Draft Specification for
Concrete Protection Lining (CPL)
Manufactured of
High Density Polyethylene (HDPE)

1. Scope

This specification covers:

- General outline of the application,
- Preliminary requirements,
- Manufacturing and supply requirements,
- Installation in pre-cast concrete elements and cast in-situ concrete structures,
- Testing,
- Repairs

2. General Outline

Installation areas:
The function of the CPL is to protect the concrete against corrosive attack by liquids or gases.

The CPL is required to be installed to all pre-cast concrete pipes and shafts, soffits to cover slabs, chambers and landings. CPL will also be required to be incorporated in the in-situ cast walls and cover slabs to sumps, channels and tanks.

Materials:
The CPL shall be manufactured of HDPE by an approved supplier, in accordance with the properties required in section 5 of this specification.

Installation:
The CPL installation contractor must be able to prove their competence and experience and shall be certified and trained by the CPL manufacturer in accordance with their handling, installation, jointing and testing procedures.

3. Preliminary Requirements

a) CPL material:

The CPL supplier / installer will be required to submit to the Consultant, details of the lining system proposed, including installation methods, jointing and testing procedures, and the data listed below for review, at least four (4)
weeks prior to commencement of any CPL manufacturing for this project. The submission must include:

1) Details of CPL manufacturer and the source of raw materials proposed for the CPL manufacture.

2) Physical properties including all aspects covered in section 5, plus proposed colour, short / long term UV resistance properties, stress cracking resistance, available sheet thickness, and dimensions.

3) Independent tests and reports on the effectiveness of the proposed anchor system.

4) A sample of the proposed CPL material.

5) Certification from the Pre-cast Concrete Manufacturer that the proposed CPL is compatible with all aspects of his product, including his manufacturing process, concrete mix and concrete curing process.

Notification:
The Consultant is to be notified at least two (2) weeks prior to the commencement of manufacture of any lined product, to provide the opportunity to arrange an audit of the process.

b) Pre-cast Concrete Preliminary Requirements:

Submit the following information to the Consultant for review at least eight (8) weeks prior to the start of production of any pre-cast concrete elements and before manufacturing, installing, and welding of any CPL:

- Dimensions of anchor knobs and bonding mechanisms;
- Dimensions and requirements for jointing strips;
- Details of any factory jointing including test procedures;
- Details of casting and installation procedures including the detailed quality assurance procedure, location of joints and welding of the lining;
- Proposal for transport and storage to protect the liner;
- Methods and procedures to protect CPL from UV degradation;
- Final QA procedure for testing the completed CPL installation. Measures to test welded joints and frequency of testing, completeness of installation and anchor embedment, as well as measures to be taken should the testing reveal non-conformance;
- Method Statement for the repair of CPL which is damaged during construction. Include methods to repair those areas where anchors are not acceptably embedded in concrete.
- Method Statement for the repair of CPL damaged after completion of the contract.
4. Design Criteria

Thicknes: \[ XX \text{ mm (insert thickness and whether minimum or nominal).} \]

Pull-off Resistance: As specified in Table 12.1

Colour: All lining to Pre-cast Concrete Elements shall be natural / white / grey / beige/ green / black. Preference will be given to pale colours for areas which are to be permanently covered and not exposed to UV radiation. Any areas of CPL which may be exposed to sunlight for long periods, during construction or operation, must be black and fully UV stabilised.

Sheet Width: Shall be adequate to line the pre-cast concrete pipes without intermediate welds within the pipes and adequate to minimise jointing required in in-situ concrete applications.

Anchoring System: Only CPL systems which utilise anchors which are integrally and homogenously formed with the sheet during manufacturing will be accepted. No systems which utilised anchors which have been glued or welded to the liner will be accepted. The system will incorporate at least 1100 individual anchors per m² of lining. Systems utilising continuous ribbed anchoring systems will not be accepted.

Ultraviolet Protection: Pale coloured CPL which is to be installed in applications not exposed to UV shall nevertheless contain adequate protection to allow for to sunlight during transportation, storage, preparation, and on-site installation.

5. Material Properties

Material:
The CPL shall be produced of a hexene or octane polymerized grade of HDPE in accordance with GRI-GM13 standard specifications.

HDPE Properties:
The HDPE liner and welding rod shall be manufactured from the same resins and shall be manufactured to meet the specifications listed below relative to each material property:
Table 12.1 HDPE CPL Properties

<table>
<thead>
<tr>
<th>Properties</th>
<th>Test Method</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>ASTM D 792</td>
<td>g/ml</td>
<td>0.94</td>
</tr>
<tr>
<td>- Light coloured material</td>
<td></td>
<td></td>
<td>0.948</td>
</tr>
<tr>
<td>- Black material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon black content (for black material only)</td>
<td>ASTM D 1603</td>
<td>%</td>
<td>2 to 3</td>
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<tr>
<td>Carbon black dispersion (for black material only)</td>
<td>ASTM D 5596</td>
<td>category</td>
<td>1 or 2</td>
</tr>
<tr>
<td>Tensile properties</td>
<td>ASTM D 6693 Type IV</td>
<td>MPa</td>
<td>&gt;15</td>
</tr>
<tr>
<td>- Yield stress</td>
<td></td>
<td></td>
<td>&gt;20</td>
</tr>
<tr>
<td>- Break stress</td>
<td></td>
<td></td>
<td>&gt;12</td>
</tr>
<tr>
<td>- Yield elongation</td>
<td></td>
<td>%</td>
<td>&gt;500</td>
</tr>
<tr>
<td>- Break elongation</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Puncture resistance</td>
<td>ASTM D 1004</td>
<td>N/mm</td>
<td>&gt;125</td>
</tr>
<tr>
<td>OIT - Std</td>
<td>ASTM D 3895</td>
<td>minutes</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Stress Cracking Resistance – single point</td>
<td>ASTM D 5397</td>
<td>hr</td>
<td>&gt;400</td>
</tr>
<tr>
<td>Anchors per m²</td>
<td></td>
<td>#</td>
<td>&gt;1100</td>
</tr>
<tr>
<td>Resistance to pull-off per m²</td>
<td></td>
<td>T/m²</td>
<td>&gt;70</td>
</tr>
</tbody>
</table>

6. Installation

Pre-cast concrete manufacture

General:
All installation works shall be carried out in accordance with the CPL Manufacturer’s approved procedures. All joints shall be formed with the minimum overlap recommended by the CPL Manufacturer to limit unattached CPL.

CPL fitting to vertically cast pipes and elements:
Care shall be taken to ensure that the CPL is fitted to the form in such a way that no concrete is able to flow between the form and the smooth surface of the CPL. No penetrations are permitted for the attachment of the CPL to the moulds. After installation, the lining shall form a smooth surface free of ripples or other unevenness.

CPL installation to spun pipes:
The concrete pipe manufacturer shall demonstrate that their CPL installation process ensures adequate resistance to pull-off between the CPL and the concrete. The use of slurry layers will not be permitted in this process.

Curing:
Steam curing shall be controlled and limited to a maximum temperature of 50°C.
Within in-situ cast structures

HDPE Lining:
Install CPL continuously as defined in the construction Drawings.

Formwork
The formwork for insitu concrete structures to be plastic lined shall facilitate the fixing of plastic lining materials in a manner which ensures continuous support of lining materials by the formwork. Prior to placing reinforcement and concrete, the plastic lining shall be aligned so that it is free from wrinkles and bulges and securely held in place.

Installation:
Any fixing holes or protrusions are to be located within areas which will be subsequently covered by jointing or patches. They are to be kept to a minimum and approved by the Consultant. Installation shall be in accordance with the CPL Manufacturer's recommendations.

Concrete Placement and Formwork Removal:
In-situ concrete shall be placed and compacted so as to produce dense homogenous concrete which securely attaches the lining anchors and avoids damage to the lining. After concrete curing, removal of formwork shall be carried out in such a manner as to avoid damage to the lining. Sharp tools shall not be used to pry forms from lined surfaces. Any damage sustained during formwork removal shall be repaired in accordance with the CPL manufacturer's recommendations.

Lining of Floors and Benching:
The planning and installation of in-situ concrete work sequence for floor or base slabs and/or benching shall comply with the CPL manufacturer’s recommendations and shall facilitate embedment of lining anchors and release of entrapped air.

7. Jointing

Welding:
All joints shall be sealed by means of the thermal welding. The welding, equipment, procedures and preparations shall be in accordance with the CPL manufacturer’s recommendations.

Methods:
Preparation of pre-fabricated panels may be carried out using extrusion, double wedge or electronic butt welding equipment. In all cases, this is to be strictly performed in accordance with the CPL manufacturers’ recommendations by operators whose competence has been certified by the CPL manufacturer or a body acceptable to the Consultant.
Weld Configuration:
The dimensions shape and form of the welds shall be in accordance with the Manufacturer’s recommendations. The extrusion welding rod shall be supplied and approved by the CPL Manufacturer.

Patch Repairs:
All patch work shall be done using CPL compatible with the primary CPL and welded in accordance with the CPL manufacturer’s recommendations.

8. Testing of seams

Requirements:
Site welds shall be tested in accordance with the Contractor’s Inspection and Test Plan. As a minimum, all extrusion welds shall be:

Procedures:
Vacuum box tested in accordance with ASTM D 4437 and ASTM D 5641 or;
Spark tested in accordance with ASTM D 6365.

Sample Welds:
At the commencement of each shift, each machine and operator are to be tested by carrying out test welds on test strips of CPL or as required by the Consultant to illustrate that the equipment is operating correctly and appropriately set for current conditions. If welding equipment has been switched off and on again during a shift, it shall be re-tested. Destructive tests will be used to confirm that the welds achieve at least 70% of the nominal CPL strength in shear mode and at least 50% of the nominal CPL strength in peel mode. Ultimate failure may only occur within the parent material, and not at the interface between the lining sheets (for wedge welding) or the lining and the weld bead (for extrusion welding). A calibrated site tensiometer shall be available on site at all times during the jointing activity.

9. Repairs
All repair works procedures shall be developed in accordance with the CPL manufacturer’s recommendations and submitted to the Consultant. Rework or repair shall not proceed until the Consultant has accepted the proposal.