	TECHNICAL SPECIFICATION	Nº: I-ET-0000.00-0000-431-P9U-001
	CLIENT: PETROBRAS	SHEET: 1 of 22
	JOB: RIGID OFFSHORE PIPELINES	CC
	AREA:	PROJECT:
DDP	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS	PUBLIC EDD / EDR

INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL
A	REVISION OF INSPECTION FREQUENCY (TABLES 14 AND 15) THIS DOCUMENT SUPERSEDES THE DOCUMENT I-ET-0000.00-6500-431-P9U-001.
B	Change from NP-1 to PUBLIC

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	07/12/2017	31/07/2018	10/11/2021						
PROJECT	EISE/EDR	EISE/EDR	EDD/EDR						
EXECUTION	UPL2	UPL2	SG5H						
CHECK	SG5H	SG5H	UPL2						
APPROVAL	CLZ2	CLZ2	CLZ2						

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SPECIFICALLY INDICATED HEREIN. THIS FORM IS PART OF PETROBRAS N-381 REV. L



TECHNICAL SPECIFICATION

Nº I-ET-0000.00-0000-431-P9U-001

REV. B

JOB: RIGID OFFSHORE PIPELINES

SHEET: 2 of 22


TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS

PUBLIC

EDD / EDR

INDEX

1. SCOPE OF DOCUMENT	3
2. WET THERMAL INSULATION REQUIREMENTS.....	3
3. ADDITIONAL, MODIFIED AND DELETED REQUIREMENTS FOR WET THERMAL INSULATION APPLICATION RELATED TO ISO 12736.	3

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-431-P9U-001	REV. B
	JOB:	RIGID OFFSHORE PIPELINES	SHEET: 3 of 22
	TITLE:	WET THERMAL INSULATION FOR FLOWLINES AND RISERS	PUBLIC
			EDD / EDR

1. SCOPE OF DOCUMENT

1.1 This Technical Specification defines the minimum requirements related to the application of wet thermal insulation for flowlines and risers and their relevant field joint coating systems.

1.2 CONTRACTOR shall fulfill all the requirements presented within this Technical Specification.

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

- ISO 12736 – First Edition
Title: Petroleum and natural gas industries – Wet thermal insulation coatings for pipelines, flow lines, equipment and subsea structures;
- I-ET-0000.00-0000-210-P9U-001
Title: Pipeline Field Joint Coating and Field Repair of Linepipe Coating;
- I-ET-0000.00-0000-210-P9U-002
Title: Factory Applied External Pipeline Coatings for Corrosion Control;

1.4 In case it is noted any sort of conflict between this Technical Specification and the aforementioned documents, the following precedence order shall be respected:

- a) This Technical Specification;
- b) ISO 12736;
- c) I-ET-0000.00-0000-210-P9U-001 and I-ET-0000.00-0000-210-P9U-002.

2. WET THERMAL INSULATION REQUIREMENTS

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

- ISO 12736 – First Edition
Title: Petroleum and natural gas industries – Wet thermal insulation coatings for pipelines, flow lines, equipment and subsea structures;

2.2 There are some additional and modified requirements, which shall be fulfilled by CONTRACTOR. Additional and modified requirements to the aforementioned document are highlighted in this Technical Specification considering the following expressions:

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

3. ADDITIONAL, MODIFIED AND DELETED REQUIREMENTS FOR WET THERMAL INSULATION APPLICATION RELATED TO ISO 12736.


3.1 The items mentioned below follow the sequence already defined within the ISO 12736. The standard section number is given in brackets.

Introduction

() Modification: “It is necessary that users of this ISO 12736 be aware that further or differing requirements can be required for individual applications. However, PETROBRAS will accept only coating systems which are foreseen within this document. In case of coating systems not contemplated herein, they shall be duly qualified by PETROBRAS prior to their inclusion within this document.”

Scope

(1) Modification: “This International Standard defines the minimum requirements for qualification, application, testing, handling, storage and transportation of new and existing wet thermal insulations systems for pipelines, flowlines and risers in the petroleum and natural gas industries. The purpose of the system is to provide external corrosion protection and thermal insulation.”

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-431-P9U-001	REV. B
	JOB:	RIGID OFFSHORE PIPELINES	SHEET: 4 of 22
	TITLE:	WET THERMAL INSULATION FOR FLOWLINES AND RISERS	PUBLIC
			EDD / EDR

Normative references

- (2) Addition: "I-ET-0000.00-0000-210-P9U-001, Pipeline Field Joint Coating and Field Repair of Linepipe Coating."
- (2) Addition: "I-ET-0000.00-0000-210-P9U-002, Factory Applied External Pipeline Coatings for Corrosion Control."
- (2) Addition: "DNVGL-RP-F102, Pipeline Field Joint Coating and Field Repair of Linepipe Coating."
- (2) Addition: "DNVGL-RP-F106, Factory Applied External Pipeline Coatings for Corrosion Control."

Terms and definitions

(3.22) Modification: "Pi tape: precision vernier periphery tape that allows the direct measurement of the diameter of tubular objects without the need for calipers or micrometers."

Acronyms

- (4) Deleted: "4LPP four layer polypropylene."
- (4) Addition: "5LPP five layer polypropylene."
- (4) Addition: "HGM hollow glass microspheres."

Qualification Dossier

- (6.1) Modification: "A qualification dossier of the proposed insulation system in accordance with this clause shall be presented by the system supplier for review. The requirements of this clause shall apply to all layers present in the insulations system. The content of such a dossier shall be in accordance with 6.2 and 6.3."
- (6.1) Addition: "Historical data shall have been approved by a Third Party Inspection Company or PETROBRAS representative."
- (6.3) Deletion: "The wet insulation system supplier can select any anti-corrosion coating believed to be suitable for the maximum rated temperature of its insulation system and with which the system will pass the qualification requirements of this International Standard."
- (6.3) Addition: "The anticorrosion coating system shall be indicated by PETROBRAS through a Coating Assessment Technical Specification."

Layer test requirements

- (7.1) Modification: "Table 2 specifies properties to be tested. Tests are mandatory."
- (Table 1) Modification: "Test procedure for Hydrostatic compressive behavior shall be 'Tri-axial compression and creep test'."
- (Table 1) Addition: "The test period of 'tri-axial compression and creep test' shall be at least 28 days and test period shall be enough in order to allow the extrapolation of data for 30 years."
- (Table 1) Addition: "Water absorption: it shall be considered a test period necessary for the sample to saturate in water at 23°C ± 1°C. Method 1 of ISO 62 shall be adopted. The test period shall be enough in order to allow the extrapolation of data for 30 years."
- (7.2) Addition: "These tests are mandatory and their performance shall be witnessed by a Third Party Inspection Company or an end user representative."
- (7.2.5) Addition: "In order to demonstrate the suitability of the material to UV exposure, the insulation material shall be tested in accordance with ISO 21809-1 Annex G. It shall be considered a test period of 3000 hours."



Insulation system test requirements

(8.1) Modification: “The parameters for the tests in Table 3 shall be defined by PETROBRAS (pressure, temperature, etc.). Applicator shall consider such information for the execution of testing.”

(Table 3) Modification: “The full scale bend test is mandatory for field joint coating.”

(8.2.2) Modification: “Baseline tests (mandatory).”

(8.2.2) Modification: “The following tests shall be carried out on the complete insulation system prior to any simulated installation or...”

(8.2.2) Modification: “- CD test shall be performed at 23°C for 28 days in accordance with I-ET-0000.00-0000-210-P9U-002.”

(8.2.3) Modification: “...Effects such as disbondment stress whitening, deformation, blistering, and separations between layers or tearing as deemed detrimental to the product are not acceptable and shall be brought back to the end user attention. The adhesion and CD tests are mandatory for comparison with baseline tests.”

(8.2.4) Modification: “...Effects such as disbondment, stress whitening, deformation, blistering, and separations between layers or tearing as deemed detrimental to the product are not acceptable and shall be brought back to the end user attention.”

(8.2.5) Modification: “Simulated tensioner test (mandatory).”

(8.2.7) Addition: “Test period shall be 28 days after thermal insulation stability has been established.”

(8.2.7) Modification: “...Measured radial compression of the insulation system shall be in accordance with the design basis in accordance with 8.1. The test piece shall be sectioned after completion of the test. After sectioning, the coating systems...”

(8.2.8) Addition: “Test period shall be 28 days after thermal insulation stability has been established.”

(8.2.8) Modification: “...Hot water degradation mechanisms within insulation system, especially at the interface with the parent coating (coating on both sides of the field joint, at the cutback areas), are not acceptable.”

(8.2.8) Modification: “...Measured radial compression of the insulation system shall be in accordance with the design basis in accordance with 8.1. The test piece shall be sectioned after completion of the test. After sectioning, the coating systems...”

Application process and quality control


(9.1) Addition: “If other system types are proposed, CONTRACTOR/APPLICATOR shall present a qualification dossier in accordance with this ISO standard for PETROBRAS evaluation and approval.

(9.3) Addition: “In order to speed up the approval process of APS and ITP, documents may be issued as independent documents.”

(9.4) Modification: “The APS shall be qualified by a PQT. Test methods, acceptance criteria and frequencies for PQT shall be specified in the ITP.”


(9.4) Addition: “If the proposed coating system has been already qualified by PETROBRAS, the specific conditions demanding the execution of a new PQT are as follows:

Key Variable	Specific conditions requiring a new full PQT
Insulation material	Change of any coating material composing the insulation system
Equipment	Change of methodology for the coating application
Pipe OD	Any change on the pipe OD (steel layer only)
Insulation thickness OD	Variation in thickness of coating: -30% (negative variation)
Key process parameters	Out of the tolerance previously qualified (e.g temperatures, pressure of extrusion, rotation of the screw, line speed, etc.)
Installation methodology	Installation method and/or diameter of reel (if applicable)
Qualification dossier	As per item 6

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001	REV. B		
	JOB: RIGID OFFSHORE PIPELINES			SHEET: 6 of 22		
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS			PUBLIC		
EDD / EDR						
<p>(9.4) Addition: "In case of projects with Clad/Lined pipes, the PQT may be carried out using carbon steel pipes. Nevertheless a further demonstration shall be done in a later stage considering all the necessary actions to be taken along the coating process in order to avoid the contamination of CRA material."</p> <p>(9.4) Modification: "The PQT shall be carried out in presence of the end user and designated Client's representative if applicable."</p> <p>(9.5) Modification: "A PPT shall be performed prior to the start of production to verify the PQT or any previous qualification or historical data."</p> <p>(9.6.2.2) Modification: "The 3LPP coating shall be in accordance with I-ET-0000.00-0000-217-P9U-002."</p> <p>(9.6.2.3) Deleted.</p> <p>(9.6.2.3) Addition: "The 5LPP consists of an insulation material (e.g. solid polypropylene, syntactic polypropylene) plus a solid polypropylene top coat applied on top of a 3LPP system."</p> <p>(Table 4) Modification: "Table 4 – Minimum inspection and testing for PP insulation layer application"</p>						
Property	Units	Test method	Requirements	Frequency		
				PQT	PPT	Production
Raw material testing (Manufacturer's data)						
Density	kg/m ³	ISO 1183 or ASTM D792	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
MFR	g/10min	ISO 1133 or ASTM D1238	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Density (glass microspheres)	g/cm ³	Manufacturer	$0.35 \leq \rho \leq 0.41$	Each batch	Each batch	Each batch
Crush strength (glass microspheres)	MPa	Manufacturer	$\geq 80\%$ minimum fraction survival at 5500 psi $\geq 90\%$ target fraction survival at 5500 psi	Each batch	Each batch	Each batch
Substrate preparation						
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	Each pipe	Each pipe	Start of each shift
Visual inspection of previously coated surface	-	Visual inspection	Pipe surface shall be free from moisture and contamination	Each pipe	Each pipe	Each pipe
Heating of previous coated surface (if applicable)	°C	Infrared pyrometer or equivalent	Acceptable range to be established during PQT. The surface temperature shall be continuously monitored and recorded.	Each pipe	Each pipe	Each pipe
Laboratory testing						
Interlayer adhesion test between insulation layers	MPa	ISO 4624	$\geq 5\text{MPa}$	Each pipe	2 pipes	Once per shift
Density control (GSPP)	kg/m ³	ISO 1183 or ASTM D792	Nominal density $\pm 10\text{kg/m}^3$	Each pipe	2 pipes	Once per day
Mass ratio of glass microspheres (GSPP)	kg/m ³	As per Annex J	Nominal value established during PQT $\pm 0.5\%$	Each pipe	2 pipes	Once per shift

	TECHNICAL SPECIFICATION			Nº I-ET-0000.00-0000-431-P9U-001		REV. B	
	JOB: RIGID OFFSHORE PIPELINES					SHEET: 7 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS					PUBLIC	
EDD / EDR							
Glass microspheres density after processing (GSPP)	%	As per Annex J	Acceptable range to be established during PQT	Each pipe	2 pipes	Once per shift	
Entrapped air ration (GSPP)	%	As per Annex J	Acceptable range to be established during PQT	Each pipe	2 pipes	Once per shift	
Thermal conductivity	W/(m.K)	ISO 8301	In accordance with thermal insulation design (test at 23°C ± 2°C)	5 tests on 2 pipes (total 10 samples)	3 tests	N/A	
Compressive strength	MPa	ISO 844	In accordance with thermal insulation design (test at 23°C ± 2°C)	Each pipe	One test	N/A	
Tensile strength and elongation at break	MPa %	ISO 527 or ASTM D638	In accordance with thermal insulation design (test at 23°C ± 2°C)	Each pipe	N/A	N/A	
Modulus of elasticity and secant modulus	MPa	ASTM D638	In accordance with thermal insulation design (test at 23°C ± 2°C)	Each pipe	N/A	N/A	
Hydrostatic strength – Tri-axial compression and creep test	%	Annex A	≤ 5% (extrapolated to 20 years). Test to be performed at a pressure ≥ 1.1*(Maximum water depth) during 28 days.	3 tests	N/A	N/A	
Water absorption – method 1	%	ISO 62	≤ 3% after extrapolation to design life (test at 23°C ± 2°C). Test to be performed during 28 days.	3 tests	N/A	N/A	
Final inspection							
Coated pipe surface temperature control after cooling	-	Measurement with contact thermocouple or pyrometer	< 80°C	Each pipe	Each pipe	Three times per shift	
Thickness control	-	Measurement with PI tape or electronic equipment	As per thermal insulation design.	Each pipe on 5 locations along the pipe	Each pipe on 5 locations along the pipe	Each pipe on 5 locations along the pipe	
”							
(Table 5) Modification: “Table 5 – Minimum inspection and testing for PP top coat layer application							
Property	Units	Test method	Requirements	Frequency			
				PQT	PPT	Production	
Raw material testing (Manufacturer’s data)							
Density	kg/m³	ISO 1183 or ASTM D792	Within the manufacturer’s certificate of conformity range	Each batch	Each batch	Each batch	
MFR	g/10min	ISO 1133 or ASTM D1238	Within the manufacturer’s certificate of conformity range	Each batch	Each batch	Each batch	
Substrate preparation							
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	Each pipe	Each pipe	Start of each shift	

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001		REV. B	
	JOB: RIGID OFFSHORE PIPELINES				SHEET: 8 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS				PUBLIC	
					EDD / EDR	
Control of previous coated surface	-	Visual inspection	Pipe surface shall be free from moisture and contamination. No flat spots, dents, air bubbles.	Each pipe	Each pipe	Each pipe
Heating of previous coated surface (if applicable)	°C	Infrared pyrometer or equivalent	Acceptable range to be established during PQT. The surface temperature shall be continuously monitored and recorded.	Each pipe	Each pipe	Each pipe
Top coating application						
Top coat coating thickness	mm	Measurement with PI tape or electronic equipment	In accordance with thermal insulation design, but $\geq 3\text{mm}$.	Each pipe (5 locations along the pipe)	Each pipe (5 locations along the pipe)	1 st pipe then every 20 th pipe
Laboratory testing						
Adhesion between layers	-	Visual inspection at pipe ends (cutback)	No delamination between layers	Each pipe	Each pipe	Each pipe
Interlayer adhesion test between all layers	MPa	ISO 4624	$\geq 5\text{MPa}$	Each pipe (pipe ends and central sections) ¹	N/A	N/A
Tensile strength at yield	MPa	ISO 527 or ASTM D638	$\geq 20\text{MPa}$	One pipe	N/A	N/A
Elongation at break	%	ISO 527 or ASTM D638	≥ 400	One pipe	One test	One test
Modulus of elasticity	MPa	ASTM D638	-	One pipe	One test	One test
Secant modulus	MPa	ASTM D638	-	One pipe	One test	One test
Final inspection						
Total coating thickness	mm	Measurement with PI tape or electronic equipment	As per thermal insulation design.	Each pipe on 5 locations along the pipe	Each pipe on 5 locations along the pipe	Each pipe on 5 locations along the pipe
Ovality	%	Caliper and PI tape	$(OD_{\text{max}} - OD_{\text{min}})/OD_{\text{PItape}} < 2$	Each pipe	Each pipe	1 st pipe then every 20 th pipe
Concentricity	-	Straight edge ruler or electronic equipment at cutback area	$\pm 10\%$ of nominal thickness (according to thermal insulation design)	Each pipe, 8 measurements	Each pipe, 8 measurements	Once every 20 pipes
Hardness	Shore D	ISO 868 or ASTM D2240	≥ 60	Two tests	One test	Once per shift
Cutback	mm	Measurement	By agreement	Each pipe	Each pipe	Each pipe
<p>”</p> <p>_____</p> <p>¹ Exception is made to pipes destined to full-scale tests that may be submitted to interlayer adhesion tests on pipe ends only.</p>						

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-431-P9U-001	REV. B
	JOB:	RIGID OFFSHORE PIPELINES	SHEET: 9 of 22
	TITLE:	WET THERMAL INSULATION FOR FLOWLINES AND RISERS	PUBLIC
			EDD / EDR

Polyurethane applied in liquid form


(9.6.3.1) Modification: "Polyurethane is applied in liquid form using suitable dispensing equipment. It may be either in solid or syntactic form."

(9.6.3.1) Modification: "The suitable anticorrosion coating shall be a FBE coating in compliance with the Technical Specification I-ET-0000.00-6500-217-P9U-002 in its latest revision."

(Table 6) Modification: "Table 6 – Minimum inspection and testing requirements for PU."

Property	Units	Test method	Requirements	Frequency		
				PQT	PPT	Production
Raw material testing (Manufacturer's data)						
Density (polyol)	Relative to water at 1.0	Manufacturer's method	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Viscosity (polyol)	cPs	ISO 3104 or ISO 3219	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Gel time of mixed system (polyol + Iso)	s	Manufacturer's method	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Hardness of cured system	Shore A or Shore D	ISO 868	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Isocyanate content	%	ISO 14896	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Density (glass microspheres)	g/cm ³	Manufacturer's method	0.35 ≤ ρ ≤ 0.41	Each batch	Each batch	Each batch
Crush strength (glass microspheres)	%	Manufacturer's method	≥ 80% minimum fraction survival at 5500 psi ≥ 90% target fraction survival at 5500 psi	Each batch	Each batch	Each batch
Substrate preparation						
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	Each item	Each item	Start of each shift
Anticorrosion coating surface preparation	-	Visual	If applicable, abrasion with sand paper grit 50 minimum and dust vacuum cleaning	Each item	Each item	Each item
Adhesion promoter application (if required)						
Material Certificate	-	-	Conformity certificate issued by manufacturer.	Each batch	Each batch	Each batch
Pot life	min	Stop watch	Cure time check in accordance with manufacturer's recommendation	Each batch	Each batch	Each batch
Mix ratio	Ratio by weight	Weight measurement	Ratio and tolerance according to manufacturer's recommendation	Start of PQT	Start of PPT	Each shift
Visual appearance	-	Visual	Within manufacturer's recommendation. Comparative visual test panels from PQT.	Each item	Each item	Each item
PU application						

		TECHNICAL SPECIFICATION			Nº I-ET-0000.00-0000-431-P9U-001		REV. B	
		JOB: RIGID OFFSHORE PIPELINES					SHEET: 10 of 22	
		TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS					PUBLIC	
							EDD / EDR	
Mix ratio	Ratio by weight	Weight measurement	As per manufacturer's recommendation with a maximum variation of $\pm 2\%$	Start of PQT	Start of PPT	Once per shift		
Verification of raw material properties by a "cup shot"	Visual	Cured 500cm ³ (approximately) fixed mass sample at 23°C	Good mixing. No air, no discoloration from unmixed components, etc.	Start of PQT	Start of PPT	Start of each shift		
Gel time check (machine dispensed)	s	Stop watch	To be used as reference for maximum pour time limitations	Once	Once	Once per shift		
Visual inspection of the mould prior to moulding	-	Visual	Clean, no adhering PU. Releasing agent applied on entire inner surface of the mould.	Each item	Each item	Each pipe		
Raw material processing temperature	°C	Thermocouple	As per manufacturer's recommendation	Once	Once	Once per shift		
Mould temperature	°C	Thermocouple	Acceptable range to be established during PQT	Each item	Each item	Monitor continuously and record once per hour		
Anticorrosion coating surface temperature	°C	Contact thermometer	Acceptable range to be established during PQT	Each item	Each item	Monitor continuously and record once per hour		
Minimum demoulding time	s	Stop watch	Acceptable range to be established during PQT	Each item	Each item	Monitor continuously and record once per hour		
Hardness immediately after demoulding	Shore A	ISO 868 or ASTM D2240	≥ 50	Each item	Each item	Each item		
Laboratory testing								
Density	kg/m ³	ISO 1183 or ASTM D792	In accordance with thermal insulation design (test at 23°C $\pm 2^\circ\text{C}$)	Once for PQT	Once for PPT	Once per shift		
Tensile strength at yield	MPa	ISO 527 or ASTM D638	In accordance with thermal insulation design (test at 23°C $\pm 2^\circ\text{C}$)	Once for PQT	Once for PPT	Once per shift		
Elongation at break	MPa	ISO 527 or ASTM D638	In accordance with thermal insulation design (test at 23°C $\pm 2^\circ\text{C}$)	Once for PQT	Once for PPT	Once per shift		
Modulus of elasticity	MPa	ASTM D638	In accordance with thermal insulation design (test at 23°C $\pm 2^\circ\text{C}$)	Once for PQT	Once for PPT	Once per shift		
Secant modulus	MPa	ASTM D638	In accordance with thermal insulation design (test at 23°C $\pm 2^\circ\text{C}$)	Once for PQT	Once for PPT	Once per shift		
Compressive strength	MPa	ISO 844	In accordance with thermal insulation design (test at 23°C $\pm 2^\circ\text{C}$)	Once for PQT	Once for PPT	N/A		
Thermal	W/(m.K)	ISO 8301	In accordance with thermal	5 tests on 2	3 tests	N/A		

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-431-P9U-001	REV. B
	JOB:	RIGID OFFSHORE PIPELINES	
	TITLE:	WET THERMAL INSULATION FOR FLOWLINES AND RISERS	
		SHEET:	11 of 22
		PUBLIC	
		EDD / EDR	

conductivity			insulation design (test at 23°C ± 2°C)	pipes (total 10 samples)		
Hydrostatic strength – Tri-axial compression and creep test	%	Annex A	≤ 5% (extrapolated to 20 years). Test to be performed at a pressure ≥ 1.1*(Maximum water depth) during 28 days.	3 tests	N/A	N/A
Mass ratio of glass microspheres (GSPU)	%	Annex J	Acceptable range to be established during PQT	Each item	2 items	Once per shift
Glass microspheres density after processing (GSPU)	%	Annex J	Acceptable range to be established during PQT	Each item	2 items	Once per shift
Entrapped air ratio (GSPU)	%	Annex J	Acceptable range to be established during PQT	Each item	2 items	Once per shift
Adhesion pull off	MPa	ISO 4624	≥ 5MPa	Each item	Each item	Once per shift
Hardness	Shore A or Shore D	ISO 868 or ASTM D2240	Within manufacturer's certificate of conformity range	Each item	Each item	Each item
Insulation thickness	mm	PI tape or electronic equipment	In accordance with thermal insulation design	Each item	Each item	Each item
Concentricity (for pipes only)	mm	Straight edge ruler or electronic equipment at cutback area	± 10% of nominal thickness, but not greater than 4mm	Each item, 8 measurements	Each item, 8 measurements	Once per shift
Ovality (for pipes only)	%	Caliper and PI tape	$(OD_{max} - OD_{min})/OD_{PI\ tape} < 2$	Each item	Each item	1 st pipe then every 20 th pipe
Cutback	mm	Measurement	By agreement	Each item	Each item	Each item
Removal of release agent	-	Visual	-	Each item	Each item	Each item
Visual inspection	-	Visual	Mouldings are free from large air traps, porosity, debris, knit lines, cavities, cracks and disbondments at joints and substrate interfaces. Cosmetic surface faults may be accepted.	Each item	Each item	Each item

”

PU foam application using spray or injection method with extruded polyolefin outer jacket

(9.6.3.2) Deleted.

Silicone insulation systems


(9.6.3.4) Modification: “The application of pre-cast forms is not acceptable for linepipes.”

(Table 8) Modification: “Table 8 – Minimum inspection and testing requirements for silicone

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001	REV. B		
	JOB: RIGID OFFSHORE PIPELINES			SHEET: 12 of 22		
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS			PUBLIC		
				EDD / EDR		
Property	Units	Test method	Requirements	Frequency		
				PQT	PPT	Production
Raw material testing (Manufacturer's data)						
Viscosity	cPs	ISO 2884	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Gel time	min	Manufacturer	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Hardness of cures system	Shore A	ISO 868 or ASTM D2240	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Density	kg/m ³	ISO 1183-1	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Tensile properties (modulus, elongation at break, tensile strength at break)	MPa %	ISO 37	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Density (glass microspheres) if applicable	g/cm ³	Manufacturer	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Crush strength (glass microspheres) if applicable	MPa	Manufacturer	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Substrate preparation						
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	Each item	Each item	Start of each shift
Anti-corrosion coating surface preparation	-	Visual	If applicable, abrasion with sand paper grit 50 minimum and dust vacuum cleaning	Each item	Each item	Each item
Adhesion promoter application						
Over coating time	s	-	Time check in accordance with manufacturer's recommendation	Each item	Each item	Each item
Visual appearance	-	Visual	Within manufacturer's recommendation. Comparative visual test panels from PQT	Each item	Each item	Each item
Silicon application						
Mix ratio	Ratio by weight	Weight measurements	± 5% from manufacturer's data sheet	One item	One item	Once per shift
Verification of raw material properties by a "cup shot"	Visual	Cured 500cm ³ (approximately) fixed mass sample at 23°C	Good mixing. No air, no discolouration from unmixed components, etc.	Start of PQT	Start of PPT	Start of each shift
Visual inspection of the mould	-	Visual	Clean, without any contamination	Each pipe	Each pipe	Each pipe
Laboratory testing						
Density	kg/m ³	ISO 1183	In accordance with thermal	Once	Once	Once per

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001			REV. B
	JOB: RIGID OFFSHORE PIPELINES				SHEET: 13 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS				PUBLIC	
				EDD / EDR		
			insulation design (test at 23°C ± 2°C)			shift
Tensile strength and elongation at break	MPa %	ISO 37	Within the manufacturer's certificate of conformity range	One test	One test	N/A
Compressive strength	MPa	ISO 844	Within the manufacturer's certificate of conformity range	Each pipe	N/A	N/A
Adhesion (pull off)	MPa	ISO 4624	≥ 5MPa	Each pipe	Each pipe	Once per shift
Thermal conductivity	W/m.K)	ISO 8301	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 samples	3 samples	N/A
Final inspection						
Hardness	Shore A	ISO 868	Within the manufacturer's certificate of conformity range	Each item	Each item	Each item
Insulation thickness	mm	PI tape or electronic equipment or vent port	In accordance with thermal insulation design	Each item	Each item	Each item
Concentricity (for pipes only)	mm	Straight edge ruler or electronic equipment at cutback area	± 10% of nominal thickness, but not greater than 4mm.	Each pipe, 8 measurements	Each pipe, 8 measurements	Once per shift
Ovality (for pipes only)	%	Caliper and PI tape	$(OD_{max} - OD_{min})/OD_{PItape} < 2$	Each pipe	Each pipe	1 st pipe then every 20 th pipe
Cutback	mm	Tape measurement	In accordance with thermal insulation design	Each item	Each item	Each item
Visual inspection	-	Visual and optical microscope	Free of voids, blisters, cracks and separation from anticorrosion coating.	Each item	Each item	Each item
”						
Rubber coating on steel						
(9.6.5.2) Deleted.						
Rubber coating on other materials						
(Table 10) Modification: “Table 10 – Minimum inspection and testing requirements for rubber on to other materials						
Property	Units	Test method	Requirements	Frequency		
				PQT	PPT	Production
Raw material testing (Manufacturer's data)						
Vulcanization characteristics	Nm	ISO 6502 (rheometer)	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Hardness	Shore A	ISO 7619-1	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Density	kg/m ³	ISO 2781	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Substrate preparation						

	TECHNICAL SPECIFICATION			Nº I-ET-0000.00-0000-431-P9U-001		REV. B	
	JOB: RIGID OFFSHORE PIPELINES					SHEET: 14 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS					PUBLIC	
						EDD / EDR	
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	Each item	Each item	Start of each shift	
Substrate surface preparation	-	Visual	If applicable, abrasion with sand paper grit 50 minimum and dust vacuum cleaning	Each item	Each item	Each item	
Rubber primer application							
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	Each item	Each item	Each item	
Over coating time	min	-	Time check in accordance with manufacturer's recommendation	Each item	Each item	Each item	
Visual appearance	-	Visual	Within manufacturer's recommendation. Comparative test panels from PQT	Each item	Each item	Each item	
Rubber application							
Vulcanization temperature	°C	Contact thermometer couple	Acceptable range to be established during PQT	Each item monitored	Each item monitored	Each item monitored	
Vulcanization time	min	Stop watch	Acceptable range to be established during PQT	Each item	Each item	Each item	
Vulcanization pressure	MPa	Manufacturer specification	Acceptable range to be established during PQT	Each item	Each item	Each item	
Laboratory testing							
Thermal conductivity	W/(m.K)	ISO 8301	In accordance with thermal insulation design (test to be performed at 23°C ± 2°C)	Once ^a	Once ^a	N/A	
Specific heat capacity	J/(kg.K)	ISO 11357	In accordance with thermal insulation design (test to be performed at 23°C ± 2°C)	Once ^a	Once ^a	N/A	
Tensile strength and elongation at break	MPa %	ISO 37	Within manufacturer's certificate of conformity range	Once ^b	Once ^b	N/A	
Tear strength	N/mm	ISO 34	Within manufacturer's certificate of conformity range	Once ^b	Once ^b	N/A	
Density	g/cm ³	ISO 2781	In accordance with thermal insulation design (test to be performed at 23°C ± 2°C)	Once	Once	N/A	
Adhesion test / peel test (on pipe)	N/mm	ISO 21809-1	Acceptable range do be defined during PQT, but must be greater than 2.5N/mm	Once per pipe	Once per pipe	Each vulcanization batch	
Final inspection							
Hardness	Shore A	ISO 7619-1	Within manufacturer's certificate of conformity range	Each item	Each item	Each item	
Total insulation thickness	mm	PI tape or electronic equipment	In accordance with thermal insulation design	Each item	Each item	Each item	
Concentricity	mm	Straight edge ruler or	± 10% of nominal thickness,	Each pipe, 8 measure-	Each pipe, 8 measure-	Once per	

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001		REV. B	
	JOB: RIGID OFFSHORE PIPELINES				SHEET: 15 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS				PUBLIC	
EDD / EDR						

(for pipes only)		electronic equipment at cutback area	but not greater than 4mm	ments	ments	shift
Ovality (for pipes only)	%	Caliper and PI tape	$(OD_{max} - OD_{min})/OD_{PItape} < 2$	Each pipe	Each pipe	1 st pipe then every 20 th pipe
Cutback	mm	Tape measurement	In accordance with thermal insulation design. No disbondment between layers or defects/voids	Each item	Each item	Each item
Visual inspection	-	Visual	Free from defects	Each item	Each item	Each item

a Middle layer only, due to the difficulty of machining proper samples from thin inner and outer layer.

b Middle and outer layer only, due to the difficulty of machining proper samples from thin inner layer.

”

Epoxy insulation systems
(9.6.6) Deleted.

Phenolic insulation systems
(9.6.7) Deleted.

Requirements for field joints
(10.1) Modification: “Selection and application of the field joint coating should be in accordance with project’s specific coating assessment.”


Qualification requirements
(10.3) Modification: “All parameters for the testing, such as maximum rated temperature, pressure and test parameters for Clause 8, are specified within project’s coating assessment, I-ET-0000.00-0000-210-P9U-001 and I-ET-0000.00-0000-210-P9U-002.”

Qualification of operators
(10.4) Addition: “Qualification of operators shall be performed using project’s coated pipes in order to simulate the overlap area.”

Field joint coating APS/PQT/PPT
(10.5) Modification: “Regarding to the item 9.4, steel grade won’t be considered as a key variable for the execution of a new qualification trial.”
(10.5) Modification: “The PQT and PPT shall be performed using actual project’s coated pipes. The pipes shall have a circumferential girth weld as defined for the project.”
(10.5) Addition: “A repair procedure for parent coating and field joint coating shall be agreed between PETROBRAS and CONTRACTOR before PQT phase and qualified during the PQT. Repair of the anticorrosion coating system of FJC is not acceptable in accordance with I-ET-0000.00-0000-210-P9U-001.”

Polypropylene field joint using injection moulded technique
(10.6.1) Modification: “An injection moulded polypropylene field joint shall comply with the requirements of I-ET-0000.00-0000-210-P9U-001 and the requirements of Table 13. The coating consists of three layers:

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001		REV. B	
	JOB: RIGID OFFSHORE PIPELINES				SHEET: 16 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS				PUBLIC	
					EDD / EDR	
<p>- an epoxy resin layer, applied in the form of powder by flocking or by electrostatic spray (FBE);</p> <p>- a layer of modified PP powder applied by spraying (used as adhesive);</p> <p>- an insulation layer of PP applied by injection into a mould.”</p> <p>(Table 13) Modification: “Table 13 – Polypropylene field joint using injection moulded technique</p>						
Property	Units	Test method	Requirements	Frequency		
				PQT	PPT	Production
Raw material testing (Manufacturer's data)						
Density	kg/m ³	ISO 1183 or ASTM D792	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
MFR	g/10min	ISO 1133 or ASTM D1238	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
PP application parameters						
Chamfer and overlap preheat temperatures and dwell time	°C/min	Applicator's method	Acceptable range to be established during PQT	Once	Once	Each joint
PP injection temperature	°C	Applicator's method	Acceptable range to be established during PQT	Once	Once	Each joint
Injection pressure	MPa	Applicator's method	Acceptable range to be established during PQT	Once	Once	Each joint
Hold time	s	Applicator's method	Acceptable range to be established during PQT	Once	Once	Each joint
Hold pressure	MPa	Applicator's method	Acceptable range to be established during PQT	Once	Once	Each joint
Minimum demould time	s	Applicator's method	Acceptable range to be established during PQT	Once	Once	Each joint
Quenching time	s	Applicator's method	Acceptable range to be established during PQT	Once	Once	Each joint
Laboratory testing						
Density	kg/m ³	ISO 1183 or ASTM D792	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 joints	3 joints	N/A
Peel strength	N/mm	ISO 21809-1	On steel: in accordance with requirements for 3LPP. On overlap: cohesive failure.	3 joints	3 joints	N/A
Thermal conductivity	W/(m.K)	ISO 8301	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 joints	N/A	N/A
Compressive strength	MPa	ISO 844	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 joints	N/A	N/A
Tensile at yield	MPa	ISO 527	≥ 20	3 joints	N/A	N/A
Elongation at break	%	ISO 527	≥ 400	3 joints	N/A	N/A
Simulated bend test	-	Annex B	In accordance with 8.2.3	2 joints	N/A	N/A
Sectioning of field joint	-	Cut open one joint. Look for voids and defects (such	No defects	3 joints	N/A	N/A


	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001	REV. B		
	JOB: RIGID OFFSHORE PIPELINES			SHEET: 17 of 22		
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS			PUBLIC		
			EDD / EDR			
		as unfused knit line and air entrapment).				
Final inspection						
Overall coating visual	-	Visual	Free from blisters, voids, cracks, disbondment and irregularities	Each joint	Each joint	Each joint
Overlap length (field joint)	mm	Calibrated rule	≥ 50mm	Each joint	Each joint	Each joint
Overlap and body thickness (field joint)	mm	Vernier and straight edge	In accordance with thermal insulation design	Each joint	Each joint	Once per shift
Concentricity	mm	Straight edge ruler or electronic equipment at cutback area	±10%, but not greater than 4mm	Each joint	Each joint	Once per shift
Cutback	mm	Straight edge ruler	In accordance with thermal insulation design	Each joint	Each joint	Once per shift
”						
Polyurethane field joint using casting technique						
(10.6.2) Modification: “A cast polyurethane joint consists of:						
- anti-corrosion coating (fusion bonded epoxy);						
- adhesion promoter (if applicable);						
- insulation layer of polyurethane.”						
(10.6.2) Addition: “The anti-corrosion coating (fusion bonded epoxy) shall comply with requirements of I-ET-0000.00-0000-210-P9U-001, field joint coating type 3A.”						
(Table 14) Modification: “Table 14 – Polyurethane field joint using casting technique						
Property	Units	Test method	Requirements	Frequency		
				PQT	PPT	Production
Raw material testing (Manufacturer's data)						
Density (polyol)	Relative to water at 1.0	Manufacturer	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Viscosity (polyol)	cPs	ISO 3104 or ISO 3219	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Gel time of mixed system (polyol + iso)	min	Manufacturer	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Hardness of cured system (polyol + iso)	Shore A or shore D	ISO 868 or ASTM D2240	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Isocyanate content	%	ISO 14896	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Preparation following application of fusion bonded epoxy						
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	Each item	Each item	Each item

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001	REV. B		
	JOB: RIGID OFFSHORE PIPELINES				SHEET: 18 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS				PUBLIC	
EDD / EDR						
Anti-corrosion coating surface preparation	-	-	If applicable, abrade with sandpaper grit 50 and dust vacuum cleaning.	3 joints	3 joints	Each joint
Adhesion promoter (if applicable)						
Surface pre-heat temperature	°C	Contact thermometer	Acceptable range to be established during PQT	3 joints	3 joints	Each joint
Pot life	min	Stop watch	Cure time check in accordance with manufacturer's recommendation	Start of PQT	Start of PPT	Each shift
Visual appearance	-	visual	Within manufacturer's recommendation. Comparative visual test panels from PQT	3 joints	3 joints	Each joint
Adhesion promoter mix ratio	-	Volume verification	Ratio and tolerance according to manufacturer's recommendation. The ratio defined during PQT shall be used during production.	Start of PQT	Start of PPT	Each joint
Preparation of parent applied insulation						
Inspection of parent coating	-	Visual	Free from oil, grease, dust, debris, other contamination and defects	3 joints	3 joints	Each joint
Parent coating surface preparation (all parent applied insulation systems)	-	Visual	Abrasion of chamfer and overlap areas (abraded area greater than overlap length)	3 joints	3 joints	Each joint
Surface treatment (PP applied coating only)	Dynes	Surface treatment pens	> 45	3 joints	3 joints	Each joint
Post surface treatment inspection (PP parent applied coating only)	-	Visual	No wax formation on the PP chamfer and overlap area	3 joints	3 joints	Each joint
Polyurethane application						
Verification of raw materials properties by a "cup shot"	-	Visual	No air, no discoloration from unmixed components, etc.	3 joints	3 joints	Each joint
Mould temperature	°C	Thermocouple	Acceptable range to be established during PQT	3 joints	3 joints	Each joint
Mix ratio	-	Volume measurement of each component	As per manufacturer's recommendation with a maximum variation of 2%. Verification shall be made using samples collected from pump's outlet.	Start of PQT	Start of PPT	Each shift
Mix ratio	-	Volume measurement of each component	As per manufacturer's recommendation with a maximum variation of 2%. Verification shall be made using the display of pump's	Start of PQT	Start of PPT	Each joint

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001	REV. B		
	JOB: RIGID OFFSHORE PIPELINES			SHEET: 19 of 22		
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS			PUBLIC		
			EDD / EDR			
			control system.			
Minimum demould time	min	Stop watch	Acceptable range to be established during PQT	3 joints	3 joints	Each joint
Laboratory testing						
Density	kg/m ³	ISO 1183 or ASTM D792	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 joints	3 joints	N/A
Thermal conductivity	W/(m.K)	ISO 8301	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 joints	3 joints	N/A
Tensile strength at yield	MPa	ISO 527	Within the manufacturer's certificate of conformity range	3 joints	N/A	N/A
Elongation at break	%	ISO 527	Within the manufacturer's certificate of conformity range	3 joints	N/A	N/A
Compressive strength	MPa	ISO 844	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 joints	N/A	N/A
Adhesion test / peel test (on pipe)	N/mm	ISO 21809-1	≥ 15N/mm	3 joints	3 joints	N/A
Simulated bend test	-	Annex B	In accordance with 8.2.3	2 joints	N/A	N/A
Final inspection						
Overall coating visual	-	Visual	Free from blisters, voids, cracks, disbondment and irregularities	3 joints	3 joints	Each joint
Hardness	Shore A or shore D	ISO 868 or ASTM D2240	Within manufacturer's certificate of conformity range	3 joints	3 joints	Each joint
Overlap length	mm	Calibrated rule	≥ 50mm	3 joints	3 joints	Each joint
Insulation thickness	mm	PI tape or electronic equipment	> 4mm compared to parent coating	3 joints	3 joints	Once per shift
Adhesion to parent coating on overlap and chamfer	MPa	ISO 4624, method B	≥ 5	3 joints	3 joints	N/A
Adhesion to FBE	Mpa	ISO 4624, method B	≥ 5	3 joints	3 joints	N/A
Density and void control	Visual	Optical microscope	No bubbles in sample poured in a cup	3 joints	3 joints	N/A
“						
Elastomeric field joint coating						
(10.6.3) Modification: “The Elastomeric field joint coating shall be constituted of an FBE anticorrosion coating and a elastomeric layer. The anti-corrosion coating (fusion bonded epoxy) shall comply with requirements of I-ET-0000.00-0000-210-P9U-001, field joint coating type 3A. The elastomeric layer shall comply with Table 15.”						

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001			REV. B
	JOB: RIGID OFFSHORE PIPELINES				SHEET: 20 of 22	
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS				PUBLIC	
EDD / EDR						
(Table 15) Modification: "Table 15 – Elastomeric field joint coatings						
Property	Units	Test method	Requirements	Frequency		
				PQT	PPT	Production
Raw material testing (Manufacturer's data)						
Vulcanisation Characteristics	Nm	ISO 6502 (Rheometer)	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Hardness	Shore A or shore D	ISO 7619-1	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Density	g/cm ³	ISO 2781	Within the manufacturer's certificate of conformity range	Each batch	Each batch	Each batch
Preparation following application of fusion bonded epoxy						
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	3 joints	3 joints	Each item
Anti-corrosion coating surface preparation	-	-	If applicable, abrade with sandpaper grit 50 and dust vacuum cleaning.	3 joints	3 joints	Each joint
Preparation of parent applied insulation						
Inspection of parent coating	-	Visual	Free from oil, grease, dust, debris, other contamination and defects	3 joints	3 joints	Each joint
Parent coating surface preparation	-	Visual	Abrasion of chamfer and overlap areas (abraded area greater than overlap length)	3 joints	3 joints	Each joint
Post surface treatment inspection	-	Visual	Free from oil, grease, dust, debris, other contamination and defects	3 joints	3 joints	Each joint
Rubber primer application						
Environmental conditions and substrate temperature	°C	ISO 8502-4	Minimum 3°C above dew point	3 joints	3 joints	Each joint
Over coating time	s	-	Time check in accordance with manufacturer's recommendation	3 joints	3 joints	Each joint
Visual appearance	-	Visual	Within manufacturer's recommendation. Comparative visual test panels from PQT	3 joints	3 joints	Each joint
Rubber application						
Vulcanisation temperature	°C	Contact thermocouple	Acceptable range to be established during PQT	Each item monitored	Each item monitored	Each item monitored
Vulcanisation time	°C	Stop watch	Acceptable range to be established during PQT	Each item	Each item	Each item
Laboratory testing						
Density	kg/m ³	ISO 2781	In accordance with thermal insulation design (test at 23°C ± 2°C)	Once	Once	N/A
Thermal conductivity	W/(m.K)	ISO 8301	In accordance with thermal insulation design (test at 23°C ± 2°C)	Once	Once	N/A

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-431-P9U-001	REV. B		
	JOB: RIGID OFFSHORE PIPELINES			SHEET: 21 of 22		
	TITLE: WET THERMAL INSULATION FOR FLOWLINES AND RISERS			PUBLIC		
EDD / EDR						
Specific heat capacity	J/(g.K)	ISO 11357	In accordance with thermal insulation design (test at 23°C ± 2°C)	Once	Once	N/A
Tensile strength at break	MPa	ISO 37	Within the manufacturer's certificate of conformity range	One test	N/A	N/A
Elongation at break	%	ISO 37	Within the manufacturer's certificate of conformity range	One test	N/A	N/A
Tear strength	N/mm	ISO 34	Within the manufacturer's certificate of conformity range	One test	One test	N/A
Compressive strength	MPa	ISO 844	In accordance with thermal insulation design (test at 23°C ± 2°C)	3 joints	N/A	N/A
Adhesion test / peel test (on pipe)	N/mm	ISO 21809-1	Acceptable range to be defined during PQT, but shall be greater than 2,5N/mm	3 joints	3 joints	N/A
Simulated bend test	-	Annex B	In accordance with 8.2.3	2 joints	N/A	N/A
Final inspection						
Visual inspection	-	Visual	Free from defects	Each joint	Each joint	Each joint
Hardness	Shore A	ISO 7619-1	Within manufacturer's certificate of conformity range	3 joints	3 joints	Each joint
Overlap length	mm	Calibrated rule	≥ 50mm	3 joints	3 joints	Each joint
Total coating thickness	mm	PI tape or electronic equipment	> 4mm compared to parent coating	3 joints	3 joints	Each joint
Concentricity (for pipes only)	mm	Visual and compare with factory coating	-	Each joint	Each joint	First joint
Ovality (for pipes only)	%	Caliper and PI tape	$(OD_{max} - OD_{min})/OD_{PItape} < 2$	Each pipe	Each pipe	1 st joint then every 20 th joint
<p>“</p> <p>Handling, storage and transportation requirements</p> <p>(11) Addition: “A specific procedure encompassing the operations of handling, storage at coating yard and also the transportation shall be supplied to PETROBRAS’ for approval.”</p> <p>(11) Addition: “The partial thermal insulation coating shall be protected from UV degradation ‘between passes’ (if applicable).”</p> <p>(11) Addition: “Regarding the storage of coated pipes, the pipes shall be covered all the time including pipes located at lower layers of the pile The pipes shall be storage with such a slope in order to avoid water accumulation inside the pipes.”</p> <p>Hydrostatic compressive behavior/Tri-axial test procedures</p> <p>(A.1) Modification: “Hydrostatic test is not acceptable for evaluation of parent coating and field joint coating systems mentioned within this Technical Specification. The tri-axial compression and creep test procedure shall be used.”</p> <p>(A.3) Modification: “The duration of the test is 28 days.”</p>						

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-431-P9U-001	REV. B
	JOB:	RIGID OFFSHORE PIPELINES	
	TITLE:	WET THERMAL INSULATION FOR FLOWLINES AND RISERS	SHEET: 22 of 22 PUBLIC EDD / EDR

Simulated bend test

Addition: "This test is applicable only for pipelines being installed by Reel-lay methodology."

Addition: "Minimum bending radius, rate of bending and number of bend cycles shall be in compliance with the obtained information from the vessel. At least 5 bend cycles shall be considered."

(e) Modification: "e) The pipe shall then be bent in the reverse direction..."

Cyclic (fatigue) bend test

Modification: "On completion of the test, the external surface of the coated pipe length shall be subjected to an external visual inspection and the coated pipe length shall be sectioned."

Addition: "Adhesion tests shall be performed after fatigue test."

Simulated tensioner test

Modification: "On completion of the test, the external surface of the coated pipe length shall be subjected to an external visual inspection and the coated pipe length shall be sectioned."

Simulated service test (factory applied coating)

Modification: "Test conditions shall be maintained (temperature +/-1°C, pressure +/- 0.5MPa) over the specified duration of the test, e.g. typically 7 days after the thermal stabilization and design pressure have been achieved."

Ring shear test procedure

Addition: "The test shall be carried out at the following coating interfaces:

Parent Coating:

- Insulation layer / 3LPP undercoating
- Between all the insulation layer interfaces
- Between the top coat and the last applied insulation layer.

Field Joint Coating Systems:

- Insulation layer / FBE."