

STRUCTURAL CEMENTITIOUS LINER PERMACAST® BY AP/M PERMAFORM®

1 Intent: It is the intent of this specification to provide minimum standards for materials and methods for waterproofing, sealing, structural reinforcement and corrosion protection of existing manholes, wet wells and similar underground structures. This specification provides flexibility in design by offering technologies available for repairing the various defects found in sanitary sewer structures from minor leaks to complete structural failure.

2 Applicability: These repair systems may be engineered for the depth, diameter, shape, traffic loading, groundwater pressures and condition of each manhole as a system of products, methods and certified applicators.

3 Referenced Standards

3.1	ASTM C-109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars
3.2	ASTM C-157	Modified Standard Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete
3.3	ASTM C-293	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
3.4	ASTM C-309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
3.5	ASTM C-403	Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
3.6	ASTM C-469	Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
3.7	ASTM C-496	Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
3.8	ASTM C-882	Standard Test Method for Bond Strength of Epoxy Systems Used with Concrete by Slant Shear
3.9	ASTM C-1090	Standard Test Method for Measuring Changes in Height of Cylindrical Specimens from Hydraulic-Cement Grout
3.10	ASTM C-1202	(AASHTO T 277 Equivalent) Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
3.11	ASTM F-2551	Standard Practices for Installing a Protective Cement Liner System in Sanitary Sewer Manholes

4 Infiltration Elimination

4.1 Leak Plugging and Patching Material

4.1.1 Permacast-Plug™

4.1.1.1 A quick setting hydraulic cement compound used to quickly stop running water or seepage leaks in masonry and concrete. The Permacast-Plug™ formulation is nonshrinking, nonmetallic, and noncorrosive. Permacast-Plug™ requires only potable water for mixing and achieves initial set in 1 to 3 minutes, even when applied under water.

4.1.1.2 Permacast-Plug™ is used above or below grade, interior or exterior, to stop seepage and flowing water leaks in most concrete and masonry walls and floors. The fast initial set, high strength, and controlled expansion, make Permacast-Plug™ an effective patching material for use

in manholes, wet wells, lift stations and other structures with leakage. Permacast-Plug™ will not permanently seal running water leaks that are caused by either thermal or structural movement.

4.1.2 Permacast-Patch™

4.1.2.1 A fast setting, ready-to-use, cement based concrete and masonry patching compound formulated specifically for underwater use. It requires only potable water for mixing. Permacast-Patch™ achieves initial set in 3 to 5 minutes and final set within 20 minutes even under water. After initial set, Permacast-Patch™ may be shaved to conform to the contours of the surrounding surface. Properly mixed and applied, Permacast-Patch™ quickly develops a high strength and a tenacious bond.

4.1.2.2 Permacast-Patch™ is used underwater or below grade on vertical, overhead, and horizontal surfaces. It is used for the patching of manholes in preparation for the PERMACAST® liner application and is particularly well suited to fill offset bricks in the corbel area.

4.1.3 MS-10,000 UL™

4.1.3.1 PERMACAST® MS-10,000 UL is designed to provide a thick base layer that fills mortar joints, cracks and voids in brick and masonry manholes. The base layer provides a sound substrate onto which the structural liner is spun cast at the specified thickness of 1/2"-2" to reinforce and seal the existing structure.

4.2 Chemical Grout: All chemical sealing materials needed for severe leaks in the performance of work specified shall conform to ASTM F 2304 latest edition Standard Practice for Rehabilitation of Sewers Using Chemical Grouting.

5 Inflow Control

5.1 Frame & Cover: See other section for watertight covers and inflow inserts.

5.2 Frame-Chimney Seal: See other sections for Manufactured and Applied Chimney Seals and Frame-Chimney Plastic Insert.

6 Structural Cementitious Liner

6.1 MS-10,000 Structural Liner

6.1.1 The material is an ultra high strength, high build, corrosion resistant mortar, based on silica modified Portland cement. When mixed with the appropriate amount of water, a paste-like material will develop which may be sprayed, cast, pumped or gravity-flowed into any gap 1/2 " and wider. This mortar will harden quickly without any special curing.

6.1.2 The hardened binder is dense and highly impermeable. The above performance is achieved by a complex formulation of mineral, organic and densifying agents and sophisticated chemical admixtures. Graded quartz sands are used to enhance particle packing and further improve the fluidity and hardened density. The composition also possesses excellent thin-section toughness, high modulus

of elasticity and is self-bonding. Fibers are added as an aid to casting, for increased cohesion and to enhance flexural strength.

6.1.3 The water content may be adjusted to achieve consistencies ranging from thin motor oil to modeling clay. Despite its high fluidity, the mortar has good wet adhesion and does not sag or run after placement. The mortar may be cast against soil, metals (including aluminum and lead), wood, plastic, cardboard and other normal construction material.

6.1.4 Physical properties

Unit Weight	125 pcf
Set Time at 70 °F ASTM C-403	
Initial Set	min. 120 minutes
Final Set	min. 240 minutes
Modulus of Elasticity ASTM C-469	
28 days	min. 1,500,000 psi
Flexural Strength ASTM C-293	
24 hours	min. 400 psi
28 days	>1250 psi
Compressive Strength ASTM C-109	
24 hours	3,000 psi
28 days	10,000 psi
Split Tensile Strength ASTM C-496	>700 psi
Shear Bond ASTM C-882	>1,500 psi
Shrinkage ASTM C-157, RH 90%	None
Shrinkage ASTM C-1090, RH 90%	None
Chloride Permeability ASTM C-1202	<550 Coulombs

6.2 MS-10,000 with Con^{MIC}Shield[®]

6.2.1 The material is unchanged in physical properties by adding Con^{MIC}Shield[®].

6.2.2 Con^{MIC}Shield[®] is a liquid admixture for concrete and mortars for the prevention of MIC common to concrete pipe, manholes and similar structures in municipal sewer environments. As an additive, it permeates the PERMACAST[®] mortar during the mixing phase and molecularly bonds to the cement particles to create an environment incompatible to the growth of harmful bacteria.

6.2.2.1 Con^{MIC}Shield[®] becomes an integrated component of the hardened binder. It cannot wash off, delaminate or lose its effectiveness from wear. Scraping or erosion of the concrete surface only serves to expose additional material to the environment that would otherwise foster bacterial growth. As bacterial growth is neutralized, hydrogen sulfide gases released from the raw sewerage cannot be metabolized and converted into sulfuric acid in concentrations sufficient to damage the impregnated concrete and mortar.

6.2.2.2 This material is ideally suited for concrete used to manufacture precast pipe and manholes for use in municipal sewer environments or wherever Thiobacillus bacteria may cause MIC. Repair mortars with Con^{MIC}Shield[®] subjected to concentrations of Thiobacillus bacteria in the laboratory have shown complete neutralization in just 24 hours.

6.3 CR-9,000 Mortar

- 6.3.1 CR-9000 is a 100% high grade Calcium Aluminate (CA) cement mortar with fusible fine aggregate. CR-9000 is designed as a sole protector against aggressive elements common to most sanitary sewer systems by retarding the growth of Thiobacillus bacteria. When mixed with the appropriate amount of water, a paste-like material will develop which may be sprayed, cast, pumped or gravity-flowed into any gap 1/2" and wider. This mortar will harden quickly without any special curing and can be considered mature after 24 hours. The hardened mortar has been purposely developed to be resistant to aggressive soil conditions, such as low pH and high sulfates, seawater and dilute sulfuric acid resulting from bacteriological oxidation of hydrogen sulfide common to sanitary sewers. The raw materials are carefully selected and contain no calcium sulfates, tri-calcium aluminates or agents aggressive to reinforcing steel. The mortar is designed to resist biogenic corrosion in atmospheres in which Portland cements may reach pH levels as low as 2.
- 6.3.2 The composition also possesses excellent thin-section toughness and bonding strength. Nonmetallic alkali resistant fibers control cracking and enhance its flexural resistance.
- 6.3.3 The mortar can be used as the sole protection against aggressive elements common to many sanitary sewer systems. The water content may be reduced to achieve any consistency ranging from thin motor oil to that of modeling clay. Despite its high fluidity, the mortar has good wet adhesion and does not sag or run after placement. The mortar may be cast against soil, metals, including aluminum and lead, wood, plastic, cardboard and other normal construction material.

6.3.4 Physical Properties

Unit Weight	135 pcf
Working Time	40-60 minutes @ 70° F
Final Set Time	90-120 minutes @70°F
Compressive Strength ASTM C-109	
24 hours	5000 psi
28 days	9000 psi
Flexural Strength ASTM C-293	750 psi
Tensile Strength ASTM C-496	600 psi
Thin Section Toughness	Excellent
Abrasion Resistance	2% @ 1000 cycles
Freeze/thaw Resistance	No visual damage 300 cycles
Sulfate Resistance	No attack 90 days
Biogenic Sulfide Resistance	Excellent at pH 2 and higher
Shear Bond ASTM C-882	2000 psi
Shrinkage ASTM C-596	None

- 6.4 CR-9,000QS – is calcium aluminate cement with quartz sand in lieu of fusible aggregate.
- 6.5 ST-12,000 – is Portland based cement high performance mortar for storm water structures enabling quick return to service and resistance to road salts.
- 6.6 SR-18,000 – is a very high strength and quick setting Portland cement based mortar with high tensile strengths for special conditions.

6.7 Design Criteria

- 6.7.1 Consult Tables 1 and 2 for the appropriate thickness of the cementitious liner.
- 6.7.2 If additional thickness is desired at any level, simply place the rotating applicator at that level and recommence pumping and retrieval until that area is thickened. Additional layers may be applied at any time.

Refer to ISU Design Guide

Table 1: Thickness Design of PERMACAST® Liner for Traffic Loads

Diameter (in.)	Depth (ft.)	Light Traffic			Heavy Traffic		
		12 hours	24 hours	7 days	12 hours	24 hours	7 days
		Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)
24	1	1	1	0.75	1.75	1.25	1.25
"	> 2	0.5	0.5	0.5	0.5	0.5	0.5
36	1	1.25	1	1	2	1.75	1.5
"	> 2	0.5	0.5	0.5	0.5	0.5	0.5
48	1	1.5	1.25	1	2.25	1.75	1.75
"	> 2	0.5	0.5	0.5	0.5	0.5	0.5

Table 2: Thickness Design of PERMACAST® Liner for Hydrostatic Loads

Depth (ft.)	Diameter 24 in.			Diameter 36 in.			Diameter 48 in.		
	12 hours	24 hours	7 days	12 hours	24 hours	7 days	12 hours	24 hours	7 days
	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)	Thickness (in.)
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
8	0.5	0.5	0.5	0.75	0.5	0.5	0.75	0.75	0.5
12	0.5	0.5	0.5	0.75	0.75	0.5	0.75	0.75	0.5
16	0.75	0.5	0.5	0.75	0.75	0.75	1	1	0.75
20	0.75	0.75	0.5	1	0.75	0.75	1	1	0.75
30	0.75	0.75	0.75	1	1	0.75	1.25	1	1
40	1	0.75	0.75	1	1	1	1.25	1.25	1

NOTE: Material which develop strengths less than 3,000 psi in 24 hours shall be applied at 1½ times the thickness as shown above.

6.8 Cementitious Structural Liner Installation

- 6.8.1 Design Strength/Thickness Ratio: Many factors impact optimum design thickness and these include: the condition of the existing manhole, its material composition, depth, degree of ovality, groundwater pressure, and traffic loads. The design engineer shall determine the most appropriate engineering parameters in each case. Check the manufacturer's design guide for detail. At the strength levels of

PERMACAST® materials, a thickness of 1/2" is appropriate for most manholes up to depths of 12 feet.

6.8.2 Preparation: Cover the manhole base to prevent washed debris from entering the sewer line. Wash the interior surface with a high-pressure water blast, usually 3,500 psi, sufficient to remove all laitance and loose material and flush debris downward to the covered base. Pressures sufficient to etch the existing surface will improve adhesion. Plug any active leaks with plugging material according to the instructions on data sheets, and fill voids and overhangs with patching material. Rinse in Con^{MIC}Shield® to kill bacteria

6.8.3 Equipment: Mortar mixers, compressors and pumps are standard commercial 5models. The high-speed, rotating applicator device is used to provide a densely compacted liner of uniform thickness and thorough coverage.

6.8.4 Mixing

6.8.4.1 Combine 50 pounds of the packaged dry mix with the specified amount of potable water while mixing with a high-speed shear mixer for four (4) minutes. Continue to agitate the mortar to prevent thickening beyond the desired fluidity. If it thickens, it may be retempered. The working time is approximately 40 minutes.

6.8.4.2 Con^{MIC}Shield® admixture: The liner material is mixed with just the addition of clean water and Con^{MIC}Shield®, in the prescribed amounts for Microbiologically induced corrosion (MIC) protection. No other additives shall be used at the site without prior approval.

6.8.5 Application

6.8.5.1 Position the bi-directional SpinCaster applicator within the center of the manhole at the lowest point desired for the new wall and commence pumping the mixed mortar. As the mortar begins to be centrifugally cast evenly around the interior, retrieve the applicator head at the prescribed speed for applying the thickness that has been selected. Controlled multiple passes are then made until the desired finished thickness is attained. If the procedure is interrupted for any reason, simply arrest the retrieval of the applicator head until flows are resumed.

6.8.5.2 The retrieval speed can be easily varied to create different thickness to provide the best strengths as the condition or depth of the manhole may dictate in any portion of the manhole. Because of the even application throughout the circumference, thickness may be verified at any point with a wet gage.

6.8.5.5 Clean Up: Upon completion, the base covering shall be removed and any debris disposed properly. Additional material shall be hand applied to bench surfaces at a thickness of 3 " tapering from the wall to the edge of the channel. Flows at bottom channels may remain active during the procedure.

6.8.6 Hot Weather Application (Above 80° F)

- 6.8.6.1 Do not apply Permacast mortars when ambient and surface temperatures are 100° F and above. Shade the material and prepared the surface to keep it cool.
- 6.8.6.2 To extend working time, mix the material with cool water or ice-cooled water. Be certain the substrate is saturated surface-dry (SSD) before application begins.
- 6.8.6.3 When finishing is required, work the material quickly once it has stiffened- when a finger pressed against the material will mark it lightly but not sink beneath the surface.
- 6.8.6.4 Proper curing is always required and is particularly important in hot weather. Refer to Section 8.5.7 on curing.

6.8.7 Cold Weather Application (Above 45° F):

- 6.8.7.1 Do not apply Permacast mortars when ambient temperatures are expected to fall below 45° F within 72 hours of placement. Both ambient and substrate temperatures must be at least 45° F at the time of placement.
- 6.8.7.2 Low substrate and ambient temperatures slow down rate of set and strength development. At temperatures below 45° F, warm the material, water, and substrate. Properly ventilate the area when heating. Protect the new liner from freezing.

6.8.8 Curing/Finishing: Avoid overly windy and arid curing conditions; use curing membranes per ASTM C-309 to create the most optimal curing conditions possible. The use of Cor+Gard ER evaporative reducer will help keep mortar hydrated during the curing phase. Apply Cor+Gard ER immediately after mortar placement and then finish mortar with a brush. After finishing, a follow up application of Quick Cure curing compound will further aid in proper mortar curing. If epoxy topcoats are to follow, Quick Cure should not be used. Only use products that will be compatible to enhance the epoxy bond.

7 Submittals

- 7.1 All submittals shall conform to the requirements of the Contract document.
- 7.2 In addition, the following items may be required of the installer to be submitted to the engineer at the sole discretion of the engineer. This Contract shall not be considered complete until receipt and acceptance of the following:
 - 7.2.1 Reference submittals
 - 7.2.1.1 Contractor certification
 - 7.2.1.2 Material certification
 - 7.2.2 Product data
 - 7.2.2.1 Patching and plugging material
 - 7.2.2.2 Cementitious lining material
 - 7.2.2.3 Cementitious lining with admixture

8 Product Handling

- 8.1 Special handling is not required for PERMACAST® mortar. Normal precautions for “nuisance dust” shall be observed. Consult Material Safety Data Sheet for details.
- 8.2 Con^{MIC}Shield® is non-toxic and contains no phenols, heavy metals or formaldehyde. It contains an E.P.A. registered antibacterial ingredient (E.P.A. Registration Number (75174-2-47000). It is stable in ultraviolet light and it is leach- resistant. Consult Material Safety Data Sheet for full details.
- 8.3 Personnel entry is not required to rebuild the interior wall of most manholes when using the PERMACAST® spinner head. If personnel entry becomes necessary for any reason, OSHA standards for confined space entry shall be strictly observed.

9 Quality Assurance and Acceptance

- 9.1 Two test cubes of the PERMACAST® material shall be taken randomly as directed by the inspector at owner’s expense to verify strengths. Thickness can be verified with a wet gage at any random point of the new interior surface. Any areas found to be thinner than the minimum specified thickness shall immediately receive additional material. Visual inspection should verify a leak-free, uniform appearance.

10 Measurement for Payment:

- 10.1 Payment shall be made at the unit price per vertical or square foot of finished wall for each prescribed thickness.