systems installed in recent years relate to product leaks that have been captured within the containment sumps and have gone undetected for extended periods of time. The entire concept of "secondary containment" adopted by EPA, UL, and most manufacturers is predicated on the assumption that secondary containment

products are designed to hold leaking product until it is detected by regular visual inspection or by an automatic leak detection device. Containment sumps were never designed or intended to hold undetected leaking product for months or even years. By its very definition, secondary containment, when filled with product, ceases to be secondary containment and becomes primary containment.

Installer Training and Experience

Another area of concern is centered on Installer Training. There are many state and local regulatory agencies that have no certification program for installers of underground tanks, piping, and containment sumps. There is no uniform licensing program required in many jurisdictions to install these products in accordance within product manufacturer's installation instructions. Also, the frequency and degree of inspections and enforcement by environmental regulators varies considerably from state to state. While OPW-FCS maintains a comprehensive certification program for piping and sump installers that incorporates a re-certification every two years, neither OPW-FCS, nor any other piping manufacturer, is able to completely assure fuel retailers and environmental regulators that all of its products will be installed correctly by experienced installers that are factory trained and certified.

Even with today's federal and state environmental regulations, and more stringent UL product requirements, common and reoccurring installer related problems can occur. The following list represents a sample of reported field incidents:

- Pipe entry boots installed in the wrong location on the sump wall
- Pipes entering the sump at severe angles inducing stress
- Steel riser pipes cut too long or too short inducing joint stress
- Pipe joints glued or fusion welded incorrectly
- Contamination or improper curing of pipe joints glued or fusion welded in bad weather
- Installers not using factory required installation tools

The Cost of Problems

Addressing underground problems can be quite expensive. Leak and contamination issues can be devastating, but also water infiltration or a failed system integrity test can result in costly repairs. If a problem is discovered, in many cases it is required to be reported to the regulatory authorities. Costs can mount quickly. Fuel retailers must factor in the risk associated with fixing potential problems as a cost of ownership when making equipment and installer choices. Listed are some of these cost considerations:

Finding a Leak: The costs associated with locating the source of a fuel leak in an underground piping system can also be significant. Non-retractable piping systems may require extensive integrity testing, excavation, and downtime to find the leaking pipe section or pipe joint.

Dispenser Removal: The costs associated with removing one or more dispensers from the island to gain access for repair should to be considered. Both non-retractable and retractable piping systems may require the removal of fuel dispensers to repair a pipe problem in the dispenser sump.

Excavation: The costs associated with excavation to provide access for leak repair for a non-retractable piping system can be significant. The expense of repair crews, heavy equipment, replacement product, removal and replacement of pavement and downtime needs to be considered.

Sump Repair: The cost associated with the repair or replacement of a deep dispenser sump or one or more installed pipe entries can be significant. Deep dispenser sumps and their pipe entries can fail over time due to improper installation, ground forces (to which rigid systems are particularly susceptible), or long-term exposure to fuel. Access and repair of a problem inside or outside of a deep dispenser sump can prove to be expensive, especially if the dispenser sump has to be replaced.

Clean-up: The costs associated with having a fuel release into the environment can result in significant costs to repair the leak and potentially much more to clean up thesurrounding environment through remediation or soil removal.

Downtime: There are also costs associated with business downtime if a problem requires the facility to shut down.

All will agree that problems with underground fuel systems should be avoided with all means available. Equipment quality and performance, installation quality, and the ability to identify and easily rectify problems during the life of the system are all critical factors to evaluate when contemplating a system's true cost of ownership.

The OPW-FCS Design Philosophy

At OPW-FCS, our design philosophy entails scrutinizing the complete underground piping and containment scenario in an effort to develop the ultimate system to prevent hydrocarbons from getting into the environment. The goal of this design philosophy is to develop products that are robust, simple to install, provide excellent long term performance, and facilitate easy repair in the event of a problem. The basic principals of our design philosophy for an underground piping and containment systems are as follows:

Secondary Containment of All Components: Single wall piping systems installed without containment sumps can allow leaks to go undetected and uncontained. Clearly, double wall piping complete with contained fittings, pumps, and dispensers provides a higher level of environmental protection. Additionally, multiple methods and levels of leak detection and monitoring solutions must be available to meet regulatory and customer needs.

Robust Underground Piping: The underground pipe must be designed and manufactured not solely to meet a minimum regulatory standard, but to perform flawlessly under the most extreme conditions encountered in the application. Proven materials with an extensive track record of performance with the most aggressive fuels, additives, and underground conditions must be incorporated in a robust, bonded construction. The pipe must be 100% physically and chemical compatible with the underground fueling environment without requiring supplementary layers, materials, or processes to augment its testing performance. All underground piping of the system should a flexible to accommodate movement and double wall to provide containment and monitoring capability.

Minimize Field Labor: If more components of the system can be fabricated, assembled, and tested in the controlled atmosphere of the factory assembly line, the opportunity for assembly mistakes at the jobsite is minimized. Also, if the components of the system are designed and manufactured to be very easy to install, the problems associated with field fabrication of complex systems are minimized.

Minimize Joints: The system must be designed so that primary and secondary connection joints are minimized. Data suggests that up to 95% of all reported fuel leaks originate from failed pipe connection joints. Fewer joints means fewer chances for leaks.

Contain and Provide Easy Access to Joints: As data suggests that most problems occur at pipe joints, all pipe joints should be contained, and easily accessible from the surface to inspect, maintain, and repair if necessary.

Permanent Coupling Connections: Pipe couplings should be permanently and mechanically joined to the pipe without relying on field applied adhesives, or plastic or metallic welding operations.

Pipe Retractability: All flexible supply pipe sections shall be contained within a larger diameter flexible Access Pipe that permits inspection, or replacement of a supply pipe section, without the need for excavation. While access pipe permits pipe extraction and replacement, it also serves as an additional means of leak containment and ground protection for the primary coaxial piping.

Flexible and Robust Pipe Entry Seals: All pipe and conduit entry seals into containment sumps should be flexible and mechanically sealed. Flexibility is important to minimize pipe and pipe connection stresses due to angled pipe entries, ground movement, and tank movements. Double flexible entry boots include a secondary sealing boot on the outside of the sump wall which serves to protect the sealing boot on the inside from backfill and ground pressures while providing a secondary pipe seal. Boot material must be resistant to degradation from fuel, additives, water, bacteria, ultra violet energy, and ozone.

> **Important:** Piping should not be rigidly attached to any containment sump wall by mechanical means, adhesives or plastic welding, as stress induced during installation or from ground forces and movement must be accounted for.

Structurally Sound and Accessible Dispenser Sumps: Under-dispenser containment sumps should be as shallow as possible to allow easy access for inspection or maintenance of under dispenser connections and components. Sumps should be constructed of a tough, crack-resistant material that is uniform and seamless, such as a thick rotationally molded polyethylene. Dispenser sumps should have factory-installed flexible pipe entry boots, stabilizer bars, and safety valves. Complicated height adjustment requirements to accommodate entry fitting location at the job site should be avoided.

Structurally Sound and Liquid Tight Tank Sumps: Tank sumps should be constructed of a one-piece, tough, crack-resistant material that is uniform and

seamless, such as a very thick rotationally molded polyethylene or fiberglass (FRP). They should have a liquid tight cover that is easy to remove and replace.

Interstitial Testing and Monitoring Capability: The interstice of all double wall pipe sections should have the capability to be interconnected and easily tested. The capability and means to continuously monitor the secondary containment interstice must be available for jurisdictions where this level of protection is desired. For pressure systems, having double wall flexible piping systems that are routed in series, it may be desirable that the piping be a "closed system", so as to prevent fuel or water that could collect in a containment sump from entering the piping's interstice. A pipeline, consisting of two or more flexible pipe sections, must be capable of connecting the interstice of one pipe section to another by such means that the pipe's interstice can be effectively and easily pressure tested or monitored continuously.

Sump Leak Detection: To ensure that fuel is not left in containment sumps for extended periods, each containment sump should be visually inspected regularly (at least once a month) and/or the system should have electronic or mechanical leak detection that will effectively indicate that there is fuel collecting in the sump. Fuel leaks can develop in equipment other than the piping and connections such as submersible pumps and dispensers. Fuel can also be introduced into the containment sumps during maintenance operations (i.e. line testing, changing dispenser filters, etc.). A sump inspection program and leak detection devices will identify the presence of fuel in the sump, and indicate that action needs to be taken to investigate and correct the situation.

Fire Suppression: Fire Suppression devices are recommended for installation in dispenser sumps. In the event a fire, resulting from a dispenser impact or knock-over, this device extinguishes the fire.

A Higher Level of Protection by Design

In response to growing environmental concerns, OPW-FCS initiated an intense product development program to produce piping, sumps and other related service station equipment that are more failsafe. All of the components in the underground fuel delivery system were reviewed for long-term performance and safety. As a result of these efforts, we have developed products that address the field issues associated with the installation, fabrication and assembly of underground piping systems at jobsites. System components assembled more completely at the factory, minimize the fabrication and assembly required at the jobsite by the installer, thus reducing the opportunity for mistakes.

Another approach to achieve a more failsafe underground fuel delivery system involved modifying certain piping and containment sump components that make installations easier and less likely to fail over time due to site conditions. As a solution, we have developed many new products such as double wall pipe couplings, factory assembled Quick Connect dispenser sumps, new direct-connect shear valves with added safety features, simple low cost leak detection systems, and automatic fire extinguishers that installed in unison, provide a higher level of safety and reliability.

The Loop System™

The result of our intense product development program is OPW-FCS's "Next Generation" environmentally safe underground fuel delivery and containment system that is virtually failsafe: The Loop System™. This system incorporates new types of piping connections, radically new dispenser sump designs, available continuous interstitial pipe monitoring, low cost sump leak detection, and minimized piping joints and fabrication requirements in the field.

A basic description of the Loop System™ is as follows:

A double wall coaxial piping system contained within a larger Access Pipe so that a pipe section may be removed and replaced without the need for excavation. All piping connections and fittings are secondarily contained within the containment sumps that permit easy access for inspection, testing, repair, or replacement from above ground. Tank sumps have thick walls that will not deform or crack under burial loads and have a liquid tight cover. Dispenser sumps are shallow having angled sidewalls that will not deform or crack under burial loads. All piping penetrations into the sumps are sealed with flexible double entry boots that are compatible with long-term exposure to fuel and the environment, as well as ground forces and movement.

Piping enters and exits the shallow dispenser sumps at 45° angle instead of horizontally. The ends of the coaxial piping sections are fitted with double wall swivel couplings that connect directly to shear valves having angled connection ports. This coupling and connection method eliminates the need for the rubber interstitial test boots, additional pipe fittings and, field fabricated steel riser pipes or flex-connectors typically contained within deep dispenser sumps.

All shallow dispenser sumps can be equipped with leak detection devices that will either automatically trip a shear valve if a small amount leaking fuel has collected in the bottom of the sump or send an electronic signal to a leak

detection console. The Loop System™ allows a "closed interstice" that can be continuously monitored for leaks in the primary or secondary piping system. In an effort to minimize mistakes at the jobsite, the shallow dispenser sumps are prefabricated and assembled at the factory rather than at the jobsite.

The Loop System™ Components

A. **Coaxial Supply Piping:** The Loop System™ incorporates the use of 1-1/2" and/or 2" flexible coaxial (double wall) piping. This UL listed coaxial piping has a primary pipe contained within a secondary pipe having a series of stand-off legs on its inside surface to create a non-collapsible, pressure rated interstice. All pipe connection joints are contained within containment sumps that are accessible for visual inspection at any time from above ground. OPW-FCS primary pipe utilizes an all bonded multi-layer construction with a KYNAR™ permeation barrier that has been field proven over 40 years for unparalleled resistance to all fuels and additives including E85 and Bio-fuels.

B. **Access Piping:** The Loop System™ requires that all coaxial supply pipe sections be installed inside a 4" diameter Access Pipe so that flexible pipe sections can be inspected, removed, or replaced without the need for excavation. Access Piping provides an even higher level of containment protection for the flexible supply piping and can be air tested for integrity. OPW-FCS Access Pipe feature a semi-smooth lined construction that provides excellent crush resistance and an added layer of containment protection.

C. **Double Wall Swivel Couplings:** The Loop System™ incorporates the use of new double wall pipe couplings that simplify the interstitial connection process for the flexible piping system. These new swivel type coupling eliminate the operation of cutting back the secondary jacket, and eliminate the need for rubber test boots to provide a sealed access to the pipes interstice for integrity testing or interstitial transition from one pipe section to another. Double Wall Swivel Couplings have an integral interstitial fluid path and a threaded access port located directly on the coupling collar. Installing internally expanded metallic couplings to the end of a flexible pipe section, using the appropriate coupling machine, creates a factory-like secured

connection at the jobsite. Permanent Mechanical connections to the pipe have a proven history of reliability and facilitate easy connection and disconnection to dispensers and pumps using simple tools. This mechanical method of connection is a cost effective solution which allows rapid system integrity testing as well as removal and replacement of a flexible pipe section during and after installation.

Double Wall Swivel Couplings are available in 1-1/2" and 2" sizes.

Double Wall Swivel Couplings have threaded interstitial access ports for connection of small diameter (1/8") short "Connector Tubes" for connecting the interstice of one pipe section to the next. They also allow connection of longer "Test Tubes" (36") for connection to interstitial monitoring and testing systems. The elimination of rubber test boots and the elimination of the need to cut back the secondary pipe jacket minimizes fabrication mistakes, saves time, saves money, and makes interstitial pipe testing and monitoring easier and much more reliable.

D. **Angled Direct-Connect Shear Valves:** The Loop System™ incorporates the use of a new type of modular safety shear valve, "Direct Connect Angled Shear Valves" that are installed under the fuel dispenser. The Double Wall Flexible Piping fitted with Double Wall Swivel Couplings makes a direct connection to these angles safety valves. The use of these UL listed angled shear valves eliminates the need for rubber test boots, additional T and L pipe fittings, and field fabrication of steel riser pipes, thus drastically reducing field labor as well as the overall number of piping joints. There are two types of angled shear valves available with the Loop System™: the OPW 10 Plus™ Junction Shear Valve has a 45° angled inlet and outlet; the OPW 10 Plus™ Terminating Shear Valve has a single 45° angled inlet.

The OPW 10 Plus™ shear valve features an expandable bladder that senses any slight crack in the shear groove and mechanically activates the valves trip mechanism. The OPW 10 Plus™ prevents leaks from shear valves that are not completely sheared during an impact to the dispenser.

E. **Double Entry Boots:** The Loop System™ utilizes Double Entry Boots in all containment sumps. These flexible entry boots have a boot located inside the containment sump to seal off the double wall coaxial pipe and another boot located outside the containment to secure and seal off to the Access Pipe. This double boot designs keeps backfill from entering the Access pipe and protects the inner boot from backfill pressures all while providing yet another layer of containment protection. Double entry boots totally isolate

the interstice of the access pipe from the inside of the sump to insure that no communication between sump and access pipe can occur.

F. **Quick Connect Sumps™:** The Loop System™ utilizes Quick Connect dispenser sumps. These shallow dispenser sumps have been designed to contain all of the primary and secondary piping connections. Quick Connect Sumps™ are less than half the depth of traditional deep dispenser sumps, making all piping connections easier to install and to maintain and inspect in the future. These unique shallow dispenser sumps have 45° angled sidewalls that enhance rigidity and prevent deformation from underground loads and pressures.

Quick Connect Sumps™ eliminate the need for rubber test boots, T and L pipe fittings and connections, and the need for rigid or flexible riser pipes typically used within deep dispenser sumps. Instead, these shallow sumps allow pipe sections fitted with Double Wall Swivel Couplings to be connected directly to our new line of Angled Shear Valves.

Quick Connect Sumps™ can be mounted directly into island forms, but are also grade adjustable to achieve the exact elevation required if installing without island forms. The frame has four (4) corner brackets that will accept and secure 3/4" conduit legs adjusted to the appropriate length required for the elevation needed.

A variety of Quick Connect Sumps™ models are available to accommodate the most popular fuel dispensers on the market today. These shallow dispenser sumps have factory installed double entry boots, stabilizer bars, angled shear valves, and optional sump leak detectors. The only fabrication and assembly required at the jobsite is to cut, couple, and connect the piping.

Quick Connect Sumps™ replace traditional deep dispenser sumps and provide the following advantages:

- Eliminate the need for field installation of pipe entry boots
- Eliminate the need to field adjust dispenser height to accommodate entry fitting location.
- Eliminate the need to use and connect T and L pipe fittings (eliminating joints)

- Eliminate the need for rubber test boots
- Eliminate the need to measure, cut, thread, and install steel or flexible riser pipes (more joints eliminated)
- Provide easy access just below grade to all under dispenser components and connections for inspection, repair, or testing,
- Eliminate the need to remove the dispenser to inspect, repair, or replace pipe sections.
- Resistant to damage and deformation from ground forces
- Factory pre-installed entry fittings and components minimize the opportunity for field installation errors

G. **E-Vac™:** Offered with The Loop System™ is a simple proprietary monitoring system called "E-Vac™" for continuous monitoring of the interstitial space of the double wall pipeline. This simple, yet effective, monitoring system applies a continuous vacuum, generated by the fuel pump, to the interstitial space of an entire piping run. If a leak develops in the primary or secondary wall of the pipe, liquid that is present (fuel or water) in the interstice will be immediately drawn by vacuum toward the submersible pump where it is detected by a liquid sensor. Any leaking product is automatically drained into the underground storage tank while in the alarm condition to prevent a hazardous situation. E-Vac™ monitors can be connected to a tank monitoring console or a stand alone alarm console. Refer to the E-Vac™ Product Manual for more detailed information.

Loop System™ Operation

The Loop System™ represents a paradigm shift in underground fuel delivery systems as compared to field fabricated conventional systems that incorporate deep dispenser sumps connected by either rigidly plumbed or flexible piping.

A typical piping run begins inside the tank sump with a double wall swivel coupling attached to the end of first pipe section that in turn is connected to the submersible pumps plumbing tree by means of a swivel pipe adapter. The first pipe section exits the tank sump through Access pipe that is sealed to the sump wall by a double entry boot. The Loop System™ requires that all coaxial pipe sections to be installed

within OPW-FCS Access Pipe.

The other end of first pipe section runs upward to enter the first Quick Connect Sump™ at a 45° angle in a series-piping run. The 45° angled sidewalls of this shallow dispenser sump have factory-installed double entry boots to provide a flexible seal entry for the Access Pipe and flexible pipe section. These sumps also include factory-installed stabilizer bars, shear valves and optional leak detection sensors. Quick Connect Sumps™ also eliminate a number of piping joints, other plumbing components, and 50% or more of the field installation labor.

The coupled end of the first supply piping section connects directly to the inlet port of a Junction Shear Valve, and the next pipe section is connected to the outlet port of the Shear Valve before exiting out of the junction dispenser sump through another factory installed double entry boot. The double wall pipeline is then "Looped" between all remaining junction dispenser sumps and connected as previously described. The supply pipeline terminates inside the Terminating Dispenser Sump where the double wall swivel coupling is connected to a factory installed Terminating Shear Valve.

Short, small diameter Connector Tubes are installed to the interstitial access port on the double wall swivel pipe couplings linking the interstice of one pipe section to the next within all junction dispenser sumps. Longer, small diameter Test Tubes are connected to the interstitial access ports of the pipe couplings located at the tank sump and "terminating dispenser sump" for connection to interstitial monitoring systems or pressure integrity testing equipment.

Loop System™ Applications

Pressure Piping Systems: The Loop System™ is designed for use in pressure delivery piping systems that are typically routed in single or dual series. Supply lines are "Looped" from one dispenser to the next by connecting each pipe section directly to the inlet and outlet of specially designed "Angled Shear valves". The loop system geometry provides efficient fuel flow to each dispenser and can be monitored for release detection with automatic line leak detection equipment. Pressure systems do not require the constant slope necessary in suction systems.

Suction Piping Systems: The Loop System™ is also compatible for use with suction piping systems. The major difference is that the supply piping runs are routed in a "direct method" instead of a "series method". Each dispenser is connected to the tank with a dedicated supply line. Also, per EPA requirements and PEI Recommended practices, slope back to the tank is required in Suction

Systems lieu of required release detection. The reason slope is recommended in Suction Systems is to ensure drainage of the lines back to the tank should suction be lost. The geometry of the loop sumps facilitates installation of direct piping runs with the recommended slope back to the tank in Suction Systems. Inside the shallow dispenser sumps the pipe couplings are connected to plumbing assemblies that consists of the Loop System™ male adapter connected to a 45-degree elbow fitting that is connected to a union fitting. In this application, stabilizer bars are typically not installed inside the dispenser sump.

Pipe Looping

The Loop System™ gets its name as the piping routed in series between containment sumps actually loops from one sump to the next. The Loop System™ eliminates the need for constant piping fall from the last dispenser sump in a piping series to the tank sump for pressure piping systems.

Primary Pipe Fall

The Loop System™ piping runs in pressure-piping systems do not require the gradual fall from the last dispenser to the underground storage tank that is necessary in suction systems. Fuel delivery performance is unaffected by the Looped piping runs provided that there is no piping loop point lower than the fuel level inside the tank. Pressurized line leak detection systems are unaffected by the Loop piping geometry providing that, as is also required in conventional sloped installations, traps in the delivery lines are avoided. Air introduced into the Loop System™ fuel pipe is quickly expelled through the nearest shear valve, thus eliminating the possibility of compressible air pockets that can affect the accuracy of line leak detectors.

Pipe Section Removal

By opening the shear valve at the terminating end of the pipeline and releasing the check valve at the submersible pump the primary line will drain into the tank leaving only a minimal amount of fuel left inside each pipe section. By capping each end of a pipe section, the section can be easily retracted out of the Access Pipe without removing the dispenser and with no leakage of product.

Primary Pipe Monitoring and Leak Detection

Pressurized Systems: The Loop System™ primary piping can be monitored for releases using automatic pressurized line leak detection systems in accordance with the requirements of EPA 40CFR section 280.41 and API 1615; section 8.7 (No slope requirements are mandated for pressure applications). The Loop piping geometry has no effect on the proper operation of pressurized line leak detectors provided that traps in the pressure system lines, as is also necessary

in deep sump applications, are avoided. The upward slope of each Loop pipe section facilitates a trap free installation and provides additional paths for air to be expelled from the system. Any air introduced into the system is quickly expelled through the nearest dispenser thus preventing air pockets from forming and interfering with line leak detector operation.

Suction Systems: The Loop System™ is compatible for use with suction system fuel delivery. Individual lines are run directly from the tank to each dispenser. Slope back to the tank for each suction line is recommended as per EPA 40CFR section 280.41 and API 1615 section 8.7.4 (for suction systems applications only) so that the contents of the pipe will drain back to the tank if the suction is released. No release detection is specifically mandated because suction pump hesitation would provide an indication of a non-tight system, and suction systems tends to suck in air or water if an opening exists as opposed to permitting a release.

Options for Testing and Supplemental Monitoring the Pipe and Interstitial Space

The primary pipe and secondary containment jacket interstitial space in Loop piping runs can be connected and air pressure tested in the same manner as a conventional installation in accordance with the requirements of 2008 Edition of NFPA 30A, Section 5.4, and API 1615, section 10.2. Primary and interstitial space pressure integrity tests are typically required during installation and start up, and can be easily performed periodically during the operational life of the system as required by local code.

Open System Leak Detection

Jumper connections in Loop System sumps can be disconnected after completion of integrity testing, leaving the interstitial space of each pipe section open to a containment sump. A leak into the interstitial space of the piping run from the tank to the first dispenser will flow to the tank sump as this run is sloped in the same manner as a traditional system. A leak from the primary pipe into the interstitial space in a looped section between dispenser sumps will also quickly migrate to the dispenser sump where it can be detected by a sump sensor. Slope is <u>not</u> necessary to ensure that the leak migrates to the sump as pressurized fuel will quickly fill the small interstice and flow into the sump. The interstitial volume of the OPW coaxial pipe is .0056 gallons/foot for 1.5" pipe and .0065 gallons/foot for 2" pipe. A small leak into the interstice of 0.2 gallons per hour in a 35 foot run of 1.5" pipe between dispensers will enter the sump in a maximum of 0.98 hours. A

0.2 gallons per hour leak in a 35 foot run of 2" pipe will enter the sump in a maximum of 1.14 hours. The leak will then be detected, and the situation can be addressed. The offending pipe section can be easily removed if necessary to replace the line or flush the interstice.

Closed System Leak Detection

Installation of Automatic line leak detectors, an annual line tightness test, and monthly monitoring meet the basic requirements for release detection for pressure systems. A closed Loop System interstice can be monitored by any of the commercially available pressure, vacuum, or liquid monitoring systems in jurisdictions that require it. The interstitial space of Loop System™ pipe can also be monitored continuously for the presence of liquid by employing OPW-FCS's simple vacuum interstitial monitoring system, E-Vac™. This continuous monitoring system uses the vacuum generating capability of the STP to impart a constant negative pressure (vacuum) on the pipe interstice. Any liquid that enters the interstice (fuel or water) rapidly migrates to the source of the vacuum, trips the float switch alarm when it reaches the E-Vac™, and is then harmlessly dumped into the UST. The E-Vac™ is equipped with a liquid sensor, that continuously monitors the presence of a vacuum in the pipe interstice. Switched signals from E-Vac™ can be wired to a tank monitor console or a stand alone alarm console. Vacuum gauges that can be connected to the end of each piping run to provide a visual means to check for the presence of a tight vacuum are also available.

Sump Monitoring Options

To ensure that fuel is not left in containment sumps for extended periods, each containment sump should be visually inspected regularly (at least once a month) and/or the system should have electronic or mechanical leak detection that will effectively indicate that there is fuel collecting in the sump. Fuel leaks can develop in equipment other than the piping and connections such as submersible pumps and dispensers. Fuel can also be introduced into the containment sumps during maintenance operations (i.e. line testing, changing dispenser filters, etc.). A sump inspection program augmented by a leak detection device will identify the presence of fuel in the sump, and indicate that action needs to be taken to investigate and correct the situation.

PetroTrip™ Loop System™ Quick Connect Sumps can be outfitted with an optional low cost leak detection device that will automatically trip the safety valve when there is an accumulation of leaking fuel inside the shallow dispenser sump. PetroTrip™ is a mechanical device that activates in the presence of fuel to initiate a shear valve trip. It will also activate if there is fuel floating on top of water or ice. The operation of the PetroTrip™ sensor initiates a line shut-down by tripping the shear valve. The shutdown in turn prompts a timely inspection.

Refer to the PetroTrip™ product manual for more detailed information.

Problems Solved by the Loop System™

The design of the Loop System™ was intended to minimize problems with conventional underground piping systems. Listed Below are improvements that are achieved:

A. Problems Addressed

- Makes access to all dispenser pipe connections easier without removal of the dispenser
- Makes visual inspections of dispenser sumps easier
- Dispenser sump will not deform due to backfill or ground water pressures
- Eliminates ground water infiltration
- Drastically reduces the number of pipe fittings and the associated assembly labor
- Eliminates field fabrication of steel riser pipes
- Eliminates the need for expensive flex connectors
- Eliminates the need for rubber test boots
- Eliminates the need to cut back of the pipe's secondary jacket
- Eliminates the need to field adjust the height of dispenser sumps
- Allows pipe inspection or replacement without the need for excavation
- A pipe section can be retracted without removing dispenser from island
- Reduces the number of piping joints
- Provides a lower installed cost than systems with deep dispenser sumps

B. Cost Advantages

- Factory assembled dispenser sumps reduce the costs and time required for field labor by more than 50%
- Eliminates the cost of rubber test boots, T and L pipe fittings, and fabrication and installation of steel riser pipes or flexible connectors.
- Eliminates the costs associated with field fabrication mistakes
- Eliminates the costs associated with maintenance or repairs requiring dispenser removal and/or piping excavation.

C. System Monitoring

- Pressure Systems can be monitored with automatic line leak detectors
- All containment sumps can be equipped with leak detection
- All pipelines can be equipped with continuous interstitial monitoring

Loop System™ Components

The following components make up the Loop System™:

- FlexWorks™ Double Wall Flexible Piping
- FlexWorks™ Double Wall Swivel Couplings
- Connector Tubes and Test Tubes
- FlexWorks™ Access Pipe
- Swivel Pipe Adapters
- Loop System™ Quick Couple Sumps™ equipped with:
- Flexible Double Entry Boots
- Stabilizer Bars
- OPW 10 Plus™ Direct Connect Angled Shear Valves
- Optional PetroTrip sump leak sensors
- Optional Snuffer™ Automatic Fire Extinguisher
- Optional E-Vac™ Interstitial Monitoring System
- FlexWorks™ Tank Sumps

Summary

The Loop System™ represents the state of the art in a completely integrated, environmentally secure underground fuel delivery system that employs more factory assembled components and less field labor. The Loop System™ incorporates proven technology, simplifies the piping system design, enhances the capability for leak prevention, and facilitates easy inspection, identification, and repair of any problems that may develop. The OPW-FCS Loop System™: Providing new solutions to minimize fuel delivery system problems, provide a higher level of environmental protection, and lower the cost of fuel delivery system ownership.

FlexWORKS
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