1.1 GENERAL INSTALLATION GUIDE

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Introduction to Fiberspar

Fiberspar is the world's leading innovator and manufacturer of spoolable, fiber-reinforced pipe and tubing. The company's proprietary technology (more than 25 U.S. and international patents related to spoolable products) is incorporated into product lines used in a variety of oil and gas field applications.

Fiberspar LinePipe is used in production gathering, injection and disposal applications. Fiberspar LinePipe has been installed for a wide range of customers and applications in North America, including almost every major oil and gas operator.

Fiberspar LinePipe is manufactured using an inner thermoplastic pressure barrier layer reinforced with high-strength glass fibers embedded in an epoxy matrix, and an outer thermoplastic layer is used for added impact and wear resistance. The result is a high-pressure pipe immune to corrosion, with few joints, which can be rapidly installed in the field.

The company now has sales offices in Houston and Calgary, Alberta, and field operational centers in most of the active oil and gas locations in North America, including central and south Texas, the Rocky Mountains, the U.S. Midwest and Northeast Alberta and south Saskatchewan.

Fiberspar uses proprietary technology to manufacture on a continuous, linear processing line. All key operations are carried out in-house, including liner extrusion, pipe fabrication, testing and pipe jacketing. An ISO 9001-certified quality system with complete testing laboratories and expert staff support new product development and quality-assurance testing.

Today, Fiberspar is the leading designer and manufacturer of continuous-length, spoolable fiber-reinforced pipe used in the oil and gas industry. And, with 20 years in the business, Fiberspar is one of the most experienced.

More information on Fiberspar's products and services can be found at the company's website: www.fiberspar.com.

Fiberspar proprietary fully automated manufacturing process line

LinePipe inventory at plant

LinePipe ready for transport to Canada

Product Information

This manual is applicable to installation of the FIBERSPAR LinePipe (FS LP) family of products. FS LP products are advanced composite line pipes produced in continuous lengths up to 5 miles (9 km). They are designed for storage, delivery and deployment from spools.

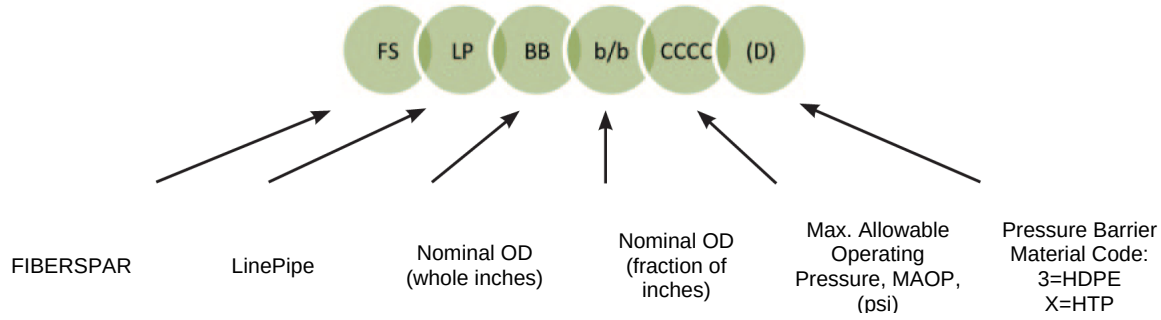
The General Installation Guide provides general information on application and installation of systems using Fiberspar LinePipe. It is not an installation manual.

The FIBERSPAR LinePipe Engineering Guide provides engineering and design data applicable to FS LP products and is available by application at www.fiberspar.com.

Product Identification

A product identification number or PIN identifies FIBERSPAR LinePipe. The PIN takes the following form:

FS LP BB b/b CCCC (D)



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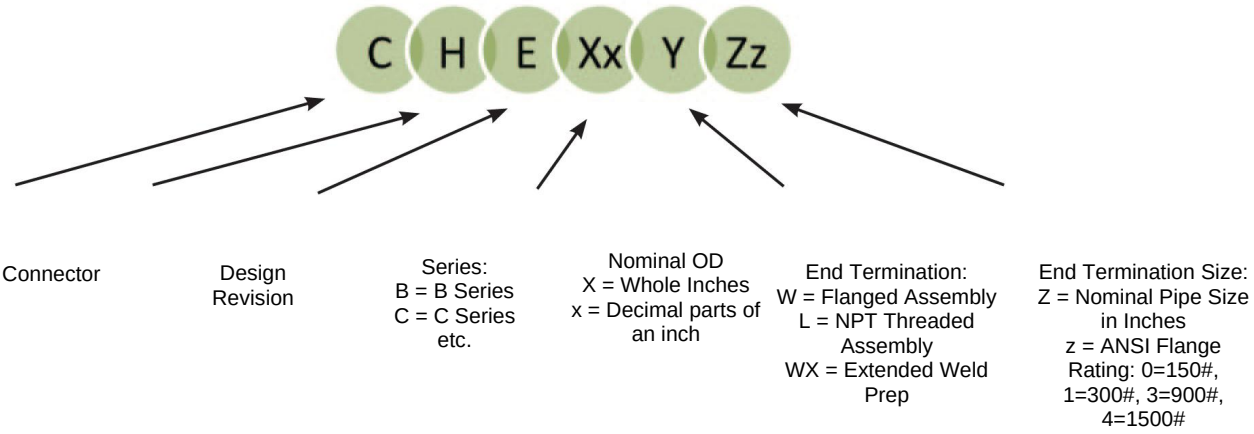


Storage and Handling

Packaging

FS LP is packaged on spools for transport, storage and deployment. The spools are fabricated from steel or wood and often weigh more than the FS LP products that are on them.

Pipe is wrapped around the spool drum in layers to the desired length. The outermost layer must be at least 1 in. (25 mm) below the spool flange. All pipe is hydro-tested on a specially designed spool at the factory. Shipping spools are not suitable for hydro-testing, and FS LP should not be filled with water and hydro-tested while on a shipping spool.

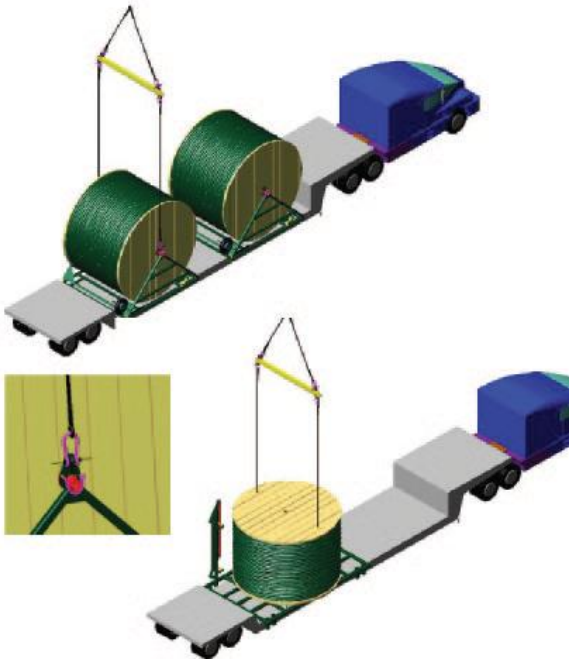
Spools of FS LP ready for transport

***CAUTION:* FS LP wound on spools has some stored energy. Ensure that the pipe end is restrained during all operations to avoid rapid release of this energy and potential injury to personnel and damage to pipe and equipment.**

Handling

FS LP will normally be deployed to location already on the spooling equipment, which eliminates the need for any local handling. In cases where this is not possible or practical it may be necessary to handle individual spools of FS LP. Care must be taken in these cases, as spools of pipe tend to be top-heavy and can overturn. A Fiberspar representative must always be on location when spools of pipe are handled.

On rare occasions it will be necessary to upright the spools after unloading in order to place them in an upright spooling frame. The preferred method for uprighting a Fiberspar spool is to use a crane equipped with a second line.



Handling spools for change outs

***CAUTION:* Improper handling of spools of FS LP can result in personnel injury as well as damage to the product. Ensure that the lifting equipment used, including straps, slings and spreader bars, are in good working condition and are rated for the load and conditions.**

The use of a spreader bar and slings is required when moving spools with a crane. In the absence of a crane, two forklifts can be used. The bar is placed through the center hole and a forklift is positioned on each side of the spool. The forks are used to lift the bar raising the spool.

***CAUTION:* Attempting to move the spool by "rolling it" is never allowed.**

Storage

Spools of product should be stored on level surfaces with no protruding objects that might contact and damage the pipe on its outermost layer. It is also required that spools placed on soft surfaces such as dirt or gravel have suitable support to prevent the spool flanges from sinking into the ground. The use of 6 in. x 6 in. (15 cm x 15 cm) timbers is recommended for this purpose. Block, or otherwise ensure, that the spool cannot roll. Do not store on slopes.

If storage is to be for an extended period of time, the pipe should be protected from freezing. Spools of FS LP may contain some water from hydro-testing or condensation that can freeze and damage the pipe.

Field Transport

When transported in the field for deployment, the spool must be mounted in a suitable spooling frame. Transport should be on a trailer that is as close to the ground as practical. Be aware of any overhead power lines or other overhead obstructions that may come into contact with the spool.

***CAUTION:* Spools make top-heavy loads that are easily overturned. The spool and frame should be mounted as close to the ground as practical and the frame securely chained to the trailer. During transport, speed should be reduced and turns negotiated with care.**

Low Temperatures

Fiberspar LinePipe has a minimum operating temperature of –29ºF (–34ºC), and a minimum installation temperature of –22ºF (–30ºC). Lower temperatures down to –50ºF (–45ºC) will not damage stored pipe. In cases where LinePipe is stored in temperatures lower than this, it is good practice to ensure that the temperature has risen to a safe level before uncoiling and handling. When at low temperature, the body of the pipe represents a substantial heat sink, and it is, therefore, important to ensure that fluids pumped into a cold line cannot freeze.

Properly chocked spools will prevent damage to the product

Spools being transported for deployment

Installation

Introduction

FIBERSPAR recommends that a Fiberspar service representative or a Fiberspar certified installer supervise all installations of Fiberspar LinePipe. Fiberspar service representatives and Fiberspar certified installers are trained and certified to handle all aspects of a LinePipe installation, and will provide advice and recommendations to ensure fast and effective installation of Fiberspar LinePipe.

FS LP is designed for storage, handling and deployment from spools. The tools and equipment required for any job are somewhat dependent on the method selected for deployment of the FS LP. The following discussion of tools considers the basic tools/equipment required for all installations. Special installations may require additional tools/equipment.

Spools

Spools are used to transport and deploy the pipe. Spools are typically 12 ft, 14 ft or 16 ft (3.7 m, 4.3 m or 4.9 m) in diameter and can be manufactured from steel or wood. The core diameters of Fiberspar spools are selected to ensure that the bending strains are within allowable limits. Only Fiberspar-supplied spools should be used to store, transport or deploy Fiberspar LinePipe. Hydro-testing of Fiberspar LinePipe is carried out on specially reinforced spools at manufacturing locations. Fiberspar LinePipe must never be subjected to pressure on a shipping spool.

Spooling Equipment

Fiberspar has designed and manufactured spooling equipment suitable for deploying and re-spooling Fiberspar LinePipe. Approved equipment must be used for these operations. Fiberspar spooling equipment safely supports the LinePipe during spooling operations and has speed control and powered braking to ensure that back tension is kept on the spooled pipe at all times.

Fiberspar currently uses three types of spooling frames for field deployment of LinePipe products. These are compared on the following page.

Rim Drive A-Frame

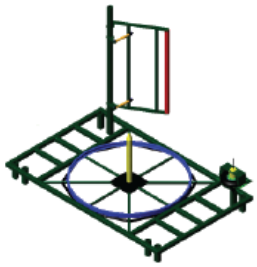
- Spool loaded vertically
- Deploys smaller-diameter spools – 12 ft (3.7 m) in U.S., 14 ft (4.3 m) in Canada – and pipe sizes up to 3-1/2 in.
- "A-frame" with an integrated driver that controls deployment rate with a hydraulically driven rubber tire in contact with one of the flanges or rims of the spool
- Low profile, allowing deployment with a loaded reel
- One or two frames can be loaded on a double-drop trailer
- Can be transported and deployed without requiring a crane on location
- Not suitable for re-spooling operations

Chain Drive A-Frame

- Spool loaded vertically
- Deploys larger-diameter spools
- "A-frame" type that has a chain and sprocket drive mechanism with integrated "drive dogs" that engage in the flange of the spool, providing a positive drive system. The spool has to be fitted with a shaft to be fitted into these frames.
- Not suitable for deployment from a truck trailer and normally restricted to spooling operations in Fiberspar yards, except in Canada, where Fiberspar has built specialized trailers permanently fitted with two chain drive units that take advantage of local height restrictions to transport two 16-ft (4.9-m) diameter spools ready for deployment
- Suitable for re-spooling operations

Carousel

- Spool loaded horizontally
- Deploys larger-diameter spools –12-ft to 19-ft (3.7-m to 5.8-m) diameter – and pipe sizes up to 6 in. – 1500 Two hydraulic rubber tires to control deployment rate
- Two level-wind arms that contain the Fiberspar LinePipe on the reel to support the pipe wraps during deployment
- Two of this type of deployment frame can be carried on a step-deck trailer, allowing the installer to deploy up to 9,000 ft (2750 m) of FS LP 4-1/2 in. – 1500 product without the necessity of a crane being on location.
- Not suitable for re-spooling operations



All three styles of frames require a hydraulic power supply for operation of the hydraulic drive control motors and the level wind arms on the carousel frames. The hydraulic power supplies are either gasoline- or diesel-driven and connect to the deployment frames via high-pressure hoses and quick-connect couplings.

For Canadian installations where 12-ft to 16-ft reels can be transported in the vertical position, Fiberspar also uses a specially designed vertical deployment spool trailer. This trailer is equipped with a hydraulic drive system that allows for direct deployment of pipe on location. The adjacent photo shows a vertical deployment spool trailer transporting two 16-ft reels of pipe.

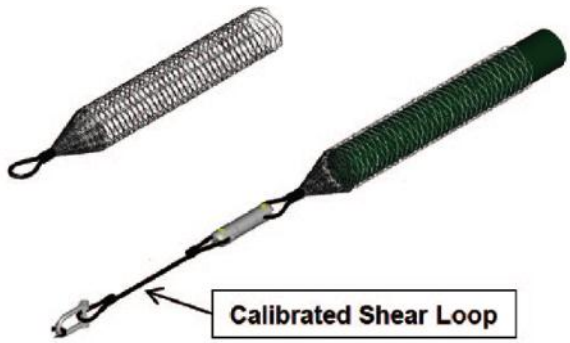
Pulling Devices

For most installations, a suitably powered device is required for pulling the pipe off the spool. Fiberspar does not normally supply this device, as suitable devices (backhoes, for example) are usually available at location. The pulling device must be selected to provide sufficient, but not excessive, pulling force under the prevailing conditions to ensure that the pipe is not damaged. Pulling capability should not exceed the recommended maximum tensile load of the FS LP product being installed. This maximum recommended tensile load varies with different FS LP designs. Calibrated shear loops or other tension-limiting devices must be used to prevent accidental over-pulling of the pipe. In some situations a load indicator may also be used to ensure installation does not result in excessive tension on the LinePipe.

For some installations, a winch or wireline-type of device with sufficient pulling capability is required. If the maximum pulling capacity could exceed the recommended maximum tensile load of the FS LP being installed, the tensile load should be monitored on a load indicator to ensure that the maximum tensile is not exceeded. Where no load indicator is available, a tension-limiting device, such as a calibrated shear loop must be used. Fiberspar can supply suitably sized calibrated shear loops.

Pulling Heads

• The pulling head is attached to the end of the FS LP by setscrews through a number of holes drilled through the side of the pipe.
• The pulling head is attached to the pulling device by a calibrated shear loop. The shear loop may also be attached to a nylon sling or strap to avoid “shock” loading during the installation process.
• Fiberspar will supply pulling heads sized and designed for the various sizes and pressure ratings of FS LP.



Multi-Grip Pulling Assembly

• The device slips over the pipe and tightens up on the pipe as you pull on it. It has a reinforced eye on the end for attachment to the pulling strap or cable.
• The multi-grip pulling assembly is attached to the pulling device by a calibrated shear loop.
• Fiberspar will supply suitably sized multi-grip pulling assemblies

Load Indicating System

When pulling pipe through a conductor, a pulling load indicator system is recommended. All Fiberspar wireline trucks and winches come equipped with these devices, and the system provides a real-time indication of the tensile load being applied to the FS LP as well as a record of the applied maximum force.

Miscellaneous

The following tools are required for all installations and are carried by Fiberspar service representatives:

- Fiberspar Liner Reaming Tool – This tool is required for sizing the ID of the FS LP before attaching the Fiberspar connector.

- Fiberspar Calibrated Shear Loop – These shear loops are used for attaching LinePipe pulling devices to the pulling equipment. The shear loops are specifically designed with a breaking strength less than the maximum recommended tensile load limit of the pipe they are intended for. The calibrated shear loops ensure that tensile limits of the pipe are not exceeded during the installation process and must be used any time the pipe is pulled.

- Power Hacksaw – Used to cut FS LP. Blades are bimetallic, 14 to 24 toothed or abrasive. As Fiberspar LinePipe cuts relatively easily, care must be exercised to avoid damaging adjacent pipe.

- **Tie Down** – Used to restrain any FS LP remaining on the spool. The pipe on the spool must be restrained at all times. The preferred method is to either use a metal clamp bolted to the spool flange or to cut the pipe at an angle and drill two holes through the exposed half of the pipe into the flange wall, and fit two bolts to hold the pipe. For temporary restraint, as when moving the spool on location, a strap or sling can be used.
- **Miscellaneous Hand Tools**
- **Pipe Cradles** – In some installations that require the Fiberspar LinePipe to "bend" around corners, it may be necessary to use "pipe cradles" to facilitate the installation. The pipe cradles are used in the bends to prevent the Fiberspar LinePipe from exceeding the minimum recommended bending radius during installation, to reduce friction and damage when pulling around a bend and to prevent any kink points. These cradles are attached to a fixed or stationary point in the bend, and the Fiberspar LinePipe is then pulled around the cradles during installation.

In addition to the tools listed, additional tools may be required for specific types of installations, and for the attachment of connectors and fittings. Fiberspar can supply these tools.

Pre-job Planning

Proper pre-job planning is essential for a trouble-free, effective installation. A Fiberspar district manager will contact a customer's site representative ahead of a planned installation to confirm job details, provide a recommended job plan and ensure that any site-specific potential issues are resolved. District managers have check lists that are the basis for this planning.

When the job begins the Fiberspar service representative will conduct meetings to discuss the details of the overall job plan and activities planned for the day. (Also see information on JSA in the next section.)

Job Documentation

The Fiberspar service representative or a Fiberspar certified installer will complete the job-specific documentation listed below:

- **Job Safety Assessment (JSA)** – The Fiberspar representative will conduct daily "tail-gate" meetings to address all aspects of safety specific to the installation. This information will be documented.
- **Job Log** – The Fiberspar representative will document in a job log details of the installation, including:
  - Foot markers and serial numbers of pipe installed
  - Connector locations
  - A chronological account of activities
  - Other pertinent information
- **Quality Job Traveler** – The job traveler documents major steps, inspection and hold points in the installation process and is signed by the Fiberspar technician and customer's representative.
- **Field Service Ticket** – Contains details of product installed, service representative time and equipment usage for billing purposes. This document is normally signed by the customer's representative on location.

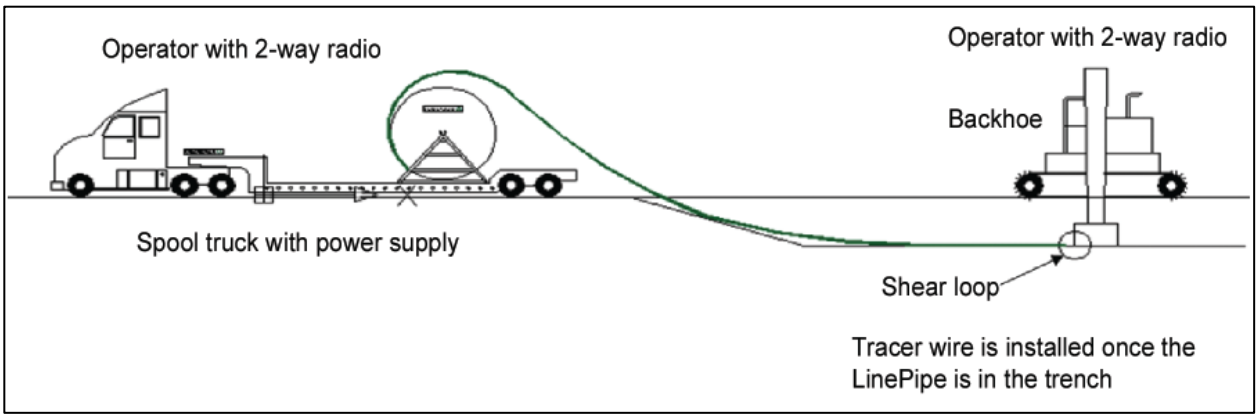
Installation Techniques

The following section is a brief description of the most common installation techniques used to install Fiberspar LinePipe. More detailed information is contained in the appendices.

A Fiberspar service representative should be present to supervise the overall installation operation, provide specific training to local helpers and fit all connectors. It is recommended that the Fiberspar service representative also be present during hydro-testing.

Crew size will be dependent on the specific installation and skill level of the work force, as well as industry practice, but typically the Fiberspar service representative will require a backhoe or similar equipment to pull the pipe and one additional helper to assist with handling.

In all operations, crew sizes will be dictated by terrain and environmental conditions.

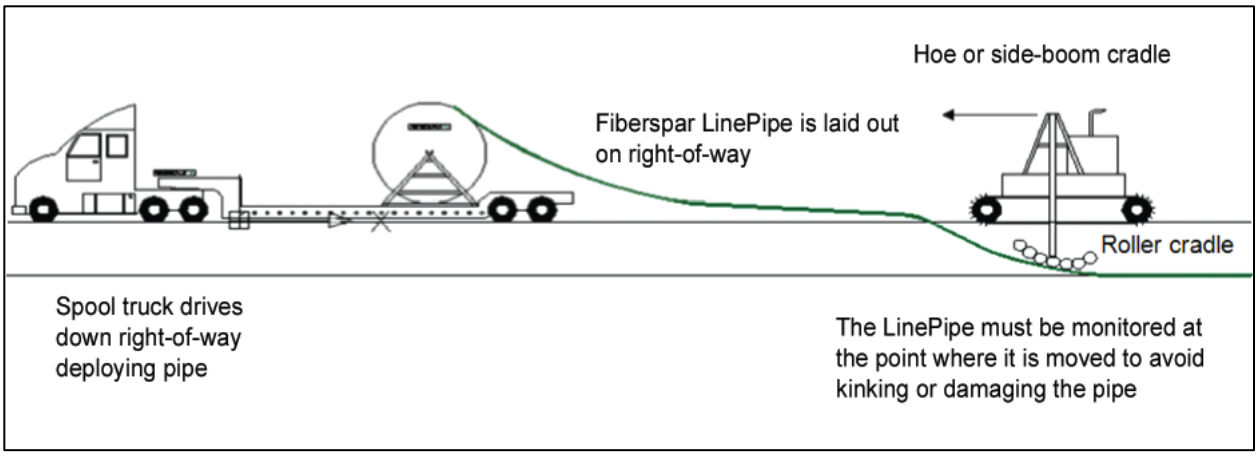


Stationary Spool – Surface and Buried

- This is the normal and preferred installation method for areas with soil that is not excessively rocky.
- The spool and spooling frame serve as an anchor point. The FS LP is deployed by pulling it from the stationary spool.
- For surface or buried lines, a truck, backhoe or other piece of construction equipment is used to pull the pipe into the trench.
- A calibrated shear loop is used to attach the end of the pipe to the equipment used to pull it in place.
- The pulling device must be properly sized, but not oversized, for the product being installed.

***CAUTION:* Since the FS LP will be pulled off the stationary reel when using this installation method, care should be taken to avoid dragging the pipe over anything that could cause damage to the OD of the pipe.**

***Note:* Pipe cannot be moved when spooled on the right of way into the trench with a chain or straps. Proper coordination of the pipe and slack is required to shift the position of the pipe from surface to trench bottom without damaging the LinePipe.**



Moving Spool

- This installation method is often used when the soil is excessively rocky or abrasive.
- It is first necessary to connect and anchor the pipe end. Connecting is accomplished using the appropriate joining system. Anchoring is accomplished by installing a thrust block or anchor post and clamping or otherwise securing the pipe in place. The anchor must be strong enough to resist loads up to the recommended tensile load of the FS LP being installed.
- This method of installation reduces abrasion damage to the pipe.
- It may involve moving a trailer with the spooling frame/spool and pipe mounted on it under off-road conditions.
- If the access is too limited for a large truck, the pipe and spooling frame can be transferred to a trailer pulled by a pickup or tracked vehicle.

***CAUTION:* This method should only be carried out where the access for the moving vehicle is flat and secure. The pipe spool represents a top-heavy load that could overturn. This type of installation should be used only with experienced drivers and performed slowly and with caution. An overturning load can result in injury to personnel and damage to equipment and the FS LP.**

Trenches

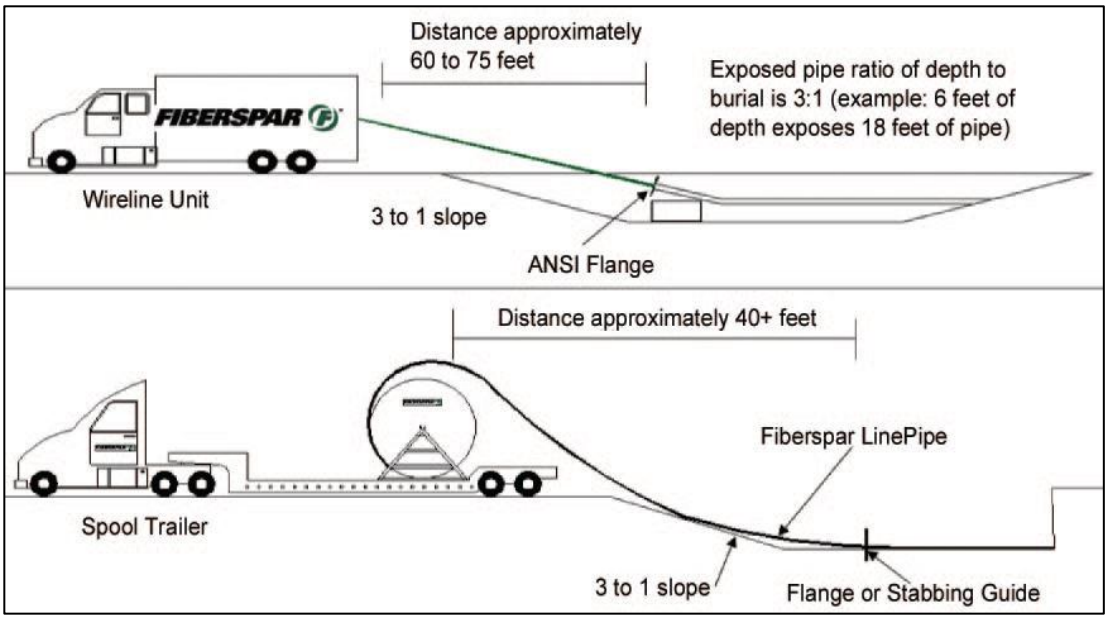
- Trenches must be prepared for accepting the pipe. Preparation involves ensuring that the bottom is reasonably smooth and level. Bedding, if required, should be in place.
- FS LP can be installed in a continuous length even where the trench is not straight. Bends should have as large a radius as possible (preferably more than 1.5 times the minimum bend radius as specified on the pipe data sheet).
- For narrow trenches slightly wider than the pipe, the FS LP can be deployed alongside and lowered into the trench manually after any necessary connections have been made, or the trench can be widened at the areas where connections will be made.

- Pipe must be inspected before testing or covering to ensure there are no sharp surfaces, such as large rocks, or contacts with other pipes. At pipe crossings, the FS LP should preferably pass under other pipes, and good padding/sandbags should be placed between the two. Direct contact (even after settlement) can result in rapid wear even from minor movement (i.e., pulsations, fluid movement or vibration).
- In trenched installations, road or river crossings are handled in a manner similar to pull-through installations. (See below.)

Surface Installations

- The techniques for surface installation are similar to those of trenched installation, but some special consideration should be given to pipe protection.
- Jacketed pipe will be used for surface installation for extra protection.
- The pipe should be installed and supported on smooth ground, not on pipe supports, as are often used for surface installation of steel pipe.
- Vehicles should not be driven over FS LP, so crossing points may have to be provided.
- Since the pipe will not be restrained during hydro-test, it can shrink in length during the test. Care should be taken to ensure that the pipe cannot move and tighten against pinch or kink points. Fiberspar engineers can advise on the amount of expected shrinkage and how to make provision for it.

CAUTION: **It can be difficult to move the unrestrained pipe around planned bends in the right of way, and pipe rollers and anchor points must be used to route the pipe. Fiberspar field supervision should be consulted in advance for advice on the route and equipment required if a surface installation is planned.**



Pipeline Remediation

- Involves pulling Fiberspar LinePipe inside an existing pipeline to effect repairs to the existing line.
- A wireline, from a winch or wireline unit, is normally pumped through the existing pipeline and used to pull the FS LP through. Only a single wireline can be used for a given run of pipe. The winch/wireline should be capable of pulling to the recommended tensile load of the FS LP. A plastic or rubber guide bushing is required at the entrance of the parent pipe to prevent damage to the FS LP.
- It is also possible to install LinePipe using an injection/pushing device rather than pulling with a wireline unit.
- In particularly difficult installations the wireline and pushing units may be used in combination.
- A more complete installation guide for pipeline remediation is contained in the appendix.

Plow-in

- Fiberspar LinePipe can be plowed in using a high-capacity plow. The plow must have sufficient capacity to bury the FS LP to the required depth and a shoe with an installation radius equal to or greater than the minimum bending radius of the FS LP.

- The buried pipe can never be inspected with a plow-in installation, so these installations must be restricted to predictable areas and good soil conditions. Conditions to be avoided include rocky ground, frozen ground and locations in which severe elevation changes occur.

- Ground would be considered unsuitable for plow-in if an additional pulling force is required to move the plow, if the plow cannot maintain a reasonably consistent plow-in speed and is stop/starting, if large rocks are being pushed to the surface or if the chute or guide is being sharply moved laterally or vertically by obstructions.

- A more complete installation guide is contained in the appendix.

Slick Bores

When applications require the use of a boring unit to pass beneath a road or swamp, it is common to pull the Fiberspar LinePipe directly into the uncased bore as the boring unit exits the hole. Extra care should always be taken whenever FS LP is pulled through holes that are not cased. Some tips for successful slick bore installation are as follows:

- Slick bore installation should only be attempted where the ground is stable.

- The bore ID must be bigger than the LinePipe by at least 0.375 in. (10 mm) or 10%, whichever is smaller.

- A pull head must always be used and not a pulling grip.

- The Maximum Recommended Tensile Load must be communicated to the bore operator prior to the job beginning (see product data sheet), and the tensile load must be monitored closely throughout the boring operation. It may be necessary to convert hydraulic equipment pressure values to obtain tensile load readings.

- If tensile load cannot be monitored a calibrated shear loop must be used to secure the pipe end to the boring unit. The shear loop should have swivels on both ends.

- Use jacketed pipe for extra protection.

- If possible, the hole should be drilled and then back-reamed as the pipe is being installed.

In some cases multiple lines are pulled into a single slick bore. If this is the case the lines must be pulled simultaneously and should be restrained as they enter the slick bore to prevent twisting and nesting. If one or more of the lines is steel, the Fiberspar pipe must be secured so that it does not become trapped under the steel during the installation.

Joining

Introduction

The Fiberspar service representative or a Fiberspar certified installer will install all service fittings on location. Assistance may be required, particularly with larger-diameter FS LP, to manipulate that pipe while the connector is being installed.

The FS LP Compression Slip Connector is a mechanical fitting that attaches to the pipe by application of compression. Two general types of connectors are used, service end and pipe-to-pipe.

Service End and Pipe-to-pipe Connectors

Connector forces are typically applied through wedge loading of a slip between two body halves. The Fiberspar LinePipe Engineering Guide provides the required formulas to calculate axial forces generated in a pipeline with Fiberspar LinePipe based on changes in pressure or temperature.

The effect of internal pressure and temperature change on axial forces in the Fiberspar LinePipe shall be taken into account when making up fittings. In preparing for attachment to another system or fitting, the needs of the customer and system must be considered and the proper end configuration ordered. Planning should consider the application and the connection means to be used. The assembly procedure may vary slightly depending upon the type of end connection involved.

Service End Connectors

- Used at the end of a pipe run to connect the pipe to another system or another fitting
- Available with a variety of end configurations commonly used in pipeline applications. Fiberspar standard configuration is an ANSI RF Flange. Other configurations supplied on request are RTJ flange, NPT pipe thread, hammer unions and other configurations specific to end-user specifications.

Pipe-to-pipe Components

- Used to join two lengths of FS LP together
- Attachment is the same as attachment of the service-end connector except that there are two pipe ends to be prepared and the connector has two slips and two slip nuts.

The attachment procedure for a connector involves the following general steps:

- The pipe end is cut square.
- The FS Reaming Tool is used to size the inside diameter of the pressure barrier.
- A chamfer is cut on the exposed end of the pressure barrier.
- The slip nut and slip are positioned on the end of the pipe.
- The service end or pipe-to-pipe connector is fitted with “O” rings, lightly lubricated and inserted into the pipe end.
- The connector and slip nut are threaded together and the threads tightened.

CAUTION: **In attaching compression slip connectors to the FS LP or the system, the pipe must not be rotated or subjected to torque. “O” rings should be installed and lubricated just prior to final assembly to avoid damage.**

Connector Selection

In order to ensure that the proper connector is used on the LinePipe product, measurements of the ID and OD of the pipe are used to determine which connector components should be installed. Components are then selected based on the range they are designed to fit and how the LinePipe measurements fit into that range.

Cathodic Protection

Some installations may require the use of Cathodic Protection (CP) for additional corrosion protection of connectors. CP is usually limited to pipe-to-pipe connectors, but may also be required for end connectors when connecting to an external non-metallic piping system. CP, from most third-party suppliers, will work with Fiberspar connectors. CP generally consists of a clamp that is attached around the connector body that is then electrically connected to a bag anode. To install, CP manufacturers’ guidelines should be followed. The general steps are as follows:

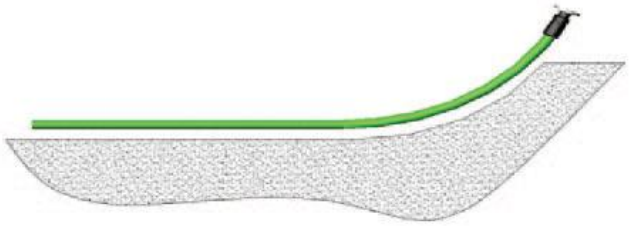
1. The anode should be installed either vertically or horizontally close to (but not touching) the connector.
2. The anode should be installed at the same depth as the connector.
3. The anode cable should be placed in direct contact with the metallic clamp.
4. The clamp/wire connection should be solid, and the whole clamp and connector then completely wrapped with a corrosion resistant tape.
5. The anode should be completely saturated with water before backfilling (approx. 4 gal (15 l)).

End Terminations

There are three common methods for terminating Fiberspar LinePipe.

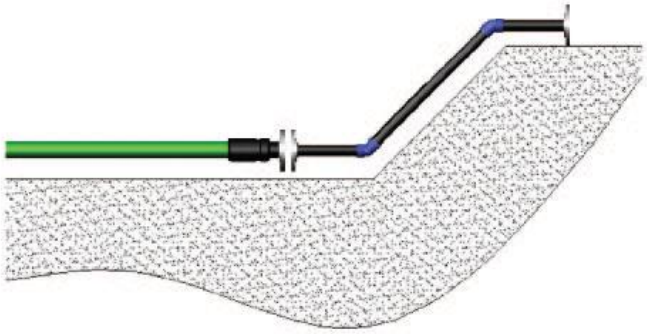
Surface Tie-in

In this configuration the pipe is brought to the surface in a gradual bend and tied in with a connection. The bell hole has to be prepared with a suitable bed shape to ensure that the pipe is not exceeding its allowable bend radius.



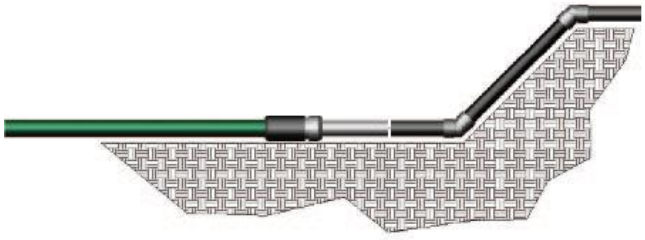
Rigid Riser

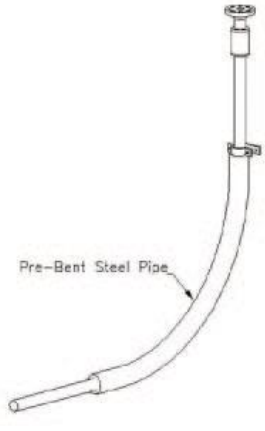
In this configuration the pipe is terminated subsurface to a rigid riser. The riser can be coated, and the Fiberspar connector is often a weld neck or a flange.



Riser Chute

In cases in which the riser must be a special material (for example in CO_2 floods), an alternative is to fabricate a riser chute through which the pipe is brought to surface.





Pipe Contraction

If FS LP is hydro-tested before a rigid riser system is installed, extra care must be taken. If both ends are not properly constrained during hydro-test the FS LP will contract slightly. This can lead to problems, as the rigid riser and FSLP may not line up correctly. In dealing with situations such as these, there are three main courses of action.

1. The most desirable option is to have the riser installed before installation of the pipe. In this scenario the pipe can be attached, and no contraction is allowed to occur.
2. The second option is to install a temporary pile to which the pipe can be attached. This would allow hydro-testing and prevent the pipe from contracting. Once the riser connector has been made up, this temporary pile could then be removed.
3. The final option would be to wait until after the hydro-test is complete to mark the location of the riser. In this way the riser can be made up to the contracted position of the pipe.

Under no circumstances should field personnel attempt to “stretch” the pipe.

For pipeline remediation it is also necessary to properly secure the pipe at the points where it exits the conduit pipeline. With relatively little friction between the LinePipe and conduit, contraction is also likely to occur at these points.

Testing and Backfilling

Introduction

All Fiberspar LinePipe is tested to 1.5 times rated operating pressure before being shipped, and by following installation procedures properly, a first time successful field-test should be the routine result. However, the field test is the last line of defense, the point at which anything that slips through the net should be caught before it becomes a damaging service failure. When field test procedures are adhered to and a successful test is achieved, service failure is very rare.

Filling

The system should be filled by pumping a pig (poly or squeegee) in front of the fluid to help force the air out of the system. In systems containing tees and branches, it may not be suitable to use a pig, as the pig may get caught in one of the side branches. Fluid should enter the system at the lowest point and air must be vented from the highest point or points. Allow fluid to flow through the vents until there is no evidence of air coming from the system. When all air is removed, seal the vents and prepare for testing.

CAUTION: **Entrapped air will cause testing problems and may result in over-pressurizing the system. Use care to ensure that all air is removed.**

Test Procedure

Following the steps below will guarantee a safe test, demonstrate whether leaks are due to a pipe problem or a back fill problem and prevent problems from shrinkage stress that takes place when pressure exceeds the pipe's rated pressure. If requested, a Fiberspar representative can be present during the test.

- The pipe should be backfilled as completely as possible, leaving only the connections exposed. This is done for two reasons:
  1. Backfilling is one of the most common sources of pipe damage and would not be detected if the pipe is tested only before backfilling.
  2. Fiberspar LinePipe will contract in length at pressures above normal rated pressure, and backfilling will prevent any movement.
- Fill pipe with water, taking all reasonable steps to remove air or gas.
- Raise pressure slowly (less than 20 percent rated pressure per minute) to around 500 psi (3,447 kPa) and check for leaks at the exposed connections. The purpose of this test is to find any obvious connector leaks or gross damage before backfilling.
- Raise pressure slowly (max 20 percent rated pressure per minute) in 500-psi (3,447-kPa) increments and hold for 5 to 15 minutes at each increase. Check for leaks. Continue to raise the pressure in this manner until reaching full test pressure, and hold.

When practical, complex piping systems should be broken into smaller runs for testing. The following guidelines and warnings must be followed carefully to avoid injury to personnel and/or damage to equipment.

CAUTION: **Testing with fluids under pressure can be hazardous. Personnel injury and/or equipment damage is possible. Exercise care and follow safety precautions. Never attempt to tighten a connector while pressurized.**

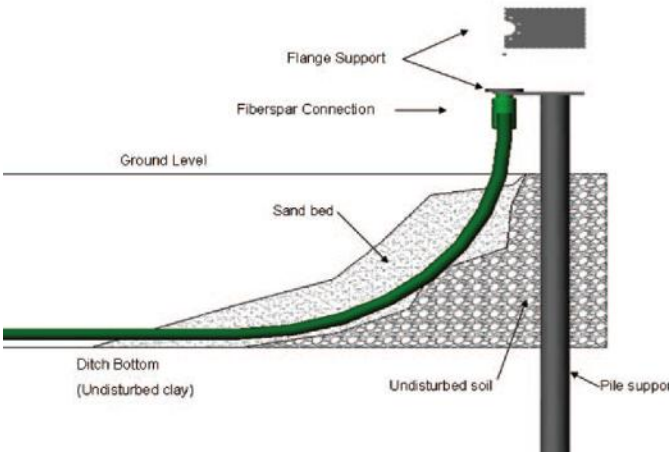
Testing with air or gas is extremely dangerous and should not normally be undertaken. Gas is compressible, and the stored energy is much higher than with fluids. If a gas test is proposed, consult with Fiberspar Technical Management.

Test Pressures

The recommended test pressure is 1.2 to 1.5 times the rated operating pressure of the system, with a maximum of 1.5 times the rated operating pressure of the Fiberspar LinePipe.

CAUTION: **Before the line is pressurized it must be at least partially covered. High-pressure fittings should be blocked.**

Due to the nature of the composite material, some time may be needed to stabilize the pipe at the desired test pressure. Overpressure up to 200 psi (1,380 kPa) above the target test pressure is acceptable to allow for this stabilization. With pressure stabilized, start the clock and monitor the pressure.



NOTE: FS LP expands slightly during initial pressurization. It is, therefore, recommended that the pipe be allowed to "stabilize" at pressure for a period of time before beginning the actual test. This stabilization period is usually about 30 minutes in lines of up to 5,000 ft (1,525 m) in length, but can be longer in lines of much greater length. It is usually obvious when the pipe stabilizes, and generally slow pressure decline (less than 25 psi/hr) during this time will be due to stabilization and not pipe leaks. Having excessive air in the line will also lengthen this stabilization period.
Temperature changes cause the test fluid to expand or contract, resulting in changes in pressure. Ambient temperature should be tracked to provide compensation on pressure graphs.

Test pressure should be held for a minimum of two hours (and preferably four hours). The customer and/or applicable regulations may require longer testing periods. Test periods as long as 24 hours are not uncommon.

Pipe Contraction/Expansion

Fiberspar LinePipe behaves differently from most other pipeline products with respect to axial contraction or expansion. Fiberspar LinePipe is designed so that there is virtually no contraction or expansion of the pipe in the axial direction at the rated operating pressure. Below the rated operating pressure there is slight initial axial expansion as the pressure is increased, but this axial expansion diminishes as the pressure nears rated pressure, becoming virtually zero at around rated pressure. However, this expansion tendency is very small, with very small axial forces, and can usually be ignored as the weight of the pipe when filled with water is more than sufficient to prevent any actual pipe movement.

When the pipe pressure is raised above rated operating pressure (normally only for test purposes) the pipe will try to contract in length. These forces are relatively small, and backfilling the pipe will normally provide enough restraining force to prevent actual movement, but if the pipe has sections not backfilled – e.g., close to risers or connections – precautions must be taken to provide support for any contraction loads that may be passed to risers or to isolate other parts of the system.

Particular care must be taken if there are long unrestrained sections, such as in a non-backfilled ditch, an above-ground installation or at a pull-through or river crossing. As well as exerting force on other parts of the system, Fiberspar LinePipe will tend to tighten around any bends or restraints and can be damaged, so provision must be made for this. Fiberspar engineers can calculate the amount of contraction and the contraction forces and provide advice on how to offset it.

***CAUTION:* Connectors should be installed in straight sections of the pipe well away from any bends, and the pipe should be supported, usually by backfilling around the bend area. No levering or forcing of the pipe should be required to line up with the connector.**

Backfilling

Before backfilling, Fiberspar LinePipe should be inspected to ensure that there is no visible damage and that the pipe is bedded on smooth soil so that the weight of backfill will not press the pipe down onto a point load underneath. Care should be taken with backfilling, particularly in shading the first 1 ft (30 cm) of cover. The first 1 ft (30 cm) of cover should not contain any large rocks, and the pipe should be covered gently, taking care not to allow mechanical equipment to come into contact with the pipe.

Large rocks, large pieces of frozen soil or tree trunks can be used as infill once a reasonable cover over the pipe is achieved, but these should not be dropped into the ditch during the backfill process.

Where Fiberspar LinePipe emerges from a conductor pipe or conduit, the pipe should be packed off at the exit point, using “linkseal” or a similar soft packing material. At the transition the pipe must be supported centrally with the conductor pipe or conduit so that no shear load will be placed on the pipe when the ditch is backfilled. This can be accomplished by placing sacks of “Sacrete,” sand bags or some similar material under the pipe, then backfilling carefully with frequent tamping to ensure consolidation.

Tracer Wire

Tracer wire or tape should be used to allow easy location of the pipe in the future. Regulations in some areas (usually areas where ground lightning strikes are common) dictate that the tracer wire should be located in the ditch about 6 in. (15 cm) above the pipe, and continuous contact with the pipe should be avoided. Fiberspar will supply tracer wire if requested.

Static Discharge

Fiberspar LinePipe is an electrical insulator, and in applications that involve transport of non-polar fluids such as dry gas, liquid fuels or pure hydrocarbons (especially at high velocities) a static charge may be generated on pipe surfaces. Grounding and static control procedures should be employed during any intervention. Static electric discharge can ignite a flammable gas or a combustible atmosphere. Where a flammable gas or combustible mixture may be encountered and static electric charges may be present, observe all company (operator, contractor, etc.) procedures for static electricity safety and control, including procedures for discharging static electricity and personnel protection as stated on relative MSDS sheets.

In Fiberspar LinePipe applications involving transport of wet gas or liquid or multiphase flow containing water, no significant static charge is generated on pipe surfaces.

Vibration, Pulsation and Flow Cycling

Applications that use pumps or include pressure cycling may require additional steps to prevent long-term pipe damage or degradation. Systems subject to severe pressure cycling or pulsation may require higher design pipe safety factors per applicable design codes. Applications that will operate on a high-pressure pump, which also cycles several times a day, must be reviewed to determine if any additional safety factors need be applied. All pumps produce pulsation, and pulsation dampeners need to be properly sized and maintained to prevent service failures. Positive displacement pumps are particularly prone to vibration and pulsation problems. Fiberspar Engineering will provide application-specific advice where vibration, pulsation or cycling is a concern.

Field Incident Reporting

Fiberspar has a system for reporting issues and incidents concerning the LinePipe product, service and installations. Any person involved with Fiberspar LinePipe has the authority to raise a Corrective Action Request (CAR). This requires only a verbal or informal note to the Engineering Department, which will raise the formal paperwork. This will trigger an investigation of the problem, determine the root cause and provide a recommendation for improvement going forward, as well as appropriate actions such as changes to documents and work instructions.

Serious incidents such as a failure on test or in service require immediate notification of the Fiberspar district manager. The district manager then initiates a process leading to an investigation that will normally result in a formal report.

Health- and safety-related incidents must follow Fiberspar accident or near-miss reporting procedures, and since most field incidents will occur on customer property, should also follow the customer-specified safety incident reporting procedures.

Appendix A

Fiberspar LinePipe Specifications – USA (Imperial)

FS LP is available with high-density polyethylene (HDPE) or high-temperature polyethylene (HTP) pressure barriers. The temperature ratings are 140ºF and 180ºF, respectively. Values given in the tables below will vary slightly depending on the pressure barrier used (HDPE or HTP). For exact values specific product data sheets should be consulted.

Product Name	ID (in.)	OD (in.)	Nominal Reinforced Wall Thickness (nom.)	Minimum Reinforced Wall Thickness (min.)	Weight (lbs/ft)	Recommended Maximum Operating Pressure* (psi)	Minimum Burst Room Temperature (psi)	Minimum Burst Operating Temperature (psi)	Maximum Recommended Install Tensile Load (lbf)	Minimum Bend Radius (in.)
300 Series										
FS LP 3" 300 (E)	2.51	3.04	0.055	0.047	1.18	300	2,219	1,886	3,000	71
FS LP 3" 300 (X)	2.51	3.04	0.055	0.047	1.18	300	2,219	1,664	3,000	71
FS LP 4" 300 (E)	3.33	4.01	0.072	0.061	2.03	300	2,165	1,840	5,480	95
FS LP 4" 300 (X)	3.33	4.01	0.072	0.061	2.03	300	2,165	1,624	5,480	95
FS LP 6" 300 (E)	4.75	5.48	0.079	0.067	2.98	300	1,698	1,443	7,960	132
FS LP 6" 300 (X)	4.75	5.48	0.079	0.067	2.98	300	1,698	1,274	7,960	132
750 Series										
FS LP 2 ½" 750 (E)	2.00	2.54	0.080	0.068	1.05	750	3,940	3,349	3,480	59
FS LP 2 ½" 750 (X)	2.00	2.54	0.080	0.068	1.05	750	3,940	2,955	3,480	59
FS LP 3" 750 (E)	2.51	3.10	0.082	0.070	1.40	750	3,266	2,776	4,480	72
FS LP 3 ½" 750 (E)	2.96	3.58	0.090	0.076	1.75	750	3,046	2,589	5,720	85
FS LP 3 ½" 750 (X)	2.96	3.58	0.090	0.076	1.75	750	3,046	2,285	5,720	85
FS LP 4" 750 (E)	3.48	4.16	0.106	0.090	2.26	750	3,101	2,636	7,960	99
FS LP 4 ½" 750 (E)	3.99	4.73	0.122	0.103	2.87	750	3,095	2,631	10,440	113
FS LP 4 ½" 750 (X)	3.99	4.73	0.122	0.103	2.87	750	3,095	2,321	10,440	113
FS LP 6" 750 (E)	4.75	5.62	0.150	0.128	4.04	750	3,200	2,720	15,360	136
FS LP 6" 750 (X)	4.75	5.62	0.150	0.128	4.04	750	3,200	2,400	15,360	136
FS LP 6 ½" 750 (E)	5.60	6.69	0.161	0.136	5.77	750	2,912	2,475	19,320	159
FS LP 6 ½" 750 (X)	5.60	6.69	0.161	0.136	5.77	750	2,912	2,184	19,320	159
1,500 Series										
FS LPJ 2 ½" 1,500 (E)	1.89	2.48	0.095	0.080	1.12	1,500	4,838	4,112	4,000	57
FS LPJ 2 ½" 1,500 (X)	1.89	2.48	0.095	0.080	1.12	1,500	4,838	3,629	4,000	57
FS LPJ 3" 1,500 (E)	2.37	3.04	0.113	0.096	1.60	1,500	4,660	3,961	5,960	71
FS LPJ 3" 1,500 (X)	2.37	3.04	0.113	0.096	1.60	1,500	4,660	3,495	5,960	71
FS LPJ 3 ½" 1,500 (E)	2.82	3.57	0.134	0.114	2.18	1,500	4,656	3,958	8,440	84
FS LPJ 3 ½" 1,500 (X)	2.82	3.57	0.134	0.114	2.18	1,500	4,656	3,492	8,440	84
FS LPJ 4" 1,500 (E)	3.33	4.18	0.161	0.136	2.95	1,500	4,722	4,014	11,920	100
FS LPJ 4" 1,500 (X)	3.33	4.18	0.161	0.136	2.95	1,500	4,722	3,542	11,920	100
FS LPJ 4 ½" 1,500 (E)	3.75	4.68	0.179	0.152	3.61	1,500	4,661	3,962	14,880	112
FS LPJ 4 ½9 1,500 (X)	3.75	4.68	0.179	0.152	3.61	1,500	4,661	3,496	14,880	112
FS LPJ 6" 1,500 (E)	4.52	5.62	0.218	0.185	5.20	1,500	4,715	4,008	22,040	135
FS LPJ 6" 1,500 (X)	4.52	5.62	0.218	0.185	5.20	1,500	4,715	3,536	22,040	135
FS LPJ 6 ½" 1,500 (E)	5.60	6.90	0.270	0.230	7.71	1,500	4,718	4,010	33,760	167
FS LPJ 6 ½" 1,500 (X)	5.60	6.90	0.270	0.230	7.71	1,500	4,718	3,539	33,760	167

2,500 Series										
FS LPJ 2 ½9 2,500 (E)	2.03	2.86	0.176	0.150	1.92	2,500	7,971	6,775	8,480	66
FS LPJ 39 2,500 (E)	2.54	3.52	0.219	0.186	2.88	2,500	7,942	6,751	13,200	83
FS LPJ 3 ½9 2,500 (E)	3.05	4.18	0.261	0.221	4.02	2,500	7,893	6,709	18,880	99
2,250 Series										
FS LPJ 4 ½9 2,250 (E)	3.57	4.79	0.284	0.241	5.06	2,250	7,411	6,299	23,800	115

*Represents thermoplastic barrier material: HDPE = (E) and HTP = (X)

**Pressure ratings are based on minimum 20 year service life using ASTM D2992 long-term test procedures. Recommended maximum operating pressure is Fiberspar's recommendation for general oilfield water, low vapor pressure hydrocarbons and multiphase service conditions at the maximum rated temperature. Consult Fiberspar for a recommended maximum pressure rating for other service conditions.

Fiberspar LinePipe Specifications – USA (Metric)

FS LP is available with high-density polyethylene (HDPE) or high-temperature polyethylene (HTP) pressure barriers. The temperature ratings are 60ºC and 82ºC, respectively. Values given in the tables below will vary slightly depending on the pressure barrier used (HDPE or HTP). For exact values specific product data sheets should be consulted.

Product Name	ID (mm)	OD (mm)	Nominal Reinforced Wall Thickness Nom (mm)	Minimum Reinforced Wall Thickness Min (mm)	Weight (kg/m)	Recommended Maximum Operating Pressure* (MPa)	Minimum Burst Room Temperature (MPa)	Minimum Burst Operating Temperature (MPa)	Maximum Recommended Install Tensile Load (kgf)	Minimum Bend Radius (cm)
300 Series										
FS LP 39 300 (E)	64	77	1.4	1.2	1.76	2.07	15.30	13.00	1,360	181
FS LP 39 300 (X)	64	77	1.4	1.2	1.76	2.07	15.30	11.47	1,361	181
FS LP 49 300 (E)	84	102	1.8	1.6	2.96	2.07	14.93	12.69	2,350	242
FS LP 49 300 (X)	84	102	1.8	1.6	2.96	2.07	14.93	11.20	2,350	242
FS LP 69 300 (E)	121	139	2.0	1.7	4.43	2.07	11.71	9.95	3,610	335
FS LP 69 300 (X)	121	139	2.0	1.7	4.43	2.07	11.71	8.78	3,610	335
750 Series										
FS LP 2 ½9 750 (E)	51	65	2.0	1.7	1.56	5.17	27.17	23.09	1,579	149
FS LP 2 ½9 750 (X)	51	65	2.0	1.7	1.56	5.17	27.17	20.37	1,570	149
FS LP 39 750 (E)	64	79	2.1	1.8	2.08	5.17	22.52	19.14	2,030	184
FS LP 3 ½9 750 (E)	75	91	2.3	1.9	2.60	5.17	21.00	17.85	2,590	215
FS LP 3 ½9 750 (X)	75	91	2.3	1.9	2.60	5.17	21.00	15.75	2,590	215
FS LP 49 750 (E)	88	106	2.7	2.3	3.36	5.17	21.38	18.17	3,610	251
FS LP 4 ½9 750 (E)	101	120	3.1	2.6	4.28	5.17	21.34	18.14	4,730	288
FS LP 4 ½9 750 (X)	101	120	3.1	2.6	4.27	5.17	21.34	16.00	4,730	288
FS LP 69 750 (E)	121	143	3.8	3.2	6.01	5.17	22.06	18.75	6,960	344
FS LP 69 750 (X)	121	143	3.8	3.2	6.01	5.17	22.06	16.55	6,960	344
FS LP 6 ½9 750 (E)	142	166	4.1	3.5	7.65	5.17	20.08	17.07	8,760	403
FS LP 6 ½9 750 (X)	142	166	4.1	3.5	7.65	5.17	20.08	15.06	8,760	403
1,500 Series										
FS LPJ 2 ½9 1,500 (E)	48	63	2.4	2.0	1.67	10.34	33.36	28.35	1,810	145
FS LPJ 2 ½9 1,500 (X)	48	63	2.4	2.0	1.67	10.34	33.36	25.02	1,810	145
FS LPJ 39 1,500 (E)	60	77	2.9	2.4	2.38	10.34	32.13	27.31	2,700	180

FS LPJ 39 1,500 (X)	60	77	2.9	2.4	2.38	10.34	32.13	24.10	2,700	180
FS LPJ 3 ½9 1,500 (E)	72	91	3.4	2.9	3.24	10.34	32.10	27.29	3,820	214
FS LPJ 3 ½9 1,500 (X)	72	91	3.4	2.9	3.24	10.34	32.10	24.08	3,820	214
FS LPJ 49 1,500 (E)	84	106	4.1	3.5	4.39	10.34	32.56	27.67	5,400	253
FS LPJ 49 1,500 (X)	84	106	4.1	3.5	4.39	10.34	32.56	24.42	5,400	253
FS LPJ 4 ½9 1,500 (E)	95	119	4.5	3.9	5.37	10.34	32.14	27.32	6,740	284
FS LPJ 4 ½9 1,500 (X)	95	119	4.5	3.9	5.37	10.34	32.14	24.10	6,740	284
FS LPJ 69 1,500 (E)	115	143	5.5	4.7	7.74	10.34	32.51	27.63	9,990	344
FS LPJ 69 1,500 (X)	115	143	5.5	4.7	7.74	10.34	32.51	24.38	9,990	344
FS LPJ 6 ½9 1,500 (E)	142	175	6.9	5.8	11.48	10.34	32.53	27.65	15,310	425
FS LPJ 6 ½9 1,500 (X)	142	175	6.9	5.8	11.47	10.34	32.53	24.40	15,310	425
2,500 Series										
FS LPJ 2 1⁄2" 2,500	52	73	4.5	3.8	2.86	17.24	54.96	46.71	3,840	169
FS LPJ 3" 2,500 (E)	64	89	5.6	4.7	4.29	17.24	54.76	46.54	5,980	211
FS LPJ 3 1⁄2" 2,500	77	106	6.6	5.6	5.99	17.24	54.42	46.26	8,560	253
2,250 Series										
FS LPJ 4 1⁄2" 2,250	91	122	7.2	6.1	7.53	15.51	51.10	43.43	10,790	292

*Represents thermoplastic barrier material: HDPE = (E) and HTP = (X)

**Pressure ratings are based on minimum 20 year service life using ASTM D2992 long-term test procedures. Recommended maximum operating pressure is Fiberspar's recommendation for general oilfield water, low vapor pressure hydrocarbons and multiphase service conditions at the maximum rated temperature. Consult Fiberspar for a recommended maximum pressure rating for other service conditions.

Fiberspar LinePipe Specifications – Canada (Imperial)

Fiberspar LinePipe is intended for corrosive gathering and injection applications including general and sour produced fluids and gases. Fiberspar LinePipe is available with high-density polyethylene or high-temperature polyethylene pressure barriers with temperature ratings to 140ºF and 180ºF, respectively. Other pressure ratings and diameters available upon request.

Product Name	ID (in.)	OD (in.)	Nominal Reinforced Wall Thickness (nom.)	Minimum Reinforced Wall Thickness (min.)	Weight (lbs/ft)	Recommended Maximum Operating Pressure* (psi)	Minimum Burst Room Temperature (psi)	Minimum Burst Operating Temperature (psi)	Maximum Recommended Install Tensile Load (lbf)	Minimum Bend Radius (in.)
300 Series										
FS LP 39 300 (E)	2.51	3.04	0.055	0.047	1.18	300	2,219	1,886	3,000	71
FS LP 39 300 (X)	2.51	3.04	0.055	0.047	1.18	300	2,219	1,664	3,000	71
FS LP 49 300 (E)	3.33	4.01	0.072	0.061	1.99	300	2,165	1,840	5,480	95
FS LP 49 300 (X)	3.33	4.01	0.072	0.061	1.99	300	2,165	1,624	5,480	95
FS LP 69 300 (E)	4.75	5.48	0.079	0.067	2.98	300	1,698	1,443	7,960	132
FS LP 69 300 (X)	4.75	5.48	0.079	0.067	2.98	300	1,698	1,274	7,960	132
750 Series										
FS LP 2 ½9 750 (E)	2.00	2.55	0.080	0.068	1.05	750	3,940	3,349	3,480	59
FS LP 2 ½9 750 (X)	2.00	2.55	0.080	0.068	1.05	750	3,940	2,955	3,480	59
FS LP 3 ½9 750 (E)	2.96	3.59	0.090	0.076	1.75	750	3,046	2,589	5,720	85
FS LP 3 ½9 750 (X)	2.96	3.59	0.090	0.076	1.75	750	3,046	2,285	5,720	85
FS LP 4 ½9 750 (E)	3.99	4.73	0.122	0.103	2.87	750	3,095	2,631	10,440	113
FS LP 4 ½9 750 (X)	3.99	4.73	0.122	0.103	2.87	750	3,095	2,321	10,440	113
FS LP 69 750 (E)	4.75	5.62	0.150	0.128	4.04	750	3,200	2,720	15,360	136
FS LP 69 750 (X)	4.75	5.62	0.150	0.128	4.04	750	3,200	2,400	15,360	136

FS LP 6 ½9 750 (E)	5.60	6.55	0.161	0.136	5.14	750	2,912	2,475	19,320	159
FS LP 6 ½9 750 (X)	5.60	6.55	0.161	0.136	5.14	750	2,912	2,184	19,320	159
1,500 Series										
FS LPJ 2 ½9 1,500 (E)	1.90	2.51	0.111	0.094	1.23	1,500	5,663	4,814	4,760	58
FS LPJ 2 ½9 1,500 (X)	1.89	2.48	0.095	0.080	1.12	1,500	4,838	3,629	4,000	57
FS LPJ 3 ½9 1,500 (E)	2.82	3.60	0.163	0.138	2.35	1,500	5,642	4,796	10,200	85
FS LPJ 3 ½9 1,500 (X)	2.82	3.57	0.134	0.114	2.18	1,500	4,656	3,492	8,440	84
FS LPJ 4 ½9 1,500 (E)	3.75	4.68	0.213	0.181	3.82	1,500	5,589	4,751	17,600	112
FS LPJ 4 ½9 1,500 (X)	3.75	4.68	0.180	0.152	3.61	1,500	4,661	3,496	14,880	112
FS LPJ 69 1,500 (E)	4.52	5.62	0.218	0.185	5.20	1,500	4,715	4,008	22,040	135
FS LPJ 69 1,500 (X)	4.52	5.62	0.218	0.185	5.20	1,500	4,715	3,536	22,040	135
FS LPJ 6 ½9 1,500 (E)	5.60	6.90	0.270	0.230	7.71	1,500	4,718	4,010	33,760	167
FS LPJ 6 ½9 1,500 (X)	5.60	6.90	0.270	0.230	7.71	1,500	4,718	3,539	33,760	167
2,500 Series										
FS LPJ 2 ½9 2,500 (E)	2.03	2.86	0.176	0.150	1.92	2,500	7,971	6,775	8,480	66
FS LPJ 3 ½9 2,500 (E)	3.05	4.18	0.261	0.222	4.02	2,500	7,893	6,709	18,880	99
2,250 Series										
FS LPJ 4 ½9 2,250 (E)	3.57	4.79	0.284	0.241	5.06	2,250	7,411	6,299	23,800	115

* Pressure ratings are based on minimum 20-year service life using ASTM D2992 long-term test procedures. Recommended maximum operating pressure is Fiberspar recommendation for general oilfield water, low-vapor pressure hydrocarbon, and multi-phase service conditions at the maximum rated temperature. Consult Fiberspar for a recommended maximum pressure rating for other service conditions.

E = High-density polyethylene (HDPE) rated from -29ºF to 140ºF

X = High-temperature polyethylene (HTP) rated from -29ºF to 180ºF

All products are hydrotested to 1.5 times maximum recommended operating pressure. Material selection is based on the desired operating temperature and chemical compatibility of Fiberspar LinePipe constituents with fluids.

Fiberspar LinePipe Specifications – Canada (Metric)

Fiberspar LinePipe is intended for corrosive gathering and injection applications including general and sour produced fluids and gases. Fiberspar LinePipe is available with high-density polyethylene or high-temperature polyethylene pressure barriers with temperature ratings to 60ºC and 82ºC, respectively. Other pressure ratings and diameters available upon request.

Product Name	ID (mm)	OD (mm)	Nominal Reinforced Wall Thickness Nom (mm)	Minimum Reinforced Wall Thickness Min (mm)	Weight (kg/m)	Recommended Maximum Operating Pressure* (MPa)	Minimum Burst Room Temperature (MPa)	Minimum Burst Operating Temperature (MPa)	Maximum Recommended Install Tensile Load (kgf)	Minimum Bend Radius (cm)
300 Series										
FS LP 39 300 (E)	64	77	1.4	1.2	1.76	2.07	15.30	13.00	1,360	181
FS LP 39 300 (X)	64	77	1.4	1.2	1.76	2.07	15.30	11.47	1,361	181
FS LP 49 300 (E)	84	102	1.8	1.6	2.96	2.07	14.93	12.69	2,350	242
FS LP 49 300 (X)	84	102	1.8	1.6	2.96	2.07	14.93	11.20	2,350	242
FS LP 69 300 (E)	121	139	2.0	1.7	4.43	2.07	11.71	9.95	3,610	335
FS LP 69 300 (X)	121	139	2.0	1.7	4.43	2.07	11.71	8.78	3,610	335
750 Series										
FS LP 2 ½9 750 (E)	51	65	2.0	1.7	1.56	5.17	27.17	23.09	1,579	149
FS LP 2 ½9 750 (X)	51	65	2.0	1.7	1.56	5.17	27.17	20.37	1,570	149
FS LP 3 ½9 750 (E)	75	91	2.3	1.9	2.60	5.17	21.00	17.85	2,590	215
FS LP 3 ½9 750 (X)	75	91	2.3	1.9	2.60	5.17	21.00	15.75	2,590	215
FS LP 4 ½9 750 (E)	101	120	3.1	2.6	4.28	5.17	21.34	18.14	4,730	288
FS LP 4 ½9 750 (X)	101	120	3.1	2.6	4.27	5.17	21.34	16.00	4,730	288
FS LP 69 750 (E)	121	143	3.8	3.2	6.01	5.17	22.06	18.75	6,960	344

FS LP 69 750 (X)	121	143	3.8	3.2	6.01	5.17	22.06	16.55	6,960	344
FS LP 6 ½9 750 (E)	142	166	4.1	3.5	7.65	5.17	20.08	17.07	8,760	403
FS LP 6 ½9 750 (X)	142	166	4.1	3.5	7.65	5.17	20.08	15.06	8,760	403
1,500 Series										
FS LPJ 2 ½9 1,500 (E)	48	64	2.8	2.4	1.83	10.34	39.04	33.19	2,150	147
FS LPJ 2 ½9 1,500 (X)	48	63	2.4	2.0	1.67	10.34	33.36	25.02	1,810	145
FS LPJ 3 ½9 1,500 (E)	72	92	4.1	3.5	3.50	10.34	38.90	33.07	4,620	216
FS LPJ 3 ½9 1,500 (X)	72	91	3.4	2.9	3.24	10.34	32.10	24.08	3,820	214
FS LPJ 4 ½9 1,500 (E)	95	121	5.4	4.6	5.69	10.34	38.53	32.75	7,980	285
FS LPJ 4 ½9 1,500 (X)	95	119	4.5	3.9	5.37	10.34	32.14	24.10	6,740	284
FS LPJ 69 1,500 (E)	115	143	5.5	4.7	7.74	10.34	32.51	27.63	9,990	344
FS LPJ 69 1,500 (X)	115	143	5.5	4.7	7.74	10.34	32.51	24.38	9,990	344
FS LPJ 6 ½9 1,500 (E)	142	175	6.9	5.8	11.48	10.34	32.53	27.65	15,310	425
FS LPJ 6 ½9 1,500 (X)	142	175	6.9	5.8	11.47	10.34	32.53	24.40	15,310	425
2,500 Series										
FS LPJ 2 ½9 2,500 (E)	52	73	4.5	3.8	2.86	17.24	54.96	46.71	3,840	169
FS LPJ 3 ½9 2,500 (E)	77	106	6.6	5.6	5.99	17.24	54.42	46.26	8,560	253
2,250 Series										
FS LPJ 4 ½9 2,250 (E)	91	122	7.2	6.1	7.53	15.51	51.10	43.43	10,790	292

*Pressure ratings are based on minimum 20-year service life using ASTM D2992 long-term test procedures. Recommended maximum operating pressure is Fiberspar recommendation for general oilfield water, low-vapor pressure hydrocarbon, and multi-phase service conditions at the maximum rated temperature. Consult Fiberspar for a recommended maximum pressure rating for other service conditions.

E = High-density polyethylene (HDPE) rated from -34ºC to 60ºC

X = High-temperature polyethylene (HTP) rated from -34ºC to 82ºC

All products are hydrotested to 1.5 times maximum recommended operating pressure. Material selection is based on the desired operating temperature and chemical compatibility of Fiberspar LinePipe constituents with fluids.

Appendix B

Factors for Successful Installation

The Four Most Important Factors for Successful Installation:

1. Use Fiberspar field service or Fiberspar certified installers to oversee Installation.
2. Follow good pre-job planning practices and follow the job documentation outlined on page 11.
3. Use care in preparing trench and backfilling the Fiberspar LinePipe.
4. Avoid the most common mistakes during open ditch installations summarized below.

- **LinePipe is damaged while being moved after unspooling**

  – Deploying LinePipe directly into the ditch minimizes the likelihood of damage during field operations. However, this is not always possible due to access or scheduling. In these cases, the pipe is deployed along the right of way for later movement into the ditch, and additional steps have to be taken to prevent damage.

  The following are best practices and hazards to avoid when it is necessary to handle LinePipe

  – If pipe is to be deployed and then moved into proper position afterwards, it is important to provide enough slack in the areas where movement is required.
  – For example, if the pipe is deployed around the inside of a field bend and must be moved to a trench in the center of the bend, the pipe requires slack to make up the additional linear distance through the bend.
  – Do not attempt to move pipe that has insufficient slack by using a chain or sling tied on at one point. This will result in a point load that will damage the pipe.
  – The proper method is to pull slack into the point where the pipe is to be moved and then to move it into place.
  – Slack can be pulled into the line by attaching a sling at a point where the pipe has no bend and pulling on the sling in a direction parallel to the pipe.
  – If the pipe is farther than 20 ft from the trench, move the pipe in multiple passes.
  – Any time the pipe is to be moved it is recommended that a Fiberspar certified installer be present.

- **LinePipe is damaged by equipment**

  – The most common cause of damage is from excavation equipment such as backhoes used to the move the pipe or backfill.
  – This can be avoided through care and diligence, but additional steps can be taken to minimize the likelihood of this occurring.
  – When the LinePipe is laid in the right of way for future trenching it should be located in a safe spot away from traffic and other operations and should be properly marked or flagged.
  – In cases where the pipe is accidentally contacted by heavy equipment it is imperative that the location of the contact be marked and brought to the attention of the Fiberspar certified installer for assessment.
  – Contractors should understand that it is easier to repair a point of known damage than it is to find the damage after failure on test or in service.

- LinePipe is damaged by improper backfill

  – Backfill that comes into contact with LinePipe should be loose dirt that contains no heavy or sharp objects.

  – The trench bottom should also be smooth, with no sharp objects beneath the pipe.
  – The pipe should first be shaded with loose dirt for the first 1 to 2 ft of cover. Large rocks or objects can then be placed on top.
  – Where local soil conditions make it difficult to control backfill quality, additional steps should be taken such as grading, using imported padding, or jacketing the pipe.
  – When soil is frozen, extra care must be taken not to allow frozen lumps to come into contact with the pipe.
  – The ditch should also be filled in a controlled manner that does not introduce any lateral or shearing loads on the pipe.

- LinePipe damaged through misalignment

  – Fiberspar LinePipe connectors are proven to be extremely reliable when correctly installed. Proper alignment of the pipe and connectors is critical for successful installation.

  Particular attention should be paid to the following issues:

  – At risers and connectors it is important that the LinePipe is not installed with a bend at the back of the connector. The transition in stiffness between the LinePipe and the metal connector can cause significant point stress on the pipe if it is installed in or close to a bend.
  – The trench bottom should be level and the pipe and riser properly supported at the point where the pipe enters the connector and attaches to the riser. This may require sandbags or a driven pile.
  – The LinePipe must also be properly aligned and supported at the entrance and exit of steel casings or bores. If misaligned, the weight of the backfill causes a shearing load on the pipe against the edge of the casing.

– Again the trench bottom should be level and the pipe supported so that when the trench is backfilled the pipe is not pressed against the edge of the casing.

Appendix C

Tips for Successful LinePipe Plow-in Installation

The Four Most Important Factors for Successful Installation:

1. Only use plows specifically approved by Fiberspar
2. Make sure the plow is set up correctly, with no point loads on pipe guides, and that the radius of the plow is greater than the minimum allowable for the pipe size to be installed.
3. Follow proper plowing procedures and techniques
4. Ensure crossings and bends are executed correctly

1. Only use plows specifically approved by Fiberspar

- For Fiberspar LinePipe to be installed successfully only “spider”-style plows should be used. Conventional plows are far less adjustable and can cause pipe damage. For example, if the front wheels of a conventional plow hit a bump the whole plow will tip, causing the shoe to move and generating a point load on the pipe. On “spider” plows all of the wheels are independent, meaning the shoe can be held in steady, even over rough terrain.
- The plow being used must have the capacity to bury the pipe to the required depth without exceeding its maximum bending radius.
- The plow must have a guide on the front to control the bend in the pipe as it enters the top of the chute.

2. Make sure the plow is set up correctly

- The chute should be properly sized and dimensioned for the particular size of pipe. Its radius must not exceed the pipe’s maximum allowable bend radius, and there should be no sharp edges that could cause damage.

- The chute should be mounted onto the plow. The bend radius should always be greater than the allowable maximum, although it should be noted that larger bend radii will lower the efficiency of the installation.

- The guide on the front of the plow should be adjusted so that it is the correct height. If it is set incorrectly the pipe will tend to rub against the top of the chute as it enters from above (too low and it rubs on the front edge, too high it rubs on the back edge). This causes stress on the pipe, which can cause failures.

3. Follow proper plowing procedures and techniques

– During plowing it is necessary to ensure that there is the correct amount of tension in the pipe as it travels over the top of the plow into the top of the chute. If the pipe does not enter the chute centrally it will rub and get pinched. Tension can best be monitored by walking alongside the plow as it is moving.

– It is especially important to monitor pipe tension when going around corners, as it is here where tension is most likely to vary. Sharp turns should be avoided.

– Changes in plow depth should always be carefully controlled and avoided if at all possible. The reason is that the plow's edges can cause point-loading on the pipe if depth change is done too rapidly. If the shoe must be raised out of the ground, it should be done slowly and closely monitored.

– During plowing, point loading must also be avoided where the LinePipe exits the plow chute.

4. Ensure crossing and bends are executed correctly

– Crossings and bends are the most vulnerable part of plowing operations and require special attention. If possible, a Fiberspar representative should be present.

– The most common error occurs when the shoe is brought to the surface too rapidly, causing damage to the pipe by point-loading. The best way to avoid damaging the pipe is by always plowing into a bell hole at a crossing. This eliminates the need to raise the plow and, as there is normally a bell hole dug at these points anyway, no extra expense is involved.

– When turning corners the maximum bend radius of the pipe should never be exceeded. Turning too sharply can also cause the pipe to rub on the edge of the shoe and can damage it. If a sharp bend is needed, a bell hole should be dug to ensure the pipe is not damaged.

– As mentioned previously, pipe tension is critical at bends and crossings and should be closely monitored to avoid problems.

Appendix D

Tips for Successful Remediation

The Four Most Important Factors for Successful Installation:

1. Follow Fiberspar pull-though procedures and techniques
2. Make sure the existing line has been properly prepared
3. Ensure bell holes are constructed in accordance with recommendations
4. Ensure existing pipe cuts and bends are handled correctly

1. Follow Fiberspar pull-though procedures and techniques

- Refer to the Fiberspar remediation procedure for detailed information on installation methods. The following points are a guide and not meant to substitute for the full procedure.
- Always maintain good communication between operators at both ends of the existing pipe. This is best done using two-way radios and clear signals. This is especially critical for long pulls when parties cannot see each other.
- Shear loops should always be installed on the pulling head, and Weight indicators need to be maintained and operable. Shear loops will prevent over-pull, which damages the Fiberspar LinePipe.
- Always install a plastic or rubber guide for the wireline at the entrance to the existing pipe to prevent damage.
- Bends and changes in direction should be identified before installation begins and a plan to deal with them made and agreed upon with a Fiberspar representative.

2. Make sure the existing line has been properly prepared

- Ensure that all hydrocarbon products from the existing pipe have been removed and use an appropriate pig to clear any debris (foam pigs are typically not acceptable). Any wax build-up inside the existing pipe should also have been removed.
- Identify any potential sharp bends in the existing pipe, remove them, and plan the bell holes accordingly.
- A sizing pig must be run to confirm that the ID of the existing pipe will not cause a blockage. Any pinch points that are present will prevent a successful LinePipe pull-though. Where required, Fiberspar can provide a suitable sizing pig.

– The aim of good preparation is to leave the existing pipe “clean, clear and round.”

3. Ensure bell holes are constructed in accordance with recommendations

– The wireline truck should be at least 60 ft (18 m) from the end of the existing pipe.
– Bell holes of a sufficient size are necessary to ensure that the wireline can pull cleanly. Bell holes should be cut back at an angle so there is a direct line of sight between the truck and the carrier pipe to ensure a clean and unimpeded pull. It is not desirable to have the wire pulled through the mud. Fiberspar can provide advice on suitable bell hole size and orientation.
– It is most desirable to pull in a straight line with the pipe. Where this is not possible, a pulley or sheave should be used. This will ensure that the wireline force is parallel to the existing pipe, facilitating an even pull.

4. Ensure existing pipe cuts and bends are handled correctly

– If the existing pipe is cut it should be fully de-burred and ground smooth so that it does not damage the LinePipe as it is pulled through.
– Once the LinePipe has been installed in the existing pipe, packing must be employed at the end of the pipe. This will ensure the LinePipe is centered and prevent unnecessary wear. Fiberspar will supply appropriate packing material.
– If it is necessary to make a bend in the LinePipe close to the end of the existing pipe, care should be taken to make sure there are no point loads. Methods for supporting the LinePipe around bends are:

  • Cradles – attached to stakes driven into the ground on the outside edge of the bend
  • Dirt – cutting the ditch so that the pipe is supported (virgin ground that has not been disturbed is preferred)

If it is not possible to properly support the pipe, a corner pull should not be attempted. In such instances a pipe-to-pipe connection should be used.

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