



PTT Exploration and Production Public Company Limited

PTTEP Engineering General Specification
(Engineering and Development Group)

Standard

Field Joint Coating for Pipelines

Document No: 10008-STD-6-COR-002-R01

September 2018

DOCUMENT REGISTER				
Document Title:		Field Joint Coating for Pipelines		
Document Reference No:		10008-STD-6-COR-002-R01		
Prepared By (Author):		Chan Nyein Aung		
Department/Division/Asset/Company:		EFE/ENC/EDE/PTTEP		
Document Custodian Approvals Register <i>(To be signed on acceptance of Revision No.R00)</i>				
Position	Name	Dept. Code	Signature	Date
Custodian:	Suchada Punpruk	12059	<i>Suchada Punpruk</i>	24/09/18
Document Management Approvals Register <i>(To be signed before release of Revision No.R00)</i>				
Approver		Signature		Date
Name:	Pongpun Urarungroj			25/09/2018
(N+2)	VP - Custodian			
	Facility Engineering Department (12059)			
Name:	Suksant Ongvises			02 OCT 2018
(N+3)	Division SVP - ENC			
	Engineering Construction Division (11016)			
THIS DOCUMENT WILL BE REVIEWED 5 YEARS FROM DATE OF APPROVAL OR REVISED EARLIER IF NECESSARY				

This page shall be retained in the master archived copy

Revision History												
Rev	Description of Revision	Date										
Old	New Document Refer : PEGS-12059-COR-002	17-Oct-16										
R01	Revision note : New document code and formatting <table><tr><th>Item No./Clause</th><th>Description of Change</th></tr><tr><td>All</td><td>Update document number and template align to PTTEP library standard</td></tr></table>	Item No./Clause	Description of Change	All	Update document number and template align to PTTEP library standard	8-Sep-17						
Item No./Clause	Description of Change											
All	Update document number and template align to PTTEP library standard											
R01	Revision note : New document code and formatting <table><tr><th>Item No./Clause</th><th>Description of Change</th></tr><tr><td>7.5.2.1</td><td>Updated greasy substances cleaning</td></tr><tr><td>7.5.2.2</td><td>Updated residual dust abrasive blast cleaning method</td></tr><tr><td>7.5.4.2</td><td>Updated liquid epoxy primer application method</td></tr><tr><td>7.6.4.5</td><td>Revised Peeling force for PE and PP as per ISO 21809-3: 2016.</td></tr></table>	Item No./Clause	Description of Change	7.5.2.1	Updated greasy substances cleaning	7.5.2.2	Updated residual dust abrasive blast cleaning method	7.5.4.2	Updated liquid epoxy primer application method	7.6.4.5	Revised Peeling force for PE and PP as per ISO 21809-3: 2016.	17-Sep-18
Item No./Clause	Description of Change											
7.5.2.1	Updated greasy substances cleaning											
7.5.2.2	Updated residual dust abrasive blast cleaning method											
7.5.4.2	Updated liquid epoxy primer application method											
7.6.4.5	Revised Peeling force for PE and PP as per ISO 21809-3: 2016.											

TABLE OF CONTENTS

1.0	INTRODUCTION.....	1
2.0	PURPOSE	1
3.0	SCOPE	1
4.0	RESPONSIBLE ACTION PARTIES.....	1
5.0	DEFINITIONS	2
5.1	Language	2
5.2	Terminology	2
5.3	Common Acronyms	3
6.0	REFERENCES.....	4
6.1	PTTEP Internal References	5
6.2	International Standards	5
6.3	Code and Other Standards	6
7.0	REQUIREMENT FOR FIELD JOINT COATING FOR PIPELINES.....	7
7.1	Approved field joint coating system	7
7.2	Information to be supplied by the company	7
7.3	Applicator's and contractor's obligations	8
7.4	Technical data sheet of products	11
7.5	Application of field joint coatings	13
7.6	Inspection and testing.....	19

1.0 INTRODUCTION

PEGS (PTTEP Engineering General Specification) is the PTT Exploration and Production PCL internal publishes standard. The objective of PEGS is to promote the best practices collecting from all PTTEP execution projects and to standardize those best practice to the future projects.

Every 5 years or upon request by the internal user, PEGS will be reviewed by related subject experts to reach decisions/agreements, then the document will be updated and publish to PTTEP intranet website. This is to ensure that all lesson learns from users can be applied to the future projects as the benefit to PTTEP.

2.0 PURPOSE

The purpose of the PTTEP General Specifications (PEGS) is to provide general technical guidance for the activities associated with engineering design, procurement, installation, and construction (EPIC) project process, to achieve technical integrity and optimum life cycle cost for constructing PTTEP facilities.

3.0 SCOPE

This specification covers the anticorrosion coatings to be applied to the steel surface which is left bare when plant coated pipes are joined by welding to constitute pipelines for the transportation of oil, gas and water. Different types of coating systems, accepted by COMPANY for buried and immersed pipelines, are defined in the section 7 of this specification.

The anticorrosion coating to be applied at field joints shall be compatible with the line pipe coating, easily applicable at site or on the barge and suitable for the service conditions during the field life. The performance of field joint coating should ideally meet or exceed the factory applied coating on line pipes.

For each of the field joint coating type, the present document specifies the minimum requirements for the following:

- 1) Application of coatings
- 2) Characteristics of coatings
- 3) Qualification testing
- 4) Pre-production and production testing and inspection
- 5) Repairs of field joint coatings

4.0 RESPONSIBLE ACTION PARTIES

N/A

5.0 DEFINITIONS

A number of different terms are commonly used to describe the work stages, processes, and approvals which take place during the early stages of a development. This can often be a source of confusion so the following section is intended to show the PTTEP preferred terminology as used in this document.

5.1 LANGUAGE

In this document, the words should and shall have the following meanings:

Shall	Indicates a course of action with a mandatory status. The term “shall” shall be used if a requirement is considered to be necessary to claim compliance with a PEGS document.
Should	Indicates a preferred course of action. Should is a non-mandatory word and is not forbidden, but use in the body of the text should be the exception. Where none mandatory terms are used, each paragraph within these clauses shall also have an associated commentary paragraph that provides the rationale for why the stated choices and modifications are appropriate and circumstance under which the stated choices and modifications might be different.

5.2 TERMINOLOGY

Terminology	Description
Applicator	The company in charge of the plant coating application and quality control which is eventually sub-contracted by the Contractor shall be referred to herein as the “Applicator”.
Approval	The authorization in writing given by the COMPANY to the Contractor to proceed the work without releasing in any way the Contractor from any of his obligations to conform with the technical specifications, requisitions, etc. The words “Approve”, “Approved” and “Approval” shall be construed accordingly
Company	PTT Exploration and Production Public Company Limited and affiliates.
Contract Documents	The material requisitions, material specifications, etc. issued by the COMPANY and attached to the Contract or the Purchase Order
Contractor	Per contract: Contractor – ‘The contractor who is a PARTY to this CONTRACT and where the context so requires including, SUBCONTRACTORS utilized by CONTRACTOR for the performance of the WORK’
Inspector	The COMPANY’s or Contractor’s representative(s), (as applicable), or member(s) from an Inspection Agency duly appointed by the COMPANY or the Contractor (as applicable) to act as its representative(s) for the purpose of the contracts
Manufacturer	The company or its sub-contractors selected by the COMPANY or the Contractor or the Supplier (as applicable) as the Manufacturer of the said material.
PPS	Designates Project Particular Specification detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions or the local legislation of the project.

5.3 COMMON ACRONYMS

Set out below in alphabetical order are common acronyms as found within this document:

3LPE	Three Layer Polyethylene
3LPP	Three Layer Polypropylene
BS	Bituminous Coating
DSC	Differential Scanning Calorimetry
FBE	Fusion-Bonded Epoxy
GFVE	Glass Flake Filled Vinylester
GPS	Geometrical Product Specifications
HDPUF	High Density Polyurethane Foam
LEP	Liquid Epoxy Primer
MFR	Melt Mass-Flow Rate
MVR	Melt Volume-Flow Rate
PE	Polyethylene
PP	Polypropylene
PPT	Pre-Production Trial
PQT	Procedure for Qualification Trial
PU	Polyurethane
VST	Vicat Softening Temperature

6.0 REFERENCES

The reference documents listed below, including Industry Codes and Standards and COMPANY specifications, form an integral part of this Engineering General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published on the effective date of a contract.

The overall order of precedence of the applicable documents shall be:

1. Applicable Laws, Rules and Regulations of the country in which the system/equipment will be operated (if any);
2. Purchase Order/ Service Order/ Contract Documents (Only applicable for direct purchase by COMPANY);
3. Project Particular Specification (PPS), and relevant data sheet(s) if any;
4. COMPANY General Specification;
5. Codes and Standards in reference.

Any conflict between any of the Contract Documents, or between this specification and any other Contract Documents, shall be reported to COMPANY for decision. In such a case, and unless otherwise agreed or decided by COMPANY, it is understood that the more stringent requirement shall apply.

Exceptions to, or deviations from this specification are not permitted unless previously accepted in writing by COMPANY. For this purpose, requests for substitutions or changes of any kind shall be completed with all pertinent information required for COMPANY assessment. COMPANY's approval, nevertheless, will not, in any way, relieve the responsibility of the Contractor to meet the requirements of the industry Codes and Standards referred to and amended herein, in the event of conflict.

6.1 PTTEP INTERNAL REFERENCES

Internal documents applicable to this document are indicated in the table below.

Document Number	Document Title
10008-STD-6-COR-001, PEGS-12059-COR-001	External Anticorrosion Coating for Pipelines

6.2 INTERNATIONAL STANDARDS

International standards applicable to this document are indicated in the table below i.e. ISO, IEC or ITU.

Document Number	Document Title
ISO 11124-2/4	Preparation of Steel Substrates before Application of Paints and Related Products. Specifications for Metallic Blast- Cleaning Abrasives
ISO 11125-1/7	Preparation of Steel Substrates before Application of Paints and Related Products. Methods for Testing Metallic Blast- Cleaning Abrasives
ISO 11126-7	Preparation of Steel Substrates before Application of Paints and Related Products. Specifications for Non-Metallic Blast-Cleaning Abrasives: Fused Aluminium Oxide
ISO 11127-1/7	Preparation of Steel Substrates before Application of Paints and Related Products. Methods for Testing Non-Metallic Blast-Cleaning Abrasives
ISO 1133	Plastics -Determination of the Melt Mass-Flow Rate (MFR) and the Melt Volume-Flow Rate (MVR) of Thermoplastics
ISO 1183	Plastics - Methods for Determining the Density and Relative Density of Non-Cellular Plastics
ISO 12809-3	Petroleum and Natural Gas Industries – External coatings for buried or submerged pipelines used in pipeline transportation systems – Part 3 Field Joints Coatings
ISO 21098-1	External coatings for buried or submerged pipelines used in pipeline transportation system : Polyolefin coatings (3-layer PE and 3-layer PP)
ISO 21809-3	External coatings for buried or submerged pipelines used in pipeline transportation system : Field joint coatings (Version – 2016)
ISO 306	Plastics - Thermoplastic Materials - Determination of Vicat Softening Temperature (VST)
ISO 527-3	Plastics -Determination of Tensile Properties - Part 3: Test Conditions for Films and Sheets

Document Number	Document Title
ISO 8501-1	Preparation of Steel Substrates before Application of Paints and Related Products. Visual Assessment of Surface Cleanliness. Part 1: Rust Grades and Preparation Grades of Uncoated Steel Substrates and of Steel Substrates after Overall Removal of Previous Coatings
ISO 8501-2	Preparation of Steel Substrates before Application of Paints and Related Products. Visual assessment of Surface Cleanliness. Part 2: Visual Assessment of Surface Cleanliness
ISO 8502-1/4	Preparation of Steel Substrates before Application of Paints and Related Products. Tests for the Assessment of Surface Cleanliness
ISO 8502-6	Preparation of Steel Substrates before Application of Paints and Related Products. Tests for the Assessment of Surface Cleanliness: Extraction of Soluble Contaminants for Analysis - the Bresle Method
ISO 8502-9	Preparation of Steel Substrates before Application of Paints and Related Products. Tests for the Assessment of Surface Cleanliness: Field Method for Conductimetric Determination of Water-Soluble Salts
ISO 8503-1/4	Preparation of Steel Substrates before Application of Paints and Related Products. Surface Profile of Abrasive Blast- Cleaned Steel
ISO 868	Plastics and ebonite - Determination of Indentation Hardness by Means of a Durometer (Shore Hardness)
NACE RP 0402	Field-Applied Fusion-Bonded Epoxy (FBE) Pipe Coating Systems For Girth Weld Joints

6.3 CODE AND OTHER STANDARDS

Codes, standards and regional legislation applicable to this document are indicated in the table below.

Document Number	Document Title
DIN 53163	Testing of pigments and extenders; determination of lightness of extenders and white pigments in powder form
EN 10204	Metallic Products - Types of Inspection Documents
EN 12068	Cathodic Protection: External Organic Coatings for the Corrosion Protection of Buried or Immersed Steel Pipelines Used in Conjunction with Cathodic Protection - Tapes and Shrinkable Materials
NF A49716	Steel tubes and fitting for onshore and offshore pipelines - External field joint coatings

7.0 REQUIREMENT FOR FIELD JOINT COATING FOR PIPELINES

7.1 APPROVED FIELD JOINT COATING SYSTEM

Acceptable field joint coatings for different types of pipe coating are summarized below. The Applicator shall select the appropriate field joint coating considering the pipe coating and service conditions (mainly maximum operating temperature). Any other coating system is subjected to COMPANY's approval based on either a:

- 1) documented file containing results of qualification tests carried out by third party laboratories or
- 2) pre-qualification test carried out in the presence of COMPANY representative.

The type(s) of field joint coating(s) accepted for a given project is/are specified in a Project Specification. Cold applied tapes are not acceptable.

7.1.1 3LPP COATED PIPES

FBE + PE heat shrinkable sleeve: acceptable for both onshore and offshore applications

LEP + PE heat shrinkable sleeve: acceptable for both onshore and offshore applications

PU tar based paints, liquid epoxy based paints and glass flake filled vinyl ester paint are acceptable for onshore application subject to COMPANY approval.

7.1.2 3LPP COATED PIPES

FBE + PP heat shrinkable sleeve: acceptable for both onshore and offshore applications

LEP + PP heat shrinkable sleeve: acceptable for both onshore and offshore applications

FBE + Flame sprayed PP: acceptable for both onshore and offshore applications

FBE + PP adhesive + Hot applied PP tape: acceptable for both onshore and offshore applications

7.1.3 FBE COATED PIPES

FBE: Acceptable for both onshore and offshore applications

7.2 INFORMATION TO BE SUPPLIED BY THE COMPANY

The COMPANY or his representative will state in his inquiry and order, by a Project Specification, the following information:

- 1) Environment (onshore, offshore), exposure (buried or not), soil conditions (dry soil, desert, swamp, wet soil)
- 2) Maximum operating temperature, minimum temperature if relevant
- 3) Pipe coating material

- 4) Accepted type of field joint coating(s)
- 5) Information on the approved Manufacturers, type of coating materials and trade names for each product and also specific information about coating application, minimum thickness, number and dimensions of repairs (if allowed) and repair procedure
- 6) Overlap of the factory applied coating

7.3 APPLICATOR'S AND CONTRACTOR'S OBLIGATIONS

7.3.1 APPROVAL OF COATING METHOD AND PRODUCTS

The Contractor shall, in his tender, submit the method of application and Manufacturer's data sheets of all the coating and repair materials for COMPANY approval in accordance with the present General Specification and the specific requirements given in the Project Specification, the tender or the order. In case of polyethylene (PE) or polypropylene (PP) based heat-shrinkable materials, the information has to be in accordance with EN 12068 (Tables 3 to 7, typical data). The minimum content of a data sheet required is indicated in the chapters related to the different field joint coating systems. These coatings shall meet as a minimum the requirements of EN 12068. Once approved, the coating products and method shall not be changed by the Applicator without prior written authorization of the COMPANY. The approval decision shall not in any case be considered as a guarantee from the COMPANY with respect to the coating material but only as an authorization for use.

The time necessary for the various operations related to surface preparation, heating, coating application and testing shall be defined by Applicator and checked and approved by Contractor in order to suit the pipeline laying operations.

7.3.2 SUPPLY OF COATING PRODUCTS

The Contractor and Applicator shall obtain from the Manufacturer and submit to COMPANY:

- 1) The guarantee that the coating products delivered shall meet the required coating characteristics as set forth according to the specified methods
- 2) Production test certificates for the coating products
- 3) In case epoxy powder is used, one test certificate per 20 tons batch approximately, including respectively the test results as defined in the present document which shall be in conformity with the specified methods and acceptable values
- 4) Standard Infra-Red Scan of epoxy powder for each production batch
- 5) Conditions of application of the coating products (field joint and repair of plant coating and field joint coating)

- 6) Packaging and storage requirements of coating materials
- 7) Marking on each packing of coating materials with mention of the following information:
 - a) Manufacturer's name
 - b) Name and complete identification of product including factory of origin
 - c) Reference to applicable coating standards
 - d) Production batch or cast number
 - e) Date of production
 - f) Limit date of use

7.3.3 QUALIFICATIONS OF THE COATING SYSTEMS, COATING APPLICATION AND APPLICATORS

Even though the present document can be used for the prequalification of a new product or new field joint coating system independently of a specific job, this document is dedicated to the application of the selected field joint coating(s) for a specific project.

For each project, the coating system, products, application process, equipment to be used for surface preparation and application of the coating system and personnel which execute the job shall be qualified. Applicators shall be qualified by test and approved by COMPANY, in the presence of a COMPANY representative, based on a Procedure for Qualification Trial (PQT). These tests should be carried out at least two months before the production startup and shall be organized jointly by the Contractor and the Applicator with the assistance of the Manufacturer whenever necessary (especially for the training of the personnel). Tests and acceptable results are those specified in the present document in the chapters related to the different field joint coating systems.

- 1) The procedure to be used shall be submitted to COMPANY for approval at least one month before PQT.
- 2) PQT shall be carried out on the actual coated project pipes. Other pipes are acceptable provided that they have the same diameter and the same thickness as the actual pipes and are coated with the same pipe coating products and with the same process as the actual project pipes.
- 3) Tests shall be carried out on test zones distributed along the coated pipe. The length of the test zones should be equivalent to the field joint coating length specified for the project.
- 4) A girth cap weld shall be added at the centre of each of the test zones in order to mimic the fields weld
- 5) All equipment (induction heating, abrasive blasting, coating application equipment

and also inspection equipment and tools) used for PQT shall be the same as the equipment which will be used for PPT and the actual field joint coating at site.

- 6) Operators should already be familiar with the application of the selected field joint coating for the project. Each operator shall coat at least three test zones. If any of them is not acceptable then the same applicator will coat three other test zones. In case of new failure, the qualification of this operator is rejected and another operator shall be trained. Qualified operators shall apply the field joint coating during pipe construction. Contractor or Applicator shall not replace the qualified applicators without informing COMPANY. A new qualification test shall be organized for the new applicators and at the Contractor's expense.
- 7) Operators shall be qualified for the field joint coating repairs during PQT.
- 8) The time for coating application on a test zone shall not exceed the estimated field joint coating time on yard or on the barge
- 9) For PP application by flame spray technique, coating samples shall be collected to measure the Oxygen Induction Time
- 10) The Contractor and the Applicator (if needed with the support of the Manufacturer) shall submit a complete report of the PQT results to the COMPANY for approval at least one month before production startup.

7.3.4 OTHER REQUIREMENTS

The Contractor shall notify the COMPANY, at least eight working days before coating application, of the dates of coating execution to permit mobilization of the COMPANY designated Inspector. Upon arrival at the field joint coating facilities, the Inspector shall receive from the Contractor/ Applicator the documents supplied by the Manufacturer as specified in section 7.3.2 and the written approved procedure by COMPANY. The Inspector shall have free access to the field coating site.

The Contractor shall provide the Inspector with all the facilities necessary for the proper execution of his mission. He will provide accommodation to him in case of offshore or remote locations. The Contractor/Applicator shall supply all personnel, coating material and repair products, equipment, application material and inspection apparatuses.

The Applicator shall store the coating materials and repair products, perform coating application and inspection in conformity with the present document and all the relevant rules of practice.

The Applicator shall, at his own expenses request assistance from Manufacturer in case of application difficulties.

Inspection operations shall be carried out as agreed between COMPANY and Applicator at the time of enquiry and order. The inspection documents should be in accordance with EN 10204.

7.3.5 ACCEPTANCE CERTIFICATES

The Contractor and the Applicator shall sign jointly with the Inspector the field joint coating acceptance certificates including the results of all tests and inspection as set forth in this specification. The acceptance certificates shall certify that all tests and inspections have been performed by the Applicator under the responsibility of the Contractor and have been witnessed by the Inspector. One copy of the acceptance certificates shall be transmitted to COMPANY and one copy to the Inspector.

7.4 TECHNICAL DATA SHEET OF PRODUCTS

The fusion-bonded epoxy powder coating shall meet the qualification requirements defined in NACE RP 0402 except when otherwise specified. Required data are summarized below. Other tests like impact resistance, indentation at ambient and maximum operating temperature, electrical insulation resistance, lap shear strength, resistance to thermal ageing and to UV radiation, etc have also to be carried out for Qualification. For these tests, methods and acceptable values are those of EN 12068 for Class C and those specified in this specification whichever is higher.

7.4.1 DATA REQUIRED FOR ALL PRODUCTS

- 1) Date of issue
- 2) Name of Manufacturer
- 3) Commercial name of the product
- 4) Storage conditions
- 5) Color
- 6) Application methods and conditions
- 7) Minimum and maximum temperature of the steel during application
- 8) Temperature limit

7.4.2 ADDITIONAL DATA REQUIRED FOR FBE PRIMER AND FBE POWDER

The following additional data are required for the FBE primer.

	FBE Primer	FBE Powder
Shelf life	X	X
Sieve analysis/ granulometry	X	X
Infrared analysis	X	X
Gel time	X	X
Time between coats	X	X
Maximum ΔT_g ¹ of the reticulated film	X	X
(NF A49716 Annex D)		
Hardness of the reticulated film (DIN 53163)		X
Maximum thickness per coat		X
Impact resistance at ambient temperature		X
X Flexibility of the reticulated film at 0 °C and 23 °C		X

Remark: 1. Minimum glass transition temperature shall be equal to or greater than the pipeline design temperature.

7.4.3 ADDITIONAL DATA REQUIRED FOR PP POWDER AND MODIFIED PP POWDER

The following additional data are required for the modified PP powder and PP powder.

	PP Powder	Modified PP Powder
Density (ISO 1183)	X	X
Sieve analysis		X
Melt Index (ISO 1133)	X	X
Elongation at break ISO 527-3	X	X
Time between coats		X
X Vicat softening point at 9,8 N (ISO 306 A50)	X	X

7.4.4 ADDITIONAL DATA REQUIRED FOR EPOXY RESIN, LIQUID POLYURETHANE AND GFVE

- 1) Density of component
- 2) Density of mixture
- 3) Dose ratio in weight and volume
- 4) Type of solvent

- 5) Solids by weight
- 6) Solids by volume
- 7) Time between coats
- 8) Shore D hardness (ISO 868)
- 9) Maximum thickness per coat
- 10) Curing time

7.5 APPLICATION OF FIELD JOINT COATINGS

7.5.1 PRE-PRODUCTION TRIAL

For each type of field joint coating and for each pipe size, a Pre-Production Trial (PPT) shall be carried out on site in the actual conditions of pipe, plant-coating, equipment, material and personnel before commencement of the job. In addition, a Production Testing program shall be implemented to verify the conformity of quality during execution of the job. Procedures, frequency and acceptable results of testing and inspections during PPT are indicated in the chapters related to the different field joint coating systems.

7.5.2 SURFACE PREPARATION

7.5.2.1 SURFACE CLEANING

Prior to field joint coating, cut back areas shall be cleaned by appropriate means to remove all contaminants (such as former coating, paint and non-adhering particles, grease and oil, salt, mud etc.) in order to have steel surface as clean as possible before abrasive blasting. The surface to be coated shall be, at the time of application, dry and free of any contamination detrimental to adhesion of the coating on the steel.

If appropriate, cleaning shall be carried out to remove the following in particular:

- 1) Mud and soluble salts: cleaning by fresh water wash
- 2) Greasy substances: cleaning by using a totally volatile solvent (containing no chloride) and is oil-free. Oil based solvent is not allowed in any case.
- 3) Weld spatters, slag, burrs that can pierce the coating: cleaning by grinding or filing. Areas of rust or scaling shall be treated in the same way

7.5.2.2 ABRASIVE BLAST CLEANING

Prior to startup of abrasive blasting at field joint area, a plastic tape, at least 60 mm wide, shall be applied on the pipe coating and FBE toes, at both sides of the field joint to prevent the contamination of the pipe coating by abrasive particles and dust.

Abrasive blast cleaning shall be carried out to obtain a surface cleanliness at least Sa 2½ as defined in ISO 8501-1. Brush cleaning, as the principal surface preparation method, is not acceptable.

The cleaned surface shall have a roughness as specified by the Manufacturer but the cleaned surface shall have a Rt roughness of 50–90 microns. It is measured according to a method given in the coating application and repair procedure.

After abrasive blast cleaning, the surface of the joints shall be inspected. All slivers, laminations, weld sharp spots and other surface imperfections made visible by the cleaning and which are detrimental to the quality of coating shall be removed.

The residual dust created by abrasive blasting shall be removed efficiently by using compressed air free of water and contaminants.

If after surface preparation, the surface is contaminated or rusted, the joint shall undergo further partial or total surface preparation. During bad weather (rain, wind, etc.) cleaning operations may only continue if effective protective awnings are installed. Any chloride contamination detrimental to the bonding of coating to steel shall be prevented and removed.

Generally the plant applied pipe coating is contaminated by dust or abrasive (in spite of protection by plastic tape) during surface preparation. At least 10 cm of the adjoining factory applied coating has to be cleaned and abraded to expose a fresh surface in order to improve the adhesion at overlap between pipe coating and field joint coating and to prevent any cracking or disbondment due to aging of adhesion.

Any conversion chemical pre-treatment of the steel to supplement the surface preparation is forbidden

7.5.3 APPLICATION

The temperature of the area to be coated shall be at least 3 °C above the dew point.

The coating of the joint shall be applied by accredited qualified personnel, in accordance with the specified procedure approved by the COMPANY.

Application of the field joint coatings shall be carried out in accordance with the recommendations of the Manufacturer. Especially, Manufacturer's recommendations regarding the pipe surface temperature range for coating application shall be strictly followed. The temperature of the joint shall be monitored using suitable means in order to make sure that the application conditions are fully satisfied. Heating of the field joint area shall not deteriorate the performance of the pipe coating. If any damage to the pipe coating is expected/observed, pipe coating shall be protected by an insulating sheet. The overlap on the factory applied coating, excluding bevels, shall not be less than 60 mm after field joint coating application.

7.5.4 GENERAL REQUIREMENTS FOR THE APPLICATION OF PRODUCTS

7.5.4.1 APPLICATION OF THE FBE PRIMER

As mentioned in section 7.1 of the present specification, FBE primer is required for the field joint coatings of 3LPE and 3LPP coated pipes.

The area to be coated is heated immediately after surface preparation up to the temperature required approximately 240 °C as resulting from PQT, by induction heating. The holding time and the temperature shall not result in oxidation of the surface of steel and of FBE.

Temperature profiling of induction equipment shall be conducted during PQT and the temperature shall be closely monitored to prevent damage to plant applied coating.

FBE shall be applied on the steel surface by spraying of the powder with a semi-automatic electrostatic coating machine or application by special spray guns, by rotation around the pipe. The thickness of the FBE shall be 120 to 200 microns. FBE thickness should not exceed 200 microns. No FBE shall be allowed on the pipe plant coating. Pipe coating shall be masked by a tape during FBE application. If any FBE is applied on the pipe coating by accident, it shall be removed before application of the next coating.

7.5.4.2 APPLICATION OF THE LIQUID EPOXY (LEP) OR LIQUID PRIMERS

As mentioned in section 7.1 of the present specification, LEP primer may be required for the field joint coatings of 3LPE and 3LPP coated pipes.

Whenever required as primer, LEP is applied on the steel surface by spraying, by brushing or by using applicator pad. The thickness shall be as per manufacturer recommendations but not less than 150 microns. No LEP shall be allowed on the pipe plant coating. Pipe coating shall be masked, if needed, by a tape during LEP application. If any LEP is applied on the pipe coating by accident, it shall be removed before application of the next coating. Temperature profiling of induction equipment shall be conducted during PQT and the temperature shall be closely monitored to prevent damage to plant applied coating.

7.5.4.3 APPLICATION OF HEAT-SHRINKABLE SLEEVES

As mentioned in section 7.1 of the present specification, heat shrinkable sleeves can be applied on top of the either FBE or LEP for the field joint coatings of 3LPE and 3LPP coated pipes.

As a general guide, the following procedure shall be adhered to:

- 1) Before welding, position a shrinkable sleeve just beside the joint or use an open type shrinkable sleeve
- 2) After welding, clean the area by abrasive blasting
- 3) Preheat the area to be coated to a temperature specified by the material

- 4) Apply the FBE or LEP primer and cure this layer by induction heating or other approved method.
- 5) Position the sleeve to provide the total of 60 mm overlap, on each side of adjacent factory coating and bevel when shrinking is completed.
- 6) From external side, heat the sleeve to a surface temperature specified by the product to be applied (from 90 to 240 °C) with a hot air ring unit or a propane gas torch. Heating shall be applied progressively and regularly, starting from the middle of the sleeve and going towards the ends to avoid forming air pockets.

7.5.4.4 APPLICATION OF PP COATING BY FLAME SPRAY

As mentioned in section 7.1 of the present specification, PP coating can be applied by flame spray on top of the FBE for the field joint coatings of 3LPP coated pipes. The complete field joint coating consists of:

- 1) FBE as mentioned in section 7.5.4.1 and
- 2) Modified polypropylene powder applied by flame spraying until the required coating thickness is obtained.

The following summarizes the application of the adhesive and PP coating.

- 1) The overlap on the factory applied coating, excluding bevels, shall not be less than 10 mm.
- 2) By flame spray in a controlled gaseous atmosphere; the chemically modified polypropylene powder is sprayed onto the surface to be coated preferably during the primer gel time, but in any case before the primer is fully cured, to get a 2 to 2.5 mm thickness coat.

The Applicator shall provide COMPANY with the test results showing that they are able to meet the COMPANY requirement related to the Oxygen Induction Time for the applied polypropylene which is 22 minutes $\pm$ 2 minutes at 220 °C for 1 gram of sample under 350 mbar of oxygen. An adequate distribution of the polypropylene particles size is an important parameter for preventing heavy oxidation of the powder during application. The Applicator shall control the powder quality. Additional heat may be added during application of the polypropylene via low pressure hot air or gas flame heated guns without damaging the factory pipe coating.

7.5.4.5 APPLICATION OF CHEMICALLY MODIFIED POLYPROPYLENE TAPES

As mentioned in section 7.1 of the present specification, PP tape coating can be applied on top of the FBE for the field joint coatings of 3LPP coated pipes. The complete field joint coating consists of:

- 1) FBE as mentioned in section 7.5.4.1 and
- 2) A coat of chemically modified polypropylene powder (adhesive) applied by spraying and

- 3) A PP tape applied by wrapping either in a spiral way or in cigarette way.

The PP tape is applied by wrapping a hot tape, either spiral wrap or cigarette wraps. Tapes shall be preheated in an oven for one hour at 120 - 140 °C. Also a proper heating system (hot air for example) has to be used during tape application (PP tape is melted) to obtain a good welding on the factory applied coating and between the successive layers of the applied tape.

The following steps shall be followed for the adhesive and tape applications:

- 1) Joint area temperature shall be raised to approximately 240 °C by induction heating. Pipe coating shall be protected by masking tape during induction heating and temperature should be monitored to prevent damage of the plant applied coating.
- 2) Following the FBE application (according to section 7.5.4.1) and before the gel time of the FBE has elapsed, the chemically modified polypropylene layer shall be applied. The thickness shall be 150 to 250 microns. The thickness along the longitudinal weld (if any) can be up to 400 microns.
- 3) Wrap the field joint area with the preheated PP tape by means of an automatic machine. For spiral PP tape application, the overlap between two successive layers shall be sufficient to reach around 2.5 mm thick coating. The temperature control at this stage is essential for the adequate coating adhesion. Some pressure is applied to the tape (especially for the cigarette wraps) along the toe of the longitudinal weld (if any) and at the intersection of the girth weld to remove any air trap.

7.5.4.6 APPLICATION OF PU TAR BASED PAINTS OR GLASS FLAKE FILLED VINYLESTER PAINT

As mentioned in section 7.1, PU tar based paints, liquid epoxy based paints or glass flake filled vinylester paint are acceptable for onshore application subject to COMPANY approval.

The coating of the joints consists in application of one or more layers of liquid epoxy resin or polyurethane or glass flake filled vinylester (GFVE). These materials are applied with or without primer. The method of application shall be in accordance with the recommendations of the Manufacturer.

The thicknesses of epoxy resins and polyurethane can be up to 1000 and 1500 microns respectively. Their limit of use is 60 °C. The thickness of the GFVE can be up to 2000 microns and its limit of use is 90 °C.

Adhesion of these coatings to PE and PP pipe coatings is very weak even with oxidizing flame treatment. If they are applied as field joint coating and the adhesion at overlap areas is not sufficient, then the field joint coating can be applied up to the limit of the plant coating. The

remaining thin gap between field joint coating and pipe coating (0.1 - 0.2 mm) should be protected by cathodic protection.

7.5.5 REQUIREMENTS FOR THE APPLICATION OF FIELD JOINT COATING SYSTEMS

7.5.5.1 3LPE COATED PIPES

- 1) Field joint: FBE + PE heat shrinkable sleeve
 - a) FBE shall be applied as per section 7.5.4.1
 - b) PE shrinkable sleeve shall be applied as per section 7.5.4.3
- 2) Field joint: LEP + PE Shrinkable sleeve
 - a) LEP shall be applied as per section 7.5.4.2
 - b) PE shrinkable sleeve shall be applied as per section 7.5.4.3
- 3) Field joint: PU tar based paints or glass flake filled vinyl ester paint

The field joint coating shall be applied according to the Manufacturer's recommendations and according to section 7.5.4.6

7.5.5.2 3LPP COATED PIPES

- 1) Field joint: FBE + PP heat shrinkable sleeve
 - a) FBE shall be applied according to section 7.5.4.1
 - b) PP shrinkable sleeve shall be applied according to section 7.5.4.3 and Manufacturer's recommendations
- 2) Field joint: LEP + PP heat shrinkable sleeve
 - a) LEP shall be applied according to section 7.5.4.2 and Manufacturer's recommendations
 - b) PP shrinkable sleeve shall be coated according to section 7.5.4.3 and Manufacturer's recommendations
- 3) Field joint: FBE + flame sprayed PP
 - a) FBE shall be applied according to section 7.5.4.1
 - b) PP shall be applied as per according to section 7.5.4.4
- 4) Field joint: FBE + adhesive + Hot applied PP tape
 - a) FBE shall be applied according to section 7.5.4.1
 - b) Adhesive and PP tape shall be applied as per according to section 7.5.4.5

7.5.5.3 FBE COATED PIPES

1) Field joint: FBE

The method of application should be in accordance with the recommendations of the Manufacturer. The surface preparation, pipe heating and the application shall be according to section 7.5.4.1 with the exception that the thickness of the FBE shall be minimum 325 microns and maximum 600 microns (for the reel barge laying the maximum thickness shall be 500 microns).

7.5.6 REPAIR OF FIELD JOINT COATING

The acceptability of field joint coating repair is not allowed, unless the repair procedure is proposed and subject to written approval by COMPANY.

7.5.7 ADDITIONAL MECHANICAL PROTECTION OR INFILL APPLICATION

Additional mechanical protection may be used as required in the Project Specification (e.g. rock shield or infill of concrete coated pipes). Mechanical protection is not covered in this document. However, for the concrete coated pipes, if an infill is to be applied on top of the field joint coating, the jacket used for infill application shall be unpainted carbon steel plate. HDPUF shall be used as infill material. Product specification is subjected to written approval by COMPANY. Non-metallic jacket is not acceptable.

7.6 INSPECTION AND TESTING

7.6.1 INSPECTION OF PRODUCTS AND STORAGE CONDITIONS

The Applicator shall make sure that:

- 1) the products comply with the project specification
- 2) the storage conditions comply with Manufacturer's requirements

7.6.2 INSPECTION OF THE SURFACE PREPARATION

Following the abrasive blasting and dust removal, visual inspection shall be carried out and surface roughness and metal temperature shall be measured. COMPANY requirements are given in Table 1.

Table 1 - Inspection and Testing of Surface Preparation

	Visual Inspection	Rz Surface Roughness in Microns	Pipe Temperature	Salt Contamination	Dust Level
Inspection method	ISO 8501-1	ISO 8503-1		ISO 8502-6 and 8503-9	ISO 8502-3
Frequency for PQT and PPT	3 joints minimum	3 joints minimum	3 joints	3 joints minimum	3 joints minimum
Frequency during production	Each joint	3 times per shift	Each joint	3 times per shift	3 times per shift
Acceptance criteria	Sa 2-½	50 to 90 micron	3 °C above air dew point	Salt content < 20mg/m ²	Maximum 2

7.6.3 CHARACTERISTICS OF THE APPLIED COATINGS

The tests detailed below shall be carried out, either for qualification (PQT) or during Preproduction Trial (PPT) or for Production Testing.

- 1) Tests common to all types of field joint coatings
- 2) Specific tests for particular coating systems

7.6.4 TESTS COMMON TO ALL TYPES OF FIELD JOINT COATINGS

7.6.4.1 DEGREE OF CURE

For the coatings having the FBE primer, the degree of cure shall be measured by differential thermal analysis of a FBE sample taken from the joint.

The test shall be carried out according to the method defined in Annex E of ISO 21809-3. Acceptance criterion is the value of ΔT_g given by the Manufacturer. Typical acceptable value is a $\Delta T_g \leq 3$ °C.

7.6.4.2 VISUAL INSPECTION DURING COATING APPLICATION

The factory coated pipes shall be visually inspected before field joint welding in order to repair any damage caused by handling or transportation.

After application of the field joint coating, the appearance of the coating applied shall be homogenous across the entire surface, in particular no surface defects detrimental to the quality of the coating (grit, foreign particles, pitting, blisters, etc) shall be observed. Any disbonding or blister between pipe coating and field joint coating shall be repaired according to the approved procedure.

- 1) Frequency for PQT and PPT: 3 joints minimum
- 2) Frequency during production: Each joint
- 3) Acceptance criteria: Homogeneous, no defect, no disbonding/blistering

7.6.4.3 THICKNESS

The minimum value of the thickness is specified either according to result of tests carried out as per this specification in section 7.3.3 or by the product manufacturer but agreed by COMPANY. The minimum value of the coating thickness measured on the body shall be not less than 90 % of the nominal thickness agreed by the COMPANY. The nominal thickness is the calculated sum of the thicknesses of all layers of the coating before application. The minimum value measured on top of the weld bead shall be not less than 75 % of the nominal thickness.

Note: The thickness on the weld bead is normally less than the thickness on the body because part of the polymeric adhesive flows during and after the application from the weld bead to the body. It is preferable to have slightly lower thickness on the weld seam rather than voids along the longitudinal or spiral welding.

On each joint, the thickness shall be measured at four quadrants. Each reading shall be the average of three measurements at these specified positions.

- 1) Method: ISO 21809-3
- 2) Frequency for PQT and PPT: 3 joints minimum
- 3) Frequency during production: Each joint (once per shift for heat shrinkable sleeves)
- 4) Acceptance criteria: 90 % of nominal thickness (75 % at welds)

7.6.4.4 HOLIDAY DETECTION

All types of field joint coatings shall be subject to holiday detection testing. The absence of holidays on the entire surface of field joint coating shall be checked at the voltage given in Table 2.

Table 2 - Voltage to be applied for the Holiday Detection

	Heat Shrinkable Sleeves	Polypropylene Coating	FBE	Epoxy, PU or GFVE
Voltage	5 kV /mm + 5 kV	10 kV/mm (25 kV max)	5V/ micro m. (5 kV max.)	8V/ micro m. (20 kV max.)

- 1) Method: ISO 21809-3
- 2) Frequency for PQT and PPT: 3 joints minimum
- 3) Frequency during production: Each joint
- 4) Acceptance criteria: No holiday

7.6.4.5 PEELING STRENGTH / ADHESION TEST

Peel strength shall be measured on the field joint coating for the PP and PE coated pipes. Adhesion test shall be carried out on the field joint of FBE coated pipe.

The minimal waiting period between application of the coating and the peel force test is 24 hr for heat-shrinkable materials. The peel strength of heat-shrinkable material overlap on factory coated pipe shall be also performed. The peel strength on the steel of the coated joint and on heat-shrinkable material overlap on factory coated pipe shall be greater than the values given in Table 3 for ambient temperature and maximum operating temperature.

Table 3 - Peeling Strength and Adhesion Tests

	Peeling Force for PP and PE Coatings	Adhesion Test for FBE, Epoxy, PU or GFVE Coating
Inspection method	ISO 21809-3 Annex D - D1 or D2 for PQT and PPT - D2 for production	ISO 21809-3 Annex C
Frequency for PQT and PPT - at ambient temperature - at max. operating temperature	3 joints minimum 3 joints minimum	3 joints minimum
Frequency during production:	Once per shift	Once per shift
Acceptance criteria: - At ambient temperature - At max. operating temperature	600 N/ 50 mm for FBE primer 300 N/ 50 mm for LEP primer 400N/ 50 mm for FBE primer 100N/ 50 mm for LEP primer (PE) 200N/50 mm for LEP primer (PP)	Level 1 (Annex C of ISO 21809-3)

7.6.4.6 CATHODIC DISBONDING

The test shall be carried out according to the method defined in Annex F of ISO 21809-3. Test duration, temperature of the tests and acceptance criteria are given in Table 4.

Table 4 - Cathodic Disbonding Test

	Duration	Temperature	Acceptance Criteria Radius Increase
PPT and PQT - Short duration	48 hours	65 °C+/-2 °C	3 mm for FBE primer 5 mm for LEP primer, Epoxy, PU and GFVE
- Long duration	28 days	23 °C+/-2 °C	5 mm for FBE primer 7 mm for LEP primer, Epoxy, PU and GFVE
- At max. operating temperature	28 days	Max. operating	11 mm for FBE 12 mm for LEP primer, PU, Epoxy and GFVE
Production	48 hours	65 °C	3 mm for FBE primer 5 mm for LEP primer, Epoxy, PU and GFVE

Three joints shall be coated for PQT. Frequency for PQT is one sample from each joint. The test shall be done at 23 °C, 65 °C and the maximum operating temperature. In total 9 tests shall be done for PQT. Production test is once per shift.

7.6.5 SPECIFIC TESTS FOR PP BASED COATING

The following tests shall be carried out in addition to the tests given in section 7.6.4

7.6.5.1 IMPACT TEST

Impact resistance test shall be applied to PP based field joint coating (PP powder applied by flame spray and hot applied PP tape). Test shall be carried out at 20 °C +/- 5 °C for diameters > 100 mm. Impact energy shall be 7J per mm of measured thickness of coating.

- | | |
|---------------------------------|--|
| 1) Method: | ISO 21809-3 Annex G |
| 2) Frequency for PQT and PPT: | 3 joints minimum |
| 3) Frequency during production: | N/A |
| 4) Acceptance criteria: | No holiday (test according to the section 7.6.4.4) |

7.6.5.2 INDENTATION TEST

Indentation resistance test shall be applied to PP based field joint coating (PP powder applied by flame spray and hot applied PP tape). It shall be carried out at ambient temperature and at 90 °C.

- | | |
|---------------------------------|---|
| 1) Method: | ISO 21809-3 Annex H |
| 2) Frequency for PQT and PPT: | 3 joints minimum |
| 3) Frequency during production: | N/A |
| 4) Acceptance criteria: | penetration $\leq 0,1$ mm at 23 ± 2 °C and $\leq 0,6$ mm
90 ± 2 °C |

7.6.5.3 OXYGEN INDUCTION TIME TEST

Oxygen induction time shall be measured during PQT only.

- | | |
|---------------------------------|------------------------------|
| 1) Method: | According to section 7.5.4.4 |
| 2) Frequency for PQT and PPT: | 3 joints minimum |
| 3) Frequency during production: | N/A |
| Acceptance criteria: | 22 ± 2 minutes |

LAST PAGE – INTENTIONALLY BLANK