PTT Exploration and Production Public Company Limited

PTTEP Engineering General Specification

(Engineering and Development Group)

Standard

Coating of Bends and Fittings for Pipelines

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Prepared By (Author):	Chan Nyein Aung
Department/Division/Asset/Company:	EFE/ENC/EDE/PTTEP

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Position	Name	Dept. Code	Signature	Date
Custodian:	Suchada Punpruk	12059	Suchada Punpruk	24/10/18

Document Management Approvals Register
(To be signed before release of Revision No.R01)

Approver		Signature	Date
Name:	Pongpun Urarungroj		
(N+2)	**VP - Custodian**	Pongpun V.	24/10/2018
	Facility Engineering Department (12059)		
Name:	Suksant Ongvises		
(N+4)	**Group EVP - EDE**		29/10/18
	Engineering and Development Group (10008)		

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Revision History

Rev	Description of Revision	Date
Old	New Document Refer: PEGS-12059-COR-003	17-Oct-16
R00	Revision note : New document code and formatting ***Item No./Clause*** / ***Description of Change*** All — Update document number and template align to PTTEP library standard	8-Sep-17
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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 fitness of purpose, technical integrity and optimum life cycle cost for constructing PTTEP facilities.

3.0 SCOPE

This specification covers the anticorrosion coatings to be applied to bends and fittings for onshore and offshore pipelines. The types of coating systems, accepted by the COMPANY, are defined in the Section 7 of this specification. The selected coatings shall be suitable for the service conditions (especially for maximum operating temperature) during the field life.

The anticorrosion coatings to be applied on bends and fittings shall be compatible with the line pipe coating and their performance should ideally meet or exceed the factory applied coating on line pipes.

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
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
Applicator	The Company in charge of the coating application and quality control which is eventually subcontracted by the Contractor shall be referred to herein as the Applicator
Company	PTT Exploration and Production Public Company Limited and affiliates.
Contract Document	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 contract
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.
Purchaser	The COMPANY or the Contractor or the Supplier (as applicable) which have placed the Purchase Order to the Supplier/Vendor/Manufacturer.

Terminology	Description
Supplier/Vendor	The company designed on the Purchase Order form or Contract as being the selected supplier of the said materials.
Purchase Order	The order issued by purchaser consisting terms and conditions and attachments thereto including but not limited to data sheets and drawings, Specifications including referenced documentation therein, and all other documents and attachments

5.3 COMMON ACRONYMS

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

DSC	Differential Scanning Calorimetry
FBE	Fusion-bonded Epoxy
OIT	Oxygen Induction Time
PE	Polyethylene
PP	Polypropylene
PPT	Pre-Production Trial
PQT	Procedure for Qualification Trial
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
10008-STD-6-COR-002 , PEGS-12059-COR-002	Field joint coating for pipelines
10008-STD-6-PIP-010 , PEGS-12059-PIP-005	Pipes, Flanges, Fittings and Bolting for Piping

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 1133	Plastics - Determination of the Melt Mass-Flow Rate and the Melt Volume-Flow Rate of Thermoplastics
ISO 11357-6	Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)
ISO 21809-1	External coatings for buried or submerged pipelines used in pipelines transportation system - Polyolefin coatings (3-layer PE and 3-layer PP)
ISO 2808	Paints and varnishes-Determination of film thickness
ISO 306	Plastics - Thermoplastic Materials - Determination of Vicat Softening Temperature (VST)
ISO 527- Part 1	Plastics -- Determination of Tensile Properties -- Part 1: General Principles
ISO 527- Part 2	Plastics -- Determination of Tensile Properties -- Part 2: Test Conditions for Moulding and Extrusion Plastics
ISO 6964	Polyolefine Pipes and Fittings: Determination of Carbon Black Content by Calcinations and Pyrolysis : Test Method and Basic Principles
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 8502-3	Preparation of Steel Substrates before Application of Paints and Related Products -- Tests for the Assessment of Surface Cleanliness -- Part 3: Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure-Sensitive Tape Method)

Document Number	Document Title
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 8503-4	Preparation of Steel Substrates before Application of Paints and Related Products. Surface Profile of Abrasive Blast-Cleaned Steel Substrate. Part 4: Method for the Calibration of Surface Profile Comparators and for the Determination of Surface Profile -- Stylus Instrument Procedure.
ISO 868	Plastics and Ebonite - Determination of Indentation Hardness by Means of a Durometer (Shore Hardness)

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
ASTM D 4940	Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives
ASTM D 570	Standard Test Method for Water Absorption of Plastics
CAN/CSA Z245-20	External Fusion Bond Epoxy Coating for Steel Pipe
MSS-SP-25	Standard Marking System for Valves, Fittings, Flanges and Union

7.0 REQUIREMENTS FOR COATING OF BENDS AND FITTING FOR PIPELINES

7.1 APPROVED COATING SYSTEM FOR FITTING AND BENDS

The following coatings are acceptable for the conditions defined below:

1) PE coating for service temperatures between -40 °C and +80 °C
2) PP coating for service temperatures between -20 °C and +120 °C

Preferably, the choice of coating type for bends and fittings will relate to the coating of the corresponding line-pipe 10008-STD-6-COR-001, PEGS-12059-COR-001 “External Anticorrosion Coating for Pipelines”.

The coating system shall consist of:

1) One layer of epoxy primer (in the range of 150 to 500 microns thick, (as per ISO 2808, Electromagnetic Gauge) except if Manufacturer requires thicker coating depending on the service conditions. The proposed value shall be documented by the Applicator. Difference between minimum and maximum thickness shall not exceed 250 micron.)
2) One chemically modified PE or PP coat (the thickness will depend on the pipe diameter but minimum required thickness for bends is 3 mm)

All other choices or combinations shall be submitted to COMPANY for approval

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:

3) Environment (onshore, offshore), exposure (buried or not), soil conditions (dry soil, desert, swamp, wet soil)
4) Maximum operating temperature, minimum temperature if relevant;
5) Pipeline coating material
6) Accepted type of coating(s) for bend and fittings
7) 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.

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.

Once approved, the coating products and method shall not be changed by the Applicator without prior written authorization from 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 with the project schedule.

7.3.2 SUPPLY OF COATING AND REPAIR PRODUCTS

For the PQT and production, the Contractor/Applicator shall supply all personnel, coating material and repair products, and application equipment and inspection apparatuses.

FBE, PP and PE shall be supplied in powder form. Powder products shall be delivered in waterproof plastic bags to prevent water contamination and absorption of humidity during storage and transportation.

1) Marking on each packing of coating materials shall mention 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) Shelf life (epoxy only). The shelf life for PE and PP powders is one year provided that the product is stored according to Manufacturer recommendations.
2) The Contractor and Applicator shall obtain from the Manufacturer and submit to the COMPANY:
    a) Guarantee that the coating products delivered shall meet the required coating characteristics as set forth in accordance with the specified application methods

b) Test certificates and conformity certificates for the coating products

c) Conditions of application of the coating products

d) Packaging and storage requirements of coating materials

7.3.3 QUALIFICATION OF THE COATING PLANT, COATING SYSTEMS, COATING APPLICATION AND APPLICATORS

Qualification shall consist of the following steps:

7.3.3.1 RAW MATERIALS

1) Conformity certificates and test certificates of the products to be applied shall be submitted to the COMPANY for approval prior to the start of the qualification process of the coating.

   Note: The conformity certificate is a document issued by the raw material Manufacturer (specific to each raw material). It is a list of physical or chemical characteristics controlled for all production batches. For each of these characteristics, a conformity range is reported by the Manufacturer. The conformity certificate shall also include the following information:

   a) Name of Manufacturer

   b) Commercial name of the product

   c) Manufacturing plant

   d) Date of issue

   e) Storage conditions

   f) Application methods and conditions (especially minimum and maximum temperature of the steel during application)

   g) Name, function and signature of the person issuing the document

   The conformity certificate shall be considered valid for one year, provided there is no change of any kind for the product for that period.

2) The certificate of analysis for each batch of the product used for the qualification process shall be submitted to the COMPANY.

   Note: The certificate of analysis is issued by raw material Manufacturer for every batch of product. It reports all characteristics controlled for the corresponding batch. The content of certificate of analysis shall be equivalent to the conformity certificate, except that measured values shall be reported instead of the conformity range or Manufacturer specification.

7.3.3.2 COATING PROCESS

For each project, the coating system, products, application process, equipment to be used and personnel who execute the job shall be qualified, witnessed by COMPANY representative, based on a Procedure for Qualification Trial (PQT). The procedure to be used for the PQT shall be submitted to the COMPANY for approval at least one month before the trial. PQT should be carried out at least two months before the production startup (in order to ensure that a suitable solution can be implemented in case test results fail to meet the requirements of this specification) and shall be organized jointly by the Contractor and the Applicator with the assistance of the Manufacturer whenever it is necessary (especially for the training of the personnel).

PQT shall be carried out on the actual project bends /fittings. Other bends /fittings are acceptable provided that they have the same diameter and the same thickness as the actual ones. The products used for PQT shall be the same as those products that are going to be used for production. Any change in the components of the system shall lead to a new qualification process.

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 the production.

A summary of tests to be done during PQT is given in Appendix 1. 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.

Operators should be already familiar with the application of the selected bend /fitting coating for the project. Operators qualified during PQT shall apply the coating during the production phase. The Contractor or Applicator shall not replace qualified applicators without informing the COMPANY. A new qualification test shall be organized for any new applicators and at the Contractor's expense.

7.3.3.3 COATING PROPERTIES

Coating process parameters shall be fully recorded during PQT. Same parameters shall be used for production, with a maximum discrepancy of 5 % for each parameter, in order to ensure that the coating properties will be in the approved range during production.

A summary of tests to be done during PQT is given in Appendix 1. 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 NOTIFICATION PRIOR STARTING COATING WORK

The Contractor shall notify the COMPANY, at least ten working days before coating application (production startup) to permit mobilization of the Inspector.

Upon arrival at the coating plant, the Inspector shall receive from the main Contractor the documents supplied by the Applicator. The Contractor shall provide the Inspector with all the facilities necessary for the proper execution of his mission including messing and accommodation in case of remote location.

7.4 CHARACTERISTICS OF PRODUCTS

7.4.1 FBE PRIMER

The epoxy primer shall be 100 % solid powder form. The use of a liquid epoxy is not allowed. The epoxy primer shall meet the technical requirements specified in Table 1.

Table 1 - Technical Requirements for the Epoxy Primer

Characteristics	Methods	Acceptable Value
Moisture content (%)	Powder: 20 g Temperature: 105 °C, time: 30 min	0.5% maximum
Glass transition temperature	Differential Scanning	No less than 95 °C for fully
(°C)	Calorimeter (DSC)	Cured material.
Bend test	CAN/ CSA/ Z245-20, Clause 12.11. Bending: 2.5° at specified minimum Temperature.	No holiday
Water absorption (wt %)	Demineralised water ASTM D570 on a free film of 500 microns ±50 microns.	Less than 10 % of weight uptake after 28 days at 80 °C.

7.4.2 PP TOP COAT

It shall be based on copolymers with grafted reactive sites. It shall be applied in powder form, and stabilized with titanium dioxide and anti-oxidant for thermal stability and UV resistance. The PP coating shall meet the technical requirements specified in Table 2.

7.4.3 PE TOP COAT

It shall be based on linear type (i.e. low pressure manufacturing process) PE with grafted reactive sites to react on the epoxy primer. It shall be applied in powder form, stabilized with carbon black for UV resistance and anti-oxidant for thermal stability. The PE coating shall meet the technical requirements specified in Table 2.

Table 2 - Technical Requirements for Top PE and PP Coats

Characteristics	Standard	Acceptable Value for PP	Acceptable Value for PE
Carbon black content (%)	ISO 6964	N/A	≥2.5
OIT (minute)	ISO 21809-1	> 30 at 220 °C	> 30 at 210 °C
VICAT softening point (°C)	ISO 306	≥ 120	≥ 80
Melt flow rate (g/10 min)	ISO 1133	> 5 (230 °C – 2.16 kg)	> 5 (190 °C – 2.16 kg)

In addition, full DSC spectra shall be provided once for each product, from – 40°C up to 250°C (for PP) and 120°C (for PE) with heating rate 20 °C/min, cooling rate 10 °C/min (first and second heating). Any change from this test shall be requested to COMPANY for further approval.

For the flame spray application, adequate distribution of the PP or PE particles size is an important parameter for preventing heavy oxidation of the powder during application.

7.5 APPLICATION OF THE COATINGS

7.5.1 SURFACE PREPARATION

7.5.1.1 SURFACE CLEANING

Prior to abrasive blasting, bends or fittings 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 ensure that the steel surface is as clean as possible.

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

1) Mud and soluble salts shall be removed by fresh water wash. Salt contamination shall be checked before abrasive cleaning and shall be lower than 2 micro grams per square cm as per ISO 8502-6 and ISO 8502-9. Only Bresle Method is acceptable to determine concentration of soluble salts on metal surfaces before coating application.
2) Greasy substances: cleaned by using a totally volatile solvent (containing no chloride)
3) Any metallic irregularity that can pierce the coating shall be removed by grinding or filing. Areas of rust or scaling shall be treated in the same way.

7.5.1.2 ABRASIVE BLAST CLEANING

Before abrasive blasting, the cleanliness and salt contamination of abrasives shall be checked in accordance with ASTM D4940. Conductivity shall be lower than 1000 microSiemens /cm and no oil visible after 30 minutes. No Silica abrasive is allowed.

All bends or fittings shall be preheated (40 to 70 °C) before abrasive blasting. Temperature shall be checked continuously with infrared camera.

Abrasive blast cleaning shall be carried out to obtain a surface cleanliness at least Sa 3 as defined in ISO 8501-1. Brush cleaning, as the principal surface preparation method, is not acceptable.

The grit shall be selected so that the average roughness Ry5 (as per ISO 8503-4) obtained ranges from 60 to 90 microns. The use of replica tape to assess the roughness is not allowed.

Immediately after abrasive blasting:

1) Dust created by abrasive blasting and the remaining abrasive shall be removed efficiently by brushing and vacuum cleaning. Maximum acceptable level shall be 2 in accordance with ISO 8502-3.
2) Each cleaned bend or fitting shall be inspected for surface defects. Any defect shall be removed.
3) Cleaned bends or fittings shall then be coated before degradation of surface preparation (bend and fittings shall be kept in a dry and clean atmosphere until coating application. The metal temperature shall be 3 °C above the ambient dew point temperature). Any bends or fittings which have not been coated before degradation of their surface shall be completely re-blasted before coating.

7.5.2 COATING APPLICATION

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.

The temperature of the surface shall be at least 3 °C above the dew point.

No conversion chemical treatment (e.g. chromates) of the steel surface is allowed to improve adhesion. Required adhesion shall be obtained only by using suitable powder epoxy primer and surface preparation process.

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

7.5.2.1 APPLICATION OF THE FBE PRIMER

The bends or fittings shall be heated by induction or in an electrical oven, whichever is the most suitable. The temperature of the bend/fitting and the intercoat time (between primer and top coat) shall be set in accordance with the gel time of the epoxy primer and following the epoxy Manufacturer recommendation. The temperature of the bend / fitting shall be as uniform as possible; the heterogeneity of temperature over the whole bend or fitting shall be 10 °C maximum.

The powder epoxy primer shall be sprayed using electrostatic spray guns or hand flock spray. The thickness of the coat shall be in the range of 150 to 500 microns (as per ISO 2808, By Electromagnetic Gauge). The proposed value shall be documented by the Applicator. Thickness difference between minimum and maximum shall not more than 250 microns. Care should be taken as to avoid any contamination of the primer layer by subsequent powder top coat.

7.5.2.2 APPLICATION OF TOP COAT

The PE or PP top coat shall be applied as follows:

1) The first layer of PP or PE shall be applied immediately after primer application and within the gel time of the epoxy at considered steel temperature (it shall be within 5 % of recorded value during PQT). Any failure to do so shall result in rejection of the coated piece with no further examination.
2) Subsequently, PP or PE powder shall be applied to build the correct thickness. Several methods, flame spray or oven melting, for example, can be used to melt the layer over which a new powder layer is applied. For the flame spray technique, nitrogen gas shall be used for propelling of PP or PE particles.

For the flame spray application, the Applicator shall provide COMPANY with the test results showing that they are able to meet the COMPANY requirements related to the Oxygen Induction Time (OIT).

Acceptance criteria are given in Table 2.

7.5.2.3 COOLING AND CUT BACK PREPARATION

The temperature of the bend / fitting will be reduced below 60 °C before handling to avoid the degradation of the coating. If the flame spray technique is used for the application of the top coat, water cooling is not permitted.

At cutbacks, the coating shall be cut just after cooling and removed manually or mechanically with power brushes. The stripped steel ends shall be brushed clean. The epoxy primer shall be visible for a few millimeters at cut back to avoid any disbonding during storage. The ends of the PE or PP coating shall be beveled in order to ensure a

satisfactory bonding of field joint material on site. The bevel angle shall be approximately 30 to 45°.

The cut backs shall be protected by peeling varnish or equivalent in order to avoid rusting of the bare metal during storage/transportation. The cut back length shall be 150 mm + 20/-0 mm minimum. The actual value shall be determined by the Contractor and Applicator to take into account the effect of the heat input on the coating during the welding process.

7.6 INSPECTION AND TESTING

Coating inspection shall be carried out by the Applicator in the presence of the Inspector from the beginning of the work and throughout production. It shall include the following four operations:

1) Inspection of the epoxy powder and top coat deliveries and conformity with the requirements,
2) Verification of the various application parameters of the epoxy primer and the top coat,
3) Systematic inspection of the applied coating or test samples taken from bend or fitting cutbacks.
4) Inspection of coated bends and fittings

The Inspector may take samples of the coating materials and test specimens of coated bends or fittings for testing in laboratories selected by the COMPANY in order to check the quality of the applied products. These tests will be at COMPANY cost if their results are satisfactory but they will be back charged to the Contractor/ Applicator if the raw coating materials and/or applied coating are not in accordance with this specification requirement.

7.6.1 INSPECTION OF COATING MATERIALS AND REPAIR PRODUCT CONFORMITY

Inspection shall be performed upon delivery of the coating materials and repair product in order to check packaging, markings and to ensure that certificates of analysis for all materials fall within the certificate of conformity.

Packaging and storage shall be in accordance with the Manufacturer's instructions and this specification and the markings shall be in conformity with this specification. Non-conformity with any of the specified requirements shall cause the immediate rejection of the delivery.

In order to prepare for any dispute arising at a later stage, three 50 g samples of each raw coating material shall be taken from each production batch. One shall be reserved for the Applicator, one shall be transmitted to the COMPANY and one shall be kept as a check sample in the Applicator's laboratory for six months, away from humidity at a temperature below to 20 °C.

7.6.2 INSPECTION OF THE APPLICATION PARAMETERS AN APPLIED COATING QUALITY

The following summarizes COMPANY requirements at each step of the coating application:

7.6.2.1 INSPECTION DURING SURFACE PREPARATION

1) Visual inspection shall be carried out on 100 % of the surface before abrasive blasting to check for the presence of contaminants. Salt contamination shall be measured in accordance with ISO 8502-6 and ISO 8502-9. It shall be lower than 2 micrograms per square cm.

2) Pre-heating temperature shall be checked by IR camera. The requirement is 40 to 60 °C. After abrasive blasting and until coating application, the temperature of the bend or fitting shall be 3 °C above dew point of the surrounding air.

3) 100 % of the prepared surface of each item shall be inspected for surface cleanliness, which shall be Sa3 as per ISO 8501-1.

4) The prepared surface shall be checked for the dust level, which shall be maximum Level 2 in accordance with ISO 8502-3.

5) Surface profile roughness Ry5 shall be measured on each item with an electronic apparatus. The roughness shall be 60 to 90 microns in accordance with ISO 8503-4.

7.6.2.2 INSPECTION DURING COATING APPLICATION

1) Prior to epoxy primer application, the temperature of the item to be coated shall be checked with an optical pyrometer (infrared camera) and temperature recorder. Homogeneity of temperature over the whole bend shall also be checked. The temperature shall be in accordance with Manufacturer recommendation (confirmed during PQT) and the maximum temperature difference, at two different locations on the bend / fitting, shall be 10 °C.

2) After coating application, the cooling temperature shall be checked. The requirement shall be 60 °C maximum for handling purposes. For testing of coating characteristics, bend/fitting shall be cooled down to ambient temperature.

7.6.2.3 INSPECTION OF THE APPLIED COATING QUALITY

1) Visual inspection shall be carried out to detect any coating imperfection or defect.

2) Thickness of epoxy primer shall be measured at one of the fitting/bend extremities where the top coat shall not be applied (within the limit of cut back area). The thickness shall be in the range of 150 to 500 microns (as per ISO 2808, By Electromagnetic Gauge). The proposed value shall be documented by the APPLICATOR. Thickness difference between minimum and maximum should not more than 150 microns. The frequency is for every bend / fitting.

3) Coating thickness shall be measured using electromagnetic gauges (individual thickness print and general histogram) on each item. The thickness shall be measured at least at 10 locations and each reading shall be the average value of three readings at a given location.

4) Cut-backs length shall be measured with ruler or specific gauge on each fitting or bend. The value shall be as specified in Section 7.5.2.3.

5) Electrical porosity test shall be carried out on all bends and fittings on 100 % of the surface. The voltage to be applied is 10 kV/ mm of coating thickness (without exceeding 25 kV). No holiday shall be detected. The holiday detector shall be calibrated once per shift.

6) Hardness shall be measured at the bend/fitting extremities before preparation of cut backs. Measurement shall be carried out in accordance with ISO 868. The frequency is one per shift.

7) Average value shall be equal or more than 45 (Shore D) for PE and 55 for PP after 15 seconds.

8) Resistance to peeling or peeling force shall be measured at the bend/fitting extremities before preparation of cut backs. The test shall be carried out in accordance with ISO 21809-1. The frequency is one per shift.

   a) For PE, the peeling strength at service temperature shall be higher than 400 N/5 cm (with cohesive failure) or alternatively no peeling with a weight of 15 kg. At ambient temperature the peeling strength shall be at least 600 N/5 cm.

   b) For PP, at service temperature (generally above 80 °C) the peeling strength shall be higher than 400 N/5 cm (with cohesive failure) or alternatively no peeling with a weight of 20 kg. At ambient temperature the peeling strength shall be at least 600 N/5 cm.

   c) Adhesive failure shall not be allowed.

   d) No peeling shall occur between steel and epoxy coat

   e) Homogeneity of the coating shall be visually checked during the peeling tests. Within the thickness of the layer, there shall be no micro-voids and/or micro-bubbles.

9) Impact resistance shall be measured at the bend/fitting extremities before preparation of cut backs. The test shall be carried out according to ISO 21809-1. The frequency is one per shift. Energy shall be equal or more than 5 Joules per mm of actual coating thickness for PE and 7 Joules per mm for PP. The coating shall be examined with a holiday detector, over the points of impact, at a voltage of 10 KV per mm of coating thickness (maximum 25 kV).

7.6.3 TEST TO BE CARRIED OUT ON TESTS SAMPLES

1) Oxygen Induction Time (OIT) shall be measured on coating samples collected during cut back preparations (for flame spray application only). One coating sample shall be collected per shift. OIT shall be (as per ISO 21809-1)

   a) For PE: Higher than 30 min at 210 °C

   b) For PP: Higher than 30 min at 220 °C

2) Elongation at break shall be measured once per shift. The acceptable values are (in accordance with ISO 527) 10 % for PE and 40 % for PP.

3) Homogeneity of the coating shall be visually checked during the peeling tests. Within the thickness of the layer, there shall be no micro-voids and/or micro-bubbles.

4) Cathodic disbonding shall be checked on coating applied on plates at the same time as on the fittings and bends. The test shall be carried out in accordance with ISO 21809-1 Annex H. The frequency is one test every two shifts. The acceptable value are :-

   - 3 mm maximum at 65 -/+ 2 °C after 48 hours,
   - 5 mm at 23 °C after 28 days
   - 15 mm at maximum operating temperature after 28 days

Note: Cathodic disbonding tests at 28 days is compulsory for PQT. Test result shall be known before start of production (28 days test).

7.7 ACCEPTANCE CERTIFICATES AND REPORTING

The Contractor and the Applicator shall sign jointly with the Inspector the coating acceptance certificates, including the results of all tests and inspections 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 the COMPANY and one copy to the Inspector.

The coating Applicator shall deliver, at the end of the coating application, a report containing all the coating material certificates, inspection results, including bend or fitting reference numbers, a list of all rejected coated pieces' reference numbers, the reason for rejection and what was, eventually, the corrective action taken for these pieces.

7.8 HANDLING, TRANSPORTATION AND STORAGE RULE

The Applicator shall be responsible for any damage occurring to the bends and fittings, from the unloading at reception of the bare pieces to the loading of the coated pieces for shipment. The Applicator shall consequently:

1) Inspect the bare pieces upon delivery to check that they have not suffered previous damage
2) Take all necessary precautionary measures to prevent any deterioration to the bevels and coating during the operations of handling, transfer to storage yard, storage and loading for shipment. All repairs and inspection shall be at the Applicator expense. Existing item marking shall be preserved or reinstated.

Stockpiling of coated bends or fittings is not allowed. If coated bends or fittings are to be stored for more than 6 months, they shall be protected against ultraviolet rays (coating) and corrosion (bare surfaces: cut back, bevels).

7.9 REPAIRS

The following is only relevant to damages having occurred to coating of bends and fittings previously properly coated but damaged during handling, transportation, storage either at Applicator premises or at construction site:

The conditions of rejection have to be agreed on, prior placing the order, between COMPANY, Contractor and Applicator.

The agreement shall be based on the number of damages, percentage of coated surface damaged, and the size of each defect.

The following figures may be considered as basis of the agreement:

- Number of damages: 1 up to 6" fittings, 2 for 8" and above
- Percentage of damaged coated surface: 0.5% up to 6" fittings; 0.25% for 8" to 16"; 0.1% for 18" and above
- Maximun size of one defect: $10cm^2$

All rejected items shall be fully recoated and subjected to all acceptance tests.

All non-rejected items shall be repaired

Repair products shall be supplied and application procedure prepared by the Applicator and approved by COMPANY (Qualification tests may be required).

Repairs shall be carried out by qualified personnel

Repaired surfaces shall be subjected to holiday detection as a minimum and thickness measurement.

7.10 TRACEABILITY

According to COMPANY specification 10008-STD-6-PIP-010, PEGS-12059-PIP-005, all bends and fittings are delivered by their manufacturer with a marking in conformance with the Standard MSS- SP 25-Section 18 in order to ensure their traceability.

Fittings and bends marking shall be preserved during the coating process or re-instated after completion of the coating so that the continuity of the traceability of each item is ensured.

8 APPENDICES

Appendix 1. Qualification Tests PQT and PPT

The following tests shall be carried out on bends and fitting used for PQT, PPT and fabrication. The acceptance criteria are the same as those given in Table 1, Table 2, Section 7.5 (application of coating) and 7.6 (inspection and testing).

Tests	PQT	PPT	Fabrication
1. Raw materials			
Conformity certificate	Each Raw materials	Each raw material	N/A
Tests results	Each raw materials	Each raw material	N/A
Epoxy primer Top coat	Every batch	Every batch	Every batch
2. Preheating	All pieces	All pieces	IR camera monitoring - All
3. Surface preparation			
Degree of cleanliness	All	All	All
Salt contamination	All	All	All
Dust level	All	All	All
Roughness	All	All	All
Steel temperature	All	All	All
4. Coating application			
Pipe temperature	All	All	All
Intercoat time	All	All	All
Cooling and cutback	All	All	All
Top coat application	All	All	All
5. Coating			
Visual aspect	All	All	All
Final coating Thickness	All	All	All
Epoxy thickness	All	All	All
Holiday detection	All	All	All
Cut-back	All at both ends	All	All at both ends
Impact resistance	All	One bend	One per shift
Shore D hardness	All	One bend	One per shift
Peeling force	All	One bend	One per shift
OIT	All	One bend	One per shift
Homogeneity of the coating	All	All	One per shift
Elongation at break	All	One bend	One per shift
Cathodic disbonding	One bend	One bend	One every two shift
Epoxy adhesion to steel	Once	Once	NA

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