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	AREA: GENERAL	PROJECT:
DDP	TITLE: FACTORY APPLIED EXTERNAL PIPELINE COATINGS FOR CORROSION CONTROL	PUBLIC EDD / EDR

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INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL This document supersedes and replaces document I-ET-0000.00-6500-210-P9U-002, rev.A.
A	Change from NP-1 to PUBLIC

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
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REV. A

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1. SCOPE OF DOCUMENT

1.1 This technical specification defines the minimum requirements related to the application of external anticorrosion coatings on pipelines.

1.2 CONTRACTOR shall fulfill all the requirements presented within this technical specification.

1.3 This document shall be read in conjunction with the following standards:

- Recommended Practice DNV-RP-F106 - May 2011
Title: Factory Applied External Pipeline Coatings for Corrosion Control
- ISO 21809-1:2011
Title: 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 21809-2:2014
Title: Petroleum and natural gas industries - External coatings for buried or submerged pipelines used in pipeline transportation systems - Part 2: Fusion-bonded epoxy coatings

1.4 In case that it is noted any sort of conflict between this technical specification and the aforementioned documents, the following precedence order shall be respected by CONTRACTOR:

- a) This technical specification;
- b) DNV-RP-F106;
- c) ISO 21809 Part 1 and 2 Standards.

2. LINEPIPE COATING REQUIREMENTS

2.1 Contractor shall fulfill the requirements of the following document for the coating manufacturing:

- Recommended Practice DNV-RP-F106 - May 2011
Title: Factory Applied External Pipeline Coatings for Corrosion Control

2.2 There are some additional and modified requirements which shall be fulfilled by CONTRACTOR. Additional and modified requirements to the aforementioned document within the item 2.1 are highlighted in this technical specification considering the following expressions:

- [ADDITION] - When CONTRACTOR shall consider new requirements.
- [MODIFICATION] - When a partial or full modification in the referred item is required.
- [DELETED] - When the referred item shall be entirely disregarded by CONTRACTOR.

3. ADDITIONAL AND MODIFIED REQUIREMENTS FOR LINEPIPE COATING APPLICATION RELATED TO DNV RP-F106 STANDARD.

3.1 The items mentioned below are in accordance with the sequence already defined within the Recommended Practice DNV-RP-F106 - May 2011. The DNV-RP-F106 paragraph number is given in brackets.

1.2 Scope

(1.2.2) Modification: "The following coating systems are covered:

- 1) Single layer fusion bonded epoxy).
- 2) 3-layer coating based on an inner layer of fusion bonded epoxy (FBE) applied by spraying, an intermediate adhesive layer applied by spraying or extrusion, and an outer jacket of polyethylene (PE) applied by extrusion).
- 3) 3-layer coating based on an inner layer of FBE applied by spraying, an intermediate adhesive layer applied by spraying or extrusion, and an outer jacket of polypropylene (PP) applied by extrusion.

Guidance note:

Pipeline operators (and installation contractors if applicable) should consider the need to carry out qualification of generic coating systems for specially demanding applications, e.g. resistance to horizontal directional drilling,



resistance to bending during installation by reeling and/or long term (>10.000h) thermal degradation of critical coating properties associated with high operating temperatures. Purchases of linepipe coating should further consider pre-qualification of the coating manufacturers prior to the issue of 'Purchase Document' (see definition in Sec. 3)."

2. References

ABNT NBR 16212 *Tubos – Estocagem em área descoberta*

3. Terminology and Definitions

Addition:

“Hold point Activity to be performed with the presence of purchaser and applicator representative.

Witness point Activity to be performed with the presence of the applicator, QA/QC inspector and FJ applicator representative. Purchaser representative is to be notified in advance but if not available activity continues.

Monitoring point Activity only to be developed with the presence of the applicator QA/QC inspector, and/or purchaser.”

6.4 Procedure Qualification Trial (PQT)

(6.4.1) Modification: “For compliance with this RP, a project specific ‘procedure qualification trial’ (PQT, also referred to as a ‘procedure qualification test’) is mandatory since no PQT track record is available for the relevant coating system. Acceptance of the PQT track record is subjected to PETROBRAS’ approval. The primary objective of the PQT is...”

(6.4.1) Modification: “...The PQT shall utilize the specific coating materials, equipment (considering their relevant spares) and procedures to be used during the ordinary production. The key personnel participating in a PQT process shall be responsible to ensure a proper training for all the employees which will be assigned to the other production shifts. Furthermore, it shall establish...”

(6.4.1) Addition: “The external surface roughening of coating shall be specified within the project material requisition.”

(6.4.1) Addition: “If a coating system has already been qualified by PETROBRAS, the conditions listed below may demand the execution of a new Procedure Qualification Trial:

Key Variable	Specific conditions requiring a new full PQT
Coating material	Change of any coating material composing the coating system
Chemical pre-treatment	Change of chemical pre-treatment after blasting operation
Equipment	Change of methodology for the coating application
Pipe OD	Any change on the pipe OD
Key process parameters	Out of the tolerance previously qualified (e.g. temperatures, line speed, etc.)
Pipe wall thickness	Pipe wall thickness variation out of ± 15%
Steel grade	Carbon steel pipe and CRA pipes

Beyond to the aforementioned conditions, the following items shall be considered:

- In case of existing PQT track records for projects having an equivalent methodology of installation, no further trial is necessary whether the aforementioned conditions are kept;
- During the PQT, at least five pipes shall be coated. Nevertheless it shall be taken into account a suitable amount of pipes in order to also cover the full scale testing protocol;
- The PQT schedule and the relevant ITP as well as the APS shall be submitted to PETROBRAS for approval at least 45 days prior to the beginning of trial.

Regarding to the installation method of pipelines, the following full scale tests are required for the coating systems:

Test	FBE	3LPE	3LPP
Impact full scale	N.A.	x	x
Ramp roller load	N.A.	x	x
Full scale bending (only for reel lay)	x	x	x
Model tensioner test	x	x	x



(not in case of J-lay collars)

- Full scale abrasion tests may be required in case of coated system which will be installed at TDZ (Touch Down Zone) for risers;
- If model tensioner tests are necessary; the relevant tests parameters such as radial and axial loads, material of clamp or tensioner, etc. shall be defined within the ambit PETROBRAS/CONTRACTOR;
- The additional testing protocol after full scale tests shall be agreed within the relevant test procedure;
- In case of existing successful full scale tests track records carried out in an equivalent condition, the test data shall be shared with PETROBRAS and CONTRACTOR for reviewing.”
- The aforementioned full scales tests shall be carried out in compliance with a relevant test procedure agreed with PETROBRAS.”

(6.10.3) Modification: “Defects in the finished coating system caused by the application process, transportation, handling and storage in the coating plant or in the storage area, as well as those pipes which have been subjected to destructive testing, shall be repaired. The repaired area shall not exceed 10cm² and the total number of repairs shall not exceed the amount of three per pipe. If the size or number of defects exceeds these limits, the affected pipe shall be stripped and recoated in accordance with the APS.”

(6.4.5) Addition: “Individual coating applicators/operators shall be duly qualified during the PQT phase carrying out the relevant repair procedures and validating them through a testing protocol.”

(6.4.8) Addition: “The availability of pipes having identical geometry and same material grade defined for the project shall be discussed with Purchaser during the coating bid phase.”

(6.4.8) Addition for the guidance note: “A trial encompassing the heating of pipe ends up to 240°C and subsequent cooling to an ambient temperature shall be done during the PQT. The test aims to simulate the heating process during FJC application. The test shall be performed at a simulated field joint heating up the steel cut-back section to 240°C using a high frequency induction coil. The temperature on parent coating at 50mm from the interface coating/steel shall be at least 120 °C. Temperatures on steel and parent coating surfaces shall be monitored through at least 12 thermocouples generating a heating profile. Thermocouples shall be brazed or screw on the bare steel of the simulated field joint. The thermocouples shall be distributed on three different sections at 12, 3, 6 and 9 o'clock positions. One section shall be at right and one at left of the girth weld close to the edge of the 3LPP factory applied coating. The third section shall be close to the girth weld. The surface temperatures on steel and parent coating at each field joint shall be checked with a digital contact thermometer. The temperatures shall be recorded on each simulated field joint. Maximum difference between the highest and lowest temperature measured by thermocouples shall be 20°C. The coating/steel interface shall be visually inspected. Bubbles or lack of adherence of coating is not acceptable. After visual inspection, four peel adhesion tests at ambient temperature shall be performed at each overlap area (within 50mm from coating/steel interface). The acceptance criterion for the tests is the same used for peel adhesion tests at ambient temperature which are performed during production. Two pipes (one simulated field joint per pipe) shall be tested during PQT, two pipes shall be tested during PPT and one pipe per each 500 pipes shall be tested during production.”

(6.4.9) Deleted.

(6.4.10) Addition: “It shall be supplied by the Purchaser a minimum amount of 10 pipes which will be used for the execution of internal trials as well as the PQT activities.”

(6.4.12) Addition: “Since that successful track record for long term cathodic disbondment tests is available and duly shared with the Purchaser, the production activities may be developed without awaiting the results of testing, under Applicator’s responsibility.”

(6.4.12) Addition: “In case of evidence of failure for a specific inspection or testing during the coating process or during the evaluation of finished coating, two additional tests shall be performed (in the same pipe) in order to verify whether the issue is an isolated case or a systematic issue. Both tests shall be approved and the root cause of the quality matter shall be identified in order to avoid its occurrence during the production phase. If the pipe where the additional tests were performed is not approved, the PQT shall be reprovved and started again. If a pipe is not approved during production, an investigation action shall start immediately and production shall be stopped”.



6.11 Pipe tracking and marking

(6.11.1) Addition: "The following markings shall be placed on the coating:

- Applicator's name or code;
- Marking required by the applicable pipe specification or standard;
- DNV Standard linepipe designation and linepipe supplementary requirements
- Lipepipe manufacturing Heat and ITP Number;
- Sour Service Severity Steel Class;
- Mark of PETROBRAS inspection representative, if applicable;
- Specified total coating thickness;
- Maximum design temperature;
- Date of coating and production shift;
- Additional marking being requested within the material requisition, e.g., a special color code identification aiming to separate the pipes at coating yard in terms of coating thicknesses, pipe wall thickness, steel grade, etc."

6.12 Handling and Storage of Pipes

(6.12.4) Addition: "The pipes shall be stored in a way which prevents accumulation of water and any other debris inside the pipes. All the requirements from ABNT NBR 16212 shall be fulfilled."

6.13 Documentation

(6.13.1) Addition: "The relevant ITP as well as the APS shall be sent for PETROBRAS' review at least 45 days prior to the beginning of production phase."

(6.13.2) Modification: "Prior to PQT (see 6.4), Applicator shall submit the following documents to Purchaser for acceptance:

- APS (see 6.1) covering PQT and production
- ITP (see 6.2) covering PQT
- Tentative Daily Log format (see 6.3)."

7.2 3LPE (CDS no. 2) and 3LPP (CDS no. 3)

(7.2.12) Addition: "The recycled FBE shall be tested in order to guarantee compliance with the manufacturer certificate. The following tests shall be performed: gel time, moisture content and thermal characteristics. The acceptance criteria shall be in accordance with the relevant coating data sheets, CDS 1, CDS 2 or CDS 3, whichever is applicable."

(7.2.17) Modification: "Unless otherwise specified or agreed by Purchaser, the outer PE/PP layer at the cutback shall be removed to expose a tail of FBE with a minimum length of 5.0 mm and maximum 20mm. The tail shall..."

(7.3) Deleted.

(7.4) Deleted.


8. ANNEX 1: Coating Data Sheets

Coating Data Sheet No.1: Single Layer Fusion Bonded Epoxy Coating

(1) Modification: "FBE layer thickness shall be between 350µm and 550µm."

(2.1.1) Modification: "Total volatile/moisture content by mass evaluation shall be carried out for each batch."

(2.1.1) Modification: "Thermal characteristics evaluation shall be carried out for each batch."

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(2.1.1) Modification: "Infrared scan shall not be performed."

(2.1.2) Addition: "Data of salt spray test is required."

(3.1) Modification: "Water soluble contamination of abrasives: Acceptance criteria is $\leq 150\mu\text{S}/\text{cm}$ in accordance with ABNT NBR 15221-2:2014."

(3.1) Addition: "Visual inspection of blasted surface: NACE No. 2/SSPC-SP 10 (Near-White Metal Blast Cleaning) standard may be considered as an alternative to ISO 8501-1."

(3.2) Modification: "Hardness test is not mandatory."

(3.2) Modification "Residual magnetism of coated pipe shall be as per Project ITP: Average of 20 Gauss (no reading above 25 Gauss) for all the pipes. The verification shall be carried out at the beginning of shift."

(3.2) Addition: "Pull-off adhesion test shall be performed in substitution of dry adhesion test. Minimum acceptance criterion is 15MPa at 23°C and the test shall be performed in accordance with ASTM D4541, method D, E or F. Five tests shall be performed during PQT and three tests shall be performed on start of each shift during production."

Coating Data Sheet No.2: 3-Layer Polyethylene Coating

(1) Modification: "FBE layer thickness shall be between 200 μm and 450 μm ".

(1) Modification: "The adhesive layer thickness shall be 200 μm as minimum".

(1) Deleted: "Thickness Polyethylene outer sheet: According to ITP (min. thickness 2.2 mm)."

(1) Modification: "The total coating thickness shall have a nominal value of 3.0 to 5.0mm. No point above 5.5mm or value defined in the Project material requisition".

(1) Addition: For horizontal directional drilling application the minimum total thickness shall be 7mm.

(2.1.1) Modification: "Infrared scan is not mandatory."

(2.1.1) Addition: "Density, Gel time at (205 \pm 3)°C, Particle size, Moisture content and Thermal characteristics may be evaluated in accordance with CSA Z245.20 Standard."

(2.1.2) Addition: "Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials".

(2.1.2) Modification: "Hot water adhesion test is not mandatory."

(2.1.2) Addition: "Data of hot water adhesion test is requested."

(2.1.2) Addition: "Data of flexibility test at 0°C is requested."

(2.1.2) Addition: "Data of impact resistance test is requested."

(2.1.2) Addition: "Data of salt spray test is requested."

(2.2.2) Addition: "Data of flexural modulus test is requested."

(2.2.2) Addition: "Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials."

(2.2.2) Addition: "Elongation at break and Tensile yield strength may be evaluated in accordance with ASTM D638 Standard."

(2.2.2) Modification: "Elongation at break at 23 \pm 2°C shall be 500% as minimum."


(2.3.1) Addition: "Melting point may also be evaluated in accordance with ASTM D3418 Standard or ISO 11357-1 and 3."

(2.3.1) Addition: "Pigment type and dispersion shall be carried out as per ISO 18553 Standard. Appearance = photograph reference maximum A3, agglomerate = average degree ≤ 3 ."

(2.3.1) Addition: "Carbon black content shall be evaluated in accordance with ISO 6964 Standard. The acceptance criterion is 'between 2.0% and 2.8%'."

(2.3.1) Addition: "Melting point test is requested."

(2.3.1) Addition: "Thermal stabilization (OIT) is requested. The acceptance criterion is min. 10min at 220°C."

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Note: Aluminum pan without cover.”

(2.3.2) Addition: “Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials.”

(2.3.2) Addition: “Hardness may be evaluated in accordance with ASTM D2240 Standard.”

(2.3.2) Addition: “Elongation at break and Tensile yield strength may be evaluated in accordance with ASTM D638 Standard.”

(2.3.2) Modification: “Indentation test is not mandatory.”

(2.3.2) Modification: “Impact resistance test is not mandatory.”

(2.4.1) Addition: “Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials”.

(2.4.1) Addition: “Data of viscosity of base and hardener is requested.”

(3.1) Modification: “Water soluble contamination of abrasives: Acceptance criteria changed to $\leq 150\mu\text{S}/\text{cm}$ in accordance with ABNT NBR 15221-2:2014.”

(3.1) Addition: “Visual inspection of blasted surface: NACE No. 2/SSPC-SP 10 (Near-White Metal Blast Cleaning) standard may be considered as an alternative to ISO 8501-1.”

(3.2.1) Modification: “Frequency for evaluation of Porosity during production: one pipe on 1st shift of the project.”

(3.2.1) Modification: “Pull-off adhesion test shall be performed in substitution of dry adhesion test. Minimum acceptance criterion is 15MPa at 23°C and the test shall be performed in accordance with ASTM D4541, method D, E or F. Five tests shall be performed during PQT and three tests shall be performed on start of each shift during production.”

(3.2.2) Modification: “The adhesive layer thickness shall be 200 μm as minimum.”

(3.2.3) Modification: “The Peel strength test temperature shall be between 20°C to 35°C.”

(3.2.3) Modification: “Adhesion (peel strength at 20°C \pm 3°C and at 80°C \pm 3°C): testing in accordance with ISO 21809-1 Annex C, constant peeling speed (hanging mass is not acceptable).”

(3.2.3) Addition: “Elongation at break may be evaluated in accordance with ASTM D638.”

(3.2.3) Modification: “Hardness: All PQT pipes shall be tested.”

(3.2.3) Modification: “Tensile yield strength at 23 \pm 2°C: frequency during PQT is one pipe. During production the test frequency will be once per PE batch.”

(3.2.3) Modification: “Residual magnetism of linepipe material: Maximum average of 20 Gauss (no reading above 25 Gauss) / all pipes during PQT / 1st pipe of the shift during production.”

Coating Data Sheet No.3: 3-Layer Polypropylene Coating

(1) Modification: “The FBE layer thickness shall be between 200 μm and 450 μm ”.

(1) Modification: “The adhesive layer thickness shall be 200 μm as minimum”.

(1) Deletion: “Thickness Polypropylene outer sheet: According to ITP (min. thickness 2.2 mm)”.

(1) Modification: “The total coating thickness shall have a nominal value between 3.0 to 5.0mm. No point above 5.5mm or in accordance with the Project material requisition”.


(2.1.1) Addition: “Density, Gel time at (205 \pm 3)°C, Particle size, Moisture content and Thermal characteristics may be evaluated in accordance with CSA Z245.20 Standard”.

(2.1.1) Modification: “Infrared scan is not mandatory.”

(2.1.2) Addition: “Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials”.

(2.1.2) Modification: “Hot water adhesion test is not mandatory.”

(2.1.2) Addition: “Data of flexibility test at 0°C is requested.”

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<p>(2.1.2) Addition: "Data of impact resistance test is requested."</p> <p>(2.1.2) Addition: "Data of salt spray test is requested."</p> <p>(2.2.2) Addition: "Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials".</p> <p>(2.2.2) Addition: "Elongation at break and Tensile yield strength may be evaluated in accordance with ASTM D638 Standard."</p> <p>(2.2.2) Addition: "Data of flexural modulus is requested."</p> <p>(2.3.1) Addition: "Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials".</p> <p>(2.3.1) Addition: "Melting point may be evaluated in accordance with ASTM D3418 Standard or ISO 11357-1 and 3".</p> <p>(2.3.1) Modification: "Pigment type and dispersion is not mandatory."</p> <p>(2.3.1) Addition: "Data of melting point is requested."</p> <p>(2.3.1) Addition: "Data of thermal stabilization (OIT) is requested. The acceptance criterion is a minimum of 40min at 220°C. Note: Aluminum pan without cover."</p> <p>(2.3.2) Addition: "Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials".</p> <p>(2.3.2) Addition: "Hardness may be evaluated in accordance with ASTM D2240 Standard".</p> <p>(2.3.2) Addition: "Elongation at break and Tensile yield strength may be evaluated in accordance with ASTM D638 Standard".</p> <p>(2.3.2) Modification: "Data of indentation is not mandatory."</p> <p>(2.3.2) Modification: "Data of impact resistance is not mandatory."</p> <p>(2.4.1) Addition: "Properties within this section shall be informed within the Technical data sheet of material. It is not necessary to carry out such tests during the inspection process of incoming materials".</p> <p>(2.4.1) Addition: "Data of viscosity of base and hardener is requested."</p> <p>(3.1) Modification: "Water soluble contamination of abrasives: Acceptance criteria is $\leq 150\mu\text{S}/\text{cm}$ in accordance with ABNT NBR 15221-2:2014."</p> <p>(3.1) Addition: "Visual inspection of blasted surface: NACE No. 2/SSPC-SP 10 (Near-White Metal Blast Cleaning) standard may be considered as an alternative to ISO 8501-1."</p> <p>(3.2.1) Modification: "Frequency for evaluation of Porosity during production: one pipe on 1st shift of the project."</p> <p>(3.2.1) Modification: "Pull-off adhesion test shall be performed in substitution of dry adhesion test. Minimum acceptance criterion is 15MPa at 23°C and the test shall be performed in accordance with ASTM D4541, method D, E or F. Five tests shall be performed during PQT and three tests shall be performed on start of each shift during production."</p> <p>(3.2.2) Modification: "The adhesive layer thickness shall be 200μm as minimum".</p> <p>(3.2.3) Addition: "Elongation at break and Tensile yield strength may be evaluated in accordance with ASTM D638 Standard."</p> <p>(3.2.3) Addition: "Acceptance criterion for OIT at 220°C shall be 40 minutes as minimum in accordance with ASTM D 3895 or ISO 11357 1 and 3."</p> <p>(3.2.3) Modification: "Adhesion (peel strength at 20°C \pm 3°C): peel strength temperature shall be from 20°C to 35°C."</p> <p>(3.2.3) Modification: "Adhesion (peel strength at 20°C \pm 3°C and at 80°C \pm 3°C): testing in accordance with ISO 21809-1 Annex C, constant peeling speed (hanging mass is not acceptable)."</p> <p>(3.2.3) Modification: "Hardness: frequency during PQT is all pipes."</p> <p>(3.2.3) Modification: "Tensile yield strength at 23 \pm 2°C: frequency during PQT is one pipe / during production"</p>			



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is each PP batch.”

(3.2.3) Modification: “Residual magnetism of linepipe material: as per ITP / average 20 Gauss (no reading above 25 Gauss) / all pipes during PQT / 1st pipe of the shift during production.”

Coating Data Sheet No. 4: Deleted.

Coating Data Sheet No. 5: Deleted.