



SPECIFICATIONS

PVC MANHOLE SYSTEM: FIBERGLASS REINFORCED PLASTIC (FRP) LINED CONCRETE AND POLYVINYL CHLORIDE RISER HYBRID MANHOLES

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I. SCOPE OF WORK

- A. This specification shall govern for the furnishing of all work necessary to accomplish and complete the installation of a PVC Manhole System, comprising fiberglass reinforced plastic lined concrete manhole base and top sections, a polyvinyl chloride riser section and all appurtenances. The PVC Manhole shall be corrosion, abrasion, inflow and infiltration resistant.
- B. The PVC Manhole System shall be modular and shall include the following main components:
 - 1) Fiberglass Reinforced Plastic (FRP) concrete protective liners for manhole base and top sections, including all appurtenances. Liners shall be **non-structural units, constructed of fiberglass reinforced unsaturated polyester resin, third-party certified for wastewater infrastructure use**, designed to provide a gastight and watertight homogenous barrier that protects the concrete manhole base and top sections from corrosion, abrasion, inflow and infiltration. FRP liners shall be manufactured by **Predl Systems North America Inc., Burnaby, BC**.
 - 2) Concrete manhole base and top sections, cast around the FRP concrete protective liners. Concrete base and top sections shall be ASTM C478 compliant and manufactured by **Diamond Precast Concrete Ltd., Burnaby, BC or a Predl Systems certified precast facility**.
 - 3) PVC riser section shall be AWWA C900 compliant, DR-51 pressure class PVC pipe, manufactured by **Diamond Plastics Corp., Grand Island, NE**.
 - 4) ASTM C990 compliant elastomeric sealant and ASTM C877 compliant external joint wrap, for the purpose of joining the lined concrete base, PVC riser and lined concrete top manhole sections, supplied by others.

II. GOVERNING STANDARDS

Manhole liners shall conform to the following design criteria:

- A. ASTM D395: Standard Test Methods for Rubber Property – Compression Set
- B. ASTM D412: Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
- C. ASTM D471: Standard Test Method for Rubber Property – Effect of Liquids
- D. ASTM D543: Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- E. ASTM D573: Standard Test Method for Rubber – Deterioration in an Air Oven
- F. ASTM D624: Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
- G. ASTM D638: Standard Test Method for Tensile Properties of Plastics

H.	ASTM D695:	Test Methods for Compressive Properties of Rigid Plastics
I.	ASTM D790:	Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and electrical Insulating Materials
J.	ASTM D792:	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
K.	ASTM D1149:	Standard Test Methods for Rubber Deterioration – Cracking in an Ozone Controlled Environment
L.	ASTM D2137:	Standard Test Methods for Rubber Property - Brittleness Point of Flexible Polymers and Coated Fabrics
M.	ASTM D2240:	Standard Test Method for Rubber Property – Durometer Hardness
N.	ASTM D2584:	Test Method for Ignition Loss of Cured Reinforced Resins
O.	ASTM D4060:	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
P.	Greenbook 2009 (or later):	Standard Specifications for Public Works Construction, Chemical Resistance Test (Pickle Jar Test)

III. GENERAL DESCRIPTION

A. Configuration:

The manhole base section shall include an FRP Baseline and the manhole top section will include an FRP Top Liner with integral Access Collar and Gasket, to accept and an FRP Telescoping access Tube. Each prefabricated FRP liner component shall be constructed from one piece homogenous composite and/or thermoplastic with minimum thickness of 3 mm (1/8"). FRP concrete protective liners shall be non-structural elements.

1. **FRP Baseliners:** Each manhole Baseline shall include:

- a) Full flow channels with side walls to the crown of the pipe(s) or above;
- b) A non-skid pattern on inner bench surfaces;
- c) Gasketed, flexible and watertight, bell type, pipe connections for specific pipe types to receive the collection pipes at the exact angles and slopes as specified on Contract Documents.

The Bells shall be monolithically attached to the manhole base liner channels, be integral to the Baseline and have a water stop on the outside and a pipe stop on the inside that matches the diameter and wall thickness of the collection pipe and ensure that the flow line from the pipe stop to the inside channels are smooth and without obstruction. The Bells shall conform to the outside and inside curve of the manhole walls.

The Baseline shall have a spigot or bell type joint facing the PVC riser tube and connecting to the inside or outside of the PVC riser, respectively. An ASTM C990 compliant butyl rubber sealant, such as ConSeal CS-102, shall be used in the joint interface. An ASTM C877 compliant external joint wrap, such as ConSeal CS-212, shall be used to seal the joint from the outside.

2. **FRP Top Liner with integral Access Collar and Gasket:** The FRP Top Liner component shall provide concrete protection from corrosion, abrasion, inflow and infiltration for the manhole cone section and shall feature an integral FRP Access Collar and Gasket at the manway opening, to receive an FRP Telescoping Access Tube.

The FRP Top Liner shall either have cone or flat top configuration depending on the requirements of Contract Documents.

The Top Liner shall have a spigot or bell type joint facing the PVC riser tube and connecting to the inside or outside of the PVC riser, respectively. An ASTM C990 compliant butyl rubber sealant, such as ConSeal CS-102, shall be used in the joint interface. An ASTM C877 compliant external joint wrap, such as ConSeal CS-212, shall be used to seal the joint from the outside.

3. **Telescoping Access Tube:** The FRP Telescoping Access Tube shall provide concrete protection from corrosion, abrasion, inflow and infiltration for the manway entry section, between the casting at the finished grade and top of the manhole top section. The Telescoping Access Tube shall accommodate grading adjustments up to 12" of height.

B. **Dimensions:**

1. FRP Baseliners and Top Liners shall have outside diameters of 51", 58" and 61.75", corresponding substantially to the outside diameters of 48", 54" and 60" C900 DR-51 PVC pressure pipes. Tolerance on the outside diameter shall be +/- 1%. Other diameters, as agreed upon between purchaser and the manufacturer, are covered by this specification.
2. FRP Baseliners and Top Liners shall have spigot joint diameters of 48.80", 55.30" and 59.19", corresponding to the inside diameters of 48", 54" and 60" C900 DR-51 PVC pressure pipes. Tolerance on the spigot joint diameter shall be +0/-0.125". Other diameters, as agreed upon between purchaser and the manufacturer, are covered by this specification.
3. Allowable tolerance for Baseline invert elevations shall be 0.125" and 2% for pipe slope.
4. Access Collars and Telescopic Access Tube shall accommodate manway openings of 24", 27", 32" or 36". Telescopic Access Tube shall have a nominal height of 15". Access Collars can be either eccentric or concentric.

C. **Marking and Identification**

Baseliner shall be marked with the following information:

- 1) Manufacturer's identification
- 2) Nominal diameter
- 3) Manhole identification
- 4) Detailed invert configuration
- 5) Installation assist marks molded into the Baseliner

All other components shall be marked with the following information:

- 1) Manufacturers Identification
- 2) Nominal Diameter
- 3) Installation assist marks, if applicable

IV. MATERIALS

- A. **FRP liner body:** The resins used shall be unsaturated, supplier certified, commercial grade polyester resins. Mixing lots of resin from different manufacturers or “odd-lotting” of resins shall not be permitted. Quality-assurance records on the resin shall be maintained.

The reinforcing materials shall be commercial grade “E-CR” type glass, specially formulated for corrosive environments, in the form of mat, chopped roving, continuous roving, roving fabric or a combination of the above, having a coupling agent that will provide a suitable bond between the glass reinforcement and resin. Fiberglass and/or polypropylene ribs and/or structural members may be utilized to meet the design criteria.

No inert fillers shall be used. Additives, such as thixotropic agents, catalysts, promoters, etc., may be added as required by the specific manufacturing process to be used to meet the requirements of this standard.

The laminate shall consist of multiple layers of glass matting and resin. The surface exposed to the sewer/chemical environment shall be resin rich and shall have no exposed fibers.

- B. **Bells:** Bell shall be manufactured from the same unsaturated, supplier certified, commercial grade polyester resins as the main FRP Baseline body. If available, polypropylene injection molded Bells are also allowed.
- C. **Gaskets:** Resilient materials for connectors and filler rings shall be manufactured from natural rubber, polyisoprene, neoprene, nitrile, or ethylene propylene diene monomer (EPDM) synthetic rubber and shall conform to the material requirements prescribed in this specification. If a splice is used in the manufacture of the seal, its strength shall be such that the seal shall with-stand a 180° bend with no visible separation.
- D. **Mechanical devices:** Expansion rings, tension bands, and take-up devices used for mechanically compressing the resilient portion of the connector against the pipe or manhole shall be made from a material or materials in combination that will ensure durability, strength, resistance to corrosion, and have properties that will ensure continued resistance to leakage.

All metallic mechanical devices and bolt assemblies used to mechanically deform resilient materials shall be constructed of corrosion resistant materials meeting the physical properties and chemical composition requirements of ASTM A493 and A666, Type 302 through Type 316.

- E. **Third party accessories:** Third party accessories integral to the PVC Manhole System or the FRP Manhole Liner (flow control devices, valves, gates, inside drop assembly, man entry ladder, etc.) shall be governed by the respective manufacturers’ materials specifications.
- F. **Concrete:** Concrete shall be wet-cast, conforming to the requirements of the most recent versions of ASTM C478, CSA A23.1, and CSA A23.4. Concrete shall have an A-3 exposure class, unless otherwise specified by the project engineer.

V. MANUFACTURE

- A. Manufacturer shall have 25 years of FRP concrete protective liner manufacturing experience and shall have fabricated and delivered at least 20,000 FRP concrete protective liners for wastewater applications.
- B. Precaster shall be certified by the National Precast Concrete Association.

VI. REQUIREMENTS

- A. **Exterior Surface:** The exterior surface shall be finished with embedded aggregates and FRP bonding bridges to allow for adequate bonding with the surrounding concrete once cast. The exterior surface shall be free of blisters larger than 0.5” in diameter, delamination and fiber show, except in the vicinity of FRP bonding bridges where fiber show is acceptable. **Gel-coat or paint or other coatings are not allowed.**

- B. **Interior Surface:** The interior surfaces shall be resin rich with no exposed fibers. Interior flow surfaces shall be smooth for improved corrosion resistance and reduced sludge build-up. The surface shall be free of crazing, delamination, blisters larger than 0.25" in diameter, and wrinkles of 0.125" or greater in depth. **Gel-coat shall be permitted on interior surfaces, no paint or other coatings are allowed.**
- C. **Repairs:** Any manhole liner repair is required to meet all requirements of this specification. All repair must all be preapproved by the manufacturer.
- G. **Chemical Resistance:** FRP manhole liners must demonstrate having sufficient corrosion resistance by passing the "Greenbook" 2009 edition (or later), Standard Specifications for Public Works Construction, Chemical Resistance Test (Pickle Jar Test), per third-party accredited laboratory test results.
- H. **Physical Properties:**

All FRP liner material shall have the following physical properties when tested at 77 °F ± 5 degrees:

Property	Standard	Units	Value
Density	ASTM D792	g/cm ³	1.02
Thickness	--	Mm	3 min.
Tensile Strength	ASTM D638	psi	6,500 min.
Hardness (Shore "A")	ASTM D2240		95-97
Weight change	--	--	--
Flexural Strength	ASTM D790	lbf/in ²	8050 min
Compressive Strength	ASTM D695	psi	6,500 min
Ignition Loss	ASTM D2584	%	52 avg.
Taber abrasion test (weight loss)	ASTM D4060	%	0.075

Tensile specimens shall be prepared and tested in accordance with ASTM D412 using Die B. Weight change specimens shall be 1 IN by 3 IN samples.

All gaskets shall have the following physical properties:

Property	Standard	Units	Requirement
Chemical resistance: 1N sulfuric acid 1N hydrochloric acid	ASTM D543 (at 24°C for 48 hr.)	% %	No weight loss No weight loss
Tensile Strength	ASTM D412	psi	1,200 min.
Elongation at Break	ASTM D412	%	350 min.
Hardness (Shore A)	ASTM D2240	--	±5 from the connector manufacturer's specified hardness
Accelerated oven aging	ASTM D573 (at 70°C for 7 days)	%	Max 15% decrease in tensile strength; Max 20% decrease in elongation
Compression set	ASTM D 395, Method B (at 70°C for 22 hr.)	%	Max 25% decrease of original deflection
Water absorption	ASTM D471 (at 70°C for 48hr.)	%	Increase of max 10% of original weight (19 by 25mm specimen)
Ozone Resistance	ASTM D1149	--	Rating 0
Low temperature brittle point	ASTM D2137	--	No fracture at -40°C
Tear resistance	ASTM D624, Die B	kN/m	34

Upon request, the manufacturer shall provide written certification that the FRP liners and gaskets used meets or exceeds the requirement of this specification.

F. Chemical resistance

After conditioning to constant weight at 110 °F, FRP liner specimens shall be exposed to the following solutions for a period of 112 days at 77 °F ± 5 degrees, as prescribed in Standard Specifications for Public Works Construction, section 211-2 (Pickle Jar Test).

At 28-day intervals, tensile specimens and weight change specimens shall be removed from each of the chemical solutions and tested. If any specimen fails to meet the 112-day requirement before completion of the 112-day exposure, the material will be subject to rejection.

Chemical Solution	Concentration
Sulfuric acid	20%*
Sodium hydroxide	5%
Ammonium hydroxide	5%*
Nitric acid	1%*
Ferric chloride	1%
Sodium hypochlorite	1%
Soap	0.1%
Detergent (linear alkyl benzyl sulfonate or LAS)	0.1%
Bacteriological	BOD not less than 700 ppm

* Volumetric percentages of concentrated C.P. grade reagents.

VII. TEST METHODS

All test methods shall be performed per corresponding ASTM standard and per “Greenbook” 2009 edition (or later), Standard Specifications for Public Works Construction, Chemical Resistance Test (Pickle Jar Test).

VIII. QUALITY ASSURANCE/QUALITY CONTROL

- A. **Examination:** Each manhole liner shall be examined for dimensional requirements and workmanship.
- B. **Composition Control:** Controls on glass and resin content shall be maintained for all manufacturing processes and for each portion of manhole liner fabrication. Records shall be maintained for these control checks. Proper glass content may be shown by glass usage checks or glass and resin application rate checks.
- C. **Certified facility:** The manhole liners shall be designed and manufactured in an ISO 9001 and 14001 certified manufacturing facility.

IX. HANDLING AND STORAGE

- A. FRP manhole liners must not be dropped or impacted. When stored for extended periods (more than a few days) Baseliners shall be stored on a flat surface, upside down to minimize deformation.

Baseliners shall not be exposed to direct sunlight for extended periods.

X. CASTING & INSTALLATION

- A. **Casting:** FRP manhole liners are non-structural components. Liners must be monolithically cast within a concrete manhole section using a wet cast method. Custom pouring supports shall be provided with FRP liners to fully support the liners during the concrete pouring process against the vertical and horizontal forces created by the concrete during casting.

The poured manhole base must not be moved until adequate hydration has occurred.

Lifting devices must not penetrate any surface of the liner. No liner may have holes or openings which will permit the intrusion of liquids or gases through the liner wall and into the concrete.

- B. **Installation:** The PVC manhole installation should strictly follow the Predl Systems' recommended installation procedures to ensure long-term corrosion resistant service.
- C.

XI. INSTALLATION

- A. **Base:** Base shall be place on a compacted, graded bedding meeting the requirements of the contract documents. Base shall be level, with the invert elevations conforming to the contract documents.

Connect pipes to the manhole base, using integral bell connectors, with gaskets supplied by the manufacturer

- B. **Riser:** Clean the joint surface of the base, ensuring no foreign material remains. Place ASTM C990 compliant butyl rubber sealant along the joint, ensuring no gaps remain.

Lower PVC riser onto joint, ensuring the butyl rubber sealant is engaged and compressed. Riser shall be set plumb.

Backfill approximately 6"-12" below the top of the riser. Compact backfill per contract documents and standard practices.

Clean the top of the PVC riser, ensuring no foreign material remains. Place ASTM C990 compliant butyl rubber sealant along top of the riser, ensuring no gaps remain.

- C. **Flat top:** Lower flat top on to PVC riser, ensuring the butyl rubber sealant is engaged and compressed. Place Telescopic Access Collar [TAC] gasket in gasket seat of manhole opening. Stack grade rings to the desired height. Place Telescopic Access Collar into grade ring opening, exert a downward force on the collar to engage the collar with the gasket, while ensuring no concentrated point loads are applied to the TAC. Ensure the gasket is fully engaged and no rolling occurred. Place butyl rubber sealant on top of collar flange, then set casting. Backfill and pave.