DEPARTMENT OF WATER AND SANITATION

STANDARD SPECIFICATION

DWS 9900

SECTION C1

CORROSION PROTECTION OF STEEL PIPES AND SPECIALS FOR PIPELINES

This document shall be read in conjunction with:
DWS 2020: Quality Assurance and Procedures

Annexures
Requirements to be specified

REVISED MARCH 2021

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1. SCOPE

This specification covers the corrosion protection of steel pipes and specials to be used for the conveyance of raw and potable water at ambient temperature, which may be buried or subjected to environments with variable corrosive tendencies.

2. INTERPRETATIONS

2.1 PROJECT SPECIFICATION

Steel pipes and specials shall be manufactured and corrosion protected in accordance with the requirements specified in the Project Specification. No deviation from specification will be allowed without the written consent of the Project Engineer. In the case of there being conflict between specifications or between specifications and product data sheets, the discrepancy shall be referred to the project engineer for resolution

2.2 APPLICATION

This specification contains clauses that are generally applicable to the corrosion protection of steel pipes and specials.

2.3 DEFINITIONS

LINING

Refers to the internal coating of pipes and specials.

COATING

Refers to the external coating of pipes and specials.

DIS-BONDED AREA

An area of lining or coating that initially did adhere to the steel substrate after application, but which subsequently became loose from the substrate as a result of mechanical, chemical or other action.

UN-BONDED AREA

An area of lining or coating which at no stage adhered to the steel substrate.

3. APPROVAL PROCEDURE

3.1 APPROVALS BEFORE AWARD OF CONTRACT

The Corrosion Protection System specified in the Project Specification, shall be agreed upon between the Corrosion Engineer, Cathodic Protection Engineer and Project Engineers.

(a) Approval by the Corrosion Engineer of the corrosion protection system, procedures and specific materials offered in the Tender. Manufacturers' data sheets or legible copies thereof shall be submitted for each product.

(b) Acceptance of the Departmental Quality Control Plan for Corrosion Protection - refer to DWS 2020 QCC1.

3.2 PRE-QUALIFICATION REQUIREMENT

Due to the specialized nature and importance of corrosion protection, pre-qualification is generally required for products, service providers and skills in corrosion protection. Users of the specification would typically be Water Service Providers/Authorities who shall stipulate detailed pre-qualification requirements.

3.3 APPLICATION APPROVALS

(a) Qualification of personnel

(b) Quality of equipment

(c) Pre-preparation

(d) Surface preparation

(e) Application

(f) Final acceptance

4. QUALITY REQUIREMENTS

4.1 QUALITY ASSURANCE AND PROCEDURES

The Contractor shall ensure that he is fully conversant with the requirements of this specification and the relevant coating systems.

Quality procedures as specified in DWS 2020 shall be adhered to.
The production and application shall be in accordance with SABS ISO 9000, Quality System.

4.1.1 QUALITY PLAN AND DOCUMENTATION

A detailed quality plan shall be submitted for approval and completion by the Corrosion Engineer before manufacture/coating is initiated – refer to DWS 2020 QCC1 section 1.

4.1.2 INSPECTION AND TESTING PLAN (ITP) / QUALITY CONTROL PLANS (QCP)

(a) An ITP or QCP is a master Quality Control Plan or document which shall include pass/fail criteria for inspections & must be agreed between Asset Owners' Corrosion Engineer or Representative and Project Manager(s) by means of pre-approval of quality control documentation generated and submitted by the contractors for approval. The master Quality Control Plan shall contain hold points agreed to by the Corrosion Engineer.

(b) After approval of the master Quality Control Plan, the documentation shall be reproduced to be used on a daily basis or per section of work completed or per batch to record all

measurements and requirements. These QCP records must include at least surface preparation standards and profile measurements, salt tests, temperature, humidity and dew point measurement, Dry Film Thickness (DFT) measurements, Electrical Insulation Defects (EIDs) & adhesion testing: all in accordance with the relevant standards and specifications.

4.1.3 METHOD STATEMENT

(a) The Method Statement is the document describing the procedures, methods, equipment, and tools to be used for surface preparation, coating and lining application.

The Application schedule shall state the time and place when the following will be conducted:-

- Inspection of material;
- Fettling or dressing;
- Degreasing;
- Water soluble salts testing;
- Blast cleaning and application of the first coat;
- Application of intermediate and final coat(s);
- The commencement of site repairs.

(b) Coating and Lining products.

4.2 QUALIFIED STAFF

4.2.1 APPLICATION

The highest standard of workmanship is required. Only experienced personnel shall be used to carry out corrosion protection work.

All work shall be carried out under the constant supervision of a qualified supervisor.

4.2.2 REPAIR WORK AT SITE

All repair work shall be undertaken by competent personnel of the approved applicator under the supervision of a qualified supervisor.

4.3 COMPATIBILITY OF MATERIALS

The Contractor shall ensure that metals or alloys are compatible or are adequately protected if, in the galvanic series, there is a 0,3 volt difference in the galvanic potential.

4.3.1 DESIGN PRECAUTIONS

All equipment shall be designed to suppress corrosion in an exposed environment.

4.3.1.1 ACCESSIBILITY

Easy access for protection and maintenance shall be provided. The use of back to back angles, partially open box sections or inaccessible stiffeners shall be avoided.

Corrosion protection of areas that are unavoidably inaccessible shall be individually specified or approved by the Corrosion Engineer.

4.3.1.2 WATER RETENTION AREAS

Pockets, recesses and crevices in which water and dirt may collect shall be avoided. Water retention areas shall be properly drained by holes as large as possible i.e. 150 mm diameter – minimum 50 mm diameter.

Surfaces of corrodible metals, such as the insides of tanks or hollow sections that cannot be protected by any method (e.g. painting or dipping), shall be avoided; or where not possible, be fully sealed against ingress of air and moisture.

4.3.2 CORROSION PREVENTION

The Contractor shall ensure that the following steps are taken to minimise corrosion:-

(a) If dissimilar metals are used:

  (i) Coat all surfaces of the whole assembly including the more noble member of the galvanic series.

(b) If the noble member of the assembly cannot be entirely covered:

  (i) Keep the anode/cathode ratio as large as possible in the particular component.

  (ii) Use electrical insulators between two metals. Insulation must be complete: a bolt requires a sleeve as well as washers of an insulating material.

(c) Joints and crevices between metals shall be sealed.

(d) Where fastening is unavoidable, the fasteners shall be more noble (cathodic) than the base material. Fasteners shall be coated where possible and/or adequately electrically insulated between fasteners and the base material.

4.4 EQUIPMENT

4.4.1 MEASURING EQUIPMENT

The Contractor shall have the following measuring equipment site at all times:

- Ambient temperature gauge;
- Replica tape for blast profile measurement;
- Visual comparators for surface cleanliness;
- Dew point instrument;
- Dry film thickness gauge;
- Electrical Insulation Defect detector;
- Surface temperature gauge;
- Relative humidity measuring instrument;
- Wet film comb.

All test equipment shall have current valid calibration certification.

Calibration of all instruments shall be verified daily, except where otherwise specified by manufacturers', to achieve the required accuracy.

Dry film thickness gauges shall be calibrated on a flat surface, provided that the surface profile is in accordance with the specification.

4.4.2 SPRAY EQUIPMENT

Equipment used for application of coatings shall be maintained in clean condition and in good working order. Spray gun orifices shall be cleaned using a suitable solvent in accordance with recommendations of the coating manufacturers' together with brushes, pipe cleaners or other suitable means to mechanically remove all coating. Plural component spray gun machines shall be regularly stripped in accordance with the manufacturers' recommendations to ensure internal cleanliness. The Engineer may require the Contractor to demonstrate that the machine is delivering components in the correct mix ratio at any reasonable time requested.

Spray equipment shall be suitable for the production of high quality work, capable of properly atomising the coating or lining material and equipped with suitable pressure regulators and gauges. Air caps, needles and nozzles shall be of the type recommended by the coating or lining manufacturer.

All spray equipment shall be fitted with suitable oil and moisture traps.

4.4.3 MIXER

A low speed mixer, which does not introduce air into the coating material being mixed, shall be utilised only.

Payment for in situ-applied linings and coatings shall be for completed linings at the rates scheduled.

5. RECOMMENDED COATING SYSTEMS

5.1 TOXICITY OF LINING MATERIAL

Materials used for the lining of pipes shall be non-toxic and shall not impart any odour, taste, or colour to the water. Certification shall be submitted to the Corrosion Engineer for his approval.

5.2 PROPRIETARY ITEMS

Components that are supplied painted or protected e.g. gearboxes, actuators etc. **shall only be accepted** provided that they meet the corrosion protection requirements of this specification. If this specification cannot be adhered to, the Contractor **shall submit full details of the equivalent coating systems** at tendering stage, for approval by the Corrosion Engineer.

5.3 COATING SYSTEMS FOR PIPES AND SPECIALS

Selection of all corrosion protection systems shall be cleared with the Corrosion Engineer before finalisation of the Project Specification.

The following tables are abbreviated guidelines and the systems are not listed in order of preference.

See **NOTES** under paragraph 5.10.

5.9 MINIMUM THICKNESS

The tables above contain the thickness specification for DFT

The default method of DFT measurement shall be in accordance with SSPC PA - 2 Procedure for the determining conformance to dry coating thickness requirements, with specific reference to Section 9 of SSPC PA - 2 and a restriction level of 1.
The method of measuring and evaluating coating and lining thickness shall be a minimum thickness which shall mean that no readings below the minimum thickness are allowed to be accepted.

5.10 ABBREVIATIONS AND NOTES

ABBREVIATIONS

DFT : Dry film thickness
FBE : Fusion-bonded Epoxy
FBPE : Fusion-bonded Polyethylene
HDG : Hot-dip galvanized
MS : Mild steel – grade 300WA
SS : Stainless steel – grades 304L
UV : Ultra Violet
3Cr12 : Corrosion resistant steel
µm : Micrometer

NOTES

The following items shall be approved by the Corrosion Engineer

1.	Hot-dip galvanizing	- Only for pipes up to 200 mm diameter maximum and flow less than 2 m/s. - Pipes shall not be embedded in concrete. - Water analysis shall be provided. - Pipes over 200 mm diameter to be coated with a duplex system
2.	Sealant	- Interfaces of different environments shall be sealed with a Polyurethane or Polysulphide flexible sealant to be applied in accordance with the manufacturer's data sheets.
3.	Un-coated stainless steel	- Only to be used if no galvanic reaction and anaerobic conditions are found.
4.	Pickle and passivate	- If not in contact with less noble material. - If exposed to anaerobic conditions seal-coat all crevices with Elastoplastic Epoxy. - Shall be done by the dipping process.
5.	Galvanic cells	- Where a galvanic cell is situated within a water path <150 mm and concrete cover <75 mm, both the MS, 3Cr12 or SS shall be coated.
6.	Anaerobic conditions	- SS grade 316L shall be used under anaerobic and aggressive water conditions.
7.	Polyurethane for colour coding	- Re-coatable or pure Aliphatic Polyurethane where required for colour coding. Only UV resistant Polyurethane shall be used.
8.	Primers	- Primers shall only be used in special cases i.e. over-coating of galvanized surfaces.
9.	3CR12	- In view of superior corrosion resistance, coated 3CR12 material is preferred
10.	Mild steel	- Mild steel may only be used where the pipe lining can be refurbished in situ
11.	Epoxy primer	- Epoxy primer may not be required if appropriate two pack Epoxy/ Re-coatable or pure Aliphatic Polyurethane is being used.

6 MANUFACTURE AND PRE-PREPARATION

STANDARDS

SANS	1344	Medium duty solvent detergent.
SANS	5770	Preparation of steel substrate before the application of paints and related products – Test for the assessment of cleanliness of blast-cleaned steel surfaces for painting - Freedom from certain soluble salts.
SANS	5772	Preparation of steel substrate before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces - Profile of blast-cleaned steel surfaces by a micrometre profile gauge.
SANS	5502-3	Preparation of steel substrate before the application of paints and related products – Test for the assessment of surface cleanliness – Part 3: Assessment of dust of steel surfaces prepared for painting (pressure sensitive tape method).
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after overall removal of previous coatings.
SANS	8501-3	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 3: preparation grades of welds, edges and other areas with Surface imperfections.
SANS	8504-2	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast cleaning.
SANS	10064	The preparation of surfaces for coating.
SANS	14713-2	Zinc coatings – Guidelines and recommendations for the protection against corrosion of iron and steel in structures. Part 2: Hot dip galvanizing.
SANS	12944-3	Paints and varnishes – Corrosion protection of steel structures by protective paint systems. Part 3: Design considerations.
ISO	11125	Preparation of steel substrates before application of paints – Metallic blast-cleaning abrasives.
ISO	11127	Preparation of steel substrates before application of paints – Non- metallic blast–cleaning abrasives.
NACE	SP0178	Fabrication details, surface finish requirements, and proper design considerations for tanks and vessels to be lined for immersion service. Appendix C - Visual comparator for acceptable weld contours.
SSPC	PA - 2	Procedure for the determining conformance to dry coating thickness requirements, with specific reference to Section 9 of SSPC PA - 2 and a restriction level of 1.
NACE/SSPC	WJ-1	Water Jetting to bare metal

6.1 RESPONSIBILITY

6.1.1 PRE-PREPARATION

The Manufacturer or Refurbisher shall be responsible for all the pre-preparation of equipment prior to surface preparation. Pre-preparation shall be carried out to the approval of the Corrosion Engineer and the Corrosion Protection Contractor.

6.1.2 PERSONNEL

Pre-preparation shall be carried out by competent personnel, under the supervision of an experienced supervisor.

6.1.3 MARKING

All items shall be permanently and indelibly marked to identify each individual item as specified by the Engineer.

6.2 FABRICATION REQUIREMENTS

6.2.1 SURFACE DEFECTS

All extrusions rolled steel and castings shall be clean and free of score marks, pits, protrusions, blisters, porosity, blowholes, cracks or any other flaws which may be detrimental.

Laminations, scabs or occluded scale shall be ground out. If such grinding penetrates deeper than 7% of the metal thickness, the area shall be repaired by welding, or the metal shall be rejected at the discretion of the Engineer.

6.2.2 UNDERCUTS, CAVITIES AND PITS

Weld undercuts and cavities as well as pits in metal surfaces are not permitted.

All undercuts, cavities and pits shall be ground out, re-welded and ground to a smooth contour.

6.2.3 WELDS

The weld finish requirements for proper corrosion protection shall be read together with SANS 8501-3 grade P3 or NACE SP0178 grade C for liquid or powder applied systems and grade B for tape and shrink sleeve systems. Furthermore, where any discrepancies may arise, the more stringent specification shall apply.

All welds shall be continuous and shall have a smooth contour. The shape of welds shall be gently convex, and the height of the weld bead shall not exceed 1mm internally and 3mm externally. Undercuts, sharp protrusions, steep angles, blowholes, and discontinuity of reinforcement are not permitted. The weld finish shall be suitable and appropriate to the type of corrosion protection.

Areas adjacent to welds shall be free from weld spatter. Such spatter shall be removed by grinding or scraping.

Welding processes used shall limit heat input to a minimum to restrict the heat affected zone.

6.2.4 LIFTING LUGS

Where required, lugs shall be fitted by the manufacturer to the requirements of the Corrosion Contractor and the approval of the Engineer.

6.2.4.1 LUGS TO BE REMOVED

After removal the damaged coating area shall be repaired in accordance with the original Specification.

6.2.4.2 PERMANENT LUGS

Lugs, not intended to be removed, shall be manufactured of equal or more noble grade than the base material in accordance with the Specification.

6.3 REFURBISHMENT

6.3.1 INSPECTION PROCEDURE

Corrosion damage must be exposed by manual, mechanical or abrasive blast-cleaning for inspection. The refurbishment procedures shall then be specified by the Engineer.

6.3.2 PREPARATION METHODS

Allowable depth of pitting is 0,8mm . Pits need to be repaired by blending in i.e. removal of sharp edges surrounding the pit. If larger pits are found these will be evaluated and if necessary repaired by means of welding and then ground smooth. This will be tendered as a rate only item.

6.4 PRE-PREPARATION

6.4.1 GENERAL REQUIREMENTS

6.4.1.1 PROTRUSIONS

Protrusions shall be removed by grinding and dressing to a smooth contour.

6.4.1.2 SHARP EDGES

Burrs shall be removed by grinding.

All sharp edges shall be radiused to a minimum of 2 mm.

6.4.1.3 WELDS

Welds shall be free from slag, slag inclusions, cracks, surface cavities and under-cuts.

Irregular projections shall be ground to a smooth contour.

Areas adjacent to welds shall be free from weld spatter. Such spatter shall be removed by grinding or scraping.

6.5 PRIMARY CLEANING

The Manufacturer or Refurbisher shall remove oil, grease, silicon weld spatter release agent or other surface contaminants with a water-soluble solvent degreaser followed by rinsing with clean, soft water before the items are despatched to the Corrosion Protection Contractor. Carry out a reliable and suitable test to ensure oil and grease is removed.

6.5.1 WELD SPATTER RELEASE AGENTS

The use of weld spatter release agents is not acceptable on the project as the typical formulations contain silicone which is difficult to observe and remove and such weld spatter release agents may result in poor adhesion of coatings and linings.

7 SURFACE PREPARATION

The best possible degree of surface cleanliness is always preferred before the application of corrosion protection materials. Should any doubt arise a cleaner surface and more stringent specification shall be required.

7.1 STANDARDS

SANS	1344	Medium duty solvent detergent.
SANS	5770	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness of blast-cleaned steel surfaces for painting - Freedom from certain soluble salts.
SANS	5772	Preparation of steel substrate before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces - Profile of blast-cleaned steel surfaces by a micrometre profile gauge.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after overall removal of previous coatings.
SANS	8502-2	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 2: - Laboratory determination of chloride on clean surfaces.
SANS	8502-3	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 3: - Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method).
SANS	8502-5	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 5: - Measurement of chloride on steel surfaces prepared for painting – ion detector tube method.
SANS	8504-2	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast cleaning.
SANS	10064	The preparation of surfaces for coating.
SANS	12944-4	Paints and varnishes – Corrosion Protection of steel structures by protective paint systems. Part 4: Types of surface and surface preparation.
ISO	11125	Preparation of steel substrates before application of paints – Metallic blast-cleaning abrasives.
ISO	11127	Preparation of steel substrates before application of paints – Non- metallic blast–cleaning abrasives.
NACE	SP0178	Fabrication details, surface finish requirements, and proper design considerations for tanks and vessels to be lined for immersion service. Appendix C - Visual comparator for acceptable weld contours.

The default surface preparation requirement shall be Sa3 as described in SANS 8501-1 and in addition shall be subject to time limitation between obtaining the degree of surface cleanliness and application of corrosion protection as described in the section that deals with quality control of coatings and linings.

In addition to this default requirement there may also be project specific surface preparation standards that will take precedence.

7.2 RESPONSIBILITY

7.2.1 SURFACE PREPARATION

The corrosion protection Contractor shall be responsible for preparation of all surfaces to be coated.

On completion of the Contract, all plant, equipment, temporary structures and materials shall be removed from the site.

7.2.2 PERSONNEL

The Contractor carrying out the surface preparation shall have competent personnel with the necessary technical knowledge of the processes involved.

All work shall be carried out under the supervision of an experienced supervisor.

7.2.3 EQUIPMENT

The Contractor carrying out the surface preparation shall have competent personnel with the necessary technical knowledge of the processes involved. All work shall be carried out under the supervision of an experienced and qualified supervisor.

To ensure skills, quality and reliability of water infrastructure and supply services, minimum qualifications and experience are required.

(a) Equipment and air supply free of oil and moisture.

(b) Compressors shall have a capacity and pressure output to achieve the required nozzle pressures. (Worn nozzles shall be replaced).

(c) All plant, equipment and temporary structures shall at all times be maintained in good and safe working order.

If the correct surface preparation is not achieved due to inadequate plant and equipment, the Engineer may order the Contractor to obtain such plant and equipment as may be necessary to achieve the specified results.

7.2.4 WORKING CONDITIONS

Surface preparation shall not take place when conditions are likely to affect the corrosion protection processes adversely.

The Contractor shall provide screens, covers, trestles or any other equipment necessary to avoid contamination of surfaces and to minimise time delays caused by inclement weather.

7.2.5 HEALTH AND SAFETY

The Contractor shall at all times enforce health and safety measures necessary to comply with the Occupational Health and Safety Act No. 85 of 1993 and the manufacturer's requirements.

7.3 PROCEDURE

7.3.1 APPROVAL OF WORKS AND PROGRAMME

The Contractor's programme, plant and equipment and works shall be approved by the Corrosion Engineer prior to commencement of surface preparation.

7.3.2 INITIAL INSPECTION

The corrosion protection Contractor shall check the initial condition of the surface for:

(a) Visible surface defects
(b) Corrosion or contamination
(c) Any required metal dressing
(d) Elimination of burrs and radiusing of edges

(f) Suitable lifting lugs

and shall bring any concerns relating to the above to the attention of the Corrosion Engineer. The Corrosion Engineer shall issue instructions for the correction thereof.

Areas subjected to chemical attack, salt spray, fungus or bacteria shall be neutralised, rinsed with clean potable water before abrasive blast-cleaning.

7.3.3 DEGREASING

All surfaces to be coated shall be tested for oil and grease contamination by the water break free test or ultra-violet light or any other method agreed to by the Corrosion Engineer.

Oil and grease contamination shall be removed by:

- Steam-cleaning.
- An emulsifiable or aqueous detergent applied in accordance with SANS 1344.
- An alkaline cleaning solution.

Allow to react, and then rinse off with clean, potable water to remove all residues prior to surface preparation, all in accordance with clauses 4.3 and 4.4 of SANS 10064.

The surfaces shall be tested after degreasing and show no oil, grease and chemical contamination after degreasing.

Care shall be taken to avoid entrapment of cleaning agents in recesses or other retention areas.

7.3.4 ROUGH / PRE-BLASTING

All rust, mill scale, old coating or marking paint shall be removed by rough / pre-blasting.

The Engineer shall be advised when blast-cleaning of the appropriate section will be completed so that an inspection can be carried out to determine if repairs are required.

Blast-cleaning shall be done in accordance with the code of practice SANS 10064 to achieve a cleanliness of Sa 2. (SANS ISO 8501-1)

7.3.5 WATER SOLUBLE SALTS

The blast cleaned surfaces to be coated shall be tested for water soluble salts. The maximum level of salts allowable on the surfaces shall not exceed the values given below.

Should these values be exceeded, the surfaces shall be cleaned by: -
(a) A liquid soluble salt remover approved by the Corrosion Engineer or
(b) Washing with a high-pressure jet of clean potable water or
(c) Water injected blast-cleaning.

Followed by re-blast or flash blast-cleaning until the soluble salts are within the specified limits.

Water soluble salt decontamination may require repeated washing and re-blasting cycles.

Prepared surfaces shall be in accordance with the table below.

WATER SOLUBLE SALTS	FOR IMMERSED OR BURIED CONDITIONS
Maximum at any point	Chloride - max 70 mg/m^2 Soluble Ferrus ion contaminants - Max 100 mg/m^2 Sulphate contaminants - max of 170 mg/m^2

NOTE: The conversion factor for salt concentration on a steel surface to change between milligrams per square metre and micro grams per square centimetre is 10 mg/m^2 to 1 $microgram/cm^2$

When so required by the Corrosion Engineer, the surface should be assessed for chloride contamination in accordance with SANS 8502-2 or SANS 8502-5, as agreed by manufacturer.

7.3.6 FINAL-BLAST

7.3.6.1 FINAL-BLAST

7.3.6.1.1 Humidity and Temperature

Final-blasting and corrosion protection shall not be carried out if the steel temperature is less than 3°C above dew point.

At the discretion of the Corrosion Engineer, and in the event that the relative humidity is consistently between 80% and 90% blast-cleaning may only take place if the steel is at least 5°C above the condensation temperature (dew point) of the air and if the steel is coated **within one hour** after blasting, provided that the paint or coating systems that are used under conditions of high humidity are **not moisture sensitive**.

For maintenance and refurbishment work of the Corrosion Engineer shall have the discretion to issue a written concession that relaxes the time limitation after grit blasting and substitutes this with a hold point inspection of the blast cleanliness standard to ensure that no deterioration has occurred due to the elapse of time. Any dispute relating to cleanliness of blasted steel that has aged shall be settled by blasting test patches to ensure that there is no colour variation between the old blasted steel and the freshly blasted steel.

7.3.6.1.2 Blasting-material

Final blast-cleaning shall be carried out using clean, uncontaminated blast-medium in accordance with paragraph 7.4.2.

7.3.6.1.3 Blast Cleanliness

All surfaces for "wet/submerged conditions" and for "dry conditions" shall be blast-cleaned to Sa 3 accordance with SANS 8501-1.

7.3.6.1.4 Profile

The required surface profile specified in paragraph 7.4.1 shall be achieved by final-blasting in accordance with SANS 10064 and/or ISO 8504-2.

7.3.6.1.5 Residual Dust and Debris

Prior to coating, dust and debris shall be removed by vacuum-cleaning. A dust and debris test shall be done in accordance with SANS 8502-3.

Only with prior approval by the Corrosion Engineer may dust and debris be removed by blowing with clean uncontaminated compressed air.

For the internal field joint as well as internal patch repairs of pipelines, all blasting grit must be removed from the pipeline before application of the protective lining.
Then contractor shall provide mobile platforms with soft wheels or stable tower scaffolding or similar to create access to the underside of the roof of large diameter pipes and tunnels.

7.3.6.1.6 Contamination

After final-blasting, the un-coated steel shall not be touched with bare hands. All applicators shall wear white gloves and shoe covers where applicable.

7.3.6.2 FLASH-BLAST

Flash blast-cleaning shall be carried out to reinstate the surfaces specified in paragraph 7.4.1, in accordance with paragraph 7.3.6.1.

7.4 SURFACE PREPARATION REQUIREMENTS

SURFACE CONDITIONS

The surface preparation requirements in the table below in Sections 0 (7.4.1 SURFACE PREPARATION PARAMETERS FOR NEW STEEL) and 0 (7.4.2 BLAST PROFILES FOR CORRODED STEEL AND CAST IRON) are general requirements. In addition to these general requirements there will also be detail projects specific surface preparation standards that will take precedence.

Refer to the notes below table in Section 0 (7.4.1 SURFACE PREPARATION PARAMETERS FOR NEW STEEL) for more information.

7.4.1 SURFACE PREPARATION PARAMETERS FOR NEW STEEL

Prepared surfaces shall be in accordance with the table below:

PROPERTY	FOR WET, BURIED CONDITIONS
Cleanliness to SANS 8501-1 (min)	Sa 3
Residual dust and debris SANS 8502-3 maximum particle size	Class 3

Residual dust and debris SANS 8502-3 maximum quantity	Rating 2 *(refer note)
Oil, grease and perspiration	Nil
Surface Profile (min) Coats up to 400 µm (max)	40 µm 80 µm
Surface Profile (min) Coats >400 µm (max)	50 µm 100 µm
Surface Profile (min) Solvent Free Coats	50 µm No maximum
Water soluble salts at any point (refer note)	Chloride - max 70 mg/m^2
	Soluble Ferrus ion contaminants - Max 100mg/m² mg/m^2
	Sulphate contaminants - max of 170 mg/m^2

NOTES:

- The conversion factor for salt concentration on a steel surface to change between milligrams per square metre and micro grams per square centimetre is 10 mg/m^2 to 1 $microgram/cm^2$
- (1ppm is equal to 1 mg/l and 1 micro grams/ml)
-
- For solvent free coatings there is no upper maximum limit for blast profile.
- For maintenance work it is recommended that the Corrosion Engineer be consulted concerning tests for bacterial contamination.
- Grit blasting DOES NOT remove all salts and bacteria and a decontaminating wash may be required followed by re-blasting.
- *Under field conditions the Corrosion Engineer may issue a relaxation so that the dust contamination shall not be in excess of dust Quantity Rating 2 as per the pictorial standard and a size Class 3 in accordance with SANS 8502-3.

7.4.2 BLAST PROFILES FOR CORRODED STEEL AND CAST IRON

Corroded steel inherently has a higher roughness surface profile due to wasting of the surface. Therefore, blast profiles on corroded steel may tend to be towards the higher of the ranges specified in Section 7.4.1 SURFACE PREPARATION PARAMETERS FOR NEW STEEL) above.

Average blast profiles above 100 microns prohibits the use of solvent borne thin coatings because of the risk of the high points greater than 25% grinning through the coating film and resulting in measle corrosion. Solvent entrapment can occur in the valleys of the high blast profile.

For blast profiles above 100 microns it is only permissible to use solvent free coatings or coatings with a volume solid 95% or above.

When using solvent free coatings, higher blast profiles may lead to an improved mechanical key due to the better anchor pattern and higher adhesive bond strengths.

7.4.3 ABRASIVE MATERIAL

7.4.3.1 MATERIAL

The blast-cleaning abrasive shall be composed of clean, sound hard particles free from foreign substances such as dirt, oil, grease, toxic substances, organic matter, water soluble salts and

foreign metals. The abrasive material shall be washed, screened and graded for size. The blasting abrasive type shall meet the requirements as specified in ISO 11125 for Metallic abrasives and ISO 11127 for Non-Metallic abrasives.

The type of grit to be used should be inert synthetic mineral with similar chemical and physical properties to aldamine garnet (Ecoblast or equivalent) Crushed or granulated slag is not permitted

7.4.3.2 CERTIFICATION

The abrasive material supplier shall certify that all products supplied conform to all the requirements specified.

7.4.3.5 pH

The pH of the prepared slurry mixture shall not be below 6,2.

7.4.3.6 WATER SOLUBLE SALTS

The conductivity of slurry shall be less than 25 mS/m in accordance with ISO 11127.

7.4.3.7 MOISTURE CONTENT

The moisture content for abrasive material shall not exceed 0,2 percent.

7.4.3.8 RE-CYCLING

Re-cycled blasting-material shall only be used if:

(a) Blasting-materials were only used on degreased surfaces
(b) Dust and debris is removed from the blasting-material
(c) Particles are kept angular and within specified sizes

Re-cycled blasting-material may only be used for rough blasting and pre-blasting.
Re-cycled blasting-material shall not be used for final blasting.

7.4.4 AIR SUPPLY

Air supply equipment shall be fitted with efficient oil and water traps to avoid contamination of the surface. At least one oil and one water trap shall be fitted at the compressor and one water trap at the blast pot.

Some tunnel liners are 1500m from the access addit therefore piping and size of compressor is important to achieve proper blast.

The air pressure shall be a minimum of 600 kPa at the nozzle measured with a needle pressure gauge but not withstanding the contractor shall ensure that both the volume and the pressure of the air is sufficient to achieve the required blast cleanliness and blast profile standard at the required rate of production.

The air pressure supply at the compressor shall, as a guideline be a minimum of 700 kPa or preferably more, to provide the minimum required nozzle air pressure.

The contactor shall be responsible for his own lack of efficiency and productivity if the compressed air that he supplies is inadequate.

(Testing Compressed Air For Oils (REFER SANS 8573)).

7.5 SURFACE PREPARATION OF OTHER MATERIALS

7.5.1 GALVANIZED SURFACES TO BE COATED

Main line bulk water pipe and buried pipes shall not be galvanized.
Structural steel for C1 to C3 atmospheric conditions as defined by ISO 12944-2 classification of environments may be hot-dip galvanized or duplex coated as per ISO 12944-5.

The use of galvanized surfaces inside valve chambers is not permitted, due to high levels of humidity that is generally found in the chambers.

7.5.1.1 PASSIVATION

Surfaces to be coated shall **not** be passivated.

7.5.1.2 DEGREASING

Galvanized steel surfaces shall be degreased prior to coating, in accordance with Section 7.3.3 and the manufacturer's instructions, or a mild acid-detergent degreasing solution to be approved by the Corrosion Engineer.

7.5.1.3 PROFILE

7.5.1.3.1 Sweep-blasting

Large areas shall be prepared by sweep-blasting with non-metallic abrasive in accordance with paragraph 7.3.6.3.

7.5.1.3.2 Mechanical

Surfaces that cannot be sweep-blasted shall be abraded manually or mechanically with abrasive paper grade 220 or by using non-metallic abrasive pads.

7.5.1.4 DUST AND DEBRIS

Finally, all dust and debris shall be removed by vacuum-cleaning.

7.5.1.5 PRIMER

Primer for galvanised surfaces shall be applied immediately after surface preparation, not exceeding the time limits specified in paragraph 7.3.6.1.1.

7.5.2 ALUMINIUM SURFACES TO BE COATED

Aluminium surfaces to be coated shall be treated as follows:

7.5.2.1 DEGREASING

Surfaces shall be degreased in accordance with paragraph 7.3.3.

7.5.2.2 PROFILE

Sweep-blast with non-metallic abrasive in accordance with paragraph 7.3.6.3.

7.5.2.3 DUST AND DEBRIS

All dust and debris shall be removed by vacuum-cleaning.

7.5.2.4 PRIMER

Primer for aluminium surfaces shall be applied immediately after surface cleaning, not exceeding the time limits specified in paragraph 7.3.6.1.1.

7.5.3 CORROSION RESISTANT AND STAINLESS STEEL

Components fabricated from corrosion resistance and stainless steel shall not be contaminated with iron or mild steel through the use of contaminated grinding discs, wire brushes, scratch marks, steel grit etc.

Conventional slag abrasives often contain up to 35% ferrous and ferric compounds where the resultant iron residues can set up corrosion cells on the surface of stainless steels. The blasting abrasive type shall meet the requirements as specified in ISO 11127 for Non-Metallic abrasives.

Note that platinum slag and garnet may contain iron in the form of ferrous and ferric compounds and should therefore preferably not used.

Permissible abrasives for blasting stainless steel which is to be coated and immersed shall be:
- Aluminium Oxide
- Glass Grit
- Stainless Steel Grit

Care must be taken to ensure that specified surface profile is achieved because stainless steel is harder than mild steel and therefore more difficult to obtain roughness.

7.5.3.1 UN-COATED SURFACES

Stainless steel surfaces shall not be contaminated with carbon steel, scratched or stressed.

The following areas shall be pickled and passivated:

(a) All un-coated areas.

(b) Ground and sheared edges.

(c) Heat affected zones caused by welding or cutting.

It is recommended that, if possible, pickling and passivation be done by the dipping process.

Proprietary pickling and passivation chemicals (as supplied by approved suppliers) shall only be used in accordance with the manufacturer's recommendations. Care shall be taken not to exceed the maximum contact time recommended.

After pickling and passivation, surfaces shall be very thoroughly washed with clean potable water to remove all traces of acid. Surfaces shall be allowed to dry, then polished where necessary, using polishing compounds recommended by the stainless steel manufacturer.

7.5.3.2 SURFACES TO BE COATED

7.5.3.2.1 Degreasing

Surfaces shall be degreased in accordance with paragraph 7.3.3.

7.5.3.2.2 Profile

Corrosion resistant steel surfaces shall be blast-cleaned with stainless steel grit or non-metallic abrasive to create a profile in accordance with table in Section 0 (7.4.1 SURFACE PREPARATION PARAMETERS FOR NEW STEEL).The use of steel shot and steel or cast-iron grit is strictly prohibited. Stainless steel tends to have a harder surface and is more difficult to obtain blast profile. Surface profile shall be a minimum of 30 µm for atmospheric corrosion conditions and 50 µm for immersed corrosion conditions.

Where blasting is impractical, the surface shall be roughened manually with abrasive paper with minimum roughness grade 50 grit, low speed disc grinders or flapper wheel disc. In all instances, clean, uncontaminated surface preparation equipment must be used.

Time Limitation of application of coating systems
The time interval between blast cleaning of stainless steel and application of coating should be immediate or as short as practically possible to prevent the formation of a chrome-oxide layer developing

7.5.3.2.3 Dust and Debris

Dust and debris shall be removed by vacuum-cleaning.

7.6 TEST METHODS

Tests, instruments, methods and criteria shall be as specified below or in the Project Specification.

7.6.1 OIL AND GREASE TEST METHOD

7.6.1.1 WETTING WITH WATER

All surfaces cleaned of oil and grease shall be tested using the "water-break-free" method. The surface shall be wetted with water and the entire surface shall be covered by an unbroken film.
Note: Due to the size of some components the water break-free test is not practical and the UV light test must then be used.

7.6.1.2 SOLVENT-WIPING

Where water soluble lubricants may be present the surface shall be further tested by wiping with a clean cotton wool swab soaked in solvent. No stain shall be evident on the swab after solvent-wiping.

7.6.1.3 ULTRA VIOLET LIGHT TEST METHOD

Suitably powerful ultra violet light equipment can be used under darkened conditions to detect oil contaminated surfaces that fluoresce.

NOTE: The majority of oils and grease fluoresce but not necessarily all oils.

7.6.1.4 TESTING COMPRESSED AIR FOR OILS (REFER SANS 8573)

The following test methods shall be used for testing compressed air for oil contamination, when the compressed air is blown onto the three surfaces mentioned below:

- The white cloth method will show the oil when held up to a bright light.
-
- The glass sheet and warm water method which will show rainbow colours on the water surface.
-
- The white paper and outline held up to a bright light.

7.6.2 WATER SOLUBLE SALT TEST METHOD

An approved method shall be used to carry out salt contamination tests prior to washing and after abrasive blast cleaning. One salt contamination test shall be carried out at each end of the pipe. For other steel structures or for maintenance work the frequency of testing shall be as indicated in the project Specification or more frequently as required by the Corrosion Engineer.

The following three tests may be used as screening for ferric chloride:

- Weber Riley spray may be used as a screening qualitative test only for atmospheric conditions to indicate the presence of ferric chloride. Weber Riley shall not be used for immersed conditions.

- Watman papers may be used as a screening qualitative test for immersed and atmospheric conditions, but only to indicate the presence of ferric chloride.

- Conductivity test instruments that use liquid swabbed on the surface to dissolve soluble metallic salts may also be used as a screening qualitative test for immersed and atmospheric conditions. Conductivity test instruments results do not accurately quantify salt concentrations for individual ions such as sulphates or nitrates. These instruments can incorrectly assume that the conductivity reading relates only to chlorides.

If any screening test indicates an unacceptable level of salt or there is any dispute in the concentration level, then the quantitative test below shall be used.

The generally accepted quantitative test methods are as follows:

- Bresle patch predominately for horizontal surfaces.

- Chlor condom tests for vertical surfaces and inverted upside-down surfaces.

- CSN test kit. (the Chloride, Sulphate and Nitrate test kit)

- Merck-o quant.

- Swab and titration.

The majority tests do not separately detect sulphates, nitrates, and soluble ferrous ion.

Substrate surfaces shall be tested for the presence of water-soluble salt contaminants using a reliable repeatable method as per above and the results shall not exceed the limits as per the table below:

WATER SOLUBLE SALTS		FOR IMMERSED OR BURIED CONDITIONS
Maximum at any point		Chloride - max 70 mg/m^2 Soluble Ferrus ion contaminants - Max 100 mg/m^2 Sulphate contaminants - max of 170 mg/m^2

NOTE: The conversion factor for salt concentration on a steel surface to change between milligrams per square metre and micro grams per square centimetre is 10 mg/m^2 to 1 microgram/cm^2.

Water soluble salt decontamination may require repeated washing and re-blasting cycles.

7.6.3 STANDARD OF MECHANICAL SURFACE PREPARATION

Mechanical surface preparation shall be visually compared to the standard shown in SANS 8501-1.

7.6.4 BLAST PROFILE

The blast profile of the substrate surfaces shall be determined in accordance with SANS 5772. (pin type profile gauge)

Alternative test methods such as profile impressive test tape (for example Testex tape) or digital ultrasonic/stylus blast profile instruments should be used at the discretion and with permission of the Corrosion Engineer.

7.6.5 RESIDUAL DUST AND DEBRIS

Substrate surfaces shall be tested for the presence of residual dust and debris in accordance with SANS 8502-3.

7.6.6 BLASTING-MATERIAL

All blasting-materials shall be approved by the Corrosion Engineer.

7.6.6.1 METALLIC ABRASIVE

Abrasive shall be tested in accordance with ISO 11125 for particle size, hardness, density, foreign matter and moisture.

9 GLASS FLAKE COATING AND LINING SYSTEMS

Glass flake coating and lining systems are generally used where higher performance and longer life expectancy is required than the base generic resin.
The Glass flake corrosion protection systems are formulated from various generic base resins or polymers such as epoxy, polyester and vinyl ester resin binders.

The principle of operation of glass flake coatings and linings is called a tortuous path that creates a longer diffusion trail in cross section through the coating thickness.

The addition of Glass flake reinforcement improves the corrosion protection properties of the coating or lining material. The improvements in performance are in areas such as permeation resistance, much slower rates of Moisture Vapour Transmission (MVT), and low rates of diffusion to small molecules such as oxygen. The consequence of adding the correct type and quantity of glass flake is an order of magnitude or more reduction in osmosis through a coating or lining film.
One benefit of the increase in resistance to permeation exhibited by glass flake coatings when compared to the same base resin is much higher aged bond strength after immersion. (% adhesion retained after time)

The addition of glass flake also improves the electrical resistance (Dielectric Insulation) of the coating and lining and substantially reduces cathodic disbondment. From a Cathodic Protection CP design perspective, glass flake reinforced coatings, reduce current drain and may result in savings on the size of CP power supply units.

The use of glass flake coatings, improves Cathodic disbonding resistance

Glass flake addition to epoxy or other resin systems, also improves properties such as wear and abrasion resistance, increased toughness, improved resistance against cutting, gouging, scour marks and scratching, when compared to the same base resin in a non-filled coating.

The addition of glass flake also improves the UV resistance of epoxy, because any chalking and subsequent loss of coating thickness is limited to the surface layers and chalking does not penetrate.

The majority of the standards, application procedures and quality control methods used for other liquid applied coatings and linings are also relevant to Glassflake coatings and linings.

9.1 STANDARDS

Equipment, materials and operational methods shall comply with the relevant SANS, ISO, BS, EN, NORSOK, ASTM or equivalent. The latest issue of the references shall be used unless otherwise agreed.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification.

Reference is made to the latest issues of the following Standard Specifications:

SANS	5769	Cleanliness of blast-cleaned steel surfaces for painting

		(dust and debris).
SANS	5772	Profile of blast-cleaned steel surfaces for painting.
SANS ISO	2808	Determination of film thickness
SANS ISO	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings
SANS ISO	8501-3	Part 3: Preparation grades of welds, edges and other areas with surface imperfections
ISO	20340	Relevant extracts from performance requirements for protective paint systems, as pre-qualification before use in this specification.
ISO	2812-2	Water Immersion
NORSOK	M-501	Surface preparation and protective coating
ASTM	D1653	Water Vapour Permeability
ASTM	D1002	Adhesive Strength onto Steel
ASTM	G95/G8	Cathodic disbonding resistance
SANS ISO	9000	Model for quality assurance in production and installation.
SSPC	PA - 2	Procedure for the determining conformance to dry coating thickness requirements, with specific reference to Section 9 of SSPC PA - 2 and a restriction level of 1.

9.2 MATERIAL

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) The Glass Flake coating or lining material shall be manufactured in accordance with SANS ISO 9000. The Corrosion Engineer shall give preference to Contractor's utilising solvent free Glass Flake epoxy coatings, especially in confined spaces.

(c) For confined space patch repairs the Corrosion Engineer may give preference to catalyst cured systems such as polyester and vinyl ester because of potential mix ratio issues when using epoxy for small local repairs.

(d) Polyester and vinyl ester Glass Flake systems are generally limited to shorter spray hose length of 50 – 100 meters, while plural sprayed epoxy Glass Flake systems are able to be sprayed through long hose lengths up to 500 meters.

(e) Glass flake linings for immersed conditions shall be of the high build type containing at least 95% solids.

(f) Materials and procedures shall comply with the relevant SANS Specifications and generally accepted best practice.

(g) All materials in a coating system shall be purchased from the same manufacturer unless approved by the Corrosion Engineer. If they do not come from the same manufacturer compatibility test demonstrating minimum acceptable bond strength must be carried out to the satisfaction of the Corrosion Engineer.

(h) The Glass Flake coating or lining materials intended to be used on a project, should preferably be pre-qualified in accordance with NORSOK M-501 or similar certification. The Contractor shall submit details on the proposed

materials for approval and the Contractor shall only proceed with the purchase of coating or lining materials upon receipt of written approval from the Corrosion Engineer.

(i) Materials offered and subsequently approved shall not be changed without written approval of the Corrosion Engineer.

(j) Coating and lining material selection shall also be approved by the material manufacturer/supplier as fit for purpose to provide the anticipated life expectancy and performance and described in chapter 10. The Contractor shall ensure that the Corrosion Engineer receive a written assurance from the material suppliers that the materials comply with the specified requirements.

(k) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or an ISO 9000 certificate where applicable

(l) All coating materials shall be kept in an approved dry and enclosed store. The storage temperature for epoxy shall not drop below 0°C nor exceed 40°C. For Polyester and Vinyl ester materials there are no minimum storage temperatures and max short term (1 month) storage temperature should not exceed 30°C.

(m) Usage of materials shall be on a first in, first out basis and no materials shall be used that have exceeded the shelf life recommended by the manufacturer.

9.3 SPECIAL COATING AREAS

(a) Areas that are inaccessible after assembly shall be prepared and fully coated with the specified system to the specified requirements before assembly. The coating shall be fully cured before assembly.

(b) Mating surfaces of joints shall be coated with Glass Flake coatings & linings, primer (where specified) or first coat only. The coating shall be uniform in thickness and shall not interfere with the mechanical tolerances. After assembly the outside surface of the joints shall be fully coated.

(c) Steel edges to be welded after coating shall not be coated for a distance of 100mm from the welding edge. The unlined strip of grit blasted surface shall be temporarily protected with a coat of (red or a different colour to the lining/coating) weldable primer between coating application and installation.

(d) Friction grip areas shall be left un-coated unless otherwise specified.

(e) For pipe diameters that are too small for safe man entry, the special coating areas (internal circumferential field joints, by-pass pipes, scour pipes etc.) shall have the internal lining application method statement and method of quality control pre-approved by the Corrosion Engineer. The contractor shall be required to

demonstrate the effectiveness of the proposed methods, before the relevant commencement of work on site.

9.4 APPLICATION

(a) The coating application technique for Glass Flake coatings is a different spray technique to obtain a smooth finish.

(b) Compared to conventional coating systems, that are sprayed, the Glass Flake coatings require higher atomisation pressures relative to un-filled resins.

(c) Glass Flake coatings applied by hand require directional brush techniques.

(d) Applicators need to demonstrate both experience of previous Glass Flake application as well as formal training certificates from a Glass flake coatings and lining manufacturer

(e) Glass Flake coating spray is usually by airless pump, but can also be by pressure pot and cup gun or even aerosol can, depending on type of glass flakes

(f) The thinner and smaller (irregular)r diameter flakes spray more easily and apply smoother than old technology Glass Flake coatings

(g) Thicker/ course Glass Flake coatings can result in a rough finish, unless applied by a skilled and experienced applicator.

(h) Quality Control of glass flake coatings and linings should always include high voltage spark testing to find both actual defects as well as potential defects

9.4.1 SURFACE PREPARATION

Pre- and surface preparation shall conform to Sections 6 and 7 respectively of this specification.

The Contractor shall satisfy himself that the condition of each item to be coated is such that it is fit for coating or lining, so that the contractor can honour his guarantee. Immediately after surface preparation each item or special shall be examined, including the inside surface, where possible, for compliance with the relevant requirements.

For pipes and specials intended for butt welding the prepared surfaces shall extend to the pipe ends.

9.4.2 COATING THICKNESSES

Coating thicknesses shall as a minimum conform to Section 5 dependant on service environment and life expectancy requirement, alternatively thicker as specified in the Project Specific Specification.

9.4.3 MANUFACTURER'S INSTRUCTIONS

Recommendations supplied by the manufacturer in the form of the latest edition of printed data sheets, or given in writing on the manufacturer's letterhead, shall be followed. The following details shall be made available to the applicator:

(a) Brand and type of Glass Flake coatings & linings resin
(b) Mixing and thinning instructions
(c) Recommended type of solvent required for cleaning, as per data sheet. Thinning of glass flake coatings with solvent for spray application is normally prohibited.
(d) Pot life of mixed product
(e) Minimum and maximum recommended dry film thickness per coat
(f) Recommended time intervals between coats unless a single coat is specified.
(g) Recommended minimum and maximum steel surface temperatures during application
(h) Time for complete drying and curing on steel surfaces
(i) All relevant information the Manufacturer wishes to submit on his product
(k) Recommended method of coating application

Verbal information by the manufacturer's representative will not be accepted unless confirmed in writing by the manufacturer.

9.5 COATING APPLICATION

9.5.1 ENVIRONMENTAL CONDITIONS

9.5.1.1 DUSTY CONDITIONS

Coatings shall not be applied in dusty or contaminated conditions.

9.5.1.2 SURFACE TEMPERATURE

(a) Coatings shall not be applied if the surface temperature of the steelwork is less than 3°C above dew point or stated differently may only be applied if the steel surface is at least 3°C warmer than dew point or condensation temperature of the air.

(b) Epoxy Glass Flake and epoxy coating should not be applied under cold condition below 7°C because of material doesn't cure properly and risks amine bloom.

(c) Polyester and vinyl ester Glass Flake coating can be applied under freezing cold conditions (sub-zero temperature) and the material will still cure properly, with consideration that curing times will become longer. When applying coating in freezing conditions, care must be taken that the steel is warm or air is very dry to prevent condensation.

(d) For very hot conditions above 40°C solvent free and high solids Glass Flake coatings may be used with consideration that pot life and curing time will decrease.

(e) When-ever coatings are to be applied under extreme conditions outside the range 7-40°C, the coating manufacturer shall be consulted and requested to confirm product suitability.

9.5.1.3 RELATIVE HUMIDITY AND TIME OF APPLICATION

The first coat shall be applied as soon as possible after blast cleaning, but not exceeding four (4) hours if the relative humidity (RH) is below 70% or two (2) hours if the RH is

between 70% and 85%. Refer to paragraph 7.3.6.1 for the conditions under which the Corrosion Engineer may in his discretion relax these requirements for project specific requirements.

No coating or lining application is permissible if the dew point temperature of the air is not at least 3°C above or warmer than the steel substrate.

9.5.1.4 AMBIENT TEMPERATURE

Coatings shall not be applied when the ambient temperature is less than the minimum or greater than the maximum specified by the manufacturer of the coating material, read together with section 9.5.1.2.

9.5.2 MIXING GLASS FLAKE MATERIAL

Epoxy glass flake materials have a base to activator mix ratio which is critical and must be adhered to. Example 70:30.
Polyester and vinyl ester glass flake materials have a base to catalyst mix ratio that must be adhered to within a range allowed by the manufacturer's data sheet. Example 98:2 or 99:1.
Curing time and pot life of polyester and vinyl ester glass flake materials may be varied with in manufacturer's allowable range to speed up or slow down polymerization and curing time.

For two pack materials, the use of part of the contents (split packs) is strictly forbidden unless written authorisation by the Corrosion Engineer is obtained.

All coating components, particularly two- or multi-component materials, shall be thoroughly mixed until a homogeneous mixture is achieved.

In the case of two-pack materials, each component base or activator shall be separately mixed. The two components shall then be mixed together in the proportions supplied by the Manufacturer until the mixture is completely homogeneous.

The use of plural spray equipment is permitted using one of two methods: at gun catalysation, or mixing block with inline mixing tube.

The plural spray mixing method statement and method of mix ratio quality control shall be pre-approved by the Corrosion Engineer. The contractor shall be required to demonstrate the effectiveness of the proposed methods over the spray hose distances required, before the relevant commencement of work on site.

9.5.3 MIXER

Power mixing must be used for all spray applications. Any deviation from mixing procedures shall be at the written discretion of the Corrosion Engineer.

For external coating patch repairs, touch ups and field joints mixing with a flat paddle by hand is only permissible for small volumes below 5 litres. The mixing with a round rod is not allowed.

For internal lining patch repairs, touch ups and field joints where man access is possible, squish packs, cartridge guns or twin pack aerosol cans, shall be used.

Where power mixers are required, a low speed power mixer, which does not introduce air into the coating material being mixed, shall be utilised. For pipeline lining application and field joints where man access for spray is possible, the use of power mixers is mandatory.

9.5.4 APPLICATION METHODS AND REQUIREMENTS

Application methods and requirements shall be as prescribed in the relevant product chapter, read in conjunction with the manufactures procedure sheets, whichever is the more stringent.

9.5.4.1 EQUIPMENT

Application equipment shall be maintained in a clean condition and in good working order. Glass flake coatings and lining may require large spray tips sizes and higher airless spray pump pressure. Worn out equipment may led to rough coating spray finish. The use of equipment not maintained in good condition may lead to rejection of the applied coating and lining.

9.5.4.2 COMPATIBILITY OF COATS

All primer, intermediate and finishing coats shall be mutually compatible with proper intercoat adhesion.

Likewise main line coating, lining and field joints shall be mutually compatible with proper intercoat adhesion.

9.5.4.3 SURFACE RESTORATION OF SUBSTRATE

Should immediate lining/coating after blasting not be possible, or should any atmospheric oxidisation take place between the completion of blast cleaning and commencement of lining/coating, such oxidisation shall be removed by flash blasting to restore the specified surface finish. Removal of dust and debris shall be in accordance with paragraph 7.3.6.1.5.

9.5.6 METHOD OF APPLICATION

9.5.6.1 APPLICATION

Coatings and Linings shall be applied by any appropriate method recommended by the manufacturer thereof and approved by the Corrosion Engineer.

9.5.6.2 CLEANLINESS DURING APPLICATION

During application and curing of the coating layers, the items shall be protected against contamination by dust or other foreign matter and shall be kept dry and shaded from direct sunlight.

If the environmental conditions such as dust and moisture are not able to be controlled on the site, the Corrosion Engineer shall have the discretion to specify an appropriate single coat system to avoid the risk of inter-coat bond contamination and subsequent bond failures.

All coats shall be clean and free from dust, oil, moisture and perspiration before over-coating. Care must be taken overnight as dew or frost may form on the previous layer and have a detrimental effect on intercoat bond strength.

Operators handling blast-cleaned or partially painted surfaces shall wear clean gloves to avoid contamination of the surface.

9.5.6.3 COAT COLOURS

The colour of each subsequent coat shall be different to that of the previous coat except where two finishing coats of the same colour are necessary for aesthetics to achieve colour uniformity.

The first coat is not permitted to be grey as it does not give adequate contrast to the grit blasted substrate.

The final coat colour is not permitted to be similar to that of rust or corrosion product (brown, orange and red).

9.5.6.4 OVER-COATING TIMES

Over-coating times shall be not less than the minimum nor greater than the maximum specified by the manufacturer relevant to the ambient temperature.

Strict adherence to over-coating time is particularly important for coatings which are subsequently immersed.

9.5.7 QUALITY AND TESTING OF COATING AND LINING

Each specific material type shall have detailed quality and testing requirements in the particular chapters and in general these requirements include but are not limited to:

Finish/Visual Inspection
Adhesion
Coating Thickness
Electrical Insulation Defects/ Holiday Inspection
Material Defects

Curing

9.6 CONTRACTOR'S AND ENGINEER'S INSPECTIONS

9.6.1 INSPECTION BY THE ENGINEER

Inspection of equipment, pipes, process plant etc. shall be carried out by the Corrosion Engineer, his appointed representative or a nominated and approved inspection authority at the manufacturer's and corrosion applicator's works. For site applied corrosion protection, inspection shall occur at the work site

The Corrosion Engineer's inspection shall in no way relieve the Contractor or Sub-contractors of any of their obligations to design, manufacture and supply superior quality and workmanship in accordance with the specification.

9.6.2 INDEPENDENT SURVEILLANCE

The Corrosion Engineer may employ an independent, technically qualified organisation to carry out quality surveillance of the work on his behalf.

The inspection authority has the right to inspect any item covered in the Contract at any stage of execution of the Contract.

Where imported supplies are to be inspected before shipment, the Contractor shall notify his suppliers abroad of the conditions applicable to inspections and also request them to notify the Department's representative abroad when consignments are ready so that arrangements for inspection may be made.

9.6.3 MATERIAL TESTS

The Manufacturer's material test data certification and the Contractor's quality records shall be subject to examination by the Corrosion Engineer or his representative. Reasonable samples of the cleaning and coating materials to be used may be removed for testing.

Rejection of the samples shall place a hold on the use of materials of the same batch number and any components that have already been cleaned / coated with rejected material shall be reworked.

9.6.4 DESTRUCTIVE TESTING

The Corrosion Engineer or his representative may carry out reasonable destructive tests to ascertain compliance with the Specification. Areas thus damaged shall be repaired by the Contractor to the satisfaction of the Corrosion Engineer at no additional cost.

9.6.5 HOLIDAY INSPECTION (ELECTRICAL INSULATION DEFECTS INSPECTION)

100 % percent of the glass flake lining ~~and coating~~ of all pipes and equipment shall be tested and there shall be no electrical insulation defects on any area inspected.

For films exceeding 500 µm thicknesses, the high voltage, sparking electrical insulation defects detector is used in accordance with SANS 1217 and approved QCP document.

Use of the wet sponge test method is not acceptable for glass flake coatings.

9.7 DRY FILM THICKNESS (DFT)

The default method of measuring and evaluating coating and lining thickness shall be a minimum thickness which shall mean that no readings are allowed below the minimum thickness.

The Corrosion Engineer shall consider the variability associated with hand spraying versus the consistency that can be obtained with automated machine spray.

(a) Measurements shall be taken in accordance with SANS ISO 2808, unless the frequency of readings is specified in the Project Specification.

(b) 100% percent of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(c) In the case of coats applied after the erection of steel work on Site, the frequency at which measurements of the DFT are taken shall be at the discretion of the Engineer's Inspector or the Engineers Representatives and may be dictated by accessibility.

(d) DFT in excess of the prescribed maxima shall not necessarily constitute reason for rejection, if the coating film is demonstrated to be sound in all respects. Over thickness for solvent free glass flake coatings is not detrimental.

(e) The default method of DFT measurement shall be in accordance with SSPC PA - 2 Procedure for the determining conformance to dry coating thickness requirements, with specific reference to Section 9 of SSPC PA - 2 and a restriction level of 1. The method of measuring and evaluating coating and lining thickness shall be a minimum thickness which shall mean that no readings below the minimum thickness are allowed to be accepted.

9.7.2 HAND AND IN-SITU APPLIED GLASS FLAKE LINING AND COATING

8 sets of readings equally spaced around the circumference shall be taken at positions not more than 10 metres apart along the length of the pipe. All the applied lining and coating thicknesses shall be tested by means of an approved eddy current or magnetic instrument. The first reading shall be over the weld bead. The thickness shall not be less than the minimum specified over 100 percent of the area including weld beads.

9.7.3 DEGREE OF CURE OF TWO-COMPONENT MATERIALS

The degree of cure of a two-component material will vary with time, temperature and ventilation and shall be assessed by solvent wiping in accordance with the method given in SANS 1217 (methyl ethyl ketone resistance rub test)

Alternatively, the degree of cure can also be determined by measuring the hardness of the polymer in Barcol, IRHD Shore A or D or other method as described by the manufacturer in the material data sheet.

9.8 DAMAGED COATINGS

Evaluation of glass flake coatings & linings to determine extent of damage and if repair or refurbishment is possible.

(a) All repairs and procedures shall be approved by the Corrosion Engineer and subject to inspection procedures.

Where the damage is extensive, the inspection procedures and repair method shall be agreed upon in writing with the Corrosion Engineer.

(b) All repairs shall comply with the requirements of the repair-product manufacturer's data sheet. The Corrosion Engineer may at his discretion request that repaired coating areas undergo adhesion tests.

(c) Any damage occurring during transit from the Contractor's premises to the site shall be the responsibility of the Contractor. The Contractor responsible for installation of equipment at site, shall repair any damage occurring on site during handling, assembly, storage, transport and erection.

(d) The repaired area shall be tested for compliance with the relevant requirements for thickness, full cure and electrical insulation defects respectively.

(e) Any item showing electrical insulation defects exceeding an average of five per square metre (a cluster of pinholes within a radius of 25 mm being regarded as a single defective area), or flaking or other signs of loss of adhesion, shall not be repaired. The item shall be blast cleaned and re-coated in accordance with the relevant requirements of the specification.

9.9 REPAIR METHODS FOR MINOR DEFECTS

The repair of areas showing electrical insulation defects, lack of full cure or low film thickness shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with paragraph 7.3.3.

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with a minimum roughness grade 100 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with SANS 5769 and paragraph 7.4.1.

(d) Wipe the abraded paint surface with methyl ethyl ketone and allow to dry

(e) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE:

1. When glass flake coatings contain solvent, the curing time between coats, as specified by the coating material manufacturer shall be adhered to.

2. Apply a final topcoat over the repaired area to achieve uniform finish of the item.

9.10 REPAIR METHODS FOR MAJOR DEFECTS

The repair of areas showing damage down to the steel surface shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with paragraph 7.3.3.

(b) Blast-clean all damaged areas to Sa 3 (SANS 8501-1).

(c) Feather the surrounding paint for a distance of 50 mm beyond the damaged areas with a minimum roughness grade 100 abrasive paper.

(d) Vacuum-clean the surface to remove dust and debris in accordance with SANS 5769 and paragraph 7.4.1.

(e) Wipe only the abraded paint surface with methyl ethyl ketone and allow to dry.

(f) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

10. PROJECT SPECIFIC SPECIFICATION

All work shall be in accordance with DWS 9900 as updated in March 2021, unless changed in the Project Specific Requirements.

Chapters 1 to 7 for general requirements on Corrosion protection
Chapter 8 and 9 for epoxy and glass flake epoxy lining
Chapter 10 Project Specific Requirements as listed below

In all cases where a potential conflict of interpretation arises, the more stringent quality specifications shall apply

10.1 SCOPE

This project specific specification covers the materials, surface preparation, application and performance of in situ steel pipe lining system for arduous applications for large bore piping > DN1000. This project specific specification shall be read together with DWS 9900 chapter 1-9

The specification has application on steel piping systems used for the conveyance of raw and potable water in arduous applications. The system may also be used as a coating or lining system on other infrastructure (e.g. penstocks and valves or steel to concrete interfaces) which are subject to abrasion and where a superior coating is required for 20+ years corrosion life expectancy. For the avoidance of doubt, the term coating refers externals of pipes, but when applied internally in a pipe is called a lining.

This specification is suitable for rehabilitation and refurbishment of aged steel pipes where the existing internal corrosion protection has failed and where pitting corrosion metal loss is known to be occurring. This system may also be used for the rehabilitation and or repairs of pipelines which have been previously lined with bitumen, coal tar epoxy or early generation epoxies such as Copon, that have started to blister. It is important to note that the specifications herein are intended only for coating applications on steel structures where the observed corrosion was determined to not compromise the structural integrity of the asset.

The rehabilitation of internal linings typically, but not always, takes place on isolated sections and the specification also deals with means to mitigate corrosion at the interface between new and existing lining systems.

10.2 DESCRIPTION, PROPERTIES AND PERFORMANCE REQUIREMENTS

The Corrosion Protection lining material / product shall:

10.2.1 Be two components, high solids > 95% $^{m}/_{m}$ two pack epoxy suitable for use on potable water and raw water pipelines and immersed steel and concrete with a characteristics and performance requirements as detailed below.

10.2.2 This project specific specification references three different thickness materials which have different life expectancies. For internals of steel pipes and steel lined tunnels, the corrosion protection material selected shall be a glass flake reinforced epoxy as per Chapter 9. Other high solids epoxy coatings may be considered provided they are proven to meet the specified service life.

For bulk heads, outside surfaces exposed to high humidity and for areas such as dewatering shafts, a lower specification can be used which shall be a glass flake reinforced epoxy. Other high solids epoxy coatings may be considered provided they are proven to meet the specified service life.

10.2.3 The resistance to moisture vapor permeation is directly related to corrosion life expectancy. Perm Inch is a commonly used American permeability co-efficient, but can also be converted to a SI unit Nano gram per second per sqm per Pascal. Test method is usually defined as per ASTM D1653 or ASTM E96.

10.2.4 The corrosion protection shall be a flexibilised material with an elongation to break of at least 4%, and a resistance to impact of minimum 15 joules, per ASTM D522. This is to ensure that the applied coating material is not too brittle and can resist small movements at many interfaces between concrete tunnels and steel pipes.

10.2.5 Have excellent adhesion properties. Adhesion to steel shall be >10 MPa under laboratory conditions when measured in accordance with ASTM D 4541 (with adequate QA/QC procedures). Higher adhesion will assist life expectancy under high flow velocity conditions and also at all the edges and corners or at circumferential welds.

10.2.6 Have excellent resistance to abrasion and be suitable to be used under conditions of high flow velocity on the internals of large diameter water pipes that can have sand or silt particles in the raw water.

10.2.7 The abrasion resistance using a Taber abrader as per procedure ASTM D4060-19 shall be less than 300 mg loss per 1000 cycles with a 1000 gram weight and using an aggressive H18 wheel, alternatively less than 100 mg loss / 1000 cycles with a 1000 gram weight for a softer CS17 wheel.

10.2.8 Have SANS 241, NSF 61 or potable water certification.

10.2.9 Have ISO 9001 certification for material manufacture.

10.2.10 Have excellent resistance to corrosion in corrosive environments as verified by a minimum of 3 case studies in the South African Bulk water industry.

10.2.11 Be available in contrasting colors for ease of identifying stripe coating and patch repairs or layers.

10.2.12 Have ability to be airless sprayed through long hoses up to 500 meters in length, as well as the ability to be applied by brush or squish pack for small areas and local repairs. Refer Section 10.10 and 10.10.5.9 for additional safety requirements.

10.2.13 Shall be available in bulk containers such as 200 liter drums and 1000 liter for bulk application as well as 5, 10 or 20 liter kits for small applications

10.2.14 For local repairs and touch ups, also be available in squish packs

10.2.15 The coating shall have ability to tolerate high relative humidity (80%) during application and curing as the internals of the LDHA, TCTA tunnels and pipes are known to suffer from condensing conditions. Coatings with lower tolerance for relative humidity during the application/curing process can also be considered with a submission of detailed plan to control the temperature and relative humidity within the plan by a contractor. The plan will be reviewed and approved by a qualified corrosion engineer.

10.2.16 The steel substrate temperature should be at least 3º C above the dew point temperature of the air, to prevent micro condensation which can negatively affect the adhesion of protective lining systems, and negatively affect cure and polymerization.

10.2.17 Previous inspections in the LDHA pipes and tunnels have indicated that humidity may be from 70 % to 95% and dew point temperature of the air relative to the steel had a difference of only between 1 to 2 degrees C. These are condensing conditions and therefore corrosion protection application, is not normally permitted unless special precautions are taken as listed below. For cases where the coating application will take place in conditions with relative humidity exceeding 80%, a dedicated ventilation plan shall be developed and approved by the contracting authority.

10.2.18 The project specific requirement is that the corrosion protection systems must be capable of being applied under conditions of high humidity. As a separate issue for QC verification, the material supplier shall confirm in writing that the material can be applied at relative humidity between 70 and 85% as detailed above.

10.2.19 The applicator shall ensure provide sufficiently large ventilation fans both blowing in and sucking out to maintain the relative humidity below 80%, and thus limit condensing conditions.

10.3 DEALING WITH PITTED STEEL AND UNDERCUTS

10.3.1 Previous inspections found areas in the pipes and tunnels with a very high density of blisters and subsequent pitting of the steel surface. Greater than 100 pits per square meter. Refer multiple DWS and LHDA inspection reports from 2019.

10.3.2 Standard DWS 9900 requirements are weld repairs, if loss of steel wall thickness is more than 20%. It is a problem for welding if there are tens of thousands of pit marks on the steel.(refer sections 6.3.2; 6.2.2 and 6.2.3)

10.3.3 However from previous inspections it is anticipated that certain areas of the pipe may require so many weld repairs that this becomes impractical. Therefore the Corrosion Engineer shall have the option to deal with any such problematic areas at his discretion with the following methods:

a. Weld repairs
b. Grinding sharp edges followed by blasting and coating
c. Blasting, priming, putty filler and specified coating
d. Blasting, priming, putty filler, carbon fiber reinforcement and specified coating

Prior to project initiation a detailed methodology guiding the selection of an applicable repair method should be submitted to the contracting authority for review and approval. The submission should also include detailed work instructions for each of the above methods.

10.3.4 Areas that are found to be suffering pit corrosion metal loss deeper than 2mm shall be measured and marked up. The areas with critical loss of material shall be measured for the wall thickness with a pit gauge or an ultrasonic steel gauge. All measurements shall be recorded and if needed recommendations with respect to welding procedures shall be drawn. The data shall be verified by LHDA/TCTA representatives, where after an instruction shall be issued to contractor which one of the above methods shall be used on the pitted areas.

10.3.5 If the weld repairs are required, then re-blasting will also be required. Re-blasting allowance for weld repairs is currently maximum 5% of the surface area in each section of site establishment. The consequence is that contractor must allow in his blasting rate the cost for re-blasting up to 5%.

10.3.6 Single coat application can be considered in some cases to prevent intercoat blisters which has been the predominant failure mechanism in bulk water systems in South Africa. This failure mechanism has also been observed in some locations during the previous two outage inspections on the LHDA/TCTA pipes and tunnels.

10.3.7 Single coat application places an obligation on the quality inspectors to do 100% high voltage spark testing per ASTM D5162 to find actual defects and potential defects.

10.3.8 The coating material that is sprayed as a lining shall be edge retentive and highly thixotropic to not shrink back on curing from edges, corners, and pit marks and in so doing reduce the QC requirements on stripe coatings. Stripe coating is an extra layer of coating applied to welds and edges where there is greater risk of future corrosion. Conventional coatings tend to shrink on edges and welds resulting in reduced thickness protection in these critical areas. Edge retentive coatings perform better than conventional coatings when used for stripe coating. The Supplier of the corrosion protection coating material shall certify that the coating material supplied is edge retentive and shall not shrink back on curing.

10.3.9 The specification shall require that all sharp edges, welds and deep pit marks or rough pit marks be stripe coated with an extra layer in a contrasting color, before spray application of the final layer. It shall be a QC requirement that the application contractor shall take photos of the stripe coating applied on welds, edges and pit marks, before they spray the main coat.

10.3.10 The over coating time interval between stripe coat and main coat shall be in accordance with the manufacturers specifications with preference given to shorter time. The supplier of corrosion protection material shall verify that stripe coating and main coat can be applied wet on wet on the top of each other, at the specified thickness, without waiting for one layer to first cure. The corrosion protection material for steel pipes shall be fast drying and tack free in less than 4 hours and have an over-coating time of up to 48 hours for ease of repair and touch up.

10.4 COATING THICKNESS

10.4.1 The previous inspection of LHDA/TCTA tunnels and pipes indicated epoxy thickness of 600-1000 microns when originally applied in 1998. The coating material showed blistering after 14 years (2012). Extensive blistering and pitting of the steel was observed after 21 years (2019).

10.4.2 The durability of a coating system depends on several parameters as listed below:

10.4.2.1 Condition of the substrate before preparation – addressed in section 10.3.3

10.4.2.2 Surface preparation quality - addressed in section 10.6.1

10.4.2.3 Standard of the application work - addressed in section 10.7

10.4.2.4 Conditions during application - addressed in section 10.2.16

10.4.2.5 Coating chemistry - addressed in section 10.2.2

10.4.2.6 Coating thickness - addressed in this section

10.4.3 The coating material comprises a relatively small part of the cost of a site work project. Per section 10.4.2.6, the thickness of a coating may be used as one of the levers to obtain longer life expectancy.

10.4.4 The total coating thickness to be in accordance with Manufacturer's instructions and the following criteria:

10.4.4.1 Total DFT for Steel Lining Systm: 40-50 MILS (1000-1200 µm) DFT

10.4.4.2 A single coat application may be desirable for speed of application due to the limited time available for the works.

10.4.2.3 A two-layer coat may also be applied if the Contractor can complete this type of coating work within the forecasted project schedule and budget, given the added benefits of a two layer coating system from a defects perspective,

The next maintenance opportunity to take the LHDA/TCTA tunnels out of service for 6 month or longer, is estimated to be at least 40 years in the future. The coating manufacturer and application contractor shall make their offer to include for the warranty requirements of Section 10.8

10.5 OTHER PROJECT SPECIFIC REQUIREMENTS

10.5.1 The LHDA/TCTA concrete tunnels and steel pipes have many interfaces. Furthermore concrete porosity may result in weeping and seepage into the pipes. Therefore a requirement exists for the specification to address ground water leaks into the pipes.

10.5.2 The corrosion protection material for steel pipes shall be compatible with wet concrete sealers and underwater curing epoxy, in both putty and laminating grades, to enable application in non-ideal conditions and in-situ applications. Typically, this is required, in the event that ground water leaks into the pipe occur and the surfaces to be coated cannot be made dry. The supplier shall verify that they have compatible sealers and under water curing materials to meet these requirements.

10.5.3 Rates for sealing wet and leaking concrete shall be quoted separately at time of tender and only used if required in the sole discretion of the corrosion engineer.

The project specific requirements below in 10.6 are already contained in DWS 9900 chapter 1-7 as updated in March 2021, but main points are repeated for ease of reference.

10.6 SURFACE PREPARATION

10.6.1 Surface roughness matching that specified by the manufacturer of the corrosion protection material shall be achieved through abrasive grit blasting per ISO 8501-1. Wire brushing and grinding or water blasting are not acceptable methods of surface preparation for the LHDA/TCTA corrosion protection project.

10.6.2 Max dust and debris shall be as per ISO 8502-3 with max dust quantity rating class 2 for particles size under normal vision without magnification.

10.6.3 Max level of residual metallic salts for new steel subject to immersion 30mg / m^2 or 3µ /cm^2 Ferric Chloride measured using Wattman papers. Salt test shall be performed per the frequencies outlined in NACE SP0716-2016. Specifically, the standard calls for five (5) tests to be performed in the first 305 m^2, two (2) to be performed in the second 305 m^2, and then one test in every subsequent 305 m^2. In the event of any non-compliance the steel shall undergo decontamination, and the testing frequency shall be restarted as if the decontaminated area is the first to be tested.

10.6.4 The first coat shall be applied as soon as possible after blast cleaning in accordance with the project specifications and approved QCP. The qualified inspector shall ensure that the relevant blast cleaning standard specified is still acceptable immediately before application of coating.

10.6.4 The internal weld bead height shall not exceed 1mm and the external weld bead height shall not exceed 2mm.

10.6.5 Weld to be slightly convex with finish and edges as per SANS ISO 8501-3 grade P3 or NACE SP0178 grade C.

10.6.6 Weld splatter release agents shall not be used as these contain silicone, are difficult to see and remove, and impair adhesion.

10.6.7 Surfaces shall be free of oil, grease and other deleterious matter. If necessary surfaces shall be degreased with an emulsifiable or aqueous detergent applied in accordance with SANS 1344 and shall have a water break-free surface.

10.6.8 Where a water break free test is impractical, a UV light may be used to prove surfaces are oil and grease free. The risk of finding oil and grease in the LDHA/TCTA pipes is very small unless the contractor's equipment is in poor condition and produces oil in the compressed air.

10.7 TESTING AND QUALITY REQUIREMENTS

The completed lined section shall be:

10.7.1 Shall be visually inspected to be free of runs, drip and sag.

10.7.2 The entire section shall be 100% free of holidays when subjected to a high voltage. The test voltage shall be a minimum of 1000 volts per 100 microns of minimum DFT

10.7.3 MEK rub test as per SANS ISO 8501 shall verify curing

10.7.4 The minimum DFT on the internals of the pipes and steel tunnel liners shall be 1000 µm nano glassflake epoxy when measured with an ISO 2808 instrument as per procedure SSPC PA2 with specific reference to Section 9 and a restriction level of 1.

10.7.5 DFT for the flange faces of adits and manhole s access shall be:

10.7.5.1 The maximum DFT on the flange faces shall be 60 - 90µm and the flange profiling shall be clearly evident over the full width and circumference of the flange.

10.7.5.2 Particular care shall be exercised to ensure that there are no runs or drips on the sealing faces and around bolt holes.

10.7.5.3 Many of the flange sealing faces has gramophone grooves and excessively thick coating prevents the gaskets from sealing properly on the grooves.

10.7.5.4 For large diameter flanges example 1.5 to 5 meters it becomes very difficult or impractical to finish flat a 1 mm thick layer of corrosion protection material. If the coating on the flange sealing faces is not even, smooth and flat, then water leaks can occur.

10.7.6 The Contractor shall prepare a QCP in accordance with the project specifications and shall include inspection hold points to the satisfaction of the Employer's Corrosion Engineer. No work shall commence until the QCP has been approved by the Employer's Corrosion Engineer before commencement of work.

10.7.7 The draft QCP proposed shall be submitted as part of the priced bid proposal to allow the Employer's Corrosion Engineer opportunity to evaluate the proposal

10.7.8 The Contractor shall submit a detailed methodology and Quality Control Plan for the entire process which shall be approved by the Employer's Corrosion Engineer prior to commencement of any work.

10.7.9 The Contractor shall grant the Employer's Agent or his representative reasonable access to carry out quality assurance inspections.

10.8 WARRANTY

10.8.1 The contractor shall provide a dual warranty on both workmanship and coating materials against corrosion in accordance with ISO 4628 grade Ri2 for a period of 20 years, such that the application contractor assumes the turnkey responsibility for the corrosion protection and the Asset Owner LDHA or DWS does not need to try and establish a cause of failure, be it materials or workmanship. The starting date of the warranty shall be from project QC signed off and shall continue until the first outage and inspection opportunity. The application contractor shall include with his price the costs for a warranty back to back with coating manufacturer for a period of 20 years.

10.8.2 The warranty documents shall be provided by the contractors at the same time when they submit their price proposal. These documents to be verified before the evaluation of the technical proposal can take place.

10.9 COATING / LINING TEAM EXPERIENTIAL REQUIREMENTS
Only skilled contractors with a proven track record may bid for critical projects

The coating/lining applicator shall satisfy the following criteria:

10.9.1 Have at least 10 years relevant experience in the coating and lining of bulk water/waste water infrastructure, with at least 5 projects executed in the last 5 years.

10.9.2 A proven track record with Southern African references of successful large projects involving in situ lining of large diameter (>DN1000) pipelines.

10.9.3 Curriculum Vitae shall be provided at time of tender for the following persons:

10.9.4 At least 24 staff members allocated to the LHDA project as paint applicators shall have SAQCC PA1 qualifications, which qualifications will be verified.

10.9.5 At least four of the corrosion protection contractor's site staff member shall have NACE CIP QC inspector certification, or SAQCC, ICORR or similar equivalent inspector certification.

10.9.6 At least one staff member shall have passed the CorrISA 5 days Corrosion engineering course or similar.

10.9.7 At least one staff member shall have passed the CorrISA 3 days Corrosion in the Water Industry course or similar.

10.9.8 At least one staff member shall have passed the CorrISA 3 days Economics of Corrosion course or the Corrosion Management course or similar.

10.9.9 For steep inclines such as Muela Power Station the contractor shall ensure that key staff shall be Rope access certified level 1, level 2 and at least one off level 3 rope access technician. Certifications required where relevant (Pipe grade exceeding 22 degrees incline for key staff in accordance with SAQA 229996: Rig working ropes, undertake rescues and perform a range of rope access tasks as well as SAQA 229997: Select equipment and rig ropes for rope access projects.

10.10 APPLICATION, HEALTH, SAFETY AND ENVIRONMENTALx

10.10.1 The Corrosion protection Contractor shall block off the air flow, or create air blocking devices where required, in the steel sections of the tunnels, to ensure that all debris is contained within the rehabilitation zone for removal through the point of access and disposal in accordance with the EMP Environmental Management Plan applicable to the project.

10.10.2 The purpose of blocking off the air flow to a section of the pipe or tunnel is to control the generation of dust and fumes during the abrasive grit blasting process and also so that dust generated in one section of the tunnel does not negatively impact on coating applications activities in another section of the pipe or tunnel.

10.10.3 The Contractor shall ensure that:

10.10.4 The Employer's Agent or his representative has access to the pipe at any time to carry out quality assurance inspections as well as Health and Safety inspections.

10.10.5 All work shall comply with the Health and Safety requirements of the contract and in particular:

10.10.5.1 All workmen and other persons have been trained by the lining material supplier in the safe and effective use of their product.

10.10.5.2 All workmen and other persons entering the tunnels and pipes shall have been certified as being competent to work in a confined space (SAQA 15304).

10.10.5.3 All workmen and other persons are to have certificates stating that they are medically fit to work in confined spaces.

10.10.5.4 All workmen and other persons shall have appropriate PPE and wear clean overalls and soft rubber soled boots whilst working within the pipe. The use of gloves, eye protection and dusk masks is mandatory.

10.10.5.5 All electrical tools shall be suitable for use in confined spaces.

10.10.5.6 Forced air ventilation or dust extraction is compulsory at all times whilst working within confined spaces such as the pipe and / tunnels, Note that the manhole entrance shall not be blocked by a fan and any entrance point to a pipe shall also allow simultaneously entry and escape routes for man access. This is a health and safety requirement

10.10.5.7 The contractor shall supply a trained hole watch at each access point into the confined space. The hole watch shall maintain a register with a names and ID numbers of each person entering and leaving the confined space.

10.10.5.8 All work in the confined space shall be carried out under constant supervision and a “buddy system” shall be practiced at all times whilst working within the pipe. It is forbidden for a single person to work alone in the confine space.

10.10.5.9 Airless spray pumps generate static electricity and will need to be earthed for safety reasons. General safe working practice is to avoid where possible taking airless spray pumps into the pipes and tunnels. Airless spray pumps require flushing with solvents which increases the risks when the pumps are used in a confined space. Therefor preference shall be for safety reasons be given to spray systems that can be located outside the tunnels with long hoses that go into the tunnels. Refer Section 10.2.12.

10.10.5.10 Grit blasting requires compressed air in accordance with Section 7.4.4. General safe working practice would be to locate diesel air compressors outside the tunnels and run long hoses into the tunnels. The majority of commercial available compressors would be rated at 7 bars and will suffer a pressure drop through long hoses. (100 to 500 meters) Once the pressure at the blast nozzle drops below 6 bar the rate of blast cleaning slows significantly, and makes work impractical.

10.10.5.11 Electric compressors can be taken inside the tunnels but will require very long and expensive electric cables. Work arrangements must be made to ensure safe access to electrical power inside the tunnel.

10.10.5.12 Taking diesel compressors inside the tunnels will require safety mitigation measures such as done to underground diesel mining machinery which is very expensive and not commercially available on compressors.

10.10.5.13 High pressure 12 bar diesel compressors can be used outside the tunnel with hoses up to a practical maximum of 300 meters before the pressure drop becomes significant.

10.10.5.14 Likewise vacuum machines and HP water jetting machine are subject to practical limitation on distance or alternatively the machines need to be taken inside the tunnels. The contractors shall supply a method statement at time of tender as to how they intend to address these challenges. The method statement shall form part of the technical bid adjudications.

10.10.5.15 The contractors must supply mobile work platforms with soft wheels and scaffolding where required because the height of the roof in large steel pipes and tunnels is such that special access to the underside of the roof is required.

10.10.5.16 The contractor's team must have registered scaffold builders, scaffold supervisors and scaffold inspectors.

10.10.5.17 The staff scaffolding qualifications and CV's must be submitted as part of the bid documentation.

10.10.5.18 The contractors are warned that some sections of pipes or tunnels have a long access route to the work front.
Example:
Pelaneng Adit (Access tunnel) 1,366.89 linear meters
Hlotse Adit (Access tunnel) 1,840 .60 linear meters

10.10.6 The contractor shall provide a detail method statement of how they propose to complete the project safely while meeting all other project requirements.

10.11 DISPOSAL OF SPENT ABRASIVE GRIT

10.11.1 The contractor shall supply front end loaders, tipper trucks, mobile cranes, rough terrain fork lifts and conveyor belt systems to deal with grit material handling requirements of the project.

10.11.2 The contractor shall supply industrial vacuum cleaning equipment capable of sucking minimum 3 tons per hour of grit blasting abrasive over a distance greater than 100 meters.

10.11.3 The contractor shall ensure that the working zone is regularly cleaned inside the pipe and outside of pipe to acceptable housekeeping standard which will be determined by the asset owner.

10.11.4 The contractor shall allow for the cost of loading and haulage of the spent abrasive grit and waste matter generated and disposing of locally in a 27km radius for LHDA low land site and around 40km radius at the Katse area, at a dump that will be designated by the asset owner/employer. The dumping cost if applicable will be for the account of the asset owner. The asset owner/employer may designate that the spent abrasive grit is donated for recycling to a local community initiative such as building roads or making concrete products.