Pipeline Coating Specifications

Amendment Details:

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<th>Revision</th>
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<th>Purpose</th>
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1.0 Preamble

1.1 Corrosion is one of the major threats to the integrity of buried steel pipelines and uncontrolled corrosion of the pipe wall may lead to leaks, service interruptions and even explosions. Hence to protect the Pipeline from corrosion, protective coatings are applied as a primary protection supplemented with cathodic protection.

1.2 Coatings can be primarily classified into four types based on their application: (a) Factory / Mill applied and (b) Field applied at pipe joints (c) Coating repairs in field during O&M (d) Refurbishment / Rehabilitation of deteriorated coating of in-service pipelines in the field.

2.0 Objective

2.1 The objective of this guidance document is to specify the minimum requirement in material specifications, application and testing for coating systems applied to line pipes in factory, joint coatings applied in field, coating repairs on pipe carried out in mills / field and refurbishment of deteriorated coating in the field.

3.0 Scope

3.1 This document specifies the requirements for qualification, application, testing and handling of materials for factory applied external three-layer polyethylene (3-LPE), Coating of field weld joint areas and buried piping at pipeline installations, Coating Repairs in Filed during O&M and Coating Refurbishments/ Rehabilitations for external corrosion protection of Carbon steel pipes. Pipes coated in accordance with this specification are considered suitable for further protection by means of cathodic protection. Internal corrosion protection by using factory applied internal coating is also covered.

4.0 Approach

4.1 The design and application of the coating system shall be done to provide a sound coating to the pipeline free of holidays and least possible permeation of moisture such that the steel substrate is isolated from its environment from harmful effects of corrosion for the intended service life.

4.2 Particular type of coating on buried pipelines whether shop or field applied, shall be selected on the basis of the following desired properties of an external coating:

- High Electrical Resistance
- Low Permeability
- Mechanical Properties to withstand damage during transport, handling, laying, bending, testing and back filling:
  - High Adhesion
  - High Impact Resistance
  - Flexibility & Elongation
- Resistance to Cathodic Disbondment
4.3 For application at shop on line pipes, Three Layer Side Extruded Polyethylene Anti-Corrosion Coating System shall be adopted in construction of buried carbon steel pipelines in GAIL. The external coating shall be such as to provide long term electrical and mechanical characteristics, which are suited to the diameter and operating conditions of the pipe and the nature of the environment. The coatings shall adhere strongly to the pipe and resist cathodic disbondment at holidays satisfactorily.

4.4 Notwithstanding the quality of fluid in service, pipes should be internally coated to prevent rusting during transit and storage.

4.5 Internal coating of line pipes by Fusion Bonded Epoxy or other alternate / superior systems shall be specified in all cases other than those limited by size as per current technology. The thickness of the internal coating material shall be selected to match the duties required, for example expected duration of storage, ability to resist corrosion of specific nature anticipated, ability to withstand pigging, etc.

4.6 Robust procedures shall be adopted in handling of line pipes and pipeline sections to avoid injuries to pipeline coating and in repair of coating holidays and other defects at the mill or in the field so that the pipeline is encapsulated with a sound coating for long life of the pipeline in service.

4.7 When, at any point during service life, the coating is observed to have deteriorated, the reasons for failure and the terrain conditions shall be studied in detail for carrying out a well-planned coating refurbishment job to enable continuous of pipeline in service.

5.0 Methodology

5.1 General

5.1.1 Line pipes to be used for building the underground pipeline shall be applied with external and internal coating in the factory or mill before transportation to construction sites. Other than short lengths of pipes to be used as pup pieces or those used for induction bends and the weld joints between pipes / bends, field coating of line pipes shall not be permitted.

5.1.2 The coating systems to be adopted for each type of application shall be selected based on successful track record of materials and applicators with a stringent quality assurance program based on stage-wise quality control.

5.1.3 The Coating Applicator / Contractor shall supply all the required coating materials and shall necessarily procure coating materials to be used for the coating of bare lines pipes for GAIL, from approved manufacturers, subject to approved combination of materials of different manufacturers to be notified at the time of tendering as part of the tender
document. The currently approved list of manufacturers is given Section 13.0 of Appendix-A.

5.1.4 GAIL in association with engineering consultants normally associated in pipeline projects shall evaluate materials of different manufacturers from time to time and keep the above list updated. A formal process of declaration of the list with inclusion or deletion based on evaluation and / or performance feedback shall be carried out at the least once every three years or earlier.

5.1.5 Coating applicators, supervisors and inspectors of the Coater and Inspectors of GAIL / PMC / Third party agencies shall be trained / certified.

5.2 Factory / Mill applied TLPE coating of line pipes & Repairs to coating at mill

5.2.1 External prepared surface of the pipes shall be electrostatically primed with epoxy powder (1st layer) followed by application of grafted co-polymer adhesive by extrusion process (2nd layer) and medium / high density polyethylene by extrusion process (3rd layer) completely forming an integrated high performance coating. Coating with Polypropylene Topcoat may be considered where higher design service temperature is specified (above 80°C but not exceeding 110°C). The coating shall conform to this document and ISO 21809-1 latest edition.

5.2.2 While ordering line pipes for pipeline construction, additional requirements in the specification for line pipes, coating and yard storage of the same shall be incorporated for long term storage. Since such additional measures recommended herein will add to the total cost of coated line pipe and storage, the same could be specified for part of the order quantity estimated to become surplus with a margin of caution (for e.g., if 3 % excess length of proposed pipeline is considered for ordering, then the additional measures for long term storage could be considered for 5% of the ordered pipelines).

5.2.3 Detailed requirement and specification for Factory Applied Three Layer Poly-Ethylene (TLPE) coating of Line pipes is given at Appendix-A.

5.3 Internal Coating of line pipes

5.3.1 Unless otherwise limited by size, all line pipes shall be ordered with internal coating to improve flow efficiency and provide corrosion protection.

5.4 Field Coating of weld joints and buried fittings, valves & piping

5.4.1 Once coated line pipes are welded and NDT cleared, the exposed steel surface at cutback area and weld joint shall be provided with a coating system compatible with the coating of the body of pipes.

5.4.2 At intermediate installations where pipelines connect with valves, by-pass piping, fittings etc. such buried piping, valves and fittings requires corrosion protection coating.

5.4.3 Field coating in both above cases shall be suitable to provide corrosion protection to the field joints and buried facilities of a pipeline to the same standard or better than the
coating system used on the body of the pipe. The field coating system shall be manufactured to obtain the required coating properties under the intended design, installation and operating conditions.

5.4.4 There are a number of coating systems that are suitable for field application on pipelines. Some of the most commonly used ones are given below with a brief description:

a) Liquid epoxy

Liquid epoxy and epoxy-modified coatings are two-pack coating systems composed of a base (epoxy resin) and a curing agent. The coating system can be modified with other components.

Reinforcement of the coating systems can be achieved by using glass fibres of glass flakes.

b) Liquid polyurethane

Liquid polyurethane and polyurethane-modified coatings are two-pack coating systems composed of polyol (pack A) and isocyanate (pack B). The coating system can be modified with other components.

Urethane coatings were developed as an anti-abrasion overcoating to an existing anti-corrosion coating such as FBE, however in some cases they have been specified as a stand-alone coating. Urethanes are typically a 100% solids content, two component urethane polymer system applied in liquid form. They are usually applied at a nominal thickness of 500 to 750 microns giving a total system thickness of 850 to 1100 microns. Urethane coatings can be applied inline or on a pipe spinning system in the pipe yard. In either case the pipe must first be coated with the anti-corrosion coating and the plant configuration changed to accommodate a spray booth and the associated liquids handling systems. Prior to the application of the urethane overcoating, the anti-corrosion coating is preheated to remove moisture and then lightly blasted in order to provide a surface profile for mechanical adhesion of the urethane to the anti-corrosion coating.

c) Heat shrink sleeve

A heat shrink sleeve is a type of field joint coating, applied to a pre-heated pipeline in the form of a sleeve or wrap, which shrinks in the circumferential direction under the influence of heat or by other means, forming an adherent field joint coating.

The shrink sleeve consists of a polyolefin (PE or PP) based backing with an adhesive layer (mastic or hot melt) on one side. The shrink sleeve may be applied with or without a primer.

d) 3 ply / 2 ply Cold Applied Tape Coating

This coating shall consist of (i) a liquid adhesive layer i.e. primer (ii) an inner layer
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<td>Reference</td>
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<tr>
<th>Tape (3 ply type) for corrosion protection (iii) an outer layer tape (2 ply type) for additional mechanical protection</th>
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<td>e) Flame sprayed polyethylene</td>
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<td>This coating shall be applied over an epoxy primer coating (either a powder applied by dusting or electrostatic spray or a spray-applied liquid coating). The primer shall be over-coated with modified polyethylene powder applied by spray or by flame spray and the required thickness shall be achieved by further flame spray application of the modified polyethylene powder.</td>
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<td>f) Fusion bonded epoxy</td>
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<td>This coating shall consist of a fusion bonded epoxy layer applied by spraying epoxy powder on an electrostatically heated pipe surface.</td>
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<td>g) Visco-elastic self-healing wrapping system</td>
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<td>This coating system shall consist of two layers. The first layer is a visco-elastic polymeric tape with self-healing properties to provide corrosion protection to the underlying substrate. The second layer is an outer-wrap applied to provide mechanical protection.</td>
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**5.4.5** In GAIL pipelines, for the purpose of coating girth weld joints, Polyethylene backed Heat Shrink Sleeves shall be used at the time of construction. The detailed technical specifications, for this system is given at Appendix-B1.

**5.4.6** The joint coating of pipeline sections to be installed across river and other utility crossings by means of Horizontal Directional Drilling (HDD) which involves pulling of an entire welded and coated section through a hole underneath the obstacle drilled and reamed to size, require special coating specification to withstand the abrasive and shear forces of installation so as to give a satisfactory service during operation. To meet this need, a separate technical specifications for the system of joint coating applicable for HDD crossings are given at Appendix-B2.

**5.4.7** In case of coating of buried piping, valves and fittings, the following coating systems shall be acceptable both at the time of construction of such facilities as well as during service life:

- a) Liquid Epoxy (Appendix – C)
- b) Liquid Polyurethane (Appendix – D)
- c) Polyethylene 3 ply / 2 ply Tape Coat System (Appendix - E)
- d) Visco Elastic Self-healing Wrapping System (Appendix - F)

**5.4.8** For coating field joints during service life, due to limitations of pipe pre-heating and terrain conditions, the following three coating systems can be employed as per technical specifications mentioned therein:

- a) Liquid Polyurethane (Appendix – D)
Title: Pipeline Coating Specifications

Type: Guidance


5.5 Field Repair of Coating

5.5.1 Field repair of coating on the body of pipes or at joints are necessitated both during construction (before lowering and backfilling) as well as during service life to repair holidays detected during CIPS / DCVG / CAT surveys, dig verification of metal loss and other anomalies detected in In-Line Inspection (ILI) and damages to pipeline arising from third party activities.

5.5.2 The system of coating repair to be adopted will depend on the original coating on the pipeline and the terrain conditions.

5.5.3 Repair shall be made in line with the repair procedure mentioned in each of the technical specifications of the different type of coatings given at the various Appendices.

5.6 Coating Refurbishment of Pipelines in field

5.6.1 When the coating of a section or whole of the buried pipeline is found deteriorated to the extent that localized repair is not feasible nor adequate, the entire pipeline coating may require to be removed and fresh coating is applied in-situ after surface preparation appropriate for the selected coating system.

5.6.2 The job of pipeline coating refurbishment, much like the pipeline laying activity, requires a full scale mobilization of material, crew and equipment together with opening of ROU to facilitate a sequential process of exposing the pipeline by making appropriate working trenches, coating removal, surface preparation, application of the coating system, inspection and testing, backfilling and restoration.

5.6.3 The coating system selected for such application should lend itself to application of satisfactorily sound system in field condition where strict control on dust level, surface preparation etc. cannot be assured. Since in most cases refurbishment will be required to be done on running lines without interruption to service, the choice is limited to cold applied systems only.

5.6.4 The following coating systems have been successfully employed in in-situ coating refurbishment in the past and any of these can be used suitable to the field condition and service requirement.

   a) Liquid Polyurethane (Appendix – D)
   b) Polyethylene Tape Coat System (Appendix - E)
   c) Visco Elastic Self-healing Wrapping System (Appendix - F)

5.7 The technical specifications for the above coating systems are given in the appendices mentioned therein. With respect to the work of coating refurbishment of extended lengths of pipeline, a standardized Scope of Work and Technical Specifications is given at Appendix H which may be adopted to the specific needs in a particular case for contracting.
SPECIFICATION FOR
FACTORY APPLIED THREE LAYER POLY-ETHYLENE (TLPE)
COATING OF LINE PIPES

1.0 General

1.1 This specification covers the minimum requirements for procurement and supply / arrangement of all materials, plants, equipment, plant sites, consumables, utilities and application including all labour, supervision, inspection, repair re-testing, performances of all operations and incidentals necessary for application of yard applied "Three Layer Side Extruded Polyethylene anticorrosion Coating (3LPE) using Medium / High Density Polyethylene" on external surface of bare pipes.

1.2 This specification for the 3LPE anti-corrosion coating is based on three International Standards ISO 21809-1, DIN 30670 and CSA Z245.21 latest edition. In case where further details are required, ISO 21809-1 latest edition shall be referred in consultation and with approval of Owner and taking into consideration that the more stringent requirements shall be applied.

1.3 The external coating shall be such as to provide long term electrical and mechanical characteristics, which are suited to the diameter and operating conditions of the pipe and the nature of the environment. The coatings shall adhere strongly to the pipe and resist cathodic disbondment at holidays satisfactorily.

1.4 External prepared surface of line pipes shall be electrostatically primed with epoxy powder (1st layer) followed by application of grafted co-polymer adhesive by extrusion process (2nd layer) and medium/ high density polyethylene by extrusion process (3rd layer) completely forming an integrated yard applied anti-corrosion 3LPE side extruded coating of thickness as specified and conforming to relevant codes and completed 3LPE coating system and shall be suitable for continuous exposure in direct sunlight and from Ultra-Violet (UV) radiation during storage.

1.5 Where separately ordered (under a separate SOR item), coating of pipes intended to be stored for long duration either stock item or as insurance spares, shall be capable of withstanding storage conditions in open yards for a minimum duration of 5 years. Such pipes shall be protected against internal corrosion by placing required quantity of desiccant and sealing of ends with appropriate leak tight end covers. These pipes shall normally be delivered as a last lot clearly marking on the external surface prominently as “Long Storage Pipes” with separate packing list and coating numbers.

1.6 The applicator / contractor shall supply all the coating materials required under this specification.

1.7 The Coating Applicator / Contractor shall necessarily procure coating materials to be used for the coating of bare lines pipes for GAIL, from approved manufacturers, subject to approved combination of materials of different manufacturers to be notified at the
1.8 The entire coating operation starting from cleaning and surface preparation till coating of the pipes including final coat shall be performed under the supervision of skilled personnel who are well versed in the work.

1.9 Inspection of the coating of the pipes shall be performed by qualified inspectors. All application and inspection personnel shall be required to undergo a training or certification program as detailed below:

- Coating inspectors and applicators shall have previous experience in 3LPE coating inspection and application respectively and should receive training in the specific project coating requirements and associated approved work procedures.

- If in the opinion of Owner and/or TPIA, personnel deployed in the work lack necessary skill or do not exercise a reasonable degree of care, shall be removed from the job.

1.10 Pipes which have been cleaned and primed or cleaned, primed and coated without having been inspected and approved by the Owner and/or TPIA shall be rejected. Final acceptance of all coating work shall be determined by the Owner and/or TPIA.

1.11 Machines and equipment used shall be approved by the Owner and/or TPIA. Equipment for rotating, handling and transporting the pipes during and in between operations shall be such as not to cause any damage to the primed and coated pipes.

1.12 When, in the opinion of the Owner and/or TPIA, it becomes necessary to suspend any operation for the purpose of making such adjustments to the equipment(s) as well improve the quality of the coating application, the cost of such suspension shall be borne by the Applicator/Contractor. Such adjustments, however, shall be made only when considered necessary for the maintenance of standards as provided in this specification.

1.13 The Applicator/Contractor shall provide access during all phases of the work to the Owner and/or TPIA. Any expense(s), caused by the Owner and/or TPIA stopping the work because of not being carried out in compliance with this or other applicable specifications/standards shall be borne by the Applicator/Contractor.

2.0 Reference Documents

2.1 The latest edition unless specified otherwise, of the following codes and standards shall establish the minimum standards and are a part of this specification. In case of conflict between referenced standards / codes and / or specifications the more stringent of these two shall apply.

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<td>36</td>
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<td>Pipeline Transportation of Liquids and Slurries</td>
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### 3.0 Plant Scale and Installation

**3.1** The Applicator / Contractor shall set the coating plant(s) for above mentioned type of coating, after evaluating the scale of work and time schedule required for the work. The geometry and dimensions of coating plant shall be such that continuous execution of work schedule is implemented. For this purpose the Applicator / Contractor shall ensure continuous work execution even in case of adverse weather conditions and for this purpose Applicator / Contractor shall install essentially required plants / equipment in a shed with adequate weather protection.

**3.2** The Plant coating capacity should be such that it can meet the delivery schedule as per tender. Accordingly all the equipment in the plant shall be capable of handling that size and quantum of pipes. Applicator/Contractor shall furnish his proposal in detail on the methodology to be adopted for keeping the above schedule.

**3.3** Plants, equipment, machinery and other facilities shall be in good operating condition to meet the job requirements of quality production.

**3.4** The Applicator/Contractor shall at its own responsibility and cost, provide for water and power supply and other utilities and consumables and obtain authorization regarding access roads and other permits required for the execution of works conforming to all the requirements of the governing Authorities.

**3.5** The Applicator / Contractor shall at his own risk and cost, provide and prepare the required area for the stacking/storage of bare and coated pipes, other materials, stock-piling area and other temporary installations required at coating plant site.

**3.6** The Applicator / Contractor shall at his own cost provide a fully equipped laboratory and test facilities with adequate inventory to carry out tests required for procedure qualification and during regular production for testing of raw materials and coated pipes.

**3.7** The Applicator / Contractor shall be fully responsible for adherence to all statutory regulations applicable for handling and disposal of the hazardous chemicals during the coating works. The Applicator / Contractor shall be responsible for obtaining all statutory approvals/clearances from relevant Authorities including Pollution Control Board, as applicable for the coating plant(s).

**3.8** This specification is not intended to be all inclusive and the use of guidelines set forth here does not relieve the Applicator/Contractor of his responsibility for the quality and performance of the applied coating system, and to supply coating materials capable of performing its intended service.

### 4.0 Submittals

**4.1** Along with the proposal the Applicator/Contractor shall submit, for the Owner approval, detailed information outlining, but not limited to, the following:
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i. Details of plant(s), detail including locations, geometry, dimensions, capacity and production rate per day in two-shift operation of 8 hours duration per shift.

ii. Facilities for handling of bare line pipes at CONTRACTOR's stockpiles at coating yard(s), and transportation within the coating yard(s) for unloading, handling, storage, production, stockpiling of coated pipes and warehouses for storage of coating materials.

iii. Bill of materials, list of Vendor's/Manufacturer of coating materials, specification of coating materials, delivery schedule of coatings material.

iv. Time schedule for all activities.

v. Details of equipment at the coating plant.

vi. Detailed organogram of manpower to be deployed.

vii. A detailed procedure for the proposed methodology of plant coating shall be formulated by Applicator/Contractor and submitted for Owner and/or TPIA approval in the form of a bound manual. The procedure shall include, but not limited to, the following information and proposals.

viii. Specific criteria for determining abrasive materials are free of impurities for shot blasting.

ix. Specific criteria for removing contamination of chlorides or other salts before application of coating to line pipes.

x. Pipe surface preparation, including materials, determining the abrasive particle size and proportions, removal of pipe defects, cleanliness, profile and methods of measurements.

xi. Procedure of removal of magnetic! solid particles from grit blasted surface, phosphoric acid wash, OM water wash and chromate treatment before fusion bonded epoxy priming.

xii. Pipe heating temperature(s) monitoring, alarm and control.

xiii. Complete details of raw materials together with quality control procedures, specifications, test methods, acceptance criteria and test certificates.

xiv. Application of coating materials, including characteristics, temperatures etc.

xv. Pipe and coating quenching and cooling, including time and temperature(s).

xvi. Tests on raw materials and coated pipes for trial production and during production.

xvii. Inspection and testing, including instrument and equipment types, makes and their utilities.
xviii. Details of instruments' and equipment' calibration methods with relevant standards and calibration values.

xix. Complete details and inventory of laboratory and test equipment / instruments.

xx. Specimen of equipment' calibration, recording and reporting formats, including laboratory reports, test certificates etc.

xxi. Specific detailed repair procedures for review and acceptance to performing holiday repairs.

xxii. Specification of coating materials for repairs.

xxiii. After obtaining the approval from the Owner and/or TPIA, changes in the above shall not be permitted. However, unavoidable changes shall be executed only after getting specific written approval from the Owner and/or TPIA.

xxiv. The Applicator/Contractor shall submit INSPECTION AND QUALITY CONTROL MANUAL as applicable for the type of coating process involved under this specification.

5.0 Functional Requirements and Properties of Coating

5.1 The coating shall be able to withstand a maximum in-service temperature of 80°C and shall conform to Class B as per ISO 21809-1:2011. In open storage the repair coating materials must be able to withstand a temperature of at least (+) 80°C without impairing its serviceability and properties.

5.2 The topcoat polyethylene used shall be black readymade compound, fully stabilized against influence of ultraviolet radiation (i.e., sunlight), oxygen in air and heat (due to environmental temperature specified above). No appreciable changes shall occur during exposure to such environments up to at least a period of 6000 hours. Certificate from manufacturer shall be obtained in this regard.

5.3 For the quantity of pipes procured for long term use (surplus as stock or as insurance pipes) shall have the coating system capable of storage in open for extended period of time not less than 5 years which can be extended by storage under covered conditions to further periods. [Note for the PMC / GAIL Engineer preparing the tender: There shall be a separate SOR item in the tender for line pipe factory coating to reflect this requirement]

5.4 Epoxy powder, adhesive and PE material for the coating shall be procured only from the list of approved vendors given at Section 13.0 of this document. The combination of epoxy powder, adhesive and MDPE/HDPE vendor / grade shall be in accordance with the approved Procedure Qualification Test (PGT) and in case a change is required, fresh PQT shall be conducted.

5.5 The coating must be able to withstand an exposure temperature of at least (+) 80°C in
open storage and expected normal service temperature as specified for the expected coating life without impairing its quality, serviceability, functional requirements and properties specified.

5.6 The coating materials used shall be of the quality which are fully stabilised against influence of ultraviolet radiation (i.e. sunlight), oxygen in air and heat (due to environmental temperature as specified before). No appreciable changes shall occur during exposure to such environments up to at least a period of 4800 hours. The UV ageing and thermal ageing test shall comply with the requirement of coating class B Annex G of ISO 21809-1 (2011). The Applicator/ Contractor shall submit test report, test certificate and guarantee certificate from Manufacturer in this regard.

5.7 The Applicator/Contractor shall furnish certificate of tests and test report for thermal ageing and ageing under exposure to light conducted previously by Manufacturer of materials, not earlier than 3 years from the date of commencement of procedure qualification tests, using the same composition of raw materials and same method of application as proposed for this work. Test results should satisfy the requirements specified hereinafter

6.0 Coating System Description

6.1 The 3LPE coating system shall consist of three layers:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Coating Material</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer</td>
<td>FBE</td>
<td>Main corrosion protection layer with good oxygen barrier and bonding to steel</td>
</tr>
<tr>
<td>Mid-coat</td>
<td>Grafted adhesive co-polymer</td>
<td>Thin adhesive layer to bond FBE primer and PE topcoat together</td>
</tr>
<tr>
<td>Top-coat</td>
<td>High Density/ Medium density polyethylene</td>
<td>Protect against mechanical damage and prevent moisture penetration.</td>
</tr>
</tbody>
</table>

6.2 The minimum DFT of the finished 3LPE coating system are specified in Table below:

<table>
<thead>
<tr>
<th>Pipe Size (Outside Diameter mm)</th>
<th>Coating thickness requirement (minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal Type (n)</td>
</tr>
<tr>
<td></td>
<td>FBE (mm)</td>
</tr>
<tr>
<td>1a</td>
<td>Top Coat: HDPE</td>
</tr>
<tr>
<td>≤ 273.1</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt; 273.1 &amp; ≤ 508</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt; 508 &amp; ≤ 813</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt; 813</td>
<td>0.2</td>
</tr>
<tr>
<td>1b</td>
<td>Top Coat: MDPE</td>
</tr>
<tr>
<td>≤ 273.1</td>
<td>0.2</td>
</tr>
<tr>
<td>&gt; 273.1 &amp; ≤ 508</td>
<td>0.2</td>
</tr>
</tbody>
</table>
6.3 1.0 mm of polyethylene sheath thickness shall be added to all pipes used for crossings and horizontal directional drilling. [Higher Adhesive thickness suggested by Bechtel (250 – 400 µm)]

6.4 Thickness to be used in case of use of HOPE and MOPE material as PE top coat shall comply with the requirement given under 1 a and 1 b respectively of table above.

6.5 Negative tolerance in total coating thickness on pipe body shall not be allowed. 10% negative tolerance on weld seam is allowed only in case of SAW pipes.

6.6 Maximum thickness is to be adhered to, as per manufacturers' recommendations. However, the coating system is required to meet the requirement of this specification and relevant codes.

7.0 Coating Materials

7.1 The coating materials manufacturer shall carry out tests of the coating material for all properties specified for each batch of epoxy, adhesive and polyethylene compound. In addition, the manufacturer shall also furnish infrared scan for each batch of epoxy powder. The manufacturer shall provide test certificates as per BS EN 10204, 3.1 for each batch of materials supplied to Applicator / Contractor indicating all contents / parameters required for batch certification as per clause 8.3 of ISO-21809-1:2011 and clause 5.0 of this specification and the same shall be submitted to owner and / or TPIA for approval prior to their use.

7.2 In addition, the Applicator / Contractor shall collect samples of the coating manufacturer's batches of coating materials as received in sufficient quantities to perform full series of all physical testing at least four times at some future date. Each sample shall be satisfactorily packaged to maintain maximum shelf or storage life. From these samples, one set each material and batch shall be promptly subjected to an analysis with regard to the parameters hereunder by the Contractor to assure that coating materials consistently conform to this specification, without variance in composition of formulation from the previously tested and approved materials. Testing shall be witnessed by GAIL representative.

   a) Epoxy Powder
      i) Density
      ii) Gel Time
      iii) Cure Time
      iv) Moisture / Water content
      v) Thermal Characteristics (Tg1, Tg2, H)

   b) Adhesive
7.3 In case of failure of any of the above tests in a batch, that batch of materials shall be tested for all the tests required as per detailed analyses given below. If all the materials pass all the tests, the batch shall be accepted for coating. If the material fails in any of the tests, entire batch shall be rejected and shall not be used in the coating. If such material(s) were used in any coating for whatsoever reasons, they shall be identified, stripped and recoated with acceptable materials.

7.4 All the materials used for coating of bare pipe shall be procured strictly from the list of approved vendors as specified in the following sections. The Applicator / Contractor shall obtain prior approval from GAIL for the combination of materials to be used furnishing full details of use.

7.5 The Applicator / Contractor shall use coating materials meeting specifications given hereinafter. This however does not relieve the Applicator / Contractor of his responsibility for the quality and performance of the applied coating system and its intended service. The final coating system shall meet the requirement as detailed in 8.4.

7.6 All material proposed to be used shall be suitably marked and identifiable with following minimum information:

   i) Name of Manufacturer
   ii) Product Number, Name and Product Identification
   iii) Batch or Lot number
   iv) Date of Manufacturing
   v) Date of Expiry
   vi) Relevant manufacturing standard specification

7.7 Applicator / Contractor shall be required to use all materials on First-in-First Used basis. Reclaimed materials shall not be used.

8.0 Coating Material Composition and Physical Properties

8.1 Properties of Epoxy Powder

<table>
<thead>
<tr>
<th>S No</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Pipeline Coating Specifications

**Title**: Pipeline Coating Specifications  
**Type**: Guidance  
**Reference**: CIMG-GD-2-2019-0001  

<table>
<thead>
<tr>
<th>S No</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Density</td>
<td>g/l</td>
<td>Within ±0.05 of the manufacturer’s specified nominal value</td>
<td>ISO 21809-1 Annex N</td>
</tr>
<tr>
<td>(ii)</td>
<td>Moisture Content</td>
<td>%mass</td>
<td>≤0.5</td>
<td>ISO 21809-1 Annex K</td>
</tr>
<tr>
<td>(iii)</td>
<td>Flexibility Test at 0°C</td>
<td>Per diameter length</td>
<td>≥2.5°</td>
<td>ISO 21809-2 Annexure A13</td>
</tr>
<tr>
<td>(iv)</td>
<td>24 hour CD test at 3.5 ± 0.15V 65 ± 3°C</td>
<td>mm</td>
<td>≤6.5 mm radius</td>
<td>CAN Z245.20 Clause 12.8</td>
</tr>
<tr>
<td>(v)</td>
<td>24 hour Adhesion test at 75°C</td>
<td>Rating</td>
<td>Rating 1 to 3</td>
<td>CAN Z245.20</td>
</tr>
<tr>
<td>(vi)</td>
<td>Storage stability (at 20°C)</td>
<td>-</td>
<td>12 months min.</td>
<td>ISO 21809-1 Annexure A13</td>
</tr>
<tr>
<td>(vii)</td>
<td>Get time at 205 °C ±3 °C</td>
<td>S</td>
<td>Within 20 % of the nominal value specified by the manufacturer</td>
<td>ISO 21809-1 Annexure A13</td>
</tr>
<tr>
<td>(viii)</td>
<td>Curing condition</td>
<td>-</td>
<td>≤5°C Tg &amp; 95% cure</td>
<td>CAN Z 245.20 Clause 12.7</td>
</tr>
<tr>
<td>(ix)</td>
<td>Minimum glass transition temperature (Tg2) (DSC analysis)</td>
<td>°C</td>
<td>≥95 and within manufacturer’s specification</td>
<td>ISO 21809-1 Annexure A13</td>
</tr>
<tr>
<td>(x)</td>
<td>Particle Size</td>
<td>-</td>
<td>3.0% maximum powder retained on 150 micron mesh screen, 0.2% maximum powder retained on 250 micron mesh screen</td>
<td>ASTM D 1921</td>
</tr>
</tbody>
</table>

### Properties of Adhesives

<table>
<thead>
<tr>
<th>S No</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Specific Gravity at ±25°C</td>
<td>-</td>
<td>0.930(minimum)</td>
<td>ISO 1183 or ASTM D792 or ASTM D1505</td>
</tr>
<tr>
<td>(ii)</td>
<td>Vicat Softening temperature A/50 (9.8 N)</td>
<td>°C</td>
<td>≥100</td>
<td>ISO 306</td>
</tr>
<tr>
<td>(iii)</td>
<td>Melt Flow rate (190°C/2.16Kg)</td>
<td>gm/10 min.</td>
<td>1.0(minimum)</td>
<td>ASTM-1238</td>
</tr>
<tr>
<td>(iv)</td>
<td>Tensile yield strength at 23 °C ±2 °C (50mm/minute)</td>
<td>MPa</td>
<td>≥8</td>
<td>ISO 527-2 or ISO 527-3</td>
</tr>
<tr>
<td>(v)</td>
<td>Elongation at break at 23 °C ±2 °C</td>
<td>%</td>
<td>≥600</td>
<td>ISO 527-2 or ISO 527-3</td>
</tr>
</tbody>
</table>
### Pipeline Coating Specifications

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<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>(vi)</td>
<td>Water content</td>
<td>%</td>
<td>≤0.1</td>
<td>ISO 15512</td>
</tr>
</tbody>
</table>

#### 8.3 Virgin Polyethylene Resin Requirements

<table>
<thead>
<tr>
<th>S NO</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A)</td>
<td>PHYSICAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Density of the base resin at 23°C ±2°C</td>
<td>g/cm³</td>
<td>≥0.930</td>
<td>≥0.940</td>
</tr>
<tr>
<td>(ii)</td>
<td>Tensile yield strength at 23 °C ±2 °C</td>
<td>MPa</td>
<td>≥15</td>
<td>≥18.5</td>
</tr>
<tr>
<td>(iii)</td>
<td>Elongation at break at 23 °C ±2 °C</td>
<td>%</td>
<td>≥600</td>
<td>≥600</td>
</tr>
<tr>
<td>(iv)</td>
<td>Hardness Shore D at 23 °C +</td>
<td>-</td>
<td>≥55</td>
<td>≥60</td>
</tr>
<tr>
<td>(v)</td>
<td>Vicat softening temperature A/50(9.8 N)</td>
<td>°C</td>
<td>≥110</td>
<td>≥120</td>
</tr>
<tr>
<td>(vi)</td>
<td>UV resistance and thermal ageing</td>
<td>%</td>
<td>ΔMFR ≤ 35</td>
<td>ΔMFR ≤ 35</td>
</tr>
<tr>
<td>(vii)</td>
<td>Melting Point +</td>
<td>°C</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>(viii)</td>
<td>Melt Flow rate(190°C/2.16Kg)</td>
<td>g/10 min.</td>
<td>≥ 0.25</td>
<td>≥ 0.25</td>
</tr>
<tr>
<td>(ix)</td>
<td>Environment Stress Crack resistance (ESCR) (for F50) +</td>
<td>H</td>
<td>≥300 cond. C(MDPE)</td>
<td>≥300 cond. C(HDPE)</td>
</tr>
<tr>
<td>(x)</td>
<td>Oxidation Induction time in Oxygen at 220°C, Aluminium pan, no screen</td>
<td>Min</td>
<td>≥10</td>
<td>≥10</td>
</tr>
<tr>
<td>(xi)</td>
<td>Brittleness temp +</td>
<td>°C</td>
<td>-70 or lower</td>
<td>-70 or lower</td>
</tr>
</tbody>
</table>

#### B) ELECTRICAL

<table>
<thead>
<tr>
<th>S NO</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Volume Resistivity at 23°C ±2 °C</td>
<td>Ohm-cm</td>
<td>≥10⁻¹⁶</td>
<td>≥10⁻¹⁶</td>
</tr>
<tr>
<td>(ii)</td>
<td>Dielectric withstand at 23°C ±2 °C, 1000V/sec rise +</td>
<td>KV/mm</td>
<td>≥30</td>
<td>≥30</td>
</tr>
</tbody>
</table>

#### c) CHEMICAL

<table>
<thead>
<tr>
<th>S NO</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>Water absorption 24 hrs. at +25°C +</td>
<td>% age</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>(ii)</td>
<td>Carbon black level</td>
<td>% age</td>
<td>≥2</td>
<td>≥2</td>
</tr>
</tbody>
</table>

#### 8.4 Properties of Coating System

<table>
<thead>
<tr>
<th>S No</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
</table>

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**Issue Date:**  
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<table>
<thead>
<tr>
<th>S No</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>A)</td>
<td>PHYSICAL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i)</td>
<td>Indentation @23 +/- 3°C</td>
<td>mm</td>
<td>≤0.2</td>
<td>ISO 21809-1 Annexure F</td>
</tr>
<tr>
<td></td>
<td>@20 +/- 3°C</td>
<td></td>
<td>≥0.3</td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>Resistance to impact at 23 +/- 2°, (minimum of 30 impacts on body along the length) No Breakdown when tested at 25kV</td>
<td>j/mm of coating thickness</td>
<td>7 minimum</td>
<td>DIN 30670</td>
</tr>
<tr>
<td>(iii)</td>
<td>Flexibility</td>
<td></td>
<td>No cracking at an angle of 2° per pipe per diameter length.</td>
<td>ISO 21809-1 Annexure I</td>
</tr>
<tr>
<td>(iv)</td>
<td>Holiday Detection at 25 kV</td>
<td>-</td>
<td>No Holiday</td>
<td></td>
</tr>
<tr>
<td>(v)</td>
<td>Bond Strength(Peel Strength) @23 °C ±2°C</td>
<td>N/mm</td>
<td>≥15</td>
<td>ISO 21809-1 Annexure C</td>
</tr>
<tr>
<td></td>
<td>@80 °C ±2°C</td>
<td></td>
<td>≥3</td>
<td></td>
</tr>
<tr>
<td>(vi)</td>
<td>Elongation at break of PE/PP at 23°C ± 3°C</td>
<td>%</td>
<td>≥400</td>
<td>ISO 527-3</td>
</tr>
<tr>
<td>(vii)</td>
<td>Degree of cure of Epoxy Percentage cure ΔTg</td>
<td>% °C</td>
<td>According to the manufacturer’s specification ≥95 ≤5</td>
<td>ISO 21809-1 Annexure D</td>
</tr>
<tr>
<td>(viii)</td>
<td>Product stability during application of the PE/PP top layer process</td>
<td>%</td>
<td>≤20 ΔMFR (virgin compounded granulate before Application/coating after application of the same batch)</td>
<td>ISO 1133</td>
</tr>
</tbody>
</table>
### Pipeline Coating Specifications

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<table>
<thead>
<tr>
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<th>Unit</th>
<th>Requirement</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>B)</td>
<td>CHEMICAL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| i)   | Average radius of cathodic Disbondment  
23°C/28d; 1.5V  
65°C/24h; 3.5V  
80°C/28d; 1.5V | mm | ≤ 7  
≤ 7  
≤ 15 | ISO 21809-1 Annexure H |
| ii)  | Hot Water Immersion test | Mm | Average ≤ @ and maximum ≤ 3 | ISO 21809-1 Annexure M |
| iii) | Coating Resistivity | Ohm – m² | 10⁸ min. after 100 days  
Resistivity after 100 days / resistivity after 70 days: 0.8 min. | DIN 30670 |

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8.5 The Applicator / Contractor shall submit test report and test certificates from manufacturer for Coating Resistivity. The test report should not be earlier than 3 years from the date of commencement of procedure qualification tests, using the same composition of raw materials and same method of application as proposed for the work.

9.0 Repair Material Composition and Physical Properties

9.1 For small areas (up to 100 sq.mm): Small areas shall be repaired using adhesive coated polyethylene repair tape and filler adhesive meeting the specification requirement. The bidder shall furnish the type and other details of the repair patch material in their offer for Owner and/or TPIA approval.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Property</th>
<th>Test</th>
<th>Unit</th>
<th>Min. Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SLEEVE:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Tensile Strength</td>
<td>ASTM D638</td>
<td>MPa</td>
<td>17</td>
</tr>
<tr>
<td>2.</td>
<td>Ultimate elongation</td>
<td>ASTM D638</td>
<td>%</td>
<td>400</td>
</tr>
<tr>
<td>3.</td>
<td>Low temperature</td>
<td>ASTM D-3111</td>
<td>°C</td>
<td>Below 40</td>
</tr>
<tr>
<td>4.</td>
<td>Hardness</td>
<td>ASTM Shore D</td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>
# Pipeline Coating Specifications

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Property</th>
<th>Test</th>
<th>Unit</th>
<th>Min. Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Dielectric strength</td>
<td>ASTM D149</td>
<td>KV/mm</td>
<td>12</td>
</tr>
</tbody>
</table>

**ADHESIVE:**

1. **Softening point**
   - Test: ASTM E-28
   - Unit: °C
   - Min. Requirement: 110

**FILLER ADHESIVE:**

1. **Peel to steel 23°C**
   - Test: Rolling drum 50 mm/m in
   - Unit: N/25 mm
   - Min. Requirement: 70

2. **Shear Strength**
   - Test: EN 12068
   - Unit: N/sq.cm
   - Min. Requirement: 5.0

**INSTALLED SYSTEM:**

1. **Impact Resistance**
   - Test: EN12068
   - Min. Requirement: 15

2. **Indentation Resistance at 80Deg.c- holiday detection**
   - Test: EN12068
   - Method: No Holiday
   - Min. Requirement: Pass

3. **Resistance to Cathodic disbondment at 23°C**
   - Test: EN12068
   - Method: Mm
   - Min. Requirement: Less than 20mm

4. **Peel to PE coating at 23 °C**
   - Test: EN12068
   - Unit: N/mm
   - Min. Requirement: 2.5 N/mm

5. **Peel to PE coating at 80 °C**
   - Test: EN12068
   - Unit: N/mm
   - Min. Requirement: 0.2 N/mm

9.2 For larger areas (more than 100 sq.mm): Larger repair areas shall be repaired using hot melt adhesive type heat shrink sleeves of HTLP 80 or equivalent that employs 100% solvent free epoxy primer. Coating materials shall meet the following specifications:

<table>
<thead>
<tr>
<th>Property</th>
<th>Condition</th>
<th>Unit</th>
<th>Minimum Requirement</th>
<th>Method of test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A) Sleeve Backing:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>23°C</td>
<td>Psi</td>
<td>2200</td>
<td>ASTM D-638</td>
</tr>
<tr>
<td>Elongation to Break</td>
<td>23°C</td>
<td>Percent</td>
<td>400</td>
<td>ASTM D-638</td>
</tr>
<tr>
<td>Volume resistivity</td>
<td>23°C</td>
<td>Ohm-cm</td>
<td>10¹⁰</td>
<td>ASTM D-257</td>
</tr>
<tr>
<td>Dielectric break down voltage</td>
<td>23°C</td>
<td>KV</td>
<td>30KV</td>
<td>ASTM D-149</td>
</tr>
<tr>
<td>Hardness</td>
<td></td>
<td>Shore D</td>
<td>55</td>
<td>ASTM D-2240</td>
</tr>
<tr>
<td><strong>B) Sleeve Adhesive:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Softening point</td>
<td></td>
<td>°C</td>
<td>110 min</td>
<td>ASTM –E -28</td>
</tr>
<tr>
<td>Lap Shear to Pipe Surface</td>
<td>23°C</td>
<td>N/mm²</td>
<td>0.3</td>
<td>EN12068</td>
</tr>
<tr>
<td></td>
<td>80 °C</td>
<td>N/mm²</td>
<td>0.3</td>
<td></td>
</tr>
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**Table:**

- **Title:** Pipeline Coating Specifications
- **Type:** Guidance
- **Reference:** CIMG-GD-2-2019-0001
### Pipeline Coating Specifications

**Type:** Guidance  
**Reference:** CIMG-GD-2-2019-0001

<table>
<thead>
<tr>
<th>Property</th>
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<th>Unit</th>
<th>Minimum Requirement</th>
<th>Method of test</th>
</tr>
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<tr>
<td><strong>C) Primer:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Specific Gravity</td>
<td>23 °C</td>
<td>-</td>
<td>1.39</td>
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<tr>
<td>Part A</td>
<td></td>
<td></td>
<td>0.93</td>
<td>ASTM D-792</td>
</tr>
<tr>
<td>Part B</td>
<td></td>
<td></td>
<td></td>
<td>ASTM D-792</td>
</tr>
<tr>
<td><strong>D) Installed Sleeve System:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact Resistance</td>
<td>23°C</td>
<td>J</td>
<td>15 J Pass</td>
<td>EN12068</td>
</tr>
<tr>
<td>Indentation Resistance –</td>
<td>80°C 24 hrs</td>
<td>mm</td>
<td>0.6 mm, No</td>
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<tr>
<td>Residual thickness</td>
<td></td>
<td></td>
<td>holiday with 10 KV</td>
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<tr>
<td>Cathodic disbondment</td>
<td>80°C 30 days</td>
<td>N/mm</td>
<td>20 maximum disband radius</td>
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<tr>
<td>Peel to Steel</td>
<td>23°C</td>
<td>N/mm</td>
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<td>EN12068</td>
</tr>
<tr>
<td>Peel to PE</td>
<td>23°C</td>
<td>N/mm</td>
<td>3.5</td>
<td>EN12068</td>
</tr>
<tr>
<td>Peel to Steel</td>
<td>60°C</td>
<td>N/mm</td>
<td>1.5</td>
<td>EN12068</td>
</tr>
<tr>
<td>Peel to PE</td>
<td>60°C</td>
<td>N/mm</td>
<td>1.5</td>
<td>EN12068</td>
</tr>
<tr>
<td>Dielectric break down voltage</td>
<td>23°C</td>
<td>KV</td>
<td>30KV</td>
<td>ASTM D-149</td>
</tr>
</tbody>
</table>

#### 10.0 Measurement and Logging

10.1 The scope of the Applicator/Contractor includes maintaining records containing all the relevant data of individual pipe and pipe coating including pipe number, heat number, diameter, length, wall thickness, defects, coating number, batches of materials, sampling, testing, damages, repairs, rejects and any other information that Owner considers to be relevant and required for all incoming bare pipes and Owner approved outgoing coated pipes as applicable. The records shall be maintained in an appropriate computer database for proper tracking and filter properties. Applicator/Contractor's documentation shall be designed to ensure full traceability of pipe and coating materials through all stages of coating and testing. Applicator/Contractor shall submit this information in the form of a report at the agreed intervals, to be adjusted as per duration of production schedule. However in no case should the interval be more than 1 month for long campaign.

#### 11.0 Procedure Qualification

11.1 Prior to start of production, the Applicator/Contractor shall, at his expense, carry out a coating PQT for each pipe diameter on max. wall thickness, for each type of pipe, for each coating material combination and for each plant, to prove that his plant, materials, and coating procedures result in a quality of end product conforming to the stated properties, relevant standards, specifications and material manufacturer's...
recommendations. Contractor shall give minimum seven (7) working days’ notice to witness all procedures and tests.

11.2 A batch representing a normal production run, typically 25 pipes, shall be coated in accordance with the approved coating procedure and the coating operations witnessed by Owner Representative. Out of these pipes, at least two pipes at start and one pipe at the end of PQT shall be coated with only epoxy. Further one pipe at start and one pipe at the end of PQT will be coated partly with epoxy, partly with both epoxy and adhesive layers and partially with all three layers (approx. 1/4 length with 3LPE, 1/2 length with both epoxy and adhesive and balance length with only epoxy).

11.3 The five partially coated and at least 10 (ten) fully coated test pipes shall be selected by Owner Representative and/or TPIA for coating procedure approval tests and shall be subjected to procedure qualification testing as described hereinafter. Owner Representative and/or TPIA shall witness all tests. During PQT, the Contractor shall qualify various procedures forming a part of coating operations as detailed subsequently.

11.4 Manufacturer raw material test certificate will be reviewed which should comply with the requirement as given herein.

11.5 Testing of Thermal Ageing under Exposure of Light: Applicator/Contractor shall furnish certificate of tests along with test report for thermal ageing and ageing under exposure of light conducted previously by Manufacturer of material (not older than three (3) years from the date of commencement of procedure qualification tests) using the same composition of raw materials and same method of application.

11.6 Raw material Testing: Raw material testing will be done at Plant as per requirement mentioned herein.

11.7 Epoxy Powder Application and Recycling: During pre-qualification, air pressure in the epoxy spray guns, satisfactory functioning of monitoring system, line speed v/s coating thickness, etc. shall be established. Dew point of air used to supply the fluidized bed, epoxy spray system and epoxy recycling system shall be recorded during the PQT. Also, the Contractor shall remove samples of reclaimed powder from the reclamation system. These samples of reclaimed powder shall be subject to a detailed visual examination, thermal analysis and moisture content tests. The properties of the reclaimed powder shall be within the range specified by the Manufacturer of epoxy powder. In case the properties of the reclaimed powder are out of the range specified by the Manufacturer, Contractor shall not the use the reclaimed powder during the regular production.

11.8 Pipe Pre-heating: The Contractor shall establish the temperature variation due to incoming pipe temperature, line speed variation, wall thickness variation, emissivity, interruptions, etc. and document the same during the PQT stage. During PQT, proper functioning of pipe temperature monitoring and recording system including alarm/hooter shall be demonstrated to the Owner Representative.
11.9 Surface Preparation: The procedure to clean and prepare the pipe surface shall be in accordance with the requirements of this specification. The ratio of shot to grit shall be established during procedure qualification testing, such that the resultant surface profile is not dished and rounded. The qualification shall be performed through a visual inspection, measurement of roughness and check of the presence of dust on the abrasive blast cleaned pipe surface.

11.10 Chemical Pre-treatment

a) Phosphoric Acid Wash followed by Deionized Water Wash:

The procedure to apply the chemical pre-treatment viz. phosphoric acid wash followed by deionized water wash shall result in intended cleaning requirements of this specification. Working solution preparation, maintaining concentration, application procedure including method of spreading, spreading rate, drying times, etc. depending upon the cleanliness/temperature of the incoming pipe and the line speed shall be established. Temperature of the chemical, pipe pre-heat temperature vs line speed vs dwell time, rinsing procedure, testing and control, rectification measures, drying procedure etc. shall be clearly established during PQT. Also the quality of the de-ionized water shall be established during PQT.

b) Chromate Treatment

The procedure to apply the chromate treatment shall result in intended cleaning requirements of this specification. Working solution preparation, maintaining concentration, application procedure including method of spreading, spreading rate, drying times, etc. depending upon the temperature of the incoming pipe and the line speed shall be established. Temperature of the chemical, pipe pre-heat temperature vs. line speed, pipe heating after chromating and time limit within which the pipe to be heated, testing and control, rectification measures, shall be clearly established during PQT.

c) Coating Application

The Owner Representative and/or TPIA will check the correctness of each coating application operation, values of the main parameters of each operation, pre-heating pipe surface temperature prior to epoxy powder application temperature, line speed, fusion bonded epoxy curing time, temperature and flow rate of co-polymer adhesive and polyethylene, etc. and the same shall be recorded. These values shall be complied with during regular production.

11.11 Qualification of Applied Coating

11.11.1 Tests on pipe coated partly with epoxy and partly with epoxy and adhesive layers

a) Degree of Cure

Epoxy film samples (minimum 4 nos.) shall be scrapped from the coated pipe and the samples shall be taken for cure test using Differential Scanning Calorimetry (DSC)
procedure mentioned in clause A8 of ISO 21809-2 Fusion bonded epoxy coating. Care shall be taken to remove the samples of full film thickness avoiding inclusion of steel debris. Glass transition temperature differential (Tg) and % cure (ΔH) shall comply with the specified requirements.

b) Epoxy Layer Thickness

Epoxy layer thickness shall be checked at every one metre spacing at 3, 6, 9 and 12 o'clock positions. The thickness shall comply with the specified thickness requirements.

c) Adhesive layer Thickness

Adhesive layer thickness shall be checked at every one metre spacing at 3, 6, 9 and 12 o'clock positions. The thickness shall comply with the specified thickness requirements.

d) Holiday Inspection

Entire pipe (epoxy coated) shall be subject to holiday inspection and the minimum test voltage shall be set at 5 v/micron of epoxy thickness specified.

e) Dry Adhesion

Dry adhesion test shall be carried out as per clause A.4 of ISO 21809-2 Fusion bonded epoxy coating. The rating obtained shall be either 1 or 2.

f) 24 h Adhesion Test.

Adhesion Test (24 hrs) shall be carried out on the epoxy coated pipe as per clause A.16 of ISO 21809-2 (2014). Fusion bonded epoxy coating. The rating obtained shall be from 1 to 3.

g) Flexibility test

2.5° flexibility test at 0oC shall be carried out as per annexure A.13 of ISO 21809-2 (2014) Fusion bonded epoxy coating. No cracking should be observed.

h) Porosity Test

Cross section porosity and interface porosity tests shall be carried out on the epoxy coated pipe. Test method and acceptance criteria shall comply as per clause A.12 of ISO 21809-2 (2014). Fusion bonded epoxy coating

11.11.2 Tests on pipes coated with all three layers

a) Bond Strength (Peel Test):

Five test pipes shall be selected for bond strength tests. On each of the selected pipes, three peel tests shall be performed for each specified temperature i.e. one at each end in cut back portion and one in the middle of the pipe and specified requirements shall be complied with, i.e. bond strength as well as mode of separation. Length of peel shall be minimum 140 mm. None of these samples should fail.

b) Impact Strength:
Three test pipes shall be selected for impact strength test and the test shall meet the specified requirements.

c) Indentation Hardness:

Two samples for both temperatures from all pipes shall be taken. If any one of these samples fails to satisfy the specified requirements, then the test shall be repeated on four more samples. In this case, none of the samples should fail.

d) Elongation at failure:

Six samples each from three coated pipes i.e. 18 samples in all shall be tested and the test shall comply the specified requirement. Only one sample per pipe may fail.

e) Cathodic Disbondment Test:

Three CD tests shall be carried out for the total lot of test pipes having all three layers. One test shall be carried out for 28 days 20 ± 3°C, second test for 24 hours@ 65°C ± 3°C duration and third test for 80°C, 28 days as per ISO 21809-1 Annexure E.

f) Holiday Inspection

All the pipes shall be subject to holiday inspection. The pipes shall pass the test at 25 kV.

g) Coating Thickness Measurement

All pipes shall be subject to coating thickness measurements. Acceptance criteria shall be as per Para 14.2.5 & ISO 2808.

h) Air Entrapment

One sample each from pipe body and on weld (if applicable) shall be taken from four coated pipes and the specified requirements shall be complied with.

i) Degree of Cure

Epoxy film samples (minimum 4 nos., equally spaced) shall be scrapped from one coated pipe and the samples shall be taken for cure test using Differential Scanning Calorimetry (DSC) procedure. Silicon coated sulphite paper shall be placed between the epoxy layer and adhesive layer immediately after epoxy application, to ensure physical separation of epoxy and adhesive as well as to prevent contamination of epoxy with adhesive layer, at a location from where the epoxy samples are to be removed for the test. Care shall be taken to remove the samples of full film thickness avoiding inclusion of steel debris. Glass transition temperature differential (Tg) and % cure (ΔH) shall comply with the specified requirements.

j) Hot Water Immersion:

One test pipe shall be selected for hot water immersion test. The test method and acceptance criteria shall be as per annexure M of ISO 21809 Part 1- Polyolefin Coatings.

k) Flexibility:
One test pipe shall be selected for flexibility test. The test method and acceptance criteria shall be as per annexure I of ISO 21809 Part 1- Polyolefin Coatings.

11.12 All pipes shall be subject to the following inspections:

i) Surface cleanliness, surface roughness measurements and dust control immediately after second abrasive blast cleaning and salt test. Criteria for checking degree of dust shall be as per ISO 8502-3. The dust level on the blast-cleaned surface shall be of Class 1 for both size and quantity in accordance with ISO 8502-3.

ii) Visual inspection of finished coating, cut back dimension, internal/external cleanliness, end sealing and bevel inspection.

11.13 After completion of the qualification tests and inspection as above, the Applicator/Contractor shall prepare and issue to Owner for approval a detailed report of the above tests and inspection including test reports/certificates of all materials and coatings tested. Only upon written approval from Owner, Contractor shall commence production coating.

11.14 On successful completion of PQT, coating of all test pipes shall be removed and completely recycled as per the approved coating procedure specification, at Contractor's expense. Remaining pipes will be accepted by Owner provided they meet the requirements of this specification and need not be stripped and re-cycled.

11.15 The Contractor shall re-establish the requirements of qualification and in a manner as stated before or to the extent considered necessary by Owner, in the event of, but not limited to the following:

- Every time there is a change in the previously qualified procedure.
- Every time there is a change in the manufacturer and change in formulation of any of the raw materials and change in location of raw material manufacture.
- Every time the coating yard is shifted from one location to the other or every time the critical coating equipment (induction heater, epoxy spray system, extruder, etc.) are shifted.
- Any change in window setting parameters like line speed, pipe preheat temperature before Epoxy application, coating thickness etc. during coating application.
- Any time when in Owner's opinion the properties are deemed to be suspect during regular production tests.

11.16 Owner reserves the right to conduct any or all the tests required for qualification through an independent laboratory or agency at the cost of Applicator/Contractor when in Owner's opinion, the results are deemed suspect. Owner's decision shall be final.
12.0 Application of Coating

12.1 Surface Preparation and Treatment

12.1.1 Proper equipment for the handling, unloading, and temporary storage of bare pipe shall be used to avoid any damage to bare pipe and pipe ends, or obliteration of necessary pipe markings. Each pipe shall be marked as necessary to maintain its identification throughout the processing sequence and remain on the exterior of the extruded PE after processing in accordance with procurement documents and the CONTRACTOR's acceptable procedures.

12.1.2 Pipe shall be visually inspected for dents, bevel damage or other damage. The CONTRACTOR shall isolate all damaged pipe in a hold area and issue a non-conformance report. Corrective action shall be taken and each corrected pipe shall be re-inspected prior to accepting the pipe for surface preparation. Pipe damaged beyond repair shall be removed from the site as soon as practical.

12.1.3 Two abrasive blast cleaning units shall be available so that contamination on the pipe is kept to a minimum and the profile capability is greater.

12.1.4 Debris inside pipe shall be removed. All oil, grease, dirt or other deleterious contamination shall be removed from the exterior and interior of pipe by solvent cleaning with a non-oily solvent in accordance with SSPC SP1 or by detergent washing or steam cleaning. Gasoline or kerosene shall not be used for this purpose. No residue that will affect adhesion shall be left on the surface. Interior pipe cleanliness is important when using recirculated abrasive system. Steel surface shall be allowed to dry before abrasive cleaning.

12.1.5 All external surface preparation shall be done in such a manner that bevelled ends, internal lining, and internal cleaned surfaces will not be damaged. The interior surfaces of each joint of unlined pipe shall be cleaned in the shop prior to the processing of the exterior surfaces.

12.1.6 The Applicator/Contractor shall thoroughly clean, dry and shot blast the pipes using a mix of steel grit with steel shot to obtain profile having uniform roughened/angular surface profile. Shot blast operation shall be carried out using automatic abrasive blasting equipment. The standard or finish for cleaned pipe shall conform to Sa 2 ½ of Swedish Standard SIS-055900/8501-1, latest edition. A dense, angular anchor pattern is required in order to obtain the greatest, cleaned surface area and maximum adhesion of the FBE to the substrate. A rounded, dished profile is not acceptable when viewed with 30X magnification. The degree of preparation required to obtain an end product that fulfils the requirements of this specification may not be sufficiently covered and is not limited by SIS-055900. Surface of pipe after shot blasting shall have an anchor pattern of 75 to 100 micron (ISO 8503-1 C1 & C2 Surface Profile Comparators). This shall be measured by a portable digital surface roughness tester like Mitutoyo surf test.
12.1.7 Recycled abrasives may be used. When using a steel grit and shot mix as the abrasive, the percentage of steel shot in the abrasive mix shall not be greater than 50%. If the surface profile does not produce an angular or rough profile, the percentage of steel grit shall be increased as necessary to meet this requirement. The Applicator/Contractor shall obtain an approval of the ratio of such mix from Owner and/or TPIA on the basis of trial runs. The minimum definition of an angular profile is where scratching the surface using a fingernail is equal to the roughness of the 4.5 mil tab of a Keane-Tatar grit profile comparator. The working abrasive mix shall be maintained clean of contaminants by continuous effective operations of cleaning machine scalping and air wash separators. Recirculated grit used for abrasive cleaning shall be tested for the presence of oil by immersing a sample in water and checking for oil flotation. Tests shall be made at the start of blasting and every four hours thereafter. If oil is evident, the contaminated abrasive shall be cleaned and retested or replaced. All surfaces blasted and possibly coated since the last successful test shall be completely re-blasted using clean abrasive.

12.1.8 In order to achieve a surface cleanliness of Sa 2 1/2 in accordance with ISO 8501 Part A1 (visual assessment) the correct hardness and size of abrasive must be used:

- ISO 8501 Group E Metallic Cleaning Abrasives
- ISO 11124-1 Specification for Chilled Iron Grit
- ISO 11124-2 Specification for Cast Steel Shot and Grit

12.1.9 Pipe ends shall be sealed to prevent ingress of blasting material (grit / shot).

12.1.10 For consistent surface finish in automatic blast equipment, a stabilized working mix shall be maintained by frequent small additions of new grit abrasive commensurate with consumption. Infrequent large additions of grit shall be avoided.

12.1.11 The blast cleaned surface shall not be contaminated with dirt, dust, metal particles, oil, water, or any other foreign material from any source. This includes but is not limited to the pipe transport systems, processing equipment components or tools, or airborne contaminants. In addition, the pipe surface or its anchor pattern shall not be scarred or burnished.

12.1.12 After abrasive cleaning and before coating, the surface to be coated shall be carefully inspected under adequate lighting for metal defects which may affect coating application, i.e., scabs, slivers, gouges or laminations. The CONTRACTOR shall be responsible for the repair of any defects which can be repaired by filing or grinding, and for restoring the anchor pattern at the locations of such repairs when the size of the repair exceeds 25.8 cm² (4 in²). The tools and manner employed to remove metal defects shall not burnish or destroy the anchor pattern or contaminate the surface.

12.1.13 Pneumatic tools shall not be used unless they are fitted with effective exhaust air, oil, and water traps.
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</tr>
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<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
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<tr>
<td>Reference</td>
<td>CIMG-GD-2-2019-0001</td>
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<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.1.14</td>
<td>If the profile is destroyed over a single area greater than 161 cm² (25 in²) or over a total area greater than 0.5% of a pipe spool, the pipe shall be re-blasted at no expense to OWNER.</td>
</tr>
<tr>
<td>12.1.15</td>
<td>In instances where steel or weld defects are removed by grinding and blending to a smooth contour, the remaining pipe wall thickness shall be at least 95 percent of the specified wall thickness. Areas where pipe wall thickness is less than 95 percent shall be rejected or repaired in accordance with OWNER approved procedures.</td>
</tr>
<tr>
<td>12.1.16</td>
<td>Uncoated pipe requiring further attention or inspection shall be set aside for such inspection at no additional cost to OWNER.</td>
</tr>
<tr>
<td>12.1.17</td>
<td>As required by OWNER, the CONTRACTOR shall allow OWNER's Representative to photograph and/or video all aspects of the receiving, storage, handling, surface preparation, coating and inspection process and in particular steel or coating imperfections for documentation.</td>
</tr>
<tr>
<td>12.1.18</td>
<td>The abrasive blast cleaning units shall have an effective dust collection system to ensure total removal of dust generated during blast cleaning from the pipe surface. The equipment used for abrasive blast cleaning shall meet the specified requirements and shall be free from oil, water soluble salts and other forms of contamination to ensure that the cleaning process is not impaired. Traps, separators and filters shall be checked for condensed water and oil at the start of each shift and emptied and cleaned regularly. During abrasive blast cleaning, the metallic abrasive shall be continuously sieved to remove &quot;fines&quot; and &quot;contaminants&quot; and the quality checked at every four hours. Abrasives used for blast cleaning shall comply with ISO-11124. In addition the pipe surface after blast cleaning shall be checked for the degree of cleanliness, degree of dust and shape of profile. Degree of dust shall comply with the requirements of ISO 8502-3. Acceptance limit shall be either quality rating 2 or Class 2. Tape used for assessment of dust shall comply with IEC 454-2. Pressure shall be exerted on the applied tape using a 4 kg roller, prior to peeling off to assess degree of dust.</td>
</tr>
<tr>
<td>12.1.19</td>
<td>Suitable plugs shall be provided at both pipe ends to prevent entry of any shot/grit into the pipe during blast cleaning operations. These plugs shall be removed after blast cleaning. Alternatively, the Applicator/Contractor may link the pipes suitably together to prevent the entry of any shot/grit into the pipe.</td>
</tr>
<tr>
<td>12.1.20</td>
<td>The abrasive blast materials shall be free of impurities such as clay, dirt, debris, oil, grease, salts or other contamination, Applicator/Contractor to specify the specific criteria for determining abrasive materials are free of impurities. Routine check (once per shift) on quality of the mix (shot and grit) to be carried out to ensure minimum dust, salt, other contamination and to be mentioned in QA/QC.</td>
</tr>
<tr>
<td>12.1.21</td>
<td>Applicator/Contractor to verify air cleanliness at the start of each shift and every four hours thereafter if compressed air is being used for blasting, blowing down the pipe or...</td>
</tr>
</tbody>
</table>
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Type: Guidance


for applying any of the coating such as the primer and method for testing the air cleanliness shall conform to ASTM D-4285.

12.1.22 Pipes shall be visually inspected by the Applicator/Contractor, immediately after every blast cleaning operation, for surface defects such as slivers, laminations, leafing, scores, indentation, slugs or any other defects considered injurious to the coating integrity by the Owner and/or TPIA. Such defects shall be reported to Owner and/or TPIA and on permission from Owner and/or TPIA, such defects shall be removed by filing or grinding in such a way as not to "blue" the steel, at no extra cost to the Owner.

12.1.23 However, Applicator/Contractor has to ensure the wall thickness after the grinding and filing operations and defects shall not reduce the wall thickness below the specified minimum wall thickness of the pipe. Rechecking of wall thickness shall be carried out in presence of owner's representative after any such defect removal.

12.1.24 Any dust or loose residues that have been accumulated during blasting and/or during filing/grinding operations shall be removed by vacuum cleaning.

12.1.25 If contamination of surface occurs, the quality of blast cleaning method and process shall be examined. If the surface roughness is outside the specified limit, the blast cleaning material shall be checked and replaced.

12.1.26 All pipes shall be preheated to a temperature range of 55° C to 85° C prior to abrasive blast cleaning. The external surface of the pipe shall be cleaned using 2 no. dry abrasive blast cleaning units to achieve the specified surface cleanliness and profile. Chemical pre-treatment with phosphoric acid solution to be carried out after the second abrasive blaster.

12.1.27 Degree of dust shall comply with requirements of ISO 8502-3. Criteria for checking degree of dust shall be as per ISO 8502-3. The dust level on the blast-cleaned surface shall be of Class 2 for both size and quantity in accordance with ISO 8502-3. Tape used for assessment of degree of dust shall be pressure sensitive adhesive tape and comply with IEC-454-2.

12.1.28 Upon Completion of the blasting operations, the quality control supervisor shall accept the pipe for further processing or return for re-blasting after removal of defects/imperfections. In case imperfections are considered detrimental to the coating quality, the same shall be reported to Owner and/or TPIA for final decision on rejection or re-blasting/removal of defects. Re-blasting / removal of defects or returning pipe to the yard shall be at the Contractor's cost. Owner and/or TPIA, in additions, reserves the right to initiate any of the above actions during periodic inspections for oil, dust, salt, imperfections, surface defects, lack of white metal finish, etc.

12.2 Chemical Pre-treatment with Phosphoric Acid Solution

12.2.1 All pipes shall be provided chemical pre-treatment with phosphoric acid solution. 10% solution of phosphoric acid, Oakite 31 / 33 or equivalent, shall be used to remove all soluble salts and other soluble contaminants.
12.2.2 The CONTRACTOR shall provide data sheets and supporting documentation for the phosphoric acid to be used. The documentation shall verify that the phosphoric acid is suitable for the treatment of line pipe prior to the application of the specific fusion bonded epoxy powder being applied and the final coating will meet fully the requirements of this specification.

12.2.3 The pipe temperature immediately prior to the phosphoric acid treatment shall be in the range of 45°C to 75°C.

12.2.4 Phosphoric acid treatment shall be followed immediately by washing with de-ionized water. De-ionized water used shall conform to the following requirements:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Turbidity</td>
<td>NTU</td>
<td>1 max.</td>
</tr>
<tr>
<td>b.</td>
<td>Conductivity</td>
<td>mho/cm</td>
<td>5 max.</td>
</tr>
<tr>
<td>c.</td>
<td>Hardness</td>
<td>-</td>
<td>Nil</td>
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<tr>
<td>d.</td>
<td>Total Alkalinity as CaC03</td>
<td>mg/l</td>
<td>2 to 3</td>
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<tr>
<td>e.</td>
<td>Chloride as Cl⁻</td>
<td>mg/l</td>
<td>1 max.</td>
</tr>
<tr>
<td>f.</td>
<td>Sulphate as SO4²</td>
<td>mg/l</td>
<td>1 max.</td>
</tr>
<tr>
<td>g.</td>
<td>PH</td>
<td>-</td>
<td>6.5 to 7.5</td>
</tr>
</tbody>
</table>

12.2.5 High pressure water rinse at 500 to 1000 psi (35 to 67 bar) will be used to remove any treatment residue. A minimum of 10 litres De-ionised water per square meter of pipe surface should be used.

12.2.6 Tests to determine the above properties shall be carried out in accordance with "Standard Methods for the Examination of Water and Wastewater" published jointly by American Public Health Association, American Water Works Association and Water Pollution Control Federation.

12.2.7 Quality of the de-ionized water shall be monitored at the start of each shift and at every four hours interval. Non-compliance of de-ionized water with respect to the above requirements shall cause for stoppage of the operations.

12.2.8 The pH of the pipe surface shall be determined both before and after the deionized water rinse initially on each pipe and in case of consistent results, the frequency may be relaxed to once per hour at the discretion of COMPANY Representative. The measured pH shall be as follows:

- Before de-ionized water wash : 1 to 2
- After de-ionized water wash : 6 to 7

12.2.9 After the de-ionized water wash, the pipe shall be dried with dry air and preheated to a temperature of 65°C to 85°C.

12.2.10 The salt tests shall be carried out after de-ionized water rinse. One test shall be carried out at one end of each pipe. The acceptance criteria shall be 2 µg/cm². ISO 8502 Parts 6
and 9 shall be used for the extraction (bresle Method) and field determination of soluble salts.

12.2.11 All pipes shall be visually examined for presence of any shot / grit / loose material left inside the pipe during blast cleaning. Suitable mechanical means (stiff brush) shall be employed to remove the same before the pipes are processed further. In addition, inside surface of the pipe shall also be visually inspected for any presence of any foreign material or shots and grit (free or embedded / sticking to the pipe inside surface). The pipe inside surface shall be examined using sharp floodlight focussed at the middle of the pipe at one end while inspections is carried out visually from the other end. Any foreign material or shots / grits shall be completely removed by mechanical brush, high pressure air jets, by tilting of pipe etc.

12.2.12 At no time shall the blast cleaning be performed when the relative humidity exceeds 85%. The Contractor shall measure the ambient conditions at regular intervals during blast cleaning and coating operations and keep records of prevailing temperature, humidity and dew point.

12.2.13 Removal of dust should be via the use of vacuum "cleaning" and/or clean, dry air blast. The dust level on the blast-cleaned surface shall be of Class 1 in accordance with ISO 8502-3.

12.2.14 Drying procedure to be established during PQT stage. Arrangements to be made for complete elimination of any traces of water vapour on pipe surface which can be checked through porosity test or checking the relative humidity near coating application. Following mechanism may be followed to ensure that water (in steam/vapour form) does not get trapped and affect coating adversely.

   a) Provision in QA plan for check of relative humidity near coating application.
   b) Provision in QA plan for check of porosity in coating.
   c) Provision for water removal before entry to oven with help of hot air knife.
   d) Oven heating in two stage
   e) Suction arrangement in oven.
   f) Ascertaining above during PQT (procedure qualification lest) and bench marking on acceptance level for adhering to the same during the entire campaign.

12.2.15 Blast cleaned pipes shall be coated within 4 hours. Pipes whose coating is delayed beyond this period, or pipes showing any visible rust stains, shall be blast cleaned again.

12.3 Chemical Pre-treatment with Chromate Solution

12.3.1 Following completion of phosphoric acid treatment and DM water wash, all pipe surfaces shall be chemically pre-treated with a 10±2% strength chromate solution. Document and recommendation from manufacturer to be submitted in this regard for approval prior to PQT.

12.3.2 The Applicator/Contractor shall provide data sheets and supporting documentation for the chemical to be used. The documentation shall verify that the chemical is suitable for
the treatment of line pipe prior to the application of the specific fusion bonded epoxy powder being applied and the final coating will meet fully the requirements of this specification.

12.3.3 The chemical pre-treatment shall be applied fully in accordance with the chemical suppliers' instructions and in a manner that ensures 100% uniform coverage of the pipe surface without introducing surface contamination.

12.3.4 The Applicator/Contractor shall check that the concentration of the chemical pre-treatment solution remains within the range recommended by the chemical manufacturer for the pipe coating process. The concentration shall be checked at the make-up of each fresh solution and once per hour, using a method approved by the chemical manufacturer. The Contractor shall also ensure that the chemical pre-treatment solution remains free from contamination at all times. Recycling of chemical pre-treatment solution is not permitted. Chloride concentration of the chromate solution shall be checked every shift. The maximum residual chloride level on the blast-cleaned surface shall be 20 mg/m², in accordance with ISO 8502-2 or any other method approved by GAIL.

12.3.5 One of every 100 pipes shall be checked for chloride contamination on the blasted surface. If contamination of the surface occurs, the quality of the blast cleaning material and process shall be examined. If the conductivity of the blasting material is greater than 50 μS/cm, the blasting material shall be replaced.

12.3.6 The Applicator/Contractor shall ensure that the temperature of the substrate is maintained between 40°C and 80°C and the chromate solution temperature does not exceed 60°C or as recommended by the manufacturer.

12.3.7 The chromate coating shall be smooth, even, free from runs, drips or excessive application and lightly adherent with no flaking of the coating. The chromate coated steel must be thoroughly dried immediately after application and shall be achieved by boiling off any residual solution on the surface.

12.3.8 The Applicator/Contractor shall be fully responsible for adherence to local regulations and material safety data sheets, for using chromate solution.

12.3.9 The total allowable elapsed time between completion of the blasting operations and commencement of the pre-coating and heating operations shall be such that no detectable oxidation of the surface occurs. Relative humidity readings shall be recorded every half an hour during the blasting operations in the immediate vicinity of the operations. The maximum elapsed time shall not exceed the duration given below:

<table>
<thead>
<tr>
<th>Relative Humidity %</th>
<th>Maximum elapsed time</th>
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<tbody>
<tr>
<td>≥ 80 &amp; &lt; 85</td>
<td>1 hours</td>
</tr>
<tr>
<td>≥ 70 to &lt; 80</td>
<td>2 hours</td>
</tr>
<tr>
<td>≥ 60 to &lt; 70</td>
<td>3 hours</td>
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<tr>
<td>&lt; 60</td>
<td>4 hours</td>
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<thead>
<tr>
<th>Rev. No.</th>
<th>Report No.</th>
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<tr>
<td>00</td>
<td>CIMG-GD-2-2019-0001</td>
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</tr>
</tbody>
</table>
12.3.10 Any pipe not processed within the above time-humidity requirement shall be completely re-blasted. Any pipe showing flash rusting shall be re-blasted even if the above conditions have not been exceeded.

12.3.11 Pipe handling between abrasive blasting and pipe coating shall not damage the surface profile achieved during blasting. Any pipe affected by the damage to the surface exceeding 200 mm² in area and/or having contamination of steel surface shall be rejected and sent for re-blasting.

12.3.12 It shall be the CONTRACTOR's responsibility to stop the coating process at any time when conditions may exist that might adversely affect the coating quality. OWNER's Representative may reject any product not proven by the CONTRACTOR to be in compliance with this Specification.

12.4 Coating Application

The external surface of the cleaned pipe conforming to specifications for pipe surface preparation shall be immediately coated with 3 layer side extruded medium I high density polyethylene coating in accordance with relevant standard, this specifications and with procedures approved by Owner.

12.4.1 FBE Layer Coating

12.4.1.1 The FBE coating shall be applied to a minimum dry film thickness 0.200 mm (for normal thickness) / 0.300 mm (for reinforced thickness), unless otherwise specified. The maximum thickness shall not exceed the epoxy thickness specified by epoxy powder manufacturer.

12.4.1.2 Prior to application of the fusion bonded epoxy powder, the powder application and recovery systems shall be thoroughly cleaned. During coating application Applicator/Contractor to ensure that container/hopper shall contain powder/pellets from only one batch of material. In addition, the spray booth shall be cleaned of excess powder at the end of each shift.

12.4.1.3 Prior to starting the fusion bonded epoxy powder application, the recovery systems shall be thoroughly cleaned to remove any unused powder.

12.4.1.4 The use of recycled powder shall be limited to maximum 10%.

12.4.1.5 The coating shall be applied by electrostatic spray with the pipe at earth potential and the epoxy powder charged to high potential.

12.4.1.6 Prior to epoxy application the pipe shall be uniformly preheated using induction heating coil to a temperature of 225°C to 240°C or as per MANUFACTURER's recommendation. In any case the pipe metal temperature shall not be below 190°C or exceed 260°C. Required pipe temperature shall be maintained as it enters the coating chamber.

12.4.1.7 Temperature of the pipe surface shall be continuously monitored and recorded by using suitable instruments such as infrared sensors, pyrometer, contact thermometers,
thermocouples etc. The recording method shall allow to correlate each line pipe. The monitoring instrument shall be able to raise a visual alarm and activate audio system (hooter) in the event of tripping of induction heater or in the event of pipe temperature being outside the range recommended by the manufacturer. Any deviation from the application temperature range recommended by manufacturer shall be rectified. If immediate rectification is not feasible, the production shall be stopped until cause of deviation has been removed. Any pipe coated during the duration of temperature deviation shall be identified by marking and rejected. Such rejected pipes shall be stripped, re-cleaned and recoated.

12.4.1.8 Temperature measuring and monitoring equipment shall be calibrated twice every shift and/or as per Owner Representative's instruction.

12.4.1.9 Applicator/Contractor shall ensure that pipe surface emissivity variations are minimized during pipe heating. To avoid significant variance, more than once blasted joints should be coated at the same time and not mixed with joints blasted only once.

12.4.2 Adhesive Layer Coating

12.4.2.1 Grafted copolymer adhesive shall be applied by extrusion to a minimum thickness of 0.200 mm. The maximum thickness shall not exceed the Adhesive thickness specified by Adhesive manufacturer.

12.4.2.2 The Applicator/Contractor shall ensure that the rollers push adhesive film to eliminate any air entrapment or voids. The adhesive layer shall be applied before gel time of the FBE has expired by using either the cross-head or lateral extrusion technique. The Applicator/Contractor shall establish to the satisfaction of Owner and/or TPIA representative that the adhesive is applied within the gel time window of the FBE and at the temperature recommended by the adhesive Manufacturer. The Applicator/Contractor shall calculate inter-coat time between the last epoxy gun and start of adhesive layer and state the proposed minimum and maximum time interval between FBE and adhesive applications at the pipe temperature range and overlap and the same should comply with the manufacturer recommendation.

12.4.3 Polyethylene layer Coating

12.4.3.1 Polyethylene coating by side extrusion shall be applied over the adhesive within the time limits established during pre-production testing.

12.4.3.2 The maximum thickness shall not exceed the PE thickness specified by PE manufacturer.

12.4.3.3 The coated pipe shall be subsequently quenched and cooled in water for a period which shall sufficiently lower the temperature of pipe coating to permit ease in handling and inspection.

12.4.3.4 Any change in materials and/or coating method shall be subjected to written approval of Owner.
12.4.3.5 Prior to coating, the pipe temperature shall be checked in an approved manner with approved and calibrated pyrometer to ensure that temperature is uniform and within the acceptable limits. The pyrometer shall be calibrated twice in every shift and/or as per Owner and/or TPIA instructions.

12.4.3.6 While applying the coating, Applicator/Contractor shall ensure that there is no entrapment of air or void formation along the weld seam. This may be achieved by using appropriate pressure roller for application of adhesive. The method used shall be witnessed and approved by Owner and/or TPIA.

12.4.3.7 Air entrapment along the coating and along the overlap shall also be avoided by forcing the coating to the pipe during application using high pressure silicon roller of suitable design. In case, it is not adequately achieved, Applicator/Contractor shall supplement by other methods to avoid air entrapment. The methods used shall be witnessed and approved by Owner and/or TPIA.

12.4.3.8 The resultant coating shall be free from air bubbles, wrinkles, holidays, irregularities, discontinuities, etc., and shall be uniform in colour, gloss and thickness.

12.4.3.9 The coating and adhesive shall be removed from cut back portion at pipe ends using appropriate method. The adhesive shall seal the end of applied coating. Applicator/Contractor shall adopt an approved method of removing the coating near pipe ends.

12.4.3.10 The coating pipe shall be handled in such a manner so as to prevent any damage to the coating or steel pipe.

12.4.3.11 The uncoated ends shall be protected with compatible primer/varnish. Applicator/Contractor shall furnish details for the same and shall be approved by Owner and/or TPIA.

12.4.3.12 The coating shall be continuous for the full length of the pipe, however, cut back of 150 mm +25/(-) 0 mm on each end of the line pipe shall be provided. Bevel angle of cutback shall be <30°. A 20 ±5 mm band of epoxy coating to be maintained outside the cut-back portion. i.e. visible outside where coating ends.

12.4.3.13 The uncoated cut back ends shall be protected with compatible primer/varnish. Applicator/Contractor shall furnish details for the same and obtain the approval of Owner.

12.4.3.14 Failure to comply with any of the above applicable requirements and of the approved procedures shall be a cause for the rejection of the coating which shall be removed in a manner approved by Owner and/or TPIA at Applicator/Contractor's expense.

12.5 Inspection and Testing

12.5.1 General:

12.5.1.1 The contractors shall have the full responsibility for the coating application quality in
accordance with this Specification and shall be responsible for stopping operations when conditions develop which could adversely affect the quality of the completed work. All work shall be subject to GAIL's inspection surveillance.

12.5.1.2 The Applicator/Contractor shall at its own expense provide a fully equipped laboratory and test facilities with adequate inventory to carry out tests required for the procedure qualification and regular production.

12.5.1.3 Tests for compliance with this specification in whatever manner and as often as it is thinks necessary, and at any time prior to coated pipes being transported from yard, on the coating including any repairs, as required by the Owner's representative and/or TPIA Inspector shall be carried out by the Applicator / Contractor at no extra cost.

12.5.1.4 Inspection activities will be coordinated with operations so as to avoid delay or interfere with them as little as possible. However, methods of operations shall be changed, if necessary, to permit complete inspection and adequate repair of imperfections and retesting of the later.

12.5.1.5 No claims for extra financial compensation or time extension shall be allowed because of time required for testing and inspection by the Owner's representative and/or TPIA party Inspector.

12.5.1.6 The required instruments for testing and inspection shall be supplied, established, calibrated, correctly operated and always maintained in good working condition by the Applicator / Contractor, who shall also keep adequate inventory of spare parts as well have at least a set of critical instruments per plant for exigency. The Applicator / Contractor shall be held responsible for any delay caused by the incorrect functioning of his instruments and shall have to bear the cost of such delays.

12.5.1.7 Applicator/Contractor shall be responsible for inspection of all the activities of coating and for approval of the coated pipes in accordance with Owner's specification.

12.5.1.8 After Applicator/Contractor's inspection, the Owner's Representative and/or TPIA Inspector shall inspect and approve the coated pipes. The inspection and approval by Owner and/or TPIA shall not relieve the Applicator/Contractor from his responsibility to give quality coating job as per this specification.

12.5.1.9 The Applicator/Contractor shall establish and maintain such quality assurance system as are necessary to ensure that goods or services supplied comply in all respects with the requirements of this specification. The minimum inspection and testing to be performed shall be as indicated subsequently herein. All the inspection and testing shall be performed under the supervision of competent inspector.

12.5.1.10 In addition to the specific tests mentioned in this section, the Applicator / Contractor shall inspect and maintain record for verification of GAIL on a daily basis on the following at specified frequencies:

<table>
<thead>
<tr>
<th>S No</th>
<th>Coating / Inspection Step</th>
<th>Required Frequency</th>
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<table>
<thead>
<tr>
<th>S No</th>
<th>Coating / Inspection Step</th>
<th>Required Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Surface Cleanliness</td>
<td>Visually check 100% of every pipe</td>
</tr>
<tr>
<td>2</td>
<td>Surface Profile</td>
<td>Check three locations per pipe spool and fitting:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a. At beginning of each shift and every two hours throughout the shift.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Whenever any change in abrasive type or mix or in blast pressure is made.</td>
</tr>
<tr>
<td>3</td>
<td>Test of recycled abrasive</td>
<td>Test for oil, grease, dirt contamination at the beginning of each shift (shift ≤ 12 hours) and every 4 hours thereafter.</td>
</tr>
<tr>
<td>4</td>
<td>Test compressed air</td>
<td>Test for oil, water and dirt contamination at the beginning of each shift (shift ≤ 12 hours) and every 4 hours thereafter.</td>
</tr>
<tr>
<td>5</td>
<td>Acid/chromate/rinse water</td>
<td>Test concentrations of acid and/or chromate mix at the beginning of each shift (shift ≤ 12 hours) and every 4 hours thereafter. Test conductivity of demineralized rinse water at the beginning of each shift (shift ≤ 12) and every 4 hours thereafter. Test pH of pipe after high pressure rinse at the beginning of each shift (shift ≤ 12) and every 4 hours thereafter.</td>
</tr>
<tr>
<td>6</td>
<td>Pipe temperatures</td>
<td>Test preheat prior to blasting, prior to entry into acid washing/chromate treatment area and prior to primer application once per hour.</td>
</tr>
<tr>
<td>7</td>
<td>Test Pipe-Thicknesses</td>
<td>Five (5) measurements each on primer, adhesive and polyethylene for every test pipe. Measurements shall be uniformly distributed along the pipe length and around the pipe circumference for the area coated with each coating material.</td>
</tr>
<tr>
<td>8</td>
<td>Total Thickness</td>
<td>Ten (10) measurements per pipe spool</td>
</tr>
<tr>
<td>9</td>
<td>Holidays</td>
<td>100% of coating on every pipe inspected; 100% of all holiday repairs. Record number of repaired holidays per pipe (see Section on Holiday Testing)</td>
</tr>
</tbody>
</table>
12.5.1.11 Applicator/Contractor shall perform all inspection and tests as per the requirement of this specification and relevant codes prior to stockpiling of the coated pipes.

12.5.1.12 The contractor shall supply GAIL with a schedule for all inspection and testing. If the contractor fails to notify GAIL of witness points, or hold point inspections and testing inspections, all pipe affected may be rejected by GAIL.

12.5.1.13 Unprocessed, in-process and processed materials or materials processed subsequent to acceptance, located at the contractor’s plant, that do not meet the requirements of this specification may be rejected by GAIL.

12.5.1.14 At predetermined intervals, one pipe shall be selected for destructive testing of the coating. A sample length of approximately 1 m shall be cut from one end of this pipe and subjected to the adhesion, impact, indentation and elongation tests.

12.5.1.15 The Applicator shall ensure that individual pipes are fully traceable during and after the coating process. If the serial number of the pipe as given in the pipe mill is removed or obliterated, it shall be reapplied. The Applicator's own serial number shall be indicated on the pipe and records shall be kept to identify the sequence and time of coating and the batch of materials used for each pipe.

Such inspection and tests shall be, but not limited to, the following:

12.5.2 Incoming Raw Material Testing
12.5.2.1 The contractor shall have a fully equipped laboratory at the coating plant for the testing and evaluation of the epoxy primer, adhesive intermediate and the polyethylene top coat materials.

12.5.2.2 Each lot or batch of coating material shall be tested and accepted prior to use in accordance with the provisions and specifications given here in the document.

12.5.3 Pre-surface Preparation Inspection
12.5.3.1 At the start of each shift, the pipe on the incoming rack shall be spot checked for dents, bevel damage or other physical damage, and for oil, grease, dirt and other contaminants. All conditions that cannot be corrected prior to blasting shall be reported and the pipe marked and removed to a hold area until dispositioned by GAIL.

12.5.3.2 At the start of each shift and every four hours thereafter, the in-process pipe shall be visually inspected to verify that it is clean and dry. In addition, the pipe surface temperature, relative humidity (%RH) and the dew point temperature shall be determined using a surface thermometer or pyrometer, sling psychrometer and appropriate tables.

12.5.4 Pipe Preheat Temperature Prior to Application
12.5.4.1 At the start of each shift, the pipe temperature on the first five pipes exiting the induction heater shall be verified using a contact thermometer/pyrometer or electronic
thermocouple. The preheat temperature shall be verified once every hour of production operation thereafter.

12.5.5 Surface Preparation Inspection

12.5.5.1 Surface cleanliness, surface roughness measurements and dust control immediately after second abrasive blast cleaning and salt test. The dust level on the blast-cleaned surface shall be of max Class 2 in accordance with ISO 8502-3. Unless otherwise specified in this specification the requirement and frequency for inspection of surface preparation shall be as per table 8 of ISO 21809-1 (2011). However provision should be there for continuous monitoring of preheating temperature before coating with actuation of both visual & audio alarm on parameters getting out of range.

12.5.5.2 Surface cleanliness shall be judged against both written and visual (ISO 8501-1 or SSPC VIS-1-89) standards. Surface cleanliness must be inspected on a continuous basis.

12.5.5.3 Exterior surface preparation shall meet the requirements of as given here in Exterior Surface Preparation section. The exterior surface profile shall be verified on the first pipe of each shift with one pipe spot checked every hour thereafter. The profile shall be determined using Testex Press-0-Replica Tape and spring micro-meter or a Keane-Tatar grit profile comparator.

12.5.5.4 The removal of dust from the blasted pipe shall be visually verified on each pipe inspected for profile in paragraph above.

12.5.5.5 Recirculated grit and shot shall be checked for the presence of oil by immersing a sample in water and checking for oil flotation. Tests shall be made at the start of blasting and every four hours thereafter. If oil is evident, the contaminated abrasive shall be cleaned or replaced. All surfaces blasted and possibly coated since the last successful test shall be completely re-blasted using clean abrasive.

12.5.5.6 Grease-free chalk shall be used to mark areas which do not meet the specified requirements.

12.5.5.7 The blasted pipe shall be verified to be free of detrimental soluble salts by using the test described herein unless acid washing is an automatic part of the CONTRACTOR's surface preparation process.

12.5.5.8 When used, the acid wash stage and chromate treatment stage shall be checked at the start of each day’s work for proper solution make up and cleanliness, rinse water conductivity, rinse water cleanliness, pH of rinsed pipe surface and proper equipment operation.

12.5.6 Powder Epoxy

12.5.6.1 At the start of each shift the epoxy powder shall be verified to be clean and dry. In addition, the delivery, spray and recycle equipment shall be verified to be in good working order. No more than 25% recycle may be added to the virgin powder. Magnets in the recycle system must be checked and cleaned every shift.
12.5.6.2 At the start of each shift, the epoxy primer thickness on the production test pipe shall be verified using a magnetic dry film thickness gage such as a Mikrotest or approved equal in accordance with SSPC-PA2. Five evenly spaced readings along the length of the test area shall be taken. The readings shall also be evenly distributed around the pipe circumference. The average of the five readings shall be within the specified limits. No single spot reading shall be less than 80% or more than 120% of the specified thickness.

12.5.6.3 At the start of each shift and every four hours thereafter the primer shall be verified to have full coverage and to be smooth in appearance.

12.5.7 Intermediate Adhesive Application Inspection

12.5.7.1 At the start of each shift and every four hours thereafter, the material extrusion temperature shall be verified by positioning a thermometer as close to the extruder die as possible without touching the die.

12.5.7.2 At the start of each shift and every four hours thereafter, the material extrusion overlap, extrusion width under the roller and smooth appearance shall be verified.

12.5.7.3 The intermediate adhesive shall not overlap onto extruded MDPE/HDPE. If this condition occurs all coated pipe involved shall be rejected.

12.5.7.4 At the start of each shift, the adhesive intermediate thickness on the production test pipe shall be verified using a magnetic dry film thickness gage such as a Mikrotest or approved equal in accordance with SSPC-PA2. Five evenly spaced readings along the length of the test area shall be taken. The readings shall also be evenly distributed around the pipe circumference. The average of the five reading shall be within the specified limits. No single spot reading shall be less than 80% or more than 120% of the specified thickness.

12.5.8 Polyethylene Application Inspection

12.5.8.1 At the start of each shift and every four hours thereafter verify the material extrusion temperature by positioning a thermometer as close to the extruder die as possible without touching the die.

12.5.8.2 At the start of each shift and every four hours thereafter, the material extrusion overlap, extrusion width under the roller and smooth appearance shall be verified.

12.5.8.3 At the start of each shift, the polyethylene thickness on the production test pipe shall be verified using a magnetic dry film thickness gage such as a Mikrotest or approved equal in accordance with SSPC-PA2. Five evenly spaced readings along the length of the test area shall be taken. The readings shall also be evenly distributed around the pipe circumference. The average of the five reading shall exceed the minimum thickness specified in Table 5. No single spot reading shall be less than 80% or more than 150% of the specified thickness. For pipe that will be installed by directional drilling, the OFT shall be 1.0 mm greater.
12.5.9 Cool Down

12.5.9.1 At the start of the shift and every four hours thereafter, the applied coating temperature on pipe exiting the cool down area shall be verified to be ≤ 43°C (110°F). The first three pipes at the start of each shift and one pipe every four hours thereafter, shall be examined at three spots evenly spaced along the pipe length using a suitable contact thermometer/pyrometer.

12.5.10 Visual Inspection after application all three layers

12.5.10.1 Immediately after the coating, each coated pipe shall be visually checked for imperfections and irregularities of the coating. The coating shall be of natural colour and gloss, smooth and uniform and shall be free of defects with no dust or other particulate inclusions. The coating shall not show any defects such as blisters, pinholes, scratches, wrinkles, engravings, cuts, swellings, disbanded zones, air inclusions, tears, voids or any other irregularities. Special attention shall be paid to the areas adjacent to the longitudinal weld (if applicable), adjacent to the cut-back at each end of pipe and within the body of the pipe.

12.5.10.2 In addition, inside surface of the pipe shall also be visually inspected for presence of foreign material or shots and grit (free or embedded/sticking to pipe inside surface).

12.5.11 Coating System Total Thickness

12.5.11.1 The coating thickness on every pipe shall be verified using a magnetic dry film thickness gage such as a Mikrotest or approved equal in accordance with SSPC PA2.

12.5.11.2 The average coating thickness shall be determined by measurement at 10 set of locations uniformly distributed over the length and periphery of each pipe at 3, 6, 9 and 12 o'clock positions, additionally measurement to be taken at five equidistant points along the apex of weld seam of the coated pipe. All 10 set of reading and five additional readings at seam must meet the minimum requirements.

a) Thickness of epoxy and adhesive shall be measured at the beginning of each shift and whenever the plant re-starts after any stoppage for compliance. Coating of epoxy and adhesive on portion of pipe required for this purpose, stripping and recoating of such partly coated pipes shall be at Applicator/Contractor's expense.

b) The frequency of thickness measurement as stated above shall be initially on every pipe which shall be further reduced depending upon consistency of results, at the sole discretion of Owner's representative and/or TPIA Inspector to 1 in 5 pipes.

c) Coated pipes not meeting the above requirements shall be rejected. The Applicator / Contractor shall remove the entire coating and the pipe shall be recycled for cleaning and coating operations, as per the approved procedure by OWNER and shall be to Applicator/Contractor's expense.

12.5.11.3 If a trend of more than two pipes in a row exhibit a coating thickness slightly high or low, ± 10% of the required average thickness, the production line shall be immediately
Pipeline Coating Specifications

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<thead>
<tr>
<th>Title</th>
<th>Pipeline Coating Specifications</th>
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<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
</tr>
<tr>
<td>Reference</td>
<td>CIMG-GD-2-2019-0001</td>
</tr>
</tbody>
</table>

readjusted. If the average thickness deviation is greater than ±10%, the production line shall be immediately shut down. The equipment shall be adjusted and a test pipe sent through just as if it was the start of the shift. Coated pipe with a thickness deviation > 10% shall be stripped and recoated. Coated pipe with a thickness deviation less than 10% shall be placed on hold for review and disposition by GAIL

12.5.12 Holiday Detection:

12.5.12.1 Each coated pipe length shall be tested as per NACE standard RP-02-74 by means of a 'Holiday Detector' of a type approved by Owner's representative and/or TPIA inspector for detecting holidays in the finished coating.

12.5.12.2 The holiday detector shall be a low pulse D.C. full circle electronic detector with both audible and visual alarm and precise voltage control, complying with DIN VDE 0433 Part 2. The set voltage for inspection shall be minimum 25 KV. Travel speed shall not exceed 300 mm/s.

12.5.12.3 Applicator/Contractor shall calibrate the Holiday Detector at least once in every 4 hours of production or every 25 pipes, whichever is more frequent and/or at the discretion of Owner's representative and/or TPIA inspector. Applicator/Contractor shall have necessary instruments or devices for calibrating the Holiday Detector.

12.5.12.4 Pipe coating shall be rejected if more than 1(one) holiday and area more than 100 cm² in size are detected in its length attributable to coating process. Any pipe so rejected shall have the coating removed and recycled through the complete cleaning and coating process in accordance with procedure approved by Owner and/or TPIA and shall be at Applicator/Contractor's expense.

12.5.12.5 Applicator/Contractor is required to submit specific detailed repair procedures for review and acceptance prior to performing holiday repairs.

12.5.12.6 In case of recurring defects as per clause (iv) above, Applicator/Contractor shall investigate the cause of the Holidays and take necessary remedial measures required to correct the cause in consultation with the Owner and/or TPIA.

12.5.12.7 However in case more than 5% of coated pipes per production shift (typically eight hour shift) are rejected, Applicator/Contractor shall stop production and investigate in details. Findings of such investigation and remedial measures proposed to be adopted shall be submitted to Owner and/or TPIA for approval prior to recommencing coating operation.

12.5.13 Peel Test:

12.5.13.1 Applicator/Contractor shall conduct peel test for coating as table in clause no. 8.11.4 of this specification.

12.5.13.2 The frequency of test shall be on one pipe in every ten (10) pipes initially which shall be further reduced to at least 2(two) pipes per shift depending upon consistent acceptable
results at the sole discretion of Owner's representative and/or TPIA inspector. The system shall fail only in the adhesive layer.

12.5.13.3 The test method & interpretation of test shall be as per ISO 21809-1 (2011). The failure mode shall be recorded for each test.

12.5.13.4 In case the above tests do not comply with the above requirement, Applicator / Contractor shall test all the preceding and succeeding coated pipes until the coating is proved acceptable and/or at the discretion of the Owner's representative.

12.5.13.5 The peel test on coated pipes is determined at two points of coated surface i.e. the cutback area and middle of pipe.

12.5.13.6 The areas where the coating has been removed for testing by the inspector shall be repaired by the Applicator / Contractor as per approved procedures at his own expenses.

12.5.13.7 Rejected line pipes coating shall be removed and shall be recycled through cleaning and coating process in accordance with approved procedures by Owner and/or TPIA at Applicator / Contractor's expenses.

12.5.14 Indentation Resistance:

12.5.14.1 Indentation resistance test shall be as per clause no. 8.11.4 of this specification. The frequency of test shall be initially one coated pipe in every 25 (twenty five) pipes or 2 (two) coated pipes per shift whichever is more frequent, which shall be further reduced and/or waived depending upon consistent acceptable results at the sole discretion of Owner's representative and/or TPIA inspector.

12.5.14.2 Test shall be conducted on the coating samples taken from the coated pipe in a manner approved by Owner and/or TPIA. Two samples for each temperature shall be taken from the cut back portion of coated pipe and one in the middle of the pipe for this test.

12.5.14.3 Immediately prior to testing, the thickness of the coating in test areas shall be measured and recorded.

12.5.14.4 The maximum allowable penetration shall be as per clause 8.11.4 A) i).

12.5.14.5 In case the pipe is rejected for lack of Indentation Resistance, Applicator / Contractor shall test the preceding and succeeding pipes coated until the coating proved acceptable and/or at the discretion of the Owner's representative and/or TPIA Inspector.

12.5.14.6 Rejected line pipe's coating shall be removed and shall be recycled through cleaning and coating process in accordance with the approved procedures by Owner at Applicator / Contractor's expense.

12.5.15 Impact Resistance:

12.5.15.1 Applicator/ Contractor shall conduct Impact Resistance test as per clause no. 8.11.4 of this specification. Initially the frequency of test shall be one coated pipe in every 25 (twenty five) pipes or once in every 2 (two) hours whichever is more frequent, which
shall be further reduced and/or waived depending upon consistent acceptable results at the sole discretion of Owner's representative and/or TPIA inspector.

12.5.15.2 Test shall be conducted at 30 (thirty) equidistant points along the length of the coated pipe in a manner approved by Owner and / or TPIA.

12.5.15.3 Immediately prior to testing, the thickness of the coating in test areas shall be measured and recorded.

12.5.15.4 The coating shall withstand minimum impact energy as stated in this specification.

12.5.15.5 Immediately after testing, the test area shall be subjected to holiday detection at the same voltage as used prior to impact strength test. The pipe shall be rejected if any holiday is noted in the test area.

12.5.15.6 In case the coated pipe being rejected for lack of Impact Resistance, Applicator / Contractor shall test preceding and succeeding pipes coated until the coating proves acceptable and / or at the discretion of the Owner's representative and/or TPIA inspector. Impact Strength Test shall be carried out at every change in batch of PE.

12.5.15.7 Rejected pipe coating shall be removed and shall be recycled through cleaning and coating process in accordance with the procedure approved by Owner and/or TPIA.

12.5.16 Air Entrapment Test

12.5.16.1 Strips from bond strength tests (peel test) or coated pipe may be used to help determine the porosity of the finished coating. Strip shall be also cut from longitudinal weld (if applicable) at cut back portion and examined for the presence of voids.

12.5.16.2 Bond strength strip shall be viewed from the side at the failure interface. At the pipe bond strength test location, utility knife shall be used to cut the edge of the coating to a 45° angle and view with a microscope. Similar examination shall be done in the coating cut back area.

12.5.16.3 One sample each either on the bond strength strip or coated pipe and strip cut from the longitudinal weld (if applicable) shall be examined for air entrapment per shift (Shift shall be 8 hours). Strips shall be viewed from the side.

12.5.16.4 All examination shall done using a 30X magnification hand-held microscope. The polyethylene and adhesive layers shall have no more than 10% of the observed area taken up with air entrapment (porosity or bubbles). Air entrapment shall not occupy more than 10% of the thickness in each case. Bubbles shall not link together to provide a moisture path to the epoxy layer.

12.5.16.5 In case of test failure, retesting and disposal of coated pipe shall be same as peel test at per Para 12.5.13 above.

12.5.17 Hot Water Immersion Test

12.5.17.1 The test shall consist of a hot water immersion procedure to test the resistance of factory applied, three-layer polyolefin coating on pipe to loss of adhesion from a steel
substrate in a wet environment.

12.5.17.2 Hot water immersion shall be carried out as per requirement of as per clause no. 8.11.4 of this specification. The test frequency shall be once per day.

12.5.17.3 The testing shall require that samples for testing be cut from line pipe, and is applicable to PQT and production testing and to system qualification testing, where required.

12.5.17.4 Testing procedure and acceptance criteria shall be as per Annex-M of ISO 21809-1 of 3LPE coating.

12.5.18 **Degree of Cure**

12.5.18.1 Epoxy film samples shall be removed from cutback portion of the coated pipe using hammer and cold chisel and the samples shall be taken for cure test using DSC procedure. Silicon coated sulphite paper shall be placed between the epoxy layer and adhesive layer immediately after epoxy application, to ensure physical separation of epoxy and adhesive as well as to prevent contamination of epoxy with adhesive layer, at a location from where the epoxy samples are to be removed for the test. Care shall be taken to remove the samples of full film thickness avoiding inclusion of steel debris.

12.5.18.2 At predetermined intervals, one pipe shall be selected and a coating sample taken from the pipe for the cure test. The Tg value (Glass Transition Temperature) shall be between -2 °C and +3 °C. The damage caused by the sampling shall be repaired.

12.5.18.3 Glass transition temperature differential (ΔTg) and % cure (ΔH) shall comply with the specified requirements.

12.5.18.4 1st pipe shall be subjected to this test and thereafter frequency shall be once per shift. Pipe shall be selected randomly by Company Representative during the middle of a shift. Suitable provisions/arrangements as per the instruction of Company Representative shall be made by the Contractor for this purpose.

12.5.18.5 In case of test failure, production carried out during the entire shift shall be rejected, unless the contractor proposes a method to establish the compliance with the degree of cure requirements of all pipes coated during that shift.

12.5.19 **Epoxy Layer Adhesion Test**

12.5.19.1 Adhesion of epoxy layer shall be determined at ambient temperature using method specified in A 4 of ISO 21809-2. The rating obtained shall be either 1 or 2.

12.5.19.2 Frequency of this test shall be two tests to be carried out per shift. One test to be carried out on partially coated FBE pipe and another test shall be carried out at the cutback portion on the pipe from which the Degree of Cure test has been carried out as per Para above.

12.5.19.3 In case of test failure, retesting and disposal of coated pipe shall done be as mentioned above.

12.5.20 **Cathodic Disbondment (CD) Test**
12.5.20.1 One sample pipe, from the pipes coated every day, shall be subjected to Cathodic disbondment test. To enable timely intervention in the coating process in case of failure, the 28-day test at (23 ± 2) °C may be replaced by a 7-day test at (40 ± 2) °C or a 2-day test at (65 ± 2) °C, if approved by GAIL. Such approval may be obtained if during qualification testing the alternative tests were also done on the same sample as the 28-day test for comparison.

12.5.20.2 24 hours CD test shall be conducted as per ISO 21809-1 Annexure H.

12.5.20.3 In case the test fails to conform to the specified requirement, at the option of the Applicator / Contractor, all pipes coated after the previous acceptable test and prior to next acceptable test shall be rejected or the test shall be repeated using two additional samples taken from the same end of the affected pipe.

12.5.20.4 When both retests conform to the specified requirement, the lot of pipes shall be accepted. When one or both the retests fail to conform to the specified requirement, all coated pipes after previous acceptable test and prior to next acceptable shall be rejected. All rejected pipes shall be stripped, re-cleaned and re-coated. Owner may consider a further retest program to determine whether any of the affected pipe meet the criteria for acceptance upon written request by the Applicator / Contractor.

12.5.21 Elongation at break

12.5.21.1 Elongation at break shall be carried out as per Cl. No. 8.11.4 a) iv) of this specification.

12.5.21.2 The test frequency shall be once for each batch of PE.

12.5.21.3 In case the test fails to comply with the specified requirement, the Contractor shall test the two preceding and two succeeding coated pipe. If both pairs of pipes pass the test, then the remainder of the pipes in that batch shall be deemed satisfactory. If any of these four (4) pipes fails to meet the specified requirements, all pipes coated with that batch of PE shall be tested. Rejected coated pipes shall be stripped and re-coated in accordance with approved procedure, at Applicator/Contractor's expense.

12.5.21.4 Residual magnetism to be checked for incoming and coated pipes on random basis.

12.5.22 Other

12.5.22.1 Damages occurred to pipe coating during the above tests shall be repaired in a manner approved by Owner at Applicator/Contractor's expense.

12.5.22.2 Owner and/or TPIA reserves the right to perform stage wise inspection and witness tests on all activities concerning the pipe coating operation, starting from bare pipe to finished coated pipe ready for dispatch.

12.5.22.3 Applicator/Contractor shall give reasonable notice of time and shall provide, reasonable access and facilities required for inspection to the Owner's representative and / or TPIA inspector. Inspection and tests performed or witnessed by Owner's representative and / or TPIA inspector shall no way relieve the Applicator/Contractor of its obligation to
perform the required inspection and tests. In case rate of defective or rejected pipes and/or sample tests are 5% or more for a single shift (for typically 8 hours), the Applicator/Contractor shall be required to stop production and carry out a full and detailed investigation and shall submit findings and proposed remedial measures to Owner and/or TPIA for approval. Applicator/Contractor shall recommence the production only after getting the written permission from Owner and / or TPIA.

12.5.22.4 Under no circumstances any action of the Owner's representative and/or TPIA Inspector shall relieve the Applicator / Contractor of his responsibility for materials and quality of coating produced.

12.5.22.5 No pipes shall be transported from the coating plant yard(s) unless authorized/permitted by the Owner and/or TPIA in writing.

12.5.22.6 It is Applicator / Contractor's responsibility to repair all internal and or external defects of pipes before they are coated with anti-corrosion coating. Immediately before starting coating operation pipes shall be inspected and repaired as described below:

a) Damage to the bevel ends and pipes noticed and recorded in visual inspection such as dents, flats, shall be repaired by Applicator/Contractor at his risk and cost.

b) Damage to the weld ends shall be cut off or removed and pipes re-bevelled and repaired again as necessary. The cost of this work, as well as that of pipe lost in cutting and repair shall be to the Applicator/Contractor's account. However, the minimum length of repaired pipe shall not be less than 10m.

c) Any defect discovered in the pipe during cleaning and coaling operation will be repaired by the Applicator / Contractor before application of coating.

**12.6 Repair to Coating**

12.6.1 Pipes leaving coating plant shall have sound external coating with no holiday or porosity on 100% of the surface.

12.6.2 Contractor shall submit to Company, its methods and materials proposed to be used for executing a coating repair and shall receive approval from Company prior to use. Contractor shall furnish manufacturer's test certificates for the repair materials clearly establishing the compliance of the repair materials with the applicable coating requirements indicated in this specification.

12.6.3 Defects, repairs and acceptability criteria shall be as follows:

- Pipes showing porosities or very small damage not picked up during holiday test and having a surface less than 0.5 cm$^2$ or linear damage (cut) of less than 3 cm shall be repaired using material of same quality.

- Damages caused to coating by handling such as scratches, cuts, dents, gouges, not picked up during holiday test, having a total reduced thickness on damaged portion not less than 2 mm and an area not exceeding 20 cm$^2$ shall be rebuild by...
heat shrink patch only and without exposing to bare metal.

- Defects of size exceeding above mentioned area or holidays of width less than 300 mm shall be repaired with heat shrink repair patch by exposing the bare metal surface.

- Defects exceeding the above and in number not exceeding 2 per pipe and linear length not exceeding 500 mm and not exceeding $100 \text{ cm}^2$ in cumulative area shall be repaired using heat shrinkable sleeves of HTLP 80 or equivalent.

- Pipes with bigger damage beyond the size limits mentioned above, shall be stripped and recoated.

- In case of coating defect close to coating cut back, Contractor shall remove the coating throughout the entire circumference of the pipe down to the steel surface and increase the coating cut back length. Now if the coating cut back exceeds 140 mm of linear length of pipe then the coating shall be repaired by the use of heat shrink sleeves thereby making up the coating cut back length of 120 mm.

12.6.4 Notwithstanding the above, if any defect exceeds 70 mm from the original coating cut back length, the entire coating shall be removed and the pipe shall be recycled through the entire coating procedure.

12.6.5 Irrespective of type of repair, the maximum numbers of repair of coating shall be as follows:

- Holiday repair of size $\leq 100 \text{ cm}^2$ attributable to process of coating application shall be maximum one number per pipe.

- In addition to the above, defects to be repaired by heat shrink patch/sleeve shall be maximum 2 (two) per pipe.

12.6.6 Defects exceeding the above limits shall cause pipe coating rejection, stripping and recoating. The above is exclusive of the repairs warranted due to testing as per this specification.

12.6.7 All repairs carried out to coating for whatever reason shall be to the account of Contractor.

12.6.8 Cosmetic damages occurring in the polyethylene layer only need not be repaired by exposing up to steel surface, as deemed fit by the Company Representative. In any case the Contractor shall establish his material, methods and procedure of repair that result in an acceptable quality of product by testing and shall receive approval from Company prior to use.

12.6.9 Testing of repairs shall be in the same form as testing coating. All repairs shall result in a coating thickness no less than the parent coating thickness. Contractor shall test repairs to coating as and when required by Company.
12.7 Handling, Storage and Transport of Bare and Coated Pipe

12.7.1 General

12.7.1.1 The Contractor shall take receipt of the pipes delivered by the pipe Manufacturer/Supplier, and shall keep a record of the serial numbers of the delivered pipes. Upon receipt, the pipes shall be inspected for transport damage or other defects. Damaged pipes shall be separately stored and reported to the Principal. Repairs shall only be carried out after approval by the Principal.

12.7.1.2 During the various stages of the complete coating process, the Contractor shall ensure that all pipes shall be handled, stored and transported in such a manner that no damage is caused to the pipes and the applied coating. Instructions by the pipe Manufacturer and/or coating Manufacturer shall be strictly followed. The following instructions shall also apply.

12.7.2 Handling of Pipes

12.7.2.1 Bevel protectors and/or end caps as installed by the pipe Manufacturer shall always be reinstalled after coating and before handling of the pipes.

12.7.2.2 Pipes shall only be lifted by means of slings, lifting hooks or vacuum lifters, fitted with suitable spreader bars. Hooks shall be padded with soft material to prevent damage to the bevelled ends. Wire ropes shall not be used to lift coated pipes; chains shall never be used to lift the pipes.

12.7.2.3 Lifting trucks or front-end loaders shall have soft padded forks or grips to prevent damage to pipes or pipe coating.

12.7.2.4 Coated pipes shall not be rolled or dragged over the ground.

12.7.2.5 Pipes shall not be lifted in bundles without prior approval by the Principal.

12.7.2.6 When more than one pipe is lifted, separate slings or hooks shall be used for each pipe and coated pipes shall be provided with soft padding between the pipes.

12.7.3 Storage and Stockpiling of Pipes

12.7.3.1 Pipes shall be stored in designated areas. Pipes shall not be stored with other consignments or pipes for other contracts.

12.7.3.2 Pipes shall be stacked only to such a height that no damage is caused to the pipes or their coating due to the weight of other pipes.

12.7.3.3 Pipe supports shall be spaced such that no bending of pipes occurs.

12.7.3.4 Pipe supports shall be made of soft padded wooden bolsters or sand rows, free of stones, covered with plastic sheets. The pipe surface shall not be in contact with the soil.

12.7.3.5 Piles of pipe shall be secured by wooden wedges or ground pins, provided with adequate padding to prevent coating damage, and of sufficient size to prevent collapse of the piles.
12.7.3.6 Coated pipes shall be stacked using soft separators such as rubber pads or tyre tread. When stored outdoors, pipes shall be placed at a small angle to allow drainage of any rainwater from the inside of the pipes.

12.7.4 Transport of Coated Pipe

12.7.4.1 Coated pipes shall be prepared for transport or shipment in accordance with specifications API RP 5L1 or API RP 5LW, whichever is applicable.

12.7.4.2 During transportation, pipes shall be stacked and secured so as to prevent movement, abrasion and/or peening.

12.8 Marking

12.8.1 Upon receipt of bare pipes from the pipe mill, the coating contractor shall duplicate the Pipe no., heat no., diameter and wall thickness etc., at a suitable location in the inside of the pipe where the possibility of eroding I fading of the marking due to shot blasting is minimal, and the specific no. assigned to the pipes by the coating contractor can always be correlated to the pipe no. without difficulty.

12.8.2 Applicator/Contractor shall place marking on the outside surface of the coating at one end of the coated pipe. The marking shall indicate, but not limited to, the following information:

   i. Pipe number, heat number
   ii. Diameter, material grade, length and wall thickness
   iii. Coated Pipe Number
   iv. Inspection Mark/Punch
   v. Any other information considered relevant by Owner

12.8.3 Applicator/Contractor shall obtain prior approval from Owner for marking procedures to be adopted.

12.8.4 In addition to above, bar code stickers with relevant information shall also be applied on coated line pipes as per specification No __________________.

13.0 Acceptable Manufacturers

13.1 List of Approved Manufacturers for Coating Materials

Epoxy Powder

<table>
<thead>
<tr>
<th>Designation</th>
<th>Product</th>
<th>Manufacturer</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Corro-Coat EP-F 2001</td>
<td>Jotun</td>
<td></td>
</tr>
<tr>
<td>E3</td>
<td>Scotchkote 226N</td>
<td>3M</td>
<td></td>
</tr>
<tr>
<td>E4</td>
<td>PE 50-6109</td>
<td>BASF</td>
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</tr>
</tbody>
</table>
Adhesive

<table>
<thead>
<tr>
<th>Designation</th>
<th>Product</th>
<th>Manufacturer</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Fusabond 158D</td>
<td>Dupont</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>Lucalen G3710E</td>
<td>Lyondellbasell</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>ME 0420</td>
<td>Borealis</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>LE 149V</td>
<td>Hyundai Engineering Plastics</td>
<td></td>
</tr>
</tbody>
</table>

PE Compound

<table>
<thead>
<tr>
<th>Designation</th>
<th>Product</th>
<th>Manufacturer</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Sclair 35 BP HDPE</td>
<td>Novacor</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>Lupolen 4552 D SW 00413</td>
<td>Lyondellbasell</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>HE 3450</td>
<td>Borealis / Borouge</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>ET 509 B</td>
<td>Hyundai Engineering Plastics</td>
<td></td>
</tr>
</tbody>
</table>

Combination

<table>
<thead>
<tr>
<th>Epoxy Powder</th>
<th>Adhesive</th>
<th>PE Compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>A1</td>
<td>P1</td>
</tr>
<tr>
<td>E2 / E3</td>
<td>A2</td>
<td>P2</td>
</tr>
<tr>
<td>E2 / E3 /D4</td>
<td>A3</td>
<td>P3</td>
</tr>
<tr>
<td>E1</td>
<td>A4</td>
<td>P4</td>
</tr>
</tbody>
</table>

Notes:

1. The above combinations of coating materials are considered acceptable. In case any of the combinations listed above are offered, details regarding properties of the offered materials need not be furnished at the time of bid. However in the event of award of contract to a particular Applicator / Contractor, they shall furnish the combination(s) proposed and re-confirmation of compatibility of the proposed combination(s) from the raw materials manufacturers.

2. Although the above combinations would be acceptable to Company, the responsibility of suitability for application, performance and compliance to the coating system requirements shall unconditionally lie with the contractor.
SPECIFICATION FOR
HEAT SHRINK SLEEVE FOR FIELD COATING

1.0 General

1.1 Heat shrink wraparound sleeve shall consist of radiation cross-linked, thermally stabilized, ultraviolet resistant semi-rigid polyolefin backing with a uniform thickness of high shear strength thermoplastic/co-polymer hot melt adhesive.

1.2 The joint coating system shall consist of a solvent free epoxy primer applied to the pipe surface prior to sleeve application. The backing shall be provided with suitable means (thermo-chrome paint, dimple, or other means) to indicate the desired heat during shrinking in field is attained.

1.3 The sleeve shall be supplied in pre-cut sizes to suit the pipe diameter and the requirements of overlap.

1.4 The heat shrink wraparound sleeve shall have the required adhesive properties when applied on various commercial pipe-coating materials.

1.5 The pre-heat and application temperatures required for the application of the shrink sleeve shall not cause loss of functional properties of the pipe coating.

1.6 An Application Procedure Specification (APS) shall be prepared by the Contractor and approved by Owner meeting the requirements of this specification and the codes & standards referred therein with specific reference to the material and conditions to which the coating system is applicable.

2.0 Reference Codes / Standards

<table>
<thead>
<tr>
<th>S No</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISO 21809-3</td>
<td>Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 3: Field Joint Coatings</td>
</tr>
<tr>
<td>2</td>
<td>ASTM D-149</td>
<td>Standard Test Methods of Dielectric Breakdown voltage and Dielectric Strength of solid electrical insulating materials at commercial frequencies.</td>
</tr>
<tr>
<td>4</td>
<td>ASTM D-570</td>
<td>Standard Method of Test for Water Absorption of Plastics</td>
</tr>
<tr>
<td>5</td>
<td>ISO 8502-3</td>
<td>Preparation of Steel Substrates before Application of Paints and Related Products – Part-3 –Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape Method).</td>
</tr>
<tr>
<td>6</td>
<td>ISO:8503-1</td>
<td>Part-1: Specification and definitions for ISO surface profile</td>
</tr>
</tbody>
</table>
2.1 In case of conflict between the requirements of this specification and that of above referred documents, the requirements of this specification shall govern.

2.2 The CONTRACTOR shall be familiar with the requirements of these documents and shall make them readily available at the site to all personnel concerned with carrying out the works specified in this specification.

3.0 Material Specification

3.1 Field joint anti-corrosion coating material shall be heat shrinkable wraparound sleeve suitable for a maximum operating temperature of (+) 60°C (Tmax) and shall conform to designation EN 12068 - C HT 60 UV [This is suitable for 80°C, then why specify 60°C]. In addition, the field joint anti-corrosion coating shall comply with the requirements specified in para 3.2 of this specification.

3.2 The total thickness of heat shrinkable wraparound sleeve in the as applied condition shall be as follows:

<table>
<thead>
<tr>
<th>Pipe Size (Specified Outside Diameter)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On Pipe Body</td>
</tr>
<tr>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>≤ 30&quot; (762 mm)</td>
<td>2.0</td>
</tr>
<tr>
<td>≥ 32&quot; (813 mm)</td>
<td>2.4</td>
</tr>
</tbody>
</table>

3.3 The heat shrink wraparound sleeve shall have the required adhesive properties when applied on various commercial pipe-coating materials. The pre-heat and application temperatures required for the application of the shrink sleeve shall not cause loss of functional properties of the pipe coating.
### 4.0 Functional Requirements of Coating

#### 4.1 Properties of the PE backing shall be as follows:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Properties</th>
<th>Unit</th>
<th>Requirement</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tensile Strength @ +25 °C</td>
<td>N/mm²</td>
<td>≥ 12</td>
<td>DIN EN 12068</td>
</tr>
<tr>
<td>2</td>
<td>Ultimate Elongation @ +25 °C</td>
<td>%</td>
<td>≥ 250</td>
<td>DIN EN 12068</td>
</tr>
<tr>
<td>3</td>
<td>Dielectric withstand with 1000 Volts/sec</td>
<td>kv</td>
<td>≥30</td>
<td>ASTM D 149</td>
</tr>
<tr>
<td>4</td>
<td>Water absorption @+ 25°C for 24 hours</td>
<td>%</td>
<td>≤0.05</td>
<td>ASTM D 570</td>
</tr>
<tr>
<td>5</td>
<td>Volume Resistivity @+25°C</td>
<td>Ohm-cm</td>
<td>≥1015</td>
<td>ASTM D 257</td>
</tr>
</tbody>
</table>

#### 4.2 Functional Properties of Joint Coating System (As applied)

#### 4.2.1 As applied field joint coating system shall comply the requirements of DIN EN 12068 Table 1 and 2 corresponding to designation DIN EN 12068 – C HT 60 UV, except as modified below:

a) Cathodic Disbondment Resistance at $T_{\text{max}}$ i.e. $60 \, ^\circ \text{C}$ shall be 20mm when tested as per Annexure K of DIN EN 12068. Test shall be carried out at (+) $60\, ^\circ \text{C}$.

b) Peel Strength shall be as follows:

<table>
<thead>
<tr>
<th>Peel Strength</th>
<th>Temperature</th>
<th>Unit</th>
<th>Requirement for Mech Resistance Class C (Minimum)</th>
<th>Test Method as per DIN EN 12068</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner to Inner + Outer to Inner</td>
<td>@23°C</td>
<td>N/mm</td>
<td>1.5</td>
<td>Annexure-B</td>
</tr>
<tr>
<td></td>
<td>@T$_{\text{max}}$</td>
<td>N/mm</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Outer to Outer</td>
<td>@23°C</td>
<td>N/mm</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>@T$_{\text{max}}$</td>
<td>N/mm</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>
4.3 Contractor shall obtain prior approval from Company regarding the manufacturer of the joint coating material. Complete technical details along with test certificates complying with the requirements of clause 3.2.1 and 3.2.2 shall be submitted to Company for this purpose. The Contractor shall furnish test certificates from an independent DIN recognized/approved laboratory for all the properties required for the specified EN designation of field joint coating and the requirements of this specification.

4.4 The materials shall not be older than their period of validity at the time of application by CONTRACTOR. Deteriorated/decomposed material shall be disposed of and replaced by CONTRACTOR at his own expense.

4.5 CONTRACTOR shall ensure that the coating materials supplied by him are properly packed and clearly marked with the following:
   - Manufacturer’s name
   - Material qualification
   - Batch number
   - Date of manufacturing and date of expiry.

4.6 CONTRACTOR shall ensure that the manufacturer has carried out all quality control tests on each batch and manufacturer shall provide test certificates to certify that the supplied materials meet the manufacturer’s specifications as indicated in the purchase order and as approved by COMPANY. Certificates and data sheets certifying the qualities of the coating materials shall be submitted by

4.7 CONTRACTOR to COMPANY prior to application. COMPANY reserves the right to have the materials tested by an independent laboratory.

4.8 Materials shall be stored in sheltered storage in the manufacturer’s original packing and away from direct sunlight and in accordance with manufacturer’s instructions.

4.9 CONTRACTOR shall provide and maintain mobile facilities which contains all necessary equipment and its spares for cleaning, coating repairs, inspection and tests.

4.10 CONTRACTOR shall furnish sufficient number of the following equipment and the required spares as a minimum for inspection and test purpose for each crew.
a) Fully automatic full circle adjustable holiday detector with a visible and audible signal system for inspection of coatings.

b) Thickness gauge for measuring thickness.

c) Contact type temperature recording thermometer.

d) Roughness profile measuring (Stylus) instrument.

5.0 Surface preparation

5.1 Prior to the coating application, the surface shall be dry and free of any contamination (such as detritus, dust, non-adhering particles, grease, oil, soluble salts) detrimental to surface preparation or to adhesion of the coating on the steel.

5.2 Oil, grease and wax shall be removed from steel surface by wiping with rags soaked with suitable solvents such as naphtha or benzene. Kerosene shall not be used for this purpose. Solvent cleaning procedure according to SSPC-SP 1 shall be followed.

5.3 All visible surface imperfections of substrate caused by the girth welding operation, such as welding slag and spatter, sharp edges or burrs that could damage the coating, detected before or during surface preparation shall be removed by an approved grinding method or filing techniques according to the following grades:

- P3 of standard ISO 8501-3 for components and fittings to be used in submerged conditions (permanent or intermittent);
- P2 of standard ISO 8501-3 for components and fittings to be used in buried conditions.

5.4 Grinding of steel defects shall not reduce the wall thickness below the specified minimum wall thickness of the pipe. Areas of rust or scaling shall be removed by spot abrasive blast-cleaning or wire brushing as specified in the APS.

5.5 Each field joint shall be blast cleaned using a closed cycle blasting unit or an open expendable blasting equipment. With the first equipment type, steel or chilled shot and iron grit shall be used and Garnet material with the second one. During blast cleaning the pipe surface temperature shall be simultaneously more than 5°C and more than 3°C above ambient Dew Point, while the ambient Relative Humidity shall not be greater than 85%. Prior to surface cleaning the surface shall be completely dry. The surface shall be cleaned to a grade Sa 2½ in accordance with Swedish Standard SIS-055900 with a roughness profile of 50-70 microns. Surface roughness profile shall be measured using an approved profile comparator in accordance with ISO 8503-1 and shall be calibrated prior to the start of the work in accordance with ISO:8503-3 or ISO:8503-4. The blast cleanliness shall be checked on every joint and the roughness profile shall be checked 1 every 10 joints.

5.6 Dust girt or foreign matter shall be removed from the cleaned surface by an industrial vacuum cleaner. The dust contamination allowed shall be of a rating max 2 as per ISO:8502-3. The frequency of checking for dust contamination shall be 1 every 10 joints.
<table>
<thead>
<tr>
<th>Title</th>
<th>Pipeline Coating Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
</tr>
<tr>
<td>Reference</td>
<td>CIMG-GD-2-2019-0001</td>
</tr>
</tbody>
</table>

5.7 Blast cleaned field joint shall be coated within 2-4 hours according to the conditions below:
- Relative Humidity (RH) > 80% - 2 Hours
- Relative Humidity (RH) > 70-80% - 3 Hours
- Relative Humidity (RH) > 80% - 4 Hours

5.8 Pipes delayed beyond this point or pipes showing any visible rust stain shall be blast cleaned again.

5.8.1 The field joint surface shall be inspected immediately after blast cleaning and any feature of the steel surface such as weld spatter, scabs, laminations or other imperfections considered injurious to the coating integrity made visible during blast cleaning shall be reported to the Company Representative and on permission from Company Representative, such defects shall be removed by filing or grinding. Pipes affected in this manner shall be then re-blast cleaned if the defective area is larger than 50 mm in diameter.

5.8.2 The ends of existing pipe protective coating shall be inspected and chamfered. Unbounded portions of the coating shall be removed and then suitably trimmed. Portions where parent coating is removed shall be thoroughly cleaned as specified. The adjacent chamfered areas of the line pipe coating shall be cleaned and abraded, to expose a clean uniform fresh surface of uncontaminated factory applied coating.

5.8.3 All steel joint surfaces shall be thoroughly examined before the application of the coating in order to ensure the surfaces are free of oil, grease, rust, mud, earth or any other foreign matter. All these substances shall be removed before coating, to the procedures herein described.

5.8.4 Protection coating shall be applied on the joints immediately after the completion of cleaning operation.

5.8.5 The area being coated shall be cleaned by abrasive blast-cleaning as described in ISO 8504-2 to a minimum grade Sa 2 1/2 according to ISO 8501-1. The profile/roughness shall be in accordance with the manufacturer’s application instructions.

5.8.6 Dust contamination shall be grade 2 or better, measured in accordance with ISO 8502-3.

5.8.7 Abrasives used in the preparation of field joints shall comply with ISO 11124 or ISO 11126. Compressed air for blast-cleaning shall be free of oil, condensed moisture and any other contaminants, and shall conform to the requirements of ASTM D4285. Reclaimed abrasive blast materials shall not be used unless automatic reclaiming equipment is used. Blasting equipment that includes devices to recycle abrasives shall have equipment that ensures removal of dust, fines, corrosion products and other contaminants. The cleanliness shall be checked in accordance with the requirements of ISO 8501-1.
5.8.8 The profile/roughness shall be checked in accordance with the requirements of ISO 8503-5. The profile shall be of an angular and dense nature. In areas where the roughness of the profile does not meet these requirements, the surface shall be re-blasted. The level of soluble salts measured in accordance with the requirements of ISO 8502-6 or ISO 8502-9 shall be ≤ 20 mg/m².

5.8.9 If wire-brush cleaning is permissible, it shall be performed in accordance with ISO 8504-3. The surface preparation shall be in accordance with ISO 8501-1 grade St 3 using a power tool. Manual wire-brush cleaning shall be allowed only if the manufacturer of the FJC requires a degree of cleanliness of ISO 8501-1 grade St 2 and if defined in the APS.

5.8.10 Dust contamination shall be measured in accordance with ISO 8502-3. Chemical treatment of the steel may be used subject to the manufacturer’s recommendation.

5.8.11 The plant-coated area adjacent to the cutback shall be prepared to ensure the adhesion of the field joint coating.

6.0 Application of the coating:

6.1.1 The coating shall be applied by qualified personnel and in accordance with the APS. The coating shall be applied symmetrically and with approximately equal overlaps onto the plant-applied coating on either side.

6.1.2 The wrap around sleeve shall be of a size such that a minimum overlap of 50mm before applying is ensured (after shrinking) on both sides of the yard applied corrosion coating of pipes.

6.1.3 In the cases where carrier pipe is installed by direct boring/ jacking, the overlap on the mill coating for the leading edges of the joints shall be minimum 200mm. When this extra overlap is achieved by providing an additional patch of heat shrink tape/ wraparound, it shall be applied in such a manner that the square edge of the patch on the joint coating is in the direction opposite to the direction of boring/ jacking.

6.1.4 Before centering the wraparound sleeve, the bare steel surface shall be preheated. ONLY INDUCTION HEATING shall be permitted. In isolated cases where it is not feasible, heating by torch may be allowed only with the written application from Contractor and approval by Owner on each specific case with due process for passing on cost benefit to owner. The minimum preheat temperature shall be as recommended by manufacturer and shall be checked by means of contact type temperature recording thermometer. Temperature indicating crayons shall not be used Pre-heat temperature shall be checked on every joint. Care shall be taken to ensure that the entire circumference of the pipe is heated evenly. Temperature measuring instruments shall be calibrated immediately before the start of the works and thereafter at intervals recommended by the manufacturer of the instrument.

6.1.5 Upon pre-heating, the pipe surface shall be applied with two pack epoxy primer of wet film thickness 100 microns or as per manufacturer’s recommendation whichever is higher, to cover the exposed bare metal of the welded field joint and 10mm min. onto
the adjacent pipe coating if recommended by the manufacturer. The wet film thickness of the primer shall be checked or every joint with a wet film thickness gauge prior to installation of sleeve. Thickness gauge shall be calibrated once per shift.

6.1.6 Immediately after application of epoxy primer, the wraparound sleeve shall be entirely wrapped around the pipe within the stipulated time recommended by the manufacturer. Sleeve shall be positioned such that the closure patch is located to one side of the pipe in 10 or 2 O’clock position, with the edge of the undergoing layer facing upward and an overlap of min. 50mm. Gently heat by appropriate torch the backing and the adhesive of the closure and press it firmly into place.

6.1.7 A heat shrinking procedure shall be applied to shrink the sleeve in such a manner to start shrinkage of the sleeve beginning from the center of the sleeve and heat circumferentially around the pipe. Continue heating from the center towards one end of the sleeve until recovery is completed. In a similar manner, heat and shrink the remaining side. Shrinking has been completed when the adhesive begins to ooze at the sleeve edges all around the circumference. The complete shrinking of the entire sleeve shall be obtained without undue heating of existing pipe coating and providing due bonding between pipe, sleeve and pipe coating. The installed sleeve shall not be disturbed until the adhesive has solidified.

6.1.8 Pre-heat the area to be coated as per manufacturer’s recommendations. Where possible and/or practical, induction heating should be used. This is to ensure a uniform and consistent pre-heat level, especially for pipe diameters larger than 600 mm (24’’). Position the sleeve so as to provide the correct overlap on the plant coating when shrinking is completed. Heat the sleeve to the specified surface temperature with a gas torch or other heat source (e.g. infrared heater).

6.1.9 The heat shall be applied progressively and regularly to ensure a uniform heat pattern as specified in the APS in accordance with the manufacturer’s instructions, and demonstrated by the Contractor in the PPT, if performed. Temperature shall be checked by a temperature-measuring device (e.g. hand-held thermocouple), at a minimum of one location on each side of the pipe, immediately prior to application of the sleeve. The heating time and the temperature shall not result in visible oxidation of the surface of the steel and of the coating, detrimental to the quality of the coating of the joint or damage the plant-applied coating. In addition when using FBE as a primer, the heating time and the temperature shall not adversely affect the mechanical properties of the pipe steel. If a delay results in the surface cooling to below the temperature range specified by the powder manufacturer, the pipe shall be re-heated, and, if required, the abrasive blasting shall be repeated to meet specification requirements.

6.1.10 The overlap of shrinkable materials on the plant-applied coating shall be in accordance with the manufacturer’s application instructions. For all materials, this overlap shall be at least 50 mm after shrinking.
7.0 Pre-Qualification of Coating System

7.1 The field joint coating system materials and the procedures proposed by the Contractor shall be pre-qualified during the sleeve installation start-up phase. Five joints (5) shall be coated with the requirements of this specification and then inspected and tested in accordance with the requirements of this specification with respect to the following:

- Surface preparation cleanliness, roughness profile and dust contamination
- Pre-heat temperature (as applicable)
- Primer thickness
- As applied coating thickness
- Holiday detection
- Peel test at (+) 23°C & (+) 60°C on pipe surface & factory applied coating and at overlaps (as applicable). If required to achieve the temperature of (+) 60°C, suitable thermal blanket may be used.
- Visual appearance and void after installation on the body, area adjoining the weld and area adjoining the factory applied coating. (To establish voids adjoining the weld and factory coating a strip of 50mm wide and 200mm long shall be stripped and examined).

7.2 Company Representative shall witness the tests and inspection. Regular application of field joint coating shall commence only upon successful completion of the prequalification testing.

7.3 After successful completion of the pre-qualification testing as above, the entire field joint coating shall be removed, the pipe surface re-blasted and field joint coating re-applied as per the requirements of this specification.

8.0 Inspection & Testing

8.1 Visual Check

8.1.1 Visual inspection of the as applied coating shall be carried out on every joint, for the following:

- Mastic extrusion on either ends of the sleeve shall be examined.
- There shall be no sign of punctures or pinholes or bend failure. The external appearance of the sleeve shall be smooth, free of dimples, air entrapment or void formation. All sleeves shall be tested for the presence of voids by knocking on the sleeves. A hollow sound compared to the remainder of the sleeve may indicate the presence of voids under the sleeve. Such sleeve shall be tested for adhesion at the discretion of the Company Representative. - Weld bead profile shall be visible through the sleeve.
- Visual indicator provided on the backing and the closure patch showing desired heat is achieved.

8.1.2 Visual Inspection of the applied Coatings - applied coating shall be free of anomalies, contain no surface defects detrimental to the quality of the coating (grit, foreign particles, fish eyes, blisters, etc.) and have approximately equal overlaps onto the plant coating on either side.

8.2 Thickness:

8.2.1 Coating thickness shall be checked by non-destructive methods for each field joint. Average thickness of the as-applied coating on pipe body shall be established based on measurement at min. eight locations i.e. four measurement on either sides of the girth weld at 3, 6, 9, & 12 O’clock positions. To establish the minimum thickness on the girth weld, four measurements shall be taken on apex on the weld at 3, 6, 9 & 12 O’clock positions. All such measurements shall be recorded. Company reserves the right to ask for additional measurement at any location on the field joint coating, whenever doubt arises.

8.2.2 The total thickness of heat shrinkable wraparound sleeve in the as applied condition shall be as given at 3.2 above.

8.3 Holiday detection:

8.3.1 The holiday detector used shall be checked and calibrated daily with an accurate DC voltmeter. The detector electrode shall be in direct contact with the surface of coating to be inspected.

8.3.2 The entire surface of the joint section shall be inspected by means of a full circle holiday detector approved by COMPANY set to a DC voltage applicable as per the requirements of factory applied mainline coating specification of Company. Inspection of the sleeves shall be conducted only after the joint has cooled below 50°C. The holiday detector used shall be checked and calibrated daily with an accurate DC voltmeter. The detector electrode shall be in direct contact with the surface of coating to be inspected.

8.3.3 No field joint shall be covered or lowered in the trench until it has been approved by the COMPANY.

8.3.4 The entire surface of the coated field joint shall be checked for holidays or other discontinuities at a voltage of 5 kV/mm + 5 kV at a maximum of 25 kV. Holidays shall be repaired in accordance with the APS.

8.4 Peel strength:

8.4.1 One out of every 50 joint coatings or one joint coating out of every day’s production whichever is stringent shall be tested to establish the peel strength on steel and factory applied coating. Contractor shall carry out such testing in the presence of Company Representative.
8.4.2 From each test sleeve selected as above, one or more strips of size 25mm x 200mm shall be cut perpendicular to the pipe axis and slowly peeled off. The required peel strength shall meet the requirements of this specification as applicable for (+) 23°C or (+) 60°C whichever is feasible. This test shall be conducted between wrapping & metal and mill coating & between layers at overlap with joint coating (wherever applicable). After removal of strip, the bulk of adhesive shall remain adhered to the pipe showing no bare metal, otherwise, test shall be considered failed. The adhesive layer that remains on the pipe surface shall generally be free of voids resulting from air or gas inclusion. In case the peel strength test at a different temperature than that specified in warranted due to the ambient site conditions, then the peel strength shall comply the recommendation of the manufacturer. Manufacturer shall be asked to furnish peel strength values corresponding to various expected temperatures, prior to start of the works.

8.4.3 If the sleeve does not meet the requirements of clause 6.4.2 the adjacent two sleeves shall also be tested. If the adjacent two sleeves are acceptable the test rate shall be increased to one sleeve every twenty five until Company’s Representative is satisfied. The test rate can then be reduced as per clause 6.4.1. If either or both of the adjacent two sleeves do not meet the requirements of clause 6.4.2, the field joint shall be stopped.

8.4.4 Company reserve the right of 100% removal of sleeves if its representative is not convinced that the requirements of clause 5.4.2 are achieved.

8.4.5 The minimum waiting period between application of the coating and the peel-strength test shall be 24 hr, unless specified otherwise. The peel strength shall meet the following requirement:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Temp</th>
<th>Unit</th>
<th>Acceptance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel strength at 10 mm/min to pipe surface</td>
<td>23 Deg C</td>
<td>N/mm</td>
<td>≥ 4.0</td>
</tr>
<tr>
<td></td>
<td>Tmax</td>
<td>N/mm</td>
<td>≥ 2.0</td>
</tr>
</tbody>
</table>

8.5 **Cathodic disbondment:**

8.5.1 The cathodic disbondment after 28 days at 23 Deg C shall be ≤ 5.0 mm. Test duration of 48 hr instead of 28 days can be used for PPT provided that the test temperature is increased to 65 Deg C and that a comparison of results is performed during PQT. The cathodic disbondment after 28 days at the maximum service temperature shall be ≤ 10.0 mm.

8.6 **Hot-water immersion test:**

8.6.1 A hot-water immersion test shall be carried out with duration of 28 days, at 60° C. The peel strength after the hot-water immersion test shall be measured and shall meet the requirements:
8.7 Impact resistance:
8.7.1 The impact resistance shall be ≥ 10 J/mm when tested at 23 Deg C.

8.8 Indentation resistance:
8.8.1 The indentation resistance shall be ≥ 0.6 mm at maximum service temperature.

8.9 Lap shear strength:
8.9.1 The lap shear strength resistance shall meet the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Temp</th>
<th>Unit</th>
<th>(Tmax ≤ 110 Deg. C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lap shear strength at 10 mm/ min to pipe surface</td>
<td>23 Deg C</td>
<td>N/mm²</td>
<td>≥5</td>
</tr>
<tr>
<td>Tmax</td>
<td></td>
<td>N/mm²</td>
<td>≥1</td>
</tr>
</tbody>
</table>

9.0 Repairs:
9.1 If a field joint is detected to be unacceptable after inspection and testing as per clause no. 8.0 of this specification, the CONTRACTOR shall, at his own cost:
   - determine the cause of the faulty results of the coatings.
   - mobilize the services of expert of manufactures, if required.
   - test to the complete satisfaction of the OWNER, already completed field joint coatings.
   - stop joint coating until remedial measures are taken against the causes of such failures, to the complete satisfaction of the OWNER.

9.2 CONTRACTOR shall replace all the joints coating found or expected to be unacceptable as per clause no. 8.0 of this specification.

9.3 CONTRACTOR shall, at his own cost repair all areas where the coating has been removed for testing by the OWNER or by the CONTRACTOR to the complete satisfaction of the OWNER.

9.4 The upright edges of the damaged areas shall be chamfered, in addition to the steel shall be free from rust, dirt, oil and grease. The coating around the damaged area shall be roughened. After thorough mixing (in accordance with the recommendations of the manufacturer) the filler shall be applied, to sufficient Thickness with the aid of stooping knife, whilst observing ample overlap hardening. The material will require the approval of OWNER.

9.5 After the coating work on welded joints and repairs to the coating have been completed, The coating area as a whole shall be tested with spark-tester before lowering the pipeline.
9.6 Company shall be entitled to check the coating on buried pipelines or parts of pipelines with equipment such as the “Pearson meter” and the resistance meter. If the coating defects are established, the Contractor shall be responsible for excavation at such points, repairing the coating, spark testing and backfilling the excavations without extra charge.

10.0 Acceptable Manufacturers

10.1 Heat shrink wraparound field joint coating system manufactured by M/s Tyco Adhesives – Raychem and M/s Canusa are acceptable. The Contractor shall propose the specific grade of field joint coating system meeting the requirements of this specification from these manufacturers. In case the Contractor proposes to supply heat shrink wraparound sleeve from any other manufacturer, then the Contractor shall propose only those coating systems that have been previously used in pipelines of similar size and operating conditions.
Appendix- B2

SPECIFICATION FOR
HEAT SHRINK SLEEVE FOR FIELD COATING FOR HDD CROSSING

1.0 General

1.1 This specification shall be read together with Appendix-B1 “Specification for Heat Shrink Sleeve for Field Coating”.

1.2 This specification covers the minimum requirement for application of anticorrosion field joints coating on welded pipe section and field tie-in joints referred to herein after as Joint(s). The contractor shall perform all work in accordance with this specification, latest pipeline coating practices and to the full satisfaction of the Owner. The anticorrosion pipe joint coating shall be compatible with yard applied, Ultra Violet (UV) radiation protected, 3 layer side extruded polyethylene coating conforming to DIN-30670. The sleeve width shall be suitable for cut back of 120 ± 20 mm to be left at both the ends of coated pipes. The job includes supply of all materials equipment, consumables, labour, supervision, quality control, inspection repairs.

1.3 The CONTRACTOR shall submit a detailed written description of the internal coating equipment, procedures and materials, in the form of a Application Procedure Specification (APS), for COMPANY review and/or approval, in accordance with the contract documents. This shall include the Procedure for qualification of materials and application of coating along with details and results of tests on similar coating or trials performed by CONTRACTOR which document the quality of the finished coating. Such test results and/or trials shall demonstrate procedures and materials can supply a finished coating meeting the requirements of this Specification.

1.4 The APS shall include:

- Procedure for qualification of materials and application processes.
- Pipe handling and storage;
- Pipe cleaning and surface preparation, residual surface contamination;
- Coating application (multi-component spraying equipment);
- Testing and inspection;
- Coating repair.

1.5 The joint coating operation starting from cleaning and surface preparation till application of joint coating and wrapping of the pipe joints shall be performed under the supervision of skilled personnel who are well versed in the work.

1.6 This scope covers the minimum requirement of materials, equipment required for installation of field joint coating by wraparound fiber reinforcement heat-shrinkable sleeve used for corrosion protection and sealing of field joints in pipelines that are forced through the soil by Horizontal Directional Drilling technique. The sleeves shall be suitable for 3LPE/FBE coated pipes operating up to 60°C continuously.
2.0 Reference Codes / Standards

<table>
<thead>
<tr>
<th>S No</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISO 21809-3</td>
<td>Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 3: Field Joint Coatings</td>
</tr>
<tr>
<td>2</td>
<td>ASTM D-149</td>
<td>Standard Test Methods of Dielectric Breakdown voltage and Dielectric Strength of solid electrical insulating materials at commercial frequencies.</td>
</tr>
<tr>
<td>4</td>
<td>ASTM D-570</td>
<td>Standard Method of Test for Water Absorption of Plastics.</td>
</tr>
<tr>
<td>5</td>
<td>ISO 8502-3</td>
<td>Preparation of Steel Substrates before Application of Paints and Related Products — Part-3 —Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape Method).</td>
</tr>
<tr>
<td>8</td>
<td>SIS-055900</td>
<td>Pictorial surface Preparation Standard for Painting Steel Surfaces.</td>
</tr>
<tr>
<td>9</td>
<td>SSPC-SP 1</td>
<td>Steel Structure Painting Council – Solvent Cleaning.</td>
</tr>
<tr>
<td>10</td>
<td>DIN – 30672</td>
<td>Corrosion protection tapes and Heat Shrinkable Sleeves.</td>
</tr>
</tbody>
</table>

2.1 In case of conflict between the requirements of this specification and that of above referred documents, the requirements of this specification shall govern.

2.2 The CONTRACTOR shall be familiar with the requirements of these documents and shall make them readily available at the site to all personnel concerned with carrying out the works specified in this specification.

3.0 Material Specification

3.1 General

3.1.1 Each Joint Coating System shall consist of:

a) A wraparound heat shrinkable sleeve reinforced with fibre-glass. The sleeve shall be coated with a higher- shear- strength thermoplastic hot-melt adhesive.

b) A solvent-free, two component liquid epoxy primer

c) A specifically designed wear cone

d) A clamping belt
3.2 Sleeve Backing
3.2.1 The heat shrinkable sleeves shall be manufactured from minimum 1.0 mm thick radiation cross linked, thermally stabilized, UV -resistant heat-shrinkable fabric, composed of fibre glass reinforcement and polyolefin fibres, embedded in a polyolefin matrix.

3.3 Sleeve Adhesive
3.3.1 The inner surface of the sleeves shall be coated with a controlled thickness of minimum 1mm of adhesive which in combination with the modified epoxy primer, will bond to and seal to the steel pipe and common yard applied medium temperature yard coatings.

3.4 Epoxy Primer
3.4.1 The Epoxy primer shall be a solvent free, modified two components liquid epoxy type primer, which is applied to cleaned and dry steel surface. When the sleeve coatings, comes in contact with the liquid primer during installation, a strong bond is formed upon full curing of the system.

3.5 Heat-Shrinkable Sleeve Material

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Condition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Crack</td>
<td>ISO 4675</td>
<td></td>
<td>Below 40° C</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>ISO 175</td>
<td>168 hrs. immersion in either NaCl @ 23° C, 0.1N H₂SO₄ @23° C, 0.1N NaOH @23° C, Fuel Oil @23° C, Petroleum Jelly @ 70° C</td>
<td></td>
</tr>
<tr>
<td>Followed by test for</td>
<td>ISO 3303</td>
<td>23° C</td>
<td>1100 N Min.</td>
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<tr>
<td>bursting strength</td>
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<tr>
<td>Thermal Ageing</td>
<td>ISO 188</td>
<td>150° C 168 hrs.</td>
<td>1700 N Min.</td>
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<td>Followed by test for</td>
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<tr>
<td>bursting strength</td>
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</table>

3.6 Adhesive material

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Condition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softening Point</td>
<td>ASTM E28</td>
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<tr>
<td>Peel Strength</td>
<td>DIN 30672</td>
<td>23° C. CHS* 100 mm/min</td>
<td>200 N/cm Min.</td>
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<tr>
<td>Peel Strength</td>
<td>DIN 30672</td>
<td>23° C. CHS* 100 mm/min</td>
<td>200 N/cm Min.</td>
</tr>
<tr>
<td>After immersion for 4</td>
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<tr>
<td>weeks at 23° C ~NaOH</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>pH12 H₂SO₄ pH2 ground</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>water solution: 1.2% H₃PO₄</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Pipeline Coating Specifications

**Type:** Guidance  
**Reference:** CIMG-GD-2-2019-0001

#### Property Test Method Condition Requirement

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Condition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.6%KOH, 1.2% NaCl, 1.0% Fe₂O₃</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peel Strength after conditioning for 30 cycles from -30°C to 60°C</td>
<td>DIN 30672</td>
<td>23°C. CHS* 100 mm/min</td>
<td>60 N/cm Min.</td>
</tr>
<tr>
<td>Shear Strength</td>
<td>ISO 4587</td>
<td>23°C. CHS* 50 mm/min</td>
<td>200 N/cm Min.</td>
</tr>
<tr>
<td>Corrosive Effect</td>
<td>ASTM D2671</td>
<td>120°C 16 hrs</td>
<td>No Corrosion</td>
</tr>
</tbody>
</table>

### 3.7 Primer Material

#### Property Test Method Condition Requirement

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Condition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>ASTM D1084</td>
<td>23 ± 5°C Part A: 2 rpm, spindle #6</td>
<td>Part A: 60± 30 Pas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Part B: 20rpm, spindle #3</td>
<td>Part B: 1.55±0.55 Pas</td>
</tr>
<tr>
<td>Mixing Ratio</td>
<td>By Weight</td>
<td>23°C</td>
<td>100:40</td>
</tr>
<tr>
<td></td>
<td>By Volume</td>
<td></td>
<td>100:60</td>
</tr>
<tr>
<td>Shear Strength</td>
<td>ISO 4587</td>
<td>23°C. CHS* 50 mm/min</td>
<td>1000 N/cm Min.</td>
</tr>
</tbody>
</table>

* CHS = Cross Head Speed

3.8 Material shall be stored in sheltered storage by the Contractor in the manufacturer’s original packing and away from direct sunlight and in accordance with manufacturer’s instructions.

### 4.0 Functional Requirements of Coating

#### Property Test Method Condition Requirement

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Condition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Resistance</td>
<td>DIN 30672</td>
<td>23°C Class C</td>
<td>No holidays when tested at 20KV</td>
</tr>
<tr>
<td>Penetration Resistance</td>
<td>DIN 30672</td>
<td>60°C Class C</td>
<td>Minimum 70% original thickness left; No holidays when tested at 20KV</td>
</tr>
<tr>
<td>Specific Coating Resistance</td>
<td>DIN 30672</td>
<td>23°C Class C</td>
<td>10⁶ Ohm sq.m min.; no oxidation on pipe surface</td>
</tr>
<tr>
<td>Cathodic Disbondment</td>
<td>ASTM G42</td>
<td>60°C 30 days</td>
<td>15 mm increase in radius of disbondment max.</td>
</tr>
<tr>
<td>Resistance to split propagation</td>
<td>Test Method-1</td>
<td></td>
<td>No cut propagation</td>
</tr>
<tr>
<td>Resistance to circumferential edge</td>
<td>Test Method-2</td>
<td></td>
<td>50 KN Min.</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Condition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance to local edge loading</td>
<td>Test Method-3</td>
<td></td>
<td>6 KN Min.</td>
</tr>
</tbody>
</table>

5.0 Inspection & Testing

5.1 Resistance to split propagation (Test Method -1)

5.1.1 A rectangular piece of 50mm width by 150 mm length shall be cut from the material as delivered. A 5mm long, clean cut shall be made mid-way in the piece along once of the long edges perpendicular to this edge. The sample shall be mounted on a clamp that holds it securely and avoids any shrinking during testing.

5.1.2 The assembly shall be placed in an air-circulating oven present at 1700C. After 15 minutes, the sample shall be removed from the oven, allowed to cool down to room temperature and examined for cut propagation. This test simulates the unlikely event when the sleeve gets cut during the installation phase. Sleeves based upon extruded polyolefin show a distinct tendency to propagate the cut along the total width of the sleeve. Sleeves suitable for HDD works shall not exhibit this behaviour.

5.2 Resistance to circumferential edge loading (Test method -2)

5.2.1 The sleeve shall be installed on a DN 200 three-layer PE coated steel pipe piece. A thick wall steel ring that fits a DN 200 three-layer PE coated steel pipe with a tolerance of 0.2+-0.2 mm shall be positioned against the front edge of the wear cone sleeve and then pushed towards the sleeve system at a constant speed of 5 mm/ min over a distance of 50 mm. The forces necessary shall continuously be registered. The minimum required force shall be less than 50 KN.

5.2.2 During the pushing or pulling operation, any obstacle protruding from the smooth pipe surface is loaded by the surrounding soil that passes by. This test simulates the shear forces that are exerted on to the sleeve by rigid soil type.

5.3 Resistance to local edge loading (Chisel test: Test Method -3)

5.3.1 The sleeve shall be installed on a DN 200 three-layer-PE coated steel pipe piece. A chisel as depicted in Figure -1 shall be positioned against the front edge of the wear cone sleeve and, pushed parallel to the pipe surface towards the sleeve system at a constant speed of 5 mm/ min over a distance of 50 mm. The forces necessary shall continuously be registered. The minimum required force should not be less than 6 KN.

5.3.2 During the pushing or pulling operation, the pipe may traverse soil area containing solid particles, such as stones, pebbles or crushed rock. These particles tend to rip away the pipe coating locally. Any obstacle protruding from the smooth pipe surface is lifted, leading to soil undercutting. This test determines the resistance of sleeve against this type of abuse.
6.0 Qualification for Contractor’s supplied Materials and their Manufacturer

6.1 Prior to procurement of coating materials, Contractor shall furnish the following information for qualification of the Manufacturer and material:

   a. Complete descriptive technical catalogues describing the materials offered along with samples of corrosion coating materials, its properties and application instruction as applicable specifically to the project.
   
   b. Reference list of previous supplies, in last 5 years, of the similar material or manufacturer shall be notified to Company, whose approval in writing of all charges shall be obtained before the materials are manufactured.

6.2 Contractor shall ensure that the coating materials supplied by him are properly packed and clearly marked with the following :-

   - Manufacturer’s name
   - Material Qualification Certificate Number
   - Batch Number
   - Date of Manufacturing and date of expiry

6.3 Prior to shipment of materials from the Manufacturer’s Works. Contractor shall furnish the following documents:

   a. Test certificate/results as per Manufacturer’s Quality Control Procedure for each batch of materials complying with the requirements of relevant sub-clauses of clause no. 3.0 of this specification.
   
   b. Specific application instructions with pictorial illustrations.
   
   c. Specific storage and handling instructions.

6.4 All documents shall be in English language only.
7.0 Application Procedure

7.1 General

7.1.1 The application procedure shall be in accordance with manufacturer’s instruction and the minimum requirements required below whichever are the most stringent and shall be demonstrated to and approved by the Owner.

7.1.2 Contractor shall provide and maintain mobile facilities which contains all necessary tools, propane torches, epoxy primer pumps, silicon rollers, testing instruments, equipment, and spares for cleaning, coating, repairs, inspection and testing.

7.1.3 Contractor shall furnish sufficient number of the following equipment and the required spares as a minimum for inspection and testing purpose for each crew:

- Fully automatic full circle adjustable holiday detector with audio and visual output signal for inspection of coating.
- Portable Tensile Strength Tester
- Digital Thermometer
- Solid state digital thickness gauge for measuring thickness of joint coating.

7.2 Surface Preparation

7.2.1 The Contractor shall thoroughly clean and dry the joint surface by power tool cleaning in accordance with SSPC-SP1. The complete procedure and details of equipment used shall be prepared by the Contractor for Owner’s approval prior to commencement of joint coating work.

7.2.2 Prior to cleaning operation, Contractor shall visually examine the joint surface area and shall ensure that all defects, flats and other damages have been repaired or removed.

7.2.3 Where oil, grease or other materials detrimental to the finished coating is present, it shall be removed with a continuous removal solvents cleaning system to remove completely all such materials in accordance with SSPC-SP1.

7.2.4 The standard of finish for cleaned pipe surface shall conform to SA 2½ of Swedish Standard SIS-055900 latest edition. The degree of preparation required to obtain an end product that fulfill the requirements of this specification may not be sufficiently covered and is not limited by SIS-055900. Surface of pipe after shot blasting shall be have an anchor pattern of 50 to 70 microns.

7.2.5 Piper temperature immediately prior to blasting shall be minimum 20°C. At no time shall be blast cleaning be performed when the relative humidity exceeds 85%. Surface temperature must be at least 3°C above the dew point temperature.

7.2.6 The abrasive blast material shall be free of impurities and inclusions, water and oil. All abrasives shall be removed after blast by brush or vacuum type cleaner prior to applying
joint coating. The abrasive shall be stored in a dry condition and maintained dry during use.

7.2.7 The compressed air for blasting shall be free of water and oil. Contractor to verify air cleanliness at the start of the work and every four hours thereafter. Separators and the traps shall be provided at the compressor and blasting station. Separators and traps shall be checked daily for effective moisture and oil removal during coating operations.

7.2.8 The ends of existing line pipe protective coating shall be inspected and chamfered. Unbonded portions of the coating shall be removed and then suitably trimmed. Portions where parent coating is removed shall be thoroughly cleaned as specified.

7.2.9 Pipe shall be visually inspected by Contractor immediately after blast cleaning for surface defects such as slivers, laminations, leafing, scores, indentation slugs or any other defects considered injurious to the coating integrity. Such defects shall be reported to Owner and on permission from Owner, such defects shall be removed by filling or grinding in such a way as not to “blue” the steel.

7.3 Procedure

7.3.1 The application procedure shall be in accordance with manufacturers instruction and the minimum requirements specified below whichever are the most stringent and shall be demonstrated to and approved by the owner.

7.3.2 Applicators for coating application shall be given necessary instructions and training before start of work by the CONTRACTOR. To verify and qualify the application procedures, all coating applied during the qualification test, shall be removed for destructive testing until the requirements stated in sections ‘Inspection’ and ‘testing’ of this specification are met.

7.3.3 Prior to surface cleaning, the surface shall be completely dry. An effective heating equipment which shall not give rise to deposits shall be used. Care shall be taken to avoid damage to existing coating.

7.3.4 All pipe joint surfaces shall be thoroughly examined before the application of the coating in order to ensure that the surfaces are free of oil, grease, rust, mud, earth or any other foreign matter.

7.3.5 Liquid epoxy primer shall be applied on the joints immediately after the completion of heating operation.

7.3.6 The heat shrink sleeve is then wraparound the joint while the primer is still wet and shall overlap the existing pipe coating by minimum 100 mm on each side.

7.3.7 The wraparound sleeve is shrunk on pipe joint with a propane torch moved back and forth over the surface when heated above 125°C, the sleeve shall shrink tightly around the substrate on to the wet primer. At the time of application of the primer, the pipe surface temperature shall be at least 60°C at every point. To check this, approved temperature indicators shall be used. temperature indicating crayons shall not be used.
7.3.8 The wraparound sleeve shall be entirely wrapped around the pipe positioning the closure patch off to one side of the pipe in 10m or 2 O'clock position, with edge of the underlying layer facing upward and an overlap of min. 100 mm.

7.3.9 Heat shrinking shall be procedure shall be applied to shrink the sleeve in such a manner that all entrapped air is removed using gloved hands and hand rollers. The complete shrinking of entire sleeves shall be obtained without undue heating of existing pipe coating and providing due bonding between pipe, sleeve and pipe coating. A thermochromic paint shall be applied an closure patch to indicate that sufficient heat/temperature has been obtained. The joint coating shall have wear cone applied over the leading edge of the sleeve and the clamping belt tightened over it.

7.3.10 Application of Wear Cone - The leading edge will be given an extra wear cone. Start by heating the leading edge area of the main sleeve to 700 C. Wrap the leading edge sleeve over the transition Mill coating. Ensure that the closure is placed away from the main sleeve closure. Shrink the leading edge sleeve.

7.3.11 Application of Metal Belt - The metal belt shall be applied over the wear cone sleeve. The metal belt will be tightened using the strapper tool supplied by the manufacturer.

7.3.12 Sufficient manpower working on opposite sides of each pipe joint are required for installation of the sleeve.

7.3.13 The installed sleeve shall not be disturbed until the adhesive has solidified.

7.4 Inspection and Testing

7.4.1 Visual Inspection

7.4.1.1 For wraparound coating, a visual inspection shall be carried out for the following :

- Mastic extrusion on either ends of the sleeves shall be examined
- There shall be no sign of punctures or pinholes or bond failure. The external appearance of the sleeves shall be smooth, free of dimples, air entrapment or void formation.
- Weld bead profile shall be visible over the sleeves.
- The entire closure patch shall have changed colour uniformly.

7.4.2 Holiday Inspection

7.4.2.1 The Holiday Detector used shall be checked and calibrated daily with an accurate D.C. voltmeter. The detector electrode shall be in direct contact with the surface of coating to be inspected.

7.4.2.2 The entire surface of the joint section shall be inspected by means of a full circle Holiday Detector approved by OWNER set to DC Voltage of at least 25 kV for wraparound sleeves. Inspection of the heat shrink sleeve coating shall be conducted only after the joint has cooled below + 50°C.
7.4.2.3 All the coated joints shall be subjected to Holiday Detection test.

7.4.2.4 An installed sleeve with more than two holiday shall be stripped and a new one be installed.

7.4.2.5 OWNER reserves the right to test one out of every 30 joint coating subject to a minimum of 2 joints. CONTRACTOR shall provide all assistance in removing and testing of field joint coatings. From each test sleeve, one or more strips of size 25 mm x 200 mm shall be cut one perpendicular to the pipe axis and slowly peeled off. This test shall be conducted between either sleeve and metal or sleeve and mill coating as per direction of Owner/Engineer-in-charge.

7.4.2.6 The required peel strength shall be 60 N/cm (min.) at 23°C. The system shall fail only in the adhesive layer. No failure either in adhesion to steel or adhesion to backing shall be permitted. The adhesive layer that remains on the pipe surface shall be free of voids resulting from air or gas inclusion.

7.4.2.7 If the sleeve taken away for test does not meet the requirement of clause 7.4.2.6 above, the adjacent two sleeves do not meet the requirements of the above clause, the field joint coating shall be stopped until OWNER is satisfied with application methods.

7.4.2.8 For testing tensile strength, two parallel incisions spaced 1 cm apart are made right down to the surface of the steel. A further incision shall then be at right angles to the first angles to the first two incisions. With the aid of a 1 cm wide knife, the coating is lifted over a length of about 2 cm and clamped into the tensile tester, whereupon a uniform pull is exerted at an angle of 90 degree. The tensile strength shall be more than a 2500 psi.

7.4.2.9 Coating thickness shall be checked by non-destructive method for each field joint.

8.0 Repair of Field Joint Coating

8.1 If a field joint is detected to be unacceptable after inspection and testing as per clause no. 7.0 of this specification, the CONTRACTOR shall, at his own cost:

- determine the cause of the faulty results of the coatings.
- mobilize the services of expert of manufactures, if required.
- test to the complete satisfaction of the OWNER, already completed field joint coatings.
- stop joint coating until remedial measures are taken against the causes of such failures, to the complete satisfaction of the OWNER.

8.2 CONTRACTOR shall replace all the joints coating found or expected to be unacceptable as per clause no. 7.0 of this specification.

8.3 CONTRACTOR shall, at his own cost repair all areas where the coating has been removed for testing by the OWNER or by the CONTRACTOR to the complete satisfaction of the OWNER.
8.4 The upright edges of the damaged areas shall be chamfered, in addition to the steel shall be free from rust, dirt, oil and grease. The coating around the damaged area shall be roughened. After thorough mixing (in accordance with the recommendations of the manufacturer) the filler shall be applied, to sufficient thickness with the aid of stooping knife, whilst observing ample overlap hardening. The material will require the approval of OWNER.

8.5 After the coating work on welded joints and repairs to the coating have been completed, the coating area as a whole shall be tested with spark-tester before pull back/lowering/jacking the pipeline.

8.6 Company shall be entitled to check the coating on buried pipelines or parts of pipelines with equipment such as the “Pearson meter” and the resistance meter. If the coating defects are established, the Contractor shall be responsible for excavation at such points, repairing the coating, spark testing and backfilling the excavations without extra charge.

9.0 Acceptable Manufacturers

9.1 [To be added]
1.0 General

1.1 This Specification defines the minimum technical requirements for the Liquid Epoxy external coating of underground pipelines / piping, valve & fittings.

1.2 The CONTRACTOR shall submit a detailed written description of the internal coating equipment, procedures and materials, in the form of an Application Procedure Specification (APS), for COMPANY review and/or approval, in accordance with the contract documents. This shall include the Procedure for qualification of materials and application of coating along with details and results of tests on similar coating or trials performed by CONTRACTOR which document the quality of the finished coating. Such test results and/or trials shall demonstrate procedures and materials can supply a finished coating meeting the requirements of this Specification.

1.3 The APS shall include:

- Procedure for qualification of materials and application processes.
- Pipe handling and storage;
- Pipe cleaning and surface preparation, residual surface contamination;
- Coating application (multi-component spraying equipment);
- Testing and inspection;
- Coating repair.

2.0 Material Specification

2.1 Liquid epoxy coating consisting of an epoxy based resin applied by spray, roller, brush or trowel shall be suitable for a maximum operating temperature of (+) 60 Deg C (T_{max}).

2.2 The Contractor shall provide the data sheets of material from the manufacturer. In addition to the coating-material data sheets, the Contractor shall provide the following information from the manufacturer:

- Batch certificates certifying that the coating materials delivered meet the coating characteristics as set forth in the coating data sheets
- Any agreed optional requirements, if applied according to the manufacturer’s instructions
- Packaging, transport and storage requirements of coating materials
- Range of application conditions including minimum and maximum application Temperatures (for materials and substrate) and relative humidity
- Material safety data sheet (MSDS)
- Marking on each shipment of coating materials shall contain the following information:
  - Manufacturer’s name
### Functional Requirements of Field Joint Coating

#### 3.1 Epoxy based liquid coatings shall meet the following minimum requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Temp.</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact resistance (holiday detection at 5 kV/mm)</td>
<td>23°C -5°C</td>
<td>J/mm</td>
<td>≥3, ≥ 1.5</td>
</tr>
<tr>
<td>Indentation resistance at 10 N/mm²</td>
<td>60°C</td>
<td>%DFT</td>
<td>≤ 30</td>
</tr>
<tr>
<td>Cathodic disbondment at 28 days</td>
<td>23°C 60°C</td>
<td>mm</td>
<td>≤ 8, ≤ 15</td>
</tr>
<tr>
<td>Adhesion to pipe surface</td>
<td>23°C</td>
<td>MPa</td>
<td>≥10.0</td>
</tr>
<tr>
<td>Adhesion to FBE, liquid applied epoxy or PU plant coatings</td>
<td>23°C</td>
<td>MPa</td>
<td>≥10.0</td>
</tr>
<tr>
<td>Adhesion to polyolefin plant Coatings</td>
<td>23°C</td>
<td>MPa</td>
<td>≥3.5</td>
</tr>
<tr>
<td>Adhesion to pipe surface after 28-day hot-water immersion test</td>
<td>23°C</td>
<td>MPa</td>
<td>≥7.0</td>
</tr>
<tr>
<td>Adhesion to plant coating after 28-day hot-water immersion test at 60 Deg C</td>
<td>23°C</td>
<td>MPa</td>
<td>≥2.0</td>
</tr>
<tr>
<td>Specific electrical insulation resistance (RS100)</td>
<td>23°C</td>
<td>Ω-m²</td>
<td>≥10⁶</td>
</tr>
</tbody>
</table>

#### 4.0 Surface preparation

4.1 It shall be carried out by abrasive blasting to a minimum cleanliness of Sa 21/2. The surface profile attained shall be between 50 µm and 100 µm as measured in accordance with the requirements of ISO 8503-5.

4.2 The plant-applied coating shall be bevelled and roughened for the minimum length according to the overlap on the plant coating. The plant-applied coating shall not be removed or contaminated by abrasive dust.

4.3 Dust contamination shall be grade 2 or better measured in accordance with ISO 8502-3.

4.4 If liquid coatings are used in conjunction with a polyolefin plant-applied coating, the plant-applied coating surface may be subject to additional treatments (e.g. flame treatment, chemical treatment) as per coating manufacturer’s instructions.
5.0 Application of the coating:

5.1 The wet-film thickness shall be checked using a wet-film thickness gauge. Insufficient film thickness, bare areas and pinholes shall be corrected within the over-coating time and in accordance with the APS. The overlap with the plant-applied coating shall be not less than 50 mm, unless otherwise specified.

6.0 Pre-Qualification of Field Coating System

6.1 APS shall be qualified by a PQT.

6.2 The Contractor may request the manufacturer(s) to assist during the PQT to ensure the correct use of the coating material(s) and to train Contractor personnel.

6.3 PQT may be carried out independently of any project. In this case, representative pipes having the diameter, thickness and plant-coating as agreed upon between manufacturer, Contractor, Company and purchaser, if any, shall be used.

6.4 For a PQT related to a specific project, tests shall be carried out on test zones distributed along a pipe coated with the actual plant-applied coating. The length of the test zones shall be equivalent to the field joint coating length. The test points shall be defined in the PQT program.

6.5 If not present, a circumferential cap weld shall be added at the center of each of the test zones to simulate the field weld.

6.6 If heating of the area to be coated is specified in the APS, it shall be demonstrated that there is no visual detrimental effect such as blistering or disbondment of the plant-applied coating.

6.7 All tools and equipment (e.g. for induction heating, abrasive blasting, coating application and inspection) being used for PQT shall be of the same type as those being used for the actual field joint coating.

6.8 Unless otherwise specified, at least three test zones shall be coated.

6.9 Coating repairs and stripping of defective coating shall be included in PQT.

6.10 The time for coating application during PQT shall be consistent with the estimated field joint coating time in the field. Any significant differences in the PQT environment compared to actual production conditions should be considered, e.g. number of work stations, lifting equipment. The Contractor shall submit a complete report of the qualification test results to the purchaser for approval.

6.11 Pre-Production Trial (PPT) shall be performed on site to verify the following:

- Surface condition and adhesion of the plant-applied coating on steel in the vicinity of the cut-backs
- Field coating materials
- Application procedure;
• Equipment being used for surface preparation and coating application;
• Heating equipment (when used);
• Application of the coating system
• Qualification of the coating operatives and purchaser’s inspectors that will actually be used in the field
• Properties of the applied coating

6.12 The PPT shall be carried out in presence of the Company (or their representative) at the start of operations when equipment and personnel are mobilized on site. The PPT shall be performed on the first joints to be coated or, if agreed, on a dummy pipe.

6.13 The Contractor shall submit a complete report of the tests containing the values and other results obtained in the PPT.

7.0 Qualification of coating and inspection personnel:

7.1 The coating applicators shall be qualified to undertake the coating application procedure and repair work. The qualification may be obtained by demonstration during PQT, during PPT, through a certification organization or as agreed with the Company.

7.2 The Contractor shall request the manufacturer of the coating material(s) and equipment to provide technical assistance to the coating operatives if necessary.

7.3 Inspectors and Contractor personnel carrying out the coating inspection shall be trained and qualified. Proof of successful qualification shall be documented.

8.0 Inspection & Testing

The Contractor shall perform inspection and testing during production in accordance with standard Inspection Testing Procedure (ITP) to verify the surface preparation, coating application and the specified properties of the applied coating. The ITP shall be prepared by the Contractor and shall be approved by the purchaser prior to the start of the coating work and prior to the start of any PQT and/or PPT. The ITP shall identify all inspection activities and tests, their frequency and the relevant inspection authorities.

8.1 Thickness Measurement:

8.1.1 The minimum thickness of the coating on the body of the pipe and on the weld cap shall be defined by agreement between the Company and the Contractor and shall not be less than the manufacturer’s recommendation.

8.2 Holiday detection:

8.2.1 The entire surface of the coated field joint shall be checked for holidays or other discontinuities at a voltage of 5 kV/mm at a maximum of 25 kV. Holidays shall be repaired in accordance with the APS.

8.3 Adhesion:

8.3.1 The adhesion to the steel surface and to the plant-applied coating shall be tested in
accordance with ISO 4624 (pull-off test). Adhesion shall meet the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Temp.</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesion to pipe surface</td>
<td>23 Deg C</td>
<td>MPa</td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>Adhesion to FBE, liquid applied epoxy or PU plant coatings</td>
<td>23 Deg C</td>
<td>MPa</td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>Adhesion to polyolefin plant coatings</td>
<td>23 Deg C</td>
<td>MPa</td>
<td>≥ 3.5</td>
</tr>
</tbody>
</table>

8.4 Impact resistance:
8.4.1 The impact resistance shall meet the following requirement

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Temp.</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact resistance (holiday detection at 5 kV/mm)</td>
<td>23 Deg C</td>
<td>J/mm</td>
<td>≥ 3.0</td>
</tr>
<tr>
<td></td>
<td>-5 Deg C</td>
<td>J/mm</td>
<td>≥ 1.5</td>
</tr>
</tbody>
</table>

8.5 Cathodic disbondment:
8.5.1 The cathodic disbondment after 28 days shall meet the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Temp.</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathodic disbondment at 28 days</td>
<td>23 Deg C</td>
<td>mm</td>
<td>≤ 8.0</td>
</tr>
<tr>
<td></td>
<td>60 Deg C</td>
<td>mm</td>
<td>≤ 15.0</td>
</tr>
</tbody>
</table>

8.6 Specific electrical insulation resistance:
8.6.1 The specific electrical insulation resistance shall be measured and shall be ≥ 10⁶ Ω-m²

9.0 Repairs:
9.1 [To be added]

10.0 Acceptable Manufacturers
10.1 [To be added]
APPENDIX - D

SPECIFICATION FOR LIQUID POLYURETHANE COATING FOR FIELD APPLICATION

1.0 General

1.1 This Specification defines the minimum technical requirements for the Liquid Polyurethane external coating of underground pipelines/piping, valve & fittings. The coating material shall be 100% solids (solvent-less) two component fast curing, high build, direct-to-metal type.

1.2 It is envisaged that the Polyurethane on the steel surface will provide a hard, tough, high electrical resistance (for corrosion prevention in conjunction with cathodic protection system) surface with outstanding adhesion and resistance to cathodic protection currents as well as degradation in buried soils containing chloride salts.

1.3 The CONTRACTOR shall submit a detailed written description of the internal coating equipment, procedures and materials, in the form of a Application Procedure Specification (APS), for COMPANY review and/or approval, in accordance with the contract documents. This shall include the Procedure for qualification of materials and application of coating along with details and results of tests on similar coating or trials performed by CONTRACTOR which document the quality of the finished coating. Such test results and/or trials shall demonstrate procedures and materials can supply a finished coating meeting the requirements of this Specification.

1.4 The APS shall include:

- Procedure for qualification of materials and application processes.
- Pipe handling and storage;
- Pipe cleaning and surface preparation, residual surface contamination;
- Coating application;
- Testing and inspection;
- Coating repair.

2.0 Reference Standards

<table>
<thead>
<tr>
<th>S No</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SSPC SP – 1</td>
<td>Solvent Cleaning</td>
</tr>
<tr>
<td>2</td>
<td>SSPC SP – 10/NACE No.2</td>
<td>Near – White Blast Cleaning</td>
</tr>
<tr>
<td>3</td>
<td>SSPC – SP COM</td>
<td>Surface Preparation Commentary</td>
</tr>
<tr>
<td>4</td>
<td>SSPC PA2</td>
<td>Measurement of Dry Paint Thickness with Magnetic Gauges</td>
</tr>
</tbody>
</table>
### 3.0 Material Specification

3.1 Polyurethane coating consisting of polyurethane based resin applied by spray, roller, brush or trowel shall be suitable for a maximum operating temperature of (+) 60 Deg C (Tmax).

3.2 The Contractor shall provide the data sheets of material from the manufacturer. In addition to the coating-material data sheets, the Contractor shall provide the following information from the manufacturer:

- Batch certificates certifying that the coating materials delivered meet the coating characteristics as set forth in the coating data sheets
- Any agreed optional requirements, if applied according to the manufacturer’s instructions
- Packaging, transport and storage requirements of coating materials
- Range of application conditions including minimum and maximum application Temperatures (for materials and substrate) and relative humidity
- Material safety data sheet (MSDS)
- Marking on each shipment of coating materials shall contain the following information:
  - Manufacturer’s name
  - Name and complete identification of material, including plant of origin
  - Reference to applicable coating-material standards, if any
  - Production batch number
  - Mass/size/Quantity
  - Date of production
  - Expiry date

### 4.0 Functional Requirements of Field Joint Coating

4.1 Polyurethane based liquid coatings shall meet the following minimum requirements:
<table>
<thead>
<tr>
<th>Property</th>
<th>Test Temp.</th>
<th>Test Method</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Coating Thickness</td>
<td></td>
<td>SSPC PA2</td>
<td>Microns</td>
<td>1125 Min.</td>
</tr>
<tr>
<td>Surface Hardness</td>
<td>25 °C</td>
<td>ASTM 2240 D</td>
<td>Shore D</td>
<td>&gt; 65</td>
</tr>
<tr>
<td>Holiday Inspection</td>
<td></td>
<td>NACE RP 0188</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Impact resistance (holiday detection at 5 kV/mm)</td>
<td>23°C-5°C</td>
<td>J/mm</td>
<td></td>
<td>≥ 5.0, ≥ 2.0</td>
</tr>
<tr>
<td>Indentation resistance at 10 N/mm²</td>
<td>60°C</td>
<td>%DFT</td>
<td></td>
<td>≤ 30</td>
</tr>
<tr>
<td>Cathodic disbondment at 28 days</td>
<td>23°C, 60°C</td>
<td>mm</td>
<td></td>
<td>≤ 10, ≤ 20</td>
</tr>
<tr>
<td>Adhesion to pipe surface</td>
<td>23°C</td>
<td>Mpa</td>
<td></td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>Adhesion to FBE, liquid applied epoxy or PU plant coatings</td>
<td>23°C</td>
<td>Mpa</td>
<td></td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>Adhesion to polyolefin plant Coatings</td>
<td>23°C</td>
<td>Mpa</td>
<td></td>
<td>≥ 3.5</td>
</tr>
<tr>
<td>Adhesion to pipe surface after 28-day hot-water immersion test</td>
<td>23°C</td>
<td>Mpa</td>
<td></td>
<td>≥ 7.0</td>
</tr>
<tr>
<td>Adhesion to plant coating after 28-day hot-water immersion test at 60 Deg C</td>
<td>23°C</td>
<td>Mpa</td>
<td></td>
<td>≥ 2.0</td>
</tr>
<tr>
<td>Specific electrical insulation resistance (RS100)</td>
<td>23°C</td>
<td>Ω-m²</td>
<td></td>
<td>≥ 10⁵</td>
</tr>
</tbody>
</table>

5.0 Surface preparation

5.1 It shall be carried out by abrasive blasting to a minimum cleanliness of Sa 21/2. The surface profile attained shall be between 50 µm and 100 µm as measured in accordance with the requirements of ISO 8503-5.

5.2 The plant-applied coating shall be beveled and roughened for the minimum length according to the overlap on the plant coating. The plant-applied coating shall not be removed or contaminated by abrasive dust.

5.3 Dust contamination shall be grade 2 or better measured in accordance with ISO 8502-3.

5.4 If liquid coatings are used in conjunction with a polyolefin plant-applied coating, the plant-applied coating surface may be subject to additional treatments (e.g. flame
6.0 **Application of the coating:**

6.1 The coating shall be applied in a single coat using multiple passes of the spray gun. The finished coating shall be generally smooth and free of sharp protuberances, blistering, bubbling, cracks, de-lamination or other visible defects. A minor amount of sags, dimpling and “curtaining” or overspray spots which otherwise meets specification requirements shall not be considered cause for rejection.

6.2 The coating will be dense, free of foam/ porosity and of uniform consistency in its entire thickness.

6.3 The materials shall be applied by international standard Plural Component Airless Spray System such as **Graco, Gusmer, Wiwa** etc. as per the requirements specified by the coating material manufacturer. No make shift/ nonstandard spray equipment shall be used. Equipment shall consist of Material Feed Pumps, Purge Pump, Proportioning Pump, Mix Manifold, Static Mixer, Interconnecting Hoses etc. System shall normally be capable of 1500-3000 Psi fluid pressure (at tip) and a material supply rate of 4-10 Litres / Minute.

6.4 Resin and Activator pressures should rise (upstroke) and fall (down-stroke) together. In case there is any contrary movement, coating should be stopped. There should not be a difference in pressure of > 300 Psi between the Resin and Activator gauges.

6.5 Applicator must follow standard written instructions from coating manufacturer on material storage, handling and spray.

6.6 Partially used and unused material drums must be tightly sealed and contain a blanket of nitrogen to prevent moisture contamination when not in use.

6.7 Before application on the substrate apply a test patch for runs or drips and gel time as well as tack free time.

6.8 The proportioning pump shall be fitted with a numeric counter to keep track of the volume of materials being used while spraying. Volume of materials used shall be recorded in daily log sheets as per APS.

6.9 Entire thickness shall be built up in a single application (with a number of ‘wet-on-wet’ passes). If the surface is large enough to require more than one day for the coating, the edges of the coated areas shall be feathered and roughened with a grinding tool prior to beginning coating.

6.10 Areas not to be coated shall be masked with disposable plastic sheets, cardboard etc.

6.11 Masking tape should be put on edges of the planned coating section to obtain a clean demarcation of the coating. The tape should be removed after coating.

6.12 The wet-film thickness shall be checked using a wet-film thickness gauge. Insufficient film thickness, bare areas and pinholes shall be corrected within the over-coating time.
and in accordance with the APS. The overlap with the plant-applied coating shall be not less than 50 mm, unless otherwise specified.

7.0 Pre-Qualification of Field Coating System

7.1 APS shall be qualified by a PQT.

7.2 The Contractor may request the manufacturer(s) to assist during the PQT to ensure the correct use of the coating material(s) and to train Contractor personnel.

7.3 PQT may be carried out independently of any project. In this case, representative pipes having the diameter, thickness and plant-coating as agreed upon between manufacturer, Contractor, Company and purchaser, if any, shall be used.

7.4 For a PQT related to a specific project, tests shall be carried out on test zones distributed along a pipe coated with the actual plant-applied coating. The length of the test zones shall be equivalent to the field joint coating length. The test points shall be defined in the PQT program.

7.5 If not present, a circumferential cap weld shall be added at the center of each of the test zones to simulate the field weld.

7.6 If heating of the area to be coated is specified in the APS, it shall be demonstrated that there is no visual detrimental effect such as blistering or disbondment of the plant-applied coating.

7.7 All tools and equipment (e.g. for induction heating, abrasive blasting, coating application and inspection) being used for PQT shall be of the same type as those being used for the actual field joint coating.

7.8 Unless otherwise specified, at least three test zones shall be coated.

7.9 Coating repairs and stripping of defective coating shall be included in PQT.

7.10 The time for coating application during PQT shall be consistent with the estimated field joint coating time in the field. Any significant differences in the PQT environment compared to actual production conditions should be considered, e.g. number of work stations, lifting equipment. The Contractor shall submit a complete report of the qualification test results to the purchaser for approval.

7.11 Pre-Production Trial (PPT) shall be performed on site to verify the following:

- Surface condition and adhesion of the plant-applied coating on steel in the vicinity of the cut-backs
- Field coating materials
- Application procedure;
- Equipment being used for surface preparation and coating application;
- Heating equipment (when used);
- Application of the coating system
- Qualification of the coating operatives and purchaser’s inspectors that will actually be used in the field
- Properties of the applied coating

7.12 The PPT shall be carried out in presence of the Company (or their representative) at the start of operations when equipment and personnel are mobilized on site. The PPT shall be performed on the first joints to be coated or, if agreed, on a dummy pipe.

7.13 The Contractor shall submit a complete report of the tests containing the values and other results obtained in the PPT.

8.0 Qualification of coating and inspection personnel:

8.1 The coating applicators shall be qualified to undertake the coating application procedure and repair work. The qualification may be obtained by demonstration during PQT, during PPT, through a certification organization or as agreed with the Company.

8.2 The Contractor shall request the manufacturer of the coating material(s) and equipment to provide technical assistance to the coating operatives if necessary.

8.3 Inspectors and Contractor personnel carrying out the coating inspection shall be trained and qualified. Proof of successful qualification shall be documented.

9.0 Inspection & Testing

The Contractor shall perform inspection and testing during production in accordance with standard Inspection Testing Procedure (ITP) to verify the surface preparation, coating application and the specified properties of the applied coating. The ITP shall be prepared by the Contractor and shall be approved by the purchaser prior to the start of the coating work and prior to the start of any PQT and/or PPT. The ITP shall identify all inspection activities and tests, their frequency and the relevant inspection authorities.

9.1 Thickness Measurement:

9.1.1 The minimum thickness of the coating on the body of the pipe and on the weld cap shall be defined by agreement between the Company and the Contractor and shall not be less than the manufacturer’s recommendation.

9.2 Holiday detection:

9.2.1 The entire surface of the coated field joint shall be checked for holidays or other discontinuities at a voltage of 5 kV/mm at a maximum of 25 kV. Holidays shall be repaired in accordance with the APS.

9.3 Adhesion:

9.3.1 The adhesion to the steel surface and to the plant-applied coating shall be tested in accordance with ISO 4624 (pull-off test). Adhesion shall meet the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Title | Pipeline Coating Specifications  
Type | Guidance  
Reference | CIMG-GD-2-2019-0001

<table>
<thead>
<tr>
<th>Property</th>
<th>Test temp.</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesion to pipe surface</td>
<td>23 Deg C</td>
<td>MPa</td>
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</tr>
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<td>MPa</td>
<td>≥ 10.0</td>
</tr>
<tr>
<td>Adhesion to polyolefin plant coatings</td>
<td>23 Deg C</td>
<td>MPa</td>
<td>≥ 3.5</td>
</tr>
</tbody>
</table>

9.4 Impact resistance:
9.4.1 The impact resistance shall meet the following requirement:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test temp.</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact resistance (holiday detection at 5 kV/mm)</td>
<td>23 Deg C</td>
<td>J/mm</td>
<td>≥ 5.0</td>
</tr>
<tr>
<td></td>
<td>-5 Deg C</td>
<td>J/mm</td>
<td>≥ 2.0</td>
</tr>
</tbody>
</table>

9.5 Cathodic disbondment:
9.5.1 The cathodic disbondment after 28 days shall meet the following requirements:

<table>
<thead>
<tr>
<th>Property</th>
<th>Test temp.</th>
<th>Unit</th>
<th>Required Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathodic disbondment at 28 days</td>
<td>23 Deg C</td>
<td>mm</td>
<td>≤ 10.0</td>
</tr>
<tr>
<td></td>
<td>60 Deg C</td>
<td>mm</td>
<td>≤ 20.0</td>
</tr>
</tbody>
</table>

9.6 Specific electrical insulation resistance:
9.6.1 The specific electrical insulation resistance shall be measured and shall be ≥ 10 6 Ω-m²

10.0 Repairs:
10.1 Blisters, Cracks Bubbles, De-Lamination And Other Visible Defects; Holidays
10.1.1 Wipe clean the marked area with a clean cloth. Use solvent in case of oil / grease deposits. Allow to dry.
10.1.2 Abrade using sandpaper the marked area, including approx. 1/2” for overlap. Wipe clean with dry cloth.
10.1.3 Mix small amounts of Polyurethane Hand Mix coating in correct volumetric ratio. Apply using brush or squeegee to the discontinuity and required overlap, taking care to coat within the abraded area only
10.2 Coating Thickness Less Than Specified Thickness
10.2.1 Record the DFT of the areas marked for repairs.
10.2.2 Lightly abrade using brush off blast cleaning or power sanding. Wipe with clean cloth and compressed air.
10.2.3 Estimate materials requirement for additional coat and spray apply Polyurethane to obtain required thickness making WFT checks.

10.2.4 Test the coating in the same manner as outlined in inspection.

10.3 At Places Where Adhesion Tests Has Been Carried Out

10.3.1 Wipe clean damaged/ exposed area with a clean cloth. Use solvent in case of oil / grease deposits. Allow to dry.

10.3.2 Abrade using sandpaper the damaged/ exposed area including approx. 1/2” for overlap. Wipe clean with dry cloth.

10.3.3 Mix small amounts of Polyurethane Hand Mix coating in the correct volumetric ratio. Apply using brush or squeegee to the discontinuity and the overlap area, taking care to coat within the abraded area only. Ensure that the coating is reasonably level with no depressions in the middle. Test the coating in the manner as outlined under inspection.

11.0 Acceptable Manufacturers

11.1 [To be added]
1.0 General

1.1 This Specification defines the minimum technical requirements for the cold applied external coating of underground pipelines / piping, valve & fittings.

1.2 The CONTRACTOR shall submit a detailed written description of the internal coating equipment, procedures and materials, in the form of a Application Procedure Specification (APS), for COMPANY review and/or approval, in accordance with the contract documents. This shall include the Procedure for qualification of materials and application of coating along with details and results of tests on similar coating or trials performed by CONTRACTOR which document the quality of the finished coating. Such test results and/or trials shall demonstrate procedures and materials can supply a finished coating meeting the requirements of this Specification.

1.3 The APS shall include:

• Procedure for qualification of materials and application processes.
• Pipe handling and storage;
• Pipe cleaning and surface preparation, residual surface contamination;
• Coating application (multi-component spraying equipment);
• Testing and inspection;
• Coating repair.

2.0 Material Specification

Cold applied tapes shall consist of plastic backing with uniform thickness of self-adhesive elastomeric compound and shall confirm to EN-12068. The coating shall consist of (i) a liquid adhesive layer i.e. primer (ii) an inner layer tape (3 ply type) for corrosion protection (iii) an outer layer tape (2 ply type) for additional mechanical protection

2.1 Primer (Liquid Adhesive):

2.1.1 The primer shall consist of a mixture of butyl rubber and synthetic compound and a solvent. The primer shall be applied to a Sa 2½ prepared pipe surface before application of inner layer tape. **If it is not feasible to prepare the pipe surface by abrasive blast cleaning then surface preparation shall be done by mechanical wire brushing using a power tool, in accordance with SSPC-SP11.** The function of primer is to provide a bonding medium between the pipe surface and the inner layer tape. The primer shall be quick drying type. The primer shall be suitable for brush application. The manufacturer shall confirm the coverage of the primer; the shelf life of the primer shall be at-least 2 years. The manufacturer shall indicate recommended time lag between primer and tape application. The primer shall be free from any health hazard during storage and application. The primer shall be compatible with the offered tape and shall be suitable
for application in operation of the coated pipe with temperatures ranging from ambient to 65°C.

2.2 **Inner wrap:**
3 ply plastic tape consisting of a stabilized polyethylene backing and butyl rubber adhesive layers on both sides. The inner wrap shall be fully compatible with primer & outer wrap. The tape shall be self-amalgamating between the layers & at the overlap area. A non-sticking separator strip (release film) shall be provided in the rolls to eliminate sticking of adhesives when the tape is in roll form.

2.3 **Outer wrap:**
2 ply plastic tape consisting of a stabilized polyethylene backing and butyl rubber adhesive layer on one side. The outer wrap shall be fully compatible with inner wrap. The tape shall be self-amalgamating between the layers & at the overlap area. A non-sticking separator strip (release film) shall be provided in the rolls to eliminate sticking of adhesives when the tape is in roll form.

2.4 **Filler Material for weld reinforcements, Sleeves, Clamps etc.:**
Mouldable filler material comprising of butyl rubber based filler mastic/putty shall be used for smoothing out uneven surfaces, step downs, irregular shapes, weld seams, or cavities to minimize air voids before the application of cold-applied tape coating systems. Filler material shall be fully compatible with the properties of the primer & coating system. All specified properties of coating system should meet at pipe surfaces treated/applied filler material/filler tape. Application procedure of the offered product in the areas having weld reinforcements, girth welds, clamps/sleeves and heavily corroded areas shall also be submitted. Manufacturer’s data sheets & complete technical details for Filler Materials / Tape, required surface preparation shall be submitted.

3.0 **Functional Requirements of Field Joint Coating**

3.1 The coating materials and applied coating shall meet the following requirement:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value/Requirement</th>
<th>Unit</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application temperature</td>
<td>Ambient to + 60 °C</td>
<td>°C</td>
<td>---</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>Ambient to +50 °C</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Total coating thickness (considering 50% overlap of both Inner layer and outer layer tapes.)</td>
<td>2.5 (min)</td>
<td>mm.</td>
<td>ASTM G12</td>
</tr>
<tr>
<td>Impact Resistance (10 impacts at least 30 mm apart on same sample with impact force of &gt;15 J)</td>
<td>No holiday with a test voltage of 15 KV</td>
<td>Should pass</td>
<td>DIN EN 12068 Annex – H</td>
</tr>
</tbody>
</table>
### Pipeline Coating Specifications

**Title**: Pipeline Coating Specifications  
**Type**: Guidance  
**Reference**: CIMG-GD-2-2019-0001  

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value/Requirement</th>
<th>Unit</th>
<th>Test method</th>
</tr>
</thead>
</table>
| Indentation Resistance pressure (test condition) at  
23°C | 10 | N/mm² | DIN EN 12068 Annex - G |
| 50°C | 10 | N/mm² |
| Remaining thickness | 0.6 (min) | mm | No holiday with a test voltage of 15 KV |
| Thermal Ageing resistance Ratio  
-Tape strength | 1.25 ≥ S₁₀₀/S₀ ≥ 0.75  
S₁₀₀/S₇₀ ≥ 0.8 | | DIN EN 12068 Annex - E |
| -Elongation at Break | 1.25 ≥ E₁₀₀/E₀ ≥ 0.75  
E₁₀₀/E₇₀ ≥ 0.80 | | |
| -Peel Strength layer to layer | P₁₀₀/P₇₀ ≥ 0.75  
P₁₀₀/P₇₀ ≥ 0.80 | | |
| -Peel strength to pipe Surface | A₁₀₀/A₇₀ ≥ 0.75  
A₁₀₀/A₇₀ > 0.80 | | |
| Specific electrical wrapping resistance  
R₁₁₀₀ | ≥10⁸ | Ohm m² | DIN EN 12068 Annex - J |
| R₁₁₀₀/R₇₀ | ≥ 0.8 | |
| Cathodic Disbondment at  
@ 23 °C | ≤ 10 (max) | mm | DIN EN 12068 Annex - K |
| @ 50 °C | ≤ 15 (max) | |
| Adhesion strength at 23°C  
- Inner layer to primed pipe | ≥ 0.75 (min) | N/mm | DIN EN 12068 Annex –C |
| -Inner layer to existing CTE/Coal Tar Tape coatings | ≥ 0.4 (min) | N/mm |
| Layer to Layer  
- Inner to Inner + Outer to Inner | ≥ 1.5 (min) | N/mm | DIN EN 12068 Annex –B |
| -Outer to Outer | ≥ 0.2 (min) | N/mm | |
### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value/Requirement</th>
<th>Unit</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesion strength at 50°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inner layer to primed pipe</td>
<td>≥ 0.075 (min)</td>
<td>N/mm</td>
<td>DIN EN 12068 Annex –C</td>
</tr>
<tr>
<td>- Inner layer to existing CTE/Coal Tar Tape coatings</td>
<td>≥ 0.04 (min)</td>
<td>N/mm</td>
<td>DIN EN 12068 Annex –B</td>
</tr>
<tr>
<td>Layer to Layer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inner to Inner + Outer to Inner</td>
<td>≥ 0.2 (min)</td>
<td>N/mm</td>
<td></td>
</tr>
<tr>
<td>- Outer to Outer</td>
<td>≥ 0.2 (min)</td>
<td>N/mm</td>
<td></td>
</tr>
<tr>
<td>LAP shear strength between wrapping and metal surface of existing coating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ 23°C</td>
<td>≥ 0.05</td>
<td>N/mm²</td>
<td>DIN EN 12068 Annex –D</td>
</tr>
<tr>
<td>@ 50°C</td>
<td>≥ 0.05</td>
<td>N/mm²</td>
<td></td>
</tr>
<tr>
<td>Shelf life</td>
<td>5 years (min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>0 °C to + 50 °C</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

3.2 The tape manufacturer shall provide assistance in demonstrating the proper method of application of coating system as required by Owner. During initial application at minimum 1 location/site, tape manufacturer shall depute his representatives to demonstrate/train the field applicators of application contractor, so that coating material i.e. primer, inner tape, outer tape, filling material etc. should be applied as per manufacturer’s recommendations to achieve the desired properties/ protection of pipeline.

3.3 Following information shall be submitted by the supplier:

- The thickness of the Inner tape and outer tape offered with thickness of individual layer
- Data sheet of the Inner tape / Outer tape
- Data sheet of the primer
- Data sheet of the filler mastic
- Data sheet of hand wrapping machine
- Maximum exposure time of applied tape before backfilling.
- Recommended time lag (Maximum and minimum) between application of primer & tape.
- Application procedure of the tape system i.e. primer, inner wrap & outer wrap.
- Application procedure of filler mastic.
- Coating repair method
- Compatibility with impressed current cathodic protection system
Field test and inspection procedure of the coating including list of instrument for field-testing

Third Party Type Test Certificate for conformance to EN12068 & Test Certificates for every batch Coating system being supplied

Supply record in the last 5 years

4.0 Surface preparation

4.1.1 After the pipe has been inspected for corrosion pits / wall thickness measured, the pipe surface shall be abrasive blasted to surface finish of Sa2 1/2 and anchor profile of 50-100 microns. The salt contamination on the abrasive blasted steel surface shall be < 20mg/m2.

4.1.2 Prior to abrasive blasting it shall be ensured that pipe surface shall be free of oil, grease salts and other contaminations Suitable solvents which do not leave any residuals like benzene, xylene or equivalent shall be used. Kerosene shall not be used for cleaning. Solvent cleaning procedure shall be according to SSPC-SP1. Pipe surface will be dry prior to start of abrasive blasting.

4.1.3 Copper slag shall be used as abrasive media for surface preparation of pipe surface. The copper slag shall be supplied as per ISO 11126-3 (Preparation of steel Substrates before application of paints and related products - Specifications for non-metallic blast-cleaning abrasives - Part 3: Copper refinery slag).

5.0 Application of the coating

5.1 The coating application shall be a continuous operation starting with a properly prepared pipe surface. Three steps, which shall be performed consecutively, shall consist of (1) primer application; (2) application of the inner-layer tape directly onto the primed pipe surface; and (3) application of the outer-layer tape directly on top of the inner-layer tape. Ensure that the relative humidity is below 85% and surface temperature of pipe is at least 30 C above the dew point temperature.

5.2 The liquid adhesive (primer) shall be thoroughly and continuously mixed and agitated during application to prevent settling in the original drum. The primer shall then be taken out in a small container and the cover of the primer drum should be immediately closed and sealed to reduce evaporation loss. The small container must also have a cover to reduce evaporation loss when not in use. The container should be always in cleaned condition. The liquid adhesive shall be applied in a uniform thin film at the coverage rate recommended by the coating manufacturer. The application of the primer over steel pipe shall be carried out manually using good quality paint brush. After application, the brush shall be cleaned with suitable solvent for next day usage. It is to be ensured that there are sufficient paint brushes available at every site. In case the paint brush holder becomes loose or the bristles of the paint become hard, the paint brush shall be replaced.

5.3 While applying the primer the wet film thickness “WFT” shall be measured and
recorded. The primer WFT shall be 75-100 microns or shall be as per coating manufacturer’s requirement. Coating has to be applied only when the primer is tacky to touch dry at ambient temperature or as recommended by the coating manufacturer. The typical tacky to touch dry time is about 5 - 10 minutes. The primer will become totally dry in less than 30 minutes and hence it has to be ensured that the coating is not applied after the primer has become completely dry or as recommended by the coating manufacturer.

5.4 The liquid adhesive coat shall be uniform and free from floods, runs, sags, drips, or bare spots. In case the primer has completely dried, over-coat time interval of the primer shall be as per coating manufacturer’s recommendation.

5.5 Liquid adhesive application shall be limited to the amount of surface area that can be wrapped during the same workday as application of the liquid adhesive; otherwise, the steel must be re-primed. After liquid adhesive application and before the tape is applied, care shall be taken to prevent the contamination of the primed surface by any foreign materials, such as dirt and moisture.

5.6 Filler mastic putty shall be applied at weld seam/girth welds, circumferential welds and on dents in carrier pipe surface to get an even and smooth surface to avoid formation of air pockets between pipe and inner tape, as per manufacturing recommendations.

5.7 The inner layer tape roll shall be fitted in hand operated machine supplied by the coating manufacturer. The release liner of the inner tape shall be gripped in the take up roller when the tape is being applied on the pipe. The wheels of the hand wrapping machine shall be adjusted so that it holds the pipe surface such that the tension on the tape while application is maintained. The angle of the hand wrapping machine shall be set to get a 50% spiral overlap of the inner wrap to the tacky dry surface of the primed steel. The tension knob will be tightened so as to give sufficient neck down tension of 1-2% to the tape while wrapping.

5.8 The coating manufacturer instruction shall be followed for maintaining the tension. After a couple of wraps, the required 50% overlap shall be checked to ensure that the machine is set at the correct angle. Less overlap will imply reduced overall thickness of the coating on the pipe and more overlap will imply extra consumption of the tape. The overlap shall constantly be checked during the coating application.

5.9 When a new roll of tape is started, the ends shall be overlapped at least 4” (100 mm), measured circumferentially. The end of the spiral wrap shall be cut on the downside at the 3 or 9 o’clock position on the pipe. When the wrapping of inner layer is over, the coated surface should be checked by hammering mildly with the wooden hammer, which will indicate presence of void/loose contact or air pocket, if any.

5.10 Wrapping should be done carefully keeping required tension to avoid air pockets and wrinkles. Air pockets & wrinkles, if formed, should be repaired immediately, by puncturing air pockets and putting patch of tape over it. If wrinkling is observed over a
longer length, then tape shall be removed and the new tape shall be applied over the re-
primed steel surface.

5.11 The overlap of tape shall be at least 4 inch (100mm) or as per manufacturers required
overlap if greater than 4 inch (100 mm).

5.12 Once the application 3ply inner tape been wrapped on the primer coated pipe section,
the application of outer mechanical protection layer 2ply tape shall be carried out with
hand wrapping machine with recommended neck down tension 1-2%. The outer tape
has to be applied smoothly on the 3ply inner layer tape surface without folding and air
pockets. The minimum spiral overlap width shall be 50%. The outer tape has no plastic
release liner.

5.13 Similar procedure in-line with the application of inner wrap is to be followed for
application of outer layer two-ply tape coat. The spiral overlap of the outer wrap shall
not coincide with the overlap of the inner wrap.

5.14 The applied coating system shall have a minimum thickness of 2.5mm.

6.0 Inspection & Testing

6.1 Visual: The coated pipes shall be visually inspected for uniformity without any wrinkles,
irregularities, overlapping width, cracks, trapped air, damage etc. Any repair arising out
of visual inspection will be performed.

6.2 Thickness Measurement: Coating thickness has to be measured with a digital coating
thickness meter. Digital coating thickness meter shall be magnetic, electromagnetic or
ultrasonic measuring instrument, with ± 1 % reading accuracy, calibrated for the range
of coating thickness being measured. The coating thickness shall be measured at 3, 6, 9
and 12 o’clock locations at every 10 meters and shall be recorded in the field coating log
book. Its frequency can be increased for inspection of thickness to ensure quality
application of the coating.

6.3 Peel Test: Peel test shall be done to measure the peeling force per unit width between
the applied coating and pipe surface or the existing good coating. Peel test shall be
carried out using calibrated hand digital peel test gauge. Cut the applied coating down
to the pipe wall in the shape of a rectangular strip of 25mm wide x 200mm long. Lift off
one end of the strip from the pipe over a length of 20mm. The lift off part of the strip
shall be secured in the clamp of the hand peel test gauge. The coating shall then be
peeled off at a constant peeling rate of 10 mm/min perpendicular to the surface of the
pipe. Measure at least 10 readings (peel values) @ 6 seconds each over a peel length of
10mm. Take the arithmetic average of the readings and record. The frequency of peel
test will be one in day’s work. It shall be done after 24 hours of application:

| Type of coating system | Peel value (inner layer to pipe surface) as per
<table>
<thead>
<tr>
<th></th>
<th>ISO 21809 Part 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N/mm Kg (for 25 mm strip)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rev. No.</th>
<th>Report No.</th>
<th>Issue Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>CIMG-GD-2-2019-0001</td>
<td>Page 98 of 136</td>
</tr>
</tbody>
</table>
6.4 Holiday Inspection: Holiday testing shall be carried for detecting pinholes / porosity / discontinuities in the applied coating. The test shall be as per ISO 21809 & shall be carried after 24 hours of application or shall be as per manufacturer’s recommendation. The scanning electrode shall be passed over the surface of the coating being inspected with a continuous, relative movement not exceeding 300 mm/s. Excessive voltages, slow survey speeds or multiple passes can damage the coating. The voltage should only be applied when the electrode is moving. Ring type electrode shall be used and will fit the required pipe size. At the time of the test, the voltage shall be set at a value depending on the material and minimum thickness of the coating. Holiday testing shall be done @ 5 KV/mm or as recommended by the manufacturer. Holiday marking and repair: An electric spark between the electrode and the metal surface will indicate any holidays or missed places. All holidays or missed places so indicated shall be marked by chalk or crayon and repaired. The repair shall be carried as per the procedure given by the coating manufacturer.

7.0 Repairs:

7.1 Any spot requiring repair as a result of visual or holiday inspection shall be removed and surface prepared again for re-application of tapes as per approved procedure.

8.0 Acceptable Manufacturers

8.1 [To be added]
## Appendix- F

### SPECIFICATION FOR

**VISCO-ELASTIC COATING FOR FIELD APPLICATION**

#### 1.0 General

1.1 This Specification defines the minimum technical requirements for the visco-elastic external coating of underground pipelines / piping, valve & fittings.

1.2 The CONTRACTOR shall submit a detailed written description of the internal coating equipment, procedures and materials, in the form of a Application Procedure Specification (APS), for COMPANY review and/or approval, in accordance with the contract documents. This shall include the Procedure for qualification of materials and application of coating along with details and results of tests on similar coating or trials performed by CONTRACTOR which document the quality of the finished coating. Such test results and/or trials shall demonstrate procedures and materials can supply a finished coating meeting the requirements of this Specification.

1.3 The APS shall include:

- Procedure for qualification of materials and application processes.
- Pipe handling and storage;
- Pipe cleaning and surface preparation, residual surface contamination;
- Coating application (multi-component spraying equipment);
- Testing and inspection;
- Coating repair.

#### 2.0 Material Specification

2.1 The non-crystalline low-viscosity polyolefin tapes shall consists of a two layer system as below:

a) An inner-layer coat comprising one or several layers of a non-crystalline low-viscosity (fully amorphous, non-cross-linked) polyolefin compound tape applied without any primer or adhesive

b) A polymeric outer wrap

2.2 The inner layer shall be non-crystalline low-viscosity polyolefin compound tape with self-healing properties to provide corrosion protection to buried pipelines. The coating should show continuous fluid type behavior and wetting characteristics (i.e., the coating flows into finest pores and anomalies in substrate). A non-sticking separator strip (release film) shall be provided in the roll to avoid sticking together of the tape.

2.3 The outer wrap shall be two layer tape consisting of a PVC / PE backing layer with a laminated pressure sensitive adhesive on one side. The outer layer of the tape shall be compatible with the inner layer so that it forms a sound coating when wrapped around
pipelines with overlaps. The outer wrap shall have sufficient tensile strength to support cold flow of the inner wrap in addition to providing mechanical protection from external damages.

2.4 All material shall be packaged in suitable containers in quantities which can be reasonably handled by the applicators. The packaging shall be such that during transportation and handling at site, full quantity and performance of the material is retained.

2.5 Following shall be clearly marked as minimum on the container / package of the tape in ENGLISH:

- Trade Name and Type
- Reference / Batch No.
- Date of manufacture
- Roll Sizes – Width (mm) x Length (mm)
- Manufacturer’s Name and Address
- GAIL Order No.

2.6 Manufacturer’s Test Certificate, Data sheet and Instruction for application shall be supplied with each container / package of tape.

3.0 Functional Requirements of Coating

3.1 The coating system shall conform to the performance requirements listed in the table below:

<table>
<thead>
<tr>
<th>S No</th>
<th>Parameter</th>
<th>Test Temp</th>
<th>Unit</th>
<th>Value-Min</th>
<th>Value-Max</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Width deviation (Inner / Outer wrap)</td>
<td>-</td>
<td>mm</td>
<td>-10</td>
<td>+10</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Total Coating Thickness</td>
<td>-</td>
<td>mm</td>
<td>2.4</td>
<td>2.6</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Holiday Detection at 5 kV/mm + 5 kV</td>
<td>-</td>
<td>-</td>
<td>No holiday</td>
<td>-</td>
<td>ISO-21809 Annex-A</td>
</tr>
<tr>
<td>5</td>
<td>Indentation Resistance (pressure)</td>
<td>23 &amp; 50°C</td>
<td>N/mm2</td>
<td>10</td>
<td>-</td>
<td>ISO-21809 Annex-H</td>
</tr>
<tr>
<td>5.1</td>
<td>Holiday Detection at 5 kV/mm + 5 kV</td>
<td>-</td>
<td>-</td>
<td>No holiday</td>
<td>-</td>
<td>ISO-21809 Annex-H</td>
</tr>
<tr>
<td>5.2</td>
<td>Residual Thickness</td>
<td>mm</td>
<td>0.6</td>
<td>-</td>
<td></td>
<td>ISO-21809 Annex-K</td>
</tr>
<tr>
<td>6</td>
<td>Specific Electrical Resistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ISO-21809 Annex-K</td>
</tr>
<tr>
<td>6.1</td>
<td>Rs100</td>
<td>23°C</td>
<td>Ωm2</td>
<td>108</td>
<td></td>
<td>ISO-21809 Annex-K</td>
</tr>
<tr>
<td>6.2</td>
<td>Rs100/ Rs70</td>
<td>23°C</td>
<td>-</td>
<td>0.8</td>
<td></td>
<td>ISO-21809 Annex-K</td>
</tr>
<tr>
<td>7</td>
<td>Cathodic Disbondment at 28 days</td>
<td>23°C</td>
<td>mm</td>
<td>-</td>
<td>0</td>
<td>ISO-21809 Annex-K</td>
</tr>
<tr>
<td>S No</td>
<td>Parameter</td>
<td>Test Temp</td>
<td>Unit</td>
<td>Value-Min</td>
<td>Value-Max</td>
<td>Test Method</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>-----------</td>
<td>------</td>
<td>-----------</td>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>8</td>
<td>Peel Strength between Tape layers</td>
<td>50°C</td>
<td>mm</td>
<td>-</td>
<td>0</td>
<td>Annex-F</td>
</tr>
<tr>
<td>8.1</td>
<td>Outer to Inner</td>
<td>23 °C</td>
<td>N/mm</td>
<td>0.4</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>8.2</td>
<td>Outer to Outer</td>
<td>50°C</td>
<td>N/mm</td>
<td>0.0</td>
<td>4</td>
<td>Annex-I</td>
</tr>
<tr>
<td>8.3</td>
<td>Outer to Outer</td>
<td>23 °C</td>
<td>N/mm</td>
<td>0.4</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>8.4</td>
<td>Peel Strength Inner Wrap</td>
<td>50°C</td>
<td>N/mm</td>
<td>0.0</td>
<td>4</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>9.1</td>
<td>To steel surface and <strong>plant coating</strong></td>
<td>23 °C</td>
<td>N/mm</td>
<td>0.2</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>9.2</td>
<td>To steel surface and <strong>plant coating</strong></td>
<td>50°C</td>
<td>N/mm</td>
<td>0.2</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>10</td>
<td>To plant coating after 28 days hot-water immersion test</td>
<td>23 °C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td></td>
<td>To plant coating after 28 days hot-water immersion test</td>
<td>50°C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>11</td>
<td>Lap shear strength</td>
<td>23 °C</td>
<td>N/mm2</td>
<td>0.0</td>
<td>2</td>
<td>ISO-21809</td>
</tr>
<tr>
<td></td>
<td>Lap shear strength</td>
<td>50 °C</td>
<td>N/mm2</td>
<td>0.0</td>
<td>2</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>12</td>
<td>Self healing effect on φ6 mm artificial defect (inner wrap), 24 hrs</td>
<td>23 °C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td></td>
<td>Self healing effect on φ6 mm artificial defect (inner wrap), 24 hrs</td>
<td>50°C</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>13</td>
<td>Water Absorption (Inner wrap)</td>
<td>-</td>
<td>% by wt</td>
<td>-</td>
<td>0.05%</td>
<td>ASTM D570</td>
</tr>
<tr>
<td>14</td>
<td>Water Vapour Transmission</td>
<td>23 °C</td>
<td>% by wt perms</td>
<td>-</td>
<td>0.2</td>
<td>ASTM E96</td>
</tr>
<tr>
<td>15</td>
<td>Drip Resistance</td>
<td>50 °C</td>
<td>-</td>
<td>No dripping of compound</td>
<td>ISO-21809</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Glass Transition Temperature</td>
<td>°C</td>
<td>-</td>
<td>-20</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>17</td>
<td>Shelf Life (Inner and outer wrap)</td>
<td>-</td>
<td>Years</td>
<td>5</td>
<td>-</td>
<td>ISO-21809</td>
</tr>
<tr>
<td>18</td>
<td>Temperature</td>
<td>-</td>
<td>°C</td>
<td>0</td>
<td>50</td>
<td>ISO-21809</td>
</tr>
</tbody>
</table>
4.0 Surface preparation

4.1 Surface Preparation: Pipe after removal of the coal tar coating/primer shall be made free from mud, mill scale, coal tar, oil, grease, condensed water or any other foreign material. Visible oil and grease spots shall be removed using a solvent in accordance with SSPC SP-1. Only solvents that do not leave a residue shall be used. Surface preparation of the steel surface shall be carried out by means of wire-brush cleaning in accordance to a minimum degree of cleanliness of ISO 8501-1 grade St 2. Dust contamination shall be grade 3 or better measured in accordance with ISO 8502-3.

4.2 Pipe surfaces shall be protected from conditions of high humidity, rainfall, or surface moisture. Pipe shall be dry prior to application of the coating. Prior to start of coating, the steel surface shall be carefully visually inspected for any sign of pitting corrosion and if found shall be further inspected by buffing the steel surface with an approved power tool. The thickness of the steel at pitting locations shall be measured as per approved procedure.

4.3 In case of ground high water tables, de-watering the trench using suitably rated well point system may be deployed to ensure water level is below the working depth for pipe coating.

5.0 Application of the coating:

5.1.1 The Visco-elastic tape system comprises of two layers as indicated below.

5.1.2 The inner wrap shall consist of a non-crystalline (fully amorphous) low-viscosity (non-cross-linked) non-reactive polyolefin (e.g. poly-isobutylene, other polybutenes or atactic polypropylene) based compound layer with a direct bond to the substrate. The base compound layer shall be reinforced by fabrics. A non-sticking separators strip (release film) shall be provided in the roll to eliminate sticking.

5.1.3 The second or outer layer wrap shall be a two-layer tape consisting of a polyethylene or polyvinyl chloride backing layer with a laminated pressure sensitive adhesive on one side. The outer-layer tape shall be compatible with the inner-layer tape. This second layer should have sufficient tensile strength to provide additional pressure in order to support cold flow of the inner coat. This layer should also provide mechanical protection.

5.1.4 The inner-layer wrap (Visco-elastic wrap) shall be applied directly onto the prepared pipe surface by hand with minimum tension to avoid wrinkles and as per coating manufacturer’s application instructions. Air enclosures and voids shall be avoided. The release foil should not be removed completely before application of the visco-elastic
tape. The foil should be removed just prior to application of the tape on pipe surface. The Visco-elastic tape will be wrapped spirally with a minimum overlap of 10mm.

5.1.5 The outer-layer wrap (PVC/PE) shall be applied spirally over the inner-layer tape by hand application with tension and as per coating manufacturer’s application. The spiral overlap of the outer layer shall be minimum 50%. The overlap of the outer-layer tape shall not coincide with the overlap of the inner layer tape.

5.1.6 The applied coating system shall have a minimum thickness of 2.5mm.

5.1.7 The overlap of tapes on shall be at least 4 in. (100mm) or as per manufacturer’s required overlap if greater than 4 inch (100 mm).

6.0 Inspection & Testing

6.1 Visual: The coated pipes shall be visually inspected for uniformity without any wrinkles, irregularities, overlapping width, cracks, trapped air, damage etc. Any repair arising out of visual inspection will be performed.

6.2 Thickness Measurement: Coating thickness has to be measured with a digital coating thickness meter. Digital coating thickness meter shall be magnetic, electromagnetic or ultrasonic measuring instrument, with ± 1 % reading accuracy, calibrated for the range of coating thickness being measured. The coating thickness shall be measured at 3, 6, 9 and 12 o’clock locations at every 10 meters and shall be recorded in the field coating log book. Its frequency can be increased for inspection of thickness to ensure quality application of the coating.

6.3 Peel Test: Peel test shall be done to measure the peeling force per unit width between the applied coating and pipe surface or the existing good coating. Peel test shall be carried out using calibrated hand digital peel test gauge. Cut the applied coating down to the pipe wall in the shape of a rectangular strip of 25mm wide x 200mm long. Lift off one end of the strip from the pipe over a length of 20mm. The lift off part of the strip shall be secured in the clamp of the hand peel test gauge. The coating shall then be peeled off at a constant peeling rate of 10 mm/min perpendicular to the surface of the pipe. Measure at least 10 readings (peel values) @ 6 seconds each over a peel length of 10mm. Take the arithmetic average of the readings and record. The frequency of peel test will be one in day’s work. It shall be done after 24 hours of application:

<table>
<thead>
<tr>
<th>Type of coating system</th>
<th>Peel value (inner layer to pipe surface) as per ISO 21809 Part 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visco-elastic @23 °C</td>
<td>N/mm: ≥ 0.04, Coverage: ≥ 95% Kg (for 25 mm strip): ≥ 0.1, Coverage: ≥ 95%</td>
</tr>
</tbody>
</table>

6.4 Holiday Inspection: Holiday testing shall be carried for detecting pinholes / porosity / discontinuities in the applied coating. The test shall be as per ISO 21809 & shall be
carried after 24 hours of application or shall be as per manufacturer’s recommendation. The scanning electrode shall be passed over the surface of the coating being inspected with a continuous, relative movement not exceeding 300 mm/s. Excessive voltages, slow survey speeds or multiple passes can damage the coating. The voltage should only be applied when the electrode is moving. Ring type electrode shall be used and will fit the required pipe size. At the time of the test, the voltage shall be set at a value depending on the material and minimum thickness of the coating. Holiday testing shall be done @ 5 KV/mm or as recommended by the manufacturer. Holiday marking and repair: An electric spark between the electrode and the metal surface will indicate any holidays or missed places. All holidays or missed places so indicated shall be marked by chalk or crayon and repaired. The repair shall be carried as per the procedure given by the coating manufacturer.

7.0 Repairs:

7.1 Any spot requiring repair as a result of visual or holiday inspection shall be removed and surface prepared again for re-application of tapes as per approved procedure.

8.0 Acceptable Manufacturers

8.1 [To be added]
Appendix- G

SPECIFICATION FOR
INTERNAL EPOXY COATING OF PIPELINES

1.0 General

1.1 This Specification defines the minimum technical requirements for the internal coating of line pipe.

1.2 The internal coating shall be as per ISO 15741 – 2001 (E). The applied coating shall provide corrosion protection during storage and transport for a minimum period of one year without significant breakdown of the coating. (what about long term storage?)

1.3 The coating material shall be qualified in accordance with this specification and shall not be changed after qualification. The manufacturer of the coating material shall provide on request infrared spectrograms of the base component and the curing agent component. In addition, the manufacturer shall provide a product data sheet, a health and safety data sheet and a certificate stating the test results obtained in accordance with inspection and tests given in this specification. The manufacturer shall also provide with every batch of the coating material a batch test certificate stating the information as given in 5.8.

1.4 The typical operating-temperature range for this type of coating is between -20 °C and 110 °C. Where, subsequently, external coatings have to be applied, care shall be taken not to allow the internal coating to be damaged by the elevated temperatures which may occur.

1.5 The CONTRACTOR shall submit a detailed written description of the internal coating equipment, procedures and materials, in the form of a Application Procedure Specification (APS), for COMPANY review and/or approval, in accordance with the contract documents. This shall include the Procedure for qualification of materials and application of coating along with details and results of tests on similar coating or trials performed by CONTRACTOR which document the quality of the finished coating. Such test results and/or trials shall demonstrate procedures and materials can supply a finished coating meeting the requirements of this Specification.

1.6 The APS shall include:

- Procedure for qualification of materials and application processes.
- Pipe handling and storage;
- Pipe cleaning and surface preparation, residual surface contamination;
- Coating application (multi-component spraying equipment);
- Testing and inspection;
- Coating repair.
2.0 Reference Codes / Standards

<table>
<thead>
<tr>
<th>S No</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>API RP 5L2</td>
<td>American Petroleum Institute, Recommended Practice for Internal Coating of Line Pipe for Non-corrosive Gas Transmission Service.</td>
</tr>
<tr>
<td>3</td>
<td>SSPC-SP-1</td>
<td>Solvent Cleaning</td>
</tr>
<tr>
<td>4</td>
<td>SSPC-SP-10</td>
<td>Near-White Blast Cleaning</td>
</tr>
<tr>
<td>5</td>
<td>SSPC-VIS-1</td>
<td>Pictorial Surface Preparation for Painting Steel Surfaces</td>
</tr>
<tr>
<td>6</td>
<td>ASTM D 638</td>
<td>Test Methods for Tensile Properties of Plastics</td>
</tr>
<tr>
<td>7</td>
<td>ASTM G95</td>
<td>Test Method for Cathodic Disbonding of Pipeline Coatings.</td>
</tr>
<tr>
<td>8</td>
<td>ISO 8503-1</td>
<td>Preparation of Steel Substrates before Application of (Part 1) Paints and Related Products – Visual Assessment of Surface Cleanliness</td>
</tr>
<tr>
<td>10</td>
<td>ISO 3251</td>
<td></td>
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</tbody>
</table>

2.1 The Contractor shall notify the Company of any conflict between this specification, the related data sheets, the Codes and Standards and any other specifications noted herein. Resolution and / or interpretation precedence shall be obtained from OWNER / CONSULTANT in writing before proceeding with the design & manufacture.

2.2 In case of conflict, the order of precedence shall be:

- Coating Manufacturers Data Sheets
- This Specification
- Industry Codes and Standards

3.0 Material Specification

4.0 Functional Requirements of Field Joint Coating

4.1 Coating shall withstand the following operating conditions with no change in coating adhesiveness, efficiency and/or performance.

- Peak Internal Pressure 250 barg
- Depressurization Rate 250 barg to 0.0 barg in 5 seconds
- Minimum Operating Temp 0ºC
- Maximum Operating Temp 60ºC

4.2 Manufacturer shall present prequalification certificates including a gas and hydraulic blister test certificates. The gas and hydraulic blister tests shall be modified from API RP 5L2 to use pressurize gas to 250 barg and depressurize to 0.0 barg in 5 seconds.

4.3 Coating shall withstand the presence of scraper, gauging and intelligent pigs operating through the length of the pipe with no change in the coating’s adhesiveness, efficiency and/or performance. If required, coating shall also withstand the heat required for subsequent coal tar enamel or three layer polypropylene corrosion prevention system coatings.

4.4 The mean coating thickness, for each pipe measured using a COMPANY approved gauge, shall be a minimum of 60 microns.

4.5 The maximum coating roughness, defined as the maximum measurement between the peaks and troughs, shall be 0.0075.

5.0 Qualification of Materials and Procedure

5.1 Coating Material

The Contractor shall carry-out the tests indicated below from an independent and reputed laboratory to confirm that the material meets the quality specifications claimed by the coating materials manufacturer as per the test methods indicated below or those mentioned by the manufacturer;

<table>
<thead>
<tr>
<th>S No</th>
<th>Parameter</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-Volatile matter by mass (^{(a)})</td>
<td>ISO 3251</td>
</tr>
<tr>
<td>2</td>
<td>Ash content (^{(b)})</td>
<td>Given below</td>
</tr>
<tr>
<td>3</td>
<td>Viscosity (^{(c)})</td>
<td>Given below</td>
</tr>
<tr>
<td>4</td>
<td>Adhesion</td>
<td>ISO 2409</td>
</tr>
<tr>
<td>5</td>
<td>Buchholz Hardness</td>
<td>ISO 2815</td>
</tr>
<tr>
<td>6</td>
<td>Resistance to Neutral Salt Spray</td>
<td>ISO 7253</td>
</tr>
<tr>
<td>7</td>
<td>Resistance to Artificial Ageing</td>
<td>Given below</td>
</tr>
<tr>
<td>8</td>
<td>Bend Test (Conical Mandrel)</td>
<td>ISO 6860</td>
</tr>
<tr>
<td>9</td>
<td>Resistance to Gas Pressure Variations</td>
<td>Given below</td>
</tr>
<tr>
<td>10</td>
<td>Resistance to Water Immersion</td>
<td>ISO 2812 -2</td>
</tr>
<tr>
<td>11</td>
<td>Resistance to Chemicals:</td>
<td>Given below</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cyclo-hexane</td>
</tr>
</tbody>
</table>

CIMG-GD-2-2019-0001 - Pipeline Coating Specifications
### Pipeline Coating Specifications

<table>
<thead>
<tr>
<th>S No</th>
<th>Parameter</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95% Diethylene Glycol solution in water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hexane</td>
<td>2812 -1</td>
</tr>
<tr>
<td></td>
<td>Methanol</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Toluene</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lubricating Oil (Compressor seal oil)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Resistance to Hydraulic Blistering</td>
<td></td>
</tr>
</tbody>
</table>

(a) Separate for base component, curing agent component and mixed coating material.
(b) Separate for base component and curing agent component (if pigmented).
(c) Only for the mixed coating

### 5.2 Cured Paint Film

5.2.1 This section describes the tests to perform to quality the application process. Failure of the pipe, test panels or slides to meet each acceptance criteria specified in this section shall require a retest.

5.2.2 Test panels (glass or steel) shall be prepared by spraying the paint to the dry film thickness required under this contract. All the tests mentioned herein shall be carried out on panels at least in duplicate.

5.2.3 Unless otherwise agreed, the dry film thickness of the coating, applied on a glass or steel panel, shall be between 60 µm and 100 µm except for the test for resistance to neutral salt spray. Unless otherwise agreed, the dry film thickness shall be measured in accordance with ISO 2808: 1997, Method No. 2 for glass and Method No. 10 for blast-cleaned steel.

5.2.4 The coated test panels may be conditioned, if specified, using one of the following cycles depending on substrate and test method:

a) Cycle A: Substrate: Steel or Glass
   - Condition at 18 °C to 25 °C and ≤ 80% relative humidity until the coating is at least tack-free.
   - Dry for 30 minutes in a circulating-air oven at (75±2) °C
   - Condition for a minimum of 30 minutes at 18 °C to 25 °C and ≤ 80% relative humidity before testing.

b) Cycle B: Steel or Glass
   - Condition at 18 °C to 25 °C and ≤ 80% relative humidity until the coating is at least tack-free.
   - Dry for 30 minutes in a circulating-air oven at (150±2) °C
- Condition for a minimum of 30 minutes at 18 °C to 25 °C and ≤ 80% relative humidity before testing.

c) Cycle C: Steel or Glass
- Condition at 18 °C to 25 °C and ≤ 80% relative humidity until the coating is at least tack-free.
- Dry for 30 minutes in a circulating-air oven at (40 ±2) °C
- Condition for a minimum of 30 minutes at 18 °C to 25 °C and ≤ 80% relative humidity before testing.

5.2.5 Unless otherwise agreed, the dry film thickness of the coating, applied on a glass or steel panel, shall be between 60 µm and 100 µm except for the test described in 5.3.6 (resistance to neutral salt spray). Unless otherwise agreed, the dry film thickness shall be measured in accordance with ISO 2808: 1997, Method No. 2 for glass and Method No. 10 for blast-cleaned steel, following the procedure given in annex B.

5.2.6 Prequalification tests shall include all production tests included in Section 10.0. In addition the following tests shall be performed for qualification of the process.

5.2.7 Resistance to Neutral Salt Spray

The coating, applied on steel panels with a dry film thickness of 60 µm to 75 µm, conditioned using cycle B or C above, and with an X-cut down to the substrate at least 20 mm from any edge, shall be tested in accordance with ISO 7253 for 480 h. After the test, allow the test panels to dry for at least 30 min at 18°C to 25°C and ≤ 80% relative humidity. The coating shall be free from any signs of deterioration, for example blistering (except in the area within 2.0 mm from the X-cut), cracking and staining. Any corrosion shall extend not more than 2.0 mm at the most from the X-cut. It shall not be possible to remove by means of clear plastic tape more than 3.0 mm of the coating in any direction from the area around the X-cut.

5.2.8 Resistance to artificial ageing

Prepare two different sets of coated test panels, each set consisting of 3 steel panels. The dimensions of the panels shall be approx. 100 mm X 50 mm X 0.8 mm. Carry out the following procedure:

- Condition set 1 using cycle C
- Condition set 2 using cycle C and then age the panel 80°C in a circulating air oven for 100 h followed by conditioning for 24 h at 18°C to 25°C and ≤ 80% relative humidity.
- After ageing, subject the test panels to a bend test in accordance with section 10.0. The result of the bend test shall comply with the requirement specified therein.

5.2.9 Resistance to gas pressure variation
Prepare steel panels and condition them using cycle B or C.

Substrates can be of two types:
- approx. 100mm x 50mm x 1mm steel panels;
- lengths of steel pipe approx. 100mm long with a minimum diameter of 80 mm or, if the diameter is too large for the pipe to fit into the chamber, specimens obtained from the pipe or fitting. The surface of the test panels or lengths of the pipe shall be prepared and coated at the same time and in the same way as the corresponding production surfaces.

Unless otherwise specified by the coating material manufacturer, wait a month after the coating has been applied to the test panels or lengths of pipe before carrying out any test.

This test is carried out as a qualification test on the inside coating. Put the specimen in the chamber and subject it to the set of 10 test cycles shown schematically below, as follows:

- Progressively increase the pressure in the chamber to 100 bar. - Keep the specimen under pressure for a fixed period of time to allow the pressurizing gas to penetrate into the coating:
  - 20 h for the 1st to 4th cycles and the 6th to 9th cycles,
  - 68 h for the 5th and 10th cycles;
- Release the pressure rapidly over a few minutes (not more than 5 minutes);
- Leave the coating at atmosphere pressure for 4 h to permit the development of any blisters on the coating, so that a cycle lasts either 24 h or 72 h (this latter period corresponds to the weekend, i.e. from Friday to Monday).

Immediately at the end of the 10th test cycle, open the chamber and examine the appearance of the coating, noting all modifications (corrosion, spots or blisters). In addition, carry out an adhesion test in accordance with ISO 2409. Repeat the appearance examination after 24 h and after 48 h, again noting all modifications. Figure C.1 – Complete set of pressure cycles.
When the panels are tested as above, they shall have a generally good appearance when examined in accordance with 5.2.9 and shall not show any blistering. The adhesion value shall fulfill the requirements given in 5.3.4 after conditioning for 24 h and 40 h at 18 °C to 25 °C and ≤ 80% relative humidity.

5.2.10 Resistance to Chemicals

Prepare steel panels and condition then using cycle B or C. When the panels are tested in accordance with ISO 2812-1:1993, Method No. 1, Procedure a, for 168 h, the coating shall not show any blistering or appreciable softening. Use the following test liquid: cyclo hexane; 95% by volume di-ethylene glycol solution in water; hexane; methanol; toluene and lubricating oil (e.g. compressor shall oil in accordance with ISO 6743-4). The test panels shall be completely immersed in the test liquid.

The examination shall be carried out at 18 °C to 25 °C and ≤ 80% relative humidity 3 min after the panels have been removed from the test liquid. After conditioning for 24 h at 18 °C to 25 °C and ≤ 80% relative humidity, the adhesion value shall fulfil the requirements given in section 10. A change in the colour of the coating shall not be considered as an indication of inferior coating quality.

5.2.11 Resistance to Hydraulic Blistering

Prepare steel panels and condition them using cycle B or C.

Substrates can be of two types: - approx. 100 mm x 1 mm steel panels; - lengths of steel pipe approx. 100 mm long with a minimum diameter of 80 mm or, if the diameter is too large for the pipe to fit into the chamber, specimens obtained from the pipe or fitting. The surfaces of the test panels or length of the pipe shall be prepared and coated at the same time and in the same way as the corresponding production surfaces.

This test is carried out at least 100 bar if the maximum operating pressure is 100 bar or less. If the operating pressure is higher than 100 bar, the test pressure shall be at least the pressure specified for that pipeline. Put the specimen in the chamber and then subject it to the specified pressure specified for 24 h so that the pressurizing liquid can be penetrate into the coating. Release the pressure rapidly over a few minutes (not more than 5 minutes).

Immediately at the end of the test cycle, open the chamber and examine the appearance of the coating, noting all modifications (corrosion, spots or blisters). In addition, carry out an adhesion test in accordance with ISO 2409. Repeat the appearance examination after 24 h and after 48 h, again noting all modifications.

After the above test, the coating shall not show any blistering. The examination shall be carried out at 18 °C to 25 °C and ≤ 80% relative humidity 3 min after the panels have been removed from the test liquid. The adhesion value shall fulfil the requirements given section 10 after conditioning at 18 °C to 25 °C and ≤ 80% relative humidity for 24 h.
6.0 Pipe Receipt, Handling, Inspection and Repair

6.1 All pipes shall be thoroughly examined visually upon receipt for condition and possible damage. CONTRACTOR shall complete a COMPANY reviewed and/or approved Receiving Inspection Report which shall detail as a minimum, date, location, transport reference, pipe number, pipe length, diameter and wall thickness and coating type and thickness. Any visible damage, flaws, corrosion, dents, gouges, bevel damage, or other defects shall be reported in writing to COMPANY. Damaged pipes, especially pipes showing cuts, flattening, buckling, out-of-roundness, out of straightness and other permanent deformation on the body or ends, shall be stacked apart and provided with conspicuous marking. COMPANY may request CONTRACTOR to make good the damaged pipes. Materials furnished by COMPANY and received by CONTRACTOR shall be in the custody of CONTRACTOR from the time of receipt until used, or until returned to COMPANY custody. Pipe segments may consist of pre-joined multiple pipe lengths. CONTRACTOR shall be required to submit handling procedures for the extended lengths for COMPANY approval. The manufacturing information details of each pipe length, marks stencilled on the pipe length shall be recorded before commencement of surface preparation. CONTRACTOR shall maintain the pipe reference number throughout all processes.

6.2 After internal coating, the identification markings must be placed on the inside surface of the pipe, starting at least 50 mm from the bevelled end of the pipe, but not within 10 mm of the internal coating. The full stencil shall be placed on each end of the pipe. All damage caused to materials whilst in the custody of CONTRACTOR shall be immediately reported to COMPANY and subsequent repairs shall be performed to a COMPANY approved procedure. Repair by welding is not permitted.

6.3 The handling of pipe and other free issue materials shall be performed in a manner preventing damage to the coating, pipe wall, bevelled ends and similar items. Pipe shall not be dragged but physically lifted with wide non-abrasive belts or brass-lined end hooks. When lifting pipe with end hooks, a spreader bar shall be used between lifting lines. During handling the pipe shall not be subject to impacts or jars. All pipe handling equipment and procedures shall be set forth in the Handling Procedure submitted for the review and/or approval of COMPANY.

6.4 Line pipes shall be stacked in accordance with approved procedure and in such a manner so as to prevent damage to the pipe or coating. CONTRACTOR shall submit proposed stacking arrangements, including stacking heights and use of spaces, to COMPANY for approval prior to use.

6.5 All damage to square cut or bevelled pipe ends, including dents or gouges, shall be repaired by CONTRACTOR by removal of a cylindrical section of the pipe materials. The length of the cylindrical section removed shall vary due to the extent of damage, but as a minimum the length of the section removed shall provide for the total removal of the damaged area plus 25 mm of parent material. Removal of damaged material and
subsequent inspection of sound material shall be performed in accordance with COMPANY approved repair procedure.

6.6 Pipe lengths, in which a section of pipe is removed shall be ultrasonically inspected, circumferentially, for a distance of 100 mm from the pipe end to detect any laminations or inclusion type defects. The ultrasonic inspection shall be performed by a qualified operator and witnessed by COMPANY. The inspection procedure and equipment shall be described in the NDT Procedures reviewed and/or approved by COMPANY. The pipe identification numbers shall be preserved by CONTRACTOR during repair. Due allowance for cut-off lengths shall be made by CONTRACTOR in the tally of pipes and pipe lengths welded into the pipeline. A detailed report of the pipe end cut and ultrasonic examination shall be submitted to COMPANY. Repairs to line pipe to rectify minor surface damage such as nicks, scratches, and similar items shall be performed by grinding. Repair by grinding shall not reduce the wall thickness to less than 97% of the specified minimum wall thickness as set forth in COMPANY Specifications. The wall thickness remaining after removal of minimum surface defects shall be determined by CONTRACTOR utilizing ultrasonic inspection techniques. Identification numbers shall be transferred by CONTRACTOR to sections of the pipe length removed due to defects, by stamping on bevels. COMPANY shall witness transfer of any pipe numbers

6.7 Damage to External Coating Damage to external coating shall be repaired by CONTRACTOR in accordance with COMPANY Specifications.

6.8 CONTRACTOR shall maintain a Material Control Record to record properly the receipt, issue, return or disposal of all materials supplied by COMPANY. CONTRACTOR shall permit the inspection of these records by COMPANY at all reasonable times. In particular, the Materials Control Record shall reference the identifying number stencilled on the inside of one end of each pipe length, and the batch number of each batch of coating material received. CONTRACTOR shall submit details of his material control recording procedure to COMPANY for review and/or approval prior to commencement of the works.

7.0 Coating Materials

7.1 CONTRACTOR shall supply all materials including, but not limited to;

- Multi-component liquid coating;
- All equipment for handling, cleaning and coating line pipe;
- All equipment to test and/or inspect the pipe, panels and slides;
- All instruments or standards for calibrating such devices and all tools necessary for completing the work

7.2 CONTRACTOR shall obtain the following certified data from Manufacturer for each batch of liquid coating: (a batch being Manufacturer’s shipping pack, as covered by the certificates concerned).

- Total non-volatile content;
• Viscosity;
• Specific gravity;
• Mixing ratio;
• Stability;
• Flash point;
• Pot life at various temperatures;
• Toxicity and handling.

7.3 CONTRACTOR shall obtain the following certified test data from Manufacturer to ensure minimum physical property requirements of this Specification can be obtained. Tests shall be conducted in accordance with API RP 5L2 using testing procedures submitted to and approved by COMPANY.

- Water and Mixture (methanol and water) Immersion;
- Bend;
- Adhesion;
- Salt Spray;
- Hydraulic Blistering.

7.4 The gas blistering and hydraulic blistering tests shall be performed at a pressure of 250 barg ±7 barg for 24 hours. The remainder of the test procedures and acceptance criteria shall be in accordance with API RP 5L2. To confirm that coating materials have been manufactured, handled, shipped and stored properly, CONTRACTOR shall perform a cure test on each batch within one week of use. The cure time shall be as specified by Manufacturer.

Prepare two steel panels for each batch as described in API RP 5L2. Coat and cure each panel to manufacturer’s specification. Immerse cured panel in solvent, same as thinner used for coating material, for a period of four hours. No softening, wrinkling or blistering of the coating film shall be observed after 30 minutes recovery period at room temperature (10-25°C).

7.5 Coating materials shall be stored in accordance with Manufacturer’s recommendations.

7.6 Each batch of coating material should be used within a period of dictated by Manufacturer.

7.7 Coating materials shall be handled and stored in accordance with applicable local safety regulations and the material Manufacturer’s recommendations, and shall be used according to the Manufacturer’s batch sequence. The containers or packages of coating material to be used for coating shall be properly handled in order to avoid any damage, scattering or pollution during loading, unloading and storage.

8.0 Surface Preparation

8.1 Immediately prior to the initial blast cleaning, all pipe shall be washed to remove any loose mill scale, rust, water, oil, graphite, grease marking materials, and other foreign
materials that adversely affect the quality of the coating. Cleaning shall be performed using an emulsion cleaner and washing. Initial fresh water washing shall be carried out to ensure removal of soluble salts. Any pipe with contamination such as oil, grease, temporary coatings or other substances which may contaminate the blast cleaning medium left after washing shall be conspicuously marked and set aside for inspection by COMPANY.

8.2 After the washing process and prior to blast cleaning rinse with clear water to remove any harmful residue of cleaning agents and/or detergents. Moisture shall be removed by preheating of pipe to 65°C to 85°C. The pipe shall then be maintained, until after coating, at a temperature at least 3°C above dew-point. Pipe cleaning and drying shall be in accordance with API RP 5L2.

8.3 Internal cleaning shall be performed by rotary blast or air blast cleaning. The blast cleaning media shall be dry, clean and free from contamination. Once established, a stabilized working mix of blast cleaning media shall be maintained by frequent small additions commensurate with consumption. Large additions of new material shall be avoided. The working mix shall be frequently checked (minimum once daily) and continuously cleaned to maintain it free of contamination. In the case of oil or grease pollution, the mix shall be completely replaced. The cleaning media shall be as specified by Manufacturer and approved by COMPANY.

8.4 The interior pipe surface shall be finally cleaned to ISO 8501-1a, Sa 2½ to 3. This Standard shall be interpreted to mean that metal surfaces shall be blast cleaned to completely remove all dirt, mill scale, rust, corrosion products, oxide, paint and other foreign matter from steel surface. The surface shall have a uniform grey appearance. CONTRACTOR shall ensure all salts have been removed.

8.5 Upon completion of the blasting operation, COMPANY shall approve the pipe for coating, or return for re-cleaning, or at his discretion, reject if imperfections so warrant.

8.6 Rejected pipe shall be noted, recorded, and the pipe marked “suspect steel”. The marking shall be made on the external body of the pipe by CONTRACTOR using French chalk only; oil or paint based markers shall not be used. The pipe shall be moved to a quarantine area for further inspection/treatment. Re-cleaning or returning pipe to yard shall be at the CONTRACTOR’s expense.

8.7 The blast cleaned surface shall be vacuum cleaned of dust or other loose containments. Coating shall take place before there is any visible deterioration in the cleanliness of the surface and within 4 hours of blast cleaning.

9.0 Application of the coating

9.1 Coating components shall be mixed to a homogenous state before any part of the component is withdrawn from its container.

9.2 The components shall be mixed in accordance with the Manufacturer’s instructions. Where preheating of components is required, only COMPANY approved equipment shall
be used. Excessive heating may affect coating integrity and shall be avoided. Should preheating of surfaces to be coated be required, only COMPANY approved procedures shall be used. If externally coated, heating of surfaces shall be controlled to avoid damage to the corrosion protection coating.

9.3 Use of thinners shall not be permitted unless recommended by Manufacturer. All equipment shall be cleaned using only Manufacturer recommended solvents.

9.4 When solvent flushing of spray equipment is used between coating periods, CONTRACTOR shall ensure that solvent free material only is applied on recommencement of spraying. Additionally, all flushing operations shall be carried out by discharging any solvent into suitable containers.

9.5 Filters shall be used in spray equipment.

9.6 Coating feed lines to spray gun shall be equipped with a pressure gauge, including pulsation damper, located near to the gun tip and downstream of all pressure drop devices. Oil and water traps shall also be fitted.

9.7 CONTRACTOR shall monitor and record ambient temperature, metal surface temperature and relative humidity at all times during coating. Recordings shall be in accordance with Manufacturer’s recommendations. Coating operations shall be stopped when ambient conditions do not comply with these recommendations, and when inferior coating will result.

9.8 Application of coating material shall be applied to the prepared pipe surface leaving a cutback of 100 mm.

9.9 The roughness of the internal coating shall be measured using a profilometer. The maximum roughness may not exceed the values specified in Section 9.0 of this Specification.

10.0 Inspection & Testing

10.1 The tests described in this section shall be performed for proper quality control of the coated pipe at a frequency that will assure control. The production tests shall be performed by CONTRACTOR, at the frequencies in the table below, unless prior written agreement is given by COMPANY. During the application of coating, test panels and slides shall be prepared and coated as described in 10.2.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Material</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient Temperature</td>
<td>Environmental conditions</td>
<td>At every change of shift</td>
</tr>
<tr>
<td>Steel Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Humidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash Point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Inspection</td>
<td>Pipe (Before Surface Preparation) Imperfections</td>
<td>Each pipe</td>
</tr>
</tbody>
</table>
Test panels and slides shall be prepared and coated in accordance with API RP 5L2. Steel panels shall be sand blasted prior to coating and glass slides shall be solvent cleaned, by rinsing with xylol and then acetone, prior to coating. Test panels and slides shall be attached to the inside of a cleaned pipe prior to coating. After the test panel or slide is coated in accordance with API RP 5L2 the panel or slide is to be removed, the test area on the pipe is spot repaired as described in Section 9.0.

10.3 Visual Inspection

10.3.1 Each joint of coated pipe shall be visually inspected from each end by CONTRACTOR for surface imperfections, blemishes, and similar defects. Coating shall be smooth, blemish-free with no dust or other particular inclusions and no indication of “orange peel”. The applied coating film should be uniform in gloss, thickness, and color and should be free of irregularities. Pipe found to have defects shall be set aside for further investigations by COMPANY.
10.4 Pinhole Test
10.4.1 Observe glass slide before and after curing, holding slide over a slot in a container which houses a 100 Watt bulb, the bulb being a distance of between 100 and 130 mm from the coated slide. Evaluation shall be made by COMPANY. Pinhole dispersion shall be held to a minimum.

10.5 Film Thickness Test
10.5.1 Using a micrometer with ratchet, measure the uncoated glass slide, then coat and measure the cured slide at the same time location for slide- plus-coating thickness. The difference of the two is the coating thickness. The mean coating thickness shall be within $-0.0$ microns $+20.0$ microns of the nominal thickness specified in Section 4.4 Pipe with coating thickness measured below the minimum value shall be rejected.

10.6 Bend Test
10.6.1 Bend a cured panel, bend $180^\circ$ around a conical mandrel with a diameter of 13 mm, the panel shall show no flaking, loss of adhesion or cracking of the coating, as determined by unaided visual inspection.

10.7 Adhesion Test
10.7.1 In an area of the panel at least 13 mm removed from an edge, using a new stiff razor blade, cut the coating through to the metal with 16 lines evenly spaced over one inch. Then make 16 similar cuts at $90^\circ$ through the previously made 16 cuts. The cutting will thus produce 225 squares of coating attached to the metal, each about 1.6 mm on a side. Apply 25 mm wide clear plastic tape to the area. Firmly press with the thumb nail so as to yield a uniform color of contact area. Remove the tape with a snapping action.
10.7.2 Inspect the squares thus produced. Acceptance is constituted by lifting of no material other than cuttings.

10.8 Cure Test
10.8.1 Immerse cured panel or slide in solvent, same as thinner used for coating material, for a period of four hours. No softening, wrinkling or blistering of the coating film shall be observed after 30 minutes recovery period at room temperature.

10.9 Buchholz Hardness Test
10.9.1 This test shall be performed in accordance with ISO 2815 and the Buchholz hardness of the coating shall be at least 94.

10.10 Water Immersion Test
10.10.1 After a minimum of 4 hours immersion in either fresh water or an aqueous solution, containing (by weight) 1% sodium carbonate, the cured panel shall exhibit no loss of adhesion, softening, wrinkling, or blistering of the coating film.

10.11 Stripping Test
10.11.1 The panel shall be placed on a flat surface with the coated side up. A sharp blade, held at approximately 60° to the surface should be pushed so that the blade has a tendency to lift the coating. The coating shall not be removed from the test panel in strips but shall flake off. The flakes when rolled between the thumb and forefinger shall produce powdery particles.

11.0 Repairs:

11.1 Defective or damaged pipe coating shall be spot repaired by CONTRACTOR with a manual atomizing spray gun or brush, for up to an area of 150 sq. cm. Coating damage exceeding the pre-set acceptance criteria shall be rejected. Pipe may be stripped with no heating and re-coated at CONTRACTOR’s option.

12.0 Acceptable Manufacturers

12.1 The following coating material Manufacturer and products have prequalified for the provision of internal coating:

- PERMATEX 337;
- COPON EP 2306 HF;
- HEMPADUR GASPIPE COATING 8544;
- HEMPEL’S GASPIPE COATING 834D.

13.0 Documentation

13.1 General

13.1.1 CONTRACTOR shall submit all documentation to COMPANY for review and/or approval as required by the Contract, this Specification and other referenced Specifications.

13.2 Initial Submissions

13.2.1 Documentation shall be issued by CONTRACTOR for review and/or approval by COMPANY, to an agreed schedule.

13.2.2 The documentation shall include, but not be limited to, the following:

- All procedures stated in this Specification;
- Quality Plan;
- Stacking Procedure;
- Manufacturing Procedure Specification;
- Certificates of tests to qualify coating material.

13.3 Final Submissions

13.3.1 CONTRACTOR shall submit a Data Book, upon completion of the internal coating application containing, but not limited to, the following documentation in accordance with the Contract requirements.

- Completed Quality Plan;
<table>
<thead>
<tr>
<th>Title</th>
<th>Pipeline Coating Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Guidance</td>
</tr>
<tr>
<td>Reference</td>
<td>CIMG-GD-2-2019-0001</td>
</tr>
</tbody>
</table>

- Manufacturer’s certificates for each coating batch received;
- Records, results and other documentation for all coating components and coating tests;
- Material Control Records;
SCOPE OF WORK AND TECHNICAL SPECIFICATION FOR
COATING REFURBISHMENT OF EXTENDED LENGTHS OF BURIED PIPELINES AT SITE

1.0 Scope

1.1 This section deals with buried pipelines with coal tar/bitumen and other coatings like Cold tape, which now exhibiting signs of extreme deterioration due to their ageing. The requirements for cathodic protection have also reached a level where the existing CP system is no longer able to provide sufficient protection to the pipeline and hence corrosion may be taking place due the deterioration of the coating. This may also include the pipelines where a large percentage of the pipeline metal is now exposed to the soil and the cathodic protection systems are under performing.

1.2 If the life of the pipeline is to be extended, consideration must be given to rehabilitation of the pipeline coating and/or the cathodic protection systems. Rehabilitation may be in the form of extensive coating testing to locate areas of severe coating deterioration and then repair by excavation, removal of old coating and applying a new coating. This is a long, difficult and very costly exercise.

1.3 The contractor’s scope shall include the following and associated works and the rates quoted by the Contractor shall be deemed to include all the costs:

1.3.1 All the coating materials, consumables, equipment, measuring instruments, laboratory testing, tools and tackles required for the completion of coating refurbishment work shall be supplied by the Contractor as per the technical specifications given hereunder.

1.3.2 Assistance in opening of Right of User and liaising with land owner / cultivator, locating the pipeline route and staking, shifting of GAIL markers/CP test stations minor structures, diversion of field channels (including temporary hume-pipe channels), clearing of vegetation / crops, grading for the width in ROU required to excavate & expose pipeline (working trench) and approach / movement of vehicles / equipment for the coating work and restoration of the ROU to satisfaction of the land owner / cultivator (obtaining written certificate).

1.3.3 All the jobs mentioned in this specification and related works in making the coating refurbishment work complete in all respects.

1.3.4 GAIL’s obligation shall be providing pipeline details and maps or assistance in locating pipeline in the field and payment for the work done against certified invoices.

2.0 Coating Materials

<table>
<thead>
<tr>
<th>Coating System</th>
<th>Technical Specification Ref</th>
<th>Surface Preparation</th>
</tr>
</thead>
</table>

[GAIL site shall select either 3 ply / 2 ply Cold Applied Tape Coating or Visco Elastic Coating for the particular application based on field requirement, quantum of job and...|
other considerations; Corresponding Technical specifications given in the appendices of this Guidance Document shall be annexed to and referenced in this part of the document when used to call tenders].

3.0 Procedure for locating pipeline, excavation and pipeline exposure:

3.1 This includes clearing of ROU for carrying out coating refurbishment works, identification of buried pipeline /pipelines in the ROU using pipeline locators and cross trenching at regular intervals, marking pipeline alignment as for the trench excavation work including but not limited to cutting/clearing the ROW of all bunds, dewatering surface water in submerged section/in pipe trenches, vegetation, bushes, trees etc. to enable movement of vehicles & equipment to enable excavation of the trench for coating and wrap works.

3.2 List of Pipeline markers, turning points, boundary pillars etc. in the ROW shall be provided by GAIL. However establishing exact alignment of pipe is to be done by contractor by using Pipeline Locators or by digging bell-holes.

3.3 Earth work in excavation includes in all types of soils like hard murrum, dry/wet conditions, water logged areas requiring shoring/shuttering and de-watering of surface water / water in pipeline trench up to depth required to expose the pipeline all around and width including but not limited to road cutting and providing necessary by-pass roads for movement of vehicle / equipment etc. and further restoring the road to its original condition.

3.4 All excavations shall be carried out as per IS 3764 Excavation Work – Code of Safety and OISD-GDN- 192 – Safety Practices During Construction.

3.5 Suitable barricading of 1m height with glowing caution board shall be provided for excavation beyond 2.0 m depth.

3.6 All trenches in soil / friable or unstable rock more than 2.0 m deep shall be securely shored and timbered. In case of high water tables, continuous flow of water in the trench, shoring shall be required at lesser depth also.

3.7 Excavations shall have suitable arrangement for moving in and out of the trench like ladders etc. are to be provided every 30 m of length or fraction thereof. Ladders shall extend at least one meter above the top of the cut to provide a hand hold when stepping on or off the ladder.

3.8 Wherever necessary, suitable cross-over / temporary bridges should be provided and maintained over the open ditch to permit general public, property owners or his tenants to cross or move stock or equipment from one side of the trench to the other. The width of such crossovers shall not be less than 75 cm and shall be strong enough to withstand the intended use. During excavation, mechanical excavator should not touch GAIL pipelines or adjacent pipelines of other companies. The earth around pipeline should be removed manually to prevent any damage to pipeline.
3.9 Extra precaution must be taken while exposing pipeline. Additional precautions in places where there are other crossings like other pipelines, water pipes, OFC, power cables, drainage system underneath or above the Owner’s pipeline.

3.10 Ascertaining pipe depth by making cross-trenching at suitable intervals 100-110 meters to understand exact depth of pipe, parallel pipes in the common ROW, fibre optic cable orientation with respect to the pipe so that damage to pipe, foreign pipes, fibre optic cable by excavator during excavation is avoided.

3.11 Normally, the pipeline is buried up to a depth of 1.5m. However, the depth may vary depending on the site conditions. The depth of pipeline at Nala, Rail, Cart track and Road may be up to 3.0 m to 5.0 m or more on either side near the crossings depending on site conditions. Excavation at all places has to be carried out at all depths on ROW.

3.12 Excavation shall require mechanical means (except blasting) / chiselling / pneumatic drilling for required length of stretch along the pipeline trench.

3.13 Special care to be exercised in cleaning all debris, loose material, rock particles etc. from the ROW to prevent the soil intended to be used for backfilling the ditch, becoming mixed with such debris.

3.14 The trench is to be cut to a grade that will provide sufficient space for carrying out surface preparation and coating refurbishment works. The trench size should be such that on all sides of the exposed pipe and including bottom there has to be a clearance as given below from the outer wall of pipe.
  - Ground clearance: 500 mm
  - Lateral clearance: 800 mm

3.15 ROW facilities like TLP, boundary pillars, KM post, turning posts and caution boards etc. to be taken care during excavation. All these facilities are to be restored after coating & wrapping work to its original condition.

3.16 Trenching in all water logged areas/ marshy areas/ water crossings like canal / nala crossings etc. shall be provided with shoring and shuttering.

3.17 During excavation, the exposed pipeline section shall be provided with earth support to ensure maximum unsupported length of less than 10 m. However, if required, sand bags shall be provided to support pipe section at a suitable distance, wherever required with the help of side boom / hydra, tripods, winches etc. during the course of repair/refurbishment work.

3.18 The supported portions shall be taken up after completion of works on unsupported length. The unsupported length shall be backfilled and soil compacted adequately. Sand bags shall be provided as required to support the pipe before starting work on supported sections. The sand bags will be punctured / removed once area around it is backfilled and compacted properly.

3.19 At road crossings where pipeline crosses a kuccha or Hard standing road etc. this include
exposing the pipe by road cutting, shoring, shuttering and providing necessary by-pass roads for movement of people and vehicle/ equipment and further restoring the site to its original condition. This also includes the permissions from the concerned authorities, bodies, landowners etc.

3.20 Restoration of roads to its original shall be performed for only SH/NH, PWD or Govt. roads, defense roads, forest roads. Public travel shall not be unnecessarily inconvenienced, nor shall it be wholly constructed at any point, without consent of the responsible authorities.

3.21 Watchman, detours, lights, barricades and signage shall be provided where necessary to fully protect the public.

3.22 With regard to soil conditions and/or the topography of the ground, the trench shall be excavated and finished to the minimum dimensions as indicated above or as directed by GAIL for earth & rock with a view to expose the pipeline and to provide for sufficient working space for carrying out the coating work all round the circumference of pipeline.

3.23 The excavated length of pipeline shall be such as to carry out the intended length of coat and wrap as per standard coating practices.

3.24 While backfilling, the soil recovered from around the pipe i.e. in close vicinity of the pipeline shall be used for backfilling over the newly coated pipe, care shall be exercised to see that no loose debris or foreign material or stones are used for backfilling directly on in the trench.

3.25 The pipeline will be exposed 300-400 meters at a stretch and as directed by OIL /PMC. It is to be ensured that the exposed pipeline in the trench is re-coated within the shortest span but not more than 5 to 6 days. 24x7 security shall be provided by the contractor for the exposed pipelines. Flood lights shall be provided for safety at suitable distances.

4.0 Procedure for coating removal and inspection of pipe surface:

4.1 Before the application of coating, all paint or temporary protection, previous coatings, oils or grease, grinding and welding slags, rust, unevenness, burrs, grooves, dirt, mud, moisture and any other foreign matter must be removed from the pipeline surface.

4.2 Removal of the old coal tar coating and cleaning, surface preparation of pipe conforming to Sa 2 1/2 by abrasive blasting for 3ply / 2 ply cold applied tape coating and hand tool / power tool cleaning conforming Swedish standard St-2 or St-3 for Visco-elastic & petrolatum tape coating application.

4.3 Pipe wall thickness of each pipe length exposed for coating refurbishment shall be measured using a standard digital ultrasonic thickness gauge duly calibrated at every weld location and at locations where pitting is observed or at locations as advised by GAIL. The wall thickness data shall be properly documented along with GPS coordinates of pitted sections.

4.4 Application of the required coating system 3ply / 2 ply cold applied tape / Visco-elastic /
petrolatum tape system as per specified application procedure and manufacturer’s recommendation shall be done.

4.5 Old coating shall be manually removed using scrappers and small brass hammers. In no case hard hammer shall be used that may result in formation of dent on pipe.

4.6 The old and damaged coating over the pipe shall be removed carefully with the scrappers and small brass hammers, so that outer surface of the pipe is not damaged. After the coating is removed, the pipe surface shall be thoroughly cleaned of old primer, scales, rust, if any, and dust particles. The cleaning of pipe surface shall be carried out to the satisfaction of GAIL.

4.7 After excavation and removal of old CTE coating, thorough physical inspection of pipeline surface shall be carried out. All pitting and corrosion patch if any, depth shall be measured with the PIT gauge.

4.8 Actual wall thickness of the pipes should also be measured at every weld location and at locations where pitting is observed at four locations (12’clock, 3’o clock, 6’o clock and 9’o clock) and also the suspected area and at equal intervals with the help of the UT thickness gauge.

4.9 Based on the thickness measured, the actual health of the pipe can be known. If all these defects are within the permissible limits, only then blasting shall be allowed at normal blasting pressure.

4.10 If the pipeline defects are beyond the acceptable limit as per GAIL Policy, pipeline shall be repaired by welding full encircled metallic sleeve/Composite sleeve as per direction of GAIL.

5.0 Procedure for application of coating:

5.1 General Requirements:

5.1.1 Equipment, accessories, inspection and testing instruments for coating material as per manufacturer’s recommendation shall be in good operating conditions for completing the coating refurbishment job.

5.1.2 All the equipment like suitable Diesel Generator, Welding Machines etc. and other utilities shall be made available.

5.1.3 All the deployed/engaged personnel for Coating application (supervisors and applicators, inspections and quality assurance) shall be well trained from the manufacturer or their authorised agencies or organisations like NACE / CECRI / [To be added].

5.1.4 Only those applicators certified by the coating manufacturer’s representative shall be deployed for wrapping and coating application. In case the application crew gets replaced, certification for application of the wrapping and coating will have to be carried out by the coating manufacturer’s representative again.
5.1.5 Coating manufacturer technical representative should be available at site during the application of Coating whenever GAIL required them. It should be ensured that sufficient applicators are trained so as to ensure that there is no stoppage of work.

5.1.6 The coating material along the ROW shall be stored in a temporary storage such as it does not get damaged due to rain etc. The coating material shall be transported to ROW with proper plastic / tarpaulin cover.

5.2 Surface preparation of the pipe to Sa 2 ½ [Liquid PU and Cold Applied Tape Coat]

5.2.1 Before starting of blasting, all fire and safety precautions should be taken. All fire and safety precaution must be ensured prior to start of work. Lower explosive limit (LEL) of hydrocarbon & O₂ level near the trench must be recorded and proper escape route must be provided. Adequate Dry chemical powder fire extinguisher, water and sand must be available during working on site.

5.2.2 Abrasive used for blast cleaning should normally contain large and small size particles. Larger particles crack the mill scale and existing coatings, whereas the smaller one results in increased cleaning rate. Particle size distribution should be selected to get required anchor profile during blast cleaning.

5.2.3 A near-white blast cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dust, dirt, mill scale, rust, old paint/primer, coating, oxides, corrosion products and or any other foreign matter.

5.2.4 Relative humidity and dew point shall be recorded every 2 hours during blasting and coating application and shall be recorded in the coating log book.

5.2.5 Any unacceptable pipe defects detected at the time of surface preparation must be brought to notice and hold the pipe till cleared by owner for further action.

5.2.6 Optimal environmental conditions are essential for surface preparation, application of coating to maximize successful performance.

5.2.7 Blasting / coating activity will be done only if the relative humidity is ≤ 85%. The surface temperature of the steel pipe shall be > 3°C above dew point.

5.2.8 The following measurements shall be taken and recorded before start of the work at each site/location:

   - Ambient dew point.
   - Relative humidity
   - Dew point at near the metal surface.
   - Surface temperature of the metal pipe

5.2.9 Coating contractor shall ensure that calibrated relative humidity / dew point measurement instruments and contact digital thermometers are available at each blasting / coating location. Valid calibration certificate of measuring equipment to be submitted to GAIL.
5.2.10 After the pipe has been inspected for corrosion pits / wall thickness measured, the pipe surface shall be abrasive blasted to surface finish of Sa2 1/2 and anchor profile of 50-100 microns. The salt contamination on the abrasive blasted steel surface shall be < 20mg/m2.

5.2.11 Prior to abrasive blasting it shall be ensured that pipe surface shall be free of oil, grease salts and other contaminations. Suitable solvents which do not leave any residuals like benzene, xylene or equivalent shall be used. Kerosene shall not be used for cleaning. Solvent cleaning procedure shall be according to SSPC-SP1. Pipe surface will be dry prior to start of abrasive blasting.

5.2.12 Copper slag shall be used as abrasive media for surface preparation of pipe surface. The copper slag shall be supplied as per ISO 11126-3 (Preparation of steel Substrates before application of paints and related products - Specifications for non-metallic blast-cleaning abrasives - Part 3: Copper refinery slag).

5.2.13 Minimum 2 sets of air compressors / blasting pots per opening shall be deployed to achieve an average blasting production rate of 70 to 110 meters / day. Compressor shall not be older than 7 years from the date of award of project. Diesel engine driven air compressor used shall be of rating 60 to 75 HP to produce displacement of 5.6 to 7.0 m³/min (200 to 250cfm) of clean compressed air at a pressure of 7 Kg/cm² at nozzle.

5.2.14 Clean compressed air is required to prevent contamination of coating materials and surfaces being prepared for coating as such air compressors to be deployed shall be fitted with suitable air dryers, oil / moisture traps with desiccants. The quality of the compressed air shall be checked two times / day as per ASTM D 4285-2012 “Standard Test Method for Indicating Oil or Water in Compressed Air”.

5.2.15 All oil / air pressure gauges attached to the compressor unit shall be in perfect working condition with valid calibration. Compressors with defective instruments shall not be acceptable.

5.2.16 The moisture traps and the condition of the desiccants / air dryers shall be checked regularly. The blasting pot will be fitted with pressure regulator with safety valve, water separator / filter & hoses. The nozzle shall preferably be of ceramic type having orifice of 5/16” or as required to get the required surface finish of Sa2 1/2 with anchor profile of 50-100μ. Sufficient nozzles will always be available at each blasting location for quality blasting.

5.2.17 The abrasive blasting media to be used is copper slag. Brief specification of the abrasive media is as below:

<table>
<thead>
<tr>
<th>Specification for mineral and slag abrasives (ISO 11126-3 Part-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property</strong></td>
</tr>
<tr>
<td>Water Soluble Contaminants</td>
</tr>
</tbody>
</table>
Title: Pipeline Coating Specifications

Type: Guidance


<table>
<thead>
<tr>
<th>Property</th>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil content</td>
<td>Observing the surface of extract</td>
<td>No oil</td>
</tr>
<tr>
<td>Moisture content</td>
<td>ASTM C 566</td>
<td>0.50%</td>
</tr>
<tr>
<td>Hardness</td>
<td>ASTM C 566</td>
<td>6 minimum</td>
</tr>
<tr>
<td>Specific gravity</td>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td>Bulk density/Particle</td>
<td></td>
<td>1.87 Kg/L (Particle size ranging from 0.5-2 mm)</td>
</tr>
</tbody>
</table>

5.2.18 Test certificates of each batch complying with the above specified properties shall be obtained.

5.2.19 Blasting practices shall be such as those recommended in SSPC SP-COM. For heavily pitted localized surface, the nozzle shall be suitably rotated around its own axis in all planes and held at various angles so that the abrasive cleans out all the pores and interstices of the surface being blasted.

5.2.20 Suitable spray masks filter type air respirators, safety goggles and other safety equipment are to be provided to the persons engaged for the job. Blast cleaning team should take up precautionary measures to protect the pipeline during blasting operation. Proper personnel protection equipment required during blasting shall be used.

5.2.21 Checking of profile of the blasted surface: The blasted steel surface shall be inspected prior to application of the coating using:

- Surface finish using surface comparator – Sa 2 1/2
- Blasted profile using replica tape and micrometre (Press O Film)
- Blasted profile using digital surface profile gauge
- Chloride contamination using SCM 400 salt contamination meter

5.2.22 Blasted profile shall be measured every one meter in all the 3’o clock, 6’o clock, 9’o clock and 12’o clock locations using a surface profile gauge. Blasted profile shall also be measured every 20-30 meters at two locations 6’o clock and 12’o clock using Testex replica tape (PRESS-O-FILM). The record of blasted profile at every 30 meter shall be recorded and documented. The Testex replica tape shall be preserved and attached in the log book.

5.2.23 Chloride contamination shall be checked every 50 meters at two location 6’o clock and 12 o’clock. The measurements will be recorded in coating application log book. The chloride level should be less than 20 mg/m2 as per ISO 21809-3 Clause 9.1.2.2. In case the chloride contamination is greater than above specified value, the surface shall be washed with potable water.

5.2.24 The blasted pipe shall not be exposed to atmosphere for more than 4 hours to prevent flash rusting of the steel surface. The blast cleaned surface should never be left unprimed overnight. However, the above elapsed time between blasting and
commencement of coating activities shall be reduced in case of high humidity in the air / trench. The surface temperature of the pipeline must be at least 30°C above the dew point temperature.

5.2.25 Blast cleaning shall not be conducted during times when the surface will become wet after blast cleaning or when ambient conditions are such that visible rusting occurs before coating, if any rust forms after blast cleaning, the surface shall be re-blasted before coating.

5.3 Liquid Polyurethane Coating

[Please retain or delete this section as per coating system applicable for the job; please refer to clause 2.0]

The technical specification for Liquid Polyurethane coating shall be as per Appendix D.

5.4 3 ply /2 ply Cold Applied Tape Coating

[Please retain or delete this section as per coating system applicable for the job; please refer to clause 2.0]

The technical specification for Liquid Polyurethane coating shall be as per Appendix E.

5.5 Visco-elastic coating application:

[Please retain or delete this section as per coating system applicable for the job; please refer to clause 2.0]

The technical specification for Liquid Polyurethane coating shall be as per Appendix F.

6.0 Inspection documents and traceability:

6.1 The inspection documents shall be in accordance with ISO 10474 or EN 10204. The type of certificate of compliance shall be defined in the purchase order.

6.2 FJC reports shall identify each field joint by a unique number for identification purposes and shall record the material batch number for traceability. Test results shall be linked to the field joint number or repair on which they were performed. Records shall be maintained on a shift and daily basis and shall be available for inspection by the purchaser and/or Company.

6.3 The inspection documents signed by the Contractor (and the inspector, if applicable) shall be transmitted to the purchaser at a frequency defined in the purchase order. Cumulative production records shall be maintained daily.

6.4 Test programs for procedure qualification trials (PQT), preproduction trials (PPT) or production testing:

6.5 The Tests/ inspections that shall be carried out during PQT, PPT and production testing are summarized here below in the table. Some of the requirements for production
testing may not be achievable on site during production, hence test program may be adapted to suit the site conditions.

6.6 Any test required that is not mentioned in Table shall be documented by the manufacturers. This covers long-term tests related to the material itself, such as specific electrical insulation resistance, thermal ageing, or thermal stability etc.

6.7 If one of the tests fails, the test shall be repeated. No further failure is allowed.

6.8 Frequency of testing and inspection for Coating (joint = each pipe)

<table>
<thead>
<tr>
<th>Property</th>
<th>Method of testing</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface condition of the area to be coated before preparation</td>
<td>Visual</td>
<td>3 Joints, 3 Joints, Each Joint</td>
</tr>
<tr>
<td>Visual inspection of the cleaned surface</td>
<td>ISO 8501-1</td>
<td>3 Joints, 3 Joints, Each Joint</td>
</tr>
<tr>
<td>Roughness of the abrasive blast cleaned surface</td>
<td>ISO 8503-1</td>
<td>3 Joints, 3 Joints, 3 Times</td>
</tr>
<tr>
<td>Level of soluble salts on the abrasive blast cleaned surface</td>
<td>ISO 8502-6 and ISO 8502-9</td>
<td>3 Joints, 3 Joints, 3 Times</td>
</tr>
<tr>
<td>Dust contamination</td>
<td>ISO 8502-3</td>
<td>3 Joints, 3 Joints, 3 Times</td>
</tr>
<tr>
<td>Examination of the adjacent dulled plant-applied coating</td>
<td>Visual</td>
<td>3 Joints, 3 Joints, Each Joint</td>
</tr>
<tr>
<td>Temperature of the surface to be coated</td>
<td>_</td>
<td>3 Joints, 3 Joints, Each Joint</td>
</tr>
<tr>
<td>Application criteria</td>
<td>Standard Method</td>
<td>3 Joints, 3 Joints, Continuous</td>
</tr>
<tr>
<td>Degree of cure of Liquid epoxy</td>
<td>_</td>
<td>3 Joints, 3 Joints, _</td>
</tr>
<tr>
<td>Visual inspection of the Coating</td>
<td>Visual</td>
<td>3 Joints, 3 Joints, Each Joint</td>
</tr>
<tr>
<td>Inspection of thickness</td>
<td>Standard Method</td>
<td>3 Joints, 3 Joints, As agreed</td>
</tr>
<tr>
<td>Holiday detection test</td>
<td>Standard Method</td>
<td>3 Joints, 3 Joints, Each Joint</td>
</tr>
<tr>
<td>Test Description</td>
<td>Standard Method</td>
<td>Joints</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>--------</td>
</tr>
<tr>
<td>Impact resistance test</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Indentation resistance test</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Peel strength between layers at ambient temperature</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Peel strength between layers at maximum service temperature</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Peel strength on steel surface and plant coating at ambient temperature</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Peel strength on steel surface and plant coating at Tmax</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Adhesion to steel surface at ambient temperature</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Adhesion to steel surface and plant coating at ambient temperature</td>
<td>ISO 4624</td>
<td>3</td>
</tr>
<tr>
<td>Adhesion to plant coating at ambient temperature</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Peel strength on steel surface and plant coating at ambient temperature</td>
<td>Standard Method</td>
<td>3</td>
</tr>
<tr>
<td>Peel strength on plant coating at ambient temperature and Tmax</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Hot-water immersion test</td>
<td>Standard Method</td>
<td>As Agreed</td>
</tr>
<tr>
<td>Peel strength on pipe surface and plant coating at ambient temperature</td>
<td>Standard Method</td>
<td>3</td>
</tr>
</tbody>
</table>
### Pipeline Coating Specifications

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Standard Method</th>
<th>Joints</th>
<th>Joints</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel strength on steel surface and plant coating at ambient temperature after hot-water immersion</td>
<td>Standard Method</td>
<td>3</td>
<td>3</td>
<td>Once per day</td>
</tr>
<tr>
<td>Adhesion on steel surface at ambient temperature after hot-water immersion</td>
<td>Standard Method</td>
<td>3</td>
<td>As Agreed</td>
<td></td>
</tr>
<tr>
<td>Adhesion on steel surface and plant coating at ambient temperature after hot-water immersion</td>
<td>ISO 4624</td>
<td>3</td>
<td>As Agreed</td>
<td></td>
</tr>
<tr>
<td>Lap shear strength at ambient temperature</td>
<td>Standard Method</td>
<td>3</td>
<td>As Agreed</td>
<td></td>
</tr>
<tr>
<td>Lap shear strength at maximum service temperature</td>
<td>Standard Method</td>
<td>3</td>
<td>As Agreed</td>
<td></td>
</tr>
<tr>
<td>Cathodic disbondment test at ambient temperature</td>
<td>Standard Method</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Cathodic disbondment at maximum service temperature</td>
<td>Standard Method</td>
<td>3</td>
<td>As Agreed</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>ISO 2178</td>
<td>3</td>
<td>3</td>
<td>Each Joint</td>
</tr>
</tbody>
</table>

Testing of the soluble salt level during production may be reduced or omitted, by agreement between applicator and end user or purchaser, if a PPT has demonstrated that the application procedure ensures a salt level below these requirements.

#### 6.9 Minimum Equipment Required:

<table>
<thead>
<tr>
<th>Tests</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection of thickness</td>
<td>Magnetic/electromagnetic or ultrasonic measuring instrument, with ±10% reading accuracy, calibrated for the range of coating thickness being measured</td>
</tr>
<tr>
<td>Holiday Detection Test</td>
<td>Adjustable, high-voltage holiday detector with ±10% reading accuracy, equipped with</td>
</tr>
<tr>
<td>Title</td>
<td>Pipeline Coating Specifications</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Type</td>
<td>Guidance</td>
</tr>
<tr>
<td>Reference</td>
<td>CIMG-GD-2-2019-0001</td>
</tr>
</tbody>
</table>

| Impact Test                   | Drop weight testing machine                                           |
| Indentation Test              | Consists of the following:                                            |
|                               | Chamber or bath, thermostatically controlled to ±2 °C; penetrometer, |
|                               | comprised of the following:                                           |
|                               | A cylindrical indenter on the top of which is mounted a weight; the  |
|                               | assembly, indenter plus weight, shall produce a pressure              |
|                               | dial gauge or any other measurement system, accurate to ±0.01 mm.     |

| Specific electrical insulation resistance | Power supply Unit, direct current (dc), with a voltage of ≥50 V; |
|                                          | Voltmeter, with an accuracy of 0.1 V, and ammeter, with an accuracy of 5 %, or DC-ohmmeter, with equivalent accuracy; |
|                                          | Counter electrode (copper), inert, with an area of at least 10 cm² and conducting leads for connecting the pipe and electrode to the power supply |

| Cathodic disbondment test        | Electrical source, consisting of a controlled voltage dc power unit (potentiostat) capable of supplying 20 mA to each test area simultaneously. |
|                                 | Electrolytic cell, Reference electrode, Auxiliary electrode (anode), Working electrode (cathode) |
|                                 | Electrolyte, consisting of a 3 % solution of NaCl in distilled or deionized water, Heating equipment |

| Peel strength test              | Tensile testing machine, capable of recording the peel force with ±5 % reading accuracy |
|                                | Cutting tool, e.g. knife & measuring tape |
|                                | Spring balance or digital load cell, with a clamp, accurate to ±10 % |

| Hot water immersion test        | Oven, controllable to within ±3 °C; holiday |
detector;
Cylinder, plastic, 150 mm long, with an interior diameter of 75 mm ± 3 mm or (heated) vessel large enough to accommodate the circumferential or ring specimens;
Knife, pointed, sharp;
Adhesive, elastomeric, e.g. silicone sealant;
Hacksaw blade, small, “Junior” type or similar;
Tensile testing machine, or spring balance, or digital load cell with a clamp
Air driven disc cutter
Pull Off test apparatus

Lap shear strength
Tensile testing machine
Temperature-maintenance equipment, capable of maintaining the sample in the tensile testing machine at the test temperature;
Steel plates, 100 mm long and 50 mm wide, or of tape width in the case of narrower tapes.

7.0 Backfilling, Final Restoration of Row:

7.1 While backfilling the trench after application of tape, special care needs to be taken to ensure that the coating surface is not damaged or pebbles/ hard particles do not penetrate the same. The back filling of trench gradually shall be done with selected soft earth or fine sand all around the pipe in full trench width up to 150mm height above the pipe.

7.2 Wherever there is a sloped terrain / trench, where pipeline bend is in line with ground profile, intermittent retaining walls are to be made with the help of filled polythene sand bags and pipe level is to be maintained.

7.3 The balance excavated quantity of earth subsequent to provision of soft earth pad for the pipe by screening shall be used for providing original cover as it was before starting of the work. Sand bags used for support shall be retained to ensure that the pipe does not sag during backfilling and subsequent resettlement of soil. It is to be ensured that sand bags are punctured so that coated pipe does not get damaged.
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7.4 In case the backfill material contains stones, pebbles, rocks etc, of sizes bigger than 50mm, the same shall be removed from excavated stack to obtain backfill free from such materials. The backfill material should not contain any such item that may damage the coating at the time of backfilling.

7.5 The backfilling operation shall be performed in such a manner as to provide support under the pipe and to avoid any damages to the new coating and also to pipe. The filling material used at bottom should be compacted to provide good support and prevent resting of pipe on sharp edges.

7.6 In all stretches of rocky area fine sand padding is to be carried out. In other stretches, earth padding is to be carried out using soft soil. The soft soil used for earth padding should be free from lumps, stones, boulders, rocks, hard clay etc. If soft soil is not available or unable to sieve at/near the site, the soil is to be imported from other area for earth padding.

7.7 The excavated quantity of earth subsequent to complete backfilling shall be neatly centred over the ditch and neatly rounded there on to a minimum height of 0.30 meters above adjacent ground level (i.e. formation of crown over pipe trench).

7.8 Rocks/ boulders separated from back fill shall be disposed off suitability. The entire field/ ground shall be brought to the original level and conditions, which existed prior to taking up of the job. Also any additional backfill generated due to soft earth padding/sand shall be suitably disposed off. Backfilling at top of trench shall be with original topsoil kept separately to maintain originality and fertility of top soil.

7.9 All fencings, bunds and other structures shall be restored to their original condition and the damaged structures shall be restored to the Owner’s satisfaction. i.e. entire ROW shall be smoothened.

7.10 Trenches excavated through small watercourses shall be backfilled with the same material excavated from it. If this is unstable, backfilling shall be done with suitable material. The backfilled earth shall be properly compacted so as to ensure that the no undue settlement takes place in the area.

7.11 Effective measures (like putting sand bags at a prefixed interval or embankment protection and other civil protection works to arrest any soil or bank erosion, shall be provided, It is to be ensured that the trench is backfilled within 48 hours of completion of coating activity on the pipeline.