STANDARD OPERATING PROCEDURE

STARLINE® 2000

CURED-IN-PLACE (CIP) LINER APPLICATION

The Starline®2000 Cured-In-Place liner application is a trenchless technology designed to rehabilitate and renew existing cast iron, ductile iron and steel gas transmission pipelines. Pipe sections up to 700 feet in length and 4-inch to 24-inch in diameter can be rehabilitated. The service life of a Starline CIP lined pipe is equal to that of a newly installed pipe. The bonding strength of the liner allows for routine maintenance and repairs including service tapping and welding without special fittings or requirements. Although all leaks are sealed and internal corrosion eliminated, the Starline CIP liner relies on the host pipe for structure, so routine structural integrity must be maintained.

The lining process involves the inversion of a woven fabric hose liner with a plastic (PE) coating into the host pipe using compressed air pressure. After the host pipe has been sufficiently cleaned, a solvent-free adhesive is uniformly impregnated into the fibers of the liner during the *Wet-Out* process. The liner is then wound on to the reel of the Starline® pressure drum and attached, via transportation hoses, to the host pipe. Compressed air inverts or pushes the liner into the host pipe where the adhesive impregnated fibers come into direct contact with the cleaned surfaces of the pipe. Any existing service taps are re-established internally by a robotic cutting unit. The entire process of cleaning, lining and curing can be completed within 24 hours.

The following Standard Operating Procedures (SOP) are required to ensure a quality installation. Following the SOP listing below, each component is defined in relation to the operational process as well as its application to rehabilitate natural gas pipelines from 3” through 24” the test pipe.

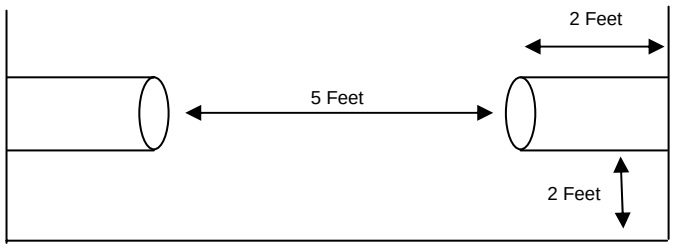
Standard Operating Procedures

1. Pipe Access Excavation & Preparation
2. Pre-Cleaning Pipe Inspection
3. Surface Preparation / Pipe Cleaning
4. Post – Cleaning Pipe Inspection
5. Adhesive Mixing
6. Liner Wet – Out / Adhesive Application
7. Liner Inversion
8. Curing & Pressure Monitoring
9. Post – Lining Inspection

10. Service Reinstatement
11. Final Pipe Construction & Restoration
12. Post Lining Pipe Maintenance
13. Pricing Information

1. Access Pit & Pipe Preparation

Prior to the lining process, the gas pipe section(s) must be purged of gas and prepared. Typically, a 5' x 8' access pit is excavated and the gas stopped off through a hot tap/stopping procedure or through valves if available. Once the line has been purged, a 5' section of main must be removed to allow for sufficient clearance for the lining equipment and fittings. The following diagram depicts the pipe preparation requirements:



Note – For pipe diameters of 16-inch and greater or excavations greater than 5 feet in depth, 8 feet of clearance is required

2. Initial Pipe Inspection

To determine the level of surface preparation required as well as confirm that there are no unmarked obstructions, drip pots or anomalies in the pipe section to be rehabilitated, an initial visual inspection is performed using a CCTV pipeline inspection system. The system is capable of providing a full 360 degree rotational image in digital clarity.

3. Surface Preparation

Surface preparation is a critical component of the Starline® 2000 process. Given the wide array of initial pipe conditions found in the field, surface preparation is quantified by cleaning the surface of the pipe to a level defined by a visual standard. This method is the most effective way to determine the appropriate level of cleaning required in each individual application.

The visual standard system jointly published by the National Association of Corrosion Engineers (NACE) and the Steel Structures Painting Council (SSPC), with technical guidance from the American Society for Testing and Materials (ASTM), is the most accepted standard across the industry.

For the Starline® 2000 application, the pipe was cleaned to a level consistent with SSPC-SP6 / NACE # 3, Commercial Blast Cleaning. This standard is defined as follows:

Commercial Blast Cleaning

Removal of mill scale, rust, rust scale, paint or foreign matter by the use of abrasives propelled through nozzles or by centrifugal wheels, to the degree specified. A Commercial Blast Cleaned Surface Finish is defined as one from which all oil, grease, dirt, rust scale and foreign matter have been completely removed from the surface and all rust, mill scale and old paint have been completely removed except for slight shadows, streaks, or discolorations caused by rust stain, mill scale oxides or slight, tight residues of paint or coating that may remain; if the surface is pitted, slight residues of rust or paint may by found in the bottom of pits; at least two-thirds of each square inch of surface area shall be free of all visible residues and the remainder shall be limited to the light discoloration, slight staining or tight residues mentioned above.

This is the required level of cleaning to obtain the proper bonding strength and achieve the desired result. And can be obtained by a grit-blasting or a water-blasting cleaning method.

The grit-blasting method involves an air driven blast medium, typically black beauty or a similar slag type of abrasive. The abrasive is propelled through the blast hose at 100 psi and up to 375 cfm and delivered to hollow blast nozzle. The nozzle houses a diversion cone which deflects the abrasive at a right angel directly to the surface of the pipe. The abrasive size directly correlates to the aggressiveness of the cleaning process. To prepare the pipe surface to the appropriate standard, (SSPC-SP12 / NACE 3) a 14-mesh abrasive is utilized. Recovery of the grit is obtained by a high capacity vacuum system.

The water-blasting process uses the power of high-pressure water to blast clean the pipe surface. The method utilized in this application is a pump-driven water jet with a rotating nozzle. The water jet pump operates at 10,000psi and 27gpm while the nozzle rotates at a speed of 150 rpm. The 6 outlet ports on the water nozzle are staggered at 90 degrees and 120 degrees to provide maximum cleaning power. As with the grit-blast method, used water is recovered from the pipe through a high capacity vacuum system. Although not as aggressive as the grit-blast system, the water jet method does obtain the level of cleaning required.

4. Post Cleaning Inspection

To confirm that the surface has been cleaned sufficiently to meet the Commercial Blast Standard, a second inspection is conducted using the CCTV inspection system.

5. Adhesive Preparation

A two-component polyurethane adhesive is utilized in the Starline® process. Prior to the inversion of the textile hose liner into the pipe, the adhesive is prepared by thoroughly mixing the hardening component with the base component using a high-speed hand mixing unit. The amount of adhesive used in this application is determined by the diameter and length of the pipe section to be lined. The quality control manual from the manufacturer provides detailed tables to ensure that the correct adhesive amounts are utilized.

6. Liner Wet – Out / Adhesive Application

After the mixing procedure is complete, the adhesive is poured into the hose liner through a funnel system. The liner is then pulled through a micrometer gauged rolling table to ensure a uniform adhesive application. The rolling table forces the adhesive into the woven polyester fibers of the liner thus assuring the complete impregnation of adhesive into the hose liner fabric. This process is also referred to as *Wetting Out* the liner.

7. Liner Inversion

Once the liner is Wetted Out with adhesive, it is attached to a retention belt and wound on to the reel of the Starline® pressure drum. Once the liner and retention belt are completely wound into the drum, the bitter end of the liner is attached and bolted to an Inversion Cone. The purpose of the inversion cone is to hold the liner in place and allow air pressure to force the liner inside-out through the pipe. The inversion cone is then attached to the pipe section through a standard bolt-on fitting. A catch basket is attached to the opposite end of the pipe to act as a receiving vessel for the inverted liner. A heavy gauge rubber Transportation Hose attaches the inversion cone to the pressure drum.

The Starline® pressure drum is then pressurized with compressed air and released through the transportation hose thus forcing the liner to invert inside itself and fill with air. The pressure then pushes or inverts the hose liner the pipe via the drum. As the liner inverts into the pipe, the adhesive impregnated side comes into contact with the prepared surface. As the liner reaches the end of the pipe section, it is captured in the catch basket and the drum shut down. The inversion process is now complete. The transportation hose is squeezed off to keep the line pressurized during the curing process. The pressure in the drum is released and a blind flange secured to the inversion cone hose unit. A pressure-monitoring device is then attached and the pipe segment secured for curing process, either ambient or heat assisted.

8. Curing & Pressure Monitoring

The polyurethane adhesive requires approximately 14 hours to fully cure in normal temperature ranges. However, heat curing (steam and/or hot water) of the lined pipe may be used to reduce the curing time. Throughout the curing process and regardless of the method used, the lined pipe remains under pressure. A calibrated data recorder, to ensure consistency, monitors the internal pressure of the lined pipe to gauge for any potential leaks. In addition, a nitrogen bottle is attached to the pressure monitor to regulate any fluctuation is curing pressure due to temperature drops.

9. Post – Lining Inspection

After the liner is completely cured, pressure is released from the test pipe and all fittings removed. The liner is then cut out and trimmed flush to each end of the pipe. The lined pipe is then visually with the CCTV inspections system to ensure that a proper installation has been performed.

10. Service Re-Instatement

If services are located on a main line system, a robotic cutting unit is utilized to cut through the liner and re-establish the service connection. This process allows services to be reinstated without excavation. Typically service taps of 1-inch and greater can be located and tapped. Service taps less than 1-incg require more time and may not be located due to the small size being filled with adhesive. The lined pipe must be air tested prior to re-instating any services. This will confirm that the lined pipe is leak free, versus a potential leak at a service tap or tee.

11. Final Pipe Construction & Restoration

Once the liner has been cut out, the section may be reconnected and put back in to service. Typically a new pipe is placed in the 5 foot gap (or 8 feet for large diameter pipe) where the main was cut. Any routine connection is possible including dresser couplings, metal to plastic transition fittings, hydraulic couplings and welding. This can all be done without the requirements of any special fittings. Finally the excavation will need to be backfilled, patched and paved.

12. Post Lining Maintenance – Leak Repair

Leaks my result from **(a)** external corrosion of the pipe with subsequent damage to the liner and **(b)** third-party damage. The CIP liner does rely on the host pipe for structure, so structural integrity of the line should be maintained. Additionally, there may be a need to "bag-off" the main to isolate a segment of the pipe. No special tools or expertise are required to maintain a pipe that has been lined.

In case (a), a decision can be made to either install an external repair fitting to seal the leak or replace the damaged section of pipe. The standard procedure for installing a leak clamp or coupling on the pipe would be the same for lined and unlined pipe. If the pipe section is to be removed and replaced, the section is generally isolated using a valve, stopple equipment, a bag-off method, or a combination of the methods. Tests performed at KeySpan Energy (Brooklyn Union Gas) and PG&E confirm that bagging and stopper procedures are effective with lined pipe.

In case (b) above (Third Party Damage), the section of damaged pipe will most likely be cut out and replaced. If so, see procedures for 12B and 12C below, as applicable.

12.B Post Lining Maintenance – Cutting Lined Pipe

Two methods, both commonly used by gas utilities, are recommended for cutting lined pipe. First, a pneumatic cutter or guillotine has been tested and proven effective to cut through both pipe and liner cleanly. Second, a circumferential hydraulic crusher can be used for cast iron pipe. When using a circumferential cutter, the operator should first support the center of the pipe between cuts. Upon completion of cuts, utilize a thin-blade knife or hack-saw to cut the liner. The operator should not allow the pipe section to fall away prior to the liner being cut as the excessive force and weight could pull and damage the liner.

12.C Post Lining Maintenance – Welding Tie-Ins to a Lined Pipe

When welding is required to join an unlined pipe to a lined main (i.e. a tie-in), measure 12 inches from the cut end into the lined pipe. Make a circular cut and remove the liner and adhesive from both ends and proceed with welding using standard welding procedures. It is important to take the time using a wire wheel to remove all remnants of the adhesive at the pipe ends.

12.D Post Lining Maintenance – Service Installations

New services can be installed on lined pipe using either mechanical or weld-on fittings.

A mechanical fitting can be installed using standard procedures. However, a high-speed drill and core bit is required for making the tap versus a tradition shell cutter (for cast iron lines).

A service tee can be welded on to a Starline CIP lined pipe. The condition of the pipe should be acceptable for making a weld and tap; no leaks and free of corrosion. The liner will be burned locally but with effective bonding, no leaks will occur beyond the affected area. A high-speed drill and core bit is used to make the tap.

Note - Starline CIP liners rely on the host pipe for structure, so structural integrity must be maintained.

13. Pricing Information

The pricing of the Starline CIP lining process (including all necessary pipeline inspections, cleaning, installations, materials and non-hazardous disposal) is provided on a case-by-case basis and is dependent upon size and length of pipe to be rehabilitated. The installation contractor, Progressive Pipeline Management, provides a free site evaluation and estimate for all lining projects. However, as a rough guide the following table indicates typical pricing based on 1000' of pipe:

Length / Size	1000 / 6"	1000 / 8"	1000 / 12"	1000 / 16"	1000 / 20"
Number Of Sections	2	2	2	2	2
Project Days	3	3	4	5	6
Price Per Foot ($)	51.00	58.00	75.00	85.00	105.00

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