ALTERNATIVE
LINING TECHNOLOGIES

CIPM™ Lining Systems

As with most sewer rehab products the AltLiner's™ two primary objectives are to prevent corrosion and stop I/I. This document will explain what the AltLiner™ is, how it accomplishes these objectives, and why it is superior to other linings and coatings.

Alternative Lining Technologies, LLC

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616-583-7100

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www.AltLiner.com

Concept

First, we will briefly cover the basic concept of the AltLiner™. The first aspect is to create a structure within a structure which is deteriorated and/or leaking. Secondly, this new structure should have an impregnable corrosion resistant protective layer. Other products work very well at one or the other of these, but fail to accomplish both in a single system. The AltLiner™ eliminates the need to combine two systems to accomplish this twofold concept. To that end we have designed the AltLiner™ utilizing 4 components.

Components

The protective layer is 25 mils of PVC, a product long used in sewers because, among other reasons, it is extremely corrosion resistant. Additionally, PVC was chosen because of its fusibility, which is how an impermeable monolithic structure is achieved. The PVC is molten embedded onto polyester fleece. The fleece serves to absorb the resin and marry the PVC to the rest of the composite.

For reinforcement, E-CR fiberglass is incorporated. Though the layers and weights vary depending on the model, we typically use two or four layers of 24 ounces per square yard woven roving. This E-CR glass is used because it is specifically designed for structural reinforcement in corrosive environments.

The final component is the backbone of the composite, a 100% solids epoxy. In addition to its impressive physical properties, it, like every other layer, is also corrosion resistant. Persons interested in receiving more information about this resin system should email info@altliner.com or call 616-583-7100 to speak with our technical team.

Liner

No two underground structures are the same. For that reason, every liner is custom designed and fabricated for the host structure to be lined. This is part of what makes the system flexible. Regardless of whether the invert is to be lined, typical liner design and fabrication results in a monolithic structure. This simply means that the liner is one continuous structure with the only opening being at the top for the installation canister. This is part of what makes the patented AltLiner™ superior to other cured-in-place manhole liners.

Chemical Resistance

The epoxy and fiberglass used in the AltLiner™ are each chemical resistant, but the exposed PVC protective layer is the first line of defense in protecting the composite and the host structure. That makes it the most important component, in regards to chemical resistance. While PVC has a proven life expectancy in sewer environments of over 50 years, it's important to note that the application of any material affects performance. The Los Angeles County Sanitation District's "Redner tests" for the Evaluations of Protective Coatings for Concrete tests sewer rehab products as a finished product to compare chemical resistance performance. The difference between the AltLiner™ and other cured-in-place liners is unmistakable. The Redner Test (2004 Update) results clearly show that the AltLiner™ (C-91) preserves the epoxy, felt, and fiberglass materials behind the PVC. This means there was no material loss under chemical attack, preserving the structural integrity of the composite.

Composite Strength

While there is no ASTM standard for cured-in-place manhole lining or testing of the composite materials there are other ASTM testing methods that are applicable. The ultimate strength of any composite is relative to conditions of the application. For instance, bond and shape are significant factors in ultimate strength. Design and application variables will be discussed in the following sections.

Model: CIPM 58

ASTM D 638	***Tensile Strength / Modulus***
Tensile Strength	17992 psi
Tensile Modulus	1.277 Mpsi
Load per Inch Width	3373 lb/in

ASTM D 695	***Compressive Strength / Modulus***
Compressive Strength	21088 psi
Compressive Modulus	1.476 Mpsi
Load per Inch Width	4028lb/in

ASTM D 790	***Flexural Strength / Modulus - 3 Point***
Flexural Strength	20134 psi
Flexural Modulus	0.4786 Mpsi
Load per Inch Width	180 lb/in

Model: CIPM 106

ASTM D 638	***Tensile Strength / Modulus***
Tensile Strength	17779 psi
Tensile Modulus	1.453Mpsi
Load per Inch Width	6237 lb/in

ASTM D 695	***Compressive Strength / Modulus***
Compressive Strength	24034 psi
Compressive Modulus	1.534 Mpsi
Load per Inch Width	7591 lb/in

ASTM D 790	***Flexural Strength / Modulus - 3 Point***
Flexural Strength	24314 psi
Flexural Modulus	0.5701 Mpsi
Load per Inch Width	307 lb/in

Results as of April 2016.

Design

Because every underground structure is unique in size, shape, and configuration, the liner must be designed to fit and perform based on that structure's environment and characteristics. The challenge is to create a structural calculation that incorporates every aspect of the host structure, environment, and composite. The dimensions of the structure are easily identified, as well as the composite strength. However, bond strength is difficult to calculate because substrate characteristics, gaps, and other factors cause inconsistencies in bond. Therefore, the AltLiner™ design calculation assumes no bond. In reality, the liner does bond to the structure, which greatly enhances the liner's ultimate strength. Similarly, ground water pressure is difficult to accurately calculate. It is known that groundwater weighs 62.4 pounds per cubic foot, but identifying the water table for each structure is impractical. For this reason, one hundred percent hydrostatic head is assumed. Now, using the known and assumed values and incorporating the same safety factor of concrete structures, a required thickness can be calculated.

Design Calculation AltLiner™ Model: CIPM™ 58

Concept: In a virtual round structure such as a typical manhole or pump station the following formula is developed to estimate the required liner thickness to resist the design hydrostatic pressure for a given structure radius. The installation technique permits the assumption that the free body diagram of the liner retains its shape under load. In determining the thickness of the liner, we ignore the adhesion of the liner to the substrate. In reality adhesion occurs and is responsible for the watertight seal between the liner and the structure[1].

$\overline{F'}_{PU}$ = ULTIMATE COMPRESSIVE STRENGTH OF COMPOSITE=21,088 PSI[2].

E_P = ELASTICITY MODULUS OF COMPOSITE = 1,277,000 PSI.

$F'_C = 0.4 \times f'_C$ = 1,200 PSI. (Match safety factor of concrete)

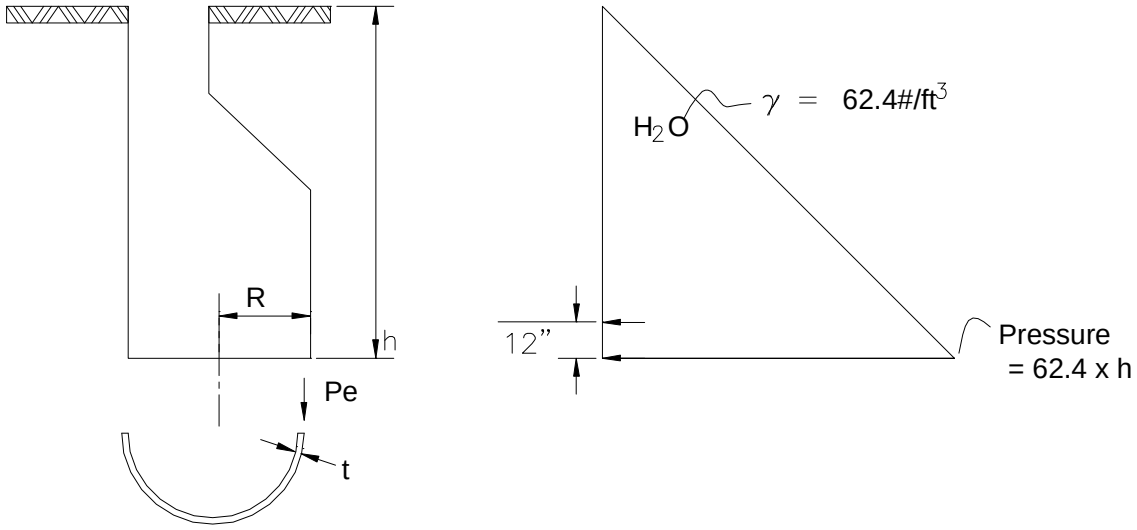
$E'_C = 57{,}000\sqrt{f'_C}$ = 3,122,019 PSI.

t = LINER THICKNESS IN MILS.

h = HYDROSTATIC HEAD IN FEET.

R = RADIUS OF THE STRUCTURE IN FEET.

γ = WATER DENSITY = 62.4 # / CUBICFOOT.



Allowable stress in the composite is:

$$F'_{pu} \therefore \frac{0.4 \times F'_{pu} \times E_p}{E'_C} = \frac{R \times \gamma \times h \times 1{,}000}{t \times 12} \quad \text{this means:} \quad t = \frac{15{,}600 \times E'_C \times R \times h}{F'_{pu} \times E_p}$$

For above material value the thickness of the liner in mils is: **t = 1.81 x R x h**

[1] Comments from Hans de Bruijn, Sales Engineer.
[2] ASTM D-695

Design Calculation AltLiner™ Model: CIPM™ 106

Concept: In a virtual round structure such as a typical manhole or pump station the following formula is developed to estimate the required liner thickness to resist the design hydrostatic pressure for a given structure radius. The installation technique permits the assumption that the free body diagram of the liner retains its shape under load. In determining the thickness of the liner, we ignore the adhesion of the liner to the substrate. In reality adhesion occurs and is responsible for the watertight seal between the liner and the structure[1].

$\overline{F'}_{PU}$ = ULTIMATE COMPRESSIVE STRENGTH OF COMPOSITE=24,034 PSI[2].

E_P = ELASTICITY MODULUS OF COMPOSITE = 1,453,000 PSI.

$F'_C = 0.4 \times f'_C$ = 1,200 PSI. (Match safety factor of concrete)

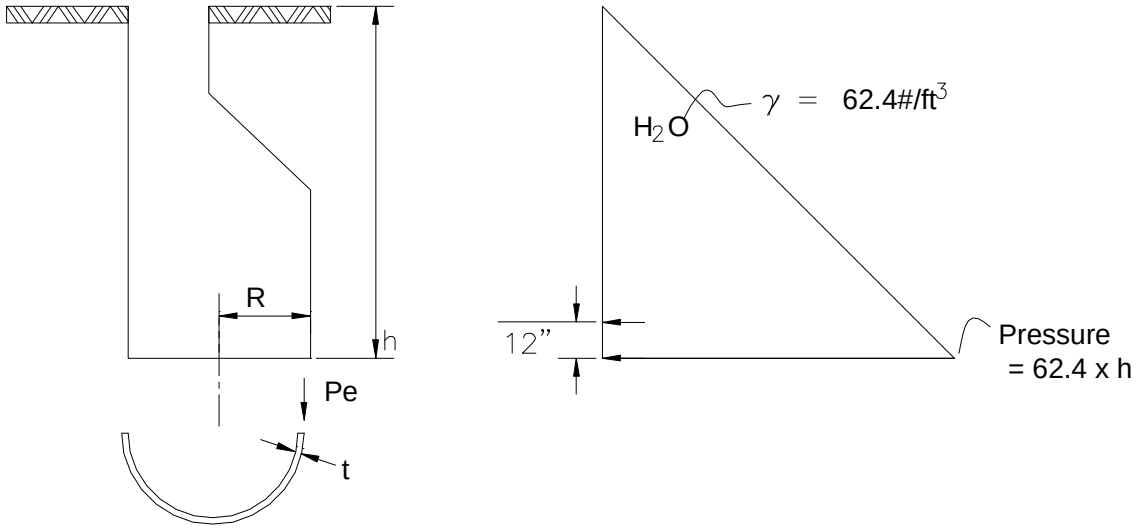
$E'_C = 57{,}000\sqrt{f'_C}$ = 3,122,019 PSI.

t = LINER THICKNESS IN MILS.

h = HYDROSTATIC HEAD IN FEET.

R = RADIUS OF THE STRUCTURE IN FEET.

γ = WATER DENSITY = 62.4 # / CUBICFOOT.



Allowable stress in the composite is:

$$F'_{pu} \therefore \frac{0.4 \times F'_{pu} \times E_p}{E'_C} = \frac{R \times \gamma \times h \times 1{,}000}{t \times 12} \quad \text{this means:} \quad t = \frac{15{,}600 \times E'_C \times R \times h}{F'_{pu} \times E_p}$$

For above material value the thickness of the liner in mils is: **t = 1.39 x R x h**

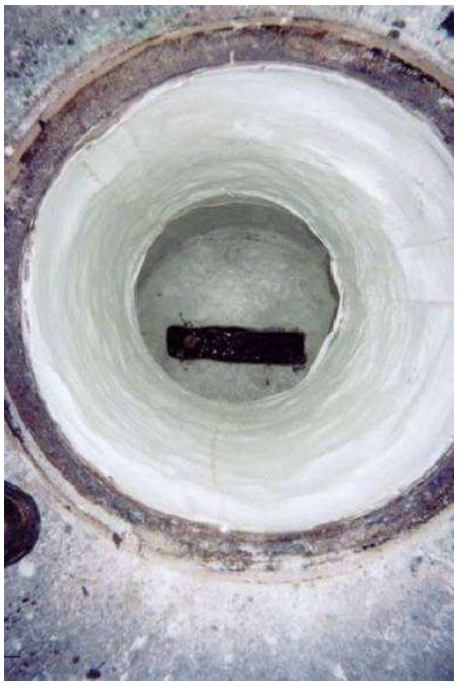
[1] Comments from Hans de Bruijn, Sales Engineer.
[2] ASTM D-695

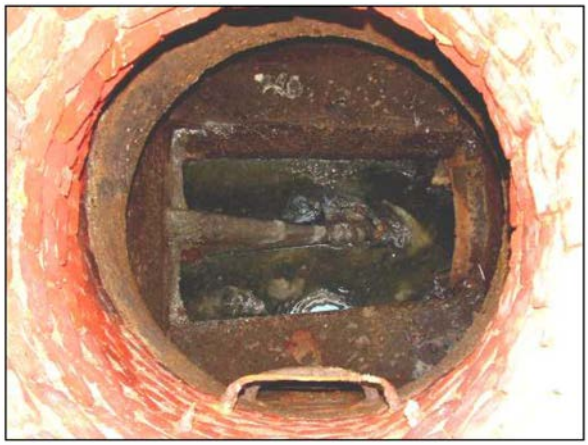
Installation

This section will explain the steps in a typical installation. For the manufacturer's complete installation instructions please see Appendix A. Like with any coating or lining, preparation of the structure is critical to the success of the AltLiner™. Creating a uniform surface for the liner to conform is a defining concept during preparation. For instance, the steps installed in most manhole need to be removed using a cutoff wheel. Next, the structure is pressure washed to remove the corroded substrate and surface contaminants. After the surface has been cleaned, any active leaks need to be stopped using hydraulic cement or chemical grout. Now the remaining protrusions, i.e. drops, inverts, etc., can be trimmed and/or profiled using cement. The bottom inverts and bench often require profiling or rebuilding. At this point the structure is left to dry while the liner and work area are prepped.

The liner is laid on plastic to protect it from dirt and the road surface from resin. The fiberglass skirt is pulled back to expose the felt, where the resin is applied. Fiberglass panels are made to fit the specific configuration of benches and flow channel. These are wet out and hand applied. The rest of the installation is completed at street level. Once the felt is saturated with resin the installation canister is attached using heavy duty ratchet straps. This area of the liner, known as the "cap", is reinforced to handle the stress. The canister is then attached to the crane and lifted above the hole. During fabrication, black straps are place at the midpoint of the corbel. This helps the installer align the bag when setting it in the structure. Once the liner is in set, a bladder is placed inside and fixed to the installation canister. Steam and air pressure are then applied to accelerate the curing process. After the liner is cooked, the cap is cut off and the laterals are reinstated. The structure is now able to be returned to service and the installation is complete.

Real-World CIPM™ Liners in Severe Conditions





AltLiner™ Limited Warranty [1]

To Whom It Concerns:

Alternative Lining Technologies, LLC provides a twenty-year performance Limited Warranty [2] that the AltLiner™ CIPM™ liner:

a. Will stop deterioration of the lined surfaces [3] by sewer gas induced corrosion;

b. Will prevent infiltration [4] of ground water into the collection system through the lined surfaces;

This Limited Warranty will commence upon completion of the installation of the AltLiner™.

Respectfully submitted,
Alternative Lining Technologies, LLC.

[1] THIS WARRANTY IS LIMITED BY AND UNDER SUBJECT TO THE TERMS AND CONDITIONS ON THE REVERSE HEREOF, WHICH ARE INCORPORATED HEREIN BY REFERENCE.

[2] The licensed installer shall separately provide a general “One Year” warranty and shall pass through any extended warranty provided by the manufacturer. Alternative Lining Technologies provides
this limited manufacturer’s warranty in conjunction with the Licensed installer. This Limited Warranty is not available as a bonded warranty underwritten by a surety company.

[3] The definition of the “lined surfaces” is the area within the boundaries of the liner edges. All cut edges will be coated with mastic. We exclude secondary intentions such as satisfactory appearance, voids behind the liner, folds and other claims that do not directly affect the twenty-year performance warranty.

[4] Neither Alternative Lining Technologies nor its installer certify the structural integrity of the host structure or claim that the lining system enhances the structural integrity of the host structure sufficiently to comply with ASTM C478 design and other applicable specifications.

Additionally any breach arising out of movement of the host structure is expressly excluded.

A. THIS LIMITED WARRANTY IS EXCLUSIVE AND IS GIVEN IN LIEU OF ANY AND ALL OTHER WARRANTIES, WHETHER THEY ARE WRITTEN, ORAL, EXPRESS OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE, AND WHETHER CREATED STATUTORILY, OR OTHERWISE. THERE ARE NO OTHER WARRANTIES, LIMITED, EXPRESS, OR IMPLIED, WHICH EXTEND BEYOND THOSE CONTAINED HEREIN.

B. This warranty is valid under normal use of the manhole. Material changes, such as holes or cuts, void the warranty unless authorized in writing by the Manufacturer.

C. When the liner is required to retain ground water pressure, consult with Manufacturer to assume proper liner thickness.

D. This Limited Warranty does not cover damage to the liner resulting from: misuse or abuse of the liner or reckless negligent acts of any person; acts of God (including, but not limited to, earthquake and flood); damage caused by the host structure or other materials or components installed in the host structure.

E. 1. All claims for breach if this Limited Warranty contained herein shall be made in writing to the Manufacturer within ten (10) days of the time the breach is discovered. Manhole and liners must be inspected periodically, at reasonable intervals, within the warranty period.

2. THE MANUFACTURER WILL NOT HONOR ANY WARRANTY CLAIM MADE PRIOR TO PAYMENT IN FULL BY THE PURCHASER OR GENERAL CONTRACTOR FOR THE WARRANTED PRODUCT.

3. Warranty service must be performed by the Manufacturer or the Manufacturer's authorized agent. Upon validation by the Manufacturer of any claim for breach of the Limited Warranty contained herein, the Manufacturer will, as its sole and exclusive option perform one of the following:

a. repair the failed or defective liner;
b. deliver a replacement liner to the point of original delivery by the Manufacturer; or
c. refund the original purchase price of the liner as was collected by the Manufacturer.

4. The provisions contained in the previous section constitute purchaser's sole and exclusive remedy under any claim or theory of liability, including any claim based upon failure of, or defect in, the liner, whether such claim, however instituted, is based upon contract, indemnity, warranty, tort (including negligence), strict liability or otherwise.

a. The Manufacturer shall not be liable for direct, indirect, consequential or incidental claims, damages or costs of any nature including, without limitation, labor costs of any kind relating to the removal of a failed or defective liner and/or installation of replacement liner or damages, claims or costs otherwise arising from, or in connection with, breach of this Limited Warranty.

b. The manufacturer shall not be liable for any pollution or other adverse environmental claims arising out of the failure of the liner or from consequential damages related thereto.

F. 1. This Limited Warranty is extended to the original purchaser of the liner from the Manufacturer only and may not be assigned by such purchaser to a third party without prior, written authorization of the Manufacturer. Assignment of this Limited Warranty without prior, written authorization of the Manufacturer will void the Limited Warranty.

2. In order for the Manufacturer to perform warranty service or repairs, the host structure must be reasonably accessible. The manufacturer will not be responsible for costs or damages to the liner or to purchaser's property as a result of liner inaccessibility for warranty repair or service.

G 1. The adjudication of any dispute arising under this Limited Warranty must be commenced no later than one (1) year from the date the breach is discovered or should have been discovered. Any adjudication shall be governed by the law of the Commonwealth of Pennsylvania and venue shall be exclusively in the Court of Common Pleas, Lancaster County, Pennsylvania or the US District Court, Eastern District of Pennsylvania.

H. This Limited Warranty contains the complete understanding of the Manufacturer and purchaser and may be modified only in writing signed by the President of Alternative Lining Technologies.

AltLiner™ Technical Specification

Alternative Lining Technologies, LLC
PO Box 123
Byron Center, MI 49315
E-Mail: info@altliner.com
Web: www.altliner.com
Phone: 616-583-7100
This specification is available on disk.

PART I- GENERAL

1.1 DESCRIPTION OF WORK

A. This work shall include the furnishing of all labor, materials, and equipment for the rehabilitation of an existing manhole with a cured-in-place PVC composite liner.

B. The manhole liner shall be manufactured to the shape of the manhole. The fibrous portion of the liner shall be saturated with a modified epoxy resin, then pressurized and cured in-place.

C. Fused seams will allow the liner to be inflated and pressurized between ½ - 8 pounds per square inch, with or without an inflation bladder.

D. The seams of the liner shall be sealed with fusion welding equipment. The design shall be as described in US Patent 6,540,438 B2.

E. The exposed surface of the liner shall be **white PVC**.

1.2 LINER PERFORMANCE REQUIREMENTS

A. Liner shall be of the type that allows rehabilitation of a concentric, eccentric or flat top manhole without removing the manhole ring and top section or corbel.

B. The liner shall be installed and cured in place via controlled curing by heat and pressurization in the manhole to complete the curing process.

C. The lining of the manhole shall result in a structure to the shape and contour of the existing manhole. The liner shall be installed and substantially bond to the interior manhole substrate and be watertight, free of any joints or openings other than pipe inlets, outlets and the cover frame opening.

D. Where indicated on the manhole schedule the lining shall be designed with independent structural hoop strength for full height hydrostatic pressure as if the liner were a secondary vessel inside the existing manhole. The manufacturer shall design adequate liner thickness into the system with or without additional fiberglass layers.

E. Where indicated on the manhole schedule the inverts shall be lined.

1.3 QUALITY ASSURANCE

A. Reference Standards: Comply with applicable provisions and recommendations of the following:

1. ASTM D 695-10 Standard Test Method for Compressive Properties of Rigid Plastics.

1.4 SUBMITTALS

A. Copies of the manhole dimensions, installation instructions, and manufacturer's product data sheet to be submitted for the Engineer's review.

B. If required, calculations for the round manhole lining that demonstrate hoop strength under maximum hydrostatic conditions. The calculation shall assume zero liner adhesion to the existing structure, but assume lateral support from the existing wall. The calculated hoop stress shall be less than 11% of the compressive strength as determined by appropriate ASTM test method.

PART 2-PRODUCTS

2.1 MATERIALS

A. Manhole interior walls and benches shall be patched with cementitious patching/plugging compounds as manufactured by Pre-Blend Products, Inc., or approved equal.

B. Channel reconstruction cement shall be Speed Plug as manufactured by Euclid Chemical, formed cement concrete of 4,000-psi compression strength, or approved equal.

C. As a minimum the manhole liner systems shall be composed of a multiple layered composite. The primary layer shall be manufactured from 25 mils PVC with 10 ounce per square yard polyester fleece. The surface hairs of the fleece must be embedded in the molten PVC during the manufacturing

process of the material. Glued laminates are not allowed. Multiple Layers of fiberglass are added to increase thickness and strength.

D. The fibrous body will be impregnated with a modified epoxy resin. Add fiberglass and resin, for additional liner thickness.

AltLiner™ models:

CIPM™ 46	100 mills installed
CIPM™ 58	150 mills installed
CIPM™ 106	200 mills installed
CIPM™ X	Custom design

E. Liner Thickness: The anticipated hydrostatic head "h" in feet above the bottom of the invert and the Radius "R" in feet of the structure shall determine the necessary liner thickness "t" in mils.

2.2 APPLICABLE MANUFACTURERS

A. Products specified by named manufacturers are specified as a standard of quality.

1. AltLiner™.
2. Approved equal.

2.3 ACCEPTABLE LINER INSTALLERS.

A. Certified installers of Alternative Lining Technologies, LLC. (the manufacturer of the AltLiner™. U.S. Patent number 5,106,440, 6,540,438 B2 and 6,540,439 B2. Phone: 800-747-4282.

B. Approved equal.

PART 3-EXECUTION

3.1 MAINTAINING WASTEWATER FLOWS

A. The OWNER shall be fully responsible for restricting the normal sewage flow through the manhole where the specified rehabilitation work demands such flow restriction. The CONTRACTOR will plan his work in order to maintain flows and not interrupt sewer service. This may include night work. The cost of any night work required will be included in the contract price of

the applicable item. The CONTRACTOR shall not perform work to manholes until plans for bypass pumping or flow restriction have been submitted by the OWNER and accepted by the CONTRACTOR. Additionally, no plugging of existing Utility System Gravity Mains will be made without the approval of the Utilities Department.

B. Unlined flow channel. Install a bridge or flow through tube and cut the liner bottom near the flow line in the channel to expose the flow channel and give access to the pipes. Plug the pipes entering the manhole through the wall and trim the pipe opening to restore flow.

C. Lined flow channel. Plug the pipes entering the manhole and line the flow channel to the edge of the pipe. Trim all pipe openings and restore the flow.

3.2 PRE-INSPECTION

A. In general, the OWNER assumes responsibility for the structural integrity of existing structure. Prior to beginning work, the manhole shall be visually inspected and any areas of apparent structural damage shall be reported to the OWNER for restoration.

3.3 CLEANING

A. All surfaces of the manhole shall be cleaned with a high-pressure water-jet sprayer with an operating pressure of at least 5,000 psi. Pressure wash the manhole to remove all dirt, grease, sand, and surface contaminants on the wall and floor leaving a clean damp surface.

B. Badly deteriorated and pitted pre-cast manholes and brick manholes, with missing bricks and grout, shall be mudded back to form a smooth compatible surface for the liner.

3.4 PLUGGING RECONSTRUCTION

A. The stopping of active hydrostatic infiltration shall be accomplished by using Speed plug as manufactured by Euclid Chemical or approved equal.

B. Water infiltration can also be stopped using expansion type grouts such as Avanti or Seal Guard II.

3.5 CHANNEL RECONSTRUCTION

A. Remove all loose grout and rubble of existing channel. Rebuild channel if required by shaping and repairing slope of shelves or benches. Work shall

include alignment of inflow and out flow ports in such manner to prevent the deposition of solids at the transition point. All inverts shall follow the grades of the pipe entering the manhole. Changes in direction of the sewer and entering branch or branches shall have a true curve of as large a radius as the size of the manhole will permit. Channels shall be shaped to allow entrance of maintenance equipment into pipes including buckets, TV camera, etc.

B. Inverts shall only be lined where indicated on the plans “lined inverts”.

3.6 LINER INSTALLATION

A. Installation shall be by an installer that is qualified by the liner manufacturer. The CONTRACTOR shall include the furnishing of all materials, equipment, tools, and labor as required for the rehabilitation of the manholes selected, including the installation of the interior liner.

B. The installation of the approved liner system shall be in strict accordance with the manufacturer’s instructions. This shall include the preparation, installation, inflation, curing, and finishing operations, required for the completion of the manhole rehabilitation process.

C. All safety rules and regulations, applicable laws and insurance requirements shall be observed in storing, handling, use and application of the liner materials, resins and any solvents.

D. Ventilation shall be provided to the workers at all times.

PART 4-WARRANTY, MEASUREMENT AND PAYMENT

A. The MANUFACTURER shall warrant to the OWNER in writing the performance of the liner for a period of twenty years.

B. Payment for the rehabilitation of the structure shall be made at the contract vertical foot price and shall include all necessary labor, material and equipment to clean, seal off any water infiltration, prepare the walls, provide and install the liner completely. The vertical foot measurement is defined as the distance between bottom of invert and top of cover. Payment value is the product of vertical foot price and vertical foot measurement.

END OF SECTION

Manufacturer's Installation Instructions

for the installation of the AltLiner™ CIPM™ Lining System

A. ***"Lining preparations"***; US Patents 6,540,438, and 6,540,439 make the process we use possible. The preparations are as following:

The resins and prefabricated liner are shipped to the job site. All manhole liners are factory marked at the cap-strip with MH ID's. Also attached to the cap-strip is a copy of the original field measuring sheet with any notes of significance.

Only an Alternative Lining Technologies' certified installer is approved to use the AltLiner™ CIPM™ lining system.

An installation truck is self-contained. All necessary tools, such as hand tools, crane, electric generator, high and low pressure pneumatics, hot water generator, power wash equipment, water tank, and the transfer canister are on the truck. A second pickup truck typically carries miscellaneous materials.

Alternately, especially useful in off-road applications is a modified trailer equipped with water tank, generator, pressure washer, portable blower and miscellaneous power and hand-tools as necessary to successfully complete installation of the AltLiner™.

B. Peripheral Considerations:
   1. Traffic: All local, state, and federal traffic regulations and permitting are to be known and abided by.
   2. By-pass: In some cases, by-pass pumping of wastewater will be necessary. The proper use standards of pumps, hoses and related equipment must be understood and followed by the personnel performing such operations.

C. Safety:
   1. It is expected that all field personnel follow standard OSHA procedures for working in a confined space environment. This includes, but is not limited to, the use of a 4-gas detector[1], fall-safe equipment (harness, tripod, cable, etc.), attendant, fresh air ventilation, etc.
   2. Confined space logs must be kept for every manhole lined and be readily available.

D. Manhole Preparation:
   1. Once the site safety concerns are dealt with, the cover of the manhole is removed, the manhole is re-examined[2], and a plan of action is confirmed for the lining of the manhole.
   2. Manufacturer supplied cure logs are started and must be maintained in real time throughout the lining. Copies of these logs are to be sent to the manufacturer ASAP for every liner installed. The manufacturer's material warranty will not be applied to any liner without a complete and accurate log.

   3. If the manhole is not too dirty, the installer might start preparation immediately by cutting

steps and other protrusions.

4. Steps shall be cut back as close to the substrate as possible and not be left protruding more than 1". Any protruding steps must be flattened or rounded-over so that no sharp edges remain. Non-shrink grout must then be applied in about 4" diameter and profiled to ensure a good mechanical bond with the CIPM™ liner.
5. If the manhole is fairly dirty, or once initial cut-out is performed, the installation will start with the power-washing of the interior of the manhole at a minimum of 5000 PSI.
6. Steps and other protrusions are removed (if not already done).
7. Pipes and protrusions are filleted to assure a good liner fit and to limit void spaces. All incoming laterals and sewer main line openings shall be properly trimmed and grouted with hydraulic or other acceptable non-shrink grout forming a radius fillet (not less than a 6 inch radius) between the structure wall and each pipe. Such application of grout shall extend at least four inches from the outlet onto the wall area making a smooth transition for the liner connection to the pipe openings, and shall be brushed to achieve a profile to ensure a mechanical bond to the liner.
8. Leaks are stopped and other cracks are patched.
9. Prior to patching severe defects in the manhole, all loose and deteriorated material shall be removed and disposed of by the Installer.
10. Any other filling or shaping of structure to assure best lining is done at discretion of installer.
11. Benches and flow channels may be rebuilt.
12. If the channel & invert are to be lined, the channel should be patched and reshaped as needed to ensure good flow characteristics and pipe accessibility[3].

E. Liner Wet-Out

1. Surfaces around the structures are protected as needed and a temporary lay-down area is created (typically with plywood and plastic).
2. Liner resin A and B are mixed at a 4:1 volume ratio. Electric drill mixers are used until a homogenous, non-streaked blend is apparent. A 2-minute *minimum* mix time is required for a 4-gallon mix.
3. The installer will have a listing of manufacturer's resin quantity estimates for each liner.
4. It is the installer's responsibility to ensure all resin-carrying fibers of the lining system are completely saturated. Though manufacturer estimates are given based on surface area of general shape, it is known that specific structure geometry and ambient site conditions will affect resin usage.
5. The liner is readied by pulling all outer layers up and away from the fleece of the innermost main liner layer. This process is called "unsocking".
6. The mix is applied to the exposed fleece of the CIPM™ liner and spread by hand until it has a semi-gloss and textured appearance. The art is to reach saturation, avoid loss of excess resin, and to avoid meager application areas.
7. The outer layers are socked back one at a time and wet-out as needed. No layer shall consist of more than 2-ply of any material (fiberglass and/or felt).
8. All areas intended to bond to the structure must receive resin.
9. When properly wet-out, the excess resin in the fleece saturates the fiberglass when the liner is pressurized during the steam cure process.
10. Liners with greater than two-ply fiberglass will require additional wet-out steps.

F. Liner Attachment to Installation Canister and Setting of Liner

1. The liner's cap-strip will be strapped to the installation canister using truck straps placed and tightened in such a manner as to assure a tight seal and one which will not allow the liner to blow-off the canister during the cure cycle. Special indicators help the installer

preserve angular alignment.

2. Liner shall then be lowered into manhole at installer's discretion to ensure the liner's best fit.
3. Adjustable legs shall be clamped to the canister to maintain the level.
4. The canister lid will then be set.
5. Connect the blower hose for initial inflation.
6. All valves on the installation manifold must be open to ensure a slow and consistent inflation of the liner.
7. *It is critical to allow the air between the substrate and the liner to escape up the walls as the liner inflates from the bottom, up. Too quick an inflation will trap air and cause poor bonding.*
8. The installer will manipulate the air and liner itself to achieve initial setting of the liner.
9. It may be necessary at times for the installer to enter the liner itself, through the installation canister, to adjust the liner for fit.
10. Once satisfied with the initial set, the inflation bladder will be introduced through the canister lid *and inflated slowly so as to minimize air entrapment between it and the liner.*
11. In some cases, the inflation bladder may be factory-inserted into the liner.
12. Pressure will be increased gradually until the friction of the liner with the surface is greater than the upward pull force from the canister. A slight lift at the support legs is acceptable. These legs should be readjusted as needed so that they sit on the ground. This is critical when the cure cycle is complete and pressure is relieved. Otherwise, the weight of the canister will come down upon the newly cured liner.

G. Liner Cure Cycle

1. The boiler will be started to prepare for the introduction of hot water into the bladder cavity. The inspection port in the canister lid is clear until hot water is allowed to enter the bladder. This enables the installer to inspect and if necessary to enter the cavity to manually correct misalignments.
2. The foreman decides when to introduce the hot water spray. The pressure may increase to a maximum of 5 PSI – 1-2 PSI is more typical.
3. The cure time "Start" is recorded as the time the temperature at the canister reaches 150 degrees Fahrenheit.
4. The cure temperature must reach a minimum of 180 degrees Fahrenheit at the canister gauge. Occasionally the air valve is closed to make up a pressure loss.
5. Typical cure heat is 200 F.
6. Adjust the support legs down to make up the lift of the canister.
7. The curing time depends on the size of the structure, ambient temperature and purpose of lining. The minimum cure time in all cases unless described in writing by the manufacturer is 1 hour[4].
8. When the foreman is satisfied with the resin condition just below the cap strip, he will lower the heat at the boiler to start the COOL DOWN cycle.
9. When the temperature reaches 170 F to 180 F, the boiler is turned off and the canister valves are opened[5].
10. Next, the blower is stopped.
11. When the pressure has dropped to zero, the lid of the canister can be removed.
12. The legs will support the canister when the pressure is off.
13. Some initial cooling of the inside of the liner (through the inflation bladder) will be achieved with the use of a high volume/low pressure blower fan.
14. A submersible pump will be introduced to remove the condensate from the bladder.
15. The canister and bladder will be cut away from the liner.

H. Cutting of the Cured Liner
    1. Cut all excess liner material from the manhole. This means trim slightly below the support lip of the cover. Trim the pipe entry points. Trim at the flow channel / bench edge, or at the inlet and outlet pipes if invert lining.

I. Site Clean-Up
    1. The work site should be cleaned to as-good-as or better-than when-found condition.

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1. Carbon monoxide (CO), hydrogen sulfide (H2S), oxygen (O2), & combustible gases (LEL).
2. An initial site visit and manhole examination has to be performed before liner is produced.
3. It should be understood that once the channel is lined, it's typically assumed that the installer is responsible for the condition of the channel.
4. The curing rate of the epoxy is accelerated with the energy the hot water releases. The curing is usually stopped when the resin near the canister is non-tacky. Prolonging the cure is entirely up to the installer and benefits the hardness of the resin. A longer cure and cool down period under pressure is needed if hydrostatic back-pressure is expected.
5. It is important to open the air valve to avoid a vacuum inside the liner.

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