Specification for 3-Layer Polypropylene Based Coating for Line Pipe
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1.0 INTRODUCTION

1.1 Scope

1.1.1 This Specification defines the requirements for the supply of a 3-layer polypropylene based coating system applied externally to bare steel pipe to provide a passive barrier against corrosion, abrasion and normal impact for design life of up to twenty (20) years. The coated line pipe is intended for operating temperatures up to 110°C. The grade of material shall be selected in line with operating temperature of the pipeline.

The coating system shall comprise of:

- Fusion bonded epoxy powder primer
  - 100 microns minimum.
- Polypropylene adhesive
  - 150 microns minimum.
- Polypropylene topcoat
  - 1.5 mm min up to 80°C.
  - 2.2 mm min above 80°C.

This specification addresses the minimum requirements to be met as regards the qualification, materials, application, inspection, testing, handling and storage of materials for the 3-layer polypropylene pipe coating system.

1.2 Definitions

1.2.1 In this document the following definitions apply:

- COMPANY
- CONTRACTOR
  The person, firm, or organisation designated on the contract or purchase order as the selected contractor for the scope of work.
- MANUFACTURER
  The party responsible for the manufacture and/or supply of all materials used.

1.3 Reference Documents

1.3.1 Except where otherwise stated in this Specification, materials and work carried out shall be in accordance with the latest edition (issued prior to the award of contract) of the following codes and standards:

International Standards

- ISO 9002 Quality Systems – Model for quality assurance in production and installation

British Standards Institution

- BS 2451 Specification for Chilled Iron Shot and Grit.
- BS 5493 Code of Practice for Protective Coating of Iron and Steel Structures against Corrosion.
- BS 7079 Preparation of Steel Substrates before Application of Paints and Related Products.

American Society for Testing Materials

1.4 Quality Systems

1.4.1 CONTRACTOR shall maintain an effective programme for quality assurance and quality control planned and developed in conjunction with all manufacturing, storage and application functions necessary to meet the requirements on the Contract or Purchase Order of which this Specification forms part. The requirements shall be met by the establishment and implementation of procedures which shall ensure that acceptable services are provided to COMPANY. The programme shall demonstrate both recognition of the quality requirements of the order and an organised approach to satisfy these requirements. The programme shall ensure that quality requirements are determined prior to commencement of the work and are maintained throughout.

1.4.2 CONTRACTOR’s quality systems and quality control procedures shall be in accordance with ISO 9001.

1.5 Reporting Procedure

1.5.1 A full recording and reporting system to be agreed with COMPANY shall be implemented and maintained throughout the duration of the Contract.

2.0 CONTRACTOR’S RESPONSIBILITIES

2.1 Receiving, offloading, inspection and storage of line pipe delivered from either pipe mill or receiving, offloading, inspecting and storage of COMPANY supplied line pipe at coating works.

2.2 Ensuring all materials furnished by COMPANY remain the property of COMPANY including surplus and scrap metals.

2.3 Procuring all consumables and materials including abrasives, powdered epoxy primer, adhesive, virgin polypropylene, coating repair material, all equipment for handling, cleaning and coating the line pipe, all test equipment to measure or inspect for profile, temperature, film thickness and
coating holidays, all instruments or standards for calibrating such devices and all tools necessary for completing the work in this specification.

2.4 Furnishing all personnel and equipment adequate to perform the work and meet the requirements of this specification including all inspection services and instrumentation. A detailed procedure for all coating applications processes shall be submitted to COMPANY for approval.

2.5 Preparing, blasting, heating and coating the line pipe lengths in accordance with the requirements of this Specification.

2.6 Inspecting work to ensure all Specification requirements have been met.

2.7 All as-received identification markings on each individual pipe shall not be lost during coating process and shall be included in the preparation of tally sheets. A unique identification number shall be maintained and recorded for all tests required by this Specification. The applicable test report shall state this identification number in all cases.

2.8 All materials shall be stored off the ground and above the level of standing water. Materials shall not be stored near sites of operations that might leave injurious deposits on the materials. CONTRACTOR shall store all materials for COMPANY in a separate location, segregated from any materials belonging to others. Line pipes shall be segregated according to pipe diameters. If necessary, further segregation of pipes shall be made with respect to their mill reference number.

2.9 Establishment and careful maintenance of records showing quantities of materials received, employed in the work, remaining in stock, surplus and scrap. These records shall be available at all times for review by COMPANY. At the completion of coating operations, CONTRACTOR shall satisfactorily account for all COMPANY supplied materials or shall reimburse COMPANY for the full cost of any materials not so accountable.

2.10 Making good any defects or damage while the line pipe is in its possession prior to final acceptance by COMPANY.

2.11 Load out and transport, to a port or site, of all pipes including surplus and scrap, when instructed to do so by COMPANY.

2.12 Submission of a daily report including an inspection report to COMPANY summarising the work accomplished during the previous day. The format of this report shall be agreed by COMPANY prior to commencement of Work and may subsequently be amended at COMPANY’s discretion.

2.13 At all times actively guarding against injury to personnel and damage to property. All work shall be performed in strict compliance with all applicable U.K. safety regulations and codes.

2.14 Immediately notifying pipe mill and/or COMPANY of shortages, damage or other discrepancies and preparing necessary documentation to support claims for such damages or shortages.

2.15 For coated line pipe where test pieces are required for bend, flexibility, resistance to hot water and resistance to cathodic disbondment tests, the cut ends shall be re-bevelled and made good prior to final acceptance by COMPANY.

3.0 COATING MATERIALS

3.1 Quality Systems
3.1.1 Acceptance of the coating material shall be subject to satisfactory results from the qualification test, as detailed in Section 4.0.

3.2 Coating System

3.2.1 The properties of the applied 3-layer epoxy-polypropylene coating system shall be in accordance with the requirements of Table 1.

3.3 Chromatic Pre-Treatment

3.3.1 The chromate pre-treatment chemical to be used prior to application of epoxy powder primer shall be of proven performance and shall be subject to COMPANY approval. Previous experience with the proposed chromate pre-treatment including appropriate test results shall be furnished by CONTRACTOR.

3.4 Powdered Epoxy Primer

3.4.1 The fusion bonded epoxy powder primer shall be specifically designed and adapted for 3-layer epoxy polypropylene coatings as regards:

- Physical properties – to provide good adhesion, maximum resistance to cathodic disbondment and flexibility to allow cold field bending.
- Chemistry – to permit a chemical reaction to occur between the partially cured epoxy primer and the reactive functional groups contained within the overlying intermediate layer.
- Film flow properties, melt viscosity, etc. to allow the application of a defect-free film over the metal surface.

3.4.2 The epoxy powder primer properties shall be in accordance with the requirements of Table 2.

3.5 Polymeric Adhesive

3.5.1 The polymeric adhesive to be used for the epoxy polypropylene coatings shall be a specifically designed polypropylene – based copolymer incorporating both polar and non-polar monomers within its structure to allow good bonding to take place.

The functional polar groups contained within the polymers shall be able to chemically react with free epoxy groups within the primer layer; while the non polar backbone shall have a high affinity for the polypropylene top layer.

3.5.2 The polypropylene – based copolymer adhesive shall have a VICAT softening temperature of at least 12WC (according to ASTM D 1525).

3.5.3 CONTRACTOR shall submit data sheets giving all properties of the proposed polymeric adhesive.

3.6 Polypropylene Top Coat

3.6.1 A block – copolymer polypropylene resin shall be used for the polypropylene top coat.

The virgin polypropylene resin properties shall be in accordance with the requirements of Table 2. CONTRACTOR shall submit data sheets with acceptable values for the properties specified in Table 2 for the polypropylene resin.

3.7 Repair Materials

3.7.1 All repair materials shall be suitable for operating temperatures up to 110 °C on pipelines permanently immersed in seawater and shall be demonstrated to be fully compatible with the applied epoxy – polypropylene pipe coating system.
CONTRACTOR shall submit data sheets with properties of the repair materials for COMPANY approval.

3.8 Materials Supply

3.8.1 CONTRACTOR shall obtain from the suppliers with each batch consignment of coating materials test certificates to cover the properties of the materials involved as required in this Specification.

3.9 Material Handling and Control

3.9.1 All packages of fusion bonded epoxy powder resin, polypropylene resin material and polypropylene based copolymer adhesive shall be marked with the following data as a minimum:

- Manufacturer’s name
- Complete material identification, including grade of powder and polypropylene
- Batch number of the powder and polypropylene
- Date and place of manufacture of the powder and polypropylene
- Safety instructions
- Expiry date of use

3.9.2 All coating materials shall be handled, stored and applied in accordance with the manufacturer’s instructions, or as directed by, an authorised representative from the manufacturer.

4.0 PROCEDURE QUALIFICATION REQUIREMENTS

4.1 Preliminary Information

4.1.1 As part of the bid submission CONTRACTOR shall include full details including product data sheets of the proposed epoxy powder and polypropylene materials intended for service conditions to which this Specification relates.

4.1.2 The documentation shall demonstrate that physical properties of the epoxy powder and polypropylene materials satisfy all the performance requirements of this Specification.

4.1.3 Alternative Qualification

The pre qualification can be waived should the contractor provide adequate documentation of earlier qualifications using identical products applied to similar sizes of linepipe.

4.2 Qualification

4.2.1 Within 3 (three) weeks of award, a detailed test programme and coating procedure for qualification of the 3-layer pipe coating system shall be prepared by CONTRACTOR and submitted for COMPANY approval.

This document shall include full details of, but not be limited to, the following activities:

Line pipe handling, storage and inspection at all stages of application work.

- Line pipe surface preparation including abrasive details, removal of steel defects and methods of surface cleaning and surface profile measurement.
- Complete details of all materials together with quality control and storage.
- Application of chromate pre-treatment chemical, epoxy powder, adhesive and polypropylene including details of line speed, thickness of each layer, pipe temperature, method of applications.
- Cure time, temperature, quenching.
- Inspection and testing including instrument and equipment types, frequency and acceptance criteria.
• Details of instrument and equipment calibration methods including relevant standards and examples of calibration certificates.
• Complete details of inventory of laboratory and equipment.
• Quality control procedures, including methods of record keeping, batch identification, details of personnel for all aspects of the work.
• Coating repair procedures and acceptance criteria for repairs and rejection.

4.2.2 The coating system and detailed coating procedure, which shall be subject to COMPANY approval, shall be qualified by coating at least five (5) pipe lengths of each pipe diameter prior to full coating production. The pipe lengths to be used for coating procedure qualification will be selected by COMPANY.

4.2.3 The cured 3-layer pipe coatings shall be inspected and tested for:

- Thickness – including degree and extent of any thickness variations
- Coating hardness
- Impact resistance
- Adhesion and peel strength
- Holiday detection
- Resistance to Hot Water Immersion
- Flexibility
- Cathodic disbondment

All testing shall be in accordance with test methods listed in Section 7.0 and Table 3.

4.2.4 CONTRACTOR shall also carry qualification tests to prove the integrity of the techniques proposed for repairing accepted defects as detailed in Section 8.0 of this Specification, by carrying out adhesion and resistance to hot water immersion testing and holiday detection at repaired areas in accordance with Section 6.0 of this Specification.

Such qualification trials shall be carried out on pipe areas where the cured pipe coating has been previously removed for adhesion tests.

4.2.5 All qualification testing shall be witnessed by COMPANY and a full set of records shall be submitted by CONTRACTOR to COMPANY for construction.

4.2.6 All qualification testing shall be satisfactorily completed prior to production coating application. CONTRACTOR shall not elect to coat any other pipe lengths before test results have been obtained and approved by COMPANY.

4.2.7 Production coating shall adhere to the procedures which were used successfully in the procedure qualification work and which have been approved by COMPANY.

5.0 SURFACE PREPARATION

5.1 Visual Inspection

5.1.1 Prior to blast cleaning, every pipe shall be 100% visually inspected for physical damage or distortion. Any damaged pipes shall be quarantined by CONTRACTOR who shall immediately notify COMPANY to determine acceptability or otherwise of the affected pipe.

5.2 Cleaning

5.2.1 Prior to blast cleaning, the pipe lengths shall be totally cleaned with a solvent or stem to remove all traces of oil and grease from surfaces to be coated. Pipes which have been exposed to salt spray shall be washed with fresh, potable water ensuring that contamination has not spread over the surface.

5.2.2 After cleaning and prior to grit blasting, the pipe shall be stored under cover and kept warm and dry. The pipe shall be handled...
and transported in such a manner as to ensure that no further contamination occurs.

5.2.3 Should the surface become contaminated with oil, grease or other medium injurious to the coating, then the entire preparation shall be repeated.

5.3 Blast Cleaning

5.3.1 Before the exterior surface is blast cleaned, every pipe shall be uniformly heated, to minimum (86°F), to remove completely all moisture and to preclude any condensation forming on the pipe after blast cleaning.

5.3.2 The total external surface of every pipe shall be blast cleaned to Sa 2½ in accordance with BS 7079 Part 1, using dry, sharp, angular abrasive and equipment and consumables acceptable to COMPANY. All blasting shall be performed under cover.

5.3.3 The abrasive shall be re-usable aluminium oxide or chilled iron or steel grit in accordance with BS 7079 and be free from contaminants.

5.3.4 The type and size of abrasive employed shall be selected to produce a sharp angular surface profile with an amplitude between 50 and 100 microns or in the range recommended by the powder supplier and as detailed in CONTRACTOR’s approved procedures.

5.3.5 Blasting abrasives shall be continually checked and sieved to removed fines and contaminants. Sieve analysis for fines and contaminants shall be carried out at least once per batch production.

Compressed air when used shall be free from water, oil, dirt and other substances likely to cause contamination. Adequate separators and traps shall be provided and these shall be purged on a frequent basis.

5.3.6 If abrasive is to be recycled then CONTRACTOR is responsible for fixing the percentage of recycled to new abrasive, such that the final preparation is adequate and complies with all aspects of this Specification.

5.3.7 After blast cleaning, all residual grit, fines, dust, etc., will be removed by rotary wire brush. It is essential that no grit or foreign matter be left embedded in the blasted surface.

All blasting media shall also be removed from the inside of pipe lengths after blast cleaning.

5.3.8 All blast cleaned surfaces shall be 100% inspected by CONTRACTOR for cleanliness, sharpness of surface profile and absence of surface irregularities such as slivers, hackles or laminations which would impair the application or performance of the finished coating.

Testex replica tape or equal shall be used for measurement of surface roughness. Surface roughness shall be checked a minimum of every 2 hours. Replica tapes shall be retained and marked by CONTRACTOR, with the relevant pipe number, time and date.

Surface preparation comparators complying with BS 7079 Part C I for grit blasted surfaces shall be used to ensure the specified profile is achieved and that the profile is sharp and angular.

5.3.9 Surface defects if found shall be brought to the attention of COMPANY who will determine suitable remedial action such as disc grinding. Any such action proposed will be subject to COMPANY approval and inspection.
5.3.10 Any remedial or grinding work must not reduce the pipe wall thickness, in the areas treated, below the specified requirements.

5.3.11 Any pipe subject to excessive remedial or grinding work shall be re-blasted and the remaining wall thickness checked in the presence of COMPANY to an approved method.

5.3.12 Any pipe found to have reduction in wall thickness or defects which exceed the levels permitted shall be quarantined for examination by COMPANY and no subsequent action taken without the agreement of COMPANY.

5.4 Environmental Control

5.4.1 The surfaces to be coated shall be completely dry during the blasting process and shall be maintained in an environment such that the steel temperature is a minimum of 5°C above the dewpoint with a maximum relative humidity of 80%.

5.4.2 Oxidation, tarnishing or contamination of the blast cleaned surface is not permitted. All blast cleaned surfaces must meet the Sa 2½ Standard as per BS 7079 Part 1, immediately prior to pre-treatment or powder coating. Any surface that shows signs of oxidation or any pipe that remains uncoated after two hours from blast cleaning shall be reblasted to the original specification.

In addition the reblasted surface shall be tested to confirm freedom from soluble ferrous salts in accordance with Appendix G of BS 5493 or COMPANY approved equivalent.

5.5 Inspection and Testing

5.5.1 Inspection and testing requirements for prepared surfaces and abrasives are defined in Section 7.0 of this Specification.

6.0 COATING APPLICATION

6.1 General

6.1.1 Blast cleaned surfaces must be kept free from grease or oil contamination. After blast cleaning no further use of solvents or washes will be permitted without specific consent from COMPANY.

6.1.2 Dust or foreign matter shall be removed from the cleaned surface by an industrial vacuum cleaner or a clean dry air jet.

6.1.3 Any pipe which has deteriorated below the standard of Sa 2½ or is contaminated by oil, grease, moisture or other matter immediately prior to application of the chromate pre-treatment shall be reblasted and the requirements of Section 5.4.2 shall apply.

6.2 Application of Pre-Treatment Chemical

6.2.1 Prior to application of the FBE powder, the external surface of each blast cleaned pipe shall be pre-treated using the chromate pre-treatment chemical. The surface treatment shall be carried out within one (1) hour of blast cleaning, without skips, misses and excessive drips and rims. A maximum of 4 hours may be permitted between chromate pre-treatment and epoxy powder coating.

6.3 Coating Process

6.3.1 Each pipe after the chromate pre-treatment wash shall be uniformly pre-heated to a temperature specified by the epoxy powder supplier for optimum application conditions, but shall not exceed 300°C at any time. Any pipe subjected to temperatures in excess of 300°C shall be rejected. Replacement with approved pipe shall be CONTRACTOR’s responsibility.
6.3.2 The pipe surface temperature shall be checked using tempilsticks. The melt flow index of each box of tempilsticks shall be checked by carrying out tests in accordance with a procedure approved by COMPANY.

6.3.3 The pipe surface temperature shall be checked at lead, middle and tail of each pipe and recorded.

6.3.4 The FBE powder application shall be by an electrostatic spray method which will result in a continuous pore-free minimum dry film thickness of 100 microns.

6.3.5 The polypropylene based adhesive and resin shall be applied at a uniform thickness either by spray or extrusion methods, with an optimum period of time of the FBE powder application and before solidification of the FBE such that all materials interact by chemical bonding.

The minimum thickness for the polypropylene adhesive shall be 150 microns.

The minimum thickness for the polypropylene top coat shall be 1.5mm or 2.2mm, depending on the operating temperature.

6.3.6 Unless otherwise specified, the FBE powder coating shall terminate nominally 100-120mm from each end of each pipe. The cut back length for the polypropylene coating shall be nominally 140-160mm from each end of each pipe. The edges of the polypropylene coating shall be chamfered by brushing to an angle of 30° relative to the pipe’s longitudinal axis. Any coating material on bevelled edges of pipes shall be removed.

6.3.7 After the 3-layer polypropylene based coating has been cured the pipe may be quenched with water (running or spray) to a temperature suitable for inspection, repair and handling.

6.2.8 The use of recycled epoxy powder may be permitted, but at no time shall the ration of recycled powder to fresh powder exceed 20%. Separators shall be cleaned as necessary, but as a minimum at least once a day.

7.0 INSPECTION AND TESTING

7.1 General Requirements

7.1.1 Only qualified and experienced employees shall be deployed to perform test and inspection activities.

7.1.2 Inspection and testing during production coating shall include as a minimum:

a) Checking and recording the environmental conditions
b) Monitoring of abrasive size and cleanliness
c) Measurement of surface profile by Testex or other approved technique
d) Visual examination for surface contaminants and defects
e) Monitoring the line pipe speed and pipe surface temperature
f) Checking and recording the coating thickness
g) Checking and recording the coating hardness and cure
h) Impact resistance tests
i) Adhesion tests
j) 10% holiday detection of all coated pipe

7.1.3 The cut ends of coated pipe lengths selected, during the procedure qualification test, for flexibility, resistance to hot water immersion and cathodic disbondment tests shall be re-bevelled and made good prior to final acceptance by COMPANY. These pipe lengths shall be included within the coated
pipe assignment subject to final acceptance of the pipe coating tests.

7.2 Abrasive Inspection

7.2.1 Periodic examination, at least once per production batch, of the abrasive shall be performed to ensure that only uncontaminated angular grit with an acceptable size distribution is used. The following are specific inspection requirements. Correct size distribution shall be confirmed by sieve analysis. A bottle test shall be used to check for oil contamination of the grit.

7.3 Surface Preparation Inspection

7.3.1 The degreased and blast cleaned surface of each pipe length shall be continuously monitored to determine compliance with the requirements of Section 5.0.

The external surface profile on every tenth pipe shall be measured using a profilometer, replicating film, or COMPANY approved equivalent. The profile shall be in accordance with the requirements of Section 5.3.4.

7.4 Surface Temperature Checks

7.4.1 The surface temperature of the pipe immediately prior to blast cleaning shall be monitored using a thermocouple or another COMPANY approved method to determine compliance with the requirements of Section 5.3.1.

7.4.2 The surface temperature of the pipe immediately prior to FBE powder application shall be monitored and controlled within the limits recommended by the material manufacturer and also to determine compliance with the requirements of Section 6.2.1 and Section 6.2.3.

7.5 Visual Examination of Applied Coating

7.5.1 Production coating on every pipe shall be 100% visually inspected. The coating shall be of uniform colour and appearance and shall be free of deleterious effects such as loose or uncured material, cissing or blistering.

7.6 Coating Thickness

7.6.1 The total coating thickness shall be measured on the 12 and 6 o’clock positions around the pipe circumference at each of the ¼, ½, and ¾ positions along each pipe with an approved instrument which shall be calibrated at least twice per shift.

7.6.2 Calibration of the coating thickness instruments shall be over the surface peaks, on selected pipes immediately after blast cleaning.

7.6.3 The total thickness of the cured 3-layer polypropylene coating shall be 1.8 mm or 2.5mm minimum as defined on the pipe coating data sheets / purchase order.

7.7 Holiday Inspection

7.7.1 CONTRACTOR shall carry out a holiday inspection over the entire coated surface of one pipe in ten. The testing shall be performed using a holiday detector of a type approved by COMPANY.

7.7.2 The holiday detector shall be a low pulse d.c. electronic detector with both audible and visual alarm and precise voltage control and shall be set to a minimum of 5 volts per micron of coating thickness.

7.7.3 CONTRACTOR shall calibrate the holiday detection equipment at least once every
7.7.4 The maximum allowable number of repairable holidays per pipe length shall not exceed:

- up to 250mm pipe diameter
- 250mm to 50mm pipe diameter

7.7.5 Holidays caused by metal surface defects shall require the removal of the defect by grinding or filing of the defect prior to application of the repair material. Under no circumstances shall a steel defect be overcoated with repair material.

7.7.6 All holidays found within the allowable limit shall be repaired in accordance with the qualified repair procedure and with Section 8.0.

7.7.7 Prior to repair, CONTRACTOR shall investigate the cause of the holiday defect(s) and take the necessary remedial action to correct any faults there may be in the coating procedure.

7.8 Coating Cure

7.8.1 CONTRACTOR shall ensure complete coating cure by maintaining pipe at the proper temperature for an adequate period of time. CONTRACTOR shall be responsible for working with the coating material manufacturer or COMPANY in establishing temperature and time conditions.

7.9 Impact Resistance

7.9.1 Once every hour or twenty pipes, whichever is the more frequent, CONTRACTOR shall determine the impact resistance of the applied coating.

7.9.2 Tests shall be carried out one third and two thirds of the way along the coated pipe.

7.9.3 Immediately prior to impact testing, the thickness of the coating in the test area shall be measured and recorded in accordance with Section 7.6.

7.9.4 CONTRACTOR shall test for holidays over the full length of impact test area in accordance with Section 7.7 and shall only use one joint length of pipe for impact testing.

7.9.5 Using an approved Gardner variable impact tester in accordance with ASTM G14, paragraph 4.2, CONTRACTOR shall submit the coating to the drop weight test to determine the acceptability of the impact resistance of the coating.

7.9.6 The coating shall withstand the impact energy of the impact tester without causing a holiday. The energy value to be used in the test shall be a minimum of 8 joules / mm of coating thickness and shall be agreed during the qualification tests as the minimum suitable for the selected FBE powder and polypropylene material, pipe size and wall thickness.

7.9.7 Immediately after impact testing the tested area shall be subjected to a holiday detection test with the voltage set to a minimum of 5 volts per micron of FBE coating thickness. This holiday detection test shall be repeated on the impact tested area after 24 hours.

7.9.8 Any pipe which shows holidays caused by impact testing shall be rejected.

7.9.9 In the event of pipe being rejected for lack of impact resistance CONTRACTOR shall test the preceding and following pipes until it has been proved that the required values are obtained.

7.9.10 If the required impact values are not achieved after testing the third consecutive pipe, the coating process shall be stopped to determine the cause. The coating
process shall not be restarted until the cause of the failures has been rectified.

7.10 Adhesion and Peel Strength

7.10.1 Once every four (4) hours the adhesion of the 3-layer coating at any one random location on a pipe (preferably at the cut back areas) shall be determined using a peel test method in accordance with DIN 30670 and as modified herein.

7.10.2 The peel test shall be carried out with the steel temperature at 110°C, using a 5mm wide strip and a 20kg load. The peeling rate shall not exceed 1cm per minute.

7.10.3 The coating shall be rejected if it shows any adhesion failure between the FBE and steel substrate and any disbondment or adhesion failure between the FBE and polypropylene.

7.11 Resistance to Hot Water Immersion

7.11.1 Hot water immersion tests, generally in accordance with BGC/PS/M6 Part 1 Appendix E except for parameters as detailed below, shall be carried out during the qualification testing only.

7.11.2 A test piece, 300mm x 50min x wall thickness shall be cold cut from the pipe and subjected to a holiday detection test at the specified voltage.

7.11.3 The bare edges of the test piece shall be coated to prevent ingress of moisture beneath the coating.

7.11.4 The coated test piece shall be immersed in a 3% salt water bath for 24 hours at 95°C ± 2°C.

7.11.5 After 24 hours the test piece shall be removed and tested in a ‘hot’ and ‘cold’ condition for adhesion in accordance with BGS/PS/M6 Part 1, Appendix E clause E.6 and E.7.

7.11.6 Immediately after testing and recording of results the test piece shall be repaired in an approved manner and resubmerged in the water bath for a further 24 hours and then re-tested.

7.11.7 The test piece when tested shall be accepted or rejected on the results in accordance with Section 7.11.5 of this Specification. In addition, the test piece shall not show disbonding or blistering of the coating at any location. A slight discoloration of the coating is acceptable.

7.12 Rejected Coated Pipe

7.12.1 Pipe which has been rejected when tested in accordance with Section 7.0 shall require complete removal of the coating and shall be completely recycled through the cleaning and coating process.

7.12.2 All pipe coating removal and recycling shall be CONTRACTOR’s responsibility.

8.0 COATING REPAIRS

8.1 Repair Methods

8.1.1 All holidays, defects, or missed places indicated shall be marked by chalk or crayon and repaired subject to the total number of area of such defects being within the limits permitted as defined in this Specification.

8.1.2 CONTRACTOR shall submit to COMPANY for review and approval, methods for repair of coating in the following cases:

- defect areas in the polypropylene coating, not reaching the metal substrate
- coating defect areas reaching / exposing the metal substrate, excluding pin holes
- pin holes
8.1.3 The total area of damaged coating shall not exceed one per cent (1%) of the total surface area of any one pipe length. Should this figure be exceeded or any pipe with defect areas greater than 650mm², exposed the metal substrate, it will be CONTRACTOR’s responsibility to re-process the coated pipe length.

8.1.4 Coating areas which have been repaired shall be checked with the holiday detector.

8.1.5 All repair materials shall be approved by COMPANY and be approved by the coating material supplier as suitable for use on subsea and pipelines up to the operating temperature.

8.2 Repair Inspection

8.2.1 The requirements of Section 7.0 shall apply to all coating repairs.

8.2.2 If a repair fails to satisfy the requirements of Section 7.0, then the pipe shall be rejected and subsequently stripped, blast cleaned and reprocessed.

9.0 HANDLING

9.1 General

9.1.1 CONTRACTOR shall be responsible for the handling, care and storage of all pipe and other items for the time of receipt until delivered by him to a designated site.

9.1.2 CONTRACTOR shall perform all unloading, loading handling, storage and shop transfer of all bare and coated pipe in such a manner as to minimise the risk of damage to the pipe or its coating.

9.1.3 Chains, books or cables around the bare or coated pipe shall not be used, CONTRACTOR shall supply full details of handling procedures and equipment to COMPANY for approval.

9.1.4 At every stage of surface preparation and coating application, pipe shall be kept under cover and protected from the outside environment.

9.1.5 A detailed handling, storage and transportation procedure shall be submitted by CONTRACTOR for COMPANY approval prior to commencing work.

9.2 Storage

9.2.1 Bare pipes shall be stored on suitably covered wooden bearers or sand rows.

9.2.2 Pipes shall be stored on a slope to prevent the accumulation of water in the pipe bores.

9.2.3 Stacking of coated pipe shall not take place until the coating has cured sufficiently to avoid damage to, or deformation of the coating.

9.2.4 The stacking height of coated pipe shall be such that no damage to the coating occurs.

9.2.5 Coated pipe shall be separated from each other by using pads approved by COMPANY.

10.0 DOCUMENTATION

10.1 General

10.1.1 CONTRACTOR shall furnish all documentation in the English Language.

10.1.2 CONTRACTOR’s documentation procedures shall be designed to ensure full traceability of pipe and coating materials through all stages of preparation, coating and testing.

10.1.3 CONTRACTOR’s documentation procedures shall be subject to review and approval by COMPANY.
10.1.4 All CONTRACTOR’s documentation of any nature shall clearly reference Contract Number together with component or material batch identification as appropriate.

10.1.5 CONTRACTOR shall maintain complete and accurate records of the work performed. These records shall be kept safe in a single location at CONTRACTOR’s site and shall be accessible to COMPANY at all times. One copy of the CONTRACTOR’s daily records shall be handed to COMPANY’s site representative by the end of the working day upon which the work is performed.

10.2 Report Documentation

10.2.1 Documentation submissions shall be in accordance with the requirements of tender documents.
### TABLE 1

**3-LAYER EPOXY – POLYPROPYLENE CURED COATING PERFORMANCE SPECIFICATION**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST DESCRIPTION</th>
<th>ACCEPTABLE VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact Resistance</td>
<td>ASTM 014 – 83 25mm tup, 1kg wgt also refer to Section 7.9</td>
<td>50 Joules minimum without breakdown or loss of adhesion of coating i.e. no flaw detected by holiday detection test.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Bend pipe sample at 25mm / min over mandrels at 0°C and 20°C also refer to Section 7.2</td>
<td>Limit of strain; 2% @ 0°C and 20°C. No sign of pinholes cracking, disbondment from steel substrate or between the FBE and PP.</td>
</tr>
<tr>
<td>Hardness</td>
<td>ASTM D 2240</td>
<td>67 Shore D minimum @ 23°C</td>
</tr>
<tr>
<td>Adhesion and Peel Strength</td>
<td>As per Section 7.10 and DIN 30670</td>
<td>Cohesive failure between FBE and steel. Peeling rate shall not exceed 1cm / minute. No disbondment or adhesive failure between FBE and PP.</td>
</tr>
<tr>
<td>Cathodic Disbondment</td>
<td>BGC/PS CW6 at 65°C</td>
<td>5mm maximum radium from edge of drilled hole.</td>
</tr>
<tr>
<td>Electrical Resistivity of Polypropylene</td>
<td>ASTM D 257</td>
<td>$10^{13}$ ohm cm minimum.</td>
</tr>
</tbody>
</table>
# TABLE 2

**FBE POWDER SPECIFICATION**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST No.</th>
<th>TEST DESCRIPTION</th>
<th>ACCEPTABLE VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Analysis</td>
<td>1</td>
<td>Any conventional technique</td>
<td>90% (by weight) of the particles shall be between 10 and 100 microns mesh.</td>
</tr>
<tr>
<td>Gel Time</td>
<td>2</td>
<td>Calibrated hot plate</td>
<td>Must be within 20% of the range specified on the SUPPLIER’s data sheet and compatible with the application of PP adhesive.</td>
</tr>
<tr>
<td>Density</td>
<td>3</td>
<td>Volumetric Displacement</td>
<td>Must be within 50 gm/l of the range specified on the SUPPLIER’s data sheet.</td>
</tr>
<tr>
<td>Moisture</td>
<td>4</td>
<td>Vacuum heating to 105°C for 30 min.</td>
<td>0.5% maximum (typically 0.3%).</td>
</tr>
<tr>
<td>Thermal Analysis</td>
<td>5</td>
<td>Differential Scanning Calorimetry</td>
<td>Must comply with the nominal behaviour (standard graph). ΔTg as determined from the graphs to be between -2°C and +3°C. Tg shall be greater than 100°C.</td>
</tr>
<tr>
<td>Infra-red</td>
<td>6</td>
<td>Any conventional technique</td>
<td>Must be within the range specified on the SUPPLIER’s data sheet.</td>
</tr>
<tr>
<td>Storage Stability</td>
<td>7</td>
<td>Age for 120 days at 25°C ± 1°C in a sealed container.</td>
<td>Powder must retain all the original properties, as required for Tests 1 to 6.</td>
</tr>
<tr>
<td>Shelf Lift</td>
<td></td>
<td></td>
<td>3 months from date of manufacture.</td>
</tr>
</tbody>
</table>
## TABLE 3

**POLYMERIC ADHESIVE SPECIFICATION**

*TO BE PROPOSED BY CONTRACTOR*

<table>
<thead>
<tr>
<th>POLYMERIC ADHESIVE SPECIFICATION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TO BE PROPOSED BY CONTRACTOR</td>
<td></td>
</tr>
</tbody>
</table>
TABLE 4

VIRGIN POLYPROPYLENE RESIN REQUIREMENTS

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST No.</th>
<th>TEST DESCRIPTION</th>
<th>ACCEPTABLE VALUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1</td>
<td>ASTM D 1505</td>
<td>0.890 gm / cm³</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>2</td>
<td>ASTM D 1238, 19°C / 2.16 kg</td>
<td>0.90 gm / 10 min</td>
</tr>
<tr>
<td>Tensile Break Strength</td>
<td>3</td>
<td>ASTM D 638</td>
<td>380 kgf / cm²</td>
</tr>
<tr>
<td>Tensile Yield Strength</td>
<td>4</td>
<td>ASTM D 638</td>
<td>220 kgf / cm²</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td>5</td>
<td>ASTM D 638</td>
<td>650%</td>
</tr>
<tr>
<td>Izot Impact Strength @ 23°C</td>
<td>6</td>
<td>ASTM D 256</td>
<td>&gt;30 kg cm / cm²</td>
</tr>
<tr>
<td>@ -20°C</td>
<td></td>
<td>ASTM D 256</td>
<td>12 kg cm / cm²</td>
</tr>
<tr>
<td>VICAT Softening Point</td>
<td>7</td>
<td>ASTM D 1525</td>
<td>145°C</td>
</tr>
<tr>
<td>DSC Melting Point</td>
<td>8</td>
<td>Any conventional technique</td>
<td>160°C</td>
</tr>
<tr>
<td>Brittleness Temperature</td>
<td>9</td>
<td>ASTM D 746</td>
<td>45°C</td>
</tr>
<tr>
<td>Shelf Life</td>
<td></td>
<td></td>
<td>3 months from date of manufacture</td>
</tr>
</tbody>
</table>

ASTM STANDARDS


D1238 – 90b Test Method for Flow Rates of Thermoplastics by Extrusion Plastomer.
