REVISION INDEX

REV	DESCRIPTION AND/OR AFFECTED SHEETS
0	FIRST ISSUE
A	INCLUDED ITEM 7.4 AND REVISED TABLE IV

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
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STANDARDIZED FORM FROM PETROBRAS N-381-REV.L STANDARD

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1. OBJECTIVE

To establish the applicable minimum requirements for the three-layer extruded polyethylene coating, applicable to the external surface of steel pipes to be used in buried pipelines, operating at temperatures between - 40 ºC and 80 ºC.

Notes:

1. Anti-corrosive coating considered by this technical specification comprises a **coating system** type three-layer, composed by the following materials: epoxy powder (primer), adhesive copolymeric and high-density polyethylene.
2. The application of this coating shall be realized according to an Application Procedure achieved by the manufacturer, according to item 3. The procedure shall be qualified according to item 4 of this technical specification, before the beginning of the production tasks of the coating system at the manufacturer, except the procedure is qualified at PETROBRAS.

2. REFERENCE STANDARDS

The standards listed below contain provisions that, when mentioned on this document, become prescriptions of this technical specification. If there are any differences between the requirements of these standards and what has been defined on this technical specification, what has been defined on this document shall prevail.

- ASTM D 257 - Standard test methods for DC resistance or conductance of insulating materials;
- ASTM D 638 - Standard test method for tensile properties of plastics;
- ASTM D 790 - Standard test methods for flexural properties of unreinforced and reinforced plastics and electrical insulating materials;
- ASTM D 792 - Standard test methods for density and specific gravity (relative density) of plastics by displacement;
- ASTM D 1238 - Standard test method for melt flow rates of thermoplastics by extrusion plastometer;
- ASTM D 1525 - Standard test method for Vicat softening temperature of plastics;
- ASTM D 1603 - Standard test method for carbon black in olefin plastics;
- ASTM D 1693 - Standard test method for environmental stress-cracking of ethylene plastics;
- ASTM D 2240 - Standard test method for rubber property – durometer hardness;
- ASTM D 3349 - Standard test method for absorption coefficient of ethylene polymer material pigmented with carbon black;
- ASTM D 3418 - Standard test method for transition temperatures of polymers

by differential scanning calorimetry;

- ASTM D 3895 - Standard test method for oxidative-induction time of polyolefin by differential scanning calorimetry;
- ASTM D 4218 - Standard test method for determination of carbon black content in polyethylene compounds by the muffle-furnace technique;
- ASTM D 4940 - Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives;
- CAN/CSA Z245.20-2002 - External fusion bond epoxy coating for steel pipe;
- DIN 30670 - Polyethylene coatings for steel pipes and fittings;
- ISO 306 - Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST);
- ISO 1133 - Plastics - Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics;
- ISO 1183-1 - Plastics – Methods for determining the density and relative density of non-cellular plastics;
- 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 8502-3 - Preparation de Steel Substrates Before Application de Paint and Related Products - Tests for the Assessment de Surface Cleanliness;
- ISO 8502-6 - Preparation of Steel Substrates before Application of Paints and Related Products -Tests for the Assessment of Surface Cleanliness-Part 6: Extraction of water soluble contaminants for analysis (Bresle method);
- ISO 8502-9 - Preparation of Steel Substrates before Application of Paints and Related Products -Tests for the Assessment of Surface Cleanliness-Part 9: Field Method for the Conductometric Determination of Water-Soluble Salts;
- ISO 8503-4 - Preparation of Steel Substrates before Application of Paints and Related Products -Surface Roughness Characteristics of Blast-Cleaned Steel Substrates -Part 4: Method for the Calibration of ISO Surface Profile Comparators and for the Determination of Surface Profile -Stylus Instrument Procedure;
- ISO 8503-5 - Preparation of Steel Substrates before Application of Paints and Related Products -Surface Roughness Characteristics of Blast-Cleaned Steel Substrates-Part 5: Replica Tape Method for the Determination of the Surface Profile;
- ISO 11357-1 - Plastics – Differential scanning calorimetry (DSC) – Part 1: General principles
- ISO 11357-3 - Plastics – Differential scanning calorimetry (DSC) – Part 3: Determination of temperature and enthalpy of melting and

cristalization;

- ISO 11357-6 - Plastics – Differential scanning calorimetry (DSC) – Part 6: Determination of oxidation induction time;
- ISO 18553 - Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds;
- ISO 21809-1 - Petroleum and natural gas industries – External coatings for buried or submerged pipelines used in pipeline transportation systems – Part 1: Polyolefin coatings (3-layer PE and 3-layer PP);
- ISO 22088-3 - Plastics – Determination of resistance to environmental stress cracking (ESC) – Part 3: Bent strip method
- NACE Nº2/SSPC-SP10 - Surface preparation specification no. 10, near-white blast cleaning;
- NACE Standard SP-0274 - High-voltage electrical inspection of pipeline coating prior to installation;
- SSPC Guide 15 - Field methods for retrieval and analysis of soluble salts on steel and other nonporous substrates;

3. COATING APPLICATION PROCEDURE

The manufacture Application Procedure of the coating system shall meet all the requirements of this document and it shall include at least the following items:

a) Identification of plant;

b) Technical document or standard on which the procedure was based, if any;

c) Scope;

d) Identification of the coating system, indicating the pipeline operating maximum temperature where the system can be used;

e) List of equipment and measurement instruments that shall be used;

f) Plan of receiving, storing and transportation coating materials and bare pipes;

g) Coating application method, contemplating:

- Cleaning of pipes;
- Surface blast, mentioning degree of preparation, equipment and materials to be used;
- Application method of materials;
- Pipe quenching method;

j) Repair methods on applied coating;

k) Identification system of coated pipes;

l) Plan of handling and storing coated pipes;

m) Method used to determine the causes of defects with an incidence above the acceptable levels;

n) Entity responsible by the tests.

4. COATING APPLICATION PROCEDURE QUALIFICATION

4.1 Before the beginning of this qualification, the applier shall present the Application Procedure approved by PETROBRAS, as well as the Quality Certificates of the coating materials containing, at least, the commercial reference and physic-chemicals characteristics, according to item 5.

4.2 The coating materials that will be used shall undergo lab tests, as to verify if they comply with the requirements of item 5.

4.3 Then, at least five pipes shall be coated, in conformity with the Application Procedure, and all the tests and inspections defined on items 8 and 9.2 shall be performed to each and every one of them and recorded, regardless of the frequencies defined on their tables.

4.4 The description of the activities, inspection points, the criteria of acceptance, frequency of the checks, remedial actions, reporting shall be attached to Tests and Inspection Plan (ITP).

Note: The qualification of the Application Procedure shall be interrupted whenever any test or inspection performed presents an unacceptable result and the whole qualification process shall be started again. During the new qualification, the material that already complied with Item 4.2 can be skipped of new lab tests. The procedure shall be considered qualified when all tests and inspections are according to the requirements established in this Technical Specification.

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

4.6 Once the procedure qualification has been concluded, the applicator of the coating system shall issue, for PETROBRAS' final approval and before the beginning of the production tasks, a Databook just identify, containing at least the following information and/or documentation:

a) Providers of coating materials (primer epoxy, copolymer adhesive and polyethylene);

b) Specification of coating materials;

c) Quality Certificate of coating materials;

d) Coating Application Procedure;

e) Equipment and measurement instruments (with the respective calibration certificate) of the application process;

f) ITP approved;

g) Results of the inspections and tests of the coating materials, during coating production, as well as the applied coating, issued by the corresponding entity that carried out the tests.

5. TECHNICAL CHARACTERISTICS OF COATING MATERIALS

Coating materials shall comply with the requirements mentioned on Tables I, II and III.

Table I – Epoxy Powder Requirements

Properties (1)		**Units**	**Limit Values**	**Test Methods**
Density (3)		g/cm³	(2)	CAN/CSA Z245.20 Item 12.6
Particle size	Retained on 60 mesh sieve (250 µm)	%	Max. 0.2	CAN/CSA Z245.20 Item 12.5
	Retained on 100 mesh sieve (150 µm)		Max. 4.0	
Gel time at 205 ºC		s	(3)	CAN/CSA Z245.20 Item 12.2
Cure time at 232 ºC		s	(3)	CAN/CSA Z245.20 Item 12.1
Glass transition temperature	Tg_1	ºC	(3)	CAN/CSA Z245.20 Item 12.7
	Tg_2		Min. 95	
Moisture content		% in mass	Max. 0.6	CAN/CSA Z245.20 Item 12.4
Flexibility of the Coating 2,5º/PD at 30ºC (Film applied on metallic panel, with 250 µm ± 100 µm thickness)		(4)		CAN/CSA Z245.20 section 12.11

Notes:

1) It shall be informed on the Quality Certificate of the material;
2) The value shall be specified by the manufacturer, accept a tolerance of 0,05 g/cm3;
3) The value shall be specified by the epoxy powder manufacturer, not exceeding ± 20 %;
4) Without cracking, disbondment or discontinuity.

Table II – Copolymer Adhesive Requirements

Properties (1)	Units	Limit Values	Test Methods
Melt flow index 190 ºC / 2.16 kg (2)(4)	g/10 min	Max. 9	ASTM D 1238 or ISO 1133
Density (2)	g/cm^3	0,91 to 0,96	ASTM D 792 or ISO 1183-1
Yield strength (3)	MPa	Min. 10	ASTM D 638
Elongation at break (3)	%	Min. 500	ASTM D 638
Softening point (VICAT) 10N @ 50ºC/h	ºC	Min. 90	ASTM D 1525 or ISO 306
Melting point (5)	ºC	Min. 115	ASTM D 3418 or ISO 11357-1 and 3

Notes:

1) It shall be informed on the Compliance Certificate of the material;
2) It shall be informed on the Quality Certificate of the material;
3) Test specimen type IV, with 50 mm/min speed of testing;
4) The value shall be specified by the manufacturer, not exceeding ± 20 %;
5) The value is linked the higher melting point observed.

Table III – Polyethylene Requirements (HDPE)

Properties (1)		Unit	Limit Values	Test Method
Density with carbon black (2)		g/cm^3	≥ 0.950	ASTM D792 or ISO 1183-1
Pigment dispersion (3) (4)	Appearance	Photo	Max. A3	ABNT NBR ISO 18553
	Agglomerate	Grade	Averange ≤ 3	
UV Absorption coefficient		Abs/cm	Min. 3.000	ASTM D3349
Melt flow index 190 ºC/2.16 kg (2)(3)		g/10min	0.1 to 0.8	ASTM D1238
Carbon black content (2) (5)		%	2 to 2.8	ASTM D1603
Yield strength at 23 ºC (2)(4)		MPa	Min. 21	ASTM D638
Elongation at break at 23 ºC (2)(4)		%	Min. 700	ASTM D638
Flexural modulus		MPa	Min. 900	ASTM D790 Procedure B

Oxidative-induction time in oxygen at 220ºC (aluminum pan, no screen) (2)	Minute	Min. 10	ASTM D3895 or ISO 11357-1 and 11357-6
Environmental stress-crack resistance condition	h	Min. 500 (for F50) condition "B"	ASTM D1693 or ISO 22088-3
Hardness Shore D (t=1s) (2)	-	Min. 60	ASTM D2240
Volume resistivity	Ω.cm	Min. 10^{14}	ASTM D257
Softening point (VICAT) 10N @ 50ºC/h	ºC	Min. 115	ASTM D1525 or ISO 306
Melting point	ºC	Min. 125	ASTM D3418 or ISO 11357-1 an ISO 11357-3

Notes:

1) It shall be informed on the Compliance Certificate of the material;
2) It shall be informed on the Quality Certificate of the material;
3) The value shall be specified by the manufacturer, not exceeding ± 20 %;
4) Test specimen type IV, with 50 mm/min speed of testing;
5) Alternatively, the test may be carried out by microwave method in accordance with ASTM D 4218.

6. STORAGE AND TRANSPORTATION OF COATING MATERIALS AND PIPES

6.1 Coating Materials

6.1.1 Storage

6.1.1.1 Epoxy powder shall be conditioned at a temperature not higher than 27 °C and the air relative humidity lower than or equal to 70%. It shall be at least 10 cm distant from the ground and inside its original package.

6.1.1.2 All other materials needed for the coating shall be stored on covered and ventilated place, where the ambient temperature shall not exceed 45 °C. They shall be stored inside their original packages at least 10 cm distant from the ground in order to avoid damages and far from occasional heat sources.

6.1.1.3 All the materials shall be stored strategically so that the ones to be utilized first are the ones marked with the oldest expiring dates.

6.1.1.4 The storage conditions shall attend the material manufacture’s instruction.

6.1.2 Transportation

6.1.2.1 The coating materials shall be transported in a way to avoid damages.

6.1.2.2 Packages with the coating materials shall not be left under the weather.

6.2 Pipes

6.2.1 Storage

6.2.1.1 Storage shall be done so as to avoid any kind of damage or wear that may endanger the performance of the coating to be applied.

6.2.1.2 Pipes having a diameter/thickness relation above 120, wooden crosspieces shall be installed at their ends to avoid out-of roundness.

6.2.2 Transportation

6.2.2.1 Coated pipes transportation shall be made so as to avoid coating damages.

6.2.2.2 Pipes having a diameter/thickness relation above 120, wooden crosspieces shall be installed at their ends to avoid out-of roundness.

7. COATING APLICATION METHOD

7.1 Surface Preparation

7.1.1 Cleaning

7.1.1.1 Pipe surfaces shall be free from oil, grease, burrs or loose oxide layers and other foreign materials.

7.1.1.2 The contamination by soluble salts shall be checked in conformity with ISO 8502-6 and ISO 8502-9 or by method described in subsection 4.6 of SSPC Guide 15. The maximum allowable contaminant value is 2 $\mu g/cm^2$, measured by electronic instrument.

7.1.2 Preheating

Prior blast cleaning (abrasive cleaning), if necessary, the pipe shall be preheated to remove moisture. The pipe surface shall be kept at a temperature of at least 3°C above dew point, however below 100°C.

7.1.3 Blast cleaning

7.1.3.1 Surface blast cleaning shall be performed in two steps, that are:

a) The first blast may use steel shot or mixture of shot and grit, aim to attend item 7.1.3.2;

b) The second blast should use angular steel grit, aim to attend item 7.1.3.2 and 7.1.3.4.

7.1.3.2 The surface to be coated shall be subject to blasted until near-white metal, as per standard NACE nº2/SSPC-SP10 or Sa 2 1/2 of standard ISO 8501-1.

7.1.3.3 Inspection of the abrasive:

a) Contamination by oil or grease: shall be verified through a sample of the mixture taken from the blasting equipment. This sample, of approximately 100 g, shall be placed inside a clean glass recipient, which shall be filled with distilled water. After 3 min, the water surface shall be checked for the presence of oil or grease spots.

b) Contamination by soluble salts: shall be verified the concentration according to ASTM D 4940 with maximum acceptable value of 1000 µmho/cm.

c) The abrasive shall be free of visible signs of impurities.

d) The abrasive shall be free of oxidation.

e) The granulometry of the new abrasive shall meet the specified.

7.1.3.4 The resulting roughness profile shall be between 60 μm and 100 μm, measured by means the method "Replica Tape" (Press-o-Film) in accordance with ISO 8503-5 or Stylus method as per ISO 8503-4 and, in this case, considering the parameter Rz_{DIN} or Ry5 and have angular nature. The total roughness value shall be obtained from the average of three random measures over the pipe surface.

7.1.3.5 All abrasive remaining inside the pipe shall be removed.

7.1.3.6 The pipe shall be free from welding contamination and lamination defects. If any, they shall be removed by grinding, regarding the thickness limits defined by the pipe manufacture specifications. Each abraded area shall not be greater than 150 cm^2 and the total area shall not exceed 0.5% of the external pipe surface area. Otherwise, pipes shall be blasted cleaning again.

7.1.3.7 Blasted pipes, clean and accepted for coating shall be coated within a period of two hours. Whenever the relative humidity is greater than 85%, or it is raining, this period of time shall be reduced to one hour. Whenever there is oxidation, the pipe shall be blasted again.

7.1.3.8 The surface of the blasted pipe shall be free from powder contamination, which shall not exceed as indicated in figure 2 of the ISO 8502-3.

7.2 Heating

7.2.1 Pipe heating is to be preferably performed by induction oven or any other process assuring non-contamination of the surface. Direct flame heating is not allowed.

7.2.2 The temperature shall be checked before epoxy application at maximum intervals of 60 minutes, by contact thermometer or thermal pens that do not contaminate the pipe surface.

7.2.3 The pipe surface temperature shall be continuously monitored by an infrared optic pyrometer (immediately before and after epoxy application), connected to a graphic recorder.

7.2.4 The external pipe temperature shall be defined by the applicator and in accordance with recommendations of the epoxy powder manufacturer. The pipes that have exceed the recommendation shall be rejected.

7.3 Application of Coating Materials

7.3.1 Application of Epoxy Powder

7.3.1.1 The epoxy powder shall be applied by an electrostatic spray gun connected to a compressed air system. The air that feeds the system shall be free from water, oil, and any other impurities. The equipment shall be provided at least with separating filters containing silica gel and carbon active, to remove water and oil, respectively, or other drying device that assures air purity.

7.3.1.2 Recycling processed epoxy powder is not allowed.

7.3.2 Application of the Copolymer Adhesive

7.3.2.1 Minimum overlapping of 10 mm between the adhesive layers shall be assured when applied by lateral extrusion.

7.3.2.2 At the beginning of each work shift or interruption exceeding one hour, full elimination of the material remaining inside the extruder shall be provided.

7.3.2.3 The adhesive extrusion temperature shall be provided within the limits established by the manufacturers of such raw material.

7.3.2.4 Recycling of copolymer adhesive is not allowed.

7.3.3 Application of Polyethylene

7.3.3.1 Polyethylene extrusion temperature shall be provided within the limits established by the manufacturer of such raw material.

7.3.3.2 At the beginning of each work shift or interruption exceeding one hour, full elimination of the material remaining inside the extruder shall be provided.

7.3.3.3 Recycling of polyethylene adhesive is not allowed.

7.4 Pigment for identification of coated pipes

7.4.1 When requested in material requisition identification by color, the external coating shall be pigmented with a fourth layer using pigmented powder polyethylene (micronized polyethylene).

7.4.2 This micronized polyethylene shall be applied with concentration of at least 250 g/m^2 by spray gun. The color tone and the concentration of micronized polyethylene used should allow the contrast of the coated pipe and the identification at a distance.

Note: Item not applicable when the color indicated is black, which is the basic color of the coating.

7.5 Quenching

Following the application of the polyethylene layer, the pipe shall be cooled by water quenching so that at the end of the line the pipe temperature is less than 90ºC.

7.6 Pipe Ends

7.6.1 All pipes shall be supplied with a strip of 120 ± 10 mm without coating on both ends.

7.6.2 The ends of the coating shall be chamfered with an angled less them 30º in relationship to the external surface of the pipe.

7.6.3 Cutbacks shall receive a temporary anticorrosive protection with at least 30 days useful life and be easily removed, except contrary consent between the coating applier and the client.

8. APPLIED COATING REQUIREMENTS

8.1 Thickness of the Applied Coating

It shall comply with the indicated in table IV.

Table IV –Thickness of the Coating

Pipe Diameter	FBE	Adhesive	HDPE	Total
Up to 20” (up to 500 mm)	250 ± 100 µm	min. 200 µm	Note	min 1.6 mm
From 22” to 30” (550 to 750 mm)				min 1.8 mm
Greater than 30” (greater than 750 mm)				min 2.2 mm
FOR DIRECTIONAL DRILLING				
Up to 20” (up to 500 mm)	250 ± 100 µm	min. 200 µm	Note	min 2.4 mm
From 22” to 30” (550 to 750 mm)				min 2.7 mm
Greater than 30” (greater than 750 mm)				min 3.3 mm
Note The PE layer shall have a thickness that meets the minimum total thickness.				

8.2 Properties of the Applied Coating

The values of Table V shall be obtained for coating as applied on pipe.

Table V – Requirements of the Applied Coating

Properties	Units	Limit Values	Test Method
Impact at 60 °C ± 2 ºC (5)	J/mm	Min 7	ISO 21809-1 Annex E
Peel strength at 23 °C ± 2 ºC (1)	N/mm	Min 15	ISO 21809-1 Annex C
Peel strength at 80 °C ± 2 ºC (1)	N/mm	Min 3	ISO 21809-1 Annex C
Bending at temperature of 0 °C ± 2ºC	Degrees per pipe length diameter	No cracking at an angle of 2,5 º per pipe diameter length	ISO 21809-1
Cathodic disbondment 24 hours / 65 ± 3°C / - 3,5 V (4)	mm	≤ 5	ISO 21809-1
Cathodic disbondment 28 days / 23 ± 3°C / - 1,5 V (4)	mm	≤ 7	ISO 21809-1
Cathodic disbondment 28 days / 80 ± 3°C / - 1,5 V (4)	mm	≤ 15	ISO 21809-1
Resistance to hot water immersion test	mm	Average ≤ 2 and maximum ≤ 3	ISO 21809-1 Annex M
Discontinuity Test	-	No holidays	Item 9.3.4
Elongation at break (2)(3)	%	Min. 400	ASTM D638
Yield Strength (2)(3)	MPa	Min. 17	ASTM D638

Melt flow index variation after thermal ageing at 100 ºC in 10 days	%	Max. 25	Ageing as per standard DIN-30670. Melt flow Index as per standard ASTM D 1238 or ISO 1133
Indentation at 70 °C ± 3ºC (3)	mm	≤ 0.3	ISO 21809-1
Degree of Cure of the epoxy ΔTg	ºC	-2 ≤ ΔTg ≤ +3	ISO 21809-1

Notes:

1) Peel Strength test shall be done complying with item 9.2.4 and 9.2.5;
2) Test specimen type IV, with 50 mm/min speed of testing;
3) These tests shall be performed on the applied PE and detached from the pipe;
4) The voltage at the reference electrode and the temperature of the metallic substrate of the specimen shall be monitored ad recorded continuously (24h a day);
5) The impact test shall be done at ten points of the pipe, at least 30 mm far from each other.

9. INSPECTION AND PRODUCTION TESTS

9.1 Coating Materials

9.1.1 Inspection when materials are received shall include at least the following:

a) Concordance with purchasing documents and required specific conditions;

b) Checking the certificate of quality, which shall certify compliance with the requirements of Tables I, II and III;

c) Checking the temperature record during the epoxy powder transportation according to 6.1.2. In case of the temperature was exceed, the manufacturer shall be asked aiming to certify the material quality;

d) Checking the packages integrity;

e) Checking the presence of moisture inside the packages. Should it occur, the packages shall be set aside and the manufacturer asked what are the actions that shall be taken;

f) Epoxy material of the each arrived vehicle shall be analyzed and comply with the requirements of gel time, glass transition temperature and moisture content;

9.1.2 The material storage conditions shall be verified in accordance with 6.1.1. If these conditions are not complying, the material shall be set aside and the manufacturer asked what are the actions that shall be taken. In case of epoxy powder, requirements of gel time, glass transition temperature and moisture content shall be met.

9.1.3 If the result of any of the tests indicate a failure, to carry out 2 additional tests. If the result is confirmed, the batch shall be rejected and all the other batches shall be tested.

9.2 Inspection and Tests During Coating Production

These inspection and tests shall comply Table VI requirements.

Table VI – Inspection and Tests during Coating Production

Inspection	Criterion/item	Frequency
Pipe cleaning before blast	7.1.1	All pipes
Soluble salt contamination	7.1.1.2	At the beginning of every shift
Blasted surface	7.1.3.2	At the beginning or restart of every shift and every 1 h
Abrasive inspection	7.1.3.3	At the beginning of every shift and every 4 h
Roughness profile	7.1.3.1	At the beginning or restart of every shift and every 1 hour
Visual after blasting	7.1.3.2	All pipes
Environmental conditions	7.1.2 and 7.1.3.7	At the beginning or restart of every shift and every 1 hour
Dust contamination	7.1.3.8	At the beginning or restart of every shift and every 1 hour
Pipe surface temperature	7.2.1	Item 7.2.2 and 7.2.3
Epoxy layer thickness	Table IV	At the beginning or restart of every shift and after procedure changing
Degree cure of FBE	Table V	At the beginning or restart of every shift and after procedure changing
Copolymeric adhesive thickness	Table IV	At the beginning or restart of every shift and after procedure changing
Visual of the coating	9.2.1	All pipes
Yield Strength	Table V	5 tests at the beginning and after procedure changing
Elongation	Table V	5 tests at the beginning and after procedure changing
Indentation	Table V	3 tests at the beginning of the production and after batch changing
Holiday detector	9.2.3	All pipes
Total thickness	Table IV	1 every 10 pipes
Peel Test at 23°C	Table V	9.2.4
Peel Test at 80 ºC	Table V	9.2.5
Cathodic disbondment 24 h / 65 ± 3°C / - 3,5 V	Table V	At the beginning of every shift and after procedure changing
Bending	Table V	3 tests at the beginning of the shift and after batch changing
Residual magnetism	9.2.6	At the beginning of every shift and after procedure changing

9.2.1 Visual Inspection of the Coating

Visual inspection shall be made on all coated pipe surface. The defects shall be corrected in accordance with item 10.

9.2.2 Total Coating Thickness

9.2.2.1 Measurement shall be made by an electromagnetic, magnetic or ultra-sound device (accuracy of 5μm) on at least at 12 points of the coating, equally distributed along the extension and circumference of the pipe. The minimum, medium and maximum values shall be recorded.

9.2.2.2 Measurement device shall be gauged at least once every eight hours.

9.2.2.3 In case of lateral extrusion the thickness measurement shall be made away of the overlapping.

9.2.2.4 Minimum total thickness of the coating shall comply table IV of this ET.

9.2.3 Coating Discontinuity

9.2.3.1 Discontinuity inspection shall be made along the entire coated pipe surface.

9.2.3.2 The test voltage shall be 12 kV/mm of total coating thickness, limited to 25 kV. Shall be inspected using a pulsating high voltage equipment (holiday detector), dry test, in compliance with NACE SP-0274 Standard. The device shall be calibrated, at its sensitivity at least once every eight hours of work.

9.2.3.3 The contact electrode shall be made of conductive rubber, copper brush or square section wire spring and shall travel over the pipe at a maximum speed of 18 m/min.

9.2.3.4 Maximum acceptable number of holidays detected by the device is three per pipe.

9.2.3.5 All the defects detected on non rejected pipes shall be repaired according to item 10.

9.2.4 Adhesion at 23ºC

9.2.4.1 Ten tests shall be made on the pipe distributed along its length.

a) First pipe;

b) Every 500 pipes

9.2.4.2 Carry out a test which consist 4 peel tests in each of the positions 0h, 3h, 6h and 9h in the region of one of the cutbacks.

9.2.4.3 The adhesion test can be performed by any of the methods mentioned in Annex C of ISO 21809-1. No conditioning is required before the test.

9.2.5 Adhesion at 80ºC

9.2.5.1 Carry out a test which consist 4 peel tests in each of the positions 0h, 3h, 6h and 9h in the region of one of the cutbacks.

9.2.6 Residual magnetism

9.2.6.1 After applying the coating, the pipes must present residual magnetism with a value of less than 20 Gauss, in all its extension. Measurements must be performed at both ends of the pipe.

10. COATING REPAIRS

10.1 After inspection, the defective area shall be marked, thus making it easier to locate the defective areas.

10.2 The defects are classified into 3 types, that are:

a) Type I Defect – pinhole or defect with an area smaller than or equal to 1 mm2 detected by the coating discontinuity test;

b) Type II Defect – defect with an area smaller than 100 cm^2, and it does not reach the metal surface.

c) Type III Defect – defect with an area smaller than 100 cm^2, and it reachs the metal surface;

10.3 Imply the rejection of the coating:

a) more than 3 defects;

b) defect with an area greater than 100 cm^2;

c) defects located less than 20 mm from the edges of the coating.

10.4 Type I, II and III defects shall be repaired according to a procedure presented by coating and approved by customer.

10.5 All repaired area shall be submitted to discontinuity testing as per item 9.2.3.

11. COATED PIPES IDENTIFICATION

11.1 Original identification realized on the pipe by the pipe's manufacturer shall be preserved or remade if it is damaged during the coating process.

11.2 The identification on coated pipes shall be externally made on a position previously agreed upon between the applicator and the client. The identification shall contain at least the following information:

a) Logo or name of the applicator;

b) Coating type;

c) Coating application date;

d) Traceability code. Traceability code shall allow a complete verification of the steps of the pipe manufacturing.