
	<b>TECHNICAL SPECIFICATION</b>		Nº: <b>I-ET-0000.00-0000-217-P9U-003</b>
	CLIENT: <b>PETROBRAS</b>		SHEET: 1 de 22
	JOB: <b>RIGID OFFSHORE PIPELINES</b>		CC
	ÁREA:		PROJECT:
ENGENHARIA	TÍTULO: <b>INTERNAL LIQUID EPOXY ANTICORROSION COATING</b>		 EISE/EDR

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### INDEX OF REVISIONS


REV.	DESCRIPTION AND/OR REVISED SHEETS
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## 1 INTRODUCTION



- 1.1 The internal liquid epoxy anticorrosion coating for Rigid Offshore pipelines and Risers is made up of the following components and in accordance with N-2912:
- a) Component A: Novolac epoxy resin;
  - b) Component B: Polyamine base cure agent.
- 1.2 All materials and processes shall be qualified and tested prior to coating application, as described in Clauses 8, 10 and 11.



## 2 SCOPE



- 2.1 This document specifies minimum requirements to perform internal liquid epoxy coating application on Rigid Offshore Linepipes and Risers. The SUPPLIER shall prove that his plant, materials and coating procedures result in a quality of end product, as specified in Clause 5.
- 2.2 The system shall combine the high bond-strength and high anticorrosion properties of epoxy liquid coating. The Material Requisition (RM) or Coating Assesement documents will define the maximum design temperature for each specific pipeline, although SUPPLIER shall consider that PETROBRAS may require design temperatures between - 15 °C and 70 °C.
- 2.3 This technical specification lists and describes the tests to be performed during pre-qualification, pre-production and production phases in accordance with the status of each coating system.

## 3 GENERAL

- 3.1 The technical qualification for the material shall include laboratory tests and full-scale tests to assure the required properties as specified in Clause 6 and 10. SUPPLIER shall issue Procedures and Inspection and Test Plan (ITP) for all tests to be performed during all phases of project.
- 3.2 The qualification tests listed in this specification shall be performed by SUPPLIER at his expenses and the report shall be issued to PETROBRAS for approval. PETROBRAS will witness the application process and qualification tests.
- 3.3 SUPPLIER shall support the offered internal liquid epoxy coating system by submitting certificates of tests conducted by an independent national or international testing laboratory, complete details of tests conducted, methods, standards used and results in conformity with properties requirements as specified in Clause 6 and 10.

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<p>3.4 The requirements of this Technical Specification shall prevail against the requirements of Standards listed in Clause 4.</p> <p>3.5 SUPPLIER shall, at his expense, carry out coating procedures trials for operational and installation phases to prove that the coating system material has the required properties as defined in applicable technical specifications.</p> <p>3.6 The procedures and ITP shall be in accordance with this document and submitted to PETROBRAS for approval 30 days prior to the beginning of the production.</p> <p>3.7 A quality system shall be applied to assist compliance with the requirements of this document.</p> <p>3.8 PETROBRAS reserves the right to follow and witness all stages described in this document according to eventual or permanent inspection. This inspection could be done by certifying companies or duly qualified professionals indicated by PETROBRAS.</p> <p>3.9 Purchaser and the end user shall have the right to inspect applicator's records at any time during the period of the contract.</p>															
<h4>4 REFERENCES</h4> <p>4.1 The following referenced documents are required for the application of this document. The way in which these referenced documents are cited determines (in whole or in part) the extent to which they apply.</p> <p>4.2 For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.</p> <table border="0"> <tr> <td>ABNT NBR 8094</td> <td><i>Material Metálico Revestido e Não Revestido – Corrosão por Exposição à Névoa Salina – Método de Ensaio;</i></td> </tr> <tr> <td>ABNT NBR 10443</td> <td><i>Tintas e Vernizes – Determinação da Espessura da Película Seca Sobre Superfícies Rugosas – Método de Ensaio.</i></td> </tr> <tr> <td>ABNT NBR 12103</td> <td><i>Tintas – Determinação do Descaimento – Método de Ensaio;</i></td> </tr> <tr> <td>ABNT NBR 15239</td> <td><i>Tratamento de Superfícies de Aço com Ferramentas Manuais e Mecânicas;</i></td> </tr> <tr> <td>ABNT NBR 15742</td> <td><i>Tintas e Vernizes – Determinação de Vida Útil da Mistura (“Pot-Life”);</i></td> </tr> <tr> <td>API RP 5L2</td> <td><i>Recommended Practice for Internal Coating of Line Pipe for Non-Corrosive Gas Transmission Service</i></td> </tr> </table>				ABNT NBR 8094	<i>Material Metálico Revestido e Não Revestido – Corrosão por Exposição à Névoa Salina – Método de Ensaio;</i>	ABNT NBR 10443	<i>Tintas e Vernizes – Determinação da Espessura da Película Seca Sobre Superfícies Rugosas – Método de Ensaio.</i>	ABNT NBR 12103	<i>Tintas – Determinação do Descaimento – Método de Ensaio;</i>	ABNT NBR 15239	<i>Tratamento de Superfícies de Aço com Ferramentas Manuais e Mecânicas;</i>	ABNT NBR 15742	<i>Tintas e Vernizes – Determinação de Vida Útil da Mistura (“Pot-Life”);</i>	API RP 5L2	<i>Recommended Practice for Internal Coating of Line Pipe for Non-Corrosive Gas Transmission Service</i>
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ASTM C 868	<i>Standard Test Method for Chemical Resistance of Protective Linings;</i>		
ASTM D 149	<i>Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies;</i>		
ASTM D 562	<i>Standard Test Method for Consistency of Paints Measuring Krebs Unit (KU) Viscosity Using a Stormer-Type Viscometer;</i>		
ASTM D 870	<i>Standard Practice for Testing Water Resistance of Coatings Using Water Immersion;</i>		
ASTM D 1210	<i>Standard Test Method for Fineness of Dispersion of Pigment-Vehicle Systems by Hegman-Type Gage;</i>		
ASTM D 1308	<i>Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes;</i>		
ASTM D 1475	<i>Standard Test Method for Density of Liquid Coatings, Inks, and Related Products;</i>		
ASTM D 1640	<i>Standard Test Methods for Drying, Curing or Film Formation of Organic Coatings at Room Temperature;</i>		
ASTM D-2240	<i>Standard Test Method for Rubber Property - Durometer Hardness</i>		
ASTM D 2247	<i>Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity;</i>		
ASTM D 4060	<i>Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser</i>		
ASTM D 4285	<i>Standard Test Method for Indicating Oil or Water in Compressed Air</i>		
ASTM D 4541	<i>Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers</i>		
ASTM D 4703	<i>Standard Practice for Compression Molding Thermoplastic Materials into Test Specimens, Plaques, or Sheets</i>		
CAN/CSA-Z245.20	<i>External Fusion Bond Epoxy Coating for Steel Pipe</i>		

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ISO 868	<i>Plastics and Ebonite – Determination of Indentation Hardness by Means of a Durometer (Shore Hardness);</i>
ISO 4624	<i>Paints and Varnishes – Pull-Off Test for Adhesion;</i>
ISO 8501-1	<i>Preparation of Steel Substrates Before Application of Paints and Related Products-Visual Assessment of Surface Cleanliness;</i>
ISO 8502-3	<i>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)</i>
NACE Standard RP-02-74	<i>High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation</i>
NACE Nº 2/SSPC-SP10	<i>Joint Surface Preparation Standard, Near-White Metal Blast Cleaning</i>
NACE Nº 2/SSPC-SP 1	<i>Joint Surface Preparation Standard, Solvent Cleaning</i>
NACE Nº 5/SSPC-SP12	<i>Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultrahigh-Pressure Water Jetting Prior to Recoating;</i>
PETROBRAS N – 1358	<i>Sólidos por Volume – Determinação pelo Disco de Aço;</i>
PETROBRAS N – 1367	<i>Determinação do Teor de Sólidos por Massa em Tintas e Produtos Afins;</i>
PETROBRAS N – 2719	Estocagem de Tubo em Área Descoberta
PETROBRAS N - 2912	Tinta Epoxy “Novolac”
<b>5 QUALIFICATION REQUIREMENTS</b>	
5.1 Materials shall meet the requirements of the applied technical specification. Materials shall be re-qualified in case of change in either the raw materials or any other conditions as defined in applicable specification.	
5.2 SUPPLIER shall consider that, unless otherwise written agreed, all qualification tests shall be performed. Historical data will be considered as information.	

- 5.3 The pre-qualification trials for this internal liquid epoxy coating system are valid to the specific conditions utilized on the coating application. In case of any change listed below, all the pre-qualification tests shall be repeated:
- a) Coating materials;
  - b) Surface preparation level (cleanness, roughness);
  - c) Temperature range of coating application;
  - d) Pre-treatment;
  - e) Equipment for application procedure;
  - f) Range of diameters: from 4 to 10.75in; from 10.76 to 20in and from 20.1 in to larger;
  - g) Variation in thickness of coating: -30% (negative variation);
  - h) Variation in thickness of steel: +/-15%;
  - i) Installation method and/or diameter of reel (if applicable).
- 5.4 If material analyzed fails to pass any of the tests referred in clause 6.1, after two further re-test which both shall be approved, the whole qualification lot shall be rejected. All results of re-testing will be analyzed by PETROBRAS representatives.
- 5.5 Pre-qualification trials shall be done in case of the coating system is not qualified in PETROBRAS or if any of the items listed in Clause 5.3 changes.
- 5.6 Pre-production trials shall be done in case the coating system is pre-qualified in PETROBRAS and production is defined to start more than 9 (nine) months after pre-qualification or production realization. These tests shall be done and results shall be obtained prior start production or application of coating system process.
- 5.7 Production trials shall be done during linepipe coating application process.
- 5.8 During pre-qualification and pre-production phases at least 10 pipes shall be produced and PETROBRAS will choose at least 5 pipes to be tested.
- 5.9 PETROBRAS (or certified professional) will witness all the qualification tests mentioned in this specification. Before the beginning of the qualification, SUPPLIER shall present the procedures and ITP approved by PETROBRAS, as well as the quality certificates of the coating materials containing, at least, commercial reference, physic-chemicals characteristics and material security data sheets (MSDS).
- 5.10 The qualification of the Application Procedure shall be interrupted whenever any test or inspection performed presents an unacceptable result. One (1) further re-test is allowed. All specimens shall pass otherwise the whole qualification process shall be started again. The procedure shall be considered qualified when all tests and inspections are according to the requirements established in this specification.

## 6 MATERIALS PROPERTIES


- 6.1 Material defined in section 1.1 shall meet the requirements specified in standard N-2912 Tables 1 and 4. Prior to coating, liquid epoxy shall be laboratory tested to check compliance with all requirements.
- 6.2 All samples approved on Atlas Cellule Immersion shall be submitted to set of two (2) adhesion pull-off tests according to ASTM D 4541. The following acceptance criteria shall be achieved for samples after immersion: 10 MPa.
- 6.3 A Material Qualification Dossier shall be issued, by the SUPPLIER, containing at least the following information:
- a) Material(s) Qualification Certificate(s);
  - b) Raw-material(s) supplier;
  - c) Raw-material(s) specification;
  - d) Name and complete identification of material, including plant of origin;
  - e) Product application temperature range;
  - f) Surface preparation;
  - g) Surface profile;
  - h) Organization that performed the material tests;
  - i) Report of tests performed and Tests results.

## 7 COATING PROCEDURE

- 7.1 Prior to the start of production and any agreed pre-qualification or pre-productions tests, SUPPLIER shall prepare an application and repair Coating Procedure including at least the following items:
- a) List of applied standard and codes;
  - b) Material Security and Specification Data sheets (trademarks, physical and chemicals characteristics);
  - c) Manufacturers instructions for application, including characteristics of equipment and measurement instruments that shall be used;
  - d) Range of diameters;
  - e) Range of Wall thickness;
  - f) Procedure for steel surface pipe cleaning;
  - g) Procedure for preheating pipes, specifying temperature;
  - h) Pipe surface mentioning type of preparation, equipment and applied materials;
  - i) Heating conditions of bare pipe, including the method of control and the temperature measurement and record;
  - j) Procedure for application of liquid epoxy coating;
  - k) Method of quenching, if applicable;
  - l) Procedure for protecting the coating system and pipe ends;
  - m) Procedure for repair;
  - n) Inspection plan for the coating materials, coating application and coated pipe with the acceptance/rejection criteria for the tests included in the method of inspection;





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- o) Inspection plan for receipt of various materials;
- p) Identification system of the coated pipes;
- q) Entity responsible for the tests;
- r) Method for determining the causes of defects with a rate of occurrence higher than acceptable levels;
- s) Coating supplier address and telephone for technical support in Brazil;
- t) Certifying firms or duly qualified professionals that may witness the tests.

7.2 The Application and Repair Coating Procedure shall be submitted to PETROBRAS for approval at least 30 days prior to the beginning of pre-qualification, pre-production and/or production works.

7.3 Once approved, the Coating Procedure shall not be changed by SUPPLIER without PETROBRAS written authorization.

## 8 COATING QUALIFICATION

8.1 Prior to start of production, SUPPLIER shall, at his expense, carry out a coating procedure qualification trial to prove that his equipment, materials and coating procedure result in a quality of end product.

8.2 All the tests and inspections to qualification described in this specification will be followed by PETROBRAS during the coating application. This inspection could be done by certifying firms and/or duly qualified professionals indicated by PETROBRAS.

8.3 All people involved in the coating application process shall be trained and qualified. Only qualified operators are allowed to apply the coating on the pipes.

8.4 Coating materials shall be subjected to tests in accordance with requirements in Clause 6.

8.5 The procedure shall be qualified through the coating of at least 10 (ten) pipes among them PETROBRAS will select 5 (five) pipes for qualification. From these 5 (five) selected coated pipes specimens shall be taken and subjected to test frequency stated in Clause 11 in accordance with requirements for the applied coating as Clause 10.

8.6 The dimension and quantity of test specimens, acceptance and rejection criteria and the location of the qualification tests shall be described in the Inspection and Test Plan and into Application and repair Coating Procedure.

8.7 The qualification process shall be interrupted when any test or inspection realized shows unacceptable results. Only one further re-test is allowed. All specimens shall pass otherwise the whole qualification lot shall be rejected and the coating process shall be completely redone.

8.8 Qualifications tests are valid to specific process conditions used on the coating application. In case of any change on the conditions listed in clause 5.3, all the qualification tests shall be repeated:

## 9 COATING APPLICATION

### 9.1 Surface Preparation

#### 9.1.1 Surface Cleaning and Preparation

9.1.1.1 Prior to coating application, the surface shall be dry and free of any contamination (such as detritus, dust, non adhering particles, grease, oil, soluble, etc.) detrimental to surface preparation or to adhesion of the coating on the steel. Oils, grease and wax shall be removed by solvent cleaning in accordance with SSPC SP1.

9.1.1.2 Steel defects and irregularities (e.g. arc strikes, scratches, weld spatter, slag and burrs) shall be brought to the attention of PETROBRAS' representative disposition.

9.1.1.3 Salt contamination shall be verified according NACE Nº 5/SSPC-SP 12, Table 2, condition SC-2. Maximum acceptable value is 2 µg/cm<sup>2</sup>, measured by ELCOMETER 130-SCM 400 or similar equipment. If salt contamination is found, suitable chemical pre-treatment or high pressure demineralised water shall be used to eliminate it prior to blasting.

#### 9.1.2 Blasting

9.1.2.1 Compressed air for blast cleaning shall be free of oil, condensed moisture or any other contaminants and shall conform to the requirements of ASTM D-4285.


9.1.2.2 Prior to blast cleaning, the pipe shall be preheated to remove moisture. Steel surface shall be kept at least 3°C above dew point and below 100°C.

9.1.2.3 Surfaces of the bare pipe shall be blast-cleaned with steel shot shown to near white metal as per SSPC-SP10 Standard. A finishing comparable to the one shown on pictures Sa 2 1/2 of ISO 8501-1 is the least expected.

9.1.2.4 Blasting operation shall have two steps:

- a) The first blast uses steel shots, to promote the cleaning of the external surfaces of pipes;
- b) The second blast uses steel grits, to promote the anchor pattern profile. The resulting surface profile shall be within 60 up to 100µm and has an angular nature. Roughness shall be measured using profilometer, replicating film, or



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PETROBRAS-approved equivalent. The results will be obtained by the average of three measures along the pipe.

9.1.2.5 All foreign materials shall be removed from interior of the pipe prior to coating.

9.1.2.6 After blasting, internal pipe surface shall be cleaned. The residual dust contamination after blasting shall be determined by adhesive tape method (ISO 8502-3) – Acceptance criteria Figure 2. All slivers, scabs, and gouges shall be removed by grinding. Each ground area shall not exceed 150cm<sup>2</sup> and the total ground area shall not exceed 0.5% at the pipe total area. Roughness shall be reconstituted at the ground area. Otherwise the pipe shall be blasted to meet the requirements of Clause 9.1.2.4 of this Specification. Acid wash may be used to remove any remaining contamination on external pipe surface.

9.1.2.7 Re-blasting activity. In case pipes need to be internally re-blasted to remove already applied internal coating the bevels of the pipes shall be protected.

## 9.2 Pipe Heating (if applicable)

9.2.1 Pipe heating shall be done through induction oven. Exposing the pipe to a direct flame is not allowed. The pipe surface temperature shall be continuously monitored by an optical infra-red pyrometer or contact thermometer connected to a graphic recorder.

9.2.2 The temperature shall also be controlled by tempil sticks, at a maximum interval of 60 (sixty) minutes.

9.2.3 Pipe heating temperature shall be kept within the epoxy SUPPLIER recommendations.

9.2.4 Pipes that were not coated within the qualified temperature range shall be re-coated.

## 9.3 Liquid Epoxy coating Application

9.3.1 The liquid epoxy coating shall be internally applied by an air-less or special centrifugal gun connected to a compressed air system. The air that feeds the system shall be free from water, oil, and any other impurities. After at least two layers of paint the dry thickness shall be achieved.

9.3.2 Recycling of the liquid epoxy coating is not allowed.

9.3.3 Internal liquid epoxy application equipment shall assess continually the paint flow and pressure during application process. This control system shall be installed at the extremity of equipment just before the 2 (two)

components of paint are mixed to be applied. Paint Pressure and Flow shall be registered.

#### 9.4 Pipe Ends

9.4.1 All pipes shall be furnished with a strip of either 50±5mm, 100±10mm or another configuration without coating in both ends as defined into material requisition document (RM) for a specific project. The pipe ends shall be provided with an easy-off removable protection against UV radiation and moisture exposition. The kind of protection shall be specified in the Application Procedure and Inspection and Test Plan.

9.4.2 Linepipes will be delivered with a protection to end (end cap), with the objective to prevent damage to ends and avoid the dust or contamination particles. This end cap shall avoid humidity ingress into pipe, shall be applied on pipes just after epoxy cure/inspection of internal coating and shall be kept applied on ends of pipes until start of the construction of the pipeline.

9.4.3 The Residual Magnetism after coating application shall follow the Material requirement document (RM) of linepipe coated supply order. When a specific value is not stated, requirements of DNV-OS-F101 2007 App. D shall be fulfilled.

9.4.4 All coated pipes shall be identified so that it shall be tracked. Every original identification done by pipe supplier shall be preserved or remade if during application procedure it had been damaged. The pipe identification shall contain the following items:

- a) *Logo and SUPPLIER name, including plant name;*
- b) *Type of coating (internal and external);*
- c) *Coating application Date;*
- d) *Traceability code;*
- e) *All identification required at PETROBRAS Linepipe Technical Specification.*

## 10 COATING PROPERTIES

10.1 Coating as applied shall follow the requirements of Table I and Clause 10.

### 10.2 Appearance and Constitution of the Coating

10.2.1 Appearance of the coating shall be uniform, smooth, with homogeneous color. Defects in detrimental to quality of the coating, especially grooves, cracks or flaws should not be observed.

10.2.2 Coating shall be homogeneous in weight and, in particular, free of blistering and lamination.

10.2.3 Appearance and constitution of the coating shall be checked visually.

### 10.3 Coating Dry Thickness

10.3.1 Monitoring of thickness shall be carried out according to an electromagnetic equipment or US equipment (with 5µm of precision) on at least 3 sections of one (1) internally coated pipe (beginning, middle and end). At least the 12, 3, 6 and 9 hours position shall be measured at each section. One of these 4 positions shall be on the longitudinal weld seam, if applicable. All the 12 points per section shall be registered.

10.3.2 Thickness at any point of the coating, including over a weld seam, if applicable, shall not be less than the total coating thickness value defined in the design specifications


10.3.3 Measure equipment shall be calibrated at least once per 8 hours of work.

10.3.4 Thickness measurements shall be performed in accordance to Table I.

**Table I– Applied Internal Liquid Epoxy Coating Properties**

REQUIREMENTS	UNIT	VALUES	TEST METHOD
Total Coating Dry Thickness	µm	450 (-50+150)	Clause 10.3
Surface Appearance		No defects or imperfections	Clause 10.2
Holiday Detection	-	No Holiday	Clause 10.4
Adhesion Pull-Off at (23 ± 2) °C	MPa	15 min	ASTM 4541
Foaming	level/rating	2	CAN/CSA Z245.20
Cathodic Disbondment at (23 ± 2) °C at 28 days	mm	5 max.	CAN/CSA Z245.20 Item 12.8
Cathodic Disbondment at (65 ± 2) °C at 2 days	mm	5 max.	CAN/CSA Z245.20 Item 12.8
Cathodic Disbondment at (70 ± 2) °C at 28 days	mm	10 max.	CAN/CSA Z245.20 Item 12.8
Flexibility 2.50°/PD min. at (0 ± 2) °C for both minimum and	-	No cracks	CAN/CSA Z245.20 Item



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maximum thickness			12.11
Hardness	Shore D	Min 50 after complete cure	ASTM D2240
Abrasion Resistance, weight loss: 1000 cycles / 1000 g / CS 17	g	70 max .	ASTM D 4060
Thermal evaluation test	-	No lack of adherence after heating	Clause 10.7
Cure test	4 hour	No damage	API RP 5L2 clause 5.3.4.5
Water test	4 hour	No damage	API RP 5L2 clause 5.3.4.6
Stripping test	60°	No stripping	API RP 5L2 clause 5.3.4.7
Functional tests (see note)	-	No failure	-

Note: For functional tests (operation and installation phase) CONTRACTOR shall follow I-ET-0000.00-6500-431-PPR-002. The following tests shall be performed: stinger roller test (if applicable), bending test (if applicable).

#### 10.4 Holiday Detection

- 10.4.1 Coating must be free of porosity detectable by the test carried out at entire coating surface. The test shall be conducted after final layer application.
- 10.4.2 Applied voltage is 5kV/mm of thickness, being limited to the range of 3 and 5kV.
- 10.4.3 Contact electrode shall be made of conducted rubber or by several rectangular wires. Rate of inspection shall not exceed 18m/min.
- 10.4.4 Coating shall be free of any kind of defect. Defects detected shall be repaired in accordance to Clause 13.
  - i. Inspection shall be done just after application and cure of coating.

### 10.5 Cathodic Disbondment

10.5.1 Cathodic Disbondment is evaluated from the difference of initial radius and radius of the damaged edge on which the coating is detached from the metal surface. The test shall be performed in accordance to CAN/CSA Z245.20, Item 12.8:

- a) 48 hours at  $(65 \pm 2)$  °C at -3.5V;
- b) 28 days at  $(23 \pm 2)$  °C at -1.5V;
- c) 28 days at  $(70 \pm 2)$  °C at -1.5V.

10.5.2 Average disbondment shall be determined by six measurements. Acceptance criteria are defined in Table I.

### 10.6 Adhesion

10.6.1 The adhesion of the internal liquid epoxy coating shall be tested by the pull-off method in accordance to ASTM 4541 Standard. The adhesion test shall be performed at ambient temperature.

10.6.2 Cohesive failure caused by voids in the coating leaving a honeycomb structure on the steel surface constitutes a fail condition.

10.6.3 Tests to be performed on extremities and in the middle of pipes.

10.6.4 One test is composed of 4 pull-offs tests in a section of pipe on position 12:00, 3:00, 6:00 and 9:00 hours.

### 10.7 Thermal evaluation test


10.7.1 SUPPLIER shall perform the following test during qualification and production phase. Heat the steel of the coated pipe ends to 240°C in a time period not greater than 89 seconds. Apply the heat by induction to the interface steel/external coated pipe. Let the pipe return to ambient temperature. All cycle heating shall be monitored and registered. SUPPLIER shall perform adhesion test on coating starting on interface internal liquid epoxy coating/steel. Acceptance criteria shall be the same as defined for original coating (clause 10.6).

- ii. One test is composed of 4 adhesion tests on each side of a coated pipes. At least the 12, 3, 6 and 9 hours position shall be tested. Total of 8 tests.

### 10.8 Foaming

10.8.1 Liquid epoxy voids/foaming levels shall be compared against the visual standards in CAN/CSA Z245.20. Maximum level of foaming shall be level/rating 3.



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### 10.9 Flexibility

- 10.9.1 Bending test shall be performed according to CAN/CSA Z245.20, Item 12.11.
- 10.9.2 Acceptance criterion is defined in Table III. Test to be performed at  $(0 \pm 2)$  °C.
- 10.9.3 After bending, samples shall be verified using Holiday Detection.
- 10.9.4 Tests to be performed on extremities and in the middle of pipes.
- 10.9.5 One test is composed of 3 flexibility tests in a section of pipe on position 12:00, 3:00 and 6:00 hours.

## 11 FREQUENCY OF TEST


- 11.1 Table II lists the frequency of tests to be performed during pre-qualification, pre-production and production phases applicable in accordance with the status of the coatings.
- 11.2 Destructive tests might be performed on a spare pipe since this pipe has the same diameter and wall thickness of production pipes.

**Table II – Frequency of Tests**

PROPERTIES	PRE-QUALIFICATION	PRE-PRODUCTION	PRODUCTION
<b>Surface Preparation and Heating Requirements</b>			
Visual inspection of bare pipes	All pipes	All pipes	All pipes
Chloride Contamination	All pipes	All pipes	once per shift
Conductivity evaluation of abrasive material	All pipes	All pipes	once per shift
Abrasive Blast cleaning	All pipes	All pipes	4 times per shift
Dust level on the blast cleaned surface	All pipes	All pipes	4 times per shift
Roughness Profile	All pipes	All pipes	4 times per shift
Pipe surface Sa 2 ½	All pipes	All pipes	4 times per shift





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Pipe Heating (if applicable)	All pipes	All pipes	4 times per shift
Ambient Condition	All pipes	All pipes	4 times per shift
<b>Internal Liquid Epoxy Coating Requirements</b>			
Liquid epoxy Dry Thickness	All pipes	All pipes	All pipes
Appearance	All pipes	All pipes	All pipes
Holiday Detector	all	all	all
Adhesion Pull-Off at (23 ± 2) °C	3 tests on 3 pipes	3 tests on 2 pipes	2 tests on ends of pipe per shift
Foaming	2 tests on 1 pipe	-	-
Cathodic Disbondment at (23 ± 2) °C at 28 days	2 tests on each pipe	2 tests on 3 pipes	-
Cathodic Disbondment at (65 ± 2) °C at 48 hours	2 tests on each pipe	2 tests on 3 pipes	1 test per shift
Cathodic Disbondment at (70 ± 2) °C at 28 days	2 tests on each pipe	2 tests on 3 pipes	-
Flexibility at 2.5°/PD at (0 ± 2) °C	3 tests on 3 pipes	3 tests on 2 pipes	1 test per shift
Hardness	2 test on 5 pipes	-	-
Abrasion Resistance, weight loss: 1000 cycles / 1000 g / CS 17	1 test on 2 pipes	1 test on 1 pipe	1 test each 1000 pipes
Thermal evaluation test	1 test on 2 pipe	1 test on 1 pipe	1 test each 1000 pipes
Cure test	All pipes	All pipes	1 test per shift
Water test	All pipes	All pipes	1 test per shift
Stripping test	All pipes	All pipes	1 test per shift
Functional tests	1 test	1 test	-

## 12 QUALIFICATION TESTS REPORTS

- 12.1 The laboratory tests and full scale tests reports related to different project phases (pre-qualification, pre-production, production) shall be organized in a complete report and presented to PETROBRAS analysis and approval before any other phase of the project starts.
- 12.2 All test data shall be presented to PETROBRAS. These tests data shall be recorded and stored during all test time including the initial of the test (non-stabilized period) and the test period.
- 12.3 Reports shall be presented in a digital file and in paper format. After finishing the qualification procedure, SUPPLIER shall submit for PETROBRAS' approval a qualification dossier (DATA-BOOK) with the documents and/or information below:
- a) Raw material supplier and data sheets;
  - b) Coating material specifications;
  - c) Coating material quality certification;
  - d) Procedure for coating application and ITPs;
  - e) Process equipment and measuring instruments;
  - f) Calibration certificates;
  - g) Range of diameters;
  - h) Wall thickness;
  - i) Coating thickness;
  - j) Roughness of blasted steel surface;
  - k) Temperature range of coating application;
  - l) Pre-treatment;
  - m) Inspection and tests results for the coating materials;
  - n) Tests reports with organization and signature.

## 13 REPAIR

- 13.1 After producing, all the coated pipes shall be inspected in accordance to Clause 10.4.
- 13.2 Repair Criteria
- 13.2.1 If any defect or damage is found, it should be marked with paint, crayon or similar to facilitate the location of areas to be repaired.
  - 13.2.2 There are two types of defects, as described in Table III (A and B). The Defect type A requires application of a new layer of liquid epoxy coating. The Defect type B requires full blasting followed by a new coating application.

**Table III - Types of Defect**

Type	Description
A-1	Excess of pinholes observed during visual inspection performed after painting layers applications
A-2	Less than 5 Pinholes defect by Holiday detector in the total length of the linepipe
B-1	More than 5 Pinholes defect by Holiday detector in the total length of the linepipe.
B-2	Non-conformity, cracks, bubbles, lack of adherence defect by visual inspection and/or holiday detector.

### 13.3 Repair Qualification and Application

13.3.1 All over layered internal liquid epoxy coated pipe shall be marked and the maximum final dry thickness shall be approved into flexibility, adhesion pull-off .

13.3.2 The repairs shall be executed according to a qualified Repair Application Procedure. The requirements for Repair Application Procedure and its qualification shall follow the requirements below.

### 13.4 Repair Application Procedure

13.4.1 The repair application procedure shall be submitted for PETROBRAS approval inserted in Coating application procedure.

13.4.2 The repair application procedure shall contain at least the following steps:

- a) Surface re-preparation (when applicable).
- b) Over layer process with a new layer of paint.(when applicable).
- c) Required tests.
- d) Over layer internally coated pipes identification system.

13.4.3 SUPPLIER shall apply additional or modified stringent requirements if for any reason SUPPLIER realizes that the requirements above are not adequate in order to guarantee the suitability for the intended service.

13.4.4 The Repair Application Procedure shall contain all the steps to the coating repair execution, including the parameters to be controlled to guarantee the fitness of the product to its purpose. The Repair Application Procedure shall be presented in step-by-step format, with photographic/illustrative pictures for each step. The Repair Application Procedure shall be written obligatory in Portuguese and English.

13.4.5 SUPPLIER shall be responsible to keep the repair applicators and equipment following strictly the Repair Application Procedure.

13.4.6 SUPPLIER shall submit for PETROBRAS approval any kind of practice executed that do not belong to the Repair Application Procedure qualified.

13.4.7 SUPPLIER shall only execute the repairs with operators qualified. SUPPLIER shall be responsible to evaluate the number of operators to be qualified. The number of operators shall be presented to PETROBRAS together with Repair Application Procedure emission.

13.4.8 SUPPLIER shall not accept or apply raw materials without Quality Certificates and with the Pot Life or Validity exceeded.

### 13.5 Qualification Tests

13.5.1 For each specific project, PETROBRAS may requests tests to evaluate the suitability of the repair application procedure. These tests may evaluate:

- a) Raw material of Repair Coating
- b) The Coating Repair itself and the adhesion with Parent Coating
- c) Coating Manufacturer Equipment Tests
- d) Operators that will apply the repairs

13.5.2 The qualification tests shall be executed in order to verify if the raw material of repair and repair applied itself is suitable to the intended application. For raw material qualification see clause 6 and for the applied material see Table IV.


13.5.3 All the qualification tests requested by PETROBRAS shall be executed in presence of PETROBRAS official representative or Certifying authority (only if permitted by PETROBRAS). Tests executed outside this condition will not be considered valid.

13.5.4 PETROBRAS may, at its own opinion, accept waive of the test presented above based on previous project

**Table IV – Qualification Tests for Overlayer coated linepipes – Repair Applied**

Tests	Acceptance Criteria	Reference Standard
Visual inspection of repair coating	Repair coating to be homogenous across the entire surface. No surface defects	-
Holiday detector	25 kV	NACE RP0274
Adhesion Pull-Off	15MPa	ASTM D 4521
Flexibility (bending resistance) @ 0 ± 2°C and Full Scale bending (if applicable)	No cracking or disbonding	CAN/CSA Z245.20 sec 12.11



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## 14 COATED PIPE MARKING AND TRACEABILITY

- 14.1 The marking shall follow the requirements of I-ET-0000.00-6500-211-PPR-001 or I-ET-0000.00-6500-211-PPR-002 , when applicable.
- 14.2 In addition to the linepipe manufacturing marking requirements expressed in I-ET-0000.00-6500-211-PPR-001 or I-ET-0000.00-6500-211-PPR-002, the information required in Sec. 12 of NBR-15221-2 shall be inserted on the external coating.
- 14.3 SUPPLIER shall submit for PETROBRAS approval the layout of marking

## 15 STORAGE, HANDLING AND TRANSPORTATION


### 15.1 Storage

- 15.1.1 All materials required for the coating shall be stored, at least, in their original packaging in a sheltered and ventilated area, where room temperature does not exceed 45°C, and kept away from any heat sources and at least 10cm away from the floor to avoid damages.
- 15.1.2 The epoxy raw material shall be stored at a temperature not over the manufacturer recommended temperature and a relative humidity of air equal to or less than 70%. Temperature and humidity shall be monitored and registered continuously.
- 15.1.3 Bare pipes shall be stored in such a manner as to avoid any type of damage or deterioration thereof that may affect the performance of the coating to be applied.
- 15.1.4 Coated pipes shall be stored in such manner as to avoid direct contact with soil and possible damages. Therefore, padded supports or adequate spacers shall be used.
- 15.1.5 Coated pipes stored and exposed to solar irradiation up to one year or that will be exposed to more than one year shall be covered.

### 15.2 Handling

- 15.2.1 Pipe handling shall be done in such a manner as to avoid damages, especially to pipe ends and coating, if any.
- 15.2.2 During loading and unloading coated pipes shall be handled with equipment such as travelling crane, using wide belts with a minimum width of 15cm, made of rubber, plastic, leather or canvas, containing no sharp pointed parts, such as bolts and rivets. A forklift with padded forks may also be used.



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15.2.3 All coated pipe surfaces that come into contact with handling equipment shall be inspected and repaired, if necessary.

### 15.3 Transportation

15.3.1 SUPPLIER shall submit for PETROBRAS Approval a Transportation Procedure prior to the beginning of coating activities.

15.3.2 During transportation, the bottom layer of coated pipes shall be supported as specified according to the Transportation Procedure. All chains, ropes, cables, or other accessories used for fastening the load shall be carefully padded in pipe contact areas.

15.3.3 The load shall be fastened in such manner as to avoid displacement during transit. Attachment devices shall be spaced at a distance equal to or smaller than the spacing between supports.