



SPECIFICATIONS

PRECAST FRP-PVC HYBRID MANHOLE SYSTEM ("Predl PVC Manhole")

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PRECAST FRP-PVC MANHOLE SYSTEM ("PREDL PVC MANHOLE")

I. SCOPE OF WORK

- A. This specification shall govern for the furnishing of all work necessary to accomplish and complete the installation of a Predl PVC Manhole, comprising fiberglass reinforced plastic lined concrete manhole base and top sections, a polyvinyl chloride pipe 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 pressure pipe 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 pressure pipe riser and lined concrete top manhole sections.
 - 5) Grading rings, manhole ring and cover to grade, according to local jurisdictional requirements.

II. GOVERNING STANDARDS

The PVC Manhole shall conform to the following design criteria:

- | | | |
|----|------------|---|
| A. | ASTM C478 | Standard Specification for Circular Precast Reinforced Concrete Manhole Sections |
| B. | ASTM C497 | Determining Physical Properties of Concrete Pipe or Tile |
| C. | ASTM D395: | Standard Test Methods for Rubber Property – Compression Set |
| D. | ASTM D412: | Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension |
| E. | ASTM D471: | Standard Test Method for Rubber Property – Effect of Liquids |
| F. | ASTM D543: | Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents |
| G. | ASTM D573: | Standard Test Method for Rubber – Deterioration in an Air Oven |
| H. | ASTM D624: | Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers |

- I. ASTM D638: Standard Test Method for Tensile Properties of Plastics
- J. ASTM D695: Test Methods for Compressive Properties of Rigid Plastics
- K. ASTM D790: Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and electrical Insulating Materials
- L. ASTM D792: Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
- M. ASTM D1149: Standard Test Methods for Rubber Deterioration – Cracking in an Ozone Controlled Environment
- N. ASTM D2137: Standard Test Methods for Rubber Property - Brittleness Point of Flexible Polymers and Coated Fabrics
- O. ASTM D2240: Standard Test Method for Rubber Property – Durometer Hardness
- P. ASTM D2584: Test Method for Ignition Loss of Cured Reinforced Resins
- Q. ASTM D4060: Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
- R. Greenbook 2009 (or later): Standard Specifications for Public Works Construction, Chemical Resistance Test (Pickle Jar Test)

III. GENERAL DESCRIPTION

A. Configuration:

1. **General Overview:** The manhole base and top section shall be ASTM C478 compliant precast concrete manhole sections with an integral cast-in FRP Baseline and Top Liner respectively, providing corrosion, abrasion, inflow and infiltration resistance to the precast concrete manhole sections. The FRP Top Liner shall incorporate an integral Access Collar and Gasket to accept and an FRP Telescoping access Tube providing corrosion, inflow and infiltration resistance from the grade ring down.

Each cast-in 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 are non-structural elements and structural integrity must be provided by the precast concrete manhole sections.

The manhole riser section shall be a one-piece AWWA C900 compliant, DR-51 pressure class PVC pipe. PVC pipe to FRP liner joints shall be a spigot joints with rubber butyl sealant and optional external joint wrap.

2. **Cast-in FRP Baselines:** Each FRP 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 joint facing the PVC riser tube and connecting to the inside of the PVC pressure pipe riser. 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.

The FRP Baseline shall be monolithically precast in an ASTM C478 compliant steel reinforced manhole base section. Poured in place concrete bases are not acceptable.

3. **Cast-in 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 joint facing the PVC riser tube and connecting to the inside of the PVC pressure pipe riser. 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.

The FRP Top liner shall be monolithically precast in an ASTM C478 compliant steel reinforced manhole lid section. Poured in place concrete lid sections are not acceptable.

4. **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.
5. **Precast concrete manhole sections:** Precast manhole sections cast around the FRP liners result in a lined manhole sections with no bare concrete exposed to the wastewater environment. Precast manhole sections shall be manufactured in accordance with and meet the requirements of specification ASTM C-478. All precast manhole sections shall be monolithically manufactured by the wet cast method.
6. **PVC riser tube:** The one-piece AWWA C900 compliant, DR-51 pressure class PVC pipe shall function as a corrosion resistant manhole riser. The PVC riser tube shall accommodate penetrations as specified in Contract Documents, including gasketed pipe connections using Inserta-Tee-type flexible connectors.

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.

5. Precast concrete segments will strictly follow dimensions stipulated in Contact Documents and, unless otherwise indicated, shall have outside diameters substantially corresponding the outside diameter of the PVC riser section.

C. Marking and Identification

Baseliners 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 Baseline

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 liners:** 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.

1. **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.
2. **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.
3. **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.

4. **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.

- B. Precast concrete manhole sections: The manhole base and top sections shall be constructed of precast reinforced concrete, for the purpose of providing structural integrity to the FRP manhole liners. The sections shall conform to the requirements of ASTM C-478 and shall be manufactured using the wet cast method.
- C. **Manhole PCV riser:** The PVC riser pipe shall strictly comply with AWWA C900 and shall have DR-51 pressure rating.
- D. **Grading Rings:** Grade rings shall be constructed of reinforced precast concrete.
- E. **Ring and Cover:** Casting shall be tough gray iron, free from cracks, holes, swells, and cold shuts. All manhole casting shall be made accurately to the pattern and to the dimensions shown on Contract Documents.
- F. **Mortar:** Mortar to be used in setting manhole frames shall be prepared by thoroughly mixing: one (1) volume of Type II Portland Cement with three (3) volumes of sand and sufficient clean water to produce a rich mass of approved consistency. Mixing mortar on the ground or any paved surface shall not be permitted. Sand to be used in making mortar shall be clean, well-graded, and shall pass a standard No. 4 sieve.
- G. **Backfill Material:** The initial backfill material, in direct contact with the PVC Manhole, shall be composed of well graded, crushed stone or gravel conforming to the following requirements, unless modified by the Contract Documents:

Crushed Stone or Gravel	Percent
Passing 1-1/2 inch sieve	100
Passing 1 inch sieve	95 to 100
Passing 3/8 inch sieve	25 to 60
Passing No. 4 sieve	0 to 10
Passing No. 8 sieve	0 to 5

V. MANUFACTURE

- A. FRP Liner 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. Precast concrete plant shall be NPCA certified.

VI. REQUIREMENTS

- A. **FRP Liner 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. **FRP Liner 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. **FRP Liner Repairs:** Any manhole liner repair is required to meet all requirements of this specification. All repair must all be preapproved by the manufacturer.

D. **FRP Liner 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.

E. **FRP Liner Physical Properties:**

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

Property	Standard	Units	Initial	(Par. VI.F.)
Density	ASTM D792	g/cm ³	1.02	
Thickness	--	Mm	3 min.	--
Tensile Strength	ASTM D638	psi	7,000 min.	6,500 min.
Hardness (Shore “A”)	ASTM D2240		95-97	89-97
Weight change	--	--	--	0.05% max.
Flexural Strength	ASTM D790	lbf	124 avg.	--
Compressive Strength	ASTM D695	psi	13,000	--
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. **FRP Liner 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.

G. Precast Concrete Requirements

All precast manhole sections shall be manufactured by the wet cast method.

The minimum compressive strength of the concrete for all precast concrete sections shall be 4000 psi (27 MPa). The maximum allowable absorption of the concrete shall not exceed 9 percent of the dry weight.

Steel reinforcement for all manhole diameters shall be in accordance with ASTM C-478 and per Contract Documents.

VII. MATERIALS TEST METHODS

- A. All FRP Liner 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).
- B. Concrete tests, when required, shall be in accordance with ASTM C-497.

VIII. QUALITY ASSURANCE/QUALITY CONTROL

- A. **Examination:** Each FRP manhole liner shall be examined for dimensional requirements and workmanship prior to precasting.
- B. **Resin 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:** FRP manhole liners shall be designed and manufactured in an ISO 9001 and 14001 certified manufacturing facility. Concrete precast plants shall be NPCA certified.

IX. PRECASTING

- 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.

- B. Baseliners shall not be exposed to direct sunlight for extended periods, either before or after precasting.
- C. Liners must be monolithically cast within a concrete manhole section using the 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.
- D. The poured manhole base must not be moved until adequate hydration has occurred.
- E. Lifting devices, no more than 3 per section, 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.

X. FIELD INSTALLATION

- A. PVC manhole installation should strictly follow the Predl Systems' recommended installation procedures to ensure long-term corrosion resistant service. In addition, local codes may apply and should be consulted as applicable in manhole installation.
- B. Excavation at manhole location shall be wide enough to provide working room around manhole. Ensure the depth of manhole is sufficient to accommodate for at least two concrete rings for adjustment of ring and cover at top of final grade and for a minimum of 6 inches (152 mm) of crushed stone directly below the manhole base for the purpose of adequate leveling.
- C. Set and level manhole base section and connect sewer lines to manhole.
- D. Install rubber butyl sealant on manhole base spigot joint following manufacturer's installation instructions.
- E. Lift PVC riser in place using recommended lifting apparatus and set plumb and level. Ensure that a positive seal is established between the manhole base and the PVC riser.
- F. Install rubber butyl sealant on manhole top lid spigot joint following manufacturer's installation instructions.
- G. Lift manhole top section in place and set level. Ensure that a positive seal is established between the manhole top section and the PVC riser.
- H. If specified, install apply external joint wrap on joint sections, following manufacturer's installation instructions.
- I. Initial backfill material shall be used for backfilling around the manhole for a minimum distance of one foot from the outside surface and extending from the bottom of the excavation to the top of the reducer section. Secondary backfill material may be used for the remainder of the backfill. This material will be subject to approval by Engineer.
- J. Backfill shall be placed in layers of not more than 12 loose measure inches and mechanically tamped to 95% Standard Proctor Density, unless otherwise approved by Engineer. Flooding will not be permitted. Backfill shall be placed in such a manner as to prevent any wedging action against the PVC manhole structure.
- K. Bring to Grade: Construct reinforced concrete ring encasement as identified on details. The top the PVC manhole may be brought to proper grade for receiving manhole frames by using not more than four courses precast concrete grade rings.

XI. FINAL TESTING AND ACCEPTANCE

- A. **Hydrostatic Testing:** Hydrostatic testing shall be conducted, as required, by plugging with approved plugs all influent and effluent pipes in the manhole and filling the manhole to the top of the manhole cone with water. Additional water may be added over a 24-hour period to compensate for evaporate losses. At the conclusion of the 24-hour saturation period the manhole shall be filled to the top of the manhole cone and observed. A loss within a 30-minute period shall be considered an unsuccessful test.
- B. **Vacuum Testing:** Manholes shall be tested, as required, after installation and prior to backfilling with all connections (existing and proposed) in place, in general accordance with ASTM C1244.

The lines entering the manhole shall be temporarily plugged with the plugs braced to prevent them from being drawn into the manhole. The plugs shall be installed in the lines beyond drop connections, gas sealing connections, etc. The test head shall be inflated in accordance with the manufacturer's recommendations. A vacuum of 10 inches of mercury shall be drawn, and the vacuum pump will be turned off. With the valve closed, the level vacuum shall be read after the required test time. If the drop in the level is less than 1-inch of mercury (final vacuum greater than 9-inches of mercury), the manhole will have passed the vacuum test. The required test time is determined from the table below:

Depth (ft)	Nominal Diameter (in)								
	30	33	36	42	48	54	60	66	72
	Time (seconds)								
<4	6	7	7	9	10	12	13	15	16
6	9	10	11	13	15	18	20	22	25
8	11	12	14	17	20	23	26	29	33
10	14	15	18	21	25	29	33	36	41
12	17	18	21	25	30	35	39	43	49
14	20	21	25	30	35	41	46	51	57
16	22	24	29	34	40	46	52	58	67
18	25	27	32	38	45	52	59	65	73
20	28	30	35	42	50	53	65	72	81
22	31	33	39	46	55	64	72	79	89
24	33	36	42	51	59	64	78	87	97
26	36	39	46	55	64	75	85	94	105
28	39	42	49	59	69	81	91	101	113
30	42	45	53	63	74	87	98	108	121

- C. **Acceptance:** Manholes will be accepted with relation to the hydrostatic test requirements and the vacuum test requirements if they meet the criteria above. Any manhole which fails the initial test must be repaired or replaced prior to backfilling. The manhole shall be retested as described above until successful tests have been made. After the successful tests, the temporary plugs will be removed.