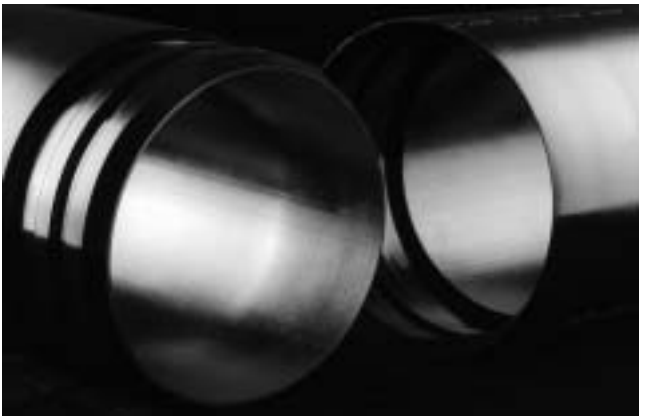
Snap-Tite® Culvert Lining Installation Guide



SNAP-TITE

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Coming through.

ISCO Industries, LLC

SNAP-TITE® CULVERT LINER INSTALLATION GUIDE FOR SLIPLINING AND GROUTING CULVERTS

Contents

How This Guide Can Help You

This manual was written for the installer and those who handle and install Snap-Tite® Culvert Liners.

This manual is not intended to provide design information, nor to assume the responsibility of the engineer (or other customer representative) in determining procedures for the specific job conditions to attain best performance of the liner.

Contractors, maintenance crews, engineers, superintendents, foremen, and laying crews will find information to guide them in the following pages. This manual will also be of help in selecting the needed materials when ordering the liner.

A Liner can strengthen the road bed, provide flow capacity, but it can not straighten an old culvert or change elevation.

Warranty

ISCO Industries, LLC warrants that our products are manufactured in accordance with the applicable material specifications, and are free from defects in workmanship and materials using our specifications as a standard. Every claim under this warranty shall be deemed waived unless in writing and received by ISCO Industries, LLC within thirty (30) days of the date the defect was discovered, or should have been discovered and within one (1) year of the date of the shipment of the product. **ISCO Industries, LLC makes no other representation or warranty of any kind, expressed or implied, in fact or in law, including without limitation, the warranty of merchantability or the warranty of fitness for a particular purpose, other than the limited warranty set forth above.**

Limitation of Liability

ISCO Industries, LLC's liability is limited to the replacement of defective product, and ISCO Industries, LLC shall have no liability whatsoever, except where damage or a claim results solely from breach of ISCO Industries, LLC warranty. **In no event shall ISCO Industries, LLC be liable for any special, incidental, consequential, or other damages whether or not similar to the preceding, under any theory including negligence, breach of warranty, or strict liability.**

Receiving and Handling Liner Shipments

Upon arrival of each liner shipment, the liner should be carefully inspected. The liner was carefully loaded at the factory using methods acceptable to the carrier and it is their responsibility to deliver the pipe in good condition. **It is the responsibility of the receiver to make certain there has been no loss or damage in transit.**

The packing list, which accompanies each shipment, provides a complete list of all items included. **Check the load against the packing list, and report any error to the transportation agent immediately and have proper notations made on the packing list.**

Preparation

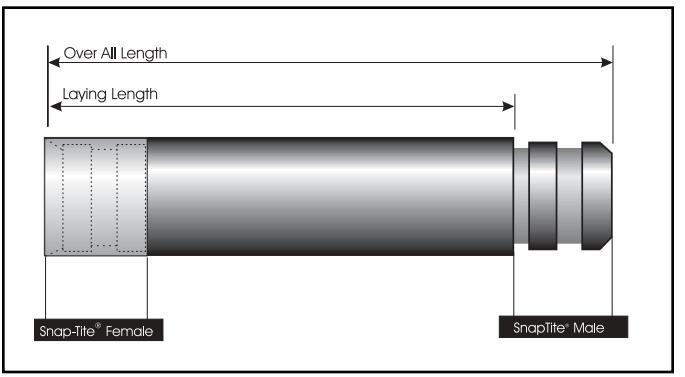
The area near the culvert must be cleared for access to the culvert. Dirt and rock must be removed from the culvert. If there are voids around the old culvert, these voids can be filled prior to lining. After the culvert has been cleaned and prepared for lining, make sure there is nothing protruding from the culvert that will damage the liner.

Also, a work area for unloading and handling the liner must be selected. A flat area will offer a safe place to unload and handle the liner.

Product

The diagram below illustrates the design attributes of the Snap-Tite® joint design.

Drawing 1: Snap-Tite® Design



Equipment

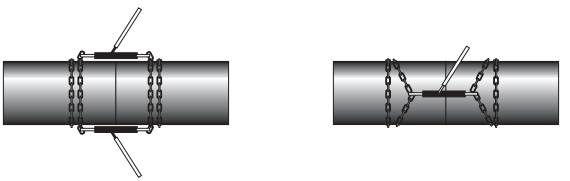
Snap-Tite® is so easy to install that most jobs can be completed with a backhoe, shovels, a come-along, and chains. If a culvert requires cleaning, a water truck or jet cleaner may be needed.

Chains and come-alongs capacities are based on the size of liner to be installed. Standard chain come-alongs are available with load ratings of 1,000 to 5,000 lbs. of force. Verify the amount of force that the come-alongs are capable of applying before using them. For safety reasons, the chains normally are able to handle twice the load applied by each come-along.

Chains are sold based on working load. The working load is the normal rating for typical lifting applications. The strength at failure is usually four times the working load. When a chain is wrapped around a Snap-Tite® liner and tightened with a chain binder, it is under tensile loading.

After a come-along is attached to a chain link, the link is subject to cross loading. A cross load occurs because the chain must wrap around the pipe to transfer the forces. As the cross load is increased, the angle of the chain around the liner changes. See diagram below:

Drawing 2: Chain Wrap Position



Position of chain before load
Top View

Chain under load
Side View

Chain manufacturers reduce the working load by 25% for cross loading. A chain with a standard rating of 6,000 lbs. is only rated for 4,500 lbs. in this application. If you have determined that you need 6,000 lbs. working load on the chain for a Snap-Tite® Installation, then an 8,000 lbs. working load rated chain is needed.

Table 1: Estimated Force to Join Snap-Tite® Liner

Liner Size OD	Weight per Ft.	Weight of 24 Ft.	Estimated Joining Force	Total Force	Typical Min. Load Rating For Each Come-along, Lbs.
10.75"	4.75	114	500	614	1,000
12.75"	6.67	160	1,000	1,160	1,000
14"	8.05	193	1,000	1,193	1,000
16"	10.5	252	1,000	1,252	1,000
18"	13.3	319	1,000	1,319	1,000
20"	16.43	394	1,000	1,394	1,394
22"	19.86	477	1,000	1,477	1,000
24"	23.62	566	1,500	2,066	2,000
28"	32.19	773	1,500	2,273	2,000
30"	36.93	886	1,500	2,386	2,000
32"	42.04	1,009	2,000	3,009	3,000
36"	53.2	1,277	2,000	3,255	3,277
39.37	63.69	1,529	3,000	4,529	3,000
42"	72.37	1,737	3,000	4,737	3,000
48"	94.55	2,269	3,000	5,279	5,269
54"	119.7	2,873	3,000	5,873	3,000
63"	162.98	3,912	4,000	7,912	4,000

Joining Forces changes with temperature, type of lubrication, male-female joint alignment, presence of debris, slope and time. Forces are estimated for slow application of force with flat slope and lubricated joint. A slow application of force allows materials to stretch. Fast joining requires more force and energy because material does not immediately increase in size. More force will be required below 73 degrees F. Forces are estimated only! Forces given in Table 1 are based on 24 ft lengths. If different lengths are used, more or less force will be required.

Full load is applied when the male and female joints come together straight on and part of the flat surface on both sides "catches." The best joining procedure is to watch the joining process and make corrections based on observations. When pipe movement requires more force than expected, look for a reason. If the joints do "catch", rotation of the two liner sections or alignment with a pry bar may solve the problem.

If the male end is at a slight angle to the female and partially inserted, lower force is required to make the joints mate. Apply force from one come-along until liner bends slightly. Apply force slowly, this allows the female joint to expand. **Be cautious when tightening a chain or cable!**

Snap-Tite® liners are not always round. Care should be taken to get alignment around all of the Snap-Tite® joint. Pry bars are sometimes used to help align the joints. Changing the position of come-along on the Snap-Tite® liner may be helpful.

Be aware of the force being applied. Allow only needed personnel near the come-along and chains. All others must remain at a safe distance from the chain. All personnel must use safety equipment during installation. Gloves, hard hats, and safety glasses are always needed.

Chain wraps on the liner slip less than cable. Chains appear to be safer for this use. The mechanisms used in a come-along often fail when over stressed; **be careful when using come-along**!

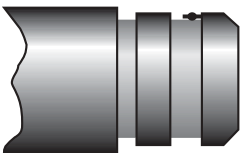
Special safety equipment is required if there is moving water present, electrical lines are close to installation or if there are hazardous material in pipes. Check your job site and be prepared.

Installation Steps

Step 1 – Select and prepare the existing culvert. Inspect the culvert to ensure the liner can be inserted without obstruction. Flush and/or clean the existing culvert.

Step 2 – Insert one end of Snap-Tite® Culvert Liner into existing culvert. This can be done using a variety of techniques. Leave about five feet of liner exposed prior to this step. Prior to installation of first section, it may be necessary to create a "nose cone" by cutting the ends of the pipe. See Drawing 3 on page 10.

Step 3 – Position the next section of Snap-Tite® Culvert Liner with proper alignment. Place the opposing end of a second section against the exposed end of the first section. The two sections must be in alignment and have the same slope.



Male Snap-Tite®

Step 4 – Lubricate the male side of Snap-Tite® joint. A gasket is normally supplied with Snap-Tite® pipe.

It is installed on the male end to help make a watertight seal, and should be placed in the first groove from the end. The gasket will not be as wide as the groove. Make sure that one end of the gasket is touching the side of the groove that is closest to the end. Check the alignment of the gasket around the liner. Apply lubricant to the entire circumference of the liner. The lubricant must be applied evenly to reduce the chance of a torn or rolled gasket.

Option: Mastic can be applied to second groove to reduce chance of leakage when joints are deflected. Carefully apply mastic to second groove. Too much or too little mastic can increase chance of leakage.

Completed Snap-Tite® Joint

Step 5 – Attach the chains and couplings. Double-wrap the chains approximately two feet from the coupling end and tighten with binders. Attach one come-along on each side of coupling, 180 degrees apart.

Step 6. Snap liner together. Align the ends of the male bevel inside the female bevel. Use a pry bar or move the come-along to different positions on liner if pipe is out of round to improve alignment. Be sure male end has been properly lubricated. Pull the couplings together slowly, forcing the female end to expand and allow the male end to move into the female end. Apply force slowly and make observations. Apply force to one side until liner slightly deflects, then apply force on other side. Look for the female side to increase in OD as force is applied.

Caution! If chain or come-along appears to be overstressed, stop operation! Quickly move away from the chain! When lands and grooves are aligned, the couplings will "snap" and lock together. Allow time for this to occur.

If operation is stopped, check alignment. Often poor alignment or a stone or dirt in the land causes the need for additional pressure. Rotation of the liner will change alignment. Clean out the joint if needed.

Step 7 – Push joined liners into culvert and repeat until completely lined. Remove chains, push joined liners into culvert and repeat steps 1-6. Each new piece of pipe is snapped onto the proceeding pipe and pushed into the culvert, leaving enough pipe protruding from the culvert to join with the next length of liner.

Step 8 – Seal the culvert ends. Make an end seal for the annular space a distance of one to two feet at each end using an appropriate grout. A relatively dry cement grout is used in most situations. Chemical grout, oakum, and other seals are used depending upon the situation. *Annular Space Back Fill.*

Step 9 – Grout the annular space. It is recommended that the annular space between the existing culvert and the liner be grouted. This will help fill the voids created by previous washouts, provide additional structural support, and prevent point loading. More information on grouting is provided starting on page 9 of this guide. Additional information on grouting is provided in "Snap-Tite®: Your Culvert Lining Solution", Chapter 10, *Annular Space Back Fill.*

Lubricants

Most standard pipe and gasket lubricants can be used with Snap-Tite® Culvert Liner and gaskets. Aromatic hydrocarbons (like gasoline) and most petroleum based lubricants must be avoided. Vegetable oil and mineral oil are acceptable in most formulations.

In environmentally challenging applications, spray-on lubricants like SLIKSTYX™ may be the best choice. SLIKSTYX™ can be applied at low concentrations by spraying it on the joint and gasket. The product is NSF approved.

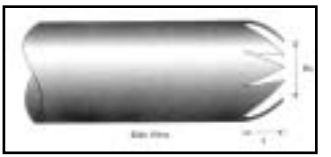
Creating a Nose Cone

Snap-Tite® can be installed with or without a nose cone. In pipes that are relatively straight, no nose cone is needed. In pipes that are misaligned, partially collapsed, or have dropped joints, a nose cone makes installation easier.

The nose cone is made by making a banana peel cut on the end of the Snap-Tite® Culvert Liner. Drawing 2 shows a typical nose cone. ISCO Industries, LLC makes these nose cones for sale. Using the information provided below, a nose cone can be constructed.

Drawing 3: Nose Cone Typical

Side View
L = about 12" to 16"
D_N = about 3/4 Dia. of pipe



End View
Make 8 Dovetails
Drill 1/2" dia. hole about 1" from point of Dovetail.

Example: 24" pipe, D_N = 18"
36" pipe, D_N = 27"
42" pipe, D_N = 32"

Draw pieces toward each other by connecting wire to opposite holes and twisting the wire to tighten.

All dimensions can be varied to suit specific conditions.

General Grouting Requirements

Warning: All piping materials can be collapsed if excessive grouting pressures are used. Use Table 2, "Ring Compression Strength For Snap-Tite® Culvert Liners to determine the maximum grouting pressures.

Snap-Tite® Culvert Liners are normally supplied with a wall thickness of DR 32.5. The ring compression strength of this pipe is provided in Table 1. It is important to analyze the application before coming to

Table 2:
Ring Compression Strength for Snap-Tite® Culvert Liner

Service Life	Pipe DR 32.5
Short term (>10 hours)	7.9 psi
10 hours	4.2 psi
Long Term	2.2 psi

Values are based on 1% deflection in Snap-Tite® liner.
Liner with more deflection can handle less loading. Grouting pressure should exceed 2 psi in most applications. At 140 degrees F, the values in the table are about 1/2 the values at 73 degrees F.

Table 3: Snap-Tite® Dimensions and Weights for DR 32.5 Liner

Culvert Size ID	Liner Size	OD Weight/ft
12" ID	10.75"	4.75
15" ID	12.75"	6.67
18" ID	14"	8.05
18" ID	16"	10.50
21" ID	16"	10.50
21" ID	18"	13.30
24" ID	20"	16.42
24" ID	22"	19.86
27" ID	22"	19.86
27" ID	24"	23.62
30" ID	24"	23.62
30" ID	28"	32.19
36" ID	28"	32.19
36" ID	30"	36.93
36" ID	32"	42.04
42" ID	34"	47.43
42" ID	36"	53.20
48" ID	39.37"	63.69
48" ID	42"	72.37
54" ID	42"	72.37
54" ID	48"	94.55
60" ID	48"	94.55
60" ID	54"	119.70
72" ID	54"	119.70
72" ID	63"	162.98
84" ID	63"	162.98

Liner Assembly and Installation

Following are listed the normal steps required to install Snap-Tite®. In many installations, the liner can be assembled with a come-along and pushed in place with a backhoe. This procedure follows.

When a nose cone is needed, ISCO can provide the nose cone. If you prefer to make your own, instructions are provided (see page 10).

Joint Integrity

Carefully following the procedures set out in this Installation Guide will reduce the chance of leaks between joints. Dirt, sand, or rock in the joint area may affect the integrity of the joint and create leaks. In addition, placement of a joint where the existing culvert bends or deflects, or where the joint is otherwise stressed also increases the chance of leakage. In these situations, a special length of Snap-Tite® Culvert Liner may sometimes be used to avoid the problem.

Grouting the Liner in Place

Snap-Tite® is the liner pipe used to rehab culverts. The annular space between the Snap-Tite® Culvert Liner and the culvert should be filled with grout or flowable fill in most cases. Grouting the annular space provides additional strength to the existing culvert and liner.

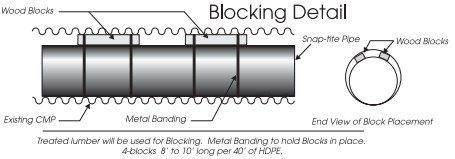
While grouting provides additional strength, the liner will be above the old flow line. Depending upon the condition of the old culvert and the grade of the old culvert, the liner is usually not be on grade after grouting. The grouting process provides strength to the old culvert and the liner provides a smooth flow surface. The flow in the lined culvert is usually about the same or great than the old culvert. Do no expect the liner to be arrow straight after grouting. Some variation in the flow line is to be expected.

A clearance of 10% of the ID of the culvert is normally used between the Snap-Tite® Culvert Liner and the culvert. This clearance permits the liner to slide easily into the culvert. Liners 10% smaller than the culvert size provides 100% or more flow in most cases. Also, this provides space for grout to easily flow around the liner.

After the Snap-Tite® Culvert Liner has been placed in the culvert, remove any water above the invert. Water can interfere with the curing of the grout. Keep water out of the annular space during the grouting process.

Block the liner to prevent flotation during grouting. Wooden blocks or skids are used to center the pipe prior to grouting. Drawing 4 shows the use of blocks and skids and their placement.

Drawing 4: Blocking Detail



To maintain grade, blocking the liner in place is important. The location of the liner inside the culvert must be controlled. The bedding of the culvert must be evaluated. If there are voids around the culvert, these voids should be filled with grout. The grouting of voids can best be done before lining. If a high flow grout is used, these voids will often be filled as the liner is grouted.

Blocking usually is not required for smaller culvert sizes. When a 22" liner is installed in a 24" culvert, blocking is not normally used. As the culvert size increases and the liner size decreases, the need for blocking to hold grade becomes more important. An example of this is when a 54" Snap-Tite® Culvert Liner is used in a 72" CMP culvert; blocking is used to keep the liner close to the bottom of the culvert.

Site Preparation

Prior to lining, each culvert should be checked for access. There must be an open area equal to the liner section to be used on at least one end of the culvert. The safety of the installation area should be evaluated.

Snap-Tite® culvert liners can be installed when water is present. Installation during low flow conditions presents low safety risk. Fast flowing water can create a safety hazard. Use good judgement if water is present. Grouting with standard cement grout can be done when water is present. Cellular grout cannot usually be installed when water is present. Consult your grout supplier if water is present.

Centering the Liner

As discussed above, flotation of the liner is of concern when a liner is to be grouted or there is ground water present. To prevent flotation, using blocks or skids around the pipe can center the Snap-Tite®

Culvert Liners. Drawing 4 shows typical blocking of Snap-Tite® Culvert Liner. Blocks or skids are typically installed in a staggered pattern. Spaces are left between the blocks or skids to get grout under and around the liner.

When grouting from the inside with a wand, it is important to know approximately where the blocks and skids are located. Thumping on the liner will often help locate blocks. Usually there is a difference in sound where the blocks or skids are located.

Blocks are installed in the top 120 degrees of the culvert. For culverts 36" in diameter or larger, blocks are attached to the old culvert. The first block is often installed at 11 o'clock, then a space of four feet. The second block is installed at 12 o'clock, then a space, and the third block is installed at 1 o'clock. These blocks are usually four to eight feet in length. The thickness is determined by the difference in the ID of the culvert and the liner.

The upper skids must have structural strength adequate to resist the buoyant force created as the liner is grouted in place. Wood and solid plastic will work. Styrofoam does not have adequate compressive strength to work for many liner sizes.

Liner Insertion

The specific instructions for joining and inserting the liner have been covered starting on Page 6. The first piece of Snap-Tite® Culvert Liner is placed in the old culvert. The second piece is aligned male-to-female. Check vertical and side to side alignment. Be sure to lubricate the male end of the liner before assembling male and female connections. The joint is assembled using two come-along 180 degrees apart.

After the connection is made, all blocks, chains, and other equipment should be removed from the trench. Repeat the joining procedure until all pipe is assembled.

Filling the Liner with Water

In some applications, the liner has been filled with water. The mass of the water is suppose to counter the buoyancy of the grout and resist deflection caused by the grout (See Table 4) . Our experience is that the liner must be blocked to prevent movement when the liner is filled with water. If the liner can deflect, it will leak.

Also, in many applications the weight of the water is not great enough to overcome the buoyancy of the liner. Grout usually has a density greater than water; therefore the liner floats and moves.

Based on our experience, filling with water prior to grouting is not recommended. If you must fill with water, then the liner must be blocked in place to reduce movement. Since movement can cause the liner to leak, no responsibility for this method of installation will be accepted by ISCO.

Testing Installed Snap-Tite® Culvert Liner

It is usually not necessary to test the Snap-Tite® Culvert Liner. However, if you decide to test the Snap-Tite® Culvert Liner, you should use either a water test or an air vacuum test. Air pressure tests should never be used with plastic pipe for safety reasons.

The suggested test period for Snap-Tite® Culvert Liner is 10 to 15 minutes at 10 feet (5 psi) of hydrostatic pressure.

If Snap-Tite® is to be filled with water for test purposes, be sure the pipe does not span over a large void area. A skid may be needed under the liner to support it over the void area. If the liner deflects more than a few degrees at the joint, the gasket may no longer seal the joint.

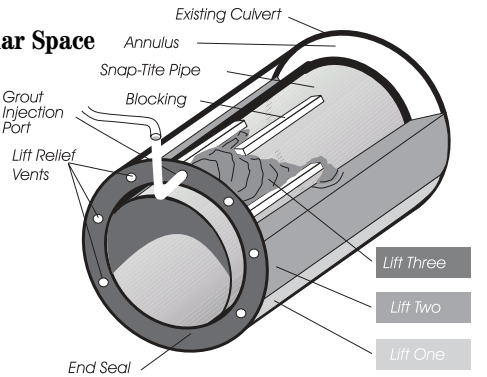
However, if the purpose of testing is to make sure that the liner joints are secure before grouting, water test may not be the best test method. Grouting applies ring compression loading on the liner. A vacuum test better evaluates joint condition for grouting. Table 1 on page 11 shows that the Snap-Tite® Culvert Liner will handle six feet of water (five in Hg) in vacuum.

ISCO Industries, LLC is not responsible for liner pipe that does not pass pressure or vacuum tests.

Preparation

Before grouting, the annular space at both ends of the liner and culvert must be sealed. Bulkheads are the best way to seal the annular space and stop erosion. See Drawing 5 below. The end seal in the annulus can be made by using various materials. Bricks, bags of cement, thick cement, oakum and chemical grout have been used successfully.

Drawing 5:
Sealing the Annular Space



While sealing the annular space, vents to allow air to escape must be installed. Depending upon the grouting plan, vents for each lift must be installed. Usually vents are installed at both ends of the culvert.

Based on the size of culvert and liner, elevation change, length of culvert and other factors, the number of lifts required to fill the annular space must be determined. Of prime concern is the pressure that will be applied on the liner during installation. Adequate safety factor must be allowed for the liner during installation to prevent collapsing the liner. Table 2 on page 11 shows ring compression loading ratings for Snap-Tite® Culvert Liners.

Data Needed to Plan Grouting

The following information is needed to plan a grouting project:

1. What is the elevation of the road or ground above the old pipe or culvert?
2. What is the elevation of the bottom of the old pipe or culvert?
3. What is the elevation of the top of the culvert on each side of highway? (Note: This includes single lane, two lane, and multi-lane highways.)
4. How far will the grout flow in the annular space?
5. How much does the grout weigh per cubic foot? How does the grout . . . flow?

6. How is the end annular space sealed?
7. What is the elevation of the pipe or culvert at the upstream end?
8. What is the elevation of the pipe or culvert at the downstream end?
9. What is the old pipe size?
10. What is the liner size?
11. What is the old pipe made of?
12. What is the desired elevation of the liner after grouting? Should it be on the bottom of the old pipe/culvert?

Developing Your Plan

The purpose of your plan is to prevent the following problems:
1) Floating the liner
2) Making joints leak during grouting
3) Collapsing the liner

A liner is like a boat - it displaces the grout and if the liner weighs less than the grout, the liner floats. Filling the liner with water is one way to reduce flotation. Since water weight is 62.4 lbs. per cubic foot, if the grout weighs 120 lbs. per cubic foot, filling the liner with water may not solve the problem. Filling the liner with water is usually not recommended.

Table 4: Flotation Force per Linear Foot of Liner

Flotation Force			
Liner Size Nominal Inches	**Water[1] lbs.**	**Cellular[2] Grout**	**Portland[3] Cement**
10	34	22	71
12	48	31	99
14	58	37	119
16	78	49	157
18	97	63	199
20	118	76	244
22	145	94	297
24	172	111	353
28	235	151	481
30	269	174	552
36	381	251	795
42	527	341	1,081
48	689	445	1,412
54	872	564	1,788
63	1,187	767	2,433

[1] Water weighs 62.4 lbs. per cubic foot.
[2] Based on cellular grout with a density of 42 lbs. per cubic foot.
[3] Assumes Portland Cement grout weighs 120 lbs. per cubic foot.

Blocking with timbers at the top of the old culvert prevents or limits liner flotation. The position of the blocking is important. Blocking pieces should be staggered. If the pieces used for blocking are all centered, then the force of flotation may deflect the liner.

What causes joints to leak? Misalignment, over pressurizing from the inside, and over pressurizing from the outside, all can cause the liner to leak during installation. If grout is poured on or near a joint from several feet above, it will cause the liner to deform and leak. Timbers in the shape of a ladder are used inside the liner to limit deflection.

Most liners are rated to handle four to six feet of water above the liner without collapsing. If a grout pressure of more than six feet of water is applied to the outside of the liner, then the liner will begin to deform if it is not braced with internal supports. See Drawing 4 on page 13.

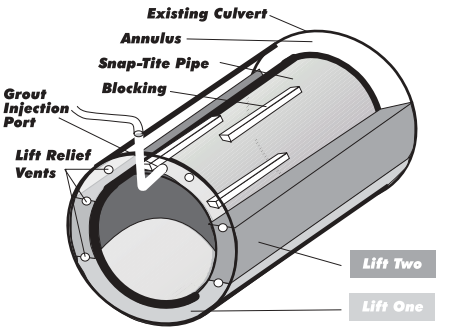
If the grout weighs twice as much as water (62.4 lbs../cubic ft.) or about 125 lbs.. per cubic foot, then the liner will support only half as much grout as water. While six feet of water above the liner will cause collapse; three feet of grout above the liner will cause collapse.

A technique used to support the liner is to fill the annular space in lifts. Filling the annular space with grout in multiple lifts adds support to the liner. When a liner is grouted in lifts, the entire annular space is not filled at one time. Grouting in lifts means that only a part of the grout is flowed around the liner and allowed to harden. As pipe size increases, it becomes more important to grout in lifts.

Grouting in lifts minimizes pressure and provides some support to the liner during the grouting process. With a 54" liner, three or more lifts may be used rather than grouting all of the annular space at one time. See Drawing 6 below. As the first lift cures, it supports the liner. Each additional lift increases the support around the liner after the grout hardens. When there is several feet of grout over the liner, the weight of the grout is large. In this case the grout must be installed in lifts to prevent collapsing the liner.

Cellular grout is often thought to solve the flotation problem. The use of cellular should be carefully considered. Since the grout flows like water, the old culvert must be sealed before grouting or much of the grout will be lost. The grout may cause the pipe to move and open the joints if pressure is applied. Once there is grout in the joint, the joint may leak and the grouting must be stopped.

Drawing 6: Grouting in Lifts



Flowable fill has been used for many years to grout Snap-Tite® Culvert Liners in place. Many mixes of flowable fill have been successfully used. A mix that is like mortar works in the widest range of conditions.

If a liner is being grouted from the center, a standpipe is formed to fill the annular space between the pipe/culvert and the liner. If the old pipe/culvert is 10 feet deep and the old pipe is five feet in diameter, the force at the bottom of the liner is equal to fifteen feet of water or grout if the liner is grouted in place in one pour or lift. This force of water or grout will usually collapse the liner when more than 6 feet of head pressure is applied to the liner. In this application, grouting in lifts is usually the best application method.

Grout Selection

The basic requirements for grout selection are flow and strength. You must be able to make the grout flow into the annular space with minimum pressure and it must have adequate strength to support the liner and reinforce the soil around the old culvert.

Cellular grouts are usually the only type of grout that will flow long distances with low pressure. Select a cellular grout with a compressive strength in the range of 100 to 300 psi minimum compressive strength. This compressive strength will adequately support the Snap-Tite® Culvert Liner in most situations. Have a structural engineer make recommendations for your specific application.

Increasing the size of the aggregate in the grout makes high compressive strength grout. As the aggregate size increases, the pressure and velocity required to keep the large aggregate from settling out becomes higher.

Bridging occurs when sand or other aggregates deposit in one area causing a blockage. If pressure is increased to get flow beyond the blockage, then there is danger of collapsing the liner..

Below are grout mixes that have been used for grouting the annular space between the liner and the old culvert. These mixes are provided as guides only. Aggregates vary greatly. Consult your local ready mix supplier for their recommendations for grout and flowable fill.

Below is a mix for a batch of flowable fill to make one cubic yard:

Cement	800 lbs.
Fine sand	2,000 lbs.
Water	680 lbs.

This mix will flow about 100 ft. with 10 feet of head. It can be foamed with Rheocell 15 in a foam machine. Fine sand is defined as mortar sand.

Batch mix formulations from Master Builders Technologies are provided below. These mixes include Master Builder's Rheocell 15 or Rheocell 30 foaming agent.

Regular CLSM	Mass as Batched
Type 1 Cement	575 lbs.
Class C Fly Ash	500 lbs.
Sand	2,050 lbs.
Water	320 lbs.
Unfoamed density	135 lbs. per cubic foot

A foam time of 76 seconds gives a wet density grout with a 91 lbs. per cubic foot weight and 28 day compressive strength of 440 psi.

Another mix from Master Builders for Low-Density CLSM-Straight Cement is given below.

Type I Cement	700 lbs.
Water	350 lbs.
Unfoamed density	114 lbs.

A foam time of 35 seconds gives density after foaming of 42 lbs. per cubic foot and a 28 day compressive strength of 240 psi.

In California, the "Green Book" suggests the use of grout with a 300 psi compressive strength. Master Builders suggest the following materials for a 300 psi compressive strength:

Type I Cement	650 lbs.
Fly Ash	650 lbs.
Water	900 lbs.

Add to Rehocell 30 just prior to installing. The foam density should be about 50 lbs. per cubic foot. The compressive strength should be about 300 psi.

Grouting Methods

Grout can be injected into the annular space in between a Snap-Tite® Culvert Liner and a culvert in many different ways. Each job must be evaluated based on the existing conditions. Some of these factors are:

- Size of liner and size of culvert
- Elevation changes from upstream end to downstream
- Access to injection point or points
- Limitations on injection points
- Length of culvert
- Cost

For runs of culvert and liner less than eighty feet, grout often can be injected by pouring the grout into place. When the grade is relatively flat, this is a good approach. Pressure on the liner is usually minimal.

Information on grout mixes provided as a guide only. Consult suppliers of grout additives or grouting contractors for exact information. Master Builders is a supplier of foaming agents and other additives. Other suppliers may have equal products.

When it is possible to bore multiple openings in the culvert at regular intervals (often 20-foot spacing), grout can easily be poured in place. Since most culverts are under roadways, this will usually require stopping traffic at least in one lane. Also, the borehole must be repaired. Again the pressure on the liner is minimal, however there are other considerations.

When there is a large change in elevation from one end of the culvert to the other, the force on the liner may require that the grout be injected in lifts. Filling the entire annular space may collapse the liner.

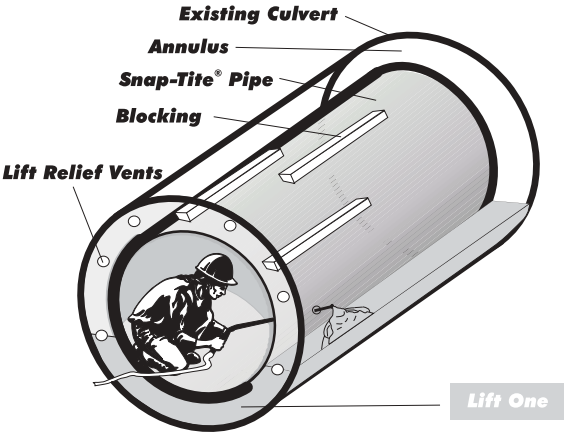
Multiple fill pipes can be used to fill the annular space. Vents are set at elevations required for each lift. Each fill pipe will be used to fill to a required elevation for that lift. Each fill pipe will usually be of a different length and elevation in the annular space.

Filling the annular space for a 400 to 600 foot culvert with liner will require multiple fill points and vents. Cellular grout will normally be used because of the difficulties of pumping or just making most grout mixes to flow that distance with less than 2 psi of pressure. Grouting in lifts is usually the best way to grout long runs.

Grout can be injected from the inside of the liner in sizes 36" in diameter and above. Holes are cut in the liner and grout is injected. When grout is observed at the next hole, the grout wand is moved to the next location. Drawing 7 shows grouting from inside the liner.

Use care when using this method as work in an enclosed space is dangerous. Follow all OSHA enclosed space requirements. When working inside of a liner, always work with a second person. Test air before entering. Provide adequate ventilation. Use a harness and rope for quick exit.

Drawing 7: Grouting from Inside the Liner

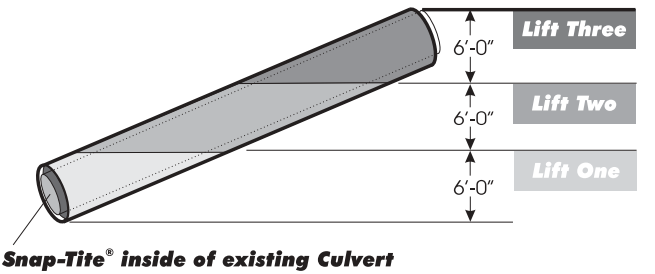


The Grouting Process

When installing grout, take your time. Watch the liner and, if you see a deflection occurring, reduce pressure and stop pumping for a short time. Many problems occur when someone gets in a hurry.

Grout is normally installed from the downstream end of the culvert. This is the rule when the culvert has a flat grade. As the elevation changes from one end of the culvert to the other, grout must be installed with fill pipes inside the annular space by filling from the upstream end, or filling from the inside. Drawing 8 shows typical large elevation changes where grouting in lifts is the best way to install grout.

Drawing 8: Grouting with Large Elevation Changes



The term "lift" indicates that only a portion of the grout is poured into the annular space at one time. By placing only a portion of the grout around the pipe at one time, the collapse force on the liner pipe is minimized.

Drawing 8 shows grouting in three lifts. Each lift is shown to have an elevation change of 5 feet. If the culvert is 100 feet in length and the ID of the culvert is 48" and the liner OD is 42", by looking in Table 4 on page 25, you can determine that it will require 1.09 cubic yards of grout per 10 feet of culvert. For a culvert 100 feet in length 10.9 cubic yards will be required to grout the annular space in total. To grout one lift will require 1/3 of the total or 3.63 cubic yards.

If cement grout with a density of 120 lbs per cubic foot is used to grout the annular space, the grout will be installed to five feet above the bottom of the liner. The collapse force will be five ft x 120 lbs/cu ft = 600 lbs per sq ft or 600/144 = 4.16 lbs per sq inch. This is above the save grouting pressure on the Snap-Tite liner. If a grout with a density of 120 per cubic foot is used with an elevation change of 15 feet of 100 feet, then six lifts of 2.5 feet are need not to exceed the grouting pressure of 2.2 psi for the Snap-Tite liner. This means that only 1.81 cubic yards of grout 120 lbs per cu ft grout should be added per lift.

If a cellular grout with a density of 42 lbs per cubic foot is used to grout the annular space to a lift height of five feet, the force on the liner will be :

5 feet x 42 lbs/cu. ft = 210 lbs/cu ft or 210/144 = 1.45 lbs per square inch. Since the collapse force on the liner is less than 2.2 psi, then it is safe to grout the annular space with cellular grout using 5 foot elevation changes. Each lift will consist of 3.63 cu yards of cellular grout.

The first lift must harden before the second lift is added. By allowing the first lift to harden before adding the second lift, collapse pressure on the liner is minimized. The second lift must harden before the third lift is added.

When grouting with multiple lifts, measure the amount of grout added per lift. Fill the annular space with the calculated amount of grout. Each lift is filled with this calculated amount of grout. If there is a void around the old culvert, then more grout will be required. If the culvert is partial collapsed, then less grout maybe required.

Fill ports are used in some situations to determine grout levels in the annular space. In the example above, when grout runs out of the fill port which is five feet in height then the correct amount of grout has been added. When the elevation change is 15 feet as in the example, fill ports are usually not practical to use. Fill ports work well when elevation change in the culvert is relatively flat. When the elevation change is flat, the fill port can be attached to the bottom end seal.

When the elevation change is great, grout moves to the bottom of the annular space and fills the fill pipe. When the grout hardens, the fill pipe can no longer be used.

Grouting starts at one end of the line and proceeds to the other end. Grout will become visible at each succeeding grout hole. Grouting will continue until each hole is filled with grout. Air must be pushed out of the annular space. If grout does not fill the annular space, there will be voids. Take your time; let air work its way out. Voids reduce the strength of the system. Air entrapped in the annular space can cause flotation. Deflection and buckling are more likely in unreinforced liner areas. When void areas are detected, a hole can be drilled and grout injected with a wand.

Long runs should be grouted with a high flow grout (like cellular grout) or from multiple fill pipes or from multiple holes in the liner (see Drawing 7). Keeping pressure low is the key to preventing liner collapse. When grouting from holes cut inside the liner as shown in Drawing 7, make holes larger than the grout wand. As the annular space fills, grout will flow from the space around the nozzle and the next hole indicating the annular space has filled.

Table 5: Determining Grout Requirements

Grout Requirements			
Culvert Size	Liner Size OD	Cu Ft/Ft	Cu Yd/10 Ft
12" ID	10.75"	0.25	0.10
15" ID	12.75"	0.34	0.13
18" ID	16"	0.7	0.26
18" ID	16"	0.37	0.14
21" ID	16"	1.01	0.37
21" ID	18"	0.63	0.24
24" ID	20"	0.96	0.36
24" ID	22"	0.5	0.19
27" ID	22"	1.34	0.49
27" ID	24"	0.83	0.31
30" ID	24"	1.77	0.65
30" ID	28"	0.63	0.23
36" ID	28"	2.79	1.03
36" ID	30"	2.16	0.80
36" ID	32"	1.48	0.55
42" ID	34"	3.31	1.23
42" ID	36"	2.55	0.95
48" ID	39.37"	4.11	1.52
48" ID	42"	2.94	1.09
54" ID	42"	6.28	2.33
54" ID	48"	3.73	1.38
60" ID	48"	7.46	2.76
60" ID	54"	3.73	1.38

Definitions

Ad mix – Additives for changing the characteristics of a concrete mix. Additives can reduce the amount of water needed, entrain air around particles or many other changes.

Annular space – When one pipe is inside of another, the area between the outside diameter (OD) of the smaller pipe and the inside diameter (ID) of the larger pipe.

Annulus – When one pipe is inside of another, the area between the OD of the smaller pipe and the ID of the larger pipe.

Barrel diameter – The size of the pipe.

Blocking – The use of blocks of wood or other materials on the top or side of a liner pipe to reduce or prevent flotation.

Definitions

Blocks – Pieces of wood or other materials used to reduce or prevent flotation when attached to the top or side of a liner pipe.

Cellular grout – Cement based grout made with a multitude of macroscopic, non-interconnected air cells, which are distributed throughout the mass.

Collapse strength – The amount of force, usually expressed in feet of head, required to cause a pipe or structure to deform or flatten.

Come-along – Lever chain puller.

Displacement – The weight or the volume of fluid displaced by floating or submerged body.

Flotation – The act of being on top of a liquid. The force applied when a liquid is displaced.

Flowable fill – A cement, sand, and water plus additive mix used in place of granular materials for construction. Typically flowable fill is used in place of granular (sand or crushed stone) fill to support pipe in a trench. Snap-Tite® Culvert Liners are often grouted into a rehabilitated culvert with flowable fill.

Fly ash – The powdery residue of matter that remains after burning coal in a power plant. It is a fine residue that, when dry, literally flies in air.

Gasket – A rubber packing used to make a watertight connection.

Grout – A thin, coarse mortar used for filling a void area.

Grout pump – A machine for moving a thin, coarse mortar.

ID – Inside diameter is the measure of the actual opening of a pipe, liner, or tank.

Internal support – Usually wooden boards used inside of a pipe, liner, or tank to prevent deformation when load is applied from the outside.

Ladder bracing – Wooden planks assembled between two long boards to support a pipe, liner, or tank. The assembled support looks like a ladder.

Lands and Grooves – Land is a term used to describe a flat, machined surface on a circular part. A groove is a long, narrow cut into a surface. The Snap-Tite® connection is made by machining the OD (male end) on one end of a liner pipe forming lands and grooves; the ID (female end) of the other pipe to be joined with surfaces that will fit and make a strong connection.

Definitions

Lift – The act of raising the level. This term is used to describe the process of partial filling of a pipe or trench with material. When the annular space between a Snap-Tite® Culvert Liner and culvert is partially filled, a lift has been poured or pumped in place.

Lift relief pipes – A relief pipe allows air and water to be removed from the annular space. A lift relief pipe allows filling of the annular space to the level of the relief pipe. When grout flows from the lift relief pipe, the level for that lift has been reached.

Lubricant – A substance used for reducing friction. Soap, vegetable oil, or other non-petroleum-based substance can be used to reduce the force required to make a Snap-Tite® connection. Place the lubricant on the male end of the Snap-Tite® Culvert Liner to reduce the chance that the gasket will be moved out of the groove during installation.

Mastic – A resin used to make an adhesive cement. Sometimes used in addition to the Snap-Tite® gasket to insure a watertight connection.

Nose cone – A tapered shaped cut into the liner pipe to make it slide into place as the liner is pulled into place.

OD – Stands for outside diameter of the liner.

Retarder – Additives used to delay the time before the curing or setting up of the cement mix.

Ring compression strength – The force applied to a pipe, tank, or circular object when equal loads are applied around the circumference. Water applies this loading to a submerged pipe. Vacuum on the inside of a pipe applies this loading.

Screen – A plate with openings of set sizes to allow only particles of that size or smaller to pass. A 16-mesh screen means that there are 16 holes per square inch. Each hole would be less than .25 inches in diameter.

Service life – The expected use time in hours, months, or years for a pipe or liner when exposed to a given load at a given temperature.

Skids – Wooden, plastic, or metal blocks mounted on the bottom of pipe, liner or other device for support from the bottom.

Sliplining – The process of pulling or pushing a smaller pipe or liner inside of an existing pipe or culvert.

Definitions

Skids – Wooden, plastic, or metal blocks mounted on the bottom of pipe, liner or other device for support from the bottom.

Sliplining – The process of pulling or pushing a smaller pipe or liner inside of an existing pipe or culvert.

Vents – Openings formed to allow the escape or entry of gas or liquid into or out of an enclosed area.

Voids – An empty space within a solid section. When air is trapped in the annular space between the liner and the culvert, grout cannot fill this space. A "void" is formed in the grout. There is a loss of strength in the grout because of the void.

Weight of cement mix – Cement mixes typically weigh from 100 to 140 lbs. per cubic foot. The aggregate used in the cement mix increases or decreases the weight of the mix.

Weight of grout – Cement grout is usually made using fine sand aggregate. Typical weights are from 75 to 100 lbs. per cubic foot.

Weight of water – Water weighs 62.4 lbs.. per cubic foot.

List of Illustrations

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