



Offshore Design Section
Engineering Services
ISO – 9001:2008

**FUNCTIONAL
SPECIFICATION FOR
3LPP**

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**FUNCTIONAL SPECIFICATION
FOR
3LPP (3 LAYER POLY PROPELENE)
CORROSION COATING FOR LINE PIPES**

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1.0 SCOPE

This specification covers the minimum requirements for supply/arrangement of all materials, plant, equipment, plant sites, consumables, utilities and application including all labour, supervision, inspection and tests etc. for application of external anti-corrosion coating of pipes for sub-sea pipelines by using 3 Layer Polypropylene coating conforming to DIN-30678.

The requirements specified are to apply externally the 3LPP coating system on the pipes to protect its corrosion. The coating system shall be suitable for overcoating with concrete coating and installation using the S-lay method.

2.0 REFERENCE DOCUMENTS

The latest edition (edition enforce at the time of issue of enquiry) of the following standards, codes and specifications shall establish the minimum standards for the work.

Deutsches Institut für Normung (DIN)

DIN 30678 Polypropylene Coatings for Steel Pipes.

DIN EN 10204 Inspection Documents for Metallic Products.

DIN 53735 Testing of Plastics: Determination of Melt Index of Thermoplastics.

Association Francaise de Normalisation (AFNOR)

NF A49-711 Steel Pipes: External coating with three layer polypropylene based coating: application by extrusion

API (American Petroleum Institute)

RP 5L9 External fusion bonded Epoxy Coating of linepipe

International Organisation for Standardisation (ISO)

ISO 2808 Paints and Varnishes – Determination of film thickness

ISO 8501-1 Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

ISO 8502-2 Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 2: Laboratory determination of chloride on cleaned surfaces

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 11124 Preparation of Steel Substrates Before Application of Paints and Related Products

National Association of Corrosion Engineers (NACE)

NACE RP 0185 Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NACE RP 0274 High- Voltage Electrical Inspection of Pipeline Coatings.

NACE RP 0394 Application, Performance and Quality Control of Plant Applied Fusion Bonded Epoxy External Pipeline Coating

NFA 49-711 Steel Tubes- 3Layer External Coating Based on Polypropylene Application by Extrusion

CSA Z245.20-02 External Fusion Bonded Epoxy Coating for Steel Pipe.

Relevant ASTM standards

The CONTRACTOR shall be familiar with the requirements of these reference documents and shall make them available, as required, at the coating plant during the execution.

3.0 GENERAL REQUIREMENTS

3.1 The Contractor shall perform all work in accordance with this specification and other requirements noted.

Contractor shall submit a detailed written description in the form of a manual covering coating equipment, procedure, materials, inspection, tests and repair etc. for Company approval.

3.2 The Contractor shall provide the skilled personnel required for execution of this work. The equipment required shall be in good operating condition. Improvised equipment shall not be acceptable.

3.3 The Contractor shall supply all coating materials required by this specification and shall carry out tests on one sample per batch of supply as described subsequently. The tests shall be carried out by the Contractor at his yard and the results shall be reported to the Company for approval and acceptance.

3.4 The Contractor shall unload the pipes at the coating plant, tally, store and provide security for the pipes during coating and storage. The Contractor shall be responsible for placement of the bare and coated pipes in storage in accordance with the reference specifications.

3.5 All coating and wrapping operations shall be performed under the supervision of and performed by, personnel skilled in the application of the coating system. Inspection of



the coating and wrapping of the pipes shall be performed by qualified inspectors. The qualification of the inspectors shall be verified and approved by the Company's Representative prior to the start of work. Final acceptance of all coating works shall be determined by the Company's Representative.

3.6 The Contractor shall provide access, during all phases of work, to the Company and Company's Representatives/inspectors. Any expense caused by the Company inspector stopping the work because it is not being carried out as per this specification shall be borne by Contractor.

3.7 All tools and equipment furnished by the Contractor shall be of good quality, maintained in good operating condition and suitable for use to apply materials as per this specification. All equipment shall be subject to approval by the Company Representative.

All cleaning, priming and coating machines shall be equipped with rubber or wheels overlaid with hard fiber to prevent marking or denting the pipe.

3.8 The CONTRACTOR shall be responsible for obtaining all statutory approvals / clearances from relevant Authorities including Pollution Control Board, as applicable for the coating plant(s).

4.0 COATING MATERIALS

4.1 The three layer coating system shall comprise of a powder epoxy primer, polymeric adhesive and a polypropylene top coat. Additionally, anti slip polypropylene granule coat shall be applied. Coating materials shall be suitable for the service conditions and the pipe sizes involved. The coating materials i.e. epoxy powder, adhesive and polypropylene compound shall have proven compatibility. The coating system and materials shall be prequalified and approved by COMPANY in accordance with provisions of Annexure-I of this specification. CONTRACTOR shall obtain prior approval from COMPANY for the coating system and coating materials.

4.2 The coating materials Manufacturer shall carry out tests for all properties specified in para 5.2 for each batch of epoxy, adhesive and polypropylene compound. In addition, the Manufacturer shall also furnish Infra-red scan for each batch of epoxy powder. The coating materials Manufacturer shall issue test certificates as per the relevant standards/ methods specified in para 5.2, for each batch of materials supplied to Contractor and the same shall be submitted to Company for approval prior to their use.



4.3 In addition to Manufacturer's certificate, the CONTRACTOR shall draw samples from each batch of epoxy, adhesive and polypropylene in the presence of COMPANY REPRESENTATIVE and test for the following properties at the coating yard at least one week prior to its use, to establish compliance with the Manufacturer's test certificates.

a) **FBE Powder**

- Gel time
- Sieve analysis
- Adhesion
- Density
- Moisture content
- Thermal analysis

b) **Adhesive**

- Melt flow index
- Vicat Softening Point
- Adhesion to FBE and polypropylene layers at 25°C, 60°C, 110°C and 120°C
- Density

c) **Polypropylene Material**

- Density
- Melt flow index
- Moisture Content
- Oxidative Induction Time
- Shore hardness
- Vicat softening point

The polypropylene shall be chemically modified for use at operating temperatures of up to 120°C on external surface of sub-sea pipeline section and shall contain additives as required to provide UV protection and shall be suitable for 3-layer polypropylene coating system.

4.4 In case of failure of any of the above tests in a batch, that batch of material shall be tested for all other tests required as per para 5.2.1 to 5.2.3 including the tests which failed. If all tests pass, the batch shall be accepted for coating. If any of the tests fail, entire batch of material shall be rejected and shall not be used for the coating.

4.5 All packages of powder shall be marked with the following data as a minimum.

- Manufacturer



- Material identification
- Batch number
- Place & Date of manufacture
- Shelf Life/ Expiration date (if applicable)
- Quantity
- Safety instructions
- Storage instructions (storage shall normally be at a temperature not greater than 25°C).

All materials without above identification shall be rejected by Company. Such materials shall not be used for coating and shall be removed from site.

4.6 Contractor shall ensure that all coating materials are properly stored in accordance with the Manufacturer's recommendation at all times, to prevent damage and deterioration in quality prior to use.

4.7 Contractor shall be required to use all materials on a date received rotation basis, i.e. first in-first used basis.

5.0 FUNCTIONAL REQUIREMENTS AND PROPERTIES OF COATING SYSTEM

5.1 The coating shall be able to withstand the maximum in service operating temperature of 120°C for sub-sea pipeline system.

5.2 Properties

Properties of coating system and coating material shall comply the requirements indicated in subsequent paragraphs. In case, the coating/ material properties are tested as per test methods/ standards other than specified herein below, the same may be accepted provided the test procedures and test conditions are same or more stringent than the specified.

5.2.1 Properties of FBE Powder

Contractor shall select epoxy powder that will achieve the functional requirements and properties of coating system as specified in para 5.1 and 5.2.4 of this specification respectively.

Typical Properties of FBE Powder shall be as follows:

| Sl. No. | Properties | Requirement | Applied Standard |
|---------|------------------------|----------------------------|------------------|
| 1. | Specific Gravity | As defined by Manufacturer | ISO 2811-1 |
| 2. | Moisture content | 0.50% Max | API RP 5L9 |
| 3. | Total Volatile content | 0.60% Max | API RP 5L9 |
| 4. | Particle size | 0.2% Max Retained on 60 | API RP 5L9 |



| | | | |
|-----|----------------------------------|--|-------------------------------|
| | | Mesh(250 Microns) | |
| 5. | Cure Cycle | Capable of Cure at temperature below 260 °C | API RP 5L9 |
| 6. | Glass Transition Temperature | Tg1 40-75 °C Tg2 >120 °C | NACE RP 0394 |
| 7. | Wet Glass Transition Temperature | Tg2 ≥120 °C | Manufacturer's Test Procedure |
| 8. | Heat of Reaction | As defined by Manufacturer | NACE RP 0394 |
| 9. | Gel Time | As defined by Manufacturer | NACE RP 0394 |
| 10. | Hardness Shore D | 80-90 | ASTM D 2240 |
| 11. | Flexibility | Flexibility > (3 %PD) at 0°C PD: Pipe Dia. | API RP 5L9 |
| 12. | Impact Resistance | 2.0 Joule | API RP 5L9 |
| 13. | Abrasion Resistance | 300 mg Max (note-1) | API RP 5L9 |
| 14. | Cathodic Disbondment | = 5 mm at 23 °C/28 days or = 7 mm at 95 °C/ 48 hour | AFNOR A49-711 |
| 15. | Dielectric Strength | Strength > 500 Volt / mil mil = 25 microns | ASTM D 149 |
| 16. | Hot Water Soak Test | 30% max. of coating can be removed as per rating 2 of standard | API RP 5L9 |

Note-1: Abrasive resistance is equal 300 mg max. by C.S 17 abrasive wheel /1000 gram / 1000

5.2.2 Properties of Adhesive

Contractor shall select adhesive that will achieve the functional requirements and properties of coating system as specified in para 5.1 and 5.2.4 of this specification respectively.

| Sl. No. | Properties | Requirement | Applied Standard |
|---------|--------------------------------------|------------------------------|------------------|
| | Physical | | |
| 1. | Specific Gravity | 0.89 – 9.2 | ASTM D 1505 |
| 2. | Melt flow rate (MFR) 230 °C/ 2.16 kg | 0.75 – 1.2 g/10 min | ISO 1133 |
| 3. | Water Content | Equal or less than 0.1% | ISO 15512 |
| | Mechanical | | |
| 4. | Tensile Yield Strength | Equal or Greater than 20 Mpa | ASTM D 638 |
| 5. | Tensile Elongation | Equal or Greater than 350 | ASTM D 638 |
| 6. | Hardness Shore D | Equal or Greater than 57 | ASTM D 2240 |



| | | | |
|----|--|------------------------------|-------------|
| 7. | Brittle Point | -20 °C | ASTM D 746 |
| | Impact | | |
| 8. | Notched izod impact strength at +23 °C | +45 KJ/ m | ISO 180 |
| | Thermal | | |
| 9. | Vicat softening temperature | Equal or Greater than 130 °C | ASTM D 1525 |

5.2.3 Properties of Polypropylene Compound

The polypropylene compound shall be UV and thermal stabilized co-polymer, designed for extrusion and suitable for continuous service at operating temperatures of up to 120 °C for sub-sea/ onshore buried pipeline application.

Typical Properties of Polypropylene coating (Top Coat) shall be as follows:

| Sl. No. | Properties | Requirement | Applied Standard |
|---------|--|----------------|------------------|
| | Physical | | |
| 1. | Specific Gravity | 0.89 | ASTM D 1505 |
| 2. | Water Absorption | Min. 0.02% wgt | ASTM 570 |
| 3. | Water Content | < 0.05 % | ISO 15512 |
| | Mechanical | | |
| 4. | Tensile Yield Strength | 20 Mpa | ASTM D 638 |
| 5. | Tensile Elongation | 400 % | ASTM D 638 |
| 6. | Hardness Shore D | 60 | ASTM D 2240 |
| | Impact | | |
| 7. | Notched izod impact strength at +23 °C | 50 KJ / m | ISO 180/1A |
| | Thermal | | |
| 8. | Vicat softening temperature | > 130 °C | ASTM D 1525 |

5.2.4 Properties of Coating System

| Sl. No. | Properties | Requirement | Applied Standard |
|---------|----------------|---------------------------------|------------------|
| 1. | Appearance and | Uniform colour, free of defects | AFNOR A49-711 |



| | | | |
|-----|--|--|---------------|
| | continuity | and discontinuities, delamination, separations and pinholes | |
| 2. | Impact Strength | No failure after 30 impacts, when tested with 25KV | DIN 30678 |
| 3. | Indentation (mm) at 90 ±5°C | 0.3 mm | DIN 30678 |
| 4. | Elongation at break of the PP | 400 % | ASTM D 638 |
| 5. | UV aging (Elongation break) | 260 % | AFNOR A49-711 |
| 6. | Bond Strength | 100 N/cm at 50±5°C (at peel off rate 10mm/min) 80 N/cm at 50±5°C (at peel off rate 10mm/min) | DIN 30678 |
| 7. | Hot water soak test for FBE cure | No loss of adhesion | API RP 5L9 |
| 8. | Degree of cure of the epoxy (1st layer) | Temp. variation (Max. ΔTg):- 2°C to +3°C) | AFNOR A49-711 |
| 9. | Porosity of FBE (cross sectional & Interface) | Rating 1 | NACE RP 0394 |
| 10. | Interface contamination of FBE | Maximum 20% | NACE RP 0394 |
| 11. | Shore D Hardness | 57 | ASTM 2240 |
| 12. | Product stability during extrusion of the PP top layer process | ≤35 % (virgin compound granulate before extrusion/extruded foil after extrusion of the same batch) | ISO 1133 |
| 13. | Average cathodic disbanding length | ≤ 5 mm at 23°C/28 days or ≤ 7 mm at 95°C/48 hours | AFNOR A49-711 |

6.0 MEASUREMENT AND LOGGING

CONTRACTOR shall maintain records in computer using MS ACCESS database Software containing all the relevant data of individual pipe and pipe coating including pipe number, heat number, diameter, length, wall thickness, defects, coating number, batches of materials, sampling, testing, damages, repairs, rejects and any other information that COMPANY considers to be relevant and required for all incoming bare pipes and COMPANY approved outgoing coated pipes as applicable. CONTRACTOR's documentation shall be designed to ensure full traceability of pipe and coating materials through all stages of coating and testing. CONTRACTOR shall submit this information in



the form of a report at the agreed intervals. The above data shall also be provided in MS ACCESS format in Compact Disc (CD). CONTRACTOR shall provide one Computer Terminal to COMPANY Representative for monitoring/tracking of the above. The CONTRACTOR shall also submit the material balance details to COMPANY for information at the end of each shift.

7.0 COATING PROCEDURE AND QUALIFICATION

7.1 Upon award of the CONTRACT, the CONTRACTOR shall submit within two (2) weeks, for COMPANY approval, a detailed report in the form of bound manual outlining, but not limited to, the following:

- a. Details of plant(s), location(s), layout, capacity and production rate(s).
- b. Details of the equipment available to carry out the coating works including surface preparation, epoxy powder application and its recycling system, adhesive & polypropylene extrusion, moisture control facilities available for coating materials.
- c. Details of process control and inspection equipment required for the coating process such as temperature control, thickness control, holiday testers, etc.
- d. Facilities in the yard for unloading, handling, transport, production, storage, stockpiling, loading of bare and coated pipes and warehouses for storage of other coating materials.
- e. Plant Organisation Chart and availability of manpower including coating specialist
- f. Details of utilities/facilities such as water, power, fuel, access roads and communication etc.

After COMPANY has given approval, no change in plant set-up shall be made. However, unavoidable changes shall be executed only after obtaining written approval from COMPANY.

7.2 At least four (4) weeks prior to the commencement of production coating, a detailed procedure of the CONTRACTOR's methods, material proposed, etc., shall be formulated by the CONTRACTOR and submitted for COMPANY approval in the form of a bound manual. The procedure shall include, but not limited to, the following information and proposals:

- a. Pipe inspection at the time of bare pipe receipt.
- b. Steel surface preparation, including preheating, removal of steel defects, method of pipe cleaning, dust removal, abrasive blast cleaning and surface profile; methods of measurements and consumables.



- c. Pipe heating, temperatures and control prior to epoxy application.
- d. Complete details of raw materials including current data sheets showing values for all the properties specified together with quality control and application procedure recommendations from manufacturer(s).
- e. Application of FBE powder, adhesive and polypropylene, including characteristics, temperature, line speed, application window, curing time, etc.
- f. Quenching and cooling, including time and temperature.
- g. Quality Assurance System, Quality Plan, Inspection and Test Plan and reporting formats, including instrument and equipment types, makes and uses, etc.
- h. Detailed method of repair of coating defects duly classified depending upon nature and magnitude of defects and repair thereof including coating stripping technique
- i. Details of instrument and equipment calibration methods including relevant standards and examples of calibration certificates.
- j. Complete details and inventory of laboratory and equipment for procedure qualification and regular production
- k. Pipe handling and stock piling procedures
- l. Sample of recording and reporting formats, including laboratory reports, certificates and requirement as per clause 6.0 of this specification.
- m. Complete details of test certificates for raw materials including test methods and standards used.
- n. Test certificates from PP compound manufacturer for tests for thermal aging, coating resistivity and aging under exposure to light. These test certificates shall not be older than three years.
- o. Health, Safety and Environment Plans.
- p. Storage details of coating materials and chemicals.
- q. Continuous temperature monitoring at various stages of coating

Procedure Qualification Tests (PQT) shall be carried out only after obtaining written approval of the above procedure from COMPANY. No change in the procedure shall be made after the COMPANY has given approval. However, unavoidable changes shall be executed only after obtaining written approval from COMPANY.

- 7.3 Prior to start of production, the CONTRACTOR shall, at his expense, carry out a coating PQT for each pipe diameter on max. wall thickness, for each type of pipe, for each coating material combination, and for each plant, to prove that his plant, materials, and



coating procedures result in a quality of end product conforming to the properties stated in clause 5.2, relevant standards, specifications and material manufacturer's recommendations.

CONTRACTOR shall give seven (7) working days' notice to witness all procedures and tests.

A batch representing a normal production run, typically 15 pipes, shall be coated in accordance with the approved coating procedure and the coating operations witnessed by COMPANY Representative. Out of these pipes, at least one pipe shall be coated partly with epoxy and partly with both epoxy and adhesive layers.

At least 5 (five) test pipes shall be selected by COMPANY Representative for coating procedure approval tests and shall be subjected to procedure qualification testing as described hereinafter. COMPANY Representative shall witness all tests. Out of 5 (five) test pipes, 1 (one) pipe partly coated with epoxy and partly coated with both epoxy and adhesive layers shall be included. Remaining 4 (four) test pipes shall have all three layers.

During PQT, the CONTRACTOR shall qualify various procedures forming a part of coating operations as detailed subsequently. pipe partly coated with epoxy and partly coated with both epoxy and adhesive layers and the pipes coated with all three layers shall be subjected to complete set of tests as detailed in para 7.5 and specified in Appendix-1.

Pipes selected for PQT shall pass all the criteria contained in Appendix-1 before production commences.

7.4 **Qualification of Procedures**

7.4.1 **Epoxy Powder Application & Recycling**

During pre-qualification, air pressure in the epoxy spray guns, satisfactory functioning of monitoring system, line speed vs coating thickness, etc. shall be established. Dew point of air used to supply the fluidised bed, and epoxy spray system shall be recorded during the PQT. No epoxy recycling is permitted.

7.4.2 **Pipe Pre-heating**

The CONTRACTOR shall establish the temperature variation due to in-coming pipe temperature, line speed variation, wall thickness variation, emissivity, interruptions, etc. and document the same during the PQT stage. During PQT, proper functioning of pipe



temperature monitoring and recording system including alarm/hooter shall be demonstrated to the COMPANY Representative.

7.4.3 **Surface Preparation**

The procedure to clean and prepare the pipe surface shall be in accordance with the requirements of para 8.0 of this specification. The ratio of shot to grit shall be established during procedure qualification testing, such that the resultant surface profile is not dished and rounded. The qualification shall be performed through a visual inspection, measurement of roughness and check of the presence of dust on the abrasive blast cleaned pipe surface.

7.4.4 **Coating Application**

The COMPANY Representative will check the correctness of each coating application operation, values of the main parameters of each operation, pre-heating pipe surface temperature prior to epoxy powder application temperature, line speed, fusion bonded epoxy curing time, temperature and flow rate of co-polymer adhesive and polypropylene, etc. and the same shall be recorded. These values shall be complied with during regular production.

7.5 **Qualification of Applied Coating**

7.5.1 **Tests on pipe coated partly with epoxy and partly with epoxy & adhesive layers**

a. **Degree of Cure**

Epoxy film samples (minimum 4 no.) shall be scrapped from the coated pipe and the samples shall be taken for cure test using Differential Scanning Calorimetry (DSC) procedure. Care shall be taken to remove the samples of full film thickness avoiding inclusion of steel debris. Glass transition temperature differential (ΔT_g) and % cure (ΔH) shall comply with the specified requirements.

b. **Epoxy Layer Thickness**

Epoxy layer thickness shall be checked at every one metre spacing at 3, 6, 9 and 12 o'clock positions. The thickness shall comply with the specified thickness requirements.

c. **Adhesive layer Thickness**

Adhesive layer thickness shall be checked at every one metre spacing at 3, 6, 9 and 12'o clock positions. The thickness shall comply with the specified thickness requirements.

d. **Holiday Inspection**



Entire pipe shall be subject to holiday inspection and the test voltage shall be set @5 v/micron (minimum) of epoxy thickness specified for the portion coated only with epoxy layer.

e. Adhesion Test

- i. Adhesion Test (24 hrs or 48 hrs) shall be carried out on the epoxy coated pipe. Test method, no. of test specimen and acceptance criteria shall comply DIN 30678.
- ii Adhesion of FBE shall also be separately determined at ambient temperature at two locations by the “St Andrews Cross” method and the test shall comply with the specified requirements.

f. 2.5° Flexibility Test

2.5° Flexibility test shall be carried out on the epoxy coated pipe at test temperature of 0°C. Test method, no. of test specimen and acceptance criteria shall comply API RP 5L9.

g. Cross-section & Interface Porosity Test

Cross section porosity and interface porosity tests shall be carried out on the epoxy coated pipe. Test method, no. of test specimen and acceptance criteria shall comply NACE RP 0394.

7.5.2 Tests on pipes coated with all three layers

a. Bond Strength:

Three test pipes shall be selected for bond strength tests. On each of the selected pipes, three bond strength test shall be performed for each specified temperature i.e. one at each end and one in the middle of the pipe and specified requirements shall be complied with, i.e. bond strength as well as mode of separation. Length of peel shall be minimum 65 mm. None of these samples shall fail.

b. Impact Strength:

Three test pipes shall be selected for impact strength test and the test shall meet the specified requirements.

c. Indentation Hardness:

Two samples for both temperatures from all pipes shall be taken. If any one of these samples fail to satisfy the specified requirements, then the test shall be repeated on four more samples. In this case, none of the samples shall fail.

d. Elongation at failure:



Six samples each from three coated pipes i.e. 18 samples in all shall be tested and the test shall comply the specified requirement. Only one sample per pipe may fail.

e. Cathodic Disbondment Test:

Three CD tests shall be carried out for the total lot of test pipes having all three layers. One test shall be carried out for 30 days duration and two tests for 48 hours duration at 65°C & 95°C respectively. The tests shall comply the specified requirement. Whenever Procedure Qualification is necessitated for different pipe size with same coating material combination, 48 hours test only be conducted. 30 days CD test is not mandatory in this case.

f. Holiday Inspection

All the pipes shall be subject to holiday inspection. The test voltage shall be as specified in para 10.5.2.

g. Coating Thickness Measurement

All pipes shall be subject to coating thickness measurements. Acceptance criteria shall be as per para 10.4.3.

h. Air Entrapment

One sample each from pipe body and on weld (if applicable) shall be taken from all four coated pipes and the specified requirements shall be complied with.

i. Degree of Cure

Epoxy film samples (minimum 4 no., equally spaced) shall be scrapped from one coated pipe and the samples shall be taken for cure test using Differential Scanning Calorimetry (DSC) procedure. Silicon coated sulphite paper shall be placed between the epoxy layer and adhesive layer immediately after epoxy application, to ensure physical separation of epoxy & adhesive as well as to prevent contamination of epoxy with adhesive layer, at a location from where the epoxy samples are to be removed for the test. Care shall be taken to remove the samples of full film thickness avoiding inclusion of steel debris. Glass transition temperature differential (ΔT_g) and % cure (ΔH) shall comply with the specified requirements.

7.5.3 Inspection of all test pipes

All pipes shall be subject to the following inspections:

- a. surface cleanliness, surface roughness measurements and dust control immediately after second abrasive blast cleaning and salt test.



b. visual inspection of finished coating, cut back dimension, internal/external cleanliness, end sealing and bevel inspection.

Acceptance criteria for all inspection and testing shall be as specified in this specification.

7.6 After completion of the qualification tests and inspection as per para 7.4 and 7.5 above, the CONTRACTOR shall prepare and issue to COMPANY for approval a detailed report of the above tests and inspection including test reports/certificates of all materials and coatings tested. Only upon written approval from COMPANY, CONTRACTOR shall commence production coating.

7.7 On successful completion of PQT, coating of all five (5) test pipes shall be removed and completely recycled as per the approved coating procedure specification, at CONTRACTOR's expense. Remaining pipes will be accepted by COMPANY provided they meet the requirements of this specification and need not be stripped and re-cycled.

7.8 The CONTRACTOR shall re-establish the requirements of qualification and in a manner as stated before or to the extent considered necessary by COMPANY, in the event of, but not limited to, the following:

- Every time there is a change in the previously qualified procedure.
- Every time there is a change in the manufacturer and change in formulation of any of the raw materials and change in location of raw material manufacture.
- Every time the coating yard is shifted from one location to the other or every time the critical coating equipments (induction heater, epoxy spray system, extruder, etc) are shifted.
- Any change in line speed during coating application
- Any time when in COMPANY's opinion the properties are deemed to be suspect during regular production tests.

7.9 COMPANY reserves the right to conduct any or all the test required for qualification through an independent laboratory or agency at the cost of CONTRACTOR when in COMPANY's opinion, the results are deemed suspect. COMPANY's decision shall be final.

8.0 PIPE SURFACE PREPARATION

8.1 Unless specified otherwise, the pipes shall be supplied free from mill applied oils but may be subject to contamination occurring during transit.



- 8.2 Prior to cleaning operation, CONTRACTOR shall visually examine the pipes and shall ensure that all defects, flats and other damages have been repaired or removed. The CONTRACTOR shall also remove marking stickers, if any, present within the pipe. Record shall be kept of such marking on the stickers to ensure traceability of pipe after coating.
- 8.3 Any oil, grease, salt or other contaminants detrimental to the formation of a good coating bond or coating quality shall be removed prior to coating application. Contaminants may be removed by the use of non-oily solvents. Gasoline or kerosene shall not be used for this purpose. Visible oil and grease spots shall be removed by solvent wiping. Solvent cleaning shall be in accordance with SSPC-SP1. Steel surface shall be allowed to dry before abrasive cleaning.
- 8.4 All pipes shall be preheated to a temperature of 65°C to 85°C prior to abrasive blast cleaning. The external surface of the pipe shall be cleaned using 2 no. dry abrasive blast cleaning units to achieve the specified surface cleanliness and profile. After first abrasive blast cleaning, chemical pre-treatment with phosphoric acid solution as per para 8.6 shall be carried out prior to second abrasive blast cleaning. However at the option of CONTRACTOR, chemical pre-treatment with phosphoric acid solution as per para 8.6 may be carried out after the second abrasive blaster.
- The abrasive blast cleaning units shall have an effective dust collection system to ensure total removal of dust generated during blast cleaning from the pipe surface. The equipment used for abrasive blast cleaning shall meet the specified requirements and shall be free from oil, water soluble salts and other forms of contamination to ensure that the cleaning process is not impaired. Traps, separators and filters shall be checked for condensed water and oil at the start of each shift and emptied and cleaned regularly. During abrasive blast cleaning, the metallic abrasive shall be continuously sieved to remove “fines” and “contaminants” and the quality checked at every four hours. Abrasives used for blast cleaning shall comply ISO-11124.
- 8.5 Suitable plugs shall be provided at both pipe ends to prevent entry of any shot/grit into the pipe during blast cleaning operations. These plugs shall be removed after blast cleaning. Alternatively the CONTRACTOR may link the pipes suitably together to prevent the entry of any short/grit into the pipe.
- 8.6 Chemical Pre-treatment with Phosphoric Acid Solution.



- 8.6.1 All pipes shall be provided chemical pre-treatment with phosphoric acid solution. 10% solution of phosphoric acid, Oakite 31 / 33 or equivalent, shall be used to remove all soluble salts and other soluble contaminants.

The CONTRACTOR shall provide data sheets and supporting documentation for the phosphoric acid to be used. The documentation shall verify that the phosphoric acid is suitable for the treatment of line pipe prior to the application of the specific fusion bonded epoxy powder being applied and the final coating will meet fully the requirements of this specification.

- 8.6.2 The pipe temperature immediately prior to the phosphoric acid treatment shall be in the range of 45 to 75 °C. Phosphoric acid treatment shall be followed immediately by washing with de-ionised water. Deionised water used shall conform to the following requirements:

| Sl. No. | Properties | Unit | Requirement |
|---------|---------------------------------------|---------|-------------|
| 1. | Turbidity | NTU | 1 max. |
| 2. | Conductivity | µmho/cm | 5 max. |
| 3. | Hardness | - | NIL |
| 4. | Total Alkalinity as CaCO ₃ | mg/l | 2 to 3 |
| 5. | Chloride as Cl ⁻ | mg/l | 1 max. |
| 6. | Sulphate as SO ₄ | mg/l | 1 max. |
| 7. | PH | - | 6.5 to 7.5 |

Tests to determine the above properties shall be carried out in accordance with “Standard Methods for the Examination of Water and Wastewater” published jointly by American Public Health Association, American Water Works Association and Water Pollution Control Federation.

Quality of the deionised water shall be monitored at the start of each shift and at every four hours interval. Non-compliance of deionised water wrt the above requirements shall cause for stoppage of the operations.

- 8.6.3 The pH of the pipe surface shall be determined both before and after the de-ionised water rinse initially on each pipe and in case of consistent results, the frequency may be



relaxed to once per hour at the discretion of COMPANY Representative. The measured pH shall be as follows :

Before de-ionised water wash: 1 to 2

After de-ionised water wash: 6 to 7

8.6.4 After the deionised water wash, the pipe shall be dried with dry air and preheated to a temperature of 65°C to 85°C.

8.6.5 The salt tests shall be carried out after deionised water rinse. One test shall be carried out at one end of each pipe. The acceptance criteria shall be 2µg/cm². An approved salt meter (SCM 400 or equivalent) shall be used to carry out salt tests and shall be calibrated in accordance with the equipment manufacturer's recommendations.

8.7 Abrasive cleaning carried out shall be such that the resultant surface profile is not dished and rounded when viewed with 30X magnification. The standard of finish for cleaned pipe shall conform to near white metal finish to Sa 2 ½ of Swedish Standard SIS 055900 latest edition. Surface of pipe after abrasive blast cleaning shall have an anchor pattern of 50 to 70 microns(RZ). This shall be measured for each pipe by a suitable instrument such as surface profile depth gauge. In addition the pipe surface after blast cleaning shall be checked for the degree of cleanliness (Sa 2½), degree of dust and shape of profile. Degree of dust shall comply the requirements of ISO 8502 – 3. Acceptance limit shall be either quality rating 2 or Class 2.

8.8 All pipes shall be visually examined for presence of any shot/grit/loose material left inside the pipe during blast cleaning. Suitable mechanical means (stiff brush) shall be employed to remove the same before the pipes are processed further. In addition, inside surface of the pipe shall also be visually inspected for presence of any foreign material or shots and grit (free or embedded/sticking to pipe inside surface). The pipe inside surface shall be examined using sharp floodlight focused at the middle of the pipe at one end while inspection is carried out visually from other end. Any foreign material or shots/grit present in the pipe shall be completely removed by mechanical brush, high pressure air jets, by tilting of pipe, etc.

8.9 At no time shall the blast cleaning be performed when the relative humidity exceeds 85%. The CONTRACTOR shall measure the ambient conditions at regular intervals during blast cleaning and coating operations and keep records of prevailing temperature, humidity and dew point.



- 8.10 The blast cleaned surface shall not be contaminated with dirt, dust, metal particles, oil, water or any other foreign material, nor shall the surface or its anchor pattern be scarred or burnished. All blast cleaned pipe surface shall be kept in dust free enclosure prior to coating. After blast cleaning, all surfaces shall be thoroughly inspected under adequate lighting to determine anchor pattern, quality of blasting and identify any surface defects prior to coating application. All surface defects such as slivers, scab, burns, laminations, welds spatters, gouges, scores, indentations, slugs or any other defects considered injurious to the coating integrity made visible during blast cleaning shall be reported to the COMPANY Representative and on permission from COMPANY Representative, such defects shall be removed by filing or grinding. After any grinding or mechanical repairs, the remaining wall thickness shall be checked and compared with specified thickness. Any pipes having thickness less than 95% of specified thickness shall be kept aside and disposed off as per the instructions of COMPANY Representative. The method employed to remove surface defects shall not burnish or destroy the anchor pattern or contaminate the surface. Pneumatic tools shall not be used unless they are fitted with effective air/oil and water traps. Where burnishing results in destruction of anchor pattern, the anchor pattern shall be restored by suitable means. Pipes which have damages repaired by grinding and have ground areas more than 50mm in diameter shall be re-blasted. Any dust or loose residues that have been accumulated during blasting and/or during filing/grinding operations shall be removed by vacuum cleaning.

If contamination of surface occurs, the quality of blast cleaning method and process shall be examined. If the surface roughness is outside the specified limit, the blast cleaning material shall be checked and replaced.

- 8.11 Upon Completion of the blasting operations, the quality control supervisor shall accept the pipe for further processing or return for re-blasting after removal of defects/imperfections. In case imperfections are considered detrimental to the coating quality, the same shall be reported to COMPANY's Representative for final decision on rejection or re-blasting / removal of defects. Re-blasting / removal of defects or returning pipe to the yard shall be at the CONTRACTOR's cost.

COMPANY's Representative, in additions, reserves the right to initiate any of the above actions during periodic inspections for oil, dust, salt, imperfections, surface defects, lack of white metal finish, etc.



- 8.12 In order to ensure that pipe with defects are not processed further, provisions shall be available to lift the pipes from inspection stand.
- 8.13 Chemical Pre-treatment with Chromate Solution
- 8.13.1 Following completion of abrasive blast cleaning, all pipe surface shall be chemically pretreated with a 10% strength chromate solution.
- 8.13.2 The CONTRACTOR shall provide data sheets and supporting documentation for the chemical to be used. The documentation shall verify that the chemical is suitable for the treatment of line pipe prior to the application of the specific fusion bonded epoxy powder being applied and the final coating will meet fully the requirements of this specification.
- 8.13.3 The chemical pre-treatment shall be applied fully in accordance with the chemical suppliers' instructions and in a manner that ensures 100% uniform coverage of the pipe surface without introducing surface contamination.
- 8.13.4 The CONTRACTOR shall check that the concentration of the chemical pre-treatment solution remains within the range recommended by the chemical manufacturer for the pipe coating process. The concentration shall be checked at the make up of each fresh solution and once per hour, using a method approved by the chemical manufacturer. The CONTRACTOR shall also ensure that the chemical pre-treatment solution remains free from contamination at all times. Recycling of chemical pre-treatment solution is not permitted.
- 8.13.5 The CONTRACTOR shall ensure that the temperature of the substrate is maintained between 40°C and 80°C and the chromate solution temperature does not exceed 60° or as recommended by the manufacturer.
- 8.13.6 The chromate coating shall be smooth, even, free from runs, drips or excessive application and lightly adherent with no flaking of the coating. The chromate coated steel must be thoroughly dried immediately after application and shall be achieved by boiling off any residual solution on the surface.
- 8.14 The total allowable elapsed time between completion of the blasting operations and commencement of the pre-coating and heating operations shall be such that no detectable oxidation of the surface occurs. Relative humidity readings shall be recorded every half an hour during the blasting operations in the immediate vicinity of the operations. The maximum elapsed time shall not exceed the duration given below:

| Relative Humidity % | Maximum elapsed time |
|---------------------|----------------------|
| > 80 | 2 hours |
| 70 to 80 | 3 hours |



< 70

4 hours

Any pipe not processed within the above time-humidity requirement shall be completely reblasted. Any pipe showing flash rusting shall be re-blasted even if the above conditions have not been exceeded.

- 8.15 Pipe handling between abrasive blasting and pipe coating shall not damage the surface profile achieved during blasting. Any pipe affected by the damage to the surface exceeding 200mm² in area and/or having contamination of steel surface shall be rejected and sent for re-blasting.

9.0 COATING APPLICATION

The external surface of the cleaned pipe conforming to clause 8.0 of this specification shall be immediately coated with 3-layer polypropylene coating in accordance with the procedures approved by COMPANY, relevant standards and this specification. In general the procedure shall be as follows:

9.1 Pipe Heating

- 9.1.1 Immediately prior to heating of pipe, all dust and grit shall be removed from inside of the pipe by a combination of air blast, brushing and vacuum cleaning. Suitable arrangement shall be made to protect the bevel ends from getting damaged during the coating operation.
- 9.1.2 Induction heater or gas fired heating shall be used for heating the pipe. The method shall be capable of maintaining uniform temperature along the total length of the pipe, and shall be such that it shall not contaminate the surface to be coated. In case of induction heating, appropriate frequency shall be used to ensure 'deep heating' and intense skin heating is avoided. Gas fired heating system shall be well adjusted so that no combustion products are deposited on the steel surface. This shall be demonstrated on bare pipes prior to start of PQT. Oxidation of the cleaned pipe surfaces prior to coating (in the form of blueing or other apparent oxide formation) is not acceptable.
- 9.1.3 The pipe shall be uniformly preheated to a temperature of 220°C to 235°C (425 to 450°F) as per MANUFACTURER's recommendation. The pipe metal temperature shall not exceed 275°C (575°F).
- 9.1.4 Temperature of the pipe surface shall be continuously monitored & recorded by using suitable instruments such as infrared sensors, contact thermometers, thermocouples etc. The recording method shall allow to correlate each linepipe. The monitoring instrument shall be able to raise an alarm / activate audio system (hooter) in the event of tripping of induction heater / gas fired heater or in the event of pipe temperature being



outside the range recommended by the manufacturer. Any deviation from the application temperature range recommended by manufacturer shall be rectified. If immediate rectification is not feasible, the production shall be stopped until cause of deviation has been removed. Any pipe coated during the duration of temperature deviation shall be identified by marking and rejected. Such rejected pipes shall be stripped, re-cleaned and recoated.

9.1.5 Temperature measuring & monitoring equipment shall be calibrated twice every shift and/or as per COMPANY Representative's instruction.

9.1.6 CONTRACTOR shall ensure that pipe surface emissivity variations are minimised during pipe heating. To avoid significant variance, more than once blasted pipes should be coated at the same time and not mixed with pipes blasted only once.

9.2 FBE Layer Coating

9.2.1 Thickness of FBE layer shall be between 350 and 450 microns.

9.2.2 Oxidation of the steel prior to coating in the form of 'blueing' or other apparent oxide formation is not acceptable. If such oxidation occurs, the pipe shall be set aside and recleaned.

9.2.3 Prior to starting the fusion bonded epoxy powder application, the recovery systems shall be thoroughly cleaned to remove any unused powder.

9.2.4 The use of recycled powder shall not be permitted.

9.2.5 Epoxy powder is sprayed using electrostatic spray guns. Pipe must be well grounded during the entire process of coating application. Proper charge on the powder must be maintained. Guns should be positioned to make optimum use of electrostatic properties and to minimize overspray.

9.3 Adhesive Layer Coating

9.3.1 Thickness of adhesive shall be between 250 and 350 microns.

The CONTRACTOR shall ensure that the rollers push adhesive film to eliminate any air entrapment or voids. The adhesive layer shall be applied before gel time of the FBE has expired by using either the cross-head or lateral extrusion technique. Application of the adhesive shall not be permitted after the FBE has fully cured. The CONTRACTOR shall establish to the satisfaction of COMPANY's representative that the adhesive is applied within the gel time window of the FBE and at the temperature recommended by the adhesive MANUFACTURER. The CONTRACTOR shall state the proposed minimum



and maximum time interval between FBE and adhesive applications at the pipe temperature range and overlap.

9.3 Polypropylene Layer Coating

- 9.3.1 The number of wrap and overlapping shall be such that they polypropylene thickness achieved meets the overall specified thickness requirement.
- 9.3.2 Polypropylene may be applied by either the cross-head or lateral extrusion technique. The polypropylene shall be applied over the adhesive within the time limits established during pre-production testing.
- 9.3.3 As the concrete weight coating will be applied on the three layer polypropylene system, the coating surface shall be worked in a way to improve friction coefficient and enhance the bonding of concrete to the extruded polypropylene surface. Granules of polypropylene shall be spray applied to the hot extruded polypropylene surface before quenching. Such granules shall not be totally melted to provide a rough surface.
- 9.3.4 The coating shall be cooled to below 80°C before handling.
- 9.3.5 Coating and/or adhesive shall terminate 120 mm (+) 20 / (-) 0 mm from pipe ends. The adhesive shall seal the end of applied coating. CONTRACTOR shall adopt mechanical brushing for termination of the coating at pipe ends. Edge of the coating shall be shaped to form a bevel angle of 30° to 45°. The cut back length shall be 150 (+) 20/(-) 0 mm width, bevel 30° to 45° if specified by purchaser (in case of Automatic UT and Automatic Welding).
- 9.3.6 Immediately after the coating is fully cured, pipe identification marks shall be reapplied to the coated pipe using a method approved by the COMPANY's representative. Additional identification shall be made in order to monitor the coating and test batches. All such markings shall be within 2 meters of the pipe end.
- 9.3.7 Failure to comply with any of the above applicable requirement and of the approved procedure shall be cause for the rejection of the coating and such coating shall be removed in a manner approved by COMPANY at CONTRACTOR's expense.

10.0 INSPECTION AND TESTING

10.1 General

In addition to the tests required on the material batches, the CONTRACTOR shall perform the tests detailed below on finished production coatings to demonstrate



compliance with this specification. Details of all inspections and testing shall be fully documented in accordance with Section 15.

10.2 Production Testing

10.2.1 Production testing shall be performed at the frequency shown in Appendix 2.

10.2.2 The frequency of tests shown in Appendix 2 will be for normal production operations. This frequency of tests will also be required after a change in normal operations as a result of material change or quality acceptance.

10.3 Visual Inspection

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

- Adjacent to the cut-back at each end of pipe.
- Adjacent to the longitudinal weld
- Within the body of the pipe.

The coating shall be of natural colour, smooth & uniform and shall be blemish free with no dust or other particulate inclusions. The coating shall not show any defects such as blisters, pinholes, wrinkles, scratches, engravings, cuts, swellings, excess material thickness, dis-bonded zones, air inclusions, tears, voids, etc. In addition, inside surface of the pipe shall also be visually inspected for presence of any foreign material or shots and grit (free or embedded/sticking to pipe inside surface). The pipe inside surface shall be examined using sharp floodlight focused at the middle of the pipe at one end while inspection is carried out visually from other end.

10.4 Coating Thickness

10.4.1 The thickness of the cooled polypropylene coating system shall be checked using an approved magnetic or electro-magnetic thickness gauge.

10.4.2 Measurements shall be made at 12 points uniformly spaced over the length and circumference of pipe. In case of welded pipes, five of the above readings shall be made at the apex of the weld seam, uniformly distributed over the length of the coated pipe.

10.4.3 The minimum coating thickness on pipe surface shall be as per the table below. However, localized coating thickness of less than the permissible minimum thickness can be tolerated on the condition that it does not attain a total extent of more than 5 cm² per meter length of coated pipe, and the actual coating thickness does not drop more than 10% below the permissible minimum coating thickness at these locations.

| Pipe OD (Inch) | Coating Thickness (mm) |
|----------------|------------------------|
|----------------|------------------------|



| | |
|-------------------|-----|
| ≤6.625 | 2.5 |
| >6.625 and ≤12.75 | 3.0 |
| >12.75 and ≤16" | 3.5 |

10.4.4 The frequency of thickness measurement as stated above shall be initially on every pipe upto at least 100 pipes but may be reduced depending upon the consistency of result to one pipe in every fifty (50) instead of every pipes, at the sole discretion of the COMPANY Representative. Results of all measurements shall be recorded.

10.4.5 Thickness of epoxy and adhesive shall be measured at the beginning of each shift and whenever the plant re-starts after any stoppage for compliance. Coating of epoxy and adhesive on portion of pipe required for this purpose, stripping and recoating of such partly coated pipes shall be at CONTRACTOR's expense.

10.4.6 Coated pipes not meeting the above requirements shall be rejected. Rejected coated pipes shall be stripped and re-coated in accordance with approved procedure, at CONTRACTOR's expense.

10.5 Holiday Detection

10.5.1 Each coated pipe length shall be checked over 100% of coated surface by means of a "holiday detector" of a type approved by COMPANY for detecting holidays in the finished coating.

10.5.2 The holiday detector shall be a low pulse D.C. full circle electronic detector with audible alarm and precise voltage control complying with DIN VDE 0433 Part 2. The set voltage for inspection shall be minimum 25 KV. The operating voltage between electrode and pipe shall be checked at least twice per working shift, and shall be maintained at 25 kilovolts.

10.5.3 CONTRACTOR shall demonstrate to the COMPANY that setting of the detector is satisfactory for detecting pin holes. CONTRACTOR shall calibrate the holiday detector at least once every 4 hours of production. CONTRACTOR shall have necessary instruments or devices for calibrating the holiday detector. The correct travel speed shall be determined by consistent detection of an artificial pinhole made in a good coating sample but shall not exceed 300 mm/s.

10.5.4 Any pipe coating shall be rejected if more than 1(one) holiday & area more than 100 cm² in size are detected in its length attributable to coating process.



10.5.5 Holidays which are lesser in size than those mentioned in para 10.5.4 above, shall be repaired in accordance with a approved procedure and shall be at CONTRACTOR's expense.

10.5.6 If there is an excess occurrence of holidays on successive pipes, the CONTRACTOR shall immediately stop the coating operation to determine the cause and remedy it.

10.6 Adhesion Test

10.6.1 The coating adhesion shall be determined in accordance with either of the methods described in DIN 30678. The test shall be performed at 90°C, 110°C and 120°C in accordance with NF A 49-711.

10.6.2 Minimum adhesion strength shall be in accordance with DIN 30678, 80 newtons per centimeter width of strip peeled at 90°C and 40 newtons or 30 newtons per centimeter width of strip peeled at 110°C or 120°C respectively in accordance with NF A 49-711.

10.6.3 The frequency of test for cut back portions shall be one pipe in every fifteen (15) pipes coated and for middle of pipe shall be one pipe in every sixty (60) pipes coated or one pipe per shift whichever is higher. On each selected pipe, adhesion test shall be performed for each specified temperature. Test shall be performed at each cut back portion and one in the middle of pipe. The system shall disbond/separate cohesively either in adhesive layer or in polypropylene layer. Majority of the peeled off area on the pipe shall show presence of adhesive. Disbondment/separation at epoxy to steel interface or epoxy / adhesive interface or adhesive / polypropylene interface shall not be permitted. The failure mode shall be recorded for each test.

10.6.4 The frequency of adhesion test as per para 10.6.3 for cut back portion may be reduced depending upon the consistency of result to one pipe in every twenty five (25) instead of every fifteen pipes, at the sole discretion of the COMPANY Representative.

10.6.5 During adhesion testing, samples of coating shall be examined using 30X microscope for air entrapment on the body of the pipe as per para 10.10.

10.7 Penetration Indentation Test

10.7.1 Three samples shall be cut from each of three pipes and tested for resistance to indentations in accordance with the method stated in NF A 49-711. The test shall be performed at a temperature of 110°C.

10.7.2 Maximum penetration depth exhibited after testing shall not exceed 0.45 mm.

10.7.3 The frequency of test shall be initially 2 (two) coated pipes per shift which shall be further reduced to one test each on 2 coated pipes per week at random after 1 week of



consistently acceptable results. Two samples for each temperature shall be taken from the cut back portion of coated pipe and one in the middle of the pipe for this test.

10.8 Impact Test

- 10.8.1 A sample of coated pipe shall be impact tested in accordance with the procedures specified in both DIN 30678. Tests shall be performed at temperatures of 0°C, 50°C.
- 10.8.2 Acceptance criteria for the number of blows per coating breakdown shall be as detailed in both DIN 30678.
- 10.8.3 Impact test shall also be carried out at 110°C and the results shall be recorded for COMPANY's representative evaluation.
- 10.8.4 Initially the frequency of test shall be two (2) coated pipes per shift that may be further reduced to one coated pipe per 2 weeks depending upon consistently acceptable results at the sole discretion of COMPANY's Representative.

10.9 Cathodic Disbondment Test

Cathodic disbondment testing shall be performed for 48 hours at an electrolyte temperature of 95°C. The acceptance criteria shall be 7 mm maximum disbondment from the edge of the pre-drilled hole. The test shall be performed in accordance with NF A 49-711. The frequency of this test shall be once in every two weeks or one test representing each batch of epoxy powder used, whichever is more frequent.

In case the test fails to conform to the specified requirement, at the option of the CONTRACTOR, all pipes coated after the previous acceptable test and prior to next acceptable test shall be rejected or the test shall be repeated using two additional samples taken from the same end of the affected pipe. When both retests conform to the specified requirement, the lot of pipes shall be accepted. When one or both the retests fail to conform to the specified requirement, all coated pipes after previous acceptable test and prior to next acceptable shall be rejected. All rejected pipes shall be stripped, re-cleaned and re-coated. COMPANY may consider a further retest program to determine whether any of the affected pipe meet the criteria for acceptance upon written request by the CONTRACTOR.

10.10 Air Entrapment Assessment

- 10.10.1 No more than 10% of the observed area shall be taken with air entrapment (porosity or bubbles). Bubble size in the polypropylene layer shall be limited to less than half the thickness of polypropylene layer in height or circumference. Bubbles shall not link together to provide a moisture path to the adhesive/FBE layers.



10.10.2 Air entrapment or porosity shall be similarly rated for the adhesive and FBE layers of coating.

10.10.3 The strips of coating from the adhesion test should be studied to determine the level of air entrapment at the failure interface. This same area can be used to determine the air entrapment by cutting the coating at 45° angle along the edge of the remaining coating on the pipe at the test area.

10.10.4 See Appendix 3 for Air Entrapment Assessment.

10.11 Degree of Cure

A thermal analysis shall be carried out using a Differential Scanning Calorimeter (DSC). Epoxy film samples shall be removed from the coated pipe using hammer and cold chisel. This produces furled coating flakes. Care shall be taken to remove samples of full film thickness but at the same time avoid the inclusion of steel debris and contamination with adhesive or polypropylene. The sample shall be tested for cure using DSC procedure. The glass transition temperature differential (ΔT_g) and % cure (ΔH) shall be the test used to verify cure along with a visual examination to ensure no residual cure in the portion of the graph beyond the glass transition temperature.

The required cure characteristics are:

$$\Delta T_g = -2^{\circ}\text{C to } +3^{\circ}\text{C } (\Delta T_g = \Delta T_g \text{ final} - \Delta T_g \text{ initial})$$

Only a 95% minimum cured coating shall be acceptable.

$$\% \text{ Cure} = (\Delta H - \Delta H \text{ residual}) \times 100$$

ΔH

(ΔH = exothermic heat of reaction)

Frequency of this test shall be once per shift. Pipe shall be selected randomly by COMPANY Representative during the middle of a shift. Suitable provisions/arrangements as per the instructions of COMPANY Representative shall be made by the CONTRACTOR for this purpose.

In case of test failure, production carried out during the entire shift shall be rejected, unless the CONTRACTOR proposes a method to establish the compliance with the degree of cure requirements of all pipes coated during that shift.

10.12 Destructive Tests

10.12.1 For coating destructive tests listed in Appendices 1 and 2, a sufficient length of production pipe shall be cold cut to provide the required number of samples for testing.



10.12.2 The coating on the cut end of the pipe length shall be cut back to comply with para. 9.3.4 of this specification.

10.13 Test Failure

10.13.1 In the event that a production coated pipe fails to meet the acceptance criteria for a specified test, the CONTRACTOR shall test the preceding and succeeding coated pipe. If both pipes pass the test, then the remainder of the pipe lengths in that shift shall be deemed satisfactory. If either pipe fails to meet the specified requirements, all pipes coated during that shift shall be tested until the coating is proved acceptable. Rejected coated pipes shall be stripped and re-coated in accordance with approved procedure, at CONTRACTOR's expense.

10.13.2 COMPANY reserves the right to perform inspection and witness tests on all activities concerning the pipe coating operations starting from bare pipe to finished coated pipe ready for despatch and also testing of raw materials. CONTRACTOR shall give reasonable notice of time and shall provide without charge reasonable access and facilities required for inspection to the COMPANY's representative. Inspection and tests performed or witnessed by COMPANY's representative shall in no way relieve the contractors obligation to perform the required inspection and tests.

10.13.3 In case rate of defective or rejected pipes and/or samples tests are 10% or more for a single shift (typically 8 hours), CONTRACTOR shall be required to stop production and carry out a full and detailed investigation and shall submit findings to COMPANY for approval. CONTRACTOR shall recommence the production only after getting the written permission from COMPANY.

Under no circumstances any action or omission of the COMPANY's Representative shall relieve the CONTRACTOR of his responsibility for material and quality of coating produced. No pipes shall be transported from the coating plant unless authorised by COMPANY in writing.

11.0 HANDLING, TRANSPORTATION AND STORAGE OF MATERIALS

11.1 Contractor shall develop the method of stock piling and loading out bare and coated pipes and shall receive approval from Company's Representative prior to handling coated pipes.

11.2 The Contractor shall unload, load, stockpile and transport the bare pipes using suitable means and in a manner to avoid damages to pipes. Pipe shall not be allowed to drop or strike objects which will damage the pipe but shall be lifted or lowered from one



level to another by suitable equipment, preferably by vacuum lifting equipments. Lifting hooks when used, shall be equipped with a plate curved to fit the curvature of the pipe. In loading pipe on trucks each length shall be lowered to position without dropping and each succeeding length shall rest on special supports on the truck and shall be separated from the adjacent pipes. After loading, suitable chains and padding shall be used to tie the load securely to each bolster. Pipe, when stock piled, shall be placed on suitable skid to keep it clear of the ground and flood water. Care shall be exercised in handling or stock-piling pipes in order to avoid distortion, flattening, denting or other damages. The Contractor shall provide all necessary timber or other materials required for the stock-piling. While stacking, the number of allowable layers of bare pipes shall be calculated as per API RP 5L 1 and shall be agreed with the Company. The stacks must be properly secured against sliding and shall consist of pipes of the same diameter and wall thickness. Adjacent stacks of pipes having different dimensional characteristics shall be clearly separated. Bare / coated pipes at all times shall be stacked completely clear from the ground, at least 300 mm, so that the bottom row of pipes remains free from any surface water. The pipes shall be stacked at a slope so that driving rain does not collect inside the pipe. Bare / coated pipes may be stacked by placing them on ridges of sand free from stones and covered with a plastic film or on wooden supports provided with suitable cover. This cover can be of dry, germ free straw covered with plastic film, otherwise foam rubber may be used. The supports shall be spaced in such a manner as to avoid permanent bending of the pipes.

- 11.3 Contractor shall load out the coated pipes onto rail-car or trucks and barges and shall furnish special loading spacers, bolsters and the like, approved by the Company's Representative, to protect the pipe during transport.
- 11.4 Coated pipe shall be handled at times with wide non-abrasive or leather belts or other equipment designed to prevent damage to the coating. All such equipment shall be kept in proper working order so as to prevent injury to the coating. The use of tongs, bare pinch bars, chain slings, protruding rivets, pipe hooks without proper padding, or any other handling equipment that may be injurious to the coating shall not be permitted.
- 11.5 Yard coated pipe shall be raised or lowered to or from stock pile, ground, barge, rail car or truck by means of brass lined or padded pipe end hooks engaging the ends of



the pipe and carried by wire rope on chain slings with “spreader bars” between lifting lines. The bolster of the trailer or barge shall have a bearing surface not less than 300 mm wide to give necessary support to the padding which protects the coating.

Sacks partly filled with sand or saw dust shall be placed on the bolster and between the outside bottom pipes and bolster stacks. All chains, cables or other equipment used for fastening shall be padded.

- 11.6 The maximum stack height for various types of coated pipes shall be limited to such heights as will not cause damage to the pipe and coating. The stacking shall conform to the requirements of API RP 5L 1 and API RP 5L 5. Only coated pipes of same outside diameter and wall thickness shall be nested together.
- 11.7 All pipes shall be tightly nested (laid parallel with full length in contact). Corrosion coated pipes shall not be loaded, piled or nested with the concrete coated pipes.
- 11.8 In case of any marine transportation of bare/coated line pipes involved, the same shall be carried out in compliance with API RP 5LW. CONTRACTOR shall furnish all details pertaining to marine transportation including drawings of cargo barges, storing/stacking, sea fastening of pipes on the barges/marine vessels to the company for approval prior to undertaking such transportation works. In addition contractor shall also carry out requisite analyses considering the proposed transportation scheme and establish the same is safe and stable. On-deck overseas shipment shall not be allowed.
- 11.9 Material Control Records**
- 11.9.1 CONTRACTOR shall record the receipt, issue return or disposal of all materials supplied by COMPANY and shall permit inspection of those records by COMPANY at all reasonable times. In particular, the records shall reference the pipe number of each pipe.
- 11.9.2 CONTRACTOR shall submit details of material control recording procedure to COMPANY for review prior to commencement of the works.
- 11.9.3 CONTRACTOR shall submit details of his traceability procedure for COMPANY’s review and approval. The complete mill markings on the bare pipe along with the pipe number and project specific description shall be stencilled with indelible markings on both ends on outside surface of the pipe within 200 mm of the ends.
- 11.9.4 A detailed procedure for marking and transferring the full traceability of the pipe from the bare pipe to the external surface of the coated line pipes after coating shall be submitted



to the COMPANY for review and approval. Material Test Certificates and MANUFACTURER Test Reports shall be traceable to each pipe within the APPLICATOR's Coating Book, which shall be part of the QC Data Book.

- 11.9.5 All coated line pipes shall be provided with full traceability details stenciled on the external surfaces of the coated pipes as per para 11.9.3 above.

12.0 REPAIR OF COATING

CONTRACTOR shall submit to COMPANY, its methods and materials proposed to be used for executing a coating repair and shall receive approval from COMPANY prior to use. In open storage the repair coating materials must be able to withstand a temperature of at least (+) 80°C without impairing its serviceability and properties. CONTRACTOR shall furnish manufacturer's test certificates for the repair materials clearly establishing the compliance of the repair materials with the applicable coating requirements indicated in this specification.

All pipe leaving coating plant, shall have sound external coating with no holiday or porosity on 100% of the surface.

Defects, repairs and acceptability criteria shall be as follows:

- Pipes showing porosities or very small damage not picked up during holiday test and having a surface less than 0.5 cm² or linear damage (cut) of less than 3 cm shall be repaired by stick using material of same quality.
- Damages caused to coating by handling such as scratches, cuts, dents, gouges, not picked up during holiday test, having a total reduced thickness on damaged portion not less than 2 mm and an area not exceeding 20 cm² shall be rebuild by heat shrink patch only and without exposing to bare metal.
- Defects of size exceeding above mentioned area or holidays of width less than 300 mm shall be repaired with heat shrink repair patch by exposing the bare metal surface.
- Defects exceeding the above and in number not exceeding 2 per pipe and linear length not exceeding 500 mm shall be repaired using heat shrinkable sleeves.
- Pipes with bigger damage shall be stripped and recoated.
- In case of coating defect close to coating cut back, CONTRACTOR shall remove the coating throughout the entire circumference of the pipe down to the steel surface and increase the coating cut back length. Now if the coating cut back exceeds 140 mm of linear length of pipe then the coating shall be repaired by the



use of heat shrink sleeves thereby making up the coating cut back length of 120 mm.

Notwithstanding the above, if any defect exceeds 70 mm from the original coating cut back length, the entire coating shall be removed and the pipe shall be recycled through the entire coating procedure.

Irrespective of type of repair, the maximum numbers of repair of coating shall be as follows:

- Holiday repair of size ≤ 100 cm² attributable to process of coating application shall be maximum one number per pipe.
- In addition to the above, defects to be repaired by heat shrink patch/sleeve shall be maximum 2 (two) per pipe.

Defects exceeding the above limits shall cause pipe coating rejection, stripping and recoating. The above is exclusive of the repairs warranted due to testing as per this specification.

All repairs carried out to coating for whatever reason shall be to the account of CONTRACTOR.

Cosmetic damages occurring in the polypropylene layer only need not be repaired by exposing up to steel surface, as deemed fit by the COMPANY Representative. In any case the CONTRACTOR shall establish his material, methods and procedure of repair that result in an acceptable quality of product by testing and shall receive approval from COMPANY prior to use.

Testing of repairs shall be in the same form as testing of coating. All repairs shall result in a coating thickness no less than the parent coating thickness. CONTRACTOR shall test repairs to coating as and when required by COMPANY.

13.0 MARKING

CONTRACTOR shall place marking on the outside surface of the coating at one end of the coated pipe, and marking shall indicate, but not limited to the following information:

- a. Pipe number, Heat number
- b. Diameter & Wall thickness
- c. Coated pipe number
- d. Colour band
- e. Any other information considered relevant by COMPANY.
- f. Pipe Manufacturer Name



g Inspection Mark/Punch

CONTRACTOR shall obtain prior approval on marking procedure to be adopted from the COMPANY.

14.0 QUALITY ASSURANCE

14.1 The CONTRACTOR shall have established within his organisation and, shall operate for the contract, a documented Quality System that ensures that the requirements of this specification are met in all aspects. The Quality System shall be based upon ISO 9001/2 or equivalent.

14.2 The CONTRACTOR shall have established a Quality Assurance Group within its organisation that shall be responsible for reviewing the Quality System and ensuring that it is implemented.

14.3 The CONTRACTOR shall submit the procedures that comprise the Quality System to the COMPANY for agreement.

14.4 The CONTRACTOR's Quality System shall pay particular attention to the control of Suppliers and Sub-contractors and shall ensure that the requirements of this specification are satisfied by the Suppliers and Sub-contractors operating Quality system in their organisation.

14.5 The CONTRACTOR shall, prior to the commencement of work, prepare and issue a Quality Plan for all of the activities required to satisfy the requirements of this specification. The plan shall include any sub-contracted work, for which the sub-contractors Quality Plans shall be submitted. The plan shall be sufficiently detailed to indicate sequentially for each discipline the requisite quality control, inspection, testing and certification activities with reference to the relevant procedures and the acceptance standards.

14.6 The CONTRACTOR's Quality system and associated procedures may, with due notice, be subject to formal audits. The application of quality control by the CONTRACTOR will be monitored by the COMPANY Representatives who will witness and accept the inspection, testing and associated work required by this specification.

15.0 DOCUMENTATION

APPLICATOR shall submit the type and quantity of details and documentation for CONTRACTOR's authorization or information as listed in the individual Material Requisitions and Purchase Orders.



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

- Material batch numbers and certificates detailing all the information required for each batch as defined in this specification
- Details of blasting abrasive, measurement of surface profiles, surface preparation standard and recording of environment conditions prevailing during blasting
- Recording of steel surface defects and repairs
- Surface temperature of items prior to coating
- Results of all tests as defined in this specification
- Details of repairs to coating defects exposed during testing and the repair techniques used
- Details of rejected items, with reasons for failure
- Information on items which, after rejection, require complete recycling

Such information shall be submitted daily by the APPLICATOR to the CONTRACTOR.

Absence of documentation shall be considered a just cause for rejection of coating system.

The following documentation, written in the English Language, shall be submitted to COMPANY for review.

Prior to the start of Production Operations, CONTRACTOR shall submit the following documentation to the COMPANY:

- Quality Plan
- Production Schedule
- Coating and Testing Procedures
- Detailed Description of Coating Equipment and Materials
- Pipe Handling Equipment Description and Procedures
- Pipe Stacking Arrangements
- Material Control Recording Procedure
- Inspection Quality Plan
- Inspection and Testing Plan
- Repair Procedure
- Procedures for all PQT and Production Tests

CONTRACTOR shall submit to COMPANY the following documentation prior to the return of coated pipe to COMPANY:



- Mill Certificates for Line Pipe Received
- MANUFACTURER's Certificates for Each Batch of Coating Materials
- Certification/Calibration Certificates for all Testing and Coating Equipment
- Inspection and Test, Records, Results, and other Documentation of all Material and Coating Tests
- Certificate of conformance and dimensional check report
- Verification certificates for standard compliance
- All concession requests

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

16.0 PREPARATION FOR SHIPMENT

The CONTRACTOR shall submit shipping and handling procedures to the COMPANY for approval. The procedures should adequately address storage, shipping and handling in view of the long voyage from manufacturing locations and climatic extremes at the job site.

An appropriate design of end cap shall be fitted to each opening to protect the butt weld ends and prevent ingress of foreign material. Handling shipping and storage procedure shall incorporate requirements given in Section 7 of NACE 0185.



ANNEXURE-I

LIST OF ACCEPTABLE COMBINATIONS OF COATING MATERIALS

The following combinations of coating materials' manufacturers are considered acceptable.

In case any of the combinations listed below are offered, details regarding the offered materials and its properties need not be furnished with bid. However, In the event of award of contract, manufacturer's trade name and data sheets/ properties for each coating material proposed by the CONTRACTOR and compatibility certificate for the proposed combination (s) from the raw materials Manufacturers, shall be submitted for COMPANY's approval prior to the placing of any order for coating work.

| Epoxy Powder (Manufacturer) | Adhesive (Manufacturer) | PE Compound (Manufacturer) |
|---|--|--|
| JOTUN or BASF or 3M | DUPONT or LYONDELLBASELL or BOREALIS | DUPONT or LYONDELLBASELL or BOREALIS |

Although the above combinations would be acceptable to COMPANY, the responsibility of suitability for application, performance and compliance to the coating system requirements shall unconditionally lie with the CONTRACTOR.



**APPENDIX 1: INSPECTION SUMMARY FOR PROCEDURE QUALIFICATION TEST ON
PPCOATING SYSTEM FOR ONE PIPE DIAMETER**

| Property | Relevant Clause | Acceptable Values | Number of Tests |
|---|-----------------|---|--|
| <u>Before Cleaning</u> | | | |
| • Pipe condition | 8.2 | Conditions A&B of ISO 8501 (part I) | 5 pipes |
| <u>After Cleaning</u> | | | |
| • Cleanliness | 8.7 | Sa 2 ¹ / ₂ | 5 pipes |
| • Profile | 8.7 | 50 - 80 µm. | 5 pipes |
| • Chloride | 8.6.5 | 2 µ gram/cm ² | 15 (3x5 pipes) |
| • Oil contamination | 8.3 | No indications of oil contamination | 5 pipes |
| • Degree of Dust | 8.7 | quality rating 2 or class 2 of ISO 8502-3 | 5 pipes |
| • Wall thickness (after grinding of defects, if applicable) | 8.10 | > 95% of specified thickness (pipes with ground areas > 50mm in dia shall be re-blasted) | each pipe after grinding/ repair |
| <u>Coating Thickness</u> | | | |
| • FBE coated | 7.5.1(b) | 350 µm - 450 µm | 12 (12x1 pipes) |
| • FBE + Adhesive | 7.5.1(c) | 600 µm - 800 µm | 12 (12x1 pipes) |
| • FBE + Adhesive + PP. | 10.4.3 | Pipe DN up to 150 mm = min. 2.5 mm. Pipe above DN 150 mm & upto 300 mm = min. 3.0 mm. Pipe above DN 300 mm & upto 400 mm = min. 3.5 mm. | 48 (12x4 pipes) |
| <u>Visual Examination</u> | | | |
| • Partly coated pipes | 7.5.3 & | Smooth with no surface defects | 1 pipe |
| • FBE + Adhesive + PP. | 10.3 | Smooth with no surface defects | 4 pipes |
| <u>Holidays</u> | | | |
| • Partly coated pipes | 7.5.1(d) | max. 1 no. & area upto 100 cm ² in size per pipe length | 1 pipe |
| • FBE + Adhesive + PP. | 10.5.4 | ----- Do ----- | 4 Random |
| <u>Adhesion</u> | | | |
| • Partly coated pipes | 7.5.1(d) & | Refusal to peel or a cohesive failure | 1 pipe |
| • FBE + Adhesive + PP. | Test 10.6.2 | 80N/cm at 90°C, 40N/cm at 110°C, 30N/cm at 120°C | 9 (3x3 pipes) for each specified temp. |



| | | | |
|---|--|--|-----------------------------------|
| <u>Cathodic disbondment</u> <ul style="list-style-type: none">FBE + Adhesive + PP. | 7.5.2 | Average radius of disbondment 5 mm | 2 Random |
| <u>Impact Resistance</u> <ul style="list-style-type: none">Partly coated pipesFBE + Adhesive + PP. | ASTM-G14 7.5.2(b) | 18J (minimum) See DIN 30678 and NFA 49.711 | 1 3 Random |
| <u>Penetration (indentation) testing</u> <ul style="list-style-type: none">FBE + Adhesive + PP. | 7.5.2(c) | 0.45 mm at 110°C | 8 (2x4 pipes) |
| <u>Degree of Cure</u> <ul style="list-style-type: none">Partly coated pipesFBE + Adhesive +PP. | 7.5.1(a) 7.5.2(i) | -2°C ≤ ΔTg ≤ + 3°C 95% min. cured coating | 4 (4x1pipe) 4 Random (4x1pipe) |
| <u>Flexibility Bend Test</u> <ul style="list-style-type: none">Partly coated pipes | See Appendix 4 & 7.5.1(f) | API RP 5L9 No cracking/disbondment pinholes | 1 |
| <u>Air Entrapment</u> <ul style="list-style-type: none">Partly coated pipesFBE + Adhesive + PP. | See Appendix 3 and 10.10 & 7.5.2(h) | No air entrapment in pipe or cut back. | 1 8 (2x4 pipes) |

Number of Tests can be increased at the sole discretion of COMPANY.



APPENDIX 2: INSPECTION SUMMARY FOR PRODUCTION TESTING ON FULL PP-COATINGSYSTEM FOR ONE PIPE DIAMETER

| Property | Relevant Clause | Acceptable Values | MINIMUM Frequency * |
|---|-----------------|---|---|
| <u>Before Cleaning</u> | | | |
| • Pipe condition | 8.2 | Conditions A&B of ISO 8501 (part I) | Each Pipe |
| <u>After Cleaning</u> | | | |
| • Cleanliness | 8.7 | Sa 2 ¹ / ₂ | Each pipe |
| • Profile | 8.7 | 50 - 80 µm. | 1 per 50 pipes |
| • Chloride | 8.6.5 | 2 µ gram/cm ² | 1 per 100 pipes at 3 locations |
| • Oil contamination | 8.3 | No indications of oil contamination | 1 per 100 pipes |
| • Degree of Dust | 8.7 | quality rating 2 or class 2 of ISO 8502-3 | 1 per 100 pipes |
| • Wall thickness (after grinding of defects, if applicable) | 8.10 | ≥ 95% of specified thickness (pipes with ground areas > 50mm in dia shall be re-blasted) | |
| <u>Coating Thickness</u> (minimum) | 10.4.3 | Pipe DN up to 150 mm = min. 2.5 mm. Pipe above DN 150 mm & upto 300 mm = min. 3.0 mm. Pipe above DN 300 mm & upto 400 mm = min. 3.5 mm. | (At 12 locations) Each pipe upto 100 pipes & 1 per 50 pipes on getting consistent results |
| <u>Holidays</u> | 10.5 | No holidays | Each pipe |
| <u>Visual Examination</u> | | | |
| • Surface of coating | 10.3 | No surface defects | Each pipe |
| • Cut backs | 9.3.5 | 120 (+) 20/(-) 0 mm width, bevel 30° to 45° (Note1) | Each pipe |
| <u>Adhesion</u> | | | |
| • At 90° C | 10.6. | 80 Newtons per cm width of strip peeled | For cut-back : 1 per 15 pipes & 1 per 25 pipes on getting consistent results. For middle of pipe : 1 per 60 pipes & 1 per shift whichever is higher on getting consistent results. |
| • At 110° C | 10.6. | 40 Newtons per cm width of strip peeled | |
| • At 120° C | 10.6. | 30 Newtons per cm width of strip peeled | |
| <u>Cathodic disbondment</u> | 10.9 | < 5 mm radius of disbondment | Once per 2 weeks or one test per batch of epoxy powder whichever is more. |
| <u>Impact Resistance</u> | ASTM-G14 | 18J (minimum) | 2 pipes per shift & reduced to one pipe per 2 weeks |



| | | | |
|--|--------------------------|--|--|
| | 10.8 | See DIN 30678 and NFA 49.711 | on getting consistent results. |
| <u>Penetration (indentation) testing</u> | 10.7 | 0.45 mm at 110°C | 2 pipes per shift & reduced to 1 test each on 2 coated pipes per week on getting consistent results. |
| <u>Degree of Cure</u> | 10.11 | -2°C ≤ ΔTg ≤ + 3°C 95% min. cured coating | Once per shift |
| <u>Air Entrapment</u> | See Appendix 3 and 10.10 | No air entrapment in pipe or cut back. | Once per shift |

Note:

1. The cut back length shall be 150 (+)20/ (-)0 mm width, bevel 30° to 45° if specified by purchaser (in case of Automatic Welding and AUT)

*COMPANY reserves the rights to increase inspection and testing frequency if warranted by the circumstances.



APPENDIX 3

AIR ENTRAPMENT ASSESSMENT

1.0 Scope

To determine the amount of cross section and interface air entrapment (porosity or bubbles in the plant applied coating.

2.0 Equipment

2.1 Microscope - Hand Held 30 X.

2.2 Utility knife.

3.0 Test Specimen

Strips from Adhesive Tests, coating disbondment (CD) test samples, and coated pipe may all be used to help determine the rating.

4.0 Procedure

4.1 Adhesion strip shall be viewed from the side ant the failure interface.

4.2 Cathodic disbondment samples shall be viewed from the side before tests begins. Scraping with a sharp knife to remove cutting damage on the edge of the coating may be necessary to provide a smooth surface for viewing.

4.3 At the pipe adhesion test site use a utility knife to cut the edge of the coating to a 45° angle and view with a microscope.

4.4 Perform a similar test in the cut back area. This should be used for information to determine if further testing is needed.

5.0 Reporting and Grading

5.1 Report pipe joint number, date pipe was coated, coating batch number, and date of test.

5.2 Report rating of cross-section and interface entrapment.

5.3 A rating of 1 or 2 is passing.

Rating will be on a scale of 1 to 5 as follows:

Rating

1. Very Good - Passing

2. Good - Passing

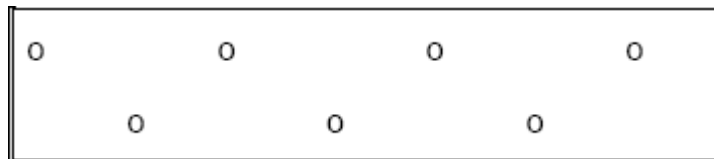
3. Fair - Failing

4. Poor – Failing

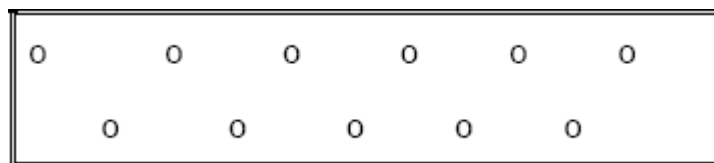
5. Very Poor - Failing



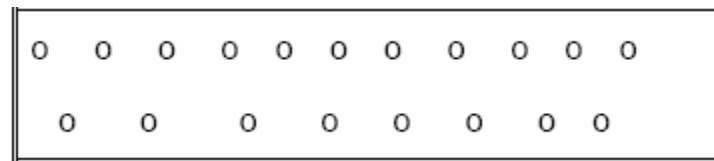
Rating for each area of concern:



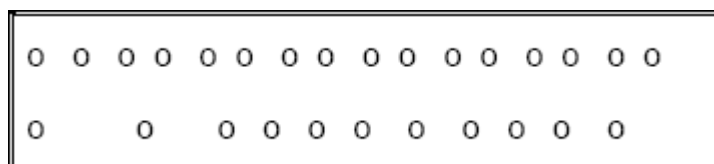
No. 1 Rating – Passing Less than 10% of area with bubbles.



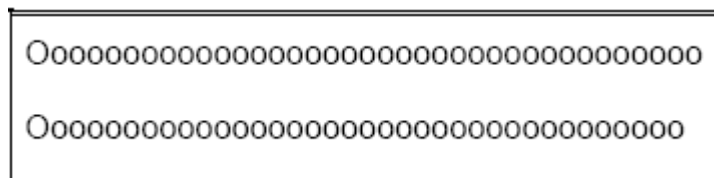
No. 2 Rating – Passing Less than 20% / more than 10%



No. 3 Rating – Failing Less than 30% / more than 20%



No. 4 Rating – Failing Less than 40% / more than 30%



No. 5 Rating – Failing Over 50% of area taken by air entrapment (bubbles)

By looking at the top (outside) surfaces the same type rating system can be used.



APPENDIX 4
FOR FBE LAYER COATING PQT

1. Test Method

The flexibility of the coating shall be determined once on the first day of production of only FBE layer coated pipes (2 Nos.) by the following method:

Coated samples (300 mm x 50 mm x thickness of pipe wall) taken from a FBE coated pipe joint shall be subjected to a bend test at a temperature of 0°C and 20°C to induce a 2% and 3% strain respectively in the sample.

At each temperature the test shall be carried out twofold.

The deflection loading rate during bend testing shall be 25 ± 2 mm/min.

The mandrel sizes shall be selected according to the following formula:

$$D = t (1-s)/s$$

D = mandrel diameter (mm)

t = specimen wall thickness (mm)

s = 0.02 at 0°C

0.03 at 20°C

2. Acceptance Criteria

The coating shall not exhibit any signs of cracking, disbondment or pinholes.