ETHEKWINI MUNICIPALITY

ETHEKWINI WATER AND SANITATION

DEPARTMENTAL SPECIFICATION

FOR STEEL PIPES

100mm TO 2 000mm NOMINAL DIAMETER

STPIPE v13.1: DATED 2017-06-26

REVISIONS

Version No.	Section(s)	Clause(s)	Information
STPIPEv13	Rigid Polyurethane Coating	Table PCS5.2	Item 4: Corrected Frequency
	2 Layer PE Coating	PSC7 PSC7.2 Table 7.2	Amended Title Amended incorrect table reference Item 2: Corrected Requirement & Test Method
	2 Layer GRE Coating	PSC8	Added section "PSC8: Two Layer Glass-fibre Reinforced Epoxy (GRE)/Visco-elastic Polyisobutene Coating System"
STPIPEv12	Plant	A.4.3	Corrections to Repair of damage to coating/lining references
	2 Layer PE Coating	PSC7	Visco-elastic Polyisobutene (2LPE) Coating added
STPIPE v11	Tolerances & Testing	A6, A7	Updates SANS references
STPIPE v10	Rigid Polyurethane	PSC5.3	Mixing ratio of 1:1 added

INDEX TO PART A : STEEL PIPES 100MM TO 2 000MM NOMINAL DIAMETER
LIST OF CLAUSE HEADINGS

CLAUSE	HEADING	PAGE
A1	SCOPE	4
A2	INTERPRETATIONS	4
A2.1	Supporting Specifications	4
A2.2	Application	5
A2.3	Terminology	5
A3	MATERIALS	6
A3.1	Steel	6
A3.2	Internal Linings	6
A3.3	External Coatings	6
A4	PLANT	6
A4.1	General	6
A4.2	Handling	6
A4.3	Off-Loading	7
A4.4	Storage	7
A5	CONSTRUCTION	7
A5.1	Steel Pipe	7
A5.1.1	General	7
A5.1.2	Grade of Steel	8
A5.1.3	Outside Diameter of Pipes	8
A5.1.4	Weld Reinforcement	8
A5.1.5	End Preparation	8
A5.1.6	Preparation of Pipes for Coating	9
A5.1.7	Condition of Pipes	9
A5.1.8	Length of Pipes	9
A5.1.9	Marking	9
A5.2	Internal Linings	10
A5.3	External Coatings	10
A6	TOLERENCES	10
A7	TESTING	10
A7.1	Steel Pipe	10
A7.2	Internal Linings	11
A7.2.1	External Coatings	11
A7.3	Inspection of Manufacture and Material Delivery	11
A7.3.1	Quality Control	11
A7.3.2	Quality Surveillance	11
A8	MEASUREMENT AND PAYMENT	11

APPENDIX A:	APPROVED INTERNAL LINING SYSTEMS	13
APPENDIX B:	SPECIFICATION DETAILS FOR INTERNAL LININGS	14
APPENDIX C:	APPROVED EXTERNAL COATING SYSTEMS	21
APPENDIX D:	SPECIFICATION DETAILS FOR EXTERNAL COATING SYSTEMS	22

PART A : STEEL PIPES 100mm TO 2 000mm NOMINAL DIAMETER

A.1 SCOPE

This specification covers the material and manufacturing requirements for electric welded low carbon steel pipes in sizes 100mm to 2 000 mm nominal diameter to be buried in soil and to be used for the conveyance of potable water. The pipes shall be internally lined and externally coated with systems selected from Appendices A to D. The requirements of SANS 1217 'Guidelines for internal and external organic coating protection for buried pipelines' shall apply to all coating and lining activities. Where there is conflict between this document and the SANS specification, the requirements of this document will prevail.

A.2 INTERPRETATIONS

A.2.1 Supporting Specifications

Reference to Standard Specifications and Codes of Practice shall be deemed to be references to the latest issues or amendments of the relevant Specifications and Codes at the time of tender.

Any reference to a South African Standard shall be deemed to include approved equivalent International Standards. Copies of the South African National Standards specifications (S.A.N.S.) can be obtained from:
S A Bureau of Standards
Private Bag X191
PRETORIA 0001
SOUTH AFRICA

S.A.N.S.62-1 Steel Pipes Part 1: Pipes suitable for threading and of nominal size not exceeding 150 mm.

S.A.N.S.62-2 Steel Pipes Part 2: Screwed pieces and pipe fittings of nominal size not exceeding 150 mm.

S.A.N.S.719 Electric welded low carbon steel pipes for aqueous fluids (large bore)

S.A.N.S.1083 Aggregate from natural sources – Aggregate for concrete

S.A.N.S.1117 Plastic wrappings for the protection of steel pipelines.

S.A.N.S.1217 Guidelines for internal and external organic coating protection for buried pipelines.

S.A.N.S.1224 Polish stripper.

S.A.N.S.1365 Solvent degreaser that contain chlorinated hydrocarbons.

S.A.N.S.2808 Paints and Varnishes – Determination of film thickness

S.A.N.S.5767 Cleanliness of blast-cleaned steel surfaces for painting (assessed by pictorial standards)

S.A.N.S.5769 Cleanliness of blast-cleaned steel surfaces for painting (assessed by freedom from dust and debris)

S.A.N.S.5772 Profile of blast cleaned steel surfaces for painting (determined by micrometer profile gauge)

S.A.N.S.5863 Concrete Tests – Compressive strength of hardened concrete.

S.A.N.S.10129 Plastic tape wrapping of steel pipelines.

A.S. 4321 (Australian Standard) Fusion-bonded medium-density polyethylene coating and lining for pipes and fittings – 1995

ASTM D2370-82 Tensile Properties of Organic Coatings.

ASTM D2240 Standard Test Method for Rubber Property (Durometer Hardness)

ASTM D4541 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

ASTM D5162 Standard practice for discontinuity (holiday) testing of nonconductive protective coating on metallic substrates

ASTM G8 Standard Test Methods for Cathodic Disbonding of Pipeline coatings.

ASTM G14 Direct and Reverse Impact

BS 3900 Part F3 Resistance to artificial weathering (enclosed carbon arc)

BS 3900 Part F4 Resistance to continuous salt spray.

CAN/CSA-Z245.20-02 (National Standards of Canada) External Fusion Bond Epoxy Coating for Steel Pipe.

CAN/CSA-Z245.21-02 (National Standards of Canada) External Polyethylene Coating for Pipe.

GBE/CW6: Part 1 (British Gas) Requirements for Coating Materials and Methods of Test

ISO 4624 Paints and varnishes – Pull off test for adhesion

ISO 8501-1 Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness.

NACE RP0394 Application, Performance, and Quality Control of Plant-applied, Fusion-Bonded Epoxy External Pipe Coating

A.2.2 Application

The pipes supplied are to be used for the transportation of potable water and shall be internally lined and externally coated with systems selected from Appendices A and B respectively. The length, size, wall thickness, grade of steel and type of lining and coating required shall be as detailed in the schedule of technical requirements which forms part of these tender documents.

A.2.3 Terminology

For the purposes of this contract the client is defined as being eThekwini Water and Sanitation.

Reference made to the "Head: eThekwini Water and Sanitation " shall also imply any official appointed by eThekwini Water and Sanitation.

Whenever the terminology "approved by eThekwini Water and Sanitation", "to the satisfaction of eThekwini Water and Sanitation", etc., is used, it shall also imply that such work is to the satisfaction and approval of an independent inspectorate body appointed by the eThekwini Water and Sanitation to carry out Quality Assurance on any materials and goods covered by this contract.

A.3 MATERIALS

A.3.1 Steel

Steel from which the pipes are to be manufactured shall comply with clause 3 of S.A.N.S. 719, API Line Pipe Specification or an equivalent International Standard and shall be one of the following grades:

i) Grade X -42
ii) Grade X -52
iii) Grade X -65

The Contractor shall, if required by the Head: Water and Sanitation, provide certificates covering the chemical analysis and physical properties of the steel used in the manufacture of the pipes.

A.3.2 Internal Linings

Appendix A lists the approved internal lining systems. Appendix B contains the specification details for each system.

A.3.3 External Coatings

Appendix C lists the approved external coating systems. Appendix D contains the specification details for each system.

A.4 PLANT

A.4.1 General

As this contact includes not only the manufacture of the pipes but also their delivery, off-loading and stacking, it is of prime importance that the pipes and the protective systems are not damaged. Any damaged pipes may be rejected or acceptance by eThekwini Water and Sanitation may be withheld until such damages are reinstated to the full satisfaction of the Head: eThekwini Water and Sanitation.

A.4.2 Handling

Coated pipes shall be moved with the use of padded slings of width sufficient to prevent damage to the coating. Chain slings, hooks, wire ropes, rope slings without canvas covers, composition belt slings with protruding rivets, and any other equipment liable to damage the coating shall not be used. Lifting centres shall not be less than 6m apart. To ensure that coated pipes do not bear against each other whilst being transported, use shall be made of a resilient material as dunnage

which shall not disintegrate or deteriorate when exposed to the elements for prolonged periods. The pipes shall be stacked with a minimum clearance of 50mm between adjacent pipe walls.

The pipes shall be stacked in a manner that limits the loading on the lower layer of pipes. Any pipe showing permanent ovality due to surcharge loading shall be rejected. Stacking of smaller diameter pipes within larger diameter pipes will be accepted for unlined/uncoated pipes. This method of stacking will not be accepted for pipes which are lined and coated unless adequate dunnage is provided to prevent damage to the coating and lining. All ropes used for fastening shall be so padded as to prevent damage to the coating.

A.4.3 Off-Loading

The Contractor shall be responsible for off-loading the pipes at the pipe yard and shall ensure that the plant used shall be such that no pipe shell is over-stressed. Any pipes showing signs of damage to the coating are to be repaired as specified in the relevant lining/coating specification, where applicable - and such repaired surfaces "Holiday" tested prior to stacking.

All pipes are to be lifted with the aid of a "spreader" lifting beam and special care is to be taken to ensure that no damages occur to the pipe coatings by preventing the pipes from sliding on or hitting adjacent pipes.

Slings as specified in clause A.4.2 above shall be suitably rated for the loads to be handled and in good condition. The use of deteriorating and frayed slings is prohibited.

A.4.4 Storage

Dunnage as specified in clause A.4.2 shall also be used in the stacking of the pipes at the pipe yard on delivery, and the Contractor shall provide sufficient bags so that the pipes can be stacked a minimum of 300mm clear of the ground and do not touch each other. Pipes in 6m lengths shall be stacked with a minimum of 2 dunnage supports. Pipes in 9m and 12m lengths shall be stacked with a minimum of 3 dunnage supports (i.e. one support at each pipe end and one at midspan). Pipes in 18m lengths shall be stacked with a minimum of 4 dunnage supports (i.e. one support at each pipe end and one 6m from each pipe end). Stacked pipes shall have a minimum clearance of 50mm between adjacent pipe walls.

A.5 CONSTRUCTION

A.5.1 Steel Pipe

A.5.1.1 General

All pipes shall be manufactured in accordance with S.A.N.S. 719 (for pipes larger than 150mm nominal diameter) and in accordance with S.A.N.S. 62 (for pipes 150mm nominal diameter and smaller), and shall be coated and lined as detailed in the schedule of technical requirements and in accordance with the technical specification of the product manufacturer and the attached technical specification.

Wherever there is conflict of requirements of the eThekwini Water and Sanitation specification shall prevail.

A.5.1.2 Grade of Steel

All pipes larger than 150mm nominal diameter shall be manufactured from the grade of steel specified in the Schedule of Technical requirements and in accordance with S.A.N.S. 719 and all pipes 150mm nominal diameter and smaller in accordance with S.A.N.S. 62 and shall be medium class unless otherwise specified in the Schedule of Technical requirements.

A.5.1.3 Outside Diameter of Pipes

The following standard outside diameter of pipes shall be used:

Nominal Internal Diameter (mm)	Standard Outside Diameter (mm)
100	114
150	165
200	219
250	273
300	324
400	406
500	508
600	610
700	711
800	813
900	914
1 000	1 016
1 200	1 220
1 400	1 420
1 800	1 820
2 000	2 020

In order to match existing pipes, non-standard outside diameter pipes may be required as detailed in the schedule of technical requirements which forms part of this tender document.

A.5.1.4 Weld Reinforcement

The shape of welds shall be gently convex and the height of the weld reinforcement shall not exceed 1mm internally and 3mm externally. Undercuts, sharp protrusions, blowholes and discontinuity of reinforcement are not permitted.

All pipes of 200mm nominal diameter or less shall be scarfed.

A.5.1.5 End Preparation

All pipes up to and including 250mm nominal diameter shall have plain ends free from indentations and projections for a length of 150mm.

All pipes from 300mm nominal diameter up to and including 600mm nominal diameter shall have one end plain and one end belled as indicated in Fig.1 attached hereto. The inside diameter of the bell shall be 3mm larger than the outside diameter of the pipe.

All pipes over 600mm nominal diameter shall have their ends finished for butt welding with a width of root face 1,6mm (+ 0,8mm) and bevelled at an angle of 30º (+5 º - 0 º).The ends shall be free of indentations and projections for a length of 50mm.

All pipe ends shall conform with the tolerances specified in clause A.6 of this specification.

A.5.1.6 Preparation of Pipes for Coating

The fabricator of the pipes shall ensure that each pipe complies with the following requirements:

i) Weld splatter shall have been removed by chipping or grinding to a smooth surface flush with the surrounding steel.
ii) Weld seams shall have a smooth contour, free from sharp edges, protrusions and undercuts.
iii) Sharp edges and protrusions shall have been removed by grinding to a smooth radius of curvature of not less than 3mm.
iv) The pipe shall have been approved for compliance with all the requirements for the pipe specification after completion of work required to comply with clauses (a) to (c) above.

A.5.1.7 Condition of Pipes

All pipes to be coated shall be in Rust Condition A to C of ISO 8501-1. Pipes in rust condition D will be rejected.

A.5.1.8 Length of Pipes

Pipes shall be 6m, 9m, 12m or 18m long as specified in the Schedule of Technical requirements. Should pipes be supplied in lengths which differ from those specified above, the total length to be ordered will be adjusted to a multiple of the nearest whole pipe length.

A.5.1.9 Marking

All pipes shall be clearly marked in characters not less than 40mm in height (for pipes 500 mm NB or larger) or not less than 25 mm in height (for pipes up to and including 450 mm NB), with the contract number, the nominal diameter and the plate thickness in durable yellow paint on a durable black background.

Steel pipes fabricated from material other than Grade B steel are to be marked externally with 50mm wide bands of enamel paint, (traffic yellow), both at the quarter and mid points of the pipe as follows:

Grade X42 steel - one band
Grade X52 steel - two bands
Grade X65 steel - three bands

In addition to the above each pipe shall be marked, by hard stamping the contract number, the relevant item number and the pipe number onto the external face of each pipe. The information shall be stamped within 50mm of the pipe end and adjacent to the weld seam. On pipes from

300mm nominal diameter up to and including 600mm nominal diameter the information shall be stamped on the belled end.

e.g. WS.5482/ (Item Number)/(Pipe Number)

The characters shall not be less than 5mm in height.

A.5.2 Internal Linings

The internal linings shall be applied in strict accordance with the requirements specified for each generic system in Appendix B.

A.5.3 External Coatings

The external coatings shall be applied in strict accordance with the requirements specified for each generic system in Appendix D.

A.6 TOLERANCES

The required tolerance and method of measurement shall be as described in Sections 5 and 6 of S.A.N.S 719. The natural sagging of the pipe shall be calculated using the empirical Mannesmann formula:

$$\text{Natural sagging (h)} = \frac{Dm^4}{t^2} \times 1{,}312 \times 10^{-6}$$

where Dm = mean diameter
t = wall thickness

A.7 TESTING

A.7.1 Steel Pipe

The steel pipe shall be subject to all tests specified in terms of:

i) clause 6 of S.A.N.S. 719 for pipes 200mm nominal bore and greater
ii) clause 5 of S.A.N.S. 62 for pipe 150mm nominal bore and smaller.

All pipes shall be hydraulically tested in accordance with:

i) clause 7.3 of S.A.N.S. 719 for pipes 200mm nominal bore and greater
ii) clause 5.2 of S.A.N.S. 62 for pipes 150mm nominal bore and smaller

The hydraulic test pressure shall be in accordance with:

i) clause 5.2.4 of S.A.N.S. 719 for pipes 200mm nominal bore and greater
ii) clause 5.2 of S.A.N.S. 62 for pipes 150mm nominal bore and smaller

Hydraulic test certificates shall be provided for each pipe, the pipe number being indicated on the test certificates.

A.7.2 Internal Linings

The performance criteria and frequency of testing shall be as specified for each generic system in Appendix B.

A.7.3 External Coatings

The performance criteria and frequency of testing shall be as specified for each generic system in Appendix D.

A.7.4 Inspection of Manufacture and Material Delivery

A.7.4.1 Quality Control

The Contractor shall ensure that all materials used in the execution of the contract comply with the technical requirements specified.

The Contractor shall maintain accurate and up to date records of all materials, processes, process parameters and measurements necessary to ensure compliance with this specification.

A.7.4.2 Quality Surveillance

eThekwini Water and Sanitation may appoint an independent body to carry out Quality Surveillance on its behalf. The Contractor shall provide all facilities and access to premises at all reasonable times as may be necessary for the independent inspectorate to carry out its function. The cost of Quality Surveillance shall be borne by eThekwini Water and Sanitation, except for surveillance resulting in rejection or a fruitless call when the cost incurred will be back charged to the Contractor.

Advance notice of a minimum of 24 hours shall be given by the Contractor to the appointed inspectorate body when requesting inspection of any portion of the goods for acceptance, and a minimum of 3 working days before commencement of the contract.

The Contractor's quality control records shall be available for inspection at all times. Copies of these records shall be made available on request.

Notwithstanding any surveillance carried out by eThekwini Water and Sanitation or its appointed representative, the Contractor shall retain full responsibility for the quality of the goods supplied under the contract.

All pipes shall be inspected on delivery to eThekwini Water and Sanitation stores and all defects shall be made good by the Contractor at his expense.

A.8 MEASUREMENT AND PAYMENT

No payment shall be made until satisfactory test certificates have been provided. Such certificates shall be posted under separate cover and not dispatched with the deliveries of pipes.

APPENDIX A: APPROVED INTERNAL LINING SYSTEMS

Specification Number	Lining Type	Page No
PLS 1	Solvent free liquid epoxy lining	13
PLS 2	Cement mortar lining	20

APPENDIX B: SPECIFICATION DETAILS FOR INTERNAL LININGS

PLS 1: Solvent Free Epoxy Lining System

PLS1.1 Approval of Supplier

The epoxy lining shall be a solvent free liquid epoxy, Copon Hycote 162 PW, Sigmalining SF23 (7623), Pipecoat SF or a similar approved liquid epoxy lining. The approved supplier shall be S.A.N.S. 9001 certificated.

The brand type or grade, and the supplier of the solvent free liquid epoxy to be used shall be approved in writing by eThekwini Water and Sanitation. To obtain approval, the supplier shall:

i) provide independent test results in writing that demonstrate that the proposed lining material is capable of meeting the requirements specified in Table PLS1.1.

ii) provide an Infrared Scan fingerprint for the material to be retained as a standard for comparison for all subsequent batches supplied to eThekwini Water and Sanitation.

To maintain their approved status, suppliers will carry out the above tests on an annual basis and submit their results to eThekwini Water and Sanitation for approval.

PLS1.2 Approval of Batches

Each batch of epoxy paint to be used by the applicator shall be approved by eThekwini Water and Sanitation before use. No change in formulation of the liquid epoxy is permitted without prior approval of eThekwini Water and Sanitation. Such approval shall not exonerate the Contractor from the due performance of the paint systems in terms of this specification.

The manufacturer shall supply Quality Control Certificates and Infrared Scan fingerprints for each batch of material supplied. The Quality Control Certificates shall include results of tests carried out in accordance with the manufacturer's approved procedures. The number of epoxy paint batches shall be kept to a minimum so as to avoid excessive costs being incurred with the Quality Control testing required prior to application of the products.

Pipes lined with epoxy paint products that have not been approved by eThekwini Water and Sanitation may be rejected.

PLS1.3 Preparation and Cleaning of Pipe

i) Degreasing

Pipes shall be degreased internally (and externally) by the use of an approved water rinsable solvent degreaser or by passing the pipes over gas burners to carbonise contaminants.

Abrasive used for blast cleaning shall be free from oil or grease, as shall be the compressed air used in air blast cleaning.

ii) Blast Cleaning

The interior surface of the pipe shall be blast cleaned by centrifugal or air blast cleaning methods, then vacuum cleaned or blown off to achieve the following standards:

a) Cleanliness shall be equal to Sa3 of ISO 8501-1 when tested in accordance with S.A.N.S. Method 767.

b) The profile produced by blast cleaning shall be angular and shall have an average peak to valley height of 50 to 100 micrometers (or as recommended by the approved supplier), when tested in accordance with either S.A.N.S. 5772 or Testex Replica Tape.

Hackles shall be removed with coarse abrasive paper.

c) Residual dust and debris shall not exceed 0,2% when tested in accordance with S.A.N.S. 5769.

d) Water soluble salts shall not exceed 100mg/m^2 at any point when tested with the Weber-Reilly Reagent.

e) Any laminations revealed by blast cleaning shall be ground out and reblast cleaned to meet the requirements given in (a) to (d) above. If grinding penetrates the steel to a depth greater than 8% of the nominal wall thickness, the pipe shall be rejected.

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be clean and free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Lining

The blast cleaned surface shall be stopped off or cut back by suitable masking which shall not contaminate the cleaned surface, to 50mm from both ends of the pipe.

v) Protection of Uncoated Pipe Ends

All pipe surfaces left unlined due to cut back of the solvent free liquid epoxy lining shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 15 to 25 micometers. This coating shall overlap the lining by 20mm.

PLS1.4 Application of Lining

i) Method of Application

The two components shall be thoroughly and completely mixed in the proportions specified by the manufacturer. Application shall be by dual feed hot airless equipment or by single component airless equipment, as appropriate and as recommended by the

material manufacturer. The lining shall be applied in a uniform manner and, when cured, shall comply with all the appropriate requirements of the specifications.

The specified thickness shall be achieved in one application for solvent free epoxies. In the event of the thickness being less than the minimum specified the lining shall be removed and the pipe length shall be reblasted and relined to comply with the specification.

The specified thickness may be achieved in multicoat applications for solvent borne epoxies. When more than one coat is applied, the time interval between coats shall be not less than the minimum, nor greater than the maximum specified by the manufacturer and appropriate to the pipe surface temperature.

Applicators are recommended to measure wet film thickness at the time of application to avoid rejection or recoating when the dry film thickness is outside the specified limits of the specification.

ii) Thickness of Lining

The pipes shall be lined to a dry film of a minimum of 300 and a maximum of 500 micrometers with a solvent free liquid epoxy as specified.

iii) Cut Back of Lining

The lining shall be cut back as specified in clause PLS1.3(iv).

iv) Repairs

Repairs of electrical insulation defects may be carried out provided that the number of repairs necessary does not exceed 20 per 12 metre length of pipe.

A cluster of pinholes within a radius of 25mm shall be regarded as one defect.

Any pipe needing repairs in excess of the number given above or where the lining shows any sign of flaking or loss of adhesion shall not be repaired. The lining shall be removed and the pipe length shall be reblasted, cleaned and recoated to comply with the requirements of the specification.

v) Method of Repair

When repairs are permissible, the following method shall be used.

a) Abrade an area at least 25mm diameter around and beyond the defective area.

The abrasive paper shall not be coarser than 220 mesh but preferably 400 mesh. It shall preferably be used wet to avoid excessive removal of coating.

The repair area shall be smoothly feathered into the surrounding sound area. The repair area shall be abraded to a matt finish, free from deep scratches and excessive removal of coating.

After abrasion, the area shall be wiped clean with M.E.K. or other suitable clean solvent and allowed to dry.

b) Repair material shall be solvent free epoxy repair material sourced from the supplier of the lining being repaired and approved by the eThekwini Water and Sanitation. The colour shall differ from the colour of the epoxy lining. It shall be thoroughly mixed in the correct proportions as recommended by the supplier. The materials shall be sufficiently thixotropic that 500 micrometres dry film thickness can be achieved in one application without sagging. If this requirement is not achieved, the material shall be rejected.

c) Repair material shall be mixed in the proportions supplied by the manufacturer. No splitting of packs shall be permitted unless the material is supplied in self metering packs.

The mixed repair material shall be applied to the clean, dry, abraded repair area so as to cover the defect and extend to within 1 or 2mm of the edge of the abraded area. A "halo" of abraded area shall be visible around the repair material.

d) After curing, the repair and at least 250mm surrounding area shall be tested for electrical insulation defects as specified in the contract. There shall be no electrical insulation defects.

PLS1.5 Performance Criteria

The applied solvent free lining shall comply with all the requirements given in TABLE PLS1.1.

PLS1.6 Frequency of Testing

Tests 1 to 3 of TABLE PLS1.1 shall be applied to each and every pipe.

Tests 4, 5(a) and 6 shall be applied to at least one pipe selected at random from the first day's production or from each batch of liquid epoxy, whichever is more frequent.

Tests 5(b) shall be applied to at least one pipe or sample panel from each lining application run. A lining application run is defined as the continuous operation of the twin feed airless spray equipment from start-up to shut-down.

TABLE PLS1.1: REQUIREMENTS OF CURED SOLVENT FREE EPOXY LINING

PROPERTY	REQUIREMENT	TEST METHOD
1. Visual	Smooth glossy or semi glossy finish, free from excessive runs, sags, orange peel, occlusions or other visible defects	Use an experienced observer. Runs may not exceed 600 micron in thickness.
2. Coating Thickness	Min. 300 Max 500 microns Thickness readings outside this range will be assessed in terms of S.A.N.S. 1217 Clause 5.1.2. using a ± 20% criteria	S.A.N.S. Method 141. Take a minimum of 2 readings per m^2 of surface up to 300mm nominal dia., or 1 reading per m^2 over 300mm.
3. Electrical Insulation Defects	Lining: Nil defects at 90 Volts, 2 MegaOhm	S.A.N.S. 1217 Section 8.12.1
4. Impact Resistance	No defect at 1 Joule	S.A.N.S. 1217 Section 8.7 but modified as given in Note 1 below
5. Degree of Cure: (a) Static Test	No softening or discolouration when fully cured	S.A.N.S. 1217 Section 8.9. Cure time shall be in accordance with the manufacturer's data
(b) Dynamic Test	No softening or discolouration when fully cured	50 double rubs with cotton wool swab soaked in MEK. Cure time shall be in accordance with the manufacturer's data See Note 2 below.
6. Adhesion (Hot water soak)	Disbonded length not to exceed 15mm from point of V	Immerse in water at 75° C for 48 hr. Remove and make V-cut at 30 degree angle. Test adhesion when cooled to 25 ° C See Note 3 below.

NOTE 1:
Impact resistance shall be carried out on a sample of production pipe firmly clamped and chocked (to be rebound free) to a rigid base. No electrical insulation defects shall be detected at the point of impact when tested at 1 Joule.

NOTE 2:
The Degree of Cure - Dynamic Test is required to confirm that the lining applied to the pipe has the correct ratio of base to curing agent as determined by the settings on the twin feed airless spraying equipment. An >off-ratio mix produces a defective lining. To enable this test to be carried out timeously, sample panels (See Note 3 below) with a maximum coating thickness of 250 micron may be force cured at 60°C for 4 hours, allowed to cool to ambient temperature, and then tested.

NOTE 3:
Tests to be carried out on a coupon cut from the pipe or a certified test panel coated during the same lining application run as the pipe. Additional tests may be required at the discretion of eThekwini Water and Sanitation.

PLS 2: Cement Mortar Lining System

PLS2.1 Cement-Mortar Lining

Cement shall comply with S.A.N.S. 471 while the aggregate shall comply with S.A.N.S. 1083 in respect of organic impurities and dust content.

PLS2.2 Thickness of Lining

a) Pipes up to and including 150mm nominal diameter: 6mm

b) Pipes greater than 150mm nominal diameter up to and including 300mm nominal diameter: 10mm

c) Pipes greater than 300mm nominal diameter up to and including 600mm nominal diameter: 12,5mm

d) Pipes greater than 600mm nominal diameter up to and including 1 200mm nominal diameter: 19mm

e) Pipes greater than 1 200mm nominal diameter: 25mm

PLS2.3 Cut Back of Lining

For diameters up to and including 250mm the lining shall run the total length of the pipe and shall finish square with the end of the pipe.

For diameters from 300mm up to and including 600mm (i.e. belled end pipe), the lining shall be stopped-off flush with the plain end and at the start of the bell section as indicated in Fig. 1. attached hereto.

For diameters of 700mm and larger the lining shall be stopped-off or cut back 50mm from the ends of the pipe.

PLS2.4 Protection of Uncoated Pipe Ends

All pipe surfaces left unlined due to cut back of the cement-mortar lining shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 25 micrometres.

PLS2.5 Cleaning of Pipe

All surfaces to be cement mortar lined shall be cleaned as follows:

a) Weld spatter shall be removed by chipping or minimal grinding or both.

b) Gross deposits of grease and oil shall be removed by scraping and wiping with cloths soaked in white spirit or a similar solvent.

c) The pipe shall be degreased internally by the use of a water rinsable solvent degreaser such as that complying with S.A.N.S. 1244 or, for use in enclosed systems, with S.A.N.S.

1365. After complete removal of oil or grease contamination, the pipe shall be thoroughly washed with clean potable water to remove all residues. The surface shall be water break free.

PLS2.6 Mixing of Cement-Mortar

The ratio of cement to aggregate shall be 1:2 by mass or richer. The water cement ratio shall be approximately 45:100. Only clean fresh water shall be used, and the cement-mortar shall be free from all foreign matter. Only freshly mixed concrete shall be used. The maximum size of aggregate shall not exceed one third the thickness of the lining. The mortar shall be mixed in batches and shall be placed within 1 hour from the time of discharge from the mixer. Re-tempering by the addition of water or other material will not be permitted.

From each batch of cement-mortar, three 150mm test cubes shall be prepared, the cubes being thoroughly vibrated, in accordance with S.A.N.S. Method 863.

When tested after 28 days curing, the compressive strength shall not be less than 30 MPa.

PLS2.7 Lining of Pipe

The cleaned pipe shall be lined by either drag trowel or spinning methods. The resultant lining shall be smooth and of uniform thickness not less than that specified in clause A.5.3.1.

The Contractor shall take whatever measurers are necessary to compensate for any bow along the pipe which will give rise to variation of lining thickness greater than the permissible tolerance (see Clause A.5.3.8)

PLS2.8 Curing of Cement-Mortar

After lining, the pipes shall be closed with approved waterproof end caps or similar means and the pipe shall be left undisturbed for 48 hours for the cement mortar to set.

After 48 hours the lining shall be sprayed with water, and shall be kept moist for 7 days. Pipes shall not be dispatched within 7 days of the date of applying the lining.

During the application and the curing of the cement-mortar lining, the pipes shall be kept covered or protected from direct sunlight to avoid "baking" of the mortar lining and the formation of excessive shrinkage cracks and disbondment.

PLS2.9 Appearance and Quality

Cement-mortar linings shall be smooth and even. The thickness tolerance shall be within $\pm$3mm for pipe 100mm up to and including 250mm diameter and $\pm$4mm for pipe larger than 250mm nominal diameter.

All defects such as substandard surface finish, thin spots, cracking as a result of impacts and spalling shall be cut out and replaced to the full required thickness of the lining.

Temperature and shrinkage cracks in the mortar lining less than 1,5mm in width need not be repaired. Cracks wider than 1,5mm shall be chipped back and the lining replaced to the full required thickness.

PLS2.10 Reinforcing

No reinforcing mesh will be required for the cement-mortar lining of pipes up to and including 1 000mm diameter unless specifically called for in the Special Conditions of Contract.

Cement-mortar lining to pipes of diameter greater than 1 000mm shall be reinforced by means of a welded or woven steel wire mesh.

The wire shall be 3mm in diameter and spaced at 100mm centres both ways.

The reinforcing shall be secured by adequate tack welding to the pipe to ensure that it is not displaced during the lining procedure.

APPENDIX C: APPROVED EXTERNAL COATING SYSTEMS

Specification Number	Coating Type	Page No
PCS 1	Fusion bonded epoxy powder	22
PCS 2	Fusion bonded medium density polyethylene powder	29
PCS 3	Bitumen/polyolefin sleeve duplex coating	36
PCS 4	3 Layer polyethylene pipe coating system	39
PCS 5	Rigid polyurethane coating	46
PCS 6	Polyamide 11 (Nylon 11) thermoplastic lining and coating for 100 to 300 mm piping	50
PCS 7	Two layer Polyethylene / Visco-elastic Polyisobutene Coating system (2LPE)	54
PCS 8	Two layer Glass-fibre Reinforced Epoxy / Visco-elastic Polyisobutene Coating system (2LGRE)	60

APPENDIX D: SPECIFICATION DETAILS FOR EXTERNAL COATING SYSTEMS

PCS 1: Fusion Bonded Epoxy Powder

PCS1.1 Approval of Supplier

The epoxy coating shall be a fusion bonded epoxy powder coating, Interpon PCL 331, Vedoc VPC 2001, BASF Basepox PE50-1080 or a similar approved fusion bonded epoxy powder.

The brand type or grade, and the supplier of the powder to be used shall be approved in writing by eThekwini Water and Sanitation. To obtain approval, the supplier shall provide independent test results in writing that demonstrate that the powder is capable of meeting the requirements 1 to 20 specified in Table PCS1.1. Following initial approval, eThekwini Water and Sanitation reserves the right to have any or all of the tests repeated on an annual basis in order to confirm that formulation changes have not been made.

PCS1.2 Approval of Batches

Each batch of powder supplied to the applicator shall be approved by eThekwini Water and Sanitation. No change in formulation of powder is permitted without prior approval of eThekwini Water and Sanitation. Such approval shall not exonerate the Contractor from the due performance of the coating system in terms of this specification.

The manufacturer shall supply Batch Conformance Certificates for each batch, which shall include results of tests 1, 2, 3, 4, 7, 8, 9, 10, 11, and 12 of Table PCS1.2. The number of batches shall be kept to a minimum so as to avoid excessive costs being incurred with the Quality Control testing required prior to application of the product.

Pipes coated with powder that has not been approved by eThekwini Water and Sanitation may be rejected.

PCS1.3 Preparation and Cleaning of Pipe

i) Degreasing

Pipes shall be degreased externally (and internally) by the use of a water rinsable solvent degreaser or by passing the pipes over gas burners to carbonise contaminants.

The pipes shall then be abrasive blast cleaned.

Abrasive used for blast cleaning shall be free from oil or grease, as shall be the compressed air used in air blast cleaning.

ii) Blast Cleaning

The exterior surface of the pipe shall be blast cleaned by centrifugal or air blast cleaning methods, then vacuum cleaned or blown off to achieve the following standards:

a) Cleanliness shall be equal to Sa3 of ISO 8501-1 when tested in accordance with S.A.N.S. 5767. Cleanliness equal to Sa2½ will be allowed when recommended by the approved powder manufacturer and quoted in his Product Data Sheet.

b) The profile produced by blast cleaning shall be angular and shall have an average peak to valley height of 40 to 90 microns (or as recommended by the approved supplier), when tested in accordance with S.A.N.S. 5772.
Hackles shall be removed with coarse abrasive paper.

c) Residual dust and debris shall not exceed 0,2% when tested in accordance with S.A.N.S. 5769.

d) Water soluble salts shall not exceed 100mg/m^2 at any point when tested with the Weber-Reilly Reagent.

e) Any laminations revealed by blast cleaning shall be ground out and reblast cleaned to meet the requirements given in (a) to (d) above. If grinding penetrates the steel to a depth greater than 8% of the nominal wall thickness, the pipe shall be rejected.

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be clean and free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Coating

The blast cleaned surface shall be stopped off or cut back by suitable masking which shall not contaminate the cleaned surface as follows:

a) All pipes up to and including 250mm nominal diameter - 100mm from both ends of the pipe.

b) All pipes from 300mm nominal diameter up to and including 600mm nominal diameter - 50mm from the belled end of the pipe and 100mm from the plain end of the pipe. (See Fig. 1).

c) All pipes larger than 600mm nominal diameter - 100mm from both ends of the pipe.

v) Protection of Uncoated Pipe Ends

All pipe surfaces left uncoated due to cut back of the fusion bonded epoxy powder coating shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 25 microns. This coating shall overlap the fusion bonded epoxy powder coating by 20mm.

vi) Chemical Treatment

Chemical pre-treatment of the blast cleaned pipe surface may be applied provided that:

a) The process to be used is approved by eThekwini Water and Sanitation in writing.

b) The process is applied in a manner and in such quantity as is specified by the manufacturer of the powder.

vii) Heating of the Pipe

Heating of the pipe shall be affected by heat soak in an oven or by the use of electric induction coils provided that:

a) The pipe surface is not contaminated by fumes, soot deposition, acid deposits or other harmful contamination

b) The pipe surface is not discoloured by excessive heat

c) The surface temperature of the pipe is uniform and does not vary by more than ±5° C from optimum coating temperature when measured immediately prior to coating. Pipe temperature shall not exceed 275° C at any point.

d) Infra red pyrometers shall be calibrated by measurement of pipe temperature by thermocouple, heat sensitive crayon or other approved method.

PCS1.4 Application of Coating

i) Method of Application

Powder shall be applied by electronic spray guns whilst the pipe is rotated and moved forward on a suitable conveyor. The number and grouping of the guns, distance from the pipe surface, angle of projection, air pressure, conveyor speed and other variables shall be determined by the Contractor to obtain a uniform application on each pipe such that the coating complies with the requirements of the specification.

Powder shall pass through a magnetic separator (which shall be regularly cleaned) in order to remove any iron or steel particles.

Powder reclaimed from the spray booth shall not be mixed with virgin powder. The normal in-process system for powder reclaiming is permitted to a maximum of 20% of virgin powder. Powder recovery during any cleaning process may not be introduced into the system.

The specified thickness shall be achieved in one application. In the event of the thickness being less than the minimum specified, the coating shall be removed and the pipe length shall be reblasted and recoated to comply with the specification.

ii) Thickness of Coating

The pipes shall be coated to a dry film of a minimum of 300 microns and a maximum of 600 microns with a fusion bonded epoxy powder.

iii) Cut back of Coating

The coating shall be cut back as specified in clause PCS1.3(iv)

iv) Handling of Coated Pipe

Coated pipe shall not touch the conveyor rollers until the coating has cured to a sufficient degree that contact with the rollers does not mark or damage the coating.

v) Quenching of the Coated Pipe

Quenching of the pipe with clean water is permitted provided that the coating is fully cured and complies in all respects with the requirements of the specification.

vi) Repairs

Repairs of electrical insulation defects may be carried out provided that the number of repairs necessary does not exceed 20 per 12 m pipe length.

A cluster of pinholes within a radius of 25mm shall be regarded as one defect.

Any pipe needing repairs in excess of the number given above or where the coating shows any sign of flaking or loss of adhesion shall not be repaired. The coating shall be removed and the pipe length shall be reblast, cleaned and recoated to comply with the requirements of the specification.

vii) Method of repair

When repairs are permissible, the following method shall be used.

a) Abrade an area at least 25mm diameter around and beyond the defective area.

The abrasive paper shall not be coarser than 220 mesh but preferably 400 mesh. It shall preferably be used wet to avoid excessive removal of coating.

The repair area shall be smoothly feathered into the surrounding sound area. The repair area shall be abraded to a matt finish, free from deep scratches and excessive removal of coating.

After abrasion, the area shall be wiped clean with M.E.K. or other suitable clean solvent and allowed to dry.

b) Repair material shall be solvent free epoxy or polyurethane repair material approved by the eThekwini Water and Sanitation. The colour shall differ from the colour of the epoxy coating. It shall be thoroughly mixed in the correct proportions as recommended by the supplier.

c) Repair material shall be mixed in the proportions supplied by the manufacturer. No splitting of packs shall be permitted unless the material is supplied in self metering packs.

The mixed repair material shall be applied to the clean, dry, abraded repair area so as to cover the defect and extend to within 1 or 2mm of the edge of the abraded area. A "halo" of abraded area shall be visible around the repair material.

d) Pipes shall not be moved until the repair material is cured and sufficiently hard to withstand the pressure of the pipes on the ramps. Cure may be accelerated by heating with infra red lamps provided that the heat applied is insufficient to cause any damage to the surrounding coating.

e) After curing, the repair and at least 250mm surrounding area shall be tested for electrical insulation defects as specified in the contract. There shall be no electrical insulation defects.

PCS1.5 Performance Criteria

The applied coating shall comply with all the requirements given in TABLE PCS1.2

PCS1.6 Frequency of Testing

Tests 1 to 3 of TABLE PCS1.2 shall be applied to each and every pipe.

Tests 4, 5, 6, and 7 shall be applied to at least one pipe selected at random from each powder application production run.

A production run is defined as the continuous operation of the FBE application plant from start-up to shut-down.

Additional tests may be required at the discretion of eThekwini Water and Sanitation.

TABLE PCS1.1: QUALIFICATION REQUIREMENTS FOR EPOXY POWDER

PROPERTY	REQUIREMENT	TEST METHOD
1. I.R. Spectrogram	For reference against contract supplies	Potassium Bromide disc
2. Thermal Characteristics	ΔT_g $\pm$5°C	Differential Scanning Calorimetry 20° C/min scan rate
3. Gel Time at 180°C	26 to 32 seconds.	Hot plate
4. Particle Size Distribution	< 1% above 250 µm < 5% above 150 µm < 8% below 10 µm	Lazer Diffraction Analyser
5. Dielectric Strength	Not less than 30 V/µm	S.A.N.S. 1217 Section 8.10
6. Accelerated Cathodic Disbonding (48 hr)	Total disbonded area (including holiday) $\leq$ 10mm dia	GBE/CW6 Part 1 Appendix F, or CAN/CZA-Z245.20-M92: 12.8 Impressed current, - 3,5V potential at 65° C for 48 hr, 3mm dia. holiday
7. Hot Water Soak Adhesion Test	Disbonded length not to exceed 5mm from point of V	Immerse in water at 75 ° C for 48 hr. Remove and make V-cut at 30 degree angle. Test adhesion when cooled to 25° C
8. Flexibility Test	No electrical insulation defects after bending over mandrels: 300 mm @ 5°C 200 mm @ 20°C	GBE/CW6 Part 1 Appendix B
9. Impact Resistance	No electrical insulation defects after impact of 6 joules	ASTM G14 direct and reverse impact on 0,8 mm sheet.
10. Density	1,45 $\pm$0,07 gm/cm^3	Mass divided by volume (g per ml) Volume determined by volumetric displacement using of a suitable solvent (white spirit) and a pycnometer.
11. Moisture Content	< 5% by weight	Mass loss of sample after 3 hours at 110°C.
12. Appearance	Free from pin-holes, blistering and cissing.	350 - 500 µm coating applied at to a pre-heated mild steel panel and visually assessed.
13. Sagging	No sagging.	350 - 500 µm coating applied at to a pre-heated vertical mild steel panel and visually assessed.
14. Hardness	F to mar.	Pencil Hardness.
15. Porosity of Coating	Rating 4	CAN/CZA-Z245.20-M92: 12.10 Figure 12.6
16. Tensile Strength and Elongation	50 MPa	ASTM D2370-82 Head speed 75mm/min
17. Water absorption (detached film)	< 3%	Water absorbed as weight gain after 3 months immersion at 20°C.
18. Strain Polarisation Cracking Test	No electrical insulation defects or disbonding	GBE/CW6 Part 1 Appendix G Bend at 20°C. Polarised @ -1,5 V for 28 days.
19. Salt Spray Resistance	No under film creep or blistering.	BS3900 F4, 1000 hrs
20. Artificial Weathering Test.	No deterioration, only superficial chalking	BS3900 F3, 1000 hrs

TABLE PCS1.2: REQUIREMENTS OF CURED FUSION BONDED EPOXY POWDER COATING

PROPERTY	REQUIREMENT	TEST METHOD
1. Visual	Smooth glossy or semi glossy finish, free from excessive runs, sags, orange peel, occlusions, lumps or other visible defects.	Use an experienced observer
2. Coating Thickness	Min. 300 Max 500 microns	S.A.N.S. Method 141. Take a minimum of 2 readings per m^2 of surface up to 300mm nominal dia., or 1 reading per m^2 over 300mm.
3. Electrical Insulation Defects	Nil defects at 3500 Volts. 20 repairs allowed per 12 m pipe length.	S.A.N.S. 1217 Section 8.12.2
4. Impact Resistance	No defect at 2 Joule	S.A.N.S. 1217 Section 8.7 but modified as given in Note 1 below
5. Degree of Cure: Thermal Characteristics	ΔT_g $\pm$5°C	Differential Scanning Calorimetry 201C/min scan rate
6. Hot Water Soak Adhesion Test	Disbonded length not to exceed 5mm from point of V	Immerse in water at 75°C for 48 hr. Remove and make V-cut at 301angle. Test adhesion when cooled to 25 °C
7. Accelerated Cathodic Disbonding (24 hr)	Total disbonded area (including holiday) $\pm$ 10mm dia	GBE/CW6 Part 1 Appendix F, or CAN/CZA-Z245.20-M92: 12.8.3.5(c) Impressed current, - 3,5V potential at 65° C for 24 hr, 3mm dia. holiday

NOTE 1:

Impact resistance shall be carried out on a sample of production pipe. The inside of the pipe shall be supported by a wooden block fitted vertically across the internal pipe diameter and chocked so as to fit tightly and immediately beneath the point of impact. Damage to the coating shall be assessed by measuring electrical insulation defects at the point of impact. No defect is permitted after impact at 2 Joules. Alternatively, the test may be carried out on a sample cut from the pipe and rigidly supported beneath the point of impact.

PCS 2: Fusion Bonded Medium Density Polyethylene Powder

PCS2.1 Compliance

The medium density polyethylene powder shall comply with clause 4 -MATERIALS of A.S. 4321. A certificate of compliance with Clauses 4.2 and 4.3 shall be provided by the polyethylene compound manufacturer.

PCS2.2 Application

Fusion Bonded Medium Density Polyethylene powder shall be applied generally in accordance with this specification and the Australian Standard AS 4321 (1995). Where a discrepancy in requirements arises the eThekwini Water and Sanitation Specification shall take precedence.

PCS2.3 Preparation And Cleaning Of Pipe

i) Degreasing

Pipes shall be degreased as specified.

ii) Blast Cleaning

Pipes shall be blast cleaned to grade SA2½ .

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be clean and free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Coating

The blast cleaned surface shall be stopped off or cut back by suitable masking which shall not contaminate the cleaned surface as follows:

a) All pipes up to and including 250mm nominal diameter - 100mm from both ends of the pipe.

b) All pipes from 300mm nominal diameter up to and including 600mm nominal diameter - 50mm from the belled end of the pipe and 100mm from the plain end of the pipe. (See Fig. 1).

c) All pipes larger than 600mm nominal diameter - 100mm from both ends of the pipe

v) Protection of Uncoated Pipe Ends

All pipe surfaces left uncoated due to cut back of the coating shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 25 microns. This

coating shall overlap the fusion bonded epoxy powder coating by 20mm.

PCS2.4 Application of Coating

i) Method of Application

The coating shall be applied in accordance with clause 5 'COATING AND LINING APPLICATION' of AS 4321.

ii) Thickness of Coating

The pipes shall be coated to a minimum film thickness as follows:

Nominal pipe diameter (mm)	Coating thickness (mm)
> 100 ≤ 250	1,6
≥ 250 < 500	1,8
≥ 500 < 750	2,0
≥750	2,3

iii) Cut Back of Coating

The coating shall be cut back in accordance with clause PCS2.3(iv).

iv) Repairs

Repairs of electrical insulation defects may be carried out provided that the number of repairs necessary does not exceed 3 per 9m pipe length (or equivalent pro rata number per pipe length). The area of any single repair shall not exceed 0,01m^2

Where a pinhole is located it shall be repaired to produce a continuous coating. Damaged areas that pass the continuity test need not be repaired provided the coating thickness remains greater than or equal to 1,0 mm.

v) Method of Repair

When repairs are permissible, they shall be carried using one of the following methods:

(a) Fusion bonded repairs.

(b) Heat shrink sleeve repairs.

(c) Hot gas welding repairs.

(d) Repairs using pipeline wrapping system.

Methods (a), (b) and (c) shall be carried out in accordance with Clause 8 of AS 4321.
Method (d) shall be carried out as follows:

vi) Repairs Using Pipeline Wrapping System

a) Description

The Repair System comprises:

a polymer bitumen primer:

Denso Primer D or equivalent approved an inner seal of modified rubber bitumen sealing tape:

Denso Mastic Sealing Tape or equivalent approved an outer protective layer of acrylic coated/modified bitumen adhesive pipeline tape:

Denso Acrylic Pipeline Tape or equivalent approved

b) Cleaning Of Area To Be Repaired - Pinholes And Large Areas.

Grease and oil shall be removed with a suitable cleaning solvent.

At each repair section, the surrounding area shall be abraded to a minimum area of 175 mm x 175 mm in the case of pinholes or small defect areas.

The area is demarcated by using a suitable template 175 mm x 175 mm and tracing the perimeter with a marking pen. The marked area shall be abraded with emery paper 80 to 100 mesh, so as to provide a suitably rough surface profile without causing the removal of excessive amounts of coating material.

All debris, dust, grease and oil shall be removed with a suitable cleaning solvent by means of a clean rag or brush.

Immediately the solvent has flashed off, apply the polymer bitumen primer at a nominal coverage rate of $8m^2/l$ by brush to the prepared surface in a uniformly thin film free of runs and sags, and allow to flash off for a minimum period of 15 minutes depending on ambient temperatures.

c) Tape Application - Pinholes

Once the polymer bitumen primer has dried, the prepared surface is then covered with a patch of modified rubber bitumen sealing tape 100 mm x 100 mm, followed by an outer patch of acrylic coated/modified bitumen adhesive pipeline tape 150 mm x 150 mm.

To ensure a bond free of voids and air bubbles, the tape is applied by firstly bonding the leading edge of the square and then smoothing out by thumbs or hand pressure in an outward direction. To ensure a perfect bond of the tape, roll out the entire area using an aluminium fluted roller.

d) Tape Application - Larger damaged areas

When repairing larger areas, the edges of the damaged coating must first be chamfered with a sharp Stanley knife or blade to remove potential void areas.

Pre-cut the correct sizes of modified rubber bitumen sealing tape and apply to the reclined and primed areas in weatherboard fashion with a 55% overlap to provide a double thickness of material, working up towards the crown of the pipe to endure that overlaps are facing downwards.

Overwork by hand or finger pressure to ensure full bond is achieved and no air is entrapped.

Finally, apply pre-cut strips of acrylic coated/modified bitumen adhesive pipeline tape with a 25 mm overlap, ensuring that it is 50 mm wider on all sides of the inner repair tape.

Notes:

Where the pipe has been severely damaged in numerous areas, a full spiral circumferential wrap is recommended.

Maximum width of the inner modified rubber bitumen sealing tape and outer acrylic coated/modified bitumen adhesive pipeline tape should not exceed 150 mm.

Apply the tapes with sufficient tension to ensure full conformance to the shop coating, and stagger the spiral overlaps which should be no less than 50 mm.

Commence and end the wrapping/repair system by a minimum of 100 mm each side of the damaged sections.

PCS2.5 Performance Criteria

The coating material shall comply with all the requirements given in TABLE PCS2.1. The applied coating shall comply with all the requirements given in TABLE PCS2.2

PSC2.6 Frequency of Testing

Tests 1 to 7 and 9 to 11 of TABLE PCS2.1 shall be carried out on the first contract using this material and thereafter at intervals of no greater than five years and at any change in formulation or source of polyurethane compounds and at any change in the application process.

Test 8 of TABLE PCS2.1 shall be carried out on the first contract using this material and thereafter at intervals of no greater than one year and at any change in formulation or source of polyurethane compounds and at any change in the application process.

Tests 1 to 3 of TABLE PCS2.2 shall be carried out on every pipe.

Test 4 of TABLE PCS2.2 shall be carried out at a frequency of two per shift.

Test 5 of TABLE PCS2.2 shall be carried out on at least two pipes selected at random from each item.

Additional tests may be required at the discretion of eThekwini Water and Sanitation.

TABLE PCS2.1: QUALIFICATION REQUIREMENTS FOR FUSION BONDED MEDIUM DENSITY POLYETHYLENE POWDER COATING

PROPERTY	REQUIREMENT	TEST METHOD
POLYETHYLENE COATING COMPOUND		
1. Thermal Stability	Melt flow index must not change by more than 35% after exposure to air at 100°C for 100 days	AS 4321, Appendix B
2. Water Absorption	≤0,1% when immersed in water at 23°C for 100days	AS 4321, Appendix C
3. Penetration Resistance	Compressive stress of 10 MPa: ≤0,15 mm penetration at 23°C ≤0,25 mm penetration at 70°C	AS 4321, Appendix D
4. Tensile Stress at Yield	≥ 15,0 MPa	AS 4321, Appendix E
5. Environmental Stress Cracking Resistance	$F_{50} \geq$ 100h	AS 4321, Appendix F
6. Density	≥ 920 kg/m^3 at 23°C	AS 4321, Clause 6.1.2.7
7. Impact Resistance	≥ 18,0 J	AS 4321, Appendix H (See Note 1)
8. Cathodic disbondment	Disbondment length ≤ 15 mm after 28 days	AS 4321, Appendix N
POLYETHYLENE REINSTATEMENT COMPOUND		
9. Water Absorption	≤0,2% when immersed in water at 23°C for 100days	AS 4321, Appendix C
10. Adhesion to Steel	Bond strength to steel ≥ 3,0 N/mm width of strip	AS 4321, Appendix I
11. Adhesion to polyethylene coating compound	Bond strength to polyurethane ≥ 3,0 N/mm width of strip	AS 4321, Appendix J

NOTE 1:
Impact resistance shall be carried out on a sample of production pipe. The inside of the pipe shall be supported by a wooden block fitted vertically across the internal pipe diameter and chocked so as to fit tightly and immediately beneath the point of impact. Damage to the coating shall be assessed by measuring electrical insulation defects at the point of impact. No defect is permitted after impact at 10 Joules. Alternatively, the test may be carried out on a sample cut from the pipe and rigidly supported beneath the point of impact.

TABLE PCS2.2: REQUIREMENTS OF CURED FUSION BONDED MEDIUM DENSITY POLYETHYLENE POWDER COATING

PROPERTY	REQUIREMENT	TEST METHOD
1. Visual	Smooth finish, free from visible defect	Use an experienced observer
2. Coating Thickness	> 100 # 250mm dia. - 1,6mm > 250 < 500mm dia. - 1,8mm ≥ 500 < 750mm dia. - 2,0mm ≥ 750mm dia. - 2,3mm	ISO 2820 Method 5. Take a minimum of 2 readings per m^2 of surface up to 300mm nominal dia., or 1 reading per m^2 over 300mm. Thickness tolerance as per AS 4321, Clause 6.3.2
3. Continuity Test (Electrical Insulation Defects)	Nil defects at 12 kV For conditions of repair see clause A.5.5.2.(vii)	S.A.N.S. 1217 Section 8.12.2 Note: DC instrument to be used
4. Bond Strength	Bond strength to steel ≥ 3,0 N/mm width of strip.	AS 4321, Appendix M
5. Cathodic disbondment	Disbondment length ≤ 15 mm after 28 days	AS 4321, Appendix N

PCS 3: Bitumen/Polyolefin Sleeve Duplex Coating

PCS3.1 Approval of Supplier

The coating shall be a bitumen/polyolefin sleeve duplex coating, TOSAWRAP, or similar approved.

PCS3.2 Approval of Batches

All raw materials as compounded in the manufacturer's Quality Assurance Manual. A compliance certificate must be provided by each raw material supplier.

PCS3.3 Preparation And Cleaning Of Pipe

i) Degreasing

Pipes shall be degreased by passing a gas flame over the surface to carbonise any contaminants.

ii) Pipe Cleaning

Pipes shall be mechanically wire brushed to Grade St 2 of ISO 8501-1 and all rust and foreign matter removed by means of blowing with compressed air, or solvent wiping.

PCS3.4 Application of Coating

i) Inner Layer

The molten compound shall be hot poured onto the pipe surface and smoothed to the required thickness before it cools.

ii) Outer Layer

Once the sleeve is positioned over the full length of the pipe, the heat shrinking of the sleeve is commenced one end to eliminate the risk of air entrapment. The sleeve edge is trimmed from each side of the pipe before it is transferred to the pipe inspection table.

iii) Thickness of Coating

The pipe shall be coated to a minimum thickness as follows;

Inner layer	1,0mm
Outer layer	1,0mm
Overall thickness	2,0mm

iv) Method of Repairs

The area of a single repair shall not exceed 10mm^2. The repair shall be carried out using a compatible melt stick. The number of repairs shall not exceed 3 per 6 metre length of pipe.

v) Cut Back of Coating

The coating shall be cut back for a distance of 100mm to facilitate site welding.

PCS3.5 Performance Criteria

The coating material shall comply with all the requirements given in TABLE PCS3.1. The applied coating shall comply with all the requirements given in TABLE PCS3.2.

PCS3.6 Frequency of Testing

Tests 2 and 6 of TABLE PCS3.1 shall be carried out on the first contract using this material and thereafter at intervals of no greater than one year and at any change in formulation or source of sleeve and primer compounds and at any change in the application process.

Tests 1, 3, 4, 5 and 7 of TABLE PCS3.2 shall be carried out on the first contract using this material and thereafter at intervals of no greater than five years and at any change in formulation or source of sleeve compounds and at any change in the application process.

Tests 1 to 3 of TABLE PCS3.2 shall be carried out on every pipe.

Test 4 of TABLE PCS3.2 shall be carried out on every 100th pipe.

Additional tests may be required at the discretion of eThekwini Water and Sanitation.

TABLE PCS3.1: QUALIFICATION REQUIREMENTS FOR BITUMEN/POLYOLEFIN SLEEVE DUPLEX COATING MATERIALS

PROPERTY	REQUIREMENT	TEST METHOD	FREQUENCY
1. Water absorption of sleeve	$\leq$ 0,1% when immersed in water at 23ºC for 100 days	S.A.N.S 1117	5 years
2. Cathodic disbondment of duplex system	Disbondment length $\leq$ 15 mm after 28 days	S.A.N.S 1117	Annually
3. Tensile strength of sleeve at yield	$\geq$ 10 MPa	ASTM D 882	5 years
4. Tensile strength of sleeve at break	$\geq$ 15 MPa	ASTM D 882	5 years
5. Elongation of sleeve at break	$\geq$ 500%	ASTM D 882	5 years
6. Adhesion to steel of duplex system	Adhesion to steel > 2 N/mm	S.A.N.S. 1117	Annually
7. Density of sleeve	$\geq$ 915 kg /m2	ASTM D1505	5 years

TABLE PCS3.2: REQUIREMENTS OF APPLIED BITUMEN/POLYOLEFIN SLEEVE DUPLEX COATING

PROPERTY	REQUIREMENT	TEST METHOD	FREQUENCY
1. Visual	Free from visible defect	Observation	100%
2. Coating thickness	2,0 mm	Take a minimum of three readings per 6 mm pipe.	100%
3. Holiday test	Nil defects at 15 KV	S.A.N.S 10129	100%
4. Bond strength	$\geq$ 1,5 N/mm width of strip (not temperature dependant)	In house	1 in 100

PCS 4: 3 Layer Polyethylene Pipe Coating System

PCS4.1 Approval of Supplier

The 3-layer polyethylene coating system consists of a powdered epoxy primer, a polymeric adhesive and a polyethylene outer sheath classified as System B1 in terms of the Canadian Standards Association specification Z245.21-02. The respective layers of the 3-layer system shall comprise of the following materials:

Fusion Bonded Epoxy primer:

Akzo Nobel	Akzo Nobel PCL 331 (or similar approved)
Jotun	Jotun CORRO-COAT EP-F 1003 HW (or similar approved)

Adhesive:

Borealis	Borcoat ME0420 (or similar approved)
Industrie Polieco M.P.B. SRL	Industrie Polieco Cohesive L8.92.8 (or similar approved)

High Density Polyethylene Outer Sheath:

Borealis	Borcoat HE3450 (or similar approved)

NOTE:
Pipe is not laid (i.e. buried) immediately upon delivery but is generally stockpiled in exposed pipe yards for "free issue" at a later date or kept as stock for emergency use. As a result of this extended exposure of the polyethylene coating to effect of UV it will be a requirement that the supplier of the coating provide written proof to the City Council that the polyethylene product to be used in the High Density Polyethylene Outer Sheath contains a **minimum of 2% finely dispersed carbon black**.

PCS4.2 Approval of Batches

Each batch of materials supplied to the applicator shall be approved by eThekwini Water and Sanitation. No change in formulation of the materials is permitted without prior approval of eThekwini Water and Sanitation. Such approval shall not exonerate the Contractor from the due performance of the coating system in terms of this specification.

The manufacturers shall supply Batch Conformance Certificates for each batch, which shall include results of all tests listed in Table PCS4.1.

Pipes coated with powder that has not been approved by eThekwini Water and Sanitation may be rejected.

PCS4.3 3 Layer Polyethylene Pipe Coating System

The 3 Layer Polyethylene Pipe Coating System shall be applied generally in accordance with this specification and the Canadian Standards Association specification Z245.21-02.

PCS4.3.1 Preparation And Cleaning Of Pipe

i) Degreasing

Pipes shall be degreased as specified.

ii) Blast Cleaning

Pipes shall be blast cleaned to Grade Sa3.

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be clean and free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Coating

The blast cleaned surface shall be stopped off or cut back by suitable masking which shall not contaminate the cleaned surface as follows:

a) All pipes up to and including 250mm nominal diameter - 100mm from both ends of the pipe.

b) All pipes from 300mm nominal diameter up to and including 600mm nominal diameter - 50mm from the belled end of the pipe and 100mm from the plain end of the pipe. (See Fig. 1).

c) All pipes larger than 600mm nominal diameter - 100mm from both ends of the pipe

v) Protection of Uncoated Pipe Ends

All pipe surfaces left uncoated due to cut back of the coating shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 25 microns. This coating shall overlap the fusion bonded epoxy powder coating by 20mm.

PCS4.4 Application of System

i) Application of Primer

The epoxy powder primer shall be applied in accordance with the powder manufacturer's recommendations. The thickness of the primer shall be between 150 and 200 µm.

ii) Application of Adhesive

The adhesive shall be applied in accordance with the powder manufacturer's recommendations. The thickness of the adhesive shall be between 150 and 250 µm.

iii) Application of Polyethylene

The polyethylene shall be applied immediately following the application of the adhesive to the pipe. The thickness of the polyethylene shall be a minimum of 1 mm.

The coating application shall be a continuous process in order to provide an outer sheath of uniform thickness, free from pin-holes, cracks and visible defects.

PCS4.5 Repairs

Any damage to the coating system occurring during manufacturing, storage or transportation of the coated pipes shall be repaired in accordance with the relevant repair procedure as follows;

i) For Damage Not Greater Than 25mm In Diameter And Where The Steel Surface Is Not Exposed.

a) Remove damaged coating with a razor knife; sand grinder, power wire brush or equivalent.

b) Care should be taken not to expose the steel surface during the repair procedure.

c) Eliminate all sharp edges.

d) Clean the damaged area and adjacent pipe coating with a dry clean cloth to remove the presence of dust, dirt and any foreign material.

e) Abrade (using sandpaper) adjacent HDPE coating extending 100mm beyond the damage.

f) Clean damaged area again

g) A melt stick (such as those obtained from CANUSA or RAYCHEM) can be used to fill the damaged area.

h) Use a low intensity yellow flame for preheating the coating and applying the repair product.

i) With quick back and forth strokes, pre-heat the repair zone sufficiently to remove moisture and assist in adhesion.

j) Heat the melt stick with the torch until it becomes fluid.

k) Heat the melt stick and repair zone simultaneously with the torch and spread the melt stick over the damaged area.

l) Keep the flame moving to prevent damage to the coating.

m) Some ignition of the melt stick is acceptable.

n) Continue spreading the melt stick over the repair zone until the entire area is covered.

o) After sufficient melt stick material is on the surface, apply additional heat in quick back-and-forth strokes to create a smooth surface.

p) Ensure that the melt stick material completely covers the repair zone.

q) The melt stick material should be spread liberally so that the material is raised above the coating surface.

r) Holiday detection shall be performed on each repair using a maximum voltage of 15kV.

ii) <u>For Damaged Areas Greater Than 25mm In Diameter, And Where The Steel Surface Is Not Exposed.</u>

a) Use an appropriate heat-shrinkable sleeve, if the damage has a diameter greater than 150mm x 150mm.

b) Mastic Filler (MF) is used to fill larger voids and deep crevices in damaged coatings prior to the application of repair patches. Melt sticks may also be used as a filler material below Coating Repair Patches.

c) Follow steps i) a) to i) f) above.

d) Unroll the filler material and cut off the required amount, leaving the release paper in place.

e) Use a low intensity yellow flame for pre-heating the coating and applying the repair products.

f) With quick back and forth strokes, pre-heat the repair zone sufficiently to remove moisture and assist in adhesion.

g) Place the filler material onto the damaged area with the release paper facing up.

h) Firmly press the material into the damaged area by hand and remove the release paper.

i) After filling the damaged area, remove the excess filler to create a smooth surface.

j) As an option, use a low intensity yellow flame to warm the filler material and assist in smoothing it out.

k) Patch Preparation:

- Cut a patch of CRP large enough to extend a minimum of 50mm beyond the edge of the repair zone.
- Trim each corner of the patch about 10-25mm at a 45° angle.

l) Warm the damaged area (repair zone + 50mm overlap) to remove moisture and assist in adhesion.

m) Take the cut repair patch and remove the release liner.

n) Place the patch with the adhesive side up on a heat resistant-gloved hand or on top of the pipe, and heat gently.

o) Heat until the adhesive softens and the surface becomes glossy. Also, reheat the damaged area to keep it warm.

p) Apply the softened adhesive side of the patch to the damaged area and press down firmly.

q) Heat the patch with a low intensity flame, and using a roller or a gloved hand, pat down and remove any air or wrinkles. Roll to ensure a good bond.

r) Allow the patch to cool down to ambient temperatures prior to further handling.

s) The heat shrink sleeve shall then be applied over the repair patch as per the manufacturer's recommendations.

t) Holiday detection shall be performed on each repair using a maximum voltage of 15kV.

iii) <u>For All Damaged Areas Where The Steel Surface Has Been Exposed.</u>

a) The repair system shall consist of two layers: a 2 part 100% solid epoxy primer and a cross-linked polyethylene, in the form of a self adhesive shrink sleeve.

b) Clean the damaged area to a "white metal finish" (Sa 2½), using sandpaper or blasting equipment.

c) Slightly abrade the line coating that shall be covered to a distance 50mm beyond the sleeve width.

d) Using a clean cloth, remove all dust and particles that may be present.

e) Follow the Preparation, Mixing and Application instructions provided with the supplied Epoxy Pack.

f) Apply mixed epoxy to a minimum uniform thickness of 150 microns on both the bare metal and the abraded portion of the mill coating, with a cloth, brush or applicator pad.

g) Preheat the area with a low to moderate intensity flame to substantially cure the epoxy and warm the surface. Drying time is dependent on preheating, weathering conditions and ambient temperature.

h) Follow steps ii) k) to ii) s) above.

i) Prior to sleeve application, check that the entire steel surface is fully covered with the epoxy. Holiday detection is suggested.

j) Using the propane torch, reheat the area to be covered with the heat shrink sleeve to the manufacturer's recommended temperature.

k) Wrap the sleeve around the heated epoxy ensuring proper overlap onto the mill applied coating.

l) Holiday detection shall be performed on each repair using a maximum voltage of 15kV.

PCS4.6 Performance Criteria

The coating material shall comply with all the requirements given in TABLES PCS4.1 and PCS4.2. The applied coating shall comply with all the requirements given in TABLE PCS4.3.

PCS4.7 Frequency of Testing

The tests of TABLE PCS4.1 shall be carried out on each batch of supplied materials.

The tests of Table PCS4.2 shall be carried out for each pipe diameter for each contract.

Tests 1 to 3 of TABLE PCS4.3 shall be carried out on every pipe.

Tests 4 and 5 of TABLE PCS4.3 shall be carried out at a frequency of one per shift.

Tests 6 and 7 of TABLE PCS4.3 shall be carried out once per week.

Additional tests may be required at the discretion of eThekwini Water and Sanitation.

TABLE PCS4.1: MATERIAL BATCH TEST REQUIREMENTS FOR POWDER PRIMER, ADHESIVE AND OUTER SHEATH OF 3 LAYER POLYETHYLENE COATING

PROPERTY	REQUIREMENT	TEST METHOD
POWDER PRIMER		
1. Gel time (s)	Within 20% of manufacturer's specified nominal	CSA Z245.20, Clause 12.2
ADHESIVE		
1. Flow rate (g/10 min)	Within 20% of manufacturer's specified nominal	ASTM D 1238 190°C/2.16 kg
POLYETHYLENE OUTER SHEATH		
1. Density (g/cm^3)	>0,940	ASTM D 792 or ASTM D 1505
2. Elongation at break (%)	600 minimum	ASTM D 638 Type IV sample: crosshead speed 50 mm/min
3. Flow rate (g/10 min)	0,15 – 0,80	ASTM D 1238 190°C/2.16 kg
4. Hardness (Shore D)	60 minimum	ASTM D 2240
5. Heat aging (MPa, %)	At least 65% of original tensile stress at yield; minimum elongation of 150%	CSA Z245.21, Clause 12.6
6. Tensile stress at yield (MPa)	18,5 minimum	ASTM D 638 Type IV sample: crosshead speed 50 mm/min
7. Oxidative-induction time in oxygen at 220°C, aluminium pan, no screen (minute)	10 minimum	ASTM D 3895
8. Brittleness temperature (°C)	-70 or lower (for F_{20})	ASTM D 746
9. Environmental stress-cracking resistance condition (h)	300 minimum (for F_{50}). Condition "B"	ASTM D 1693 100% Igepal
10. Vicat softening point (°C)	120 minimum	ASTM D 1525

TABLE PCS4.2: QUALIFICATION REQUIREMENTS FOR 3 LAYER POLYETHYLENE COATING

PROPERTY	REQUIREMENT	TEST METHOD
1. 28 d cathodic disbonding at 20ºC.	12 mm maximum radius	CSA Z245.21, Clause 12.3 *
2. Impact resistance	A minimum of 3.0 J/mm of actual total coating thickness	CSA Z245.20, Clause 12.12, except that for each µm of thickness, the voltage setting for the dc holiday detector (see Clause 12.12.3.3) shall be 10 V per µm thickness up to a maximum of 15 000 V.
3. Flexibility	No cracking of polyethylene	CSA Z245.20, Clause 12.11; bend of 2,5º
4. Peel adhesion	150.0 N minimum	CSA Z245.21, Clause 12.14 or 12.15
5. Polyethylene tensile stress at yield	17.0 MPa minimum	ASTM D 638 Type IV sample: crosshead speed 50 mm/min
6. Polyethylene elongation at break	300% minimum	ASTM D 638 Type IV sample: crosshead speed 50 mm/min

* In clause 12.3.3.6 the radial cuts may be replaced by circumferential chiseling to remove the test area circle.

TABLE PCS4.3: REQUIREMENTS OF APPLIED 3 LAYER POLYETHYLENE COATING

PROPERTY	REQUIREMENT	TEST METHOD	FREQUENCY
1. Visual	Smooth finish, free from visible defects	Visual	Every pipe
2. Coating Thickness	Minimum of 1,3 mm	ISO 2808	Every pipe
3. Holiday test	Nil defects at 15 kV	CSA Z245.21, Clause 7.4.2. 10 V per µm thickness up to a maximum of 15 000 V.	Every pipe
4. Peel adhesion	150.0 N minimum	CSA Z245.21, Clause 12.14 or 12.15	1 test per shift
5. 24 h cathodic disbondment at 65ºC.	7 mm maximum radius	CSA Z245.21, Clause 12.3 *	1 test per shift
6. Tensile stress at yield	17,0 MPa minimum	ASTM D 638 Type IV sample: crosshead speed 50 mm/min	1 test per week
7. Elongation at break	300% minimum	ASTM D 638 Type IV sample: crosshead speed 50 mm/min	1 test per week

* In clause 12.3.3.6 the radial cuts may be replaced by circumferential chiseling to remove the test area circle.

PCS 5: Rigid Polyurethane Coating

PCS5.1 Approval of Supplier

The rigid polyurethane coating system proposed by the contractor shall be prequalified in accordance with tests 1 to 7 listed in Table 11 and shall be identified in the bid by coating manufacturer name and product number. These prequalification test results shall be submitted at the time of tender. All coatings proposed shall have established case histories of use on the external surfaces of buried pipelines with complementary cathodic protection systems.

PCS5.2 Approval of Batches

Each batch of materials supplied to the applicator shall be approved by eThekwini Water and Sanitation. No change in formulation of the materials is permitted without prior approval of eThekwini Water and Sanitation. Such approval shall not exonerate the Contractor from the due performance of the coating system in terms of this specification.

The manufacturers shall supply Batch Conformance Certificates for each batch together with the FTIR Fingerprint that will be compared with the qualification fingerprint from Table PCS5.1.

Pipes coated with rigid polyurethane materials that have not been approved by eThekwini Water and Sanitation may be rejected.

PCS5.3 Rigid Polyurethane Coating

The required coating shall be a two component liquid applied rigid polyurethane, the mixing ratio being 1:1. The two coating components shall have different colours allowing the verification of the correct mixing and checking of the uniformity of the colour of the mixed product. The coating is considered cured when it has attained the hardness recommended by the product manufacturer. The coating materials shall be handled, stored, applied, and cured in accordance with the recommendation of the material manufacturers.

PCS5.4 Preparation and Cleaning Of Pipe

i) Degreasing

Prior to blast cleaning, all surfaces shall be inspected and any oil or grease shall be removed by means of solvent cleaning in accordance with the manufacturer's recommendations using water dispersible cleaners. The solvent shall leave no residue.

ii) Blast Cleaning

The exterior surface of the pipe shall be blast cleaned by centrifugal or air blast cleaning methods, then vacuum cleaned or blown off to achieve the following standards:

a) Cleanliness shall be equal to Sa3 of ISO 8501-1 when tested in accordance with S.A.N.S. 5767.

b) The profile produced by blast cleaning shall be angular and shall have an average peak to valley height as recommended by the approved supplier, when tested in accordance with S.A.N.S. 5772. When recycling abrasives, daily additions of new grit are required to retain the angularity of the profile.

Hackles shall be removed with coarse abrasive paper.

c) Residual dust and debris shall not exceed 0,2% when tested in accordance with S.A.N.S. 5769.

d) Water soluble salts shall not exceed 100mg/m^2 at any point when tested with the Weber-Reilly Reagent.

e) Any laminations revealed by blast cleaning shall be ground out and reblast cleaned to meet the requirements given in (a) to (d) above. If grinding penetrates the steel to a depth greater than 8% of the nominal wall thickness, the pipe shall be rejected.

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be clean and free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Coating

The blast cleaned surface shall be stopped off or cut back by suitable masking which shall not contaminate the cleaned surface as follows:

a) All pipes up to and including 250 mm nominal diameter – 100 mm from both ends of the pipe.

b) All pipes from 300 mm nominal diameter up to and including 600 mm nominal diameter - 50mm from the belled end of the pipe and 100mm from the plain end of the pipe. (See Fig. 1).

c) All pipes larger than 600 mm nominal diameter - 100 mm from both ends of the pipe.

v) Protection of Uncoated Pipe Ends

All pipe surfaces left uncoated due to cut back of the fusion bonded epoxy powder coating shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 25 microns. This coating shall overlap the rigid polyurethane coating by 20mm.

PCS5.5 Application of Coating

i) Heating

The surface shall be heated using an induction heating coil, radiant heaters or hot air to a temperature as recommended by the coating material manufacturer and in accordance with this specification.

The use of propane torches or gas burners for pre-heating and post-heating is expressly prohibited. Infrared heaters may be used for post-heating.

The temperature of the bare steel shall be monitored using temperature-indicating crayons. The amount of crayon used shall be the minimum amount required for accurate measurement. Crayon markings shall be removed with a wire brush.

Care shall be taken to ensure a uniform heating pattern.

ii) Method of Application

The liquid coating shall be applied to the blast cleaned surfaces using the method and equipment recommended by the coating manufacturer.

If a second layer is required to reach the prescribed thickness, this shall be applied in accordance with the over-coating time prescribed by the coating manufacturer.

Particular care should be taken in the handling of the coated pipes before the coating has reached the minimum value of hardness recommended by the manufacturer.

iii) Thickness of Coating

The applied coating thickness shall be between 1,2 and 1,8 mm.

iv) Cut Back of Coating

The coating shall be cut back in accordance with clause A.5.1.5.

v) Repairs

Repairs shall be carried out with repair grade materials of the same grade as the spray-applied, and tested in accordance with the approved procedures.

PCS5.6 Performance Criteria

The coating material shall comply with all the requirements given in TABLE PCS5.1. The applied coating shall comply with all the requirements given in TABLE PCS5.2.

PCS5.7 Frequency of Testing

Tests 1 to 4 of TABLE PCS5.2 shall be carried out on every pipe. Test 5 shall be carried out once per day (or shift). Test 6 shall be carried out at the start of each new contract. Test 7 shall be carried out on each new batch of coating material, and compared with the qualification results.

TABLE PCS5.1: QUALIFICATION REQUIREMENTS FOR RIGID POLYURETHANE COATING

PROPERTY	REQUIREMENT	TEST METHOD
1. Composition	FTIR Fingerprint	
2. Hardness Shore "D"	≥75	ASTM D2240
3. Adhesion, pull-off at 23°C	>15 MPa at 1000 micron DFT	ASTM D 4541/ISO4624
4. Cathodic disbondment, 23 °C, 28 days, 1.5V	<18mm	ASTM G8, Method B only, ECD Group A compliant
5. Cathodic disbondment, 66 ± 3°C, 24 hrs, 3.5V	<6mm	NACE RP 0394
6. Adhesion to steel after hot water soak, 70 ±3°C, 30 days and 60 days	≥7MPa	ISO 4624
7. Impact resistance	3J/mm	ASTM G14, 23°C

TABLE PCS5.2: REQUIREMENTS FOR APPLIED RIGID POLYURETHANE COATING

PROPERTY	REQUIREMENT	TEST METHOD	FREQUENCY
1. Visual	Smooth finish, free from visible defects	Visual	Every pipe
2. Coating Thickness	1,2 to 1,8 mm	ISO 2820	Every pipe
3. Holiday test	Nil defects (test voltage as per manufacturer's specification)	ASTM D 5162-01	Every pipe
4. Hardness Shore "D"	≥75	ASTM D2240	1 test per day's production
5. Adhesion, pull-off at 23°C	>7 MPa at 1000 micron DFT	ASTM D 4541 /ISO4624	1 test per day's production
6. Cathodic disbondment, 23 °C, 28 days, 1.5V	<18mm	ASTM G8	1 test per contract
7. Composition	FTIR Fingerprint	Check against manufacturer's qualification scan	1 test per material batch

PCS 6: Polyamide 11 (Nylon 11) Thermoplastic Lining and Coating for 100 to 300mm Piping

PCS6.1 Approval of Supplier

The polyamide 11 (Nylon 11) thermoplastic coating and lining shall be Rilsan or similar approved. The approved supplier shall be ISO 9001 certificated.

The brand type or grade, and the supplier of thermoplastic coating to be used shall be approved in writing by eThekwini Water and Sanitation. To obtain approval, the supplier shall provide independent test results in writing that demonstrate that the proposed material is capable of meeting the requirements specified in Table PCS6.1.

To maintain their approved status, suppliers will carry out the above tests on an annual basis and submit their results to eThekwini Water and Sanitation for approval.

PCS6.2 Approval of Batches

Each batch of thermoplastic coating to be used by the applicator shall be approved by eThekwini Water and Sanitation before use. No change in formulation of the coating is permitted without prior approval of eThekwini Water and Sanitation. Such approval shall not exonerate the Contractor from the due performance of the coating systems in terms of this specification.

The manufacturer shall supply Quality Control Certificates for each batch of material supplied. The Quality Control Certificates shall include results of tests carried out in accordance with the manufacturer's approved procedures.

Pipes lined or coated with thermoplastic powder products that have not been approved by eThekwini Water and Sanitation may be rejected.

PCS6.3 Polyamide 11 (Nylon 11) Thermoplastic Lining and Coating

The polyamide 11 (Nylon 11) thermoplastic coating and lining shall be Rilsan or similar approved.

PCS6.4 Preparation And Cleaning Of Pipe

i) Degreasing

Prior to blast cleaning, all surfaces shall be inspected and any oil or grease shall be removed by means of solvent cleaning in accordance with the manufacturer's recommendations using water dispersible cleaners. The solvent shall leave no residue.

ii) Blast Cleaning

The surface of the pipe shall be blast cleaned by centrifugal or air blast cleaning methods, then vacuum cleaned or blown off to achieve the following standards:

a) Cleanliness shall be equal to Sa3 of ISO 8501-1 when tested in accordance with S.A.N.S. 5767.

b) The profile produced by blast cleaning shall be angular and shall have an average peak to valley height of 40 to 90 micron or as recommended by the approved supplier, when tested in accordance with S.A.N.S. 5772. When recycling abrasives, daily additions of new grit are required to retain the angularity of the profile.

Hackles shall be removed with coarse abrasive paper.

c) Residual dust and debris shall not exceed 0,2% when tested in accordance with S.A.N.S. 5769.

d) Water soluble salts shall not exceed 100mg/m^2 at any point when tested with the Weber-Reilly Reagent.

e) Any laminations revealed by blast cleaning shall be ground out and reblast cleaned to meet the requirements given in (a) to (d) above. If grinding penetrates the steel to a depth greater than 8% of the nominal wall thickness, the pipe shall be rejected.

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be clean and free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Coating

The blast cleaned surface shall be stopped off or cut back by suitable masking which shall not contaminate the cleaned surface as follows:

a) All pipes up to and including 250 mm nominal diameter – 100 mm from both ends of the pipe.

b) All pipes from 300 mm nominal diameter up to and including 600 mm nominal diameter - 50mm from the belled end of the pipe and 100mm from the plain end of the pipe. (See Fig. 1).

v) Protection of Uncoated Pipe Ends

All pipe surfaces left uncoated due to cut back of the thermoplastic powder coating shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 25 microns. This coating shall overlap the rigid polyurethane coating by 20 mm.

PCS6.5 Application of Coating

i) Primer Application

The cleaned pipe shall be primed with the approved primer to a nominal thickness of 8 to 12 micron.

ii) Heating

Within 8 hours of priming the pipe shall be pre-heated to the temperature recommended by the coating material manufacturer for the pipe wall thickness being coated. This temperature is typically some 350 ºC.

The temperature of the bare steel shall be monitored using temperature-indicating crayons. The amount of crayon used shall be the minimum amount required for accurate measurement. Crayon markings shall be removed with a wire brush.

Care shall be taken to ensure a uniform heating pattern.

iii) Method of Application

Following preheating the thermoplastic powder coating shall be applied by the fluidized bed process as recommended by the coating manufacturer and application equipment supplier.

iv) Thickness of Coating

The optimal applied coating thickness is 350 micron. The minimum acceptable thickness is 250 micron.

v) Cut Back of Coating

The coating shall be cut back in accordance with clause A.5.6.1.(iv).

vi) Repairs

Repairs shall be carried out with either an approved two pack solvent free epoxy or an approved hot melt compound and tested in accordance with the specified procedures.

PCS6.6 Performance Criteria

The coating material shall comply with all the requirements given in TABLE PCS6.1. The applied coating shall comply with all the requirements given in TABLE PCS6.2.

PSC6.7 Frequency of Testing

Tests 1 to 4 of TABLE PCS6.2 shall be carried out on every pipe. Test 5 shall be carried out once per day (or shift). Test 6 shall be carried out at the start of each new contract.

TABLE PCS6.1: QUALIFICATION REQUIREMENTS FOR POLYAMIDE 11 (NYLON 11) THERMOPLASTIC LINING AND COATING

PROPERTY	REQUIREMENT	TEST METHOD
1. Hardness Shore "D"	75 - 85	ASTM D2240
2. 28 d cathodic disbonding at 20°C.	12 mm maximum radius	CSA Z245.21, Clause 12.3
3. Impact resistance	> 2J/mm	ASTM G14, 23°C

TABLE PCS6.2: REQUIREMENTS FOR APPLIED POLYAMIDE 11 (NYLON 11) THERMOPLASTIC LINING AND COATING

PROPERTY	REQUIREMENT	TEST METHOD	FREQUENCY
1. Visual (Lining and coating)	Smooth finish, free from visible defects	Visual	Every pipe
2. Coating Thickness (Lining and coating)	250 micron minimum	ISO 2820	Every pipe
3. Electrical Insulation Defects (Lining and coating)	Nil defects at 90 Volts, 2 Mega Ohm	S.A.N.S. 1217 Section 8.12.1	Every pipe
4. Hardness Shore "D" (Lining and coating)	75 - 85	ASTM D2240	Every pipe
5. Adhesion, pull-off at 23°C (on test panel coated with a pipe)	>7 MPa at 1000 micron DFT	ASTM D 4541 /ISO4624	1 test per day's production
6. 28 d cathodic disbonding at 20°C. (on test panel coated with a pipe)	12 mm maximum radius	CSA Z245.21, Clause 12.3	1 test per contract

PCS 7: Two Layer Polyethylene / Visco-elastic Polyisobutene Pipe Coating System (2LPE)

A factory applied double sided non crystalline, prefab monolithic viscous polymer wrap coating with cold flow, self-healing, visco-elastic properties for corrosion prevention.

PCS7.1 Approval of Supplier

The 2-layer polyethylene pipe coating system comprises of a visco-elastic polyisobutene based coating and a polyethylene outer sheath classified as System B1 in terms of the Canadian Standards Association Specification Z245.21-02. The respective layers of the 2-layer system shall comprise of the following materials:

Visco-elastic Polyisobutene Corrosion Protection Layer:

Stopaq	Stopaq Basecoat DS (or similar approved)

High Density Polyethylene Outer Sheath:

Application Method 1:

Stopaq	Stopaq HSS Heat Shrinkable material (or similar approved)

Application Methods 2 & 3:

Borealis	Borcoat HE3450 – Extrusion material (or similar approved)

PCS7.2 Approval of Batches

Each batch of materials supplied to the applicator shall be approved by eThekwini Water and Sanitation before use. No change in product type of the material is permitted without prior approval from eThekwini Water and Sanitation. Such approval shall not exonerate the Contractor from the due performance of the coating system in terms of this specification.

The manufacturers shall supply Batch Conformance Certificates for each batch, which shall include results of all tests listed in Table 7.1.

Pipes coated with material that has not been approved by eThekwini Water and Sanitation will be rejected.

PSC7.3 Two Layer Polyethylene Pipe Coating System

The 2-layer polyethylene pipe coating system shall be applied generally in accordance with the Canadian Standards Association Specification Z245.21-02.

PCS7.4.1 Preparation and Cleaning of Pipe

i) Degreasing

Pipes shall be degreased externally by the use of an approved water rinsable solvent degreaser to remove all oils and lubricants present on the surface prior to blasting.

ii) Blast Cleaning

Pipes shall be blast cleaned to a clean finish removing all mill scale.
No surface profile is required.
No salt test is required.

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be kept clean and

free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Coating

The coating shall be cut back by 100mm from the pipe ends.

v) Protection of Uncoated Pipe Ends

Uncoated pipe ends shall be wrapped with a protective PVC tape and have a protective end cap placed at each pipe end.

PCS7.4.2 Application Methods

PCS7.4.2.1. Application method 1

PCS7.4.2.1. (a) Application of the Visco Elastic (Stopaq) Basecoat corrosion preventative layer:

i) The abraded line pipe will be protected by a visco-elastic basecoat material holding an overlap of 10mm on each round.

ii) The width of the Basecoat Material shall be as follows:

Pipe OD (mm)	Basecoat Material Width (mm)
< 200	100
200 to 1100	200
>1100	300

PCS7.4.2.1. (b) Application Mechanical Protection PE layer to the Visco-elastic Basecoat:

i) A polyethylene shrink material is applied on top of the visco-elastic basecoat coated pipe to act as the mechanical protective layer. After the application of the polyethylene shrink materials this material shall be heated to allow shrinking and adherence to the visco-elastic material.

ii) The thickness of the Mechanical Protection PE layer shall be a minimum of 1,5mm and a maximum of 2mm on the pipe with a minimum of 2mm on the weld seam.

PCS7.4.2.2 Application method 2

PCS7.4.2.2 (a) Application of the Visco-elastic (Stopaq) Basecoat corrosion preventative layer:

i) The abraded line pipe will be protected by a visco-elastic basecoat material with an overlap of 10mm on each round.

ii) The width of the Basecoat Material shall be as specified in Clause PSC7.4.2.1. (a) ii) above

PCS7.4.2.2 (b) Application Mechanical Protection PE layer to the Visco-elastic (Stopaq) Basecoat:

i) The Visco-elastic Basecoat coated pipe will pass by a side or overhead polyethylene extruder. The process delivering sufficient HDPE material to the surface of the rotating line pipe and forming a uniform mechanical

protective layer, as per thickness required by the consulting engineer, a minimum of 2mm on the weld seam.

ii) The polyethylene shall be applied immediately following the application of the visco-elastic material to the pipe. The coating application shall be a continuous process in order to provide an outer sheath of uniform thickness, free from pinholes, cracks and visible defects.

No adhesives are required between the layers; visco-elastic material is applied cold.

PCS7.4.2.3. Application method 3

PCS7.4.2.3 (a) Application of the Visco-elastic (Stopaq) Basecoat corrosion prevention layer

i) The abraded line pipe will be protected by a visco-elastic basecoat material holding an overlap of 10mm on each round.

ii) The width of the Basecoat Material shall be as specified in Clause PSC7.4.2.1. (a) ii) above

PCS7.4.2.3. (b) Application Mechanical Protection PE layer to the Stopaq Basecoat

i) The Visco-elastic Basecoat coated pipe will pass through a crosshead polyethylene extruder. The process delivering sufficient polyethylene material to the surface of the line pipe and forming a uniform mechanical protective layer at a minimum thickness of 1,5mm and a maximum of 2mm on the pipe with a minimum of 2mm on the weld seam.

ii) The polyethylene shall be applied immediately following the application of the visco-elastic material to the pipe. The coating application shall be a continuous process in order to provide an outer sheath of uniform thickness, free from pinholes, cracks and visible defects.

No adhesives are required between the layers. Visco-elastic material is applied cold.

PCS7.5 Repairs

Any damage to the coating system occurring during manufacturing, storage or transportation of the coated pipes shall be repaired in accordance with the relevant repair procedure as follows utilizing the following materials:

Corrosion Protection Layer :	Stopaq CZH Paste and CZH Wrapping band (or similar approved)
Mechanical Protection Layer – Option 1:	Stopaq Outerwrap PVC (or similar approved)
Mechanical Protection Layer – Option 2:	Stopaq Outerwrap PE (or similar approved)
Mechanical Protection Layer – Option 3:	Stopaq PE Patch Repair Material (or similar approved)

Repair Procedure:

a) Remove damaged coating with a razor knife; sand grinder, power wire brush or equivalent.

b) Care should be taken not to expose the steel surface during the repair procedure.

c) Eliminate all sharp edges.

d) Clean the damaged area and adjacent pipe coating with a dry clean cloth to remove the presence of dust, dirt and any foreign material.

e) Abrade (using sandpaper) the adjacent polyethylene coating extending 100mm beyond the damage.

f) Clean damage area again.

g) Fill voids and crevices in damaged coatings with Visco-elastic paste material prior to the application of repair patches.

h) Unroll the filler material and cut off the required amount, leaving the release paper in place.

i) Firmly press the material into the damaged area by hand and remove the release paper.

j) After filling the damaged area, remove the excess filler to create a smooth surface.

k) Patch Preparation:

- Cut a patch of visco-elastic material large enough to extend a minimum of 50mm beyond the edge of the repair zone
- Trim each corner of the patch about 10-25mm at a 45° angle.

l) Assist adhesion by removal of moisture with the use of a dry rag.

m) Remove oil with the use of isopropanol.

n) Remove the release liner from the cut repair patch.

o) Place the repair patch on the damage point and smooth down by hand.

p) Holiday detection shall be performed on each repair using a maximum voltage of 15kV.

q) Cover the coating with the relevant mechanical protection layer which has been specified on the project.

PCS7.6 Performance Criteria

The coating material shall comply with all the requirements given in TABLES 7.1 and 7.2. The applied coating shall comply with all the requirements given in TABLE 7.3.

PCS7.7 Frequency of Testing

The tests of TABLE 7.1 shall be carried out on each batch of supplied materials.

The tests of TABLE 7.2 shall be carried out for each pipe diameter for each contract.

Tests 1 to 3 of TABLE 7.3 shall be carried out on every pipe.

Tests 4 and 5 of TABLE 7.3 shall be carried out at a frequency of one per shift.

Tests 6 and 7 of TABLE 7.3 shall be carried out once per week.

Additional tests may be required at the discretion of Engineer.

TABLE 7.1: MATERIAL BATCH TEST REQUIREMENTS FOR OUTER SHEATH OF 2 LAYER POLYETHYLENE COATING

PROPERTY	REQUIREMENT	TEST METHOD
POLYETHYLENE OUTER SHEATH		
1. Density (g/cm³)	>0,940	ASTM D 792 or ASTM D 1505
2. Elongation at break (%)	600 minimum	ASTM D 638 Type IV sample: crosshead speed 50mm/min
3. Flow rate (g/10min)	0,15 – 0,80	ASTM D 1238 190°C/2.16kg
4. Hardness (Shore D)	60 minimum	ASTM D 2240
5. Heat aging (MPa,%)	At least 65% of original tensile stress at yield; minimum elongation of 150%	CSA Z245.21, Clause 12.6
6. Tensile stress at yield	18,5 minimum	ASTM D 638 Type IV sample: crosshead speed 50mm/min
7. Oxidative-induction time in oxygen at 220°C, aluminum pan, no screen (minute)	10 minimum	ASTM D 3895
8. Brittleness temperature (°C)	-70 or lower (for F20)	ASTM D 746
9. Environmental stress cracking resistance condition (h)	300 minimum (for F50) Condition "B"	ASTM D 1693 100%Igepal
10. Vicat softening point (°C)	120 minimum	ASTM D 1525

TABLE 7.2: QUALIFICATION REQUIREMENTS FOR 2 LAYER POLYETHYLENE COATING

PROPERTY	REQUIREMENT	TEST METHOD
1) 28 d cathodic disbonding at 20°C	0 mm maximum radius	CSA Z245.21, Clause 12.3*
2) Impact resistance (J/mm)	3,0 minimum	ASTM G14, 23°C
3) Flexibility	No cracking of polyethylene	CSA Z245.20, Clause 12.11; bend of 2,5°
4) Peel adhesion	Cohesive fraction of the corrosion coating	CSA Z245.21, Clause 12.14 or 12.15
5) Polyethylene tensile stress at yield	17.0 MPa minimum	ASTM D 638 Type IV sample: crosshead speed 50mm/min
6) Polyethylene elongation at break	300% minimum	ASTM D 638 Type IV sample: crosshead speed 50mm/min

*In Clause 12.3.3.6 the radial cuts may be replaced by circumferential chiseling to remove the test area circle.

TABLE 7.3: REQUIREMENTS OF APPLIED 2 LAYER POLYETHYLENE COATING

PROPERTY	REQUIREMENT	TEST METHOD	FREQUENCY
1. Visual	Smooth finish, free from visible defects	Visual	Every pipe
2. Coating Thickness	Minimum of 2mm	ISO 2808	Every Pipe
3. Holiday test	Nil defects at 15kV	CSA Z245.21, Clause 7.4.2. 10 V per µm thickness up to a maximum of 15 000 V	Every pipe
4. Peel adhesion	Cohesive fracture	CSA Z245.21, Clause 12.14 or 12.15	1 test per shift
5. 24 h cathodic disbondment	0 mm maximum radius	CSA Z245.21, Clause 12.3*	1 test per shift
6. Tensile stress at yield	17,0 MPa minimum	ASTM D 638 Type IV sample: crosshead speed 50mm/min	1 test per week
7. Elongation at break	300% minimum	ASTM D 638 Type IV sample: crosshead speed 50mm/min	1 test per week

*In Clause 12.3.3.6 the radial cuts may be replaced by circumferential chiseling to remove the test area circle.

PCS 8: Two Layer Glass-fibre Reinforced Epoxy (GRE)/Visco-elastic Polyisobutene Coating System (2LGRE)

A factory applied double sided non crystalline, prefab monolithic viscous polymer wrap coating with cold flow, self-healing, visco-elastic properties for corrosion prevention covered by a glass-fibre reinforced epoxy mechanical protection layer.

PCS8.1 Approval of Supplier

The 2 layer GRE pipe coating system comprises of a visco-elastic polyisobutene based coating and a GRE epoxy resin. The respective layers of the 2-layer system shall comprise of the following materials:

Visco-elastic Polyisobutene Corrosion Protection Layer:

Stopaq	Stopaq Fast Basecoat GRE (or similar approved)

Glass Reinforced Epoxy Resin Mechanical Protection Outer Layer:

Stopaq	Stopaq Fast GRE (or similar approved)

PCS8.2 Approval of Batches

Each batch of materials supplied to the applicator shall be approved by eThekwini Water and Sanitation before use. No change in product type of the material is permitted without prior approval from eThekwini Water and Sanitation. Such approval shall not exonerate the Contractor from the due performance of the coating system in terms of this specification.

The manufacturers shall supply Batch Conformance Certificates for each batch, which shall include results of all tests listed in Table 8.1

Pipes coated with material that has not been approved by eThekwini Water and Sanitation will be rejected.

PCS8.3 Two Layer GRE Coating System

The 2 layer GRE pipe coating system shall be applied generally as follows:

i) Load the Line pipe onto the rotation unit.
ii) Apply (viscoelastic) coating wrapping to the surface of the pipe, overlapping at 10mm.
iii) Wrap to each end leaving 200mm cut back on all pipe ends.
iv) Holiday Test the corrosion coating as per PSC8.5.1.(a).(viii) below.
v) Begin the mechanical protection - the second layer.
vi) The saturated 500/600 Glass layer/resin and tissue is to be rotated onto the pipe at 50% overlap - cold application.
vii) Complete the process to each end leaving 150mm cut back on all pipe ends.

PCS8.4 Preparation and Cleaning of Pipe

i) Degreasing

Pipes shall be degreased externally by the use of Isopropanol (or a similar approved water rinsable solvent degreaser) to remove all oils and lubricants present on the surface prior to blasting.

ii) Blast Cleaning

a) Remove loose corrosion, loose mill scale, dust or other loosely adherent contaminates to cleanliness St-2 / St-3 (hand tool / machine tool cleaning) or by means of abrasive blasting to cleanliness Sa-1 ("brush-off" blasting) in accordance with ISO 8501-01.

b) Mechanically remove all weld spatters, laminations, slivers, sharp edges, high points, and other visual roughness, which might penetrate into the corrosion protective coating layer.

c) No specific surface profile is required.

d) No salt test is required.

e) Residual dust and debris shall not exceed 0,2% when tested in accordance with S.A.N.S. 5769

iii) Handling of Cleaned Pipe

After cleaning, the pipe surface shall not be contaminated in any way. Operators shall wear clean gloves and all surfaces in contact with the pipe surface shall be kept clean and free from oil, grease, grit, dirt and other contamination.

iv) Cut Back of Coating

The coating shall be cut back by 100mm from the pipe ends.

v) Protection of Uncoated Pipe Ends

All pipe surfaces left uncoated due to cut back of the fusion bonded epoxy powder coating shall be painted with an approved weldable vinyl butyral etch primer to a dry film thickness of 25 microns. This coating shall overlap the Stopaq coating by 20mm.

PCS8.5 Application Method

PSC8.5.1. (a) Application of the Visco Elastic (Stopaq) Basecoat corrosion preventative layer:

i) The width of the Basecoat Material shall be as follows:

Pipe OD (mm)	Basecoat Material Width (mm)
< 200	100
200 - 1100	200
>1100	300

ii) Prior and during application, pipe surface shall be maintained at a temperature at least +3°C above the dew-point temperature and between -30°C and +70°C

iii) Before and during application, wrapping band shall be maintained within the temperature range +5°C to + 70°C

iv) Wrapping Band shall be applied with the sticky side in contact to the substrate, wrapped without tension, avoiding air entrapment and without tape creases and wrinkling

v) Wrapping Band overlaps shall be 10mm with itself and at least 50mm on adjacent existing epoxy coated piping. Overlaps between the end of a tape roll and the tape of a new roll shall be at least 100mm.

vi) At terminations (start and end points) one, full straight wrapping shall be applied onto substrate, following with wraps from "straight to spiral", and then continue with spiral wrapping, with 10mm minimum overlap. End with one straight, circumferential wrapping.

vii) The nominal thickness of the Wrapping Band shall not be lower than 0.85mm

viii) After wrapping and prior to application of the mechanical protective layer the Wrapping Band shall be subject to a high spark holiday test at 5 kV per mm coating thickness plus 5 kV. The Wrapping Band has a constant minimum thickness between 0.85mm and 1.2mm, therefore the testing voltage should be (1 x 5kV) + 5 kV = 10 kV. A clean, copper-brush probe is recommended for the high spark testing. Where a ring-probe is used it is recommended that the test voltage be increased by 5 kV in order to compensate the less efficient ring probe.

ix) All defects (holidays) shall be repaired with the addition of new materials and re-tested.

PCS8.5.1. (b) Application of GRE Mechanical Protection layer to the Visco-elastic Basecoat:

i) No adhesive is required between the visco-elastic basecoat corrosion protection layer and the glass reinforced epoxy mechanical protection layer.

ii) Saturate the glass fibre membrane (500 to 600 grams per m^2) with resin mix at 400 grams per m^2 and wind onto the surface of the pipe over the viscoelastic basecoat ensuring a 50% overlap of the cloth to itself.

iii) Follow this with a 30 grams per m^2 layer of fibre tissue on the same application run ensuring a 50% overlap of the cloth to itself and beginning and ending with a straight wrap covering over the glass completely.

PCS8.6 Repairs

Any damage to the coating system occurring during manufacturing, storage or transportation of the coated pipes shall be repaired in accordance with the relevant repair procedure as specified by the product supplier as follows utilizing the following materials:

Corrosion Protection Layer:	Stopaq CZH Paste and CZH Wrapping Band (or similar approved)
Mechanical Protection Layer:	Stopaq Fast GRE (or similar approved)

Repair procedure:

a) Small defects (< 20mm x 20mm) to bare steel (Factory):

i. Remove damaged coating
ii. Eliminate all sharp edges
iii. Clean the damaged area and adjacent pipe coating with a dry clean cloth to remove the presence of dust, dirt and any foreign material.
iv. Fill voids and crevices in damaged corrosion protection coating with Visco-elastic paste material
v. Fill remaining void in damaged mechanical protection layer with resin mix
vi. After filling the damaged area, remove the excess filler to create a smooth surface.
vii. Cut a patch of visco-elastic material large enough to extend a minimum of 50mm beyond the edge of the repair zone
viii. Trim each corner of the patch about 10-25mm at a 45° angle.

ix. Place the repair patch on the damage point and smooth down by hand.
x. Holiday detection shall be performed on each repair using a maximum voltage of 15kV.

b) Large defects (> 20mm x 20mm) to bare steel (Factory / field):

i. Remove damaged coating
ii. Eliminate all sharp edges
iii. Clean the damaged area and adjacent pipe coating with a dry clean cloth to remove the presence of dust, dirt and any foreign material.
iv. Cut and apply patch from Visco-elastic corrosion protection material
v. Fill remaining void in damaged mechanical protection layer with grass fiber mesh and brush in resin mix
vi. After filling the damaged area, remove the excess filler to create a smooth surface.
vii. Cut a patch of visco-elastic material large enough to extend a minimum of 50mm beyond the edge of the repair zone
viii. Trim each corner of the patch about 10-25mm at a 45° angle.
ix. Place the repair patch on the damage point and smooth down by hand.
x. Holiday detection shall be performed on each repair using a maximum voltage of 15kV.

PCS8.7 Performance Criteria

The coating materials shall comply with all the requirements given in TABLES 8.1 and 8.2. The applied coating shall comply with all the requirements given in TABLE 8.3.

PCS8.8 Frequency of Testing

The tests of TABLE 8.1 shall be carried out on each batch of supplied materials.

The tests of TABLE 8.2 shall be carried out for each pipe diameter for each contract.

Tests 1 to 3 of TABLE 8.3 shall be carried out on every pipe.

Tests 4,5 and 6 of TABLE 8.3 shall be carried out at a frequency of one per shift.

Test 7 of TABLE 8.3 shall be carried out once per 100 pipes.

Additional tests may be required at the discretion of Engineer.

TABLE 8.1: MATERIAL BATCH TEST REQUIREMENTS

PROPERTY	REQUIREMENT	TEST METHOD
CORROSION PROTECTION LAYER:		
1. Density (g/cm^2)	≥ 1.40	ISO 1183-1
2. Elongation at break (%)	> 100	ASTM D1000
3. Water absorption (%)	< 0.03	ASTM D570
4. Permeability (g/m^2/24 hrs)	< 0.20	ASTM E96
5. Glass transition temp. (°C)	≤ -65	ISO 21809-3:2008 Amendment1:2001
6. Drip resistance	No dripping of compound	Tested 72 hrs @ +130°C
MECHANICAL PROTECTION LAYER:		
7. Glass transition temp. (°C)	76	ISO 21809-3:2008 Amendment1:2001
8. Elongation at break (%)	5 - 7	ISO 527
9. Hardness (Shore D)	≥ 70	ASTM D2240
10. Bending (flexural) strength (MPa)	110 - 120	ISO 178
11. Tensile strength (MPa)	65 – 75	ISO 527
12. Impact strength (KJm^2)	13 – 17	ISO 179

TABLE 8.2: QUALIFICATION REQUIREMENTS FOR 2 LAYER GRE COATING

PROPERTY	REQUIREMENT	TEST METHOD
1. 24 hr cathodic disbonding at 23°C and 70°C	0 mm maximum radius	Artificial defect 6mm dia. self-healed after 24 hrs
2. Impact resistance (J/mm)	40 min	ISO 21809-3 Amendment 1(2011) Tested at 20°C
3. Compressive Strength (N/mm^2)	85 min	
4. Flexural strength (N/mm^2)	80 min	
5. Tensile strength (N/mm^2)	70 min	
6. Peel adhesion	Cohesive failure	CSA Z245.21, Clause 12.14 or 12.15
7. Hardness (Shore D)	≥ 70	ASTM D2240

TABLE 8.3: REQUIREMENTS OF APPLIED 2 LAYER GRE COATING

PROPERTY	REQUIREMENT	TEST METHOD	
1. Visual	Smooth finish, free from visible defects	Visual	Every pipe
2. Coating Thickness	2.5 to 3.0mm	ISO 2808	Every pipe
3. Holiday test	Nil defects	CSA Z245.21, Clause 7.4.2. (5 kV per mm thickness plus 5Kv)	Every pipe
4. Peel adhesion	Cohesive fracture	CSA Z245.21, Clause 12.14 or 12.15	1 test per shift
5. Impact resistance (J/mm)	40 min	ISO 21809-3 Amendment 1(2011) Tested at 20°C	1 test per shift
6. Hardness (Shore D)	≥ 70	ASTM D2240	1 test per shift
7. 24 h cathodic disbondment	0 mm maximum radius	CSA Z245.21, Clause 12.3*	1 test per 100 pipes