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1. INTRODUCTION



- 1.1. The internal liquid epoxy flow coating for Rigid Offshore Pipelines is made up of the following option:
 - a) Novolac epoxy resin in accordance with standard N-2912 type I;
- 1.2. All materials and processes shall be qualified and tested prior to coating application, as described in Clauses 8, 10 and 11.
- 1.3. Field joints of the pipeline will not be internally coated.

2. SCOPE

- 2.1. This document specifies minimum requirements to perform internal epoxy flow coating application on Rigid Offshore Linepipes with the objective to optimize fluid flow. The SUPPLIER shall prove that his plant, materials and coating procedures result in a quality of end product, as specified in Clause 10.
- 2.2. The coating system shall present the high bond-strength properties of epoxy coating. The Material Requisition (RM) will define the maximum design temperature for each specific pipeline, although SUPPLIER shall consider that PETROBRAS may require for this system design temperatures between - 15 °C and 50 °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 simulated service tests, laboratory tests and full-scale tests to assure the required properties as specified in Clause 6. 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.
- 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.
- 3.4. The requirements of this technical specification shall prevail against the requirements of standards listed in Clause 4.
- 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.



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- 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 application.
- 3.7. A quality system shall be applied to assist compliance with the requirements of this document.
- 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.
- 3.9. Purchaser and PETROBRAS shall have the right to inspect SUPPLIER's records at any time during the period of the contract.

4. REFERENCES

- 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.
- 4.2. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ABNT NBR 8094	- <i>Material Metálico Revestido e Não Revestido – Corrosão por Exposição à Névoa Salina;</i>
ABNT NBR 12103	- <i>Tintas – Determinação do Descaimento;</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>
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 Paint, Varnish, Lacquer and Related Products;</i>

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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>	
DNV OS F101	-	<i>Submarine Pipeline System;</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>	
ISO 868	-	<i>Plastics and Ebonite – Determination of Indentation Hardness by Means of a Durometer (Shore Hardness);</i>	
NACE Standard RP-02-74	-	<i>High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation</i>	
NACE SP 0188		<i>Discontinuity (Holiday) Testing of New Protective Coating on Conductive Substrates;</i>	
NACE Nº 2/SSPC-SP10	-	<i>Joint Surface Preparation Standard, Near-White Metal Blast Cleaning</i>	
NACE SSPC-SP 1	-	<i>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>	

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PETROBRAS N – 2719 - *Estocagem de Tubo em Área Descoberta.*



PETROBRAS N – 2912 - *Tinta Epóxi " Novolac".*

I-ET-0000.00-6500-211-PPR-001 *Linepipes*

I-ET-0000.00-6500-211-PPR-002 *Seamless Linepipes*

5. QUALIFICATION REQUIREMENTS

- 5.1. Materials shall meet the requirements of this technical specification. Materials shall be re-qualified in case of change in either the raw materials or any other conditions as defined herein.
- 5.2. SUPPLIER shall consider that unless otherwise written agreed, PETROBRAS will not accept historical data in order to waive tests or acceptance criteria.
- 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% (not applicable);
 - 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-tests, 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 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 of production or application of coating system.
- 5.7. Production trials shall be done during linepipe coating application.
- 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. 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 safety data sheets (MSDS).

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5.10. The qualification of the Application Procedure shall be interrupted whenever any test or inspection performed presents an unacceptable result and the qualification is considered rejected. SUPPLIER can consider only one further re-test in order to validate the qualification. 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 in accordance with the requirements established in this specification.

6. MATERIALS PROPERTIES

- 6.1. Material option a) defined in section 1.1 shall meet the requirements specified in standard N-2912 Tables 1 and 4.
- 6.2. 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 Safety 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 (not applicable);
 - f) Procedure for steel surface pipe cleaning;
 - g) Procedure for preheating pipes, specifying temperature (if applicable);
 - 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 (if applicable);
 - 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;
 - 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;

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- 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. 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 people involved in the coating application process shall be trained and qualified. Only qualified operators are allowed to apply the coating on the pipes.
- 8.3. Coating materials shall be subjected to tests in accordance with requirements in Clause 6.
- 8.4. The procedure shall be qualified through the coating of at least 10 (ten) pipes. Five pipes will be selected from which specimens shall be taken and subjected to test frequency stated in Clause 11 in accordance with requirements for the applied coating as Clause 10.
- 8.5. 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.
- 8.6. The qualification process shall be interrupted when any test or inspection realized shows unacceptable results and the qualification is considered rejected. SUPPLIER can consider only one further re-test in order to validate the qualification. All specimens shall pass otherwise the whole qualification lot shall be rejected and the coating process shall be completely redone.

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 for disposition.
- 9.1.1.3. Contamination by chlorides shall be verified according to NACE N° 5/SSPC-SP 12, Table 2, condition SC-2. Maximum acceptable value is 2 µg/cm², measured by ELCOMETER 130-SCM 400 or similar equipment. If chlorides contamination is found, suitable chemical pre-treatment or high pressure demineralised water shall be used to eliminate it prior to blasting.



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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 50°C.
- 9.1.2.3. Surfaces of the bare pipe shall be blast-cleaned with steel shot shown to near white metal as per NACE N° 2 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 preferably shall have two steps:
- a) The first blast uses steel shots, to promote the cleaning of the internal 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 Replica Tape (“Press-o-Film” or similar) or profilometer and in this case the parameter RZ_{DIN} and angular profile shall be considered.. 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. Blasted pipes shall be coated within a period of 2 hours.
- 9.1.2.6. After blasting, internal pipe surface shall be cleaned. The residual dust contamination after blasting shall be determined, on both ends of pipes, 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 150cm² 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.

9.2. Liquid Epoxy Coating Application

- 9.2.1. 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.
- 9.2.2. Recycling of the liquid epoxy coating is not allowed.
- 9.2.3. The maximum internal roughness profile after coating application for the dry film shall be 7µm considering the parameter Rq. The parameter Rq is obtained by the formula:

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$$Rq = \sqrt{\frac{1}{N} \sum Yi^2}$$

\sum : sum of measures;

N : number of measures;

Yi : roughness profile deviation from medium line.

9.2.4. The internal roughness profile of pipes shall also be evaluated before coating application considering the parameter Rq.

9.2.5. Tests to be performed on extremities and in the middle of pipes on PQT and PPT.

9.2.6. One test is composed of 4 roughness tests in a section of pipe on position 12:00, 3:00, 6:00 and 9:00 hours.

9.3. Pipe Ends

9.3.1. Basically all pipes shall be furnished with a strip of either 50±5mm greater than the cut back defined for the external coating. This configuration shall be tested and may be reduced if approved on Thermal Evaluation Test performed for 50, 40, 30 and 20mm. The material requisition document (RM) for the specific project may define different configuration for the cut backs.

9.3.2. 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.

9.3.3. 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.

9.3.4. 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 also 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 shall not be observed.

10.2.2. Coating shall be homogeneous all over its surface 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 2 sections of one (1) internally coated pipe (both extremities). At least the 0:00, 3:00, 6:00 and 9:00 hours position shall be measured at each section. One of these 4 positions shall be on the longitudinal weld seam, if applicable. All the 8 points per pipe shall be registered. One test is composed of 8 readings on 1 pipe.

10.3.2. During qualification phase 2 pipes shall be evaluated in the middle section.



10.3.3. 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.

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

10.3.5. Thickness measurements shall be performed in accordance with Table I.

Table I– Applied Internal Liquid Epoxy Coating Properties

REQUIREMENTS	UNIT	VALUES	TEST METHOD
Total Coating Dry Thickness	µm	150 (minimum) 300 (maximum)	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 D 4541
Foaming	level/rating	2	CAN/CSA Z245.20
Cathodic Disbondment at (23 ± 2) °C at 28 days	mm	15 max.	CAN/CSA Z245.20 Item 12.8
Flexibility 2.50°/PD min. at (23 ± 2) °C for both minimum and maximum thickness	-	No cracks	CAN/CSA Z245.20 Item 12.11

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Hardness	Shore D	Min 50 after complete cure	ASTM D2240
Abrasion Resistance, weight loss: 1000 cycles / 1000 g / CS 17	mg	Max. 70,0	ASTM D 4060
Thermal evaluation test	-	No lack of adherence after heating	Clause 10.7
Roughness profile before coating Roughness profile after coating	μm	- Maximum 7	Clause 9.2.4 Clause 9.2
Cure test (4 hours)	-	No damage	API RP 5L2 clause 5.3.4.5
Water test (4 hours)	-	No damage	API RP 5L2 clause 5.3.4.6
Stripping test at 60°C	-	No stripping	API RP 5L2 clause 5.3.4.7
Scratch Test at 23°C	-	To failure	Clause 10.10
Full Scale Cleaning Pig Test	-	-	Clause 10.11
Operation and Installation Testing in accordance I-ET-0000.00-6500-431-PPR-002	-	No failure	-


10.4. Holiday Detection

- 10.4.1. Holiday detection inspection can be performed using dry or wet medium.
- 10.4.2. 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.
- 10.4.3. Applied voltage is 5kV/mm of thickness, being limited to the range of 3 and 5kV (dry medium). Voltage for the wet medium inspection shall be defined by the equipment manufacturer and a test shall be performed before inspection starts.
- 10.4.4. Contact electrode shall be made of conducted rubber or by several rectangular wires. Rate of inspection shall not exceed 18m/min.
- 10.4.5. Coating shall be free of any kind of defect. Defects detected shall be repaired in accordance to Clause 13.
- 10.4.6. 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 with CAN/CSA Z245.20, Item 12.8:
 - a) 28 days at (23 ± 2) °C at -1.5V;

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<p>10.5.2. Average disbondment shall be determined by six measurements. Acceptance criteria are defined in Table I.</p> <p>10.5.3. Tests to be performed on extremities of pipes. During qualification phase 2 pipes shall be evaluated in the middle section.</p> <p>10.6. Adhesion</p> <p>10.6.1. The adhesion of the internal liquid epoxy coating shall be tested by the pull-off method in accordance with ASTM D 4541 Standard. The adhesion test shall be performed at ambient temperature.</p> <p>10.6.2. Cohesive failure caused by voids in the coating leaving a honeycomb structure on the steel surface constitutes a fail condition.</p> <p>10.6.3. Tests to be performed on extremities of pipes. During qualification phase 2 pipes shall be evaluated in the middle section.</p> <p>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.</p> <p>10.7. Thermal evaluation test</p> <p>10.7.1. SUPPLIER shall perform the following test during qualification and production phase. Heat all the external surface of 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).</p> <p>10.7.2. One test is composed of 4 adhesion tests on each side of a coated pipe on 12:00, 3:00, 6:00 and 9:00 hours position. One position to be over the weld seam, when applicable. Total of 8 adhesion tests.</p> <p>10.8. Foaming</p> <p>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 2.</p> <p>10.9. Flexibility</p> <p>10.9.1. Bending test shall be performed according to CAN/CSA Z245.20, Item 12.11.</p> <p>10.9.2. Acceptance criterion is defined in Table I. Test to be performed at (23 ± 2) °C.</p> <p>10.9.3. After bending, samples shall be verified using Holiday Detection.</p> <p>10.9.4. Tests to be performed on extremities and in the middle of pipes.</p> <p>10.9.5. One test is composed of 4 flexibility tests in a section of pipe on position 12:00, 3:00, 6:00 and 9:00 hours.</p> <p>10.10. Scratch Test</p>			

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10.10.1. Scratch test to be performed at 23°C. A Rockwell diamond tip to be pressed against the coated surface at a constant velocity while a steadily increasing force is applied.

10.10.2. The normal force to surface which cause first failure of the coating is defined as critical force. The objective of the test is to define the critical force. Failure of the coating can be assessed by an optical microscope.

10.10.3. One test is composed of the critical force definition on positions 12:00, 3:00, 6:00 and 9:00 hours of a section of pipe.

10.11. Full Scale Pig Test

10.11.1. The full scale pig test is composed of an internal coated pipe, a brush cleaning pig and the apparatus to insert the pig into pipe and receive the pig.

10.11.2. The test shall be performed with a cleaning pig with steel brush and nylon brush. See figure below as example.

10.11.3. This is a qualification test. One test is composed of 100 runs of the pig through the pipe. At run 5, 20, 40, 60, 80 and 100 the internal coating of the pipe shall be evaluated and thickness shall be measured on 16 positions of 2 sections of the pipe. At the end of the test, pipe shall be cut and thickness of coat shall be evaluated on middle section of the pipe.





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 characteristics (diameter, wall thickness, ...) of production pipes.

Table II – Frequency of Tests


PROPERTIES	PRE-QUALIFICATION	PRE-PRODUCTION	PRODUCTION
Surface Preparation and Heating Requirements			
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
Air quality	1 time	1 time	1 time per shift
Dust level on the blasted pipe 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
Pipe Heating (if applicable)	All pipes	All pipes	4 times per shift
Ambient Condition	All pipes	All pipes	4 times per shift
Internal Liquid Epoxy Coating Requirements			
Liquid Epoxy Dry Thickness	5 pipes 1 test per pipe	5 pipes 1 test per pipe	Start of shift and 1 test each 5 pipes
Appearance	All pipes	All pipes	All pipes
Holiday Detector	All pipes	All pipes	All pipes
Adhesion Pull-Off at (23 ± 2) °C	5 pipes 2 tests per pipe	5 pipes 2 tests per pipe	2 tests on ends of pipe per shift
Foaming	2 pipes 2 tests per pipe	-	-
Cathodic Disbondment at (23 ± 2) °C at 28 days	4 pipes 2 tests per pipe	2 pipes 2 tests per pipe	-
Flexibility at 2.5°/PD at (23 ± 2) °C	3 pipes 2 tests per pipe	2 pipes 2 tests per pipe	1 test per shift
Hardness	5 pipes 10 tests per pipe	3 pipes 10 tests per pipe	Start of shift and 1 test each 5 pipes
Abrasion Resistance, weight loss: 1000 cycles / 1000 g / CS 17	5 pipes 1 test per pipe	2 pipes 1 test per pipe	1 test each 1000 pipes
Thermal evaluation test	3 pipes 1 test per pipe	2 pipes 1 test per pipe	1 test each 1000 pipes

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Roughness profile before coating	All pipes	All pipes	1 test each 500 pipes
Roughness profile after coating	All pipes	All pipes	Start of shift and 1 test each 100 pipes on ends of pipes
Cure test	5 pipes 1 test per pipe	2 pipes 1 test per pipe	1 test per shift
Water test	5 pipes 1 test per pipe	2 pipes 1 test per pipe	1 test per shift
Stripping test	5 pipes 1 test per pipe	2 pipes 1 test per pipe	-
Scratch Test at 23°C	3 pipes 1 test per pipe	2 pipes 1 test per pipe	-
Full Scale Cleaning Pig Test	1 pipe	1 pipe	-
Operation and Installation Testing in accordance I-ET-0000.00-6500-431-PPR-002	Project requirements	Project requirements	Project requirements

12. QUALIFICATION TEST REPORTS

- 12.1. The laboratory tests, simulated service 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. 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.

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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 (one pipe)

Type	Description
A-1	More than 5 pinholes observed during visual inspection performed after painting layers applications and not detected by Holiday Detector.
A-2	Less than 5 pinholes detected by Holiday Detector in the total length of the linepipe.
B-1	More than 5 pinholes detected by Holiday Detector in the total length of the linepipe.
B-2	Non-conformity, cracks, bubbles, lack of adherence, seeping and defect by visual inspection and/or holiday detector.

13.3. Repair Qualification and Application

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

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.

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- 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 will requests tests to evaluate the suitability of the repair application procedure. These tests may evaluate:
- Raw material of repair coating;
 - The coating repair itself and the adhesion with parent coating;
 - SUPPLIER equipment tests;
 - 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.
- 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	5 kV/mm	Clause 10.4
Adhesion Pull-Off	15MPa	ASTM D 4541
Flexibility (bending resistance) @ 0 ± 2°C at maximum thickness	No cracking or disbanding	CAN/CSA Z245.20 sec 12.11

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14. COATED PIPE MARKING AND TRACEABILITY

- 14.1. The marking shall fulfill 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 ABNT 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.
- 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.

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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.