GUIDELINES FOR PIPE RELINING

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GUIDELINES
FOR
PIPE RELINING PROJECTS

I. OVERVIEW

This guideline covers the planning, design, fabrication and installation of corrugated steel pipe used for the rehabilitation of culverts and storm sewers. Rehabilitation of existing pipe by relining, offers a number of advantages. The primary advantage is the cost savings resulting from not having to excavate to and remove the existing pipe, backfill the excavation after pipe replacement and replace any surface pavement affected by construction. In addition, motorists are not subjected to detours and delays from road closure or restrictions, and motorists and construction workers have less exposure to risks of accidents.

II. PROJECT PLANNING

A. HYDRAULIC CAPACITY

Analyze the hydraulic requirements of the existing pipe or culvert to determine the waterway area required. The use of data generated in determining the initial pipe size is not recommended for the current hydraulic evaluation, without considering the possibility of changes in upstream conditions that may have taken place. Many agencies are currently over-sizing new culverts in anticipation of the need for future relining.

The use of a liner pipe will most certainly change the hydraulic capacity of the existing pipe. If the liner pipe has the sinusoidal corrugation typical of most corrugated steel pipe, the hydraulic capacity of the liner pipe may be reduced. However, the use of a corrugated steel pipe with a smooth interior may increase hydraulic capacity. If an existing corrugated steel pipe is being replaced with a corrugated steel pipe with a smooth interior, the liner pipe can be several sizes smaller and still achieve the required hydraulic capacity. Site conditions may require that the invert of the liner pipe be placed as close as possible to the existing pipe invert. This minimizes changes in the hydraulic grade line. The thin wall of corrugated steel pipe best suits this requirement.

B. LINER PIPE SIZE

Hydraulic requirements are only one factor in determining the size of the liner pipe. The need for minimum construction clearances inside the existing pipe may limit the size of liner pipe that can be used. The maximum liner pipe size can be determined by walking the existing pipe with a template, matching the outside diameter of the planned liner pipe, and verifying clearances for the full length to be relined. Another method for determining maximum liner pipe size is to pull a short length of the proposed liner pipe through the existing pipe and verifying that clearances are adequate. When determining liner pipe size, consider the need for blocking or guide rails in the invert of the existing pipe to assist in placing the liner pipe.

The size of the liner pipe must also allow proper placement of grout in the annular space between the existing pipe and the liner. Typically, grout will be pumped from inside the liner pipe into the annular space and must be able to flow freely between entry points. To be certain of proper grout movement, the minimum distance between the outside of the liner pipe barrel and the inside of the existing pipe should be one (1) inch. If this minimum spacing is not possible, the distances between grout entry locations may need to be adjusted.

If the existing sewer or culvert is a pipe-arch or is deflected to the extent that use of a round liner pipe is not feasible, consider the use of a pipe-arch liner. Applications involving ribbed pipe-arches have proven to be practical where round pipe does not satisfy project requirements.

C. LENGTH OF LINER PIPE

The alignment of the existing pipe may necessitate the use of shorter liner pipe lengths. Elbows or vertical changes in pipe gradient may prohibit passage of the standard 20-foot length of corrugated steel pipe. Alignment changes in the existing pipe may require the use of shorter lengths of liner pipe or require that liner pipe enter the existing pipe from both ends. If elbows or grade changes require installation from both ends of the existing pipe, it may be necessary to weld the liner pipe sections to create an elbow at the point of change in alignment.

D. SITE ACCESS

An important aspect of planning a relining project is evaluation of access to the existing pipe, and the workspace available at the ends of the pipe. Liner pipe may be installed by pushing or pulling the pipe. This allows flexibility in determining which end of the existing pipe will be used for liner pipe installation. Through the use of pulleys and deadmen, pulling of the liner pipe can be done from either end of the existing pipe. Site conditions related to work space and access to the existing pipe can be a major factor in planning a relining project.

III. STRUCTURAL DESIGN

Structural evaluation of a pipe-relining project will focus on the structural capacity of the liner pipe. Relining of an existing pipe is considered because the pipe has deteriorated and concern exists over its remaining service life. However, since rehabilitation of the pipe is being considered, the pipe has obviously not collapsed, which means it is still supporting the loads imposed on it. The rate of deterioration of the existing pipe will be reduced considerably after the liner pipe is installed, since it will no longer be subjected to the effects of waterside corrosion and abrasion. Although the existing pipe will remain in place and continue to support all or a portion of the loads on it, the structural contribution of the existing structure is totally ignored.

The liner pipe is designed to carry all loads imposed on the new pipe structure. Following relining, the pipe structure will consist of the existing pipe, the liner pipe and the grouted annular space between the pipes. Since the liner pipe is a flexible structure, the load is transferred to the backfill around the pipe. The load-carrying capacity of the flexible liner pipe is more dependent on the quality of the backfill than the inherent strength of the pipe. In a relining situation, the backfill surrounding the liner pipe is a cementitious mix with a stiffness greatly exceeding that of the backfill material in which flexible pipe is typically installed. In addition, this cementitious material is constrained by the existing pipe, adding to its stiffness. The stiffness and constraint of the grout envelope surrounding the liner pipe, greatly increases the load-carrying capacity of the liner pipe. However, the very substantial structural contribution of this cementitious fill in the annular space is neglected. The liner pipe is in essence designed as if it were installed in a typical earth backfill condition. The result is a very large safety factor.

Pipe durability should also be a factor in selecting the wall thickness of the liner pipe. The liner pipe will be subjected to the same waterside environmental conditions that affected the existing pipe. If soilside corrosion is a critical durability factor at the site, the liner pipe will have a much longer service life since it is isolated from soilside corrosion by the existing pipe and the grouted annular space. The liner pipe will be installed after the roadway has been in service for many years. Therefore, the service life of the liner pipe should be designed to equal the remaining service life of the roadway.

The NCSPA *CSP Durability Guide* is a valuable tool for determining the service life of corrugated steel pipe used as liner pipe. This guide will allow evaluation of a variety of material thicknesses and coating options, as an aid in selecting the pipe material and coating that matches the project requirements. By gathering data related to environmental conditions at the site, the most cost-effective liner pipe can be selected. The significant environmental conditions are the resistivity and pH of the water, since soilside corrosion will not be a factor in the durability of the liner pipe.

IV. ADVANTAGES OF CORRUGATED STEEL PIPE

Corrugated steel pipe (CSP) is becoming increasingly popular as the material of choice for liner pipe. This is due to the many advantages offered by corrugated steel pipe when used in relining projects. The positive features of CSP are available at a much lower cost than that of reinforced concrete pipe, HDPE pipe and many of the other methods used in rehabilitating drainage pipe. The major advantages of CSP are as follows.

A. STRUCTURAL INTEGRITY

CSP restores and actually enhances the structural integrity of the existing pipe. Not all pipe rehabilitation methods can make this claim. Those methods that do claim restoration of structural integrity, rely partially on the remaining structural capacity of the existing pipe. When relining with CSP, the liner pipe is designed to carry the entire load applied to the lined-pipe structure.

B. LIGHTWEIGHT

The light weight of CSP makes it much easier to handle and install. Since the ease with which liner pipe can be pushed or pulled into the existing pipe is a major factor in the cost of relining, CSP's light weight reduces placement costs. In addition, the use of smooth-wall spiral rib pipe, with its Mannings "n" value of 0.012, will permit the use of smaller diameter pipe to achieve the required hydraulic capacity.

C. VARIABLE DIAMETER

The method of manufacture of CSP allows the diameter of the pipe to be changed with relative ease. CSP is typically manufactured to standard sizes, but can be fabricated to any diameter. This is an advantage unique to CSP and allows the liner pipe diameter to be optimized for each site. This manufacturing flexibility permits the liner pipe to be fabricated to the diameter that ensures adequate clearance with the existing pipe and maximizes the hydraulic end area of the liner pipe.

D. VARIABLE LENGTH

Within limits, CSP can be manufactured in any length, without increasing project costs. When necessary, the length of CSP can be shortened to allow passage through elbows or gradient changes, or lengthened to reduce the number of joints. CSP sections can be made in the lengths that optimize installation of the liner pipe.

E. FABRICATION

CSP can be plant-fabricated into nearly any configuration to suit project conditions. In addition, the ease with which CSP can be welded on-site, makes it easy to achieve alignment requirements that cannot be achieved with plant-fabricated fittings, because the welded fitting would not pass through the existing pipe.

It is important that liner pipe be furnished with hardware to facilitate proper alignment and grout placement. Alignment bolts are required to aid in positioning the liner pipe on proper grade and alignment, and maintaining that position until the annular space is grouted. Grout fittings are required at intervals, both longitudinally and circumferentially, that are adequate to ensure proper flow of grout to all parts of the annular space. With CSP this hardware can be affixed to the liner pipe where needed for less cost than in other pipe materials.

F. INTERNAL BANDS

There are numerous methods for sealing the joints between CSP sections, when CSP is used in relining applications. In larger diameter pipe, bands may be placed inside the liner pipe by expanding the band against the inside wall of the liner pipe. Internal bands allow passage of the liner pipe through the existing pipe without the interference that might be caused by external coupler hardware. The internal bands are placed after the liner pipe is in place. A flat rubber gasket between the pipe and the internal band provides a seal to keep the grout pumped into the annular space from leaking through the joint into the pipe. After the grout has cured, the internal bands may be removed and used on another relining project. If the band is left in place, it is usually installed so that the coupler hardware is at the crown of the pipe to minimize the possibility of debris buildup. Internal bands that are permanently attached to the liner pipe are also available.

G. EXTERNAL BANDS

External bands can be used on relining pipe, but must be carefully designed and used so as to avoid possible interferences during placement of the liner pipe. External bands are used for small diameter pipe and when the relining project has only one or two joints. The external bands must be designed so that all parts and hardware outside the pipe have a low profile. These bands are typically attached with bolts or self-tapping screws, or with flat strapping. If adequate clearance exists, standard bands for CSP pipe can be used. Flat rubber gaskets between the pipe

and band are generally necessary to prevent the flow of grout through the joint.

H. OTHER JOINT SEALING METHODS

The methods used for sealing the joints in CSP liner pipe, are limited only by the imagination of those involved with the project. Since the joint sealing method may be permanent or temporary, there are numerous methods for achieving a seal. The different flow characteristics of grout make it easier to seal joints in liner pipe than in most pipe installations. One method that has been used with success is to attach expanded metal to the outside of the pipe, across the joint, and apply shotcrete to the expanded metal. When cured, this acts as a very good seal at the joint. Bells have been attached to one end of the pipe and a gasket fitted around the other end, creating a bell and spigot joint that also performs well in keeping grout out of the liner pipe.

I. HYDRAULIC CHARACTERISTICS

The CSP used most often for liner pipe is spiral rib pipe, which has a ¾" x ¾" helical rib that projects to the exterior of the pipe at a spacing of 7 ½". This corrugation configuration provides a smooth interior, with a Manning's "n" of 0.012, equal to that of concrete or HDPE pipe. The primary advantage of spiral rib pipe over other pipe materials is that the outside diameter of the pipe is less than 2 inches larger than the nominal diameter. This means that a larger diameter liner pipe can be placed in the existing pipe, while maintaining adequate space for installation clearances and grout placement. Spiral rib steel pipe allows the maximum liner pipe diameter to be installed, and in conjunction with the smooth interior, will yield more hydraulic capacity than other liner pipe materials.

J. SERVICE LIFE

As discussed previously, the service life of the liner pipe does not need to match the initial design life of the existing pipe. If specified with the proper coating and wall thickness, CSP will easily meet the liner pipe service life requirements since it is protected from soilside corrosion and has to meet a lesser service life. The pipe wall thickness should be adequate to maintain shape during handling and installation and to withstand any axial loads that might be imposed on it during placement in the culvert. Once the minimum wall thickness required for structural requirements has been established, evaluate the pipe's durability using the environmental data from the site. The *CSP Durability Guide* developed by NCSPA is extremely useful in this regard.

V. SPECIFICATION

No national or industry-wide specification currently exists for the relining of existing culverts or storm sewers. DOTs are beginning to develop relining specifications and the rapid growth of relining projects will likely result in AASHTO and ASTM specifications being developed soon. The following specification, based partly on specifications developed or being developed by several DOTs, is offered as an interim version.

DESCRIPTION:
This work shall consist of furnishing, installing and grouting liner pipe into existing culverts or storm sewers, for the purpose of rehabilitation, as per the project plans.

MATERIAL:

A. Spiral Rib Corrugated Steel Pipe

1. Corrugated Steel Pipe. Liner pipe shall be in accordance with AASHTO M 36M or ASTM A 760, Type IR (¾" x ¾" x 7 ½") corrugation. Steel pipe shall be formed from galvanized or aluminized type-2 coated sheet conforming to AASHTO M 274M, M 218M or ASTM A 929. The ends of the liner pipe shall be rerolled.

a) The diameter of round liner pipe shall be the maximum size determined to meet project requirements. The diameter may be other than the standard sizes per AASHTO M 36M, Table 6, or ASTM A 760, Table 6. If the liner pipe is a pipe-arch section, the size shall conform with the standard sizes in Table 10 of AASHTO M 36M or ASTM A 760.

b) The length of liner pipe sections shall be the manufacturer's standard length or other lengths as required by conditions in the existing pipe and agreed to by the fabricator and contractor.

c) Holes shall be drilled in the pipe at the circumferential locations and longitudinal intervals shown on the plans, for mounting of grout fittings in the pipe wall. If not detailed on the plans, the pipe fabricator and contractor shall agree on the locations.

d) Holes shall be drilled in the liner pipe for installation of alignment bolts. The holes shall be drilled at the locations and intervals shown on the plans, and nuts welded over the hole on the outside of the pipe. Recommended sizes for alignment bolts are 5/8" for pipe under 60" and a minimum of ¾" for pipe sizes 60" and greater. The size of the bolts should be increased as the length of the bolt increases. The length of the bolts shall be as shown on the plans. Alternate methods of locating and maintaining the liner pipe location may be utilized if approved by the engineer.

e) Provide an internal or external band, or other method for sealing the joints between liner pipe sections. Internal or external bands will typically be a 12-inch wide sheet, which is either flat or formed into a 2 2/3" x ½" corrugation configuration. Hardware required to fix the band into its intended location shall be furnished with the band. A 3/8" x 7" flat rubber gasket shall be placed between the pipe and expansion band. Other joint sealing methods shall be as agreed to by the pipe fabricator, contractor and engineer.

B. Guide Rails

1. Steel or Wood Guide Rails

The contractor shall provide structural steel members or wood runners between the existing and liner pipes, for the purpose of providing a sliding surface for the liner pipe. Guide rails may also be welded to the bottom of the liner pipe at the pipe plant or on-site. Structural steel members shall conform to ASTM A 36 and wood blocking shall be pressure treated lumber in accordance with AASHTO M 168. An alternate means of providing a sliding surface is the placement of a grout bed in the invert of the existing culvert.

C. Grout

1. Grout

Provide grout for filling the annular space between the existing and liner pipe. Grout shall have a minimum 28 day compressive strength of 300 psi based on the average of 3 test cylinders. Fine aggregate, fly ash and plasticizers will be permitted in the grout mix. The grout mix shall be non-acidic and contain no chlorides.

INSTALLATION:

A. Plan

Prior to beginning work, submit a written plan for the engineer's approval that details the method of water diversion, the means of access to the site, the method of liner pipe installation, the equipment to be used for installation and the method of grout placement.

B. Clean

Dewater, clean and inspect the existing pipe to determine the location of any obstacles that may prevent proper installation of the liner pipe. If the proposed liner pipe will not pass the full length of the existing pipe, the engineer shall be notified immediately. Any voids existing outside the pipe shall be filled to the engineer's satisfaction. Water will be allowed to flow through the existing pipe except during the grouting operation.

C. Guide Rails

The contractor shall install the guide rails or blocking between the existing and liner pipe. These shall be placed in the invert of the existing pipe or welded to the exterior of the liner pipe. As an alternative, the pipe fabricator may weld the guided to the pipe at the plant. The guides shall be placed to allow grout to flow between the rails and fill the void beneath the liner pipe. The use of a ribbed steel pipe will generally allow adequate room between the ribs for grout to flow under the liner pipe. Rollers or skids may be used in lieu of installed guide rails to position the liner pipe, provided the pipe is properly blocked into position after being located in its final position. If the existing pipe is of adequate size and the invert is sufficiently sound, rolling equipment may be used to move the liner pipe into position.

As an option to guide rails, a bed of low strength concrete may be placed in the invert of the culvert. The compressive strength of the concrete shall be a minimum of 1000 psi. The top surface of the bed shall be reasonably level and smooth, and finished to a depth that allows the liner pipe to rest directly on the bed. The liner pipe shall not be installed until the concrete in the bed has cured for at least three days.

D. Liner Pipe

The contractor shall install the liner pipe in accordance with the plans and the pipe manufacturer's recommendations. The liner pipe may be pushed or pulled into position. Use care to avoid damaging the liner or the existing pipe during installation. During pipe placement, take care to avoid crushing the ends of the pipe, because of excessive loads applied during pushing or pulling. Blocking should be used to distribute installation loads over as much of the pipe's periphery as possible. The liner pipes shall be positioned to allow a nominal ¾ inch gap between the ends of adjacent pipe. Once a liner pipe is in place, adjust its line and grade as needed and install the alignment bolts in the pipe to fix the liner pipe location. Take care not to damage the liner pipe by tightening the alignment bolts too tight against the existing pipe.

E. Bands

Internal or external bands shall be installed at each joint formed by two adjacent pipe sections. The band shall be located close to the joint, the rubber gasket shall be placed between the pipe and the band, and the band and gasket placed in final position. The band shall than be tightened against the pipe until the gasket is solidly in contact with the surfaces of the ends of the pipe sections. The internal bands shall remain in place until the grouting operation is completed and the grout cured after which they may be removed at the engineer's discretion. If liner pipe sections have been placed in the

existing pipe to form an elbow, it may be necessary to weld the joint between these sections, if the angle is too severe to allow the use of an internal band. Depending on the grout placement method used, it may be necessary to brace internal bands during grout placement.

F. Grouting

Upon placement of all liner pipe sections and the installation of all internal or external bands, construct bulkheads at the ends of the annular space. The bulkheads shall be of sufficient strength and rigidity to withstand the hydrostatic pressures of the grout. Grouting may proceed in accordance with the approved construction plan. Grout placement will begin at the downstream end of the culvert and proceed upstream. Pump grout at a controlled rate to prevent excessive flotation forces on the liner pipe and maintain pressures at reasonable levels.

If grouting is done through grout fittings placed in the liner pipe, begin pumping at the lower fitting on either side of the pipe. Pump at that location until the grout rises to the level of the fitting. Continue grout placement through the fitting on the opposite side of the pipe, pumping until grout rises to and spreads to the adjoining the fitting level. Continue grouting by pumping through the fittings at the springlines and moving to the crown of the pipe. Pump at the crown until resistance to pumping increases. Repeat this procedure by moving upstream to successive grout fitting locations.

Grouting of shorter length installations, may also be accomplished by placing a pump line over the top of the liner pipe or by pumping through the bulkheads at each end. Observation holes may be required in the pipe at appropriate locations to determine the extent of grout spread. If grouting is done from one end of the culvert, a vent hole may be required at the other end.

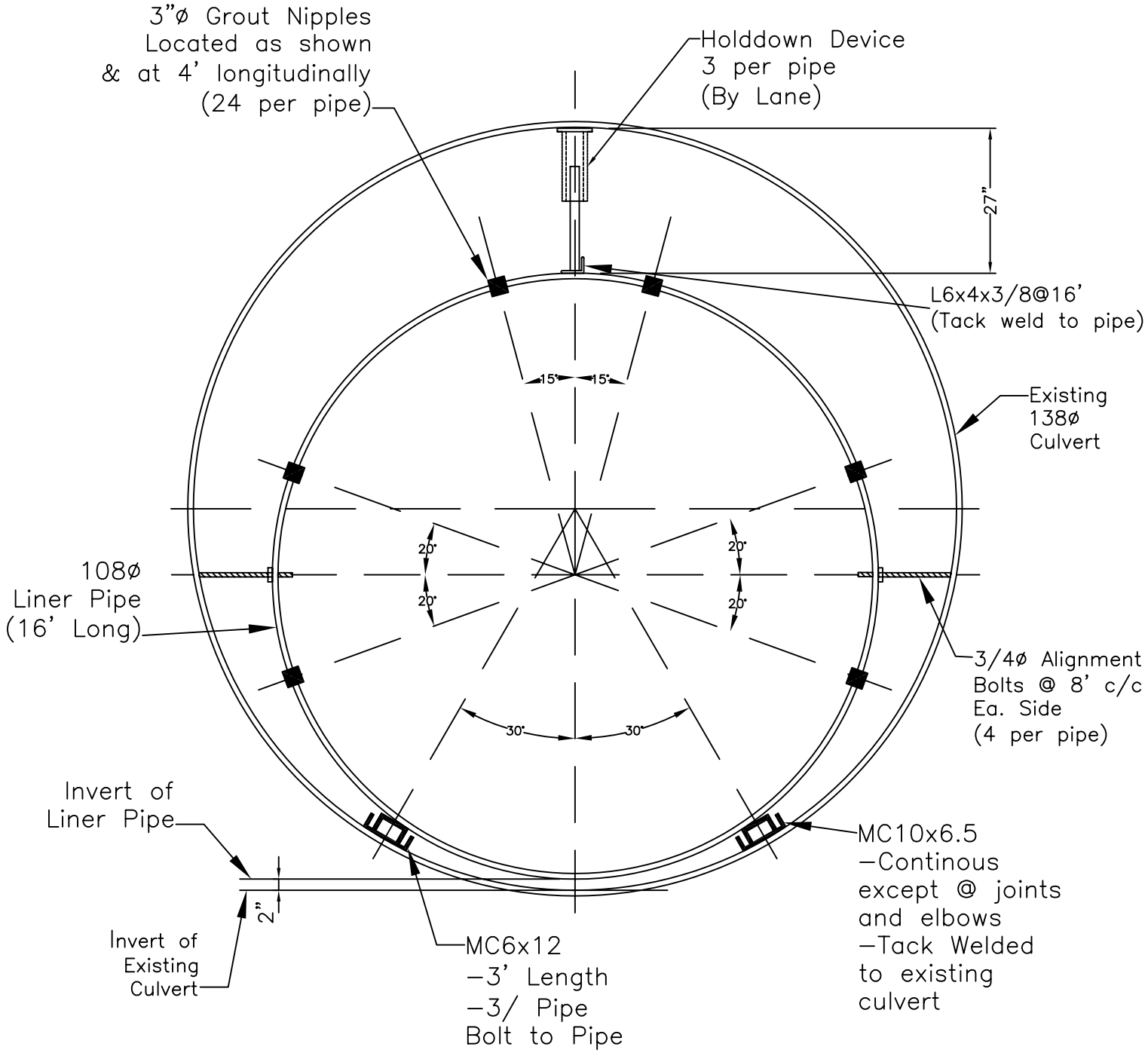
A third grout placement method is to drop the grout from the roadway surface level. As many drop locations as possible should be used to reduce the pressure needed to spread the grout. Prior to grouting through bore holes to the surface, reinforce the crown of the liner pipe in the location of each bore hole. If necessary, strut the pipe in these areas to ensure the shape of the liner pipe is maintained. Carefully evaluate this grout placement method, because the grout may need to be more fluid, thus increasing the pressure on the pipe.

After the grout has achieved initial set, the internal bands may be removed. The bulkheads may be removed after the grout has cured for at least 48 hours, although they are often left in place as the finish treatment of the ends of the new pipe structure. Following removal of the internal bands, clean the liner pipe of all excess grout and all other construction materials.

PIPE RELINING

TYPICAL DETAILS

LANE ENTERPRISES **JUNE, 2001**



LANE ENTERPRISES, INC.

TITLE

RELINING SECTION
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A0103	1 OF 1	08/30/00

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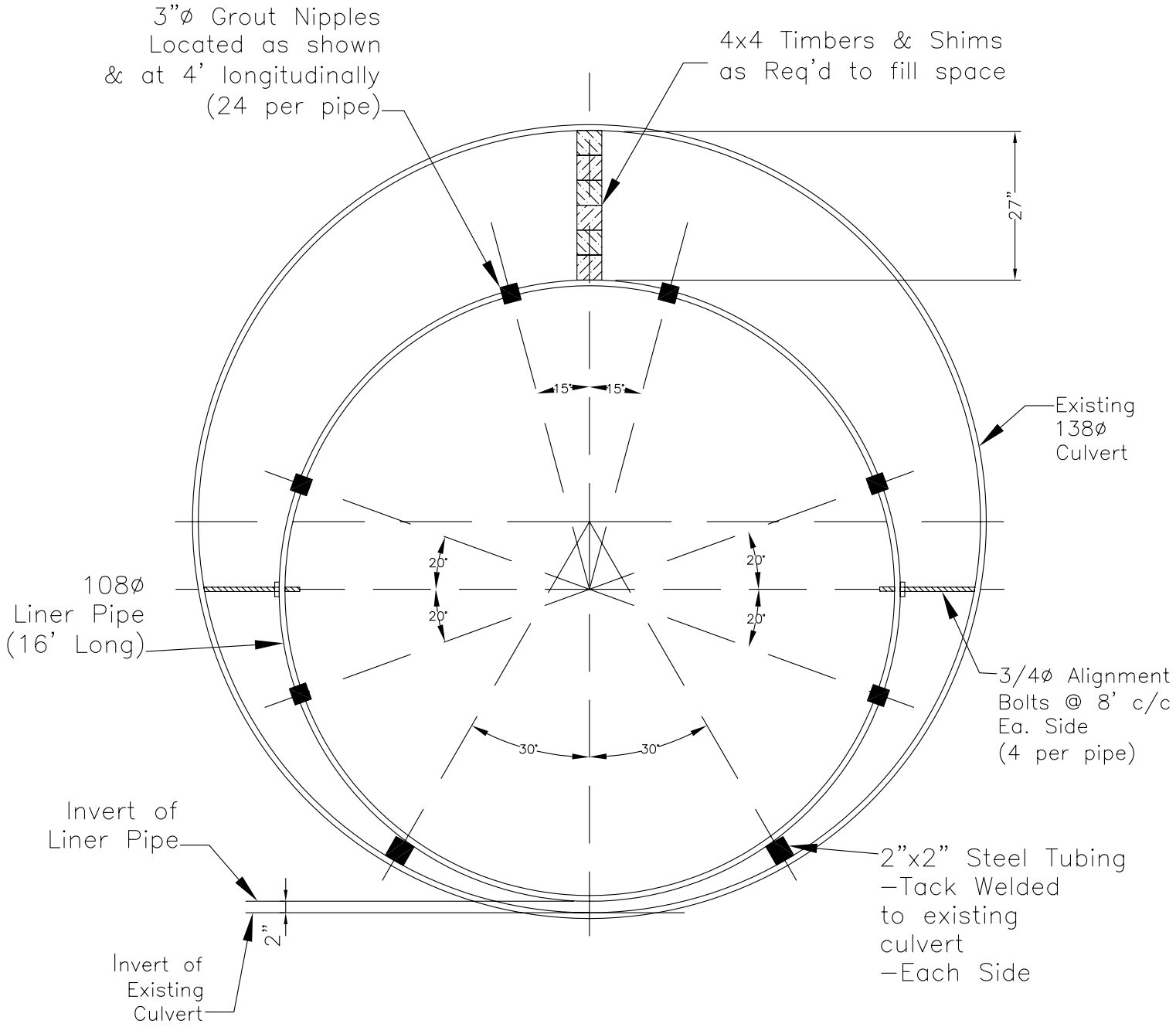

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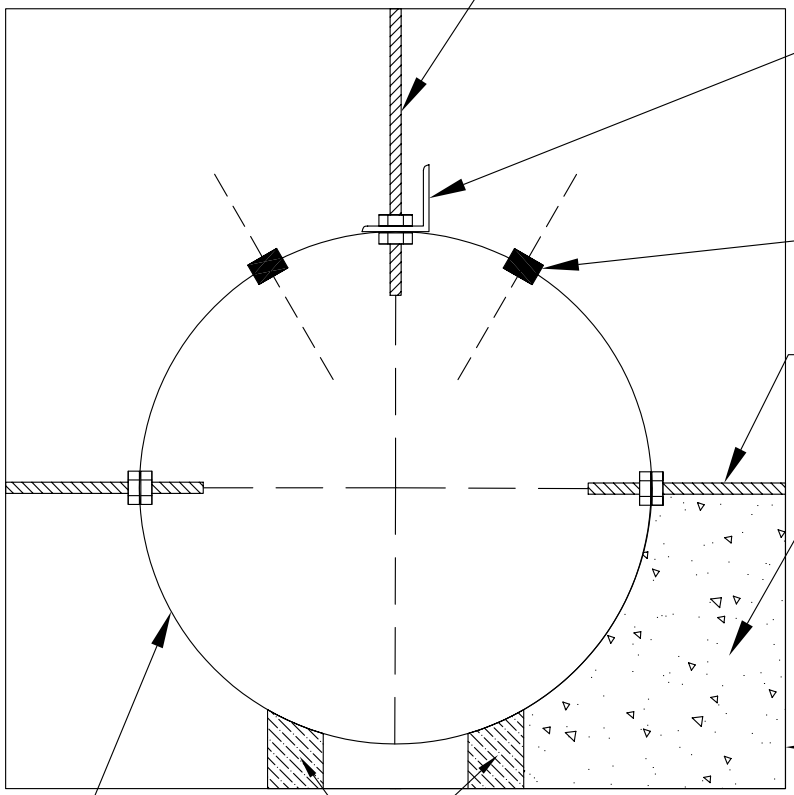

Note:
–All bolts are 1"ø

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RELINING CONCRETE BOX CULVERT (CENTERED)

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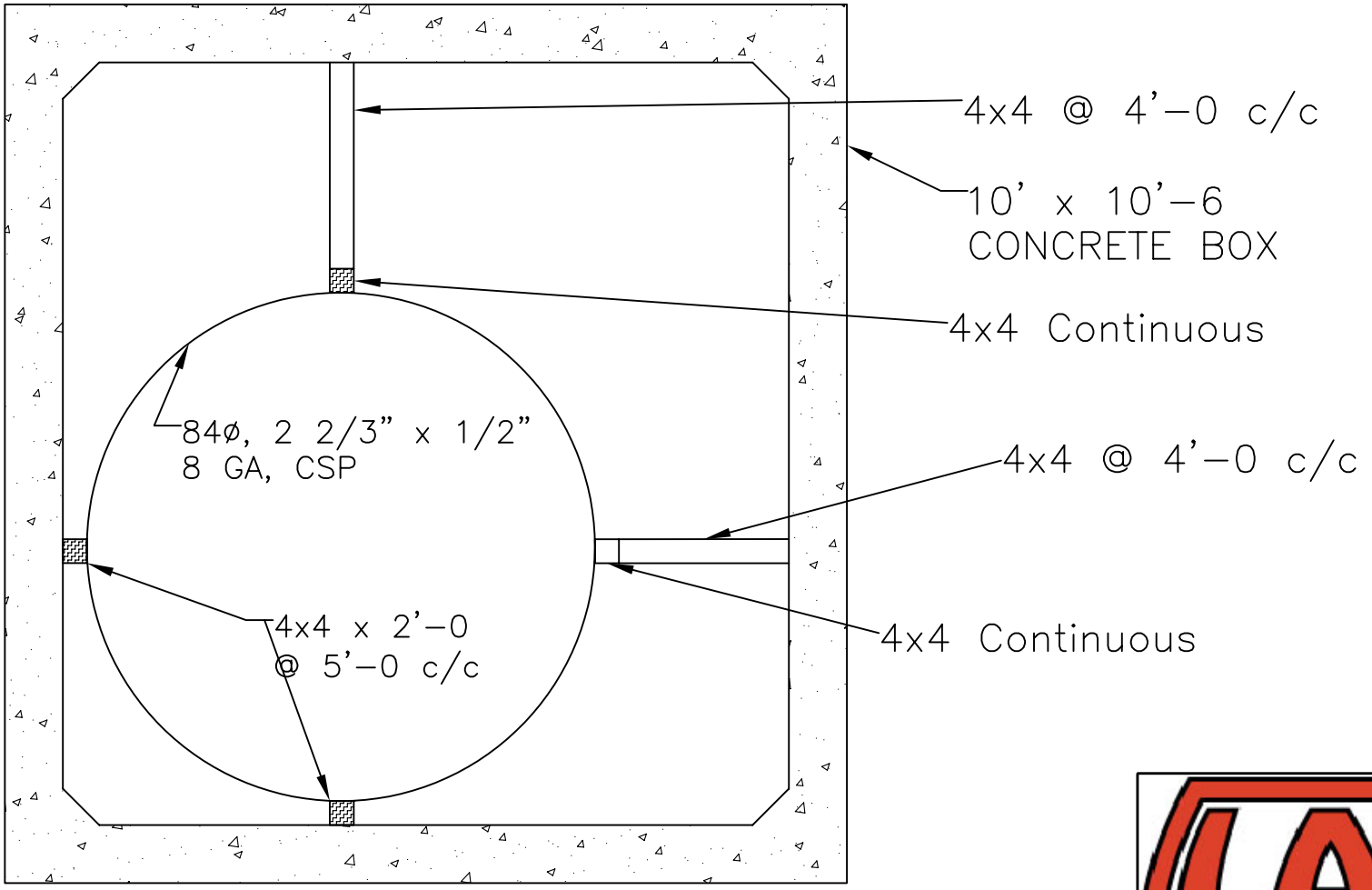

DETAIL OF 84" CSP AS LINING FOR
10' X 10'-6" CONCRETE CULVERT

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TITLE

RELINING OF
CONCRETE BOX CULVERT
(OFFSET POSITION)

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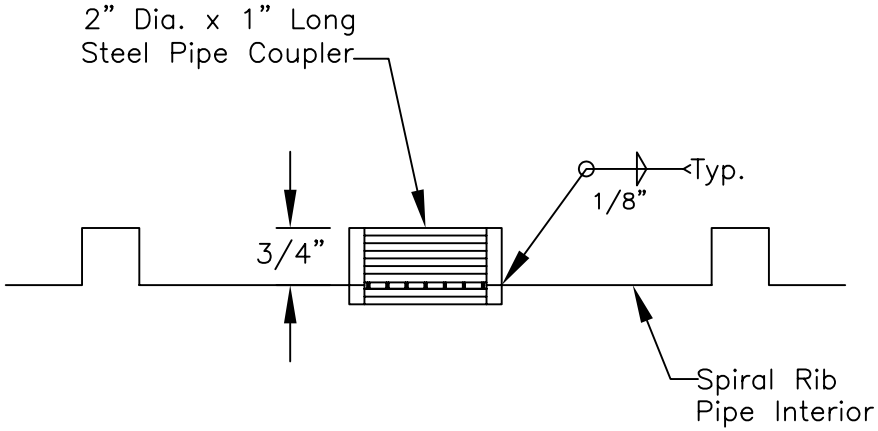
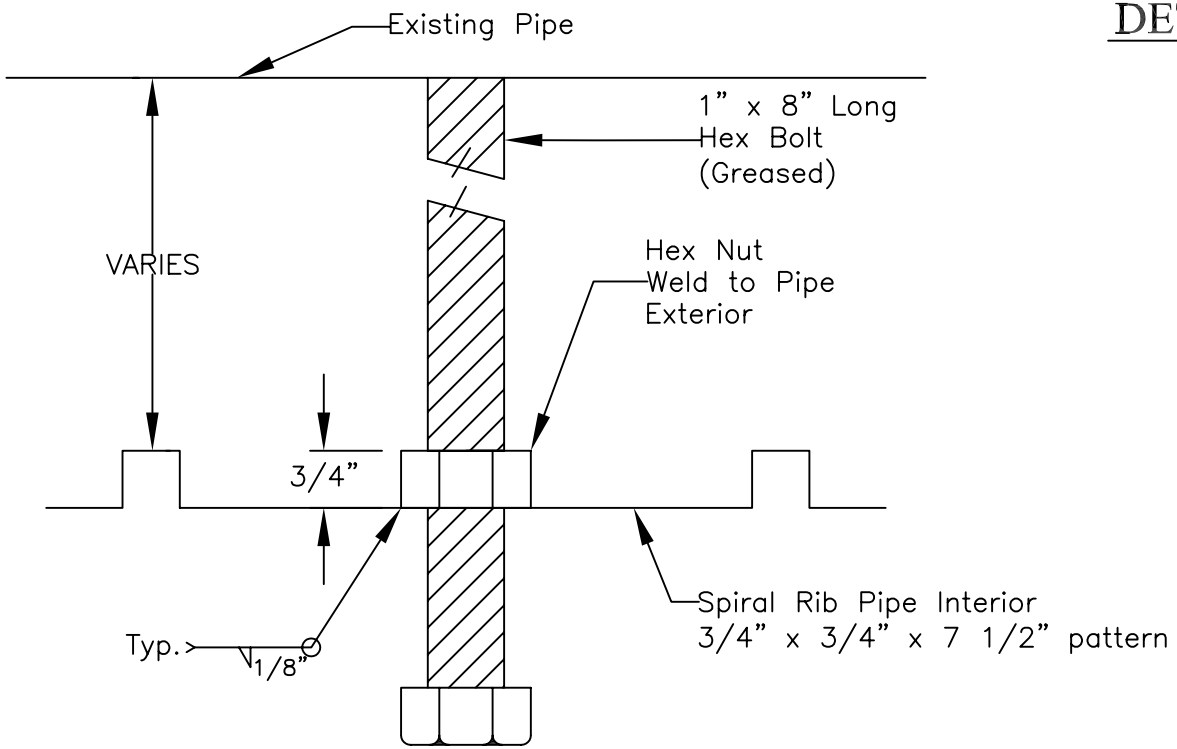


DETAIL A - GROUT NIPPLE
(N.T.S)



DETAIL B - BRACING BOLT
(N.T.S)

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TITLE: HARDWARE DETAILS FOR RELINING PIPE

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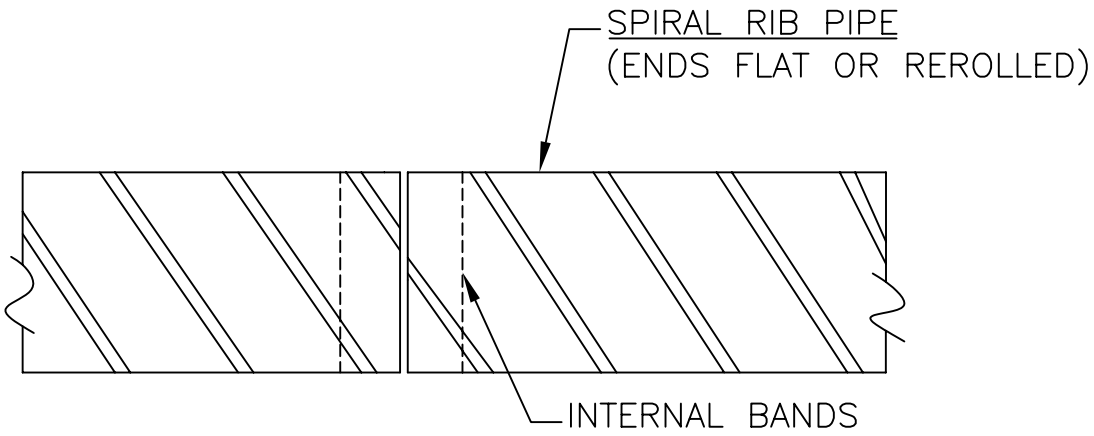

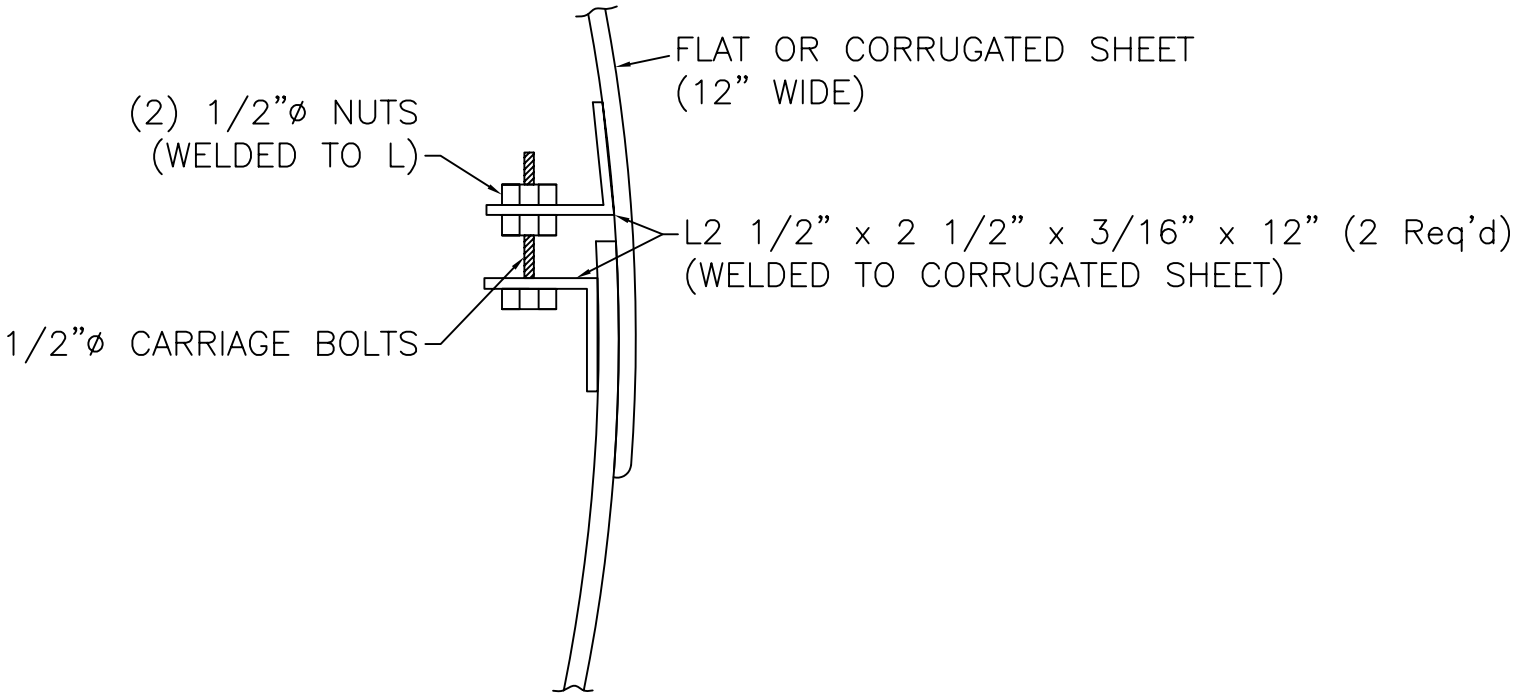

INSTALL WITH
12" X 3/8" GASKET
BETWEEN PIPE &
INTERNAL BAND

LANE ENTERPRISES, INC.

TITLE	DRAWN BY:
INTERNAL BAND FOR SPIRAL RIB RELINING PIPE	BLC

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A0100	1 OF 1	8/30/00

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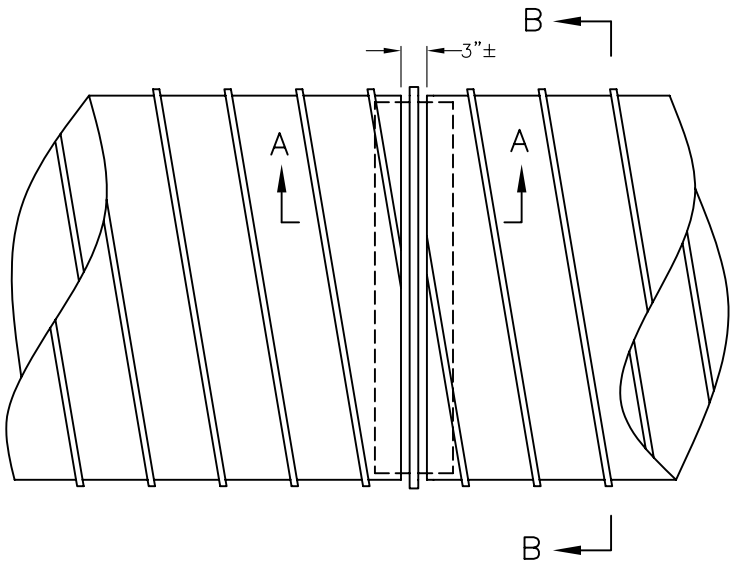
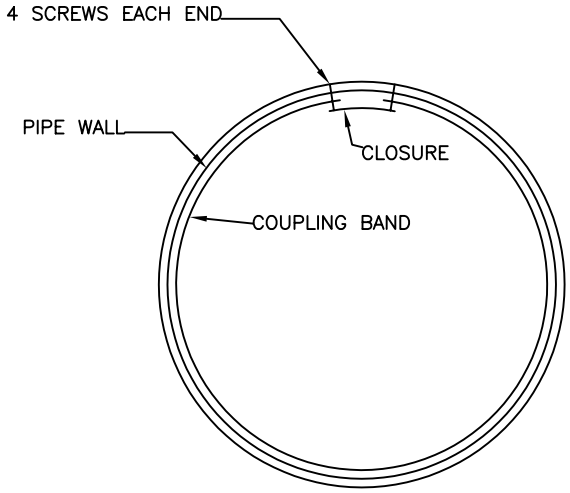


TYPICAL PIPE JOINT



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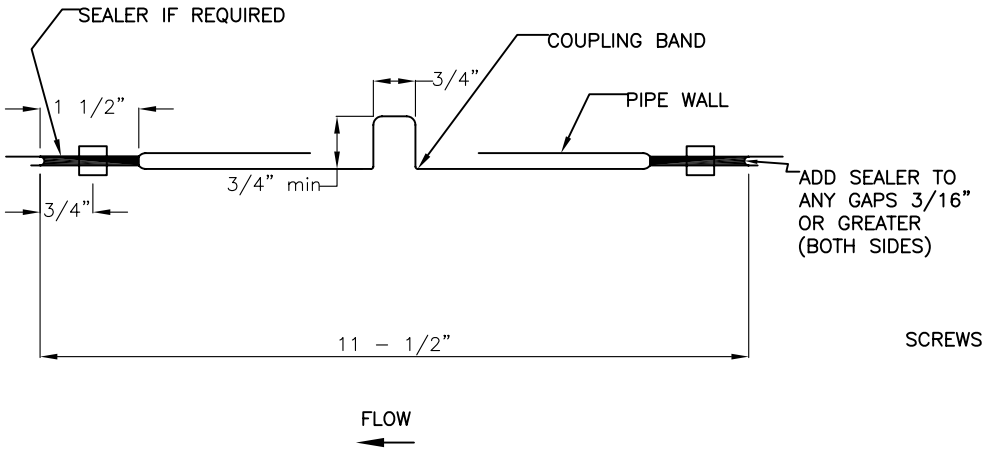

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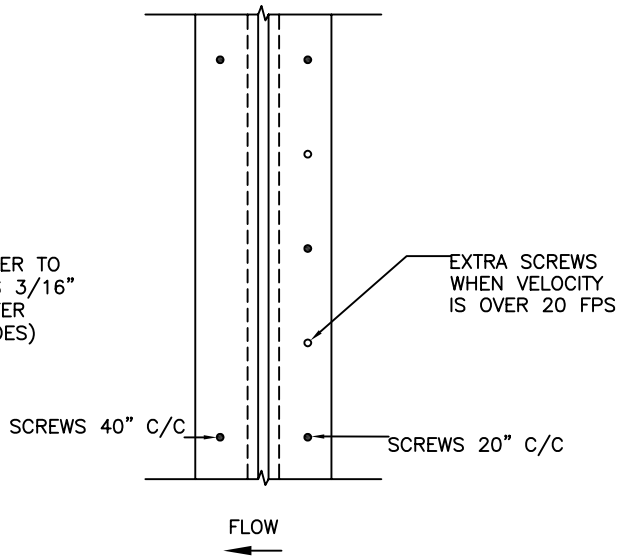

ATTACHMENT DETAILS

LANE ENTERPRISES, INC.

TITLE

ATTACHED INTERNAL COUPLER
FOR SPIRAL RIB PIPE

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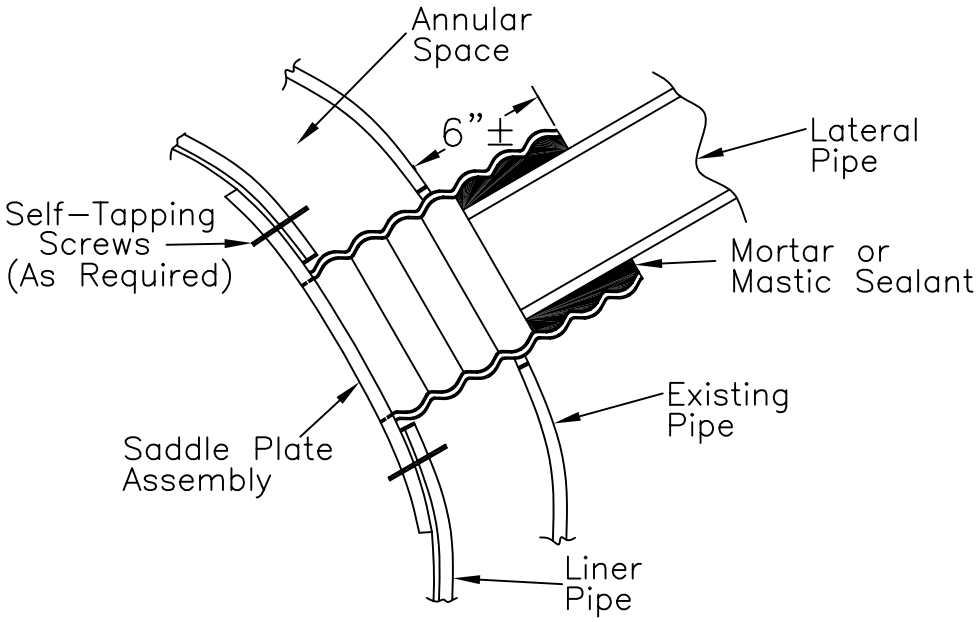
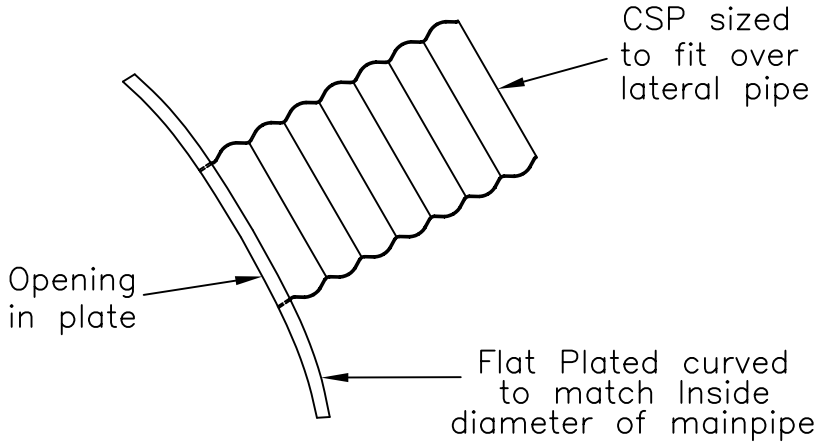


SADDLE PLATE INSTALLATION



SADDLE PLATE ASSEMBLY

LANE ENTERPRISES, INC.

TITLE	DRAWN BY:
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