



SPECIFICATIONS

FLEXIBLE REHABILITATION LINER SYSTEM FOR CONCRETE MANHOLES AND WET WELLS

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I. SCOPE OF WORK

- A. This specification shall govern the furnishing of all work necessary to accomplish and complete the installation of a flexible rehabilitation liner system for concrete manholes and wet wells.
- B. The Flexible Liner System shall be **non-structural polyurea and thermoplastic hybrid, certified for wastewater infrastructure use, and designed to be retrofitted into existing concrete manholes and wet wells to provide a gastight and watertight homogenous barrier against corrosion, abrasion, inflow and infiltration.**

The Flexible Liner System shall be modular and include the following main components, as specified in Contract Documents:

- 1) Prefabricated flexible polyurea concrete protective liner ("Flexliner") for manhole and wet well base section, including all appurtenances;
- 2) Prefabricated flexible polypropylene (PP) or high-density polyethylene (HDPE) concrete protective riser liner ("Corprotect") sections, including all appurtenances.
- 3) Cone top configuration: prefabricated flexible polyurea concrete cone liner section ("Flexliner"). The polyurea liner section will incorporate either an integral polyurea access chimney liner for round manway opening or provide a transition and welding surface for the attachment of a separate flexible thermoplastic access chimney liner;

OR

Flat top configuration: prefabricated flexible PP or HDPE concrete protective liner ("Corprotect") with integral flexible thermoplastic access chimney liner for either round manway or rectangular hatch opening;

- C. The Flexible Liner System shall custom fabricated to closely match the existing concrete manhole's or wet well's internal dimensions, as established by a 3D scan of the as-built structure.
- D. The Flexible Liner System shall be fabricated in an ISO 9001 certified facility and **manufactured by Predl Systems North America Inc, Burnaby, BC, or by Predl GmbH, Bönitz, Germany.**

II. GOVERNING STANDARDS

The Flexible Liners system 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 D1238 Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
- M. ASTM D2137: Standard Test Methods for Rubber Property - Brittleness Point of Flexible Polymers and Coated Fabrics
- N. ASTM D2240: Standard Test Method for Rubber Property – Durometer Hardness
- O. ASTM D2584: Test Method for Ignition Loss of Cured Reinforced Resins
- P. ASTM D4060: Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
- Q. DIN 53752 Testing of Plastics – Determination of the Coefficient of Linear Thermal Expansion

III. GENERAL DESCRIPTION

A. Configuration:

The Flexible Liner System shall be modular and include the following main components:

1. **Flexible Baseline:** The prefabricated baseliner shall be constructed from one-piece homogenous polyurea compound with minimum thickness of 3 mm (1/8"). Flexibility of the baseliner shall enable it to fit through the manway opening or hatch of the structure to be rehabilitated, without damage to the baseliner or to the structure itself.

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) Pipe connections with accurate invert elevations, inside diameters and slopes for incoming pipes;

The standard vertical side wall (skirt) height above the bench shall be 3". Optional extended vertical side wall (skirt) height above the bench shall be 10" - 12". Other skirt heights, as agreed upon between the purchaser and the manufacturer, are covered by this specification.

Wet well Baseliner shall include:

- a) Exact sump, chamfer and skirt configuration;
- b) Stainless steel threaded inserts with pump-specific mounting pattern;

When installing a Baseline as part of a fully lined structure, with polypropylene (PP) or high density polyethylene (HDPE) wall liners, the Baseline shall have a smooth 3mm thick transition strip of corresponding liner material embedded into the polyurea compound around the top lip at the time of manufacture to provide a transition and welding surface between the Baseline and the adjoining PP or HDPE concrete protective wall liner.

The flexible baseliner shall be accompanied with a tight-fitting extruded polystyrene (EPS) pouring support to provide temporary rigidity to the flexible liner during the grouting stage of the installation. The pouring support shall be designed in a way that will enable it to be broken down in order to fit through the manway opening or hatch of the structure of to be rehabilitated.

2. **PP or HDPE Wall Liners:** All PP or HDPE liner sheets shall be extruded with a large number of anchoring studs, a minimum of 39 per SF (420/m²), manufactured during the extrusion process in one piece with the sheet so there is no welding and no mechanical finishing work to attach the studs to the sheet. Minimum distance between studs shall be no less than 2.12". Stud height shall be no less than 13mm or 9/16".

Flat PP and HDPE sheets shall be heat welded to conform to the inside shape of the as-built structure. Penetrations through the wall liner can be accommodated with pipe sleeves monolithically attached to the Wall Liner and conforming to the outside curvature of the as-built manhole or wet well walls.

Adjoining liner sections shall be monolithically attached using an approved thermoplastic welding method during field installation.

Polypropylene ladder rungs with integral polypropylene rung inserts shall be installed as required in Contract Documents.

3. **Flexible Cone Liner** (cone top configuration only): The prefabricated cone liner shall be constructed from one-piece homogenous polyurea compound with minimum thickness of 3 mm (1/8"). Flexibility of the baseliner shall enable it to fit through the manway opening or hatch of the structure to be rehabilitated, without damage to the Cone Liner or to the structure itself.

When installing the Cone Liner as part of a fully lined structure, with polypropylene (PP) or high density polyethylene (HDPE) wall liners, the Cone Liner shall have a smooth 3mm thick transition strip of corresponding liner material embedded into the polyurea compound around the bottom lip at the time of manufacture to provide a transition and welding surface between the flexible cone liner and the adjoining PP or HDPE concrete protective wall liner.

Flexible Cone Liners shall conform to the curvature of the as-built cone.

Lining of the manway opening chimney shall be either integral to the Flexible Cone Liner, forming a one-piece polyurea liner or separate PP or HDPE flexible liner. In the latter case, the Flexible Cone Liner shall have a smooth 3mm thick transition strip of corresponding liner material embedded into the polyurea compound around the upper lip at the time of manufacture to provide a transition and welding surface between the flexible cone liner and the adjoining PP or HDPE liner. Connection between the Flexible Cone Top Liner and the thermoplastic chimney lining shall be made monolithic using an approved thermoplastic welding method during field installation.

The flexible Cone Liner shall be accompanied with a tight-fitting extruded polystyrene pouring support which will provide temporary rigidity to the flexible liner during the grouting stage of the installation. The pouring support shall be designed in a way that will enable it to be broken down in order to fit through the manway opening of the structure of to be rehabilitated.

Flexible PP or HDPE Flat Top Liner (flat top slab configuration only): All PP or HDPE liner sheets shall be extruded with a large number of anchoring studs, a minimum of 39 per SF (420/m²), manufactured during the extrusion process in one piece with the sheet so there is no welding and no mechanical finishing work to attach the studs to the sheet. Minimum distance between studs shall be no less than 2.12". Stud height shall be no less than 13mm or 9/16". Manway or hatch opening chimneys shall be lined with the same compatible material, either PP or HDPE. Connection between the Flexible Flat Top Liner and the chimney lining shall be made monolithic using an approved thermoplastic welding method during field installation.

B. Thermoplastic Heat Welding

All fabrication and welding must be done by Predl Certified welders/fabricators in accordance with the published directives and procedures of the manufacturer. When the welding is completed and tested, the finished concrete product will be protected by a homogenous monolithic Thermoplastic Liner System that will provide excellent resistance to microbial attack, abrasion, and chemicals normally found in municipal waste water or storm water and will not pull off the wall in the event that infiltration occurs.

The following welding techniques are acceptable:

1. Extrusion Welding: Used to seal all seams inside structure, primary welding method.
2. Butt Welding: Used to fuse flat sheets together.
3. Hot Air Welding: Used as a tack weld or only in triple pass method where extrusion welding is not possible.

Testing and supervision of the fabrication, installation and welding shall only be performed by Predl trained and certified personnel and must be checked when completed by visually checking and by Spark Testing all welded joints. Spark Testing shall be performed in accordance with the equipment manufacturer's recommendations. After Spark Testing the finished liner, using a Black Magic Marker, the fabricator will sign and date wall liner and will photograph or video the welds and the signature and send copies of the photographs/video to the owner. Upon request, the Certified fabricator/welder will provide written verification of current certification.

- C. **Dimensions:** All liners shall have appropriate dimensions to conform to the inner surfaces for the as-built structures being rehabilitated, as determined by a prior 3D scan, while allowing for a sufficient annular space for grouting between the host structure and the flexible liner system. Annular space requirements shall be dictated by the contract documents but shall be no less than 1". Tolerance on the liner inside diameter shall be +/- 1% while the tolerance over individual liner heights shall be the greater of +/-1% or +/- 1/8". Allowable tolerance for invert elevation shall be 0.125" and 2% for pipe slope.

Default flexible PP or HDPE liner thickness shall be 3 mm. Other liner thickness can be accommodated, as required by the Contract Documents.

D. 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 liners shall be marked with the following information:

- 1) Manufacturer's identification;
- 2) Nominal diameter;
- 3) Manhole identification;
- 4) Installation assist marks, as required.

IV. MATERIALS

- A. **Flexible Baseline and Cone Liner:** Liner material shall be a highly reactive and solvent-free compound based on high-quality aromatic polyurea, providing a flexible, viscous and elastic finish with no visible joints. Polyurea compound quality-assurance records shall be maintained.

Liner exterior shall have flexible bonding bridges and a silica based aggregate embedded in order to optimize bonding with grout during field installation.

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

- B. **PP or HDPE Liners** (Wall Liners, Flat Top Liners, Penetration Sleeves, etc.): The material used in the liner, welding strips and other accessories shall be a combination of PP or HDPE resin, pigments and plasticizers, specially compounded to remain flexible. PP and HDPE resin shall constitute not less than 99 percent by weight of the resin used in the formulation. Liner material shall be AGRU Sure-Grip HDPE or PP. Thermoplastic welding filament shall be AGRU supplied, compatible with the liner material.
- C. **Gaskets:** Resilient materials for connectors and filler rings shall be manufactured from natural or 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 baseliner (valves, gates, etc.) shall be governed by the respective manufacturers' materials specifications.

V. MANUFACTURE

- A. Manufacturer shall have 25 years of concrete protective liner manufacturing experience and shall have fabricated and delivered at least 20,000 concrete protective liners for wastewater applications.

VI. REQUIREMENTS

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

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

Property	Standard	Units	Requirement
Thickness	--	mm	3 min.
Tensile Strength	ASTM D638	psi	1,500 min.
Hardness (Shore "A")	ASTM D2240		70
Elongation at break	ASTM D638	--	300% min.

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

Property	Standard	Units	Requirement
Density	ASTM D792	g/cm ³	0.91
Thickness	--	mm	3
Melt Flow Index (230/5)	ASTM D1238	g/10min	1.25
Liner coefficient of thermal expansion	DIN 53752	K ⁻¹ x10 ⁻⁴	1.6
Tensile Strength	ASTM D638	psi	10000 min.
Elongation at max load	ASTM D638	--	140%
Elongation at break	ASTM D638	--	250% min.
Hardness (Shore "A")	ASTM D2240		90-95
Taber abrasion test (weight loss)	ASTM D4060	--	0.1%
Pullout resistance (per anchor)	Greenbook 210-2.3.4	lbf	>300

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

Property	Standard	Units	Initial
Density	ASTM D792	g/cm ³	0.94
Thickness	--	mm	3
Melt Flow Index (190/2.16)	ASTM D1238	g/10min	<=0.1
Liner coefficient of thermal expansion	DIN 53752	K ⁻¹ x10 ⁻⁴	1.2
Tensile Strength	ASTM D638	psi	>2200 min.
Elongation at break	ASTM D638	--	300% min.
Hardness (Shore "D")	ASTM D2240		54
Pullout resistance (per anchor)	Greenbook 210-2.3.4	lbf	>300

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 PP Flow Control Gates shall have the following physical properties:

Property	Standard	Units	Requirement
Density	ASTM D792	g/cm ³	0.94
Tensile Strength	ASTM D412	psi	6,500 min.
Liner coefficient of thermal expansion	DIN 53752	K ⁻¹ x10 ⁻⁴	1.6

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 liners and gaskets used meets or exceeds the requirement of this specification.

VII. QUALITY ASSURANCE/QUALITY CONTROL

- A. **Examination:** Each liner shall be examined for dimensional requirements and workmanship
- B. **Certified facility:** Liners shall be designed and manufactured in an ISO 9001 certified manufacturing facility.

VIII. HANDLING AND STORAGE

- A. Liners shall be not be impacted.
- B. Liners shall not be exposed to direct sunlight for extended periods.

IX. INSTALLATION

- A. Predl Systems' complete Manhole Rehabilitation instructions must be followed for detailed installation instructions.
- B. Flexible Rehabilitation Liners are non-structural components. To restore or achieve the desired load rating class of the rehabilitated manhole, the engineer specified grout and steel reinforcing shall be strictly followed.