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# ADNOC GROUP PROJECTS AND ENGINEERING

## EXTERNAL PIPELINE COATINGS SPECIFICATION

Specification

AGES-SP-07-002



**GROUP PROJECTS & ENGINEERING / PT&CS DIRECTORATE**

<b>CUSTODIAN</b>	Group Projects & Engineering / PT&CS
<b>ADNOC</b>	Specification applicable to ADNOC & ADNOC Group Companies

Group Projects & Engineering is the owner of this Specification and responsible for its custody, maintenance and periodic update.

In addition, Group Projects & Engineering is responsible for communication and distribution of any changes to this Specification and its version control.

This specification will be reviewed and updated in case of any changes affecting the activities described in this document.

## INTER-RELATIONSHIPS AND STAKEHOLDERS

- a) The following are inter-relationships for implementation of this Specification:
- i. ADNOC Upstream and ADNOC Downstream Directorates and
  - ii. ADNOC Onshore, ADNOC Offshore, ADNOC Sour Gas, ADNOG Gas Processing, ADNOC LNG, ADNOC Refining, ADNOC Fertilisers, Borouge, Al Dhafra Petroleum, Al Yasat
- b) The following are stakeholders for the purpose of this Specification:
- ADNOC PT&CS Directorate.
- c) This Specification has been approved by the ADNOC PT&CS is to be implemented by each ADNOC Group company included above subject to and in accordance with their Delegation of Authority and other governance-related processes in order to ensure compliance
- d) Each ADNOC Group company must establish/nominate a Technical Authority responsible for compliance with this Specification.

## DEFINED TERMS / ABBREVIATIONS / REFERENCES

“**ADNOC**” means Abu Dhabi National Oil Company.

“**ADNOC Group**” means ADNOC together with each company in which ADNOC, directly or indirectly, controls fifty percent (50%) or more of the share capital.

“**Approving Authority**” means the decision-making body or employee with the required authority to approve Policies & Procedures or any changes to it.

“**Business Line Directorates**” or “**BLD**” means a directorate of ADNOC which is responsible for one or more Group Companies reporting to, or operating within the same line of business as, such directorate.

“**Business Support Directorates and Functions**” or “**Non- BLD**” means all the ADNOC functions and the remaining directorates, which are not ADNOC Business Line Directorates.

“**CEO**” means chief executive officer.

“**Group Company**” means any company within the ADNOC Group other than ADNOC.

“**Specification**” means this External Pipeline Coatings Specification.

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# GENERAL

## 1 PURPOSE

This specification covers ADNOC technical requirements for external coating of newly constructed CS line pipes for onshore and offshore application. This specification consists external polyethylene (3-layer PE), polypropylene (3-layer PP), and fusion-bonded epoxy (1-layer and 2-layer FBE) coatings.

It's specifying coating materials suitable for several categories of pipeline design temperature up to 120 °C for corrosion protection of welded and seamless pipes for pipeline transportation systems. The main purpose of this specification is to provide all requirements related to factory applied coatings.

This standard shall be used by the nominated Engineers, Contractors and Manufacturers/Suppliers approved to select the correct coating system. It shall be used in conjunction with scope of work, MTO, environmental conditions, soil conditions and operating temperature of the pipeline.

This specification shall be read in conjunction with listed international standards referenced in Table 3.

## 2 SCOPE

This ADNOC Standard includes the minimum requirements for qualification, application, testing and handling of materials for plant application of three-layer polyethylene, three-layer polypropylene and single and dual layer fusion-bonded epoxy based coatings applied externally for the corrosion protection of bare CS pipe for use in pipeline transportation systems for the petroleum and natural gas industries. All Pipes coated in accordance with this ADNOC specification is considered suitable for further protection by means of cathodic protection.

- (a) Three-layer polyethylene-based coatings shall be used for pipelines with design temperature up to 80 °C.
- (b) Three-layer polypropylene-based coatings shall be used for pipelines with design temperature up to 110 °C.
- (c) Single-layer and dual-layer fusion-bonded epoxy coatings shall be used for pipelines with design temperature up to 120 °C.

## 3 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATION

Unless otherwise authorized by ADNOC, the distribution of this specification is confined to companies forming part of the Abu Dhabi National Oil Company and to the Engineers, Contractors and Manufacturers/Suppliers nominated by them.

If national and/or local regulations exist, in which some of the requirements may be more stringent than in this document, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Company of any deviations from the requirements of this specification which are considered to be necessary in order to comply with national and/or local regulations.

## 4 DEFINED TERMS

Table 1 - Defined Terms	
Application procedure specification (APS)	Document describing procedures, methods, equipment and tools used for coating application

Table 1 - Defined Terms	
Applicator	Company that undertakes the coating application in accordance with the provisions of this document Note: If the compounding of the top layer is done prior to or during the application process by the applicator, then the applicator is regarded as the manufacturer.
Batch	Quantity of material produced in a continuous manufacturing operation using raw materials of the same source and grade Note: Quantity of epoxy powder produced using the same formulation and raw materials of the same source during a continuous production run of not more than 8 hours.
Batch certificate	Certificate of analysis issued by the manufacturer
Certificate of compliance	Document issued in accordance with ISO 10474 or EN 10204, stating compliance with the purchase order for coated pipes, but without mention of any test results, issued in accordance with the purchasing requirements
Coating material qualification	Qualification of the coating materials properties carried out by the manufacturer before the coating system qualification
Coating system qualification	Qualification of application method, applied coating system and subsequent inspection/testing of its properties, to confirm that the APS is adequate to produce a coating with the specified properties Note: The coating system qualification is not project dependent.
Company	ADNOC
Concession / Deviation Request	Requested by the Contractor either on their behalf or on behalf of their Subcontractor(s), Vendors(s) and/or Sub-Vendor(s), after receiving the award of the Contract or Purchase Order. It usually refers to an authorisation to use, repair, recondition, reclaim, or release materials, components or equipment already in progress or completely manufactured but which does not meet or comply with Company requirements. A Concession/Deviation Request is subject to Company approval solely at their discretion.
Consultant	The party that performs specific services, which may include but are not limited to, Engineering, Technical support, preparation of Technical reports and other advisory related services specified by the party that engages them, i.e. Company, Contractor or its Subcontractors.
Contractor	The party that carries out the Design, detailed Engineering, Procurement, Construction, Commissioning and Start-up.
Cutback	Length of pipe left uncoated at each end for joining purposes
Design temperature range	Temperature range, including maximum and minimum temperatures, likely to be reached during transport, storage, handling, installation and operation Note: The design temperature range of the coating can be narrower than that specified for the steel pipe material and/or the pipeline system.
Dummy pipe	Pipe having the same outside diameter and wall thickness of the project pipes. Dummy pipes and coated dummy pipes shall be representative of the production and shall be coated in accordance with approved APS
End user	Company (companies) that own(s) and/or operate(s) pipeline(s)



Table 1 - Defined Terms	
Glass transition	Reversible change in an amorphous polymer or in amorphous regions of a partially crystalline polymer from (or to) a viscous or rubbery condition to (or from) a hard and relatively brittle one
Glass transition temperature (T <sub>g</sub> )	Characteristic value of the temperature range over which the glass transition takes place Note: The assigned glass transition temperature, T <sub>g</sub> , can vary, depending on the specific property and on the method and conditions selected to measure it.
Holiday	Coating discontinuity that exhibits electrical conductivity when exposed to a specific voltage
Inspection and testing plan (ITP)	Document providing an overview of the sequence of inspections and tests, including appropriate resources and procedures
Inspection certificate 3.2	Document in accordance with ISO 10474 or EN 10204 giving the results of the testing of coated pipes, supplied and signed by a representative of the applicator authorized to issue such documents
Laboratory-coated test specimen	Specimen taken from a laboratory-prepared panel
Manufacturer	Company responsible for the manufacture of coating material(s)
Vendor/ Supplier	The party that manufactures or supplies equipment and provides the support services at site to install and commission the supplied equipment.
Manufacturer's specification	Document that specifies the characteristics, test requirements and application recommendations for the coating materials
Operating temperature	Temperature that can be endured by a pipeline (component) and/or pipeline system during operation, within the design temperature range
Peel strength	Force required for peeling the coating from the substrate
Pipe diameter length	Length along the pipe axis equal to the specified outside diameter of the pipe
Pipeline	Components of a pipeline system connected together to convey fluids between stations and/or plants, including pipe, pig traps, components, appurtenances, isolating valves, and sectionalizing valves
Pipeline system	Pipelines, stations, supervisory control and data acquisition system (SCADA), safety systems, corrosion protection systems, and any other equipment, facility or building used in the transportation of fluids
Powder shipment	Amount of powder transported in one container
Pre-production trial (PPT)	Application of a coating and subsequent inspection/testing of its properties, to confirm that the APS is adequate to produce a coating with the specified properties, carried out in the coating plant immediately prior to start of production and to verify that the plant's equipment is adequate to consistently adhere to the APS requirements
Procedure qualification trial (PQT)	Application of a coating and subsequent inspection/testing of its properties, to confirm that the APS is adequate to produce a coating with the specified properties, carried out in correlation to a specific project and prior to the start of production
Purchaser	Company responsible for providing the purchase order requirements
Shall	Denotes mandatory action or requirement.

Table 1 - Defined Terms	
Should	Denotes an action or requirement which is not mandatory but which is strongly recommended to comply with the requirements of this document.
Start up	Coating application activities re-start in case of modification of production parameters or unplanned stoppage or production interruption exceeding 12 hours
Subcontractor	The party engaged by a Contractor to do part of the work awarded to the Contractor by the Company. The work of the Subcontractor is carried out under the direction and control of the Contractor. The Company maintains the right to review all proposed Subcontractors and Subcontracts. However, the right to review does not relieve Contractor of their obligations under the Contract nor does it create any contractual relationship whatsoever between the Subcontractor and Company.
Sub-Vendor	Any supplier of equipment and support services for an equipment/package or part thereof supplied by a Vendor.
Test report	Document that provides the quantitative test results for tests conducted in accordance with the requirements of this document
Test ring	Sample taken from production-coated pipe
Total coating thickness	Sum of all layers, namely epoxy material, adhesive material and top layer, with the exclusion of rough coat, if applicable.

## 5 ABBREVIATIONS

Table 2 - Abbreviations	
APS	Application Procedure Specification
CoP	Code of Practice
Cr	Chromium
d.c.	direct current
CS	Carbon Steel
DSC	Differential Scanning Calorimetry
EPC	Engineering, Procurement, Construction, Commissioning and Start-up
ESCR	Environmental Stress Cracking Resistance
FBE	Fusion-Bonded Epoxy
FEED	Front End Engineering Design
HRC	Rockwell C scale hardness
ID	Inner Diameter
IR	Infrared
ITP	Inspection and Testing Plan
MFR	Melt Flow Rate
MOM	Minutes of Meeting
N.A.	Not Applicable
NPS	Nominal Pipe Size

Table 2 - Abbreviations

OD	Outer Diameter
PDL	Pipe Diameter Length
PE	Polyethylene
PP	Polypropylene
ppd	per pipe diameter
PPT	Pre-Production Trial
PQT	Procedure Qualification Trial
SAW	Submerged Arc Welding
TSD	(ADNOC) Technical Standard Document
UV	Ultraviolet

## 6 REFERENCES

Table 3 - References

ISO 179-1	Plastics – Determination of Charpy impact properties – Part 1: Non-instrumented impact test
ISO 179-2	Plastics – Determination of Charpy impact properties – Part 2: Instrumented impact test
ISO 306	Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)
ISO 527-1	Plastics – Determination of tensile properties – Part 1: General principles
ISO 527-2	Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics
ISO 868	Plastics and ebonite – Determination of indentation hardness by means of a durometer (Shore hardness)
ISO 1133-1	Plastics – Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics – Part 1: Standard method
ISO 1183 (all parts)	Plastics – Methods for determining the density of non-cellular plastics
ISO 2808	Paints and varnishes – Determination of film thickness
ISO 2811 (all parts)	Paint and varnishes – Determination of density
ISO 2815	Paints and varnishes – Buchholz indentation test
ISO 3183	Petroleum and natural gas industries – Steel pipe for pipeline transportation systems
ISO 3251	Paints, varnishes and plastics – Determination of non-volatile-matter content
ISO 4892-2:2013	Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps
ISO 6964	Polyolefin pipes and fittings – Determination of carbon black content by calcination and pyrolysis – Test method
ISO 8130-2	Coating powders – Part 2: Determination of density by gas comparison pycnometer (referee method)

Table 3 - References	
ISO 8130-3	Coating powders – Part 3: Determination of density by liquid displacement pyknometer
ISO 8130-7	Coating powders – Part 7: Determination of loss of mass on stoving
ISO 8501-1:2007	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings
ISO 8502-3	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
ISO 8502-6	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method
ISO 8502-9	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 9: Field method for the conductometric determination of water-soluble salts
ISO 8503-4	Preparation of steel substrates before application of paints and related products – Surface roughness characteristics of blast-cleaned steel substrates – Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile – Stylus instrument procedure
ISO 8503-5	Preparation of steel substrates before application of paints and related products – Surface roughness characteristics of blast-cleaned steel substrates – Part 5: Replica tape method for the determination of the surface profile
ISO 10350-1	Plastics – Acquisition and presentation of comparable single-point data – Part 1: Moulding materials
ISO 10474	Steel and steel products – Inspection documents
ISO 11124 (all parts)	Preparation of steel substrates before application of paints and related products – Specifications for metallic blast-cleaning abrasives
ISO 11126 (all parts)	Preparation of steel substrates before application of paints and related products – Specifications for non-metallic blast-cleaning abrasives
ISO 11127-6	Preparation of steel substrates before application of paints and related products – Test methods for non-metallic blast-cleaning abrasives – Part 6: Determination of water-soluble contaminants by conductivity measurement
ISO 11357-1	Plastics – Differential scanning calorimetry (DSC) – Part 1: General principles
ISO 11357-2	Plastics – Differential scanning calorimetry (DSC) – Part 2: Determination of glass transition temperature and glass transition step height
ISO 11357-6	Plastics – Differential scanning calorimetry (DSC) – Part 6: Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)
ISO 13623	Petroleum and natural gas industries – Pipeline transportation systems
ISO 15512	Plastics – Determination of water content
ISO 17855-2	Plastics – Polyethylene (PE) moulding and extrusion materials – Part 2: Preparation of test specimens and determination of properties

Table 3 - References	
ISO 18553	Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds
ISO 19069-2	Plastics – Polypropylene (PP) moulding and extrusion materials – Part 2: Preparation of test specimens and determination of properties
ISO 21809-1	Petroleum and natural gas industries – External coatings for buried or submerged pipelines used in pipeline transportation systems – Part 1: Polyolefin coatings (3-layer PE and 3-layer PP)
ISO 21809-2	Petroleum and natural gas industries – External coatings for buried or submerged pipelines used in pipeline transportation systems – Part 2: Single layer fusion-bonded epoxy coatings
ISO 21809-5	Petroleum and natural gas industries - External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 5: External concrete coatings
ISO 80000-1	Quantities and units – Part 1: General
DIN 30670	Polyethylene coatings of steel pipes and fittings - Requirements and testings
EN 10204:2004	Metallic products – Types of inspection documents
API RP 5L1	Recommended Practice for Railroad Transportation of Line Pipe
API RP 5LW	Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
AS 3894.6	Site testing of protective coatings – Determination of residual contaminants
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1505	Standard Test Method for Density of Plastics by the Density-Gradient Technique
ASTM D1506	Standard Test Methods for Carbon Black - Ash Content
ASTM D1509	Standard Test Methods for Carbon Black - Heating Loss
ASTM D1510	Standard Test Method for Carbon Black - Iodine Adsorption Number
ASTM D1514	Standard Test Method for Carbon Black - Sieve Residue
ASTM D1619	Standard Test Methods for Carbon Black - Sulphur Content
ASTM D1693	Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D2414	Standard Test Method for Carbon Black—Oil Absorption Number
ASTM D3849	Standard Test Method for Carbon Black - Morphological Characterization of Carbon Black Using Electron Microscopy
ASTM D4060	Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D4527	Standard Test Method for Carbon Black - Solvent Extractables
ASTM D4940	Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blast Cleaning Abrasives
SSPC-AB 1	Mineral and Slag Abrasives
SSPC-AB 2	Cleanliness of Recycled Ferrous Metallic Abrasives
SSPC-AB 3	Ferrous Metallic Abrasive
SSPC-SP 1	Solvent Cleaning

Table 3 - References

SSPC-Guide 15	Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates
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## 7 SYMBOLS

Table 4 - Symbols

C	Percentage conversion of FBE coating, expressed as a percentage
d	Effective sample thickness, expressed in millimetres
D	Outside diameter of the pipe, expressed in millimetres
dQ/dt	Differential heat flow, expressed in watts per square metre
M	Mass, expressed in kilograms or grams
P <sub>m</sub>	Mass of bare pipe per metre length, expressed in kilograms per metre
r	Mandrel radius, expressed in millimetres
T <sub>g</sub>	Glass transition temperature, expressed in degrees Celsius
W <sub>ep</sub>	Mass fraction of the epoxy power retained on a sieve, expressed as a percentage of total sample
W <sub>m</sub>	Mass fraction of moisture, expressed as a percentage
ΔH	Exothermic heat of reaction, expressed in Joules per gram
ΔMFR	Difference in the MFR between two tests, expressed in %
ΔT <sub>g</sub>	Difference in the glass transition temperature between two successive thermal analysis scans, expressed in degrees Celsius
Δε <sub>b</sub>	Difference in tensile strain at break between 2 tests, expressed in %
ε <sub>b</sub>	Tensile strain at break, expressed in %
ρ <sub>p</sub>	Density of the epoxy powder, expressed in grams per cubic centimetre

# SECTION A

## 8 EQUIVALENT STANDARDS

Any technical deviations to this document and international codes and standards and project documents, including, but not limited to, the data sheets and job specifications, shall be sought by the vendor/contractor for company's review and approval, prior to the proposed technical changes being implemented. Any deviation based on non-technical basis, including cost and schedule, shall be rejected. Technical changes implemented prior to Company's approval are subject to rejection.

Where differences and/or conflicting issues occur between the referenced documents themselves or the requirements of this document, the requirements of this document shall overrule unless otherwise advised by ADNOC. However, all differences/conflicts shall be reported in writing to the ADNOC standards team for arbitration/resolution before fabrication commences.

## 9 HEALTH SAFETY AND ENVIRONMENT

ADNOC contractors/consultant shall be responsible for complying and consider in their works / activities the following:

- (a) The Laws of the UAE;
- (b) The ADNOC standards, regulations, and CoP(s);
- (c) ADNOC HSE standards and regulations.

## 10 DOCUMENT PRECEDENCE

The specifications and codes referred to in this specification shall, unless stated otherwise, be the latest approved issue at the time of Purchase Order placement.

It shall be the CONTRACTOR 'S responsibility to be, or to become, knowledgeable of the requirements of the referenced Codes and Standards.

The CONTRACTOR shall notify the COMPANY of any apparent conflict between this specification, the related data sheets, the Codes and Standards and any other specifications noted herein.

Resolution and/or interpretation precedence shall be obtained from the COMPANY in writing before proceeding with the design/manufacture.

In case of conflict, the order of document precedence shall be:

- (a) UAE Statutory requirements;
- (b) ADNOC Codes of Practice;
- (c) Equipment datasheets and drawings;
- (d) Project Specifications and standard drawings;
- (e) Company Specifications;
- (f) National/International Standards.

## 11 SPECIFICATION CONCESSION/DEVIATION CONTROL

Deviations from this specification are only acceptable where the MANUFACTURER has listed in his quotation the requirements he cannot, or does not wish to comply with, and the COMPANY/CONTRACTOR has accepted in writing the deviations before the order is placed.

In the absence of a list of deviations, it will be assumed that the MANUFACTURER complies fully with this specification.

Any technical deviations to the Purchase Order and its attachments including, but not limited to, the Data Sheets and Narrative Specifications shall be sought by the VENDOR only through Concession Request Format. Concession requests require CONTRACTOR'S and COMPANY'S review/approval, prior to the proposed technical changes being implemented. Technical changes implemented prior to COMPANY approval are subject to rejection.

## **12 QUALITY ASSURANCE/QUALITY CONTROL**

Quality Management Systems shall comply with the applicable requirements of ISO 9001 and ISO 9004 with due regard to ISO 19011. The Contractor shall ensure that the Vendor shall have in effect at all times, a QA programme, which clearly establishes the authority and responsibilities of those responsible for the quality system. Persons performing quality functions shall have sufficient and well-defined authority to enforce quality requirements that they initiate or identify and to recommend and provide solutions for quality problems and thereafter verify the effectiveness of the corrective action.

Quality System and Quality Control requirements shall be identified and included in the Contractor's purchase and subcontracting Document(s). Based on these requirements the Vendor and Subcontractor shall develop a QA/QC programme, which shall be submitted to the Contractor for review and approval. The Vendor's QA/QC programme shall extend to their Sub-Vendors.

Company/Contractor reserves the right to inspect materials and workmanship at all stages of manufacture and to witness any or all tests.



## SECTION B

### 13 DESIGN CONSIDERATIONS

Site conditions shall be in accordance with project specific process design basis.

### 14 INFORMATION TO BE SUBMITTED TO THE APPLICATOR

#### General Information

The purchase order shall include the following information:

- (a) Reference to the latest revision of this specification;
- (b) Reference to relevant latest revision of international standards;
- (c) Pipe quantity, outside diameter, minimum wall thickness, minimum, maximum and nominal length, and grade of steel;
- (d) Bare pipe standard or specification designation, for example ISO 3183;
- (e) Design temperature range;
- (f) Operating temperature;
- (g) Coating class and coating thickness class;
- (h) Qualification scheme;
- (i) Minimum number of coated pipes to be used for PPT and PQT (if required);
- (j) Cutback configuration and finish (length, angle, visible epoxy, temporary protection.);
- (k) Whether or not the pipe is insulated and the type of insulation should also be included;
- (l) Type of certificate of compliance;
- (m) Pipeline installation methods for offshore (for example reel lay, S-lay, J-lay).

#### Additional Information

The purchase order shall specify which of the following provisions apply for the specific item ordered:

- (a) Pipe tracking and traceability of pipes to coating materials;
- (b) Different requirements for coating materials out of classification systems;
- (c) Marking of pipes;
- (d) Handling procedures;
- (e) Storage procedures;
- (f) Documentation and schedule for supply of documentation;
- (g) Contractor and Company approval of APS/ITP;
- (h) Inspection and testing plan and/or daily log;

- (i) Pipe end protection;
- (j) Use of different test methods for soluble salt contamination measurements;
- (k) Minimum thickness of epoxy layer and/or total coating thickness required, if exceeding those in Table 18 and Table 7, respectively;
- (l) Use of dummy pipe for destructive tests;
- (m) Rough coat application (for example prior to concrete weight coating or special laying methods) and acceptance criteria;
- (n) Special requirements relative to supply of coating materials (for example FBE or liquid, manufacturer-specific products and certification);
- (o) PQT;
- (p) Coating and cutback preservation and protection against adverse ambient conditions during storage (for example UV protection, additional cutback preparation, end-caps);
- (q) Identification of pipes to be used for PPT.

For the further installation processes (for example welding processes and field joint coating application) that envisage the heating of the coated pipe, further testing (for example adhesion) shall be considered by the Contractor in order to assess the compatibility of the line pipe coating against the application parameters of the chosen field joint coating and vice-versa.

For free issued materials, Contractor and Applicator will be the same.

## 15 INFORMATION SUPPLIED BY THE APPLICATOR

Applicator shall submit the type and quantity of documentation for Contractor's authorization and Company review and approval.

All documents, drawing text and dimensions shall be expressed in English language and shall be in the metric system.

Reports shall be kept of all relevant data for each item coated. This shall include, but not be limited to the following:

- (a) Material batch numbers and certificates detailing all the information required for each batch as defined in this specification;
- (b) Details of blasting abrasive, salt contamination result, surface preparation standard and recording of environment conditions prevailing during blasting;
- (c) Recording of steel surface defects and repairs;
- (d) Surface temperature of items prior to coating, cleanliness of the surface and measurement of surface profiles;
- (e) Results of all tests as defined in this specification;
- (f) Details of all tests after repairs to coating defects and the repair techniques used;
- (g) Details of rejected items, with reasons for failure;
- (h) Information on items which, after rejection, require complete recycling.

Such information shall be submitted daily by the Applicator to the Contractor and Company. Absence of documentation shall be considered a just cause for rejection of coating process.

Prior to the start of production operations, Contractor shall submit the following documentation to the Company:

- (a) Quality Plan;
- (b) Production Schedule;
- (c) Coating and Testing Procedures;
- (d) Detailed Description of Coating Equipment and Materials;
- (e) Pipe Handling Equipment Description and Procedures;
- (f) Pipe Stacking Arrangements;
- (g) Application procedure specification (APS);
- (h) Material Control Recording Procedure;
- (i) Inspection Quality Plan;
- (j) Inspection and Testing Plan;
- (k) Repair Procedure;
- (l) Procedures for all PQT and Production Tests.

Contractor shall submit to Company the following documentation prior to the return of coated pipe to Company:

- (a) Mill Certificates for line pipe received;
- (b) Manufacturer's certificates for each batch of coating material;
- (c) Certification/calibration certificates for all testing and coating equipment used during coating application;
- (d) Inspection and test, records, results, and other documentation of all material and coating tests;
- (e) Certificate of conformance and dimensional check report;
- (f) Verification certificates for standard compliance;
- (g) All concession requests.

All reports shall be signed by Contractor to signify compliance with the requirements of this specification.

For free issued materials, Contractor and Applicator will be the same.

## 16 PRE-JOB MEETING

The Contractor shall schedule a pre-job meeting to ensure that job requirements are fully understood. The personnel present at the meeting shall include, but not be limited to, the Company's representative, contractor's and the Applicator's representatives for coating supervision, quality control and safety.

If required a technical representative of the Manufacturer shall be present. Roles and responsibilities shall be clarified at the pre-job meeting and MOM shall be issued. It shall be confirmed that all parties have the latest revision of the technical specifications, coating procedure, AFC drawings and ITP.

## 17 QUALITY CONTROL PERSONNEL

Contractor and Applicator shall provide a CV for company approval of highly experienced & certified inspectors to conduct the coating inspection and job certification. Inspector shall have minimum 5 years' experience in pipeline coating projects and NACE Coating Inspection level II certification.

Company (QA/QC) shall conduct an interview for all quality personnel candidates prior the approval. The assigned coating inspector shall witness all steps of the coating process in accordance with the approved ITP starting from the PQT until final release of the coated pipes.

## 18 COATING CLASSIFICATION

### 18.1 General

The coating class shall be selected based on the design temperature range, material of the pipe and expected field duty.

The coating thickness class shall be selected based on transport, handling, laying conditions and the expected operating and environmental conditions.

### 18.2 Coating Classes

The coating shall be capable of withstanding the temperature range required, as shown in Table 5. The coating class shall be specified in the purchase order.

Table 5 - Coating Classes and Design Temperature Ranges										
Top Layer Material	-40 °C	-20 °C	0 °C	+20 °C	+40 °C	+60 °C	+80 °C	+100 °C	+120 °C	+140 °C
PE		≥ -40 °C					≤ +80 °C			
PP *		≥ -20 °C							≤ +110 °C	
FBE		≥ -30 °C								≤ +120 °C
* Installation and transportation at temperatures below 0 °C can cause mechanical damage.										

Coating classes PE or PP can be selected because of higher mechanical properties for project or specific laying purposes rather than maximum operating temperatures listed in Table 5.

The use of coating classes outside these guidelines is acceptable provided that the applied coating shall be tested against the requirements specified in Table 14 for each relevant class (i.e. PE shall be tested against requirements for PE in Table 14, PP shall be tested against requirements for PP in Table 14).

Different requirements for coating materials outside these classification systems shall be agreed upon by the applicator and purchaser.

Use of coating classes outside these guidelines shall be approved by the purchaser or end user.

### 18.3 Coating Thickness Classes

The coating thickness class shall be selected by the Contractor based on installation and service conditions and pipe dimensions. The coating thickness class, as shown in Table 7 as a function of coating class and pipe weight, shall be specified in the purchase order.

Table 6 - Coating Thickness Classes	
Class 1 (or lower thicknesses)	Can be used only for lighter installation/laying conditions (for example sandy soils, prepared backfill with selected materials). Typically, backfilling soil is not controlled. Hence, Class 1 thickness columns in Table 7 shall not be used except for in-plant applications of limited lengths, where the backfill soil shall not be mechanically aggressive to the coating.
Class 2	Can be applied for standard conditions (for example clay soils, backfill made by native soil, not coarse materials).
Class 3 (or higher thicknesses)	Can be applied as a minimum for more severe environments and installation/laying conditions (for example offshore, rocky soils).

A 10 % total coating thickness reduction is allowed on welds seam for SAW welded pipes. Use of thickness classes outside these guidelines shall be approved by the Contractor and Company.

Table 7 - Minimum Total Coating Thickness (mm)							
$P_m$ kg/m	PE Class 1	PE Class 2	PE Class 3	PP Class 1	PP Class 2	PP Class 3	FBE Coating
$P_m \leq 15$	1.3	1.8	2.3	1.3	1.7	2.1	0.4 mm $\pm$ 0.05 mm for single layer FBE 0.8mm $\pm$ 0.05 mm for dual layer FBE.
$15 < P_m \leq 50$	1.5	2.1	2.7	2.7	1.5	1.9	
$50 < P_m \leq 130$	1.8	2.5	3.1	1.8	2.3	2.8	
$130 < P_m \leq 300$	2.2	2.8	3.5	2.2	2.5	3.2	
$P_m > 300$	2.5	3.3	4.2	2.5	3.0	3.8	
Note: a) Minimum and maximum permissible thickness of the FBE coating shall be specified in the purchase order. b) Flexibility of FBE coating may be reduced with increasing thickness higher than 500 $\mu$ m							

## 19 QUALIFICATION PROCESSES

### 19.1 General - Qualification Scheme

The qualification process as per this document includes the following qualification steps.

- Coating material qualification, by the manufacturer.
- Each coating material shall be qualified by the manufacturer in accordance with the requirements of Tables 9, 10 and 11. The manufacturer shall carry out and report the coating material qualification in

accordance with the requirements of Tables 9, 10 and 11 where applicable. The test report issued by the manufacturer shall be certified by a certification organization and submitted for Contractor and Company review and approval.

- (c) Coating system qualification, by the applicator
- (d) Each coating system shall be qualified by the applicator. Qualification shall be carried out separately for each coating application line. The applicator shall prepare an APS (see 19.2) and ITP (see 19.4) related to the qualification of the specific coating system.
- (e) The applicator shall carry out and report the coating qualification in accordance with the requirements of Table 14. The test report shall contain the results of the qualification tests as per Table 14 and technical data required in Tables 13, 17 and 18. The test report issued by the applicator may be also certified by a certification organization and submitted for Contractor and Company review and approval.
- (f) Pre-production trial. A specific ITP shall be prepared.
- (g) Procedure qualification trial. A specific ITP shall be prepared.

All steps (a) (b) (c) and (d) are mandatory.

PQT shall be executed in accordance.

Execution of all of the above can be carried out preferably as individual steps, or alternatively in conjunction with others as indicated in Table 8.

Table 7 provides qualification scheme combinations together with the identification of the tables to be considered for each phase and tests to be carried out.

Table 8 - Qualification Schemes			
Qualification Scheme	Applicable Tables and Tests		
	Coating Material Qualification / Coating System Qualification	PQT	PPT
	(a) / (b)	(c)	(d)
Option I	Table 9, 10, 11 / 14, 17 and 18	Table 17 and 18	Table 17 and 18
Option II	Table 9, 10, 11 / 14, 17 and 18		Table 17 and 18
Option III	Table 9, 10, 11 / 14, 17 and 18	Table 17 and 18	
Option IV	Table 9, 10 11 / 14, 17 and 18		
Note: If agreed, test certificates not older than three years are considered acceptable to cover requested tests for Coating Material Qualification and Coating System Qualification test report.			

Company approved coating materials and applicators (19.1.1 a, and b) shall be always used. Also, PPT and PQT (19.1.1 c, and d) are combined together prior to production. In case of qualification for new coating

materials and applicators is required based on project needs, Contractor and Applicator shall propose the applicable qualification scheme for Company review and approval.

Company shall decide the selection of qualification scheme on case by case basis.

Selection of the qualification scheme has to be carefully evaluated with respect to the availability of project pipes for PQT and the time frame required for the long-term test results for the coating materials and/or coating system qualification.

Option IV is not applicable for offshore pipelines or when Coating Class 3 is selected.

In case there are different line pipe diameters, each nominal diameter shall have separate qualification, i.e. one combined PPT and PQT testing per line pipe diameter. Different pipes, for example diameter or type of steel, can be used upon agreement, if adopted process parameters are those that will be used for the project pipes. This option shall be carefully evaluated since the use of dissimilar pipes can affect the reliability of the results.

PQT or PPT shall be repeated in case of modifications to the coating line, coating materials or application procedures.

## 19.2 Application Procedure Specification (APS)

Prior to the selected qualification process (including possible specified PQT) and start of coating production, the applicator shall prepare an APS, including:

- (a) Incoming inspection of pipes and pipe tracking.
- (b) The external surface of all seamless pipes shall be free from scabs, laps, shells, slivers, burrs, metallurgical tears and sharp edged discontinuities that may interfere with the application of thin film for example FBE) coatings, and multi-layer coatings where FBE forms the first layer.
- (c) Manufacturer's specification (data sheets) for coating materials, including any materials used for coating repairs;
- (d) Manufacturer's specification (data sheets) for abrasive blasting materials;
- (e) Certification, receipt, handling and storage of materials for coating and abrasive blasting;
- (f) Cleaning procedure for all application equipment;
- (g) Preparation of the steel surface including monitoring of environmental parameters, methods and tools for inspection, grinding of pipe surface defects and testing of surface preparation;
- (h) Coating application, including tools/equipment for control of process parameters essential for the quality of the coating;
- (i) Lay-out sketch and flow diagram for the coating plant;
- (j) Methods and tools/equipment for inspection and testing of the applied coating;
- (k) Repairs of coating defects and the associated inspection after repair;
- (l) ITP for the PPT/PQT and production;
- (m) Stripping of defective coating;
- (n) Preparation of coating cutback areas;
- (o) Marking and traceability;

- (p) Handling and storage of pipes;
- (q) Any special conditions for dispatch of coated pipes, including protection of pipe ends;
- (r) Name and credentials for the proposed coating inspectors;
- (s) Documentation and template of the testing reports.

The APS shall cover all items associated with quality control as defined in this document and any agreed amendments.

The APS, including any revisions, shall be approved by the purchaser Contractor and Company prior to the start of qualification and production.

It shall be available to the Contractor and Company on request at any time during production.

The applicator shall prepare an ITP and a daily log to record quality control data.

### **19.3 Pre-Production Trial (PPT)**

A PPT shall be carried out immediately prior to start of production.

Requirements for the frequency of testing and inspection, methods and acceptance criteria are contained in Tables 9 and 10.

All items in the APS, from surface preparation to preparation of pipe ends shall be performed and inspected/tested in presence of Contractor and Company personnel.

The specific process parameters shall be as per the approved APS and validated by the approved ITP.

The results from the PPT shall be documented in a report, including the process parameters used, the APS and the coating material certificates. Name and credentials of the actual coating inspectors shall be included.

### **19.4 Inspection and Testing Plan (ITP)**

An ITP shall be prepared for PPT/PQT and production acceptance testing.

Inspection frequencies shall be as per Tables 17 and 18.

The ITP contents shall reflect all the process items, the items to be inspected and tested as described by the APS and related frequencies.

As a minimum the following shall be recorded:

- (a) Description of the activities;
- (b) Coating system;
- (c) Inspection points for each of the activities;
- (d) Applicable reference documents;
- (e) Applicable check procedures and methods/instruments;
- (f) Acceptance criteria;
- (g) Frequency of the checks;
- (h) Remedial actions;
- (i) Persons required to be present at the inspections;



(j) Reporting.

A daily log shall be used to record all inspection and testing data, process parameters and calibrations of equipment for quality control. The daily log shall be signed by the approved and assigned Applicator/Contractor/Company inspectors on timely basis.

### 19.5 Procedure Qualification Trial (PQT)

Requirements for the frequency of testing and inspection, methods and acceptance criteria are contained in Tables 17 and 18.

All items in the APS, from surface preparation to preparation of pipe ends, shall be performed and inspected/tested on the specified number of samples.

The specific process parameters shall be selected to be used during the PQT so that the suitability of the ranges and combinations specified in the APS can be verified (for example a maximum value for one parameter can be applied in combination with a minimum value for another, if deemed critical).

Process parameters shall be monitored and recorded. For each of them the set point and allowable variations, either in absolute values or percentages, shall be provided.

The results from the PQT shall be documented in a report, including the process parameters used, the APS and the coating material certificates. Any recommendations for revision of the APS that apply for production shall be highlighted in the report.

## 20 COATING MATERIAL QUALIFICATION - 3-LAYER PE AND 3-LAYER LPP

### 20.1 Composition of the Coating System

- (a) The three layer coating system comprises:
- (b) 1st layer: fusion-bonded epoxy;
- (c) 2nd layer: adhesive applied by extrusion and/or by powder spray;
- (d) 3rd layer: PE/PP top layer applied by extrusion.

If required, a rough coat can be applied to increase slip resistance.

### 20.2 General Requirements

The manufacturer shall qualify and issue a report for each type of coating material in compliance with the requirements of this document. The qualification shall be repeated in case of changes in the material composition, changes in the production process which influence the material processing behaviour and change in production facility.

The test report shall contain the results of the qualification tests and the data required in Table 13.

The manufacturer shall carry out and report the material qualification in accordance with the requirements of Section 19 and Tables 9, 10 and 11. The test report shall contain the results of the qualification tests and the data required in Table 13. Test reports shall have three-year validity.

The applicator receiving the manufacturer's test report shall verify that it meets the requirement of this document.

### 20.3 FBE Material

The applicator shall use epoxy material that is in accordance with Table 9.

Table 9 - Requirements for FBE Material				
Properties	Unit	Test Method	Requirements	
			PE	PP
Moisture content	% mass	ISO 21809-1 Annex K	≤0.6	
Minimum glass transition temperature (Tg2) (DSC analysis*)	°C	ISO 21809-1 Annex D	≥95.0 and within manufacturer's specification	At least 5 °C above maximum pipeline design temperature with a minimum of 95.0
Particle size	%	ISO 21809-2	3.0 % retained on 150 µm sieve ≤0.2 % retained on 250 µm sieve and within the manufacturer's specification	
Gel time at 205 °C ± 3 °C	s	ISO 21809-1 Annex J	Within 20 % of the nominal value specified by the manufacturer	
Density	g/cm3	ISO 21809-1 Annex M	Within ±0.05 of the manufacturer's specified nominal value	
* Curing condition (procedure as per manufacturer's specification).				

### 20.4 Adhesive Material

The applicator shall use adhesive material that is in accordance with Table 10.

Table 10 - Requirements for the Adhesive Material (Co Polymeric or Grafted Adhesive in Pellet or Powder Form)				
Properties	Unit	Test Method	Requirements	
			PE	PP
Strain at break at 23 °C ± 3 °C*	%	ISO 10350-1 ISO 527-2	≥600	≥400
Density	g/cm3	ISO 1183 (all parts)	Within manufacturer's specification	
MFR	g/10 min	ISO 1133-1	Within manufacturer's specification	
Stress at yield at 23 °C ± 3 °C*	MPa	ISO 10350-1 ISO 527-2	≥8	≥12
Charpy impact strength, notched at minimum class temperature	kJ/m2	ISO 179-1 or ISO 179-2	—	≥3
Vicat softening temperature A/50	°C	ISO 306	≥85	≥115

Table 10 - Requirements for the Adhesive Material (Co Polymeric or Grafted Adhesive in Pellet or Powder Form)				
Water content	%	ISO 15512 pellet or powder ISO 8130-7 powder	≤0.05	≤0.05
* For testing speed refer to ISO 21809-1 Annex G - Section G.1.4.2				

## 20.5 PE/PP Top Layer Material

The applicator shall use PE/PP material that is in accordance with Table 11.

Table 11 - Minimum Requirements for PE/PP Top Layer				
Properties	Unit	Test Method	Requirements	
			PE	PP
Density of black compound	g/cm <sup>3</sup>	ISO 1183 (all parts) or ASTM D792 or ASTM D1505	≥0.940	N.A.
Density of the base resin (not black compound)	g/cm <sup>3</sup>	ISO 1183 (all parts) or ASTM D792 or ASTM D1505	≥0.930	≥0.890
Carbon black content	%	ISO 6964	2 – 3	N.A.
Carbon black dispersion	—	ISO 18553	Max Grade 3	N.A.
MFR	g/10 min	ISO 1133-1	Within manufacturer's specification	
Strain at break at 23°C ± 3°C*	%	ISO 10350-1 ISO 527-2	≥600	≥400
Stress at yield at 23 °C ± 3 °C*	MPa	ISO 10350-1 ISO 527-2	≥15	≥20
Charpy impact strength, notched at minimum class temperature	kJ/m <sup>2</sup>	ISO 179-1 ISO 179-2	—	≥3
Vicat softening temperature A/50	°C	ISO 306	≥110	≥130
Water content	%	ISO 15512 pellet or powder ISO 8130-7 powder	≤0.05	≤0.05
ESCR (50 °C, F50)	h	ASTM D1693	≥1000 Cond.B, 10 % Igepal CO630 or if density of black	N.A.

Table 11 - Minimum Requirements for PE/PP Top Layer				
Properties	Unit	Test Method	Requirements	
			PE	PP
			compound >0.955 g/cm <sup>3</sup> ≥300 Cond. B, 100 % Igepal CO630	
Hardness Shore D	—	ISO 868	≥55	≥60
Oxidation induction time (intercept in the tangent method)	min	ISO 11357-6	≥30 at 210 °C	≥30 at 220 °C
UV resistance and thermal ageing (not black PE compound)	%	ISO 21809-1 Annex G	ΔMFR ≤ 35 or Δεb ≤ 50 %	N.A.
UV resistance and thermal ageing	%	ISO 21809-1 Annex G	ΔMFR ≤ 35	ΔMFR ≤ 35
* For testing speed refer to ISO 21809-1 Annex G - Section G.1.4.2				

If the compounding is done during the application process, the applicator shall perform the qualification tests for the product in accordance with Table 10. The batch certificate, produced in accordance with Table 11, shall be issued.

The carbon black used in the production of black compound shall be P type.

Table 12 - Characteristics of "P Type Carbon Black			
Property	Unit	Requirement	Test Method
Iodine number	mg/g	79	ASTM D-1510
Oil absorption number	cc/100g	104	ASTM D-2414
Moisture as packed	%	<1.0	ASTM D-1509
325 mesh residue	ppm	<20	ASTM D-1514
Ash	%	<0.1	ASTM D-1506
Total sulphur	%	<0.1	ASTM D-1619
Particle size	nm	<25	ASTM D-3849
Toluene extract	%	<0.03	ASTM D-4527

Additives (Carbon black, anti-oxidants.) shall be incorporated by means of a master-batch. PE/PP raw material Manufacturer shall be the only one authorized to perform this step. No additivation of any kind shall be allowed at the coating plant during extrusion.

## 20.6 Batch Certificate

The applicator shall provide batch certificates supplied by the manufacturer of each material and shall contain the information given in Table 13. The batch certificate shall state test methods and acceptance criteria (i.e. acceptable ranges or min/max value).

The applicator shall identify the materials and shall confirm that the certificates comply and relate to the specified materials.

Table 13 - Batch Certificate			
Content	Coating Material		
	FBE	Adhesive	PE/PP Top Coat
Identification of the manufacturer	X	X	X
Product identification	X	X	X
Batch identification	X	X	X
Date and place of manufacturing	X	X	X
Density	X	X	—
Density of the compound	—	—	X
Melt flow rate	—	X	X
Gel time	X	—	—
Particle size	X	X*	—
Moisture/water content	X	X	X
Carbon black content	—	—	Only PE*
Carbon black dispersion	—	—	Only PE*
Thermal characteristic	X	—	—
Reactive site content (direct or indirect methods can be proposed by the manufacturer)	—	X	—
* If applicable.			

The manufacturer's specification for epoxy materials shall include the following:

- Trade name;
- Generic type;
- Mix ratio (if any);
- Maximum thickness, expressed in millimetres or micrometres (ISO 21809-1 Annex A);
- General information about application window;
- Maximum and minimum storage temperatures, expressed in degrees Celsius;
- Shelf-life at storage temperature, expressed in months;
- Physical properties, in accordance with Table 9.

The manufacturer's specification for adhesive and PE/PP materials shall include the following:

- (a) Trade name;
- (b) Description of the adhesive (if applicable);
- (c) Colour;
- (d) Maximum and minimum storage temperatures, expressed in degrees Celsius;
- (e) Shelf-life at storage temperature, expressed in months;
  - a) Physical properties, in accordance with Tables 10 and 11.

## 20.7 Storage and Handling of Coating Materials

Storage and handling of coating materials shall be in accordance with the manufacturer's specification.

## 21 COATING SYSTEM QUALIFICATION - 3-LAYER PE AND 3-LAYER PP

Each coating system shall be qualified by the applicator. Qualification shall be carried out separately for each coating application line and a specific APS and ITP shall be prepared by the applicator and submitted for Contractor and Company review and approval.

The applicator shall carry out and report the coating system qualification in accordance with the requirements of this document. The test report shall contain the results of the qualification tests and data required in Tables 13, 14, 17 and 18. The applicator shall apply coating materials qualified in accordance with the requirements of Section 20.2.

Qualification shall be repeated in case of modifications to the coating line, coating materials or application procedures.

Table 14 - Properties of the Applied Coating					
Properties		Unit	Test Method	PE	PP
Continuity		—	ISO 21809-1 Annex B	Free of defects and discontinuities, delaminations, separations and holidays	
Impact strength at 23 °C ± 3 °C		J/mm	ISO 21809-1 Annex E	>7	>10
Indentation	at 23 °C ± 3 °C	mm	ISO 21809-1 Annex F	≤0.2	≤0.1
	at maximum design temp			≤0.4	≤0.4
Strain at break of PE/PP at 23 °C ± 3 °Ca		%	ISO 527-2	≥400	≥400
Peel strength		N/mm	ISO 21809-1 Annex C	≥18.0 at ≥23 °C ≥5.0 at ≥80 °C No disbonding between steel and epoxy	≥25.0 at ≥23 °C ≥6.0 at ≥90 or at max operating temperature if above 90 °C No disbanding between steel and epoxy

Table 14 - Properties of the Applied Coating				
$\Delta T_g$	°C	ISO 21809-1 Annex D	$-3.0\text{ °C} \leq \Delta T_g \leq +3.0\text{ °C}$	
Product stability during application of the PE/PP top layer process	%	ISO 1133-1	For Classes A and B $\Delta MFR \leq 20$ ; For Class C $\Delta MFR \leq 35$ ;:(variation between virgin compounded granulate before application and coating after application of the same batch tested by the applicator)	
Cathodic disbondment	at 23 °C/28 days; -1.38 V	mm	ISO 21809-1 Annex H	$\leq 5.0$
	at 65 °C/24 hours; -3.38 V			$\leq 4.0$
	Max op. temp (max 90 °C) / 28 days; -1.38 V			$\leq 15.0$
Flexibility	Degrees per pipe length diameter	ISO 21809-1 Annex I	No cracking at an angle of 2.0° per pipe diameter length	
Resistance to hot water immersion test	mm	ISO 21809-1 Annex L	Average $\leq 2.0$ and maximum $\leq 3.0$	
* For testing speed refer to ISO 21809-1 Annex G - Section G.1.4.2				

## 22 COATING MATERIAL AND SYSTEM QUALIFICATION - FBE

### 22.1 General

The applicator shall use epoxy powder that is certified by the manufacturer to be in accordance with the requirements of Sections 22.2 and 22.5, compatible with the requirements of and identified by the manufacturer on each package with the following:

- (a) Manufacturer's name;
- (b) Product number/description;
- (c) Product temperature range (maximum and minimum);
- (d) Mass of material;
- (e) Batch number/manufacturing identification number;
- (f) Location of manufacture;
- (g) Temperature requirements for transportation and storage;
- (h) Year, month and day of manufacture;
- (i) Expiry date, and:
- (j) Handled, transported, and stored in accordance with the manufacturer's recommendations.

### 22.2 Properties

As a minimum, each batch of epoxy powder shall be tested by the manufacturer in accordance with the requirements of Table 15. Test results shall be reported in accordance with ISO 10474 and a batch certificate with the test results shall be provided by the manufacturer to the applicator.

Table 15 - Minimum Requirements for Epoxy Power			
Property	Unit	Test Method	Requirements
Cure time	s	ISO 21809-2 Clause A.2	Within the manufacturer's specification
Gel time	s	ISO 21809-2 Clause A.3	Within the manufacturer's specification
Total volatile/moisture content mass fraction	%	ISO 21809-2 Clause A.5	≤ 0.6 %
Particle size	%	ISO 21809-2 Clause A.6	Maximum retained on 150 μm and 250 μm sieves within the manufacturer's specification
Density	g/cm <sup>3</sup>	ISO 21809-2 Clause A.7	Within the manufacturer's specification
Thermal characteristics	Tg1 (°C) Tg2 (°C) ΔH (J/g)	ISO 21809-2 Clause A.8	Within the manufacturer's specification



### 22.3 Packaging

The powder shall be contained in packaging that is labelled to identify the items specified in Section 22.1.1.

### 22.4 Repair Materials

The applicator shall use repair materials that are certified by the powder manufacturer to be compatible with the epoxy powder. Repair material batches shall be identified by the product manufacturer as per 22.5.1.

Repair materials shall be handled, transported, and stored in accordance with the material manufacturer's recommendations.

### 22.5 FBE Material Qualification by Manufacturer

The manufacturer shall qualify the epoxy powder in accordance with ISO 21809-2. The qualification shall be repeated in case of changes in the material composition, changes in the production process which influence the material processing behaviour and change in production facility.

The manufacturer shall carry out the tests in accordance with the requirements of Section 22. Coatings designed for up to 95°C shall be qualified by the manufacturer through laboratory coated test specimens or plant applied coating for each of the applicable tests. The test results shall meet the acceptance criteria in Table 16.

For coatings designed for services above 95°C, in addition to the requirements in Table 16, the tests for flexibility, impact resistance, cathodic disbondment, hot water adhesion, taber abrasion and thermal characteristics shall be repeated using samples that have been conditioned in an oven at a temperature of 5°C below T<sub>g</sub> for a minimum of 30 days followed by ambient temperature for 24 hour before testing. Cathodic disbondment testing shall be performed using the method in ISO 21809-2 Clause A.10. Acceptance criteria for these tests shall be agreed between the manufacturer and the purchaser. Other temperature exposure conditions may be agreed based on the pipeline service conditions.

Laboratory test specimens shall be prepared in accordance with Section 22.6.

These test results shall be reported in accordance with ISO 10474 and shall be available to the applicator. Results shall be submitted by Applicator/Contractor to Company for review and approval.

Table 16 - Requirements for Coating Qualification			
Properties	Acceptance Criteria	Number of Test Specimens	Test Method
Thermal characteristics	Meets the manufacturer's specification	1	ISO 21809-2 Clause A.8
Cathodic disbondment: 24 hours, 65 °C ± 3 °C, -3,5 V	≤5 mm disbondment	3	ISO 21809-2 Clause A.9
24 hours hot water adhesion 75 °C ± 3 °C	Rating of 1 to 2	3	ISO 21809-2 Clause A.16
28 days hot water adhesion 75 °C ± 3 °C	Rating of 1 to 3	3	ISO 21809-2 Clause A.16
Cathodic disbondment: 28 days, 20 °C ± 3 °C, -1,5 V	≤8 mm disbondment	3	ISO 21809-2 Clause A.9
Cathodic disbondment: 28 days, 65 °C ± 3 °C, -1,5 V	≤18 mm disbondment	3	ISO 21809-2 Clause A.9

Table 16 - Requirements for Coating Qualification

Properties	Acceptance Criteria	Number of Test Specimens	Test Method
Cathodic disbondment: 28 days, max design temperature (if above 65 °C) $\pm 3$ °C, -1,5 V	$\leq 18$ mm disbondment	3	ISO 21809-2 Clause A.9
Cross-section porosity	Pass (compared with Figure A.11)	1	ISO 21809-2 Clause A.12
Interface porosity	Pass (compared with Figure A.12)	1	ISO 21809-2 Clause A.12
Flexibility at 0 °C for coating thickness of 350 $\mu$ m to 500 $\mu$ m	No cracking at 2.5° ppd	5	ISO 21809-2 Clause A.13
Flexibility at -30 °C for coating thickness of 350 $\mu$ m to 500 $\mu$ m	No cracking at 2° ppd	3	ISO 21809-2 Clause A.13
Flexibility at minimum design temperature for coating thickness of 350 $\mu$ m to 500 $\mu$ m	No cracking at 2° ppd	3	ISO 21809-2 Clause A.13
Impact at minimum design temperature	$\geq 2$ J	3	ISO 21809-2 Clause A.14
Strained coating, cathodic disbondment 28 days, 20 °C $\pm 3$ °C, -1,5 V	No cracking	3	ISO 21809-2 Clause A.15
Hardness test at maximum design temperature	Buchholz value min 80	3	ISO 2815
Taber abrasion	100 mg	3	ASTM D4060 ASTM CS-17 wheel, 1,000 cycles, 1kg mass

## 22.6 Preparation of the Laboratory Coated Test Specimens

Test specimens shall be mild steel and shall have dimensions in accordance with the applicable test method. The substrate shall be abrasively blast cleaned with steel grit, in accordance with ISO 11124-3, to provide a cleanliness in accordance with the requirements of ISO 8501-1, ISO 8502 grade Sa 2½.

The surface shall have a peak-to-trough height of between 50  $\mu$ m and 100  $\mu$ m as measured in accordance with ISO 8503-4 (Stylus method), or ISO 8503-5 (replica tape method).

Coating shall be applied in accordance with the product (data sheet) application guidelines and approved APS.

The thickness of the coating on the completed test specimen shall be 1-layer  $\geq 400$   $\mu$ m  $\pm 50$   $\mu$ m and 2-layer  $\geq 800$   $\mu$ m  $\pm 50$   $\mu$ m. This should be measured by a calibrated coating thickness gauge.

Impact Resistance on the completed test specimen shall be 1-layer 1.8 J and 2-layer 3.6 J.

### **22.7 Repair Material Qualification**

Qualification requirements for the repair material shall be agreed between repair material manufacturer and purchaser.

The repair materials to be used shall be certified by the FBE Manufacturer as compatible with the epoxy powder. FBE Manufacturer certificate regarding the repair the material shall be submitted to Company prior to use.

### **22.8 Qualification by Applicator**

The production coating shall be qualified by the applicator for each coating line. Applicator shall use coating materials qualified in accordance with the requirements of Section 22.5 and prepare coated samples in accordance with a documented APS.

Qualification shall be achieved by successful evaluation of pipe coated samples using the specified coating line and the coating qualification test results shall be reported in accordance with the requirements of this part of ISO 21809. The minimum requirements for plant qualification and production are given in Section 22.9.

The qualification shall be carried out in accordance with APS (see 22.10) and repeated in case of essential modifications of the coating line, coating materials and coating procedures.

### **22.9 Minimum Requirements for Plant Qualification and Production**

The requirements for testing pipe surface preparation are given in Table 19. Requirements of plant applied coating (quality tests) are given in Table 20.

### **22.10 Application Procedure Specification (APS)**

Prior to the start of coating production and any specified PQT, the applicator shall prepare an APS, including:

- (a) Incoming inspection of the pipe and pipe tracking;
- (b) Data sheets for coating materials, including any materials to be used for coating repairs;
- (c) Data sheets for abrasive blast materials;
- (d) Certification, receipt, handling and storage of materials for coating and abrasive blasting;
- (e) Procedure for cleaning of all application equipment;
- (f) Preparation of steel surface including monitoring of environmental parameters, methods and tools for inspection, grinding of pipe surface defects and testing of surface preparation;
- (g) Coating application, including tools/equipment for control of process parameters essential for quality of the coating;
- (h) Lay-out sketch or flow diagram for the coating plant;
- (i) Methods and tools/equipment for inspection and testing of the applied coating;
- (j) Repairs of coating defects and any associated inspection and testing;
- (k) Stripping of defective coating;
- (l) Preparation of coating cutback areas;
- (m) Marking and traceability;

- (n) Handling and storage of pipe;
- (o) Any special condition for despatch of coated pipes, including protection of pipe ends;
- (p) Documentation.

The APS shall cover all items associated with quality control as defined in this part of ISO 21809 and any agreed amendments. It shall be available to the purchaser on request at any time during production.

If specified, the APS including any revisions shall be approved by the purchaser prior to the start of production and any specified PQT.

The applicator shall prepare an ITP and a daily log to record quality control data.

## 23 APPLICATION OF THE COATING SYSTEM

### 23.1 General

The applicator shall apply qualified coating systems in accordance with requirements of Table 18.

### 23.2 Surface Preparation – Initial Preparation

All dirt, deleterious matter and contaminants, such as oil and grease, shall be removed from the pipe prior to coating. If necessary, the pipe shall be cleaned in accordance with the requirements of SSPC-SP 1.

All steel defects and irregularities (for example laminations, slivers, scratches.) shall be removed in accordance with the APS. Grinding of steel defects shall not reduce the wall thickness below the specified minimum wall thickness of the pipe.

All pipes shall be dry prior to entering the abrasive blast cleaning unit(s). The pipe temperature shall be at least 3 °C above the dew point immediately prior to abrasive blast cleaning.

### 23.3 Abrasive Blast Cleaning - Cleanliness and Surface Roughness

The abrasives used in the coating plant shall be in accordance with the respective requirements of ISO 11124 (all parts) or ISO 11126 (all parts). Pipes made of corrosion resistant alloys such as duplex stainless steel and 13 % Cr shall be blast cleaned using stainless steel abrasives or an expendable abrasive such as aluminium oxide. For carbon steel pipes lined/clad internally with CRA, care shall be exercised to prevent contamination by carbon steel abrasives on the inside of the pipe.

The abrasives (including recycled materials) shall be maintained clean, dry and free from contaminants in accordance with SSPC-AB 1, SSPC-AB 2 and SSPC-AB 3 or ASTM D4940 so as not to contaminate the substrate.

The cleanliness achieved at entry to the application line shall be in accordance with the requirements of ISO 8501-1, ISO 8502 grade SA 2½ minimum.

The Stylus method shall be used for verification. The Replica tape method may be used when a correlation is established with the Stylus (profilometer) method with a cut-off length of 2.5 mm.

If grinding is required after final blast cleaning, the maximum allowable area of grinding shall be 10 cm<sup>2</sup> per metre of pipe length or 0.5 % of the pipe surface area, whichever is lower. If the grinding area required exceeds these limits, the pipe shall be re-blasted or spot blasted on ground area. The maximum allowable area of spot blasting (measured as maximum length multiplied by the maximum width) shall be less than 5 % of the pipe surface area.

Reclaimed abrasive blast materials shall not be used unless automatic reclaiming equipment is used. Blasting equipment that includes devices to recycle abrasives shall have equipment that ensures removal of dust, fines, corrosion products and other contaminants.

#### 23.4 Surface Dust Contamination

The dust level shall be measured in accordance with the requirements of ISO 8502-3. The maximum dust quantity rating shall be 1 and the maximum dust size class shall be 1.

#### 23.5 Surface Pre-treatment and Salt Contamination

Surface pre-treatment in production stage shall be same as in qualification stage.

If the applicator chooses a surface pre-treatment (for example deionized water, phosphoric acid and/or chromate pre-treatment), the pre-treatment process shall be agreed by Company with the purchaser.

Note: Coating applicator shall be responsible for complying with the local and international HSE and environmental regulations for using the chemical treatment materials including disposal of the used chemicals.

If surface pre-treatment is used for a PQT, it shall be used for production. Process parameters (for example pressures, concentration, temperatures.) shall be verified and maintained stable along the whole production.

Testing for the presence of soluble salts on the pipe shall be undertaken in accordance with the requirements of ISO 8502-6 and ISO 8502-9. Alternatively, if allowed by the pipe temperature, a salt contamination portable instrument can be used, according to SSPC Guide 15. The maximum allowable level shall be 20 mg/m<sup>2</sup> after blasting. If levels above 20 mg/m<sup>2</sup> of soluble salts are measured, a surface pre-treatment cleaning process shall be agreed upon by the applicator and approved by Company.

#### 23.6 3-Layer PE/PP Coating System Application

The coating shall be applied in accordance with the APS. During the application of the coating components, the pre-heating temperature of the pipe shall be monitored and recorded using optical pyrometers and checked with contact thermometers. Temperature-measuring crayons shall not be used. Throughout the production, the coating and pipe temperature shall be continuously monitored (as per Table 17) and recorded once every half hour.

Throughout production, the blasting line speed, pre-heating temperature and the coating line speed shall be monitored continuously and the data recorded as per Table 17. Speed values during production run shall be within a range of  $\pm 10\%$  of the value used and verified during PPT or PQT.

Variation of the recorded values versus the set pre-heating temperature shall be within a range  $\pm 5\%$  along the pipe length with the exception of the cutback (see 23.12) lengths.

During production if the above parameters (i.e. blasting line speed, pre-heating temperature and the coating line speed) require modification from the PPT or PQT values a new PPT shall be performed.

Use of recycled coating material is not allowed with the exception listed below for FBE.

#### 23.7 FBE Application

Following surface preparation, the surface being coated shall not be exposed for a length of time that can result in flash rust. Between end of surface preparation and start of preheating, under no circumstance shall the time be more than 4 hours and the pipe temperature shall remain at least 3 °C above the dew point.

The pipe temperature prior to and during epoxy application shall be in accordance with the APS.

The thickness of the epoxy layer after curing shall be in accordance with Table 18. The  $\Delta T_g$  shall be in accordance with Table 14. The  $T_g$  shall be at least 5°C above the maximum pipeline design temperature.

Use of recycled FBE powder is allowed to a maximum of 20 %. Recycled FBE is not allowed if powder adhesive is used.

### 23.8 FBE Coating System Application

The thickness of the cured double layer FBE coating shall be  $800 \mu\text{m} \pm 50 \mu\text{m}$ , unless otherwise specified by the Company. The base coat shall each be  $400 \mu\text{m} \pm 50 \mu\text{m}$ .

The thickness of the cured FBE coating applied on bends and fittings shall be not less than  $800 \mu\text{m}$  and shall not be more than  $1000 \mu\text{m}$ .

See Table 20 for minimum requirements for the epoxy coating system.

### 23.9 Adhesive Application

The elapsed time between epoxy application and adhesive application shall be in accordance with the APS.

Adhesive layer shall be continuous. Under no circumstances can the top layer (see 20.5) be in contact with the FBE (see 20.3).

### 23.10 PE/PP application

The application of the PE/PP layer shall be in accordance with the APS.

The applied coating shall be cooled to a temperature that prevents handling damage during finishing and final inspection.

The total coating thickness shall be in accordance with Table 7.

### 23.11 Rough Coat Application

For the line piping that shall be coated with weight coating (i.e. concrete coating) for offshore application, the coating shall have rough surface finishing. Sintered PE/PP powder shall be applied on the surface of the final coat, whilst the polymer is cooling, to produce a non-slide surface.

The production method for rough coating shall be submitted by Applicator/Contractor to the Company for approval. Increasing the roughness of the coating surface shall not degrade the wear resistance of the coating system. The Company may require testing of the coating for friction and/or wear resistance, in accordance with ISO 21809-5, Annex B.

### 23.12 Cutback

The coating at the pipe ends shall be removed to expose  $150\text{mm} \pm 20\text{mm}$  a length of bare metal and as specified in the purchase order (see 14.1.1).

The FBE primer shall be visible on the cutback and shall leave minimum of 5mm long toe. In addition, the polyolefin shall be bevelled to an angle not exceeding  $30^\circ$  measured in the direction of the pipe axis.

For carbon steel pipes lined/clad internally with CRA, care shall be exercised to prevent contamination by carbon steel residues on the inside of the pipe.

Uncoated pipe ends shall be protected by a temporary protective paint for transit.

### 23.13 Procedure Qualification Trial (PQT).

The APS shall be verified by a PQT.

# SECTION C

## 24 INSPECTION AND TESTING

### 24.1 3-Layer PE/PP Inspection

Inspection and testing shall be carried out in accordance with the APS, and ITP, and meet the requirements of Tables 17 and 18.

Table 17 - Requirements for Inspection of Surface Preparation and Coating Application					
Properties	Unit	Test Method	Requirements	Frequency Coating System Qualification PQT/PPT	Frequency Production
Surface condition before blasting	—	Visual inspection	Free of contaminations	Each pipe	Each pipe
Environmental conditions	—	Calculation and direct measurement	As determined at time of measurement	Once	Every 4 hours
Pipe temperature before blasting	°C	Thermal contact probe	Minimum 3 °C above the dew point	Once	Every 4 hours
Size, shape and properties of virgin abrasive	—	Certification respective requirements ISO 11124 (all parts) (metallic) ISO 11126 (all parts) (non-metallic)	Conformity to certificate and compliance with manufacturing/working procedures	Once	Every batch
Water-soluble contamination of abrasives	µS/cm	ASTM D4940	Conductivity max. 150	Once	1/shift
Soluble salt content after blasting	mg/m <sup>2</sup>	ISO 8502-6 or ISO 8502-9 or SSPC Guide 15	Salt content (NaCl) max. 20	Each pipe	1/shift (or once/100 pipe)
Roughness of blasted surface	µm	ISO 8503-4 or ISO 8503-5	50 to 100	5 pipes to be tested	Every 1 hour
Blasting line speed	m/min	Stopwatch	Compliance to APS	Each pipe	1/shift
Visual inspection of blasted surface	—	ISO 8501-1	Grade SA 2 ½ minimum	Each pipe	Each pipe
Presence of dust after dust removal	—	ISO 8502-3	Max. quantity rating 2 Max. dust size 2	5 pipes to be tested	Every 1 hour

Table 17 - Requirements for Inspection of Surface Preparation and Coating Application

Properties	Unit	Test Method	Requirements	Frequency Coating System Qualification PQT/PPT	Frequency Production
Visual inspection of pipe prior to introduction to coating line	—	Visual	No flash rust	Each pipe	Each pipe
Temperature of extruded adhesive and top coat	°C	Thermometer or other approved equipment	Compliance to APS	Once	Every 1 hour
Pre-heating temperature before coating	°C	Pyrometer or other approved equipment	Compliance to APS	Each pipe	Each pipe
Coating line speed	m/min	Stopwatch	Compliance to APS	Each pipe	1/shift



## 24.2 Visual Inspection

The following external surfaces of the coated pipe, shall be carefully inspected:

- a) **Adjacent to the longitudinal welds.**
- b) **Adjacent to the cutback at each end of pipe.**
- c) **Within the body of the pipe.**

The coating shall be of natural colour and gloss, smooth and uniform, and shall be blemish free, with no dust or other particulate inclusions. The coating shall not show any defects such as blisters, scratches, wrinkles, engravings, cuts, swellings, excess material thickness, disbonded zones, air inclusions, tears, voids, or any other irregularities.

## 24.3 Elongation

From each pipe five coating samples are taken and the adhesive is removed from each sample. The elongation at break shall be measured in accordance with DIN 30670.

The elongation at break of a coating sample when tested at ambient temperature shall be more than 300%.

## 24.4 Coating of Resistivity

The resistivity of the coating shall be measured in accordance with DIN 30670.

The coating resistivity shall be more than 108  $\Omega$ m.

Table 18 - Minimum Frequency and Requirements for Inspection and Testing of Applied Coating						
Properties	Unit	Test Method	Requirements	Frequency PQT	Frequency PPT	Frequency Production
Epoxy thickness*	$\mu$ m	ISO 2808	FBE: min 250 Maximum 300	1st pipe	1st pipe	Once every two shifts and at every start up
Minimum adhesive thickness*	$\mu$ m	ISO 2808	150 on pipe body	1st pipe	1st pipe	Once every two shifts and at every start up
Degree of cure	$^{\circ}$ C	ISO 21809-1 Annex D	Table 12	5 pipes	5 pipes	1st production pipe and 2/shift
Continuity	—	ISO 21809-1 Annex B	Table 12	5 pipes	5 pipes	Each pipe
Total coating thickness	mm	ISO 21809-1 Annex A	Table 6	5 pipes	5 pipes	Every 10 pipes
Peel strength. Each pipe shall be tested at 23 $^{\circ}$ C at both ends with an additional test at high temperature	N/mm	ISO 21809-1 Annex C	Table 12	5 pipes	5 pipes	Every 4 hours
Impact strength	J/mm	ISO 21809-1 Annex E	Table 12	1 pipe	1 pipe	Once per 100 pipes (or once/shift)
Indentation	mm	ISO 21809-1 Annex F	Table 12	Once	Once	Once per 100 pipes (or once/shift)

Table 18 - Minimum Frequency and Requirements for Inspection and Testing of Applied Coating

Properties	Unit	Test Method	Requirements	Frequency PQT	Frequency PPT	Frequency Production
Strain at break	%	ISO 527-2	Table 12	Once	Once	Once per 100 pipes (or once/shift)
Cathodic disbondment	mm	ISO 21809-1 Annex H	23 °C/28 days; -1.38 V	Once	—	—
Cathodic disbondment	mm	ISO 21809-1 Annex H	Max Op.temp (max 90 °C)/28 days; -1.38 V	Once	—	—
Cathodic disbondment	mm	ISO 21809-1 Annex H	65 °C/24 hours; -3.38 V	Once	Once	1/day
Resistance to hot water immersion test	mm	ISO 21809-1 Annex L	Table 12	Once	Once	Once per 200 pipes (minimum one/shift)
Flexibility	Degrees per pipe length diameter	ISO 21809-1 Annex L	Table 12	Once	—	—
Product stability during application	%	ISO 1133-1	Table 12	Once	Once	1 <sup>st</sup> pipe per shift
Cutback	mm	Measuring	Section 23.12	5 pipes	5 pipes	Recorded once per hour
Residual magnetism after coating application	Gauss	Gaussmeter	As per ISO 3183	5 pipes	5 pipes	1/shift
Coating repairs	—	Visual/ ISO 21809-1 Annex B	No holidays	Once for validation	—	Each defect

\* For FBE and adhesive thickness, it is measured on part-coated pipes over the length of pipe partially coated.

## 24.5 FBE Coating System Inspection

### Minimum Requirements for Plant Qualification and Production

The requirements for testing pipe surface preparation are given in Table 19. Requirements of plant applied coating (quality tests) are given in Table 20.

Table 19 - Requirements for Inspection of Surface Preparation - Production and Plant Qualification					
Properties	Unit	Test Method	Requirements	Frequency for Qualification	Frequency for Production
Incoming FBE powder	—	Section 24	Section 24	Each batch	Each batch
Surface condition before blasting	—	Visual inspection	Free of contaminations	Each pipe	Each pipe
Environmental conditions	—	Calculation	As determined at time of measurement	Once	Every 4 hours
Pipe temperature before blasting	°C	Thermocouple	Minimum 3 °C above the dew point	Once	Every 4 hours
Size, shape and properties of abrasive	—	Visual and certification ISO 11124 (all parts) (metallic) ISO 11126 (all parts) (non-metallic)	Conformity to certificate, compliance to manufacturing/working procedures	Once	1/Day
Water soluble contamination abrasive	μS/cm	ASTM D4940	Conductivity maximum 60	Once	1/Shift
Soluble salt after blasting	mg/m <sup>2</sup>	Potassium ferricyanide indicator in accordance with AS 3894.6 and following conductive measurement, ISO 8502-9 and ISO 11127-6	Salt content (as NaCl) maximum 20	Each pipe	Every 4 hours (or once per 100 pipes)
Surface roughness of blasted surface (Rz/Ry5)	μm	ISO 8503-4 or ISO 8503-5	50 to 100 or as per coating datasheet	5 pipes	Every 1 hour (or once per 20 pipes)
Visual inspection of blasted surface	—	ISO 8501-1	Grade SA 2 1/2	Each pipe	Each pipe
Presence of dust after dust removal	—	ISO 8502-3	Maximum class 2 (for both size and quantity)	5 Pipes	Every 1 hour
Visual inspection of pipe prior to introduction to coating line	—	Visual	No rust	Each pipe	Each pipe
Preheating temperature before coating	°C	Pyrometer	Compliance to APS	Each pipe	Each pipe

Table 20 - Requirements for Plant Applied Coating - Production and Plant Qualification

Properties	Acceptance Criteria	Test Method	Frequency for Qualification	Frequency for Production
Degree of cure DSC - $\Delta T_g$	Meets manufacturers specification	ISO21809-2 Clause A.8	First pipe	First pipe of the order and then 1/shift
Porosity	Less than or equal to that illustrated in Figures U.1 and U.2	ISO21809-2 Clause A.12	First pipe	First pipe of the order and then 1/shift
Dry adhesion	Rating of 1 to 2	ISO21809-2 Clause A.4	5 pipes	Every 4 hours (or once/shift)
Impact	1-Layer $\geq 1.8$ J 2-Layer $\geq 3.6$ J	ISO21809-2 Clause A.14	3	1/shift
Flexibility at minimum design temperature for coating thickness of 350 $\mu\text{m}$ to 500 $\mu\text{m}$	No cracking at 2° ppd	ISO21809-2 Clause A.13	3	1/shift
Hot water adhesion; 24 hours, 75°C $\pm$ 3°C	Rating of 1 to 2	ISO21809-2 Clause A.16	1	1/shift
Hot water adhesion; 28 days, 75°C $\pm$ 3°C	Rating of 1 to 3	ISO21809-2 Clause A.16	1	In accordance with APS
Cathodic disbondment: 24 hours, 65°C $\pm$ 3°C – 3,5 V	$\leq 5$ mm disbondment	ISO21809-2 Clause A.9	1	1/shift
Interface contamination	30 % maximum	ISO21809-2 Clause A.11	1	1/shift
Cathodic disbondment: 28 days, at max design temperature per APS $\pm$ 3°C – 1,4 V (Ag/AgCl reference electrode)	$\leq 18$ mm disbondment	ISO21809-2 Clause A.10	1	In accordance with APS
Cathodic disbondment: 28 days 65°C $\pm$ 3°C – 1,5 V	$\leq 8$ mm disbondment	ISO21809-2 Clause A.9	1	In accordance with APS
Coating thickness	1-L $\geq 400$ $\mu\text{m} \pm 50$ $\mu\text{m}$ 2-L $\geq 800$ $\mu\text{m} \pm 50$ $\mu\text{m}$	—	In accordance with APS	In accordance with APS
Cut back	—	—	Each pipe	Each pipe
Continuity	No holidays	Section 24	Each pipe	Each pipe

## 24.6 Re-Testing

Pipes that fail to meet the requirements of Table 17 shall not be coated until the cause has been identified and corrected. Pipes that have been coated since the last acceptable test shall be accepted if they meet the requirements of Table 18.

Pipes that fail to meet the requirements of Table 18 shall be re-tested for the parameter(s) found to be out of specification. If the re-test also fails to meet the requirements in Table 18, two pipes in the coating sequence prior to the pipe that failed and two pipes in the sequence after that pipe shall be re-tested.

If the results of all re-tested pipes are satisfactory, the coating shall be considered acceptable on all pipes except the pipe that failed. If any of the re-tests also fail, the total production back to the last test passed shall be blocked and further testing shall be initiated by the applicator and agreed with the purchaser. In the case of confirmed failure, the coating shall be rejected.

## 25 COATING REPAIRS

Defects in the finished coating caused by the application process, transportation, handling and storage in the coating plant or in the storage area, as well as those that have been subjected to destructive testing, shall be repaired.

The defect area shall not exceed 10 cm<sup>2</sup> and the total number of defects shall not exceed 1 defect per metre length of pipe, unless otherwise specified. If the size or number of defects exceeds these limits, the affected pipe shall be stripped and recoated in accordance with the APS.

Defects shall be repaired and inspected using materials and procedures in accordance with the APS and any PQT. Repair materials shall be compatible with the applied coating.

If it is required to strip a pipe, it shall be carried out in accordance with the APS.

For pipes manufactured from solid CRA, all tools used to strip the coating and remove residual coating from the pipe surface shall be manufactured from a suitable material such as stainless steel in order to avoid

## 26 MARKING

### 26.1 General

Coated pipes shall be marked in accordance with the requirements of Section 26.2 and with any additional markings specified in the purchase order (see 14.2.1). Additional markings, as desired by the applicator, shall be by agreement.

### 26.2 Required Markings

Marking shall be carried out using a method such as stencil painting and/or printing to ensure legible and indelible identification and shall be in accordance with APS.

The marking shall contain the following data:

- a) **Applicator's name or code;**
- b) **Marking required by the applicable pipe specification or standard;**
- c) **Reference to this document.**
- d) **Coating thickness class;**
- e) **Specified total coating thickness from Section 18.3;**
- f) **Maximum design temperature (for Class C only).**

Example: Applicator – ISO 3183:2012 OD XYZ mm wt XYZ mm L415 – ISO 21809-1:2018 Class B2 –2.5 mm.

## 27 HANDLING AND STORAGE IN THE APPLICATOR'S FACILITIES

### 27.1 Handling

Coated pipes shall be handled in a manner that avoids damage to the pipe, pipe ends and coating. The applicator shall submit details of the handling procedures (see 14.2.1); such procedures shall include loading requirements where the applicator is responsible for loading. Loading shall not involve wire ropes or chains for the coated pipes. Pipes shall only be lifted by means of slings, lifting hooks (padded with soft material) or vacuum lifters with suitable spreader bars. Pipes shall not be lifted in bundles without approval by Company, which if granted, then separate slings or hooks shall be used for each pipe and coated pipes shall be provided with soft padding in between.

Pipes that are damaged during processing shall be repaired in accordance with the requirements of the applicable pipe specification or standard.

Coating that is damaged after the holiday inspection (see Table 18) shall be repaired in accordance with the requirements of Section 25.

All coating materials shall be furnished in unopened, clearly identified containers that include details of the material, batch number and date of manufacturing. Coating materials handling, including storage shall be as recommended by the Manufacturer. Material shall not be used after its expiry date. Contaminated material and material showing any sign of degradation shall not be used. All materials shall be approved by the Company.

The coating Applicator shall receive a copy of the pipes TALLY sheet delivered by the line pipe Manufacturer and shall keep a record of the serial numbers of the delivered pipes. Upon receipt, the pipes shall be inspected for transport damage or other defects. Damaged pipes shall be separately stored and reported to the Contractor/Company. Repairs shall only be carried out after approval by the Company.

Coated pipe, in all stages, shall be handled in a manner that avoids damage to the pipe, pipe ends and coating. Coating Applicator shall submit details of the handling procedures; such procedures shall include loading requirements where the applicator is responsible for loading. Coated pipes shall have full encirclement separators around each length. Such separators shall be sized and located in order to prevent damage to the coating.

## 27.2 Storage

The Contractor/applicator shall submit storage and coating preservation details (see 14.2.1) and shall specify in the APS details of the facilities and the methods being used for yard storage. Suitability of maximum stacking height shall be demonstrated by means of proper engineering calculations. Pipe supports shall be spaced so that no bending of pipes occurs. Pipe supports shall be made of soft padded wooden bolsters or sand rows, free of stones, covered with plastic sheets. The pipe surface shall be at least 150mm clear from the soil.

Piles of pipe shall be secured by wooden wedges or ground pins, provided with adequate padding to prevent coating damage, and of sufficient size to prevent collapse of the piles. It is required to have at least four separators (shall be properly calculated by Contractor and approved by Company) for every 12m pipe.

End caps shall remain fixed to all pipe ends at the storage yard for both bare and coated pipes.

Coated pipes shall be protected in all stages from mechanical damage and UV exposure. Contractor shall provide, for Company approval, a handling, transportation and storage procedure including protection of the coated pipes. Coating material manufacturer shall be consulted regarding the proper protection from UV. This extends to after installation of the coated pipeline for the portions that shall be fulltime exposed to UV, whereas Contractor shall provide the proper and durable UV mitigation measures for Company approval.

## 28 TRANSPORT OF COATED PIPES

Coated pipes shall be prepared for transport or shipment in accordance with API RP 5L1 or API RP 5LW, whichever is applicable. During transportation, pipes shall be stacked and secured so as to prevent movement, abrasion and/or peening.

The coated pipes shall be inspected for damages during load-out by using the holiday detection procedure as specified. Coating damage, if not exceeding the requirements of this specification, shall be repaired with no additional cost. Damaged coating that exceeds the allowable limits of this specification at load-out shall be stripped and the pipe shall be recoated with no additional cost.

## 29 TEST REPORTS AND CERTIFICATE OF COMPLIANCE

Unless otherwise specified in the purchase order (see 14.1.1), an Inspection Certificate of type 3.2 in accordance with ISO 10474:2013 (or type 3.2 in accordance with EN 10204:2004) shall be issued by the applicator, which provides the results from the inspection and testing of the coating materials and coated

pipes in accordance with the requirements of this document and any other requirements specified in the purchase order. If, however, in the purchase order, the Company does waive the requirement for an inspection certificate, then the applicator should provide a certificate of compliance.

Contractor shall keep accurate records of all relevant data of the coating process. This documentation shall include:

- a) Copies of the coating system information.
- b) Copies of qualification information.
- c) Copies of, or reference to, all procedures for coating the pipes.
- d) Serial numbers of all pipes as given by the Line Pipe Manufacturer (for example by copies of the pipe mill data sheets).
- e) Serial numbers as given by the coating Applicator (if applicable) related to the Manufacturer's serial numbers.
- f) The order of coating, the day and shift of coating of each pipe.
- g) The batch numbers of the coating materials, the day and time of loading of each batch.
- h) Serial numbers of rejected pipes and the reason for rejection.
- i) Records of any repairs.
- j) The results of all quality control testing.
- k) Records of temperatures during the coating process for each pipe, with the processing time of every tenth pipe, shall be marked on the temperature chart with the pipe number.
- l) Names and signatures of the responsible persons for the coating process and quality control.
- m) The calibration certificates of the testing and inspection instruments.

This document shall be submitted to the Company after completion of the coating works.