



Berolina CIP is not new to Australia, it was first introduced in 2010 and is in regular use now, however this is a new opportunity for ARTC to prolong current asset life.

**5 Significant Change or Not** (as determined by the Manager Standards) \*

This change in equipment or system is assessed as Significant.

**6 Review Panel** (as determined by the Manager Standards) \*

- John Furness - Manager Standards
- Peter Prasad - National Bridges & Structures Engineer
- Anthony Godfrey - Structures Manager, Interstate Network
- Dia-el-dean Amr - Project Engineer, Hunter Valley
- Denis Snowden - Work Health and Safety Advisor, Hunter Valley

**7 Safety**

Berolina systems are fully compliant with Australian occupation health and safety legislation in respect to Manufacture, Handling, Installation, Maintenance and exposure once installed and are also applicable to Track and Civil safety elements therefore safe for use on the ARTC rail network.

Berolina Liners are manufactured in Germany under the Company's ISO accreditation and DIBT construction approval, the product also has accreditation against ASTM F 2019-03 which is the North American standard for cured in place GRP thermosetting resin pipe.

Handling is documented in the product handling and operating manual and training is given to all operatives working with the product.

Installation is documented in the detailed project plan, Methodology and SWIMS as well as covered in the project risk assessment and risk registers.

Once installed and cured, the product is inert and has no long term exposure or maintenance issues.

**8 Performance and Suitability**

There are no current standards that specifically address the design and installation of linings to pipe and culverts under the Australian Standards.

Designs are therefore calculated to the loading requirements of AS5100 Bridge Design, and AS2566 Pt 1: design for buried flexible pipelines. Where pre start surveys reveal the presence of external voids these will be taken into the design considerations and filled prior to any installation of the liners.

ITS Pipetech's Berolina Liners are designed specifically to meet the requirements of every project as all will have differing local conditions.

All Berolina Liners currently meet the requirements of the following European and ASTM (North American) standards.

- \* D IN EN 1610: European Code for Cured in place pipeline: Air Tightness.
- \* WRc (Water Research Council) PT/331/0412-AS: Applicable standards and design requirements for type 1 and type 2 rehabilitation of UV Cured lining for diameters 150 to 1200 mm.
- \* BS EN 11296-4: & EN ISO 11296-4: European Code for the Appearance and Mechanical Testing of Flexible lining systems.
- \* D IN EN 18820 Pt 1: European Code for Polyester / Vinylester Resins
- \* D IN EN 295-3: European code for Abrasion testing
- \* D IN EN 19523: European code for High Pressure Jetting Resistance Test
- \* D IN ISO 175: European code for Water Absorption and Resistance Test
- \* MFPA Leipzig: German Fire Resistance Test
- \* D IN EN 53769: European Code for short and long term Flattening Tests
- \* D IN EN ISO 527-4: European code for Tensile Strength Test
- \* D IN EN 13591: European Code for Environmental Compatibility
- \* DIBT (German Construction Approval Standards) Z-42.3-336 National Technical Approval for UV CIP Lining systems
- \* D IN EN 14020: European code for corrosion resistant Glass Fibre
- \* ASTM F2019-03 (2009): North American Standard for Cured in Place GRP Thermosetting Resin pipe

Berolina Liners applicable to Australian Track and Civil Elements take specific guidance from the ARTC Code of Practice: Structures; section 9, This CoP is considered along side the requirements of AS5100 Bridge Design and AS2566 pt 1- Buried Flexible structural pipelines.

When considering the Berolina Liner system for a structural rehabilitation to a deteriorated under track crossing the design assesses the loadings in accordance with the specifications relevant to the Railway, the Asset owner, the Water or Road Authority and the National standards that require the liner to be designed to AS2566 pt 1 "Buried Flexible Structural Pipeline".

The structural design is the same as would be for a new flexible pipeline installed by traditional trenching open cut methodology where backfilling and embedment around the pipe develop a uniform hoop stress and ring compression to allow the pipe to flex. The design of the Berolina liner is therefore the same as with a new culvert.

Examples of previous designs in accordance with this method are appended in the accompanying Annexure.

(i) **Use in other rail networks**

In Australia, Berolina has been used for culvert rehabilitation with Calibre Rail and BHP Iron Ore in WA and with John Holland (Brookfield) Rail again in WA. Photographs of these installations are appended in the accompanying Annexure.

BKP Berolina liner is frequently used as a remediation system under rail Networks across Europe, Canada and North America.

A detailed list of previous contracts together with referees is detailed in the accompanying Annexure.

(ii) **Use in the ARTC network**

The Berolina CIP system can be used for the insitu rehabilitation of any existing pipe or conduit regardless of the host material from 150mm to 1200mm in diameter, the maximum length of section that can be relined in a single operation ranges from 30 to 200 lm in distance depending on the diameter (the smaller the diameter the further can be lined in one operation) Berolina can be used on a selection of different profiles as long as the surfaces are curved, ie Circles, Elipse, Oviform section.

Flexible Lining rehabilitation systems have previously been used on the ARTC network supplied and installed by other Contracting specialists such as has Hobas pipe which is a factory manufactured fiberglass pipe.

(iii) **Issues arising from usage of the equipment/system**

The principle issues to consider when utilising Berolina for a rehabilitation medium is : A) the intended loading and B) the presence of voids externally to the extrados of the host structure.

Pre survey investigation will determine if voiding is present and will detail the pre works required before any lining is installed.

If it is known that voiding exists, stabilisation of these voids will be required to prevent deterioration of the backfill surrounding the host and new lining.

The contractor will determine if the void filling will be undertaken either pre or post rehabilitation depending on the severity and size of the voiding and the risk to the installation.

If no voids are located or known to exist then no further consideration other than above is required.

The load determination for dead weight, track loading and Dynamic loading should be a pre requisite of the design brief issued to the designers.

(iv) **Changes required to infrastructure or systems for use of the equipment**

Following Technical approval, a change to the current ARTC procedures and management controls will be required to cover the aspects of structures inspection and technical properties of this new product.

**9 Reliability**

The production of the Berolina Lining is Internationally certified according to DIN EN ISO 9001 : 2008 and is regularly inspected by the TUV (German Technical Monitoring Association).

In order to ensure compliance continual Quality testing at the highest level is undertaken on all production batches. Alongside this continual testing of the liners is undertaken in the factory as well as on site which is covered by the site practice manual with CCTV inspection before during and post installation which is fully documented in the QA documentation.

**Fatigue**

Berolina Liner has undergone extensive testing for durability and as this is a flexible ductile liner with a high strain capability the liner is able to accommodate repeated cyclic loading far in excess of a metal structure or a thin shell unreinforced concrete liner that is designed as a composite element.

Design of Liners consider the effects of repeated cyclic loading and includes the effects of Dynamic loading in accordance with AS5100 part 2 "Bridge Design" and takes account of these fatigue effects and the reduction thereof with increased cover beneath the tracks.

**Durability**

All underground pipelines including linings are dependent on the response to:

- 1 Loading
- 2 Corrosion
- 3 Abraision
- 4 Fire Resistance
- 5 Deflection
- 6 Reactivity.

1 Loading of flexible liners infers that the lining will move and distort within permissible limits to accommodate the

loadings imposed from the ground and the train movements above the structure (Live and Dynamic load). As such the design accommodates this and the liner is sized sufficiently to withstand cracking therefore maintaining its structural integrity.

Design of Flexible liners in accordance with Australian Standard AS2566 Pt 1 and International Standards ensure that once installed the liner will not exceed its design safety tolerance and will maintain its design profile for the life of the product.

2 All Liners are designed with a resin compound specially formulated to resist corrosion and is generally resistant to most commonly encountered substances. If it is known that certain aggressive compounds will be encountered a special formulation for the resin design can be prepared to combat against this condition.

3 Abrasion is recognised as a major factor in the degradation of installed liners - Berolina linings are tested in accordance with DIN 19 565 Pt 1 and EN295-3 which requires a rotational cyclic test with a section of liner filled with granulated material inside the test piece - the success of the test must confirm that the internal surfaces remain intact with minimal loss of resin or exposure of glass fibre. Tests on the Berolina Liner after 100,000 cycles resulted in a reduction of the inner liner by an average of 0.3mm over a 1.0m \* 0.3mm bore which is inside the acceptable standard.

4 Fire resistance is an inherent property of the Berolina Liner system and the product has been subjected to extensive testing with different Igniters and accelerants. The summary is that the liner is inflammable under normal applications and will not suffer degradation in the event of exposure to a bush fire- details of the fire tests are appended in the accompanying Annexure.

5 Deflection- the lining is designed to move and deflect as load is applied which is an integral reaction with the surrounding soil and as such has a high elastic modulus which enables the material to return back to shape when loading is relieved.

6 Reactivity - The lining has a natural resistant PH range of between 4 to 12. In areas outside of this limits special resins need to be developed in the design phase.

Inspection regimes for culverts and pipes relined with Berolina cured in place pipes should be visually inspected every 4 years.

Movement up to 10% of pipe diameter are well within the operating parameters of the product.

Movement between 10 to 20% of pipe diameter need to be observed and monitored.

Movement in excess of 20% of pipe diameter need engineering advice.

The material is not Viscoelastic and has no property relative to this condition.

The Lining is designed to have a 100 year performance life.

<p>10 <b>Maintainability</b></p> <p>Pipes and Culverts that have been lined with a Berolina Liner require the minimum of maintenance. This will be typically limited to a periodic inspection either by CCTV or visual inspection subject to size and limitations on access.</p> <p>Installed linings require no special maintenance, the internal surface is self cleaning.</p>						
<p>11 <b>Approval *</b></p> <p>ITS are seeking approval of the Berolina Liner UV Cured in place pipe for under track pipes and culverts from 150 to 1200mm in profile to act as a rehabilitation technology for the preservation of under track assets across the ARTC Network.</p>						
<p>12 <b>Is the supplier accredited to ISO 9001 specifically for this product? *</b></p> <p>Details of accreditation as per the attached annexure reference ISO 9001 certificate 214-2254</p>	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>		
<p>13 <b>Conditions of Approval *</b></p> <ol style="list-style-type: none"> <li>All Berolina Liners to be manufactured by BKP Berolina GmbH of Germany and must be designed, supplied and installed by ITS in accordance with manufacturer's written instructions.</li> <li>Condition assessment of the existing structure via visual or CCTV is required to assess suitability of the liner.</li> <li>Any substantial voids around the existing structure must be grouted up prior to the installation of the liner.</li> <li>The lining shall be used only for openings between 150mm and 1200mm in profile.</li> <li>Standard liners shall be used only in areas with a natural PH range of 4 to 12. Special designed liners must be used when outside the normal PH ranges.</li> <li>The lining shall not be used in Box cell culverts.</li> </ol>						
<p>14 <b>Does the Originator accept the additional Conditions of Approval as set by the Review Panel:</b></p>	Yes	<input checked="" type="checkbox"/>	No	<input type="checkbox"/>	N/A	<input type="checkbox"/>

15 **Sign off**

*ARTC office use only*

**Review Panel:**

John Furness

**On File**

Date: **25 March 2015**

Peter Prasad

**On File**

Date: **27 February 2015**

Anthony Godfrey

**On File**

Date: **2 March 2015**

Dia-el-dean Amr

**On File**

Date: **2 March 2015**

Denis Snowden

**On File**

Date: **11 March 2015**

**Approval:**

Rob Rath (On File)

Date: 17 April 2015

Acting General Manager Technical Standards