TECHNICAL SPECIFICATION

EXTERNAL POLYETHYLENE AND POLYPROPYLENE COATING FOR LINE PIPE

DEP 31.40.30.31-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies the minimum requirements for factory applied external polyethylene and polypropylene coating of steel pipes, bends and fittings used for the construction of buried or submerged pipelines. It specifies the requirements for coating materials, coating application, inspection and testing and gives procedures for the qualification of coating materials and coating applicators.

The DEP is applicable to coating applied on line pipe by one of the following coating processes:

- powder sintering;
- sleeve or cross-head extrusion;
- side extrusion.

It is also applicable to coating applied on bends and fittings by the powder sintering process.

This DEP is a revision of the DEP of the same number and title dated December 1994. A summary of changes from the previous edition is given in (1.6).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group Company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is intended to be used by all involved in the design, procurement, manufacturing, coating and transport of polyethylene or polypropylene coated line pipe for oil and gas production, oil refineries, chemical plants, gas plants and marketing depots and installations. When DEPs are applied, a Management of Change (MOC) process should be implemented. This is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviations from the requirements of this DEP which are considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

adhesive - an intermediate coating layer to improve adhesion between the primer and the coating (three layer system) or between the steel and the coating (two layer system).

Applicator - the party that applies the coating to the line pipe in its coating plant.

batch – the amount of materials produced within one uninterrupted production run of maximum 8 hours under constant production conditions.

chemical pre-treatment - Treatment of the blast cleaned pipe surface with a chemical solution before application of the primer or adhesive to improve adhesion of the first coating layer (phosphate, chromate).

holiday - a defect penetrating through the coating to the steel pipe surface, of such dimensions that it is detectable by means of the specified procedures.

Inspector - the party appointed by the Principal to witness the Applicator's quality control of coating materials and the coating process.

primer - an intermediate coating layer, applied directly onto the pre-treated steel surface to improve the adhesion of the final coating to the pipe surface. In two layer coating systems both the words primer and adhesive are sometimes used to name the same layer.

shift – a set of pipes coated in one production run of which the beginning and end coincide with a change in personnel. In the context of the quality control procedures of this DEP, the maximum duration of a shift is 10 h.

side extrusion - a coating process whereby hot extruded films of coating materials are wrapped around the pipe in layers. The pipes are moved past the extrusion head in a spiral motion. The extruded coating film is fused together to form a continuous adherent sheath around the pipe.

sintering - the coating process whereby the coating material is sprayed on the preheated pipe surface in the form of powder and is fused to a homogeneous and continuous layer under the influence of the heat from the pipe material.

sleeve extrusion or **crosshead extrusion** - a coating process whereby a hot extruded sleeve of coating material is applied around the pipes while the pipes are moved through the extrusion head in a linear motion.

three layer system - a pipe coating system consisting of three layers: primer, adhesive and outer layer.

two layer system - a pipe coating system consisting of two layers: primer and outer layer or adhesive and outer layer.

unit of production - Unless otherwise specified, a set of pipes coated in one production run on the same coating line, using the same coating technique, having the same nominal diameter and wall thickness and coated with the same coating products. Breaks in production caused by equipment or plant breakdown, factory shutdown or any other interruption exceeding three days shall be the end of a production run. Subsequent start-up constitutes a new unit of production.

1.4 ABBREVIATIONS

DN - Diameter Nominal (mm)
FBE - Fusion Bonded Epoxy
PE - Polyethylene
PP - Polypropylene
UV - Ultraviolet light

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (11).

1.6 CHANGES FROM THE PREVIOUS EDITION

The previous edition of this DEP was dated December 1994. This revision includes a general rearranging of sections in order to produce a more logical topical sequence. Other than the rearranging, editorial and formatting revisions, the following are the main changes to that edition:

Old section	New Section	Change
--	2.1	New section.
3.2	4.1	New references to ISO 8502-2 and ISO 8502-3.
3.4.4	3.2.4	New requirement for recording minimum peel resistance. Table 2 updated.
3.4.6	3.2.6	Table 4 updated.
3.4.9	3.2.9	Requirement added regarding elongation.
3.4.10	3.2.10	Requirement added regarding elongation.
3.4.11	3.2.11	Table 5 updated.
4.4.3	6.4	Table 6 re-numbered to Table 7 and updated.
5.7	4.3.11	Table 7 re-numbered to Table 6 and updated.
5.3	4.3.4	Requirement added regarding conductivity.
7.1	7.1	Surface finish requirements updated.
7.3	7.3	Maximum test voltage of 25 kV specified.
7.5	7.5	Impact resistance requirements updated.
7.9	7.9	References to DIN and ISO standards updated.
7.10	7.10	References to ISO standards updated.
-	7.12	New section on degree of cure of FBE primer.
--	7.13	New section on conductivity monitoring.

1.7 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the DEP Administrator at standards@shell.com.

Shell staff may also post comments on this DEP on the Surface Global Network (SGN) under the Standards/DEP 31.40.30.31-Gen. folder. The DEP Administrator and DEP Author monitor these folders on a regular basis.

2. GENERAL INFORMATION

2.1 GENERAL

This DEP can be used for general qualification purposes or for specific projects.

General coating qualification is performed for the purpose of an overall qualification of coating system and Applicator, but is not necessarily related to a specific project. With this process, a list of qualified coating systems and Applicators is developed, from which the Principal may select a coating system and Applicator for a specific project. It saves time and avoids re-qualification for similar projects.

The general qualification is given independent of line pipe diameter and wall thickness. When required for specific projects, additional testing should be performed on different line pipe diameters and wall thicknesses.

The coating system shall be suitable for the temperature class, based on the maximum operating temperature or design temperature of the pipeline. This DEP does not identify maximum temperature limits for polyethylene and polypropylene coating systems because there are a large variety of available grades of primer, adhesisves and polymers. The maximum allowable temperature per coating system is defined by the choice of the individual components.

For general coating qualification, the coating Manufacturer/Applicator shall specify the temperature class.

The suitability of a coating system for a particular temperature class shall be demonstrated by performing the qualification tests at the relevant test temperature given in this DEP, see Tables 2, 4 and 5. For a specific project, additional testing should be performed at temperatures specified by the Principal.

2.2 COATING SYSTEM DESCRIPTION

The pipeline coating system described in this DEP shall be manufactured with polyethylene or polypropylene as the main coating material, and with suitable primers and adhesives to obtain the required coating properties under the prevailing installation and operating conditions.

2.3 INFORMATION TO BE SUBMITTED BY THE PRINCIPAL

For a project qualification, the Principal shall supply technical information to the Contractor regarding the project, in particular the installation and operating conditions. This information shall contain as a minimum:

- project name;
- the type and thickness of coating required (PE/PP);
- the maximum operating temperature of the pipeline;
- description of steel pipe;
- the applicable line pipe specification;
- the geographical area (land/subsea);
- expected ambient temperatures during installation;
- installation method;
- soil and backfill conditions for land pipelines;
- seabed trenching, laying and burial conditions for subsea pipelines;
- subsequent coatings to be applied (e.g. weight coating, insulation);
- requirements for anti-slip treatment;
- type of cathodic protection system.

The Principal shall indicate whether a specific brand of coating shall be used or whether the Contractor shall select the coating.

2.4 INFORMATION TO BE SUBMITTED BY THE CONTRACTOR

The Contractor shall submit information to the Principal on the coating system to be used. This information shall contain as a minimum:

- system identification (5.2);
- Manufacturer's data (5.3);
- system qualification information (5.4);
- coating application procedures;
- the name(s) of the proposed coating applicator(s);
- Applicator's qualification information (6);
- Quality Plan.

The Contractor shall confirm that the coating system is suitable for use under the specified conditions (2.3).

3. COATING SYSTEM REQUIREMENTS

3.1 GENERAL

The coating system shall be suitable for the pipeline installation and operating conditions specified by the Principal (2.3).

Prior to beginning any production run, the Contractor shall demonstrate that the coating system will fulfil the qualification requirements in accordance with (5.4). Any modification of a qualified coating system shall require re-qualification of the modified system.

The Contractor shall demonstrate by effective quality control procedures in accordance with (4.3) that the coating, as applied during normal production, fulfils the requirements of this DEP.

3.2 FINISHED COATING SYSTEM REQUIREMENTS

3.2.1 Visual appearance

The coating shall be free from blisters, pinholes, scratches or any other irregularities and shall have a uniform colour and gloss.

3.2.2 Total coating thickness

For polyethylene and polypropylene coating systems, the minimum thickness of the total coating system shall be as specified in Table 1 unless otherwise specified by the Principal.

The coating thickness shall be measured in accordance with (7.2).

Table 1 Minimum total coating system thickness for polyethylene and polypropylene pipeline coating systems

	Minimum total coating thickness, mm	
DN	Polyethylene	Polypropylene
≤ 100	2.5	1.8
> 100 and ≤ 250	2.7	2.0
> 250 and < 500	2.9	2.2
≥ 500 and < 800	3.2	2.5
≥ 800	3.7	2.5

3.2.3 Holidays

The coating system shall be free from holidays when tested in accordance with (7.3).

3.2.4 Adhesion

The adhesion of the coating system shall be determined by peel resistance, measured at room temperature and at a test temperature related to the operating temperature in accordance with Table 2, using the test procedure in (7.4).

For crosshead-extruded coatings, the peel resistance shall also be measured in the longitudinal direction of the pipe at 20 °C and shall be at least 35 N/10 mm.

The minimum peel resistance values at the given test temperatures shall be as specified in Table 2.

If the coating cannot be peeled from the line pipe, the minimum peel resistance value shall be recorded as greater than the measured tensile force at yield.

Table 2 Minimum coating peel resistance for polyethylene and polypropylene pipeline coating systems

		Peel resistance, N/10 mm	
Operating temperature, °C	Test temperature, °C	Polyethylene	Polypropylene
< 20	23 ± 2	> 35	> 150
20 - 50	50 ± 2	> 25	> 100
50 - 60	60 ± 2	> 20	> 80
60 - 80	80 ± 2	> 20	> 80
> 80	operating temperature ± 2	>20	> 40

3.2.5 Impact resistance

The impact resistance of the PE coating system shall be tested only at (23 ± 2) °C; the impact resistance of PP shall be tested at (0 ± 2) °C and (23 ± 2) °C. The testing shall be carried out in accordance with the procedure in (7.5) and the minimum impact resistance shall be as specified in Table 3.

Table 3 Minimum impact resistance for polyethylene and polypropylene pipeline coating systems

	Minimum impact resistance, J		
DN	PE at 23 °C	PP at 0 °C	PP at 23 °C
≤ 100	6.5	6.5	18
> 100 and ≤ 250	8.5	8.5	20
> 250 and ≤ 500	11.0	11.0	22
> 500	12.5	12.5	25

3.2.6 Indentation resistance

The indentation resistance of the coating system shall be tested at room temperature and at a temperature related to the maximum operating temperature as given in Table 4, in accordance with the procedure in (7.6). The maximum allowable indentation shall be as specified in Table 4.

Table 4 Indentation resistance for polyethylene and polypropylene pipeline coating systems

		Max. Indentation, mm	
Operating temperature, °C	Test temperature, °C	Polyethylene	Polypropylene
< 20	23 ± 2	≤ 0.2	≤ 0.1
20 - 50	50 ± 2	≤ 0.3	≤ 0.2
50 - 60	60 ± 2	≤ 0.3	≤ 0.2
60 - 80	80 ± 2	≤ 0.3	≤ 0.3
> 80	operating temperature ± 2	≤ 0.4	≤ 0.4

3.2.7 Elongation

The elongation at break of a coating sample, when tested at ambient temperature in accordance with (7.7), shall be more than 300 % for both polyethylene and polypropylene coatings.

3.2.8 Coating resistivity

The coating resistivity shall be more than 10^8 Ω·m when tested in accordance with the procedure in (7.8).

3.2.9 Thermal ageing

After exposure to elevated temperatures in accordance with the procedure in (7.9) the melt mass flow rate of the coating material shall vary by not more than ± 35 % from the melt mass flow rate before the exposure, or the elongation at failure of the aged coating material shall be > 50 % of the elongation of the unexposed coating material.

3.2.10 Ageing under exposure to light

After exposure to ultraviolet light radiation in accordance with the procedure in (7.10) the melt mass flow rate of the coating material shall vary by not more than ± 35 % from the melt mass flow rate before irradiation, or the elongation at failure of the radiated coating material shall be > 50 % of the elongation of the unexposed coating material.

3.2.11 Cathodic disbonding resistance

Cathodic disbonding tests shall be carried out in accordance with (7.11) at a test temperature related to the operating temperature as specified in Table 5. After the test, the maximum radius of disbonding shall be less than the value listed in Table 5.

Table 5 Cathodic disbonding resistance for polyethylene and polypropylene pipeline coating systems

		Max. disbonding radius, mm	
Operating temperature, °C	Test temperature, °C	Polyethylene	Polypropylene
< 20	23 ± 2	10	3
20 to 50	50 ± 2	10	5
50 to 60	60 ± 2	15	7
60 to 80	80 ± 2	15	7
> 80	operating temperature ± 2 (maximum temperature is 95 ± 2)	15	7

3.2.12 Degree of cure of FBE primer

The degree of cure of the FBE primer shall be determined by differential scanning calorimetry in accordance with (7.12). The ΔTg value shall be between -2 °C and +3 °C.

4. COATING SYSTEM APPLICATION AND QUALITY CONTROL

4.1 PIPE SURFACE PREPARATION

Before blast cleaning and application of the coating system, the pipe surface shall be free of all surface contamination. Oil, grease, and other contaminants shall be removed, before blast cleaning, by a suitable solvent or detergent. Salt contamination, chemical cleaning agents and remaining detergents shall be washed off using potable water.

The pipe surface shall be cleaned of mill scale, rust and other foreign matter by a blast cleaning or another abrasive cleaning method to achieve a minimum surface cleanliness of Sa 2½ (7.1). For stainless steel pipes, stainless steel abrasives or non-ferrous abrasives shall be used for blast cleaning. The surface profile shall be as specified by the coating Manufacturer in his application instructions. During blast cleaning the pipe surface temperature shall be simultaneously higher than 5 °C and more than 3 °C above the ambient dew point. The ambient relative humidity shall not exceed 85 %.

The maximum residual chloride level on the blast-cleaned surface shall be 20 mg/m^2, in accordance with ISO 8502-2 (7.1) or any other method approved by the Principal.

The dust level on the blast-cleaned surface shall be of Class 1 in accordance with ISO 8502-3 (7.1).

Immediately after blast cleaning, all remaining weld spatter and irregularities shall be removed from the pipe surface by chiselling and/or grinding. Any treated surface with an area larger than 25 cm^2 shall be re-blasted to the cleanliness and roughness as specified above.

No repairs to the pipe shall be made without a procedure agreed by the Principal.

After any grinding or mechanical repairs, the remaining wall thickness shall be checked and compared with the minimum requirements of the code/specification. Pipes not meeting the minimum wall thickness shall be rejected.

Before coating, the pipe surface shall be cleaned from all dust and foreign matter using clean dry compressed air or vacuum cleaning. The compressed air shall be free of any trace of oil.

4.2 COATING APPLICATION

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

The application of the coating shall be strictly in accordance with the coating Manufacturer's application procedures. For multi-layer systems, the temperature and time between subsequent layers shall be controlled to obtain sufficient interlayer adhesion.

The required layer thickness of the primer and adhesive layer shall be specified in the application procedures.

For all coating processes, the preheating temperatures and extrusion temperatures shall comply with the requirements specified in the application procedures. Heating equipment shall be controlled to maintain uniform temperatures throughout the coating process.

Batches of polymer shall be used in the same sequential order in which they were manufactured.

During coating, the bevelled ends of the pipes and the pipe bore shall be protected against mechanical damage and against contamination with coating material.

At the pipe ends, the coating shall be cut back over a length of 150 mm ± 20 mm unless otherwise specified. At the cutback, the coating edge shall be shaped to form a bevel angle of 30° to 45°. For stainless steel pipes, non-ferrous or stainless steel tools shall be used.

Uncoated pipe ends shall receive a temporary protective coating for transit.

4.3 QUALITY CONTROL

4.3.1 General

During production application of the coating, the Applicator shall carry out all quality control activities needed to ensure that the coating is being applied in accordance with the approved coating application procedures and that the final product complies with the requirements of this DEP.

The minimum quality control tests to be performed shall be as indicated in Table 6.

Records of all coating application and quality control test results shall be kept in accordance with (9).

4.3.2 Ambient conditions

The Applicator shall measure the ambient conditions at regular intervals during blasting and coating and keep records of prevailing temperature, humidity and dew point. If the conditions are outside the limits specified in this DEP, the process shall be suspended until the requirements are met.

4.3.3 Inspection of uncoated pipes before blasting

Before surface preparation starts, each pipe shall be visually examined for dents, laps, defective bevels and any other defects to avoid coating unusable pipes. Defective pipes shall be removed from the coating line for repair or, if repair is not possible, rejection.

The pipe surface shall be visually checked for contamination with salts, oil or grease. Contaminated pipes shall be cleaned again.

4.3.4 Inspection after blasting

Each pipe shall be inspected for surface cleanliness. Pipes that do not comply with the requirements of (4.1) shall be rejected and cleaned again.

The surface profile shall be measured at regular intervals and on the first 5 pipes following each change of blast-cleaning material. If the surface profile is outside the specified limits, the blasting material shall be checked and replaced as necessary. The affected pipes shall be re-blasted.

One of every 100 pipes shall be checked for chloride contamination on the blasted surface (7.1). If contamination of the surface occurs, the quality of the blast cleaning material (7.13) and process shall be examined. If the conductivity of the blasting material is greater than 50 µS/cm, the blasting material shall be replaced.

4.3.5 Application temperatures

The temperature of the pipe surface shall be continuously monitored and recorded by means of suitable instruments, e.g., infrared sensors, contact thermometers or thermocouples. The extrusion temperatures of the adhesive and coating material shall be continuously recorded.

The monitoring instruments shall be independent of the temperature control equipment. The instruments shall be calibrated prior to each unit of production.

Any deviation from the recommended application temperature range shall be rectified. If immediate rectification is not possible, the production shall be stopped until the cause of the deviation has been eliminated.

Any pipes coated during the duration of the temperature deviation shall be identified by marking and subjected to additional quality control tests (4.3.6) at the discretion of the Inspector. Pipes that do not comply with the quality control requirements shall be rejected, cleaned and recoated.

4.3.6 Appearance, thickness and holidays

Immediately following coating application, each coated pipe shall be visually checked for imperfections and irregularities of the coating (3.2.1), for coating thickness (7.2) and for the absence of holidays (7.3). Pipes that do not comply with the requirements shall be marked and removed from the coating line for repair or recoating. If subsequent pipes do not comply with the requirements, the coating process shall be checked or stopped to eliminate the cause of the problem.

Per joint or fitting, a maximum of two pinholes or one larger area of damage (max. 40 cm^2) may be repaired. If the number or size of damage sites exceeds these figures, the whole pipe shall be re-coated.

Each pipe shall be checked for cleanliness of the pipe ends and for damage to the bevelled ends. Damaged bevels shall be repaired by means of procedures approved by the Principal.

4.3.7 Destructive testing

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 indicated in Table 6.

The tests shall commence as soon as possible after coating to allow readjustment of the coating process if required.

After cutting of the test sample, the remaining pipe shall be marked with the remaining length and the coating cutback reinstated in accordance with (4.2). The pipe end bevel shall be re-machined to the original pipe specification.

4.3.8 Cathodic disbonding test

One sample, at predetermined intervals, shall be subjected to a cathodic disbonding 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 the Principal. 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.

4.3.9 Degree of cure

At predetermined intervals, one pipe shall be selected and a coating sample taken from the pipe for the cure test. The cure test shall be carried out in accordance with (7.12) and the ΔTg value shall be between -2 °C and +3 °C. The damage caused by the sampling shall be repaired.

4.3.10 Acceptance of failed pipes

In the event of pipes failing to meet the requirements of sections (4.3.6) to (4.3.9), preceding pipes coated after the last acceptable pipes and the pipes coated following the failed pipe shall be considered suspect and shall be marked for further testing.

The Applicator shall propose and agree with the Principal a test programme to trace any of the suspect pipes affected by the same failure. Further testing shall involve inspection and examination similar to that carried out on the original rejected test pipe(s). Based on the test results, the final acceptance or rejection of the suspect pipes shall be made by the Principal.

No pipes shall be dispatched from the coating yard before the Principal has approved the quality control results.

The Principal retains the right to reject any shift's or day's production if the reject rate of that production is more than 10 % and/or if sample tests are found to be outside the specification in this DEP.

In addition, the Applicator may be required to stop production and carry out a full investigation into the source of the problem; he shall submit the results to the Principal before receiving permission from the Principal to recommence production.

4.3.11 Traceability of pipes and coating

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.

Table 6 Minimum quality control requirements for polyethylene and polypropylene pipeline coatings

Property	Paragraph	Test method	Test frequency
Ambient conditions	(4.3.2)		once per shift
Surface condition before blasting	(4.3.3)	visual	each pipe
Cleanliness of blast cleaned surface	(4.3.4)	(7.1)	each pipe
Surface profile	(4.3.4)	(7.1)	one of 20 pipes
Surface cleanliness Chlorides	(4.3.4)	(7.1)	one of 100 pipes
Blast cleaning materials and process	(4.3.4)	(7.13)	once per shift or related to (4.3.3)
Pipe surface temperature	(4.3.5)	-	Continuous
Coating application temperature	(4.3.5)	-	Continuous
Appearance	(4.3.6)	visual	each pipe
Coating thickness	(4.3.6)	(7.2)	each pipe
Holiday detection	(4.3.6)	(7.3)	each pipe
Pipe ends	(4.3.6)	visual	each pipe
Adhesion	(4.3.7)	(7.4)	one of 100 pipes
Impact	(4.3.7)	(7.5)	one of 100 pipes
Indentation	(4.3.7)	(7.6)	one of 100 pipes
Elongation	(4.3.7)	(7.7)	one of 100 pipes
Cathodic disbonding	(4.3.8)	(7.11)	one of 200 pipes (minimum one pipe per unit of production)
Degree of cure of FBE	(4.3.9)	(7.12)	one of 200 pipes (minimum one pipe per unit of production)

5. COATING SYSTEM QUALIFICATION

5.1 GENERAL

Before a coating system may be applied in a production run, the Contractor shall submit all the data specified in (5.2) and (5.3) and shall ensure that both the coating system and the Applicator have been qualified in accordance with the procedures in (5.4) and (6).

5.2 SYSTEM IDENTIFICATION

The Contractor shall submit all details to identify the coating system. Details shall include:

- system designation or trade name;
- name of coating Manufacturer(s);
- generic type of system (polyethylene or polypropylene);
- coating process (sintering, side extrusion or crosshead extrusion);
- system structure (2-layer or 3-layer);
- structure components (primer, adhesive, outer layer) ;
- service temperature range;
- total nominal coating thickness;
- relevant international/national coating standard approvals.

5.3 MANUFACTURER'S DATA

5.3.1 Primer

The following data shall be submitted on the primer (if applicable):

- the generic type of primer;
- for liquid primers the solids content, the type of solvent and the density;
- for powder epoxy primers the density, gel time, particle size, recommended film thickness, colour;
- typical film properties (flexibility, cathodic disbonding resistance, etc.);
- the method of application (brush, roller, spray, electrostatic spray, etc.);
- storage conditions and shelf life;
- the nominal dry film thickness or spreading rate;
- application procedures, temperature, pot life, overcoating times;
- HSE datasheets.

5.3.2 Adhesive

The following data shall be submitted on the adhesive (if applicable):

- the generic type of adhesive;
- the method of application (powder spray, extrusion etc.);
- the nominal thickness;
- storage conditions and shelf life.

5.3.3 Coating material

The following data shall be submitted on the polyethylene or polypropylene outer layer material:

- generic type of material (e.g. high/medium/low density PE/PP);
- delivered product (powder, granules, liquid etc.);
- storage conditions, shelf life;
- colour;
- nominal thickness of the outer layer;

- mechanical properties of the outer layer film (tensile strength, elongation);
- data on resistance to bio-degradation.

5.3.4 Chemical pre-treatment

If any chemical pre-treatment of the blasted steel is carried out the following data shall be submitted:

- generic type of chemical;
- preparation, concentration, etc.;
- application procedure, including spreading rate (m^2/l), and drying times.

5.4 QUALIFICATION

Before a coating system can be specified for an application, the Contractor or the coating Manufacturer shall apply for qualification of the coating system. Qualification shall be carried out according to the following procedures.

The Contractor or the coating Manufacturer shall submit all data specified in (5.2) and (5.3).

The Contractor or the coating Manufacturer shall show that samples of the coating system applied on pipes of the specified pipe material have been successfully subjected to the tests as specified in Table 7, columns 3 and 4. The tests shall be carried out by an independent test laboratory or, if approved by the Principal, by the coating Manufacturer. The Principal shall witness the application and the tests.

The number of pipes to be tested and the test procedures are given in Table 7.

If agreed by the Principal, previous qualification data can be used provided that the referred tests have been carried out using the same coating system (5.2) and the same coating process as specified in the contract.

With the approval of the Principal, tests carried out in accordance with other coating standards may be used insofar as their procedures are the same as or more stringent than the procedures in this DEP. Such information shall include full reports on test procedures and results and be signed by the laboratory representatives and certification body.

6. APPLICATOR QUALIFICATION

6.1 GENERAL

Before production application of a coating system may commence, the Applicator shall be qualified to apply the coating system. The qualification shall be carried out according to the following procedures:

6.2 COATING PROCESS AND APPLICATOR SELECTION

The Contractor shall submit to the Principal information on the required coating process and recommended applicators. The information shall include:

- description of the coating process for line pipe, bends and fittings;
- pipe cleaning and surface preparation (cleanliness, profile, chemical pre-treatment, etc.);
- required surface and material application temperatures;
- recommended applicators;
- coating repair procedures (8).

6.3 COATING PLANT

To demonstrate that the available equipment is capable of applying the specified coating according to the required standards, each recommended Applicator shall submit full details of the coating plant, including:

- layout diagram of the coating plant and plant flow scheme;
- general description of the equipment available to carry out the coating process;
- details of process control and inspection equipment required for the coating process such as temperature control, thickness control, holiday testers, laboratory equipment, etc.;
- details on the line pipe marking, handling, storage and transport equipment and procedures;
- Applicator’s quality control procedures.

6.4 QUALIFICATION

After approval of the process and plant details (6.2) and (6.3) and before production starts, the Applicator shall submit evidence that he has successfully applied the coating system before on pipes of the specified material, and that the product complied with the requirements (3) of this DEP for the tests indicated in Table 7, columns 3 and 5.

The Applicator shall coat at least 2 pipes with the proposed coating system and shall subject samples from these pipes to the tests given in Table 7. These tests may be carried out in the Applicator's own laboratory, or by an independent laboratory. The Principal shall witness the application and the tests. The results of the tests shall be reported to the Principal, signed by the head of the laboratory and the witness.

When this specification is used for the coating of bends and/or fittings, the Applicator shall coat at least one fitting or bend as agreed with the Principal and subject this coating to the same qualification tests.

Table 7 Minimum requirements for polyethylene and number of pipes required during qualification

			Number of pipes required	
Property	Paragraph	Test method	Coating system qualification	Applicator qualification
Cleanliness of blast cleaned surface	(4.1)	(7.1)	5 pipes	2 pipes
Surface roughness	(4.1)	(7.1)	5 pipes	2 pipes
Pipe surface temperature	(4.2)	-	5 pipes	2 pipes
Coating application temperature	(4.2)	-	5 pipes	2 pipes
Appearance	(3.2.1)	visual	5 pipes	2 pipes
Coating thickness	(3.2.2)	(7.2)	5 pipes	2 pipes
Holiday detection	(3.2.3)	(7.3)	5 pipes	2 pipes
Adhesion	(3.2.4)	(7.4)	5 pipes	2 pipes
Impact	(3.2.5)	(7.5)	5 pipes	2 pipes
Indentation	(3.2.6)	(7.6)	5 pipes	2 pipes
Elongation	(3.2.7)	(7.7)	5 pipes	2 pipes
Coating resistivity	(3.2.8)	(7.8)	5 pipes	not required
Thermal ageing	(3.2.9)	(7.9)	2 pipes	not required
UV stability	(3.2.10)	(7.10)	2 pipes	not required
Cathodic disbonding	(3.2.11)	(7.11)	2 pipes	1 pipe
Degree of cure of FBE	(3.2.12)	(7.12)	2 pipes	1 pipe
System identification/ Manufacturer's data	(5.2) (5.3)		Available to Principal	-
Coating process and plant data	(6.2) (6.3)		-	Approved by Principal

7. INSPECTION AND TEST PROCEDURES

The inspection and test procedures are specified herein.

7.1 SURFACE FINISH AFTER BLAST CLEANING

The surface finish after blast cleaning shall be inspected with the following International Standards:

- surface cleanliness shall be determined by means of ISO 8501-1;
- chloride contamination shall be determined by means of ISO 8502-2;
- dust levels shall be determined by means of ISO 8502-3;
- surface profile shall be determined by means of ISO 8503-2;
- the surface profile comparator shall comply with ISO 8503-1 and shall be calibrated before every unit of production in accordance with ISO 8503-3 or ISO 8503-4.

7.2 COATING THICKNESS

The coating thickness shall be measured by means of a thickness meter based on eddy current or electromagnetic techniques, in accordance with ISO 2808, method 6A or 6B.

Magnetic thickness gauges shall not be used, either for qualification testing or for quality control purposes.

The thickness gauge shall be calibrated at least once per shift. Calibration shall be carried out on a steel plate of a similar thickness to the pipe wall by means of plastic shims of the same thickness as the nominal coating system.

For quality control purposes the coating thickness shall be measured at three locations per pipe, equally spaced along the length of the pipe. At each location, the thickness shall be measured at four positions, equally spaced around the circumference of the pipe.

7.3 HOLIDAY TEST

A holiday test shall be carried out by means of an adjustable high voltage holiday tester having an audible and visual alarm. The scanning electrode shall consist of a metal brush or coil spring, fitting the diameter of the coated pipe.

The earth connection shall be made directly on the pipe.

The test voltage shall be 1 kV for each 0.1 mm of coating thickness with a maximum of 25 kV.

The test voltage shall be checked at least once per shift by means of a special high voltage meter.

When the holiday test is carried out the external pipe surface shall be free of moisture.

The electrode shall be moved over the pipe surface at a speed of not more than 0.3 m/s. The entire pipe surface shall be covered by the test.

When used in conjunction with the impact resistance test (7.5), a suitable metal brush shall be used to inspect the impacted surface.

7.4 COATING ADHESION

7.4.1 General

The coating adhesion shall be determined by measuring the peel strength, i.e. the force required to peel a strip of coating from the pipe surface. Two test methods are allowed: Method 1 (7.4.2) is recommended as the preferred method and shall be used for pipe DN $\leq$ 400; Method 2 (7.4.3) may be used for pipe DN > 400. The test method used shall be stated in the test report.

Any method using a force gauge of spring balance type shall not be used.

For testing at elevated temperatures, a sample of pipe shall be conditioned for at least one hour at the test temperature. The test shall be carried out under conditions that ensure that the temperature of the outer steel surface is maintained at the required test temperature. The surface temperature shall be monitored during the test and the results reported.

The procedure and the type of heating equipment shall be proposed by the test laboratory and approved by the Principal.

7.4.2 Peel strength test, Method 1

A strip of coating with a width of between 20 mm and 50 mm shall be peeled off the pipe surface in the circumferential direction over the full pipe circumference or at least 300 mm length, by means of a tensile machine and the stripping arrangement shown in Figure 1. Apparatus as used in the relevant test method of DIN 30670 is satisfactory.

The coating shall be peeled at an angle of 90° to the pipe surface with a pulling rate of 10 mm per minute. The force required for the peeling shall be continuously recorded. The peeling force shall be the mean value of this recording, disregarding the first and last 20 mm. The recording shall not show any section of more than 20 mm length having a peeling force less than 75 % of the mean value.

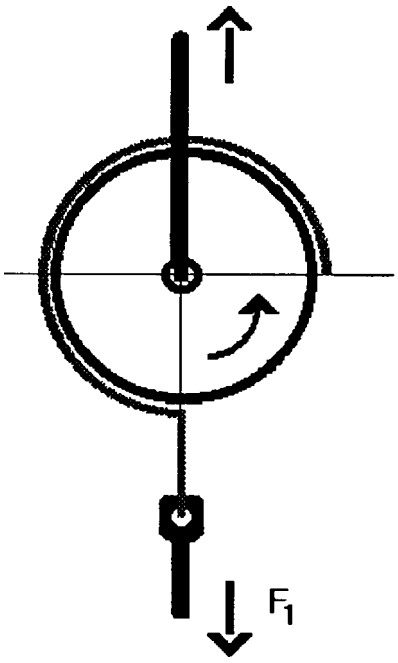
The peel strength is calculated as:

$$\frac{F_m \times 10}{W} \qquad \text{(N/10 mm)}$$

where: F_m is the mean pulling force in N
W is the width of the strip in mm.

The peel tests shall not be carried out on coating over welds, coating overlaps or within $1.5 \times$ DN or 300 mm, whichever is smaller, from the edge of the coating. The test strips shall be at least 50 mm apart.

FIGURE 1 ARRANGEMENT FOR THE PEEL STRENGTH TEST, METHOD 1



7.4.3 Peel strength test, Method 2

A strip of coating with a width of between 20 mm and 50 mm shall be peeled off the pipe surface in the circumferential direction over a distance corresponding to 45° of the pipe circumference under the force of a dead weight as shown in Figure 2.

After manually peeling the strip down to the 45° position as shown, a weight is suspended from the strip. The time required to peel the coating over the 45° angle (peel time) shall be measured. This peel time shall correspond to a peeling rate of 10 mm/min and shall be:

$0.04 \times D$ (minutes) +20 % / -10 %

where: D is the pipe outside diameter in mm.

When the peel time is outside this range, further tests shall be performed using an adjusted weight until the correct peel time is achieved.

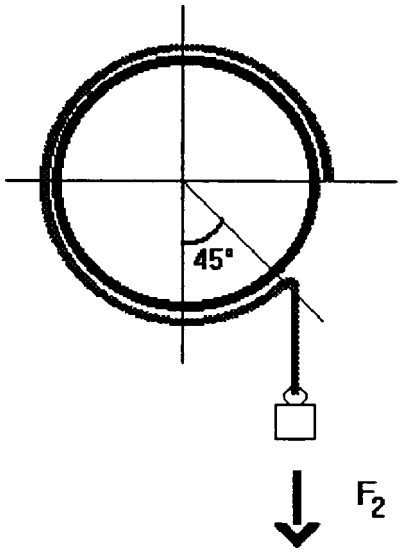
The peel strength shall be calculated as:

$$\frac{9.81 \times M \times 10}{W} \quad \text{(N/10 mm)}$$

where: M is the mass of the weight in kg and
W is the width of the strip in mm.

The peel tests shall not be carried out on coating over welds, coating overlaps or within $1.5 \times$ DN or 300 mm, whichever is smaller, from the edge of the coating. The test strips shall be at least 50 mm apart.

FIGURE 2 ARRANGEMENT FOR THE PEEL STRENGTH TEST, METHOD 2



7.5 IMPACT RESISTANCE

The impact test shall be performed by means of a falling weight impact testing machine as described in DIN 30670 (PE) or DIN 30678 (PP) or by ASTM G14. The falling weight shall have a smooth hemispherical head with a diameter of 25 mm.

Before the test, the pipe surface shall be tested for the absence of holidays.

The pipe sample shall be placed horizontally, supported directly under the impact area to avoid the effect of the elastic response of the pipe. The testing machine shall be placed in a vertical plane perpendicularly on the top of the pipe surface.

For impact testing of PP coating at 0 °C, the pipe sample shall be conditioned at 0 °C for 12 h, and the test performed before the coating temperature rises above +2 °C.

Each test shall comprise a series of 10 impacts, using a combination of weight and height corresponding to the predetermined impact energy. The impacts shall not be on pipe welds, coating overlaps or within 1.5 $\times$ DN or 300 mm, whichever is smaller, from the edge of the coating. The impacts shall be at least 50 mm apart. After the impacts have been made, each point of impact shall be tested for the presence of a holiday in accordance with (7.3). The number of holidays shall be noted.

When no defects can be found, even at impact levels twice as high as the minimum required impact resistance, this value shall be rated as the minimum impact resistance.

For the purpose of quality control testing, one series of 10 impacts shall be made with the impact energy set at the specified minimum requirement (3.2.5). No failures of the pipe coating shall be found during the holiday test of the impact points. If holidays are found, two pipes each coated immediately before, and two pipes each coated immediately after the failed pipe shall be tested and shall show no failures. If these pipes fail, the coating process shall be stopped and the cause investigated and eliminated before production is resumed. All pipes coated since the last successful impact test shall be considered suspect and shall be impact tested individually or rejected.

7.6 INDENTATION

The number of pipes to be tested is indicated in the relevant table in this DEP. From each pipe a coating sample is taken and the adhesive is removed from each sample. The indentation test shall further be carried out in accordance with DIN 30670 (PE) or DIN 30678 (PP).

7.7 ELONGATION

The number of pipes to be tested is indicated in the relevant table in this DEP. From each pipe five coating samples are taken and the adhesive is removed from each sample. The elongation at break shall be measured in accordance with DIN 30670 (PE) or DIN 30678 (PP).

7.8 COATING RESISTIVITY

The resistivity of the coating shall be measured in accordance with DIN 30670 (PE) or DIN 30678 (PP). The number of samples shall be in accordance with the relevant table in this DEP.

7.9 THERMAL AGEING

Thermal ageing shall be carried out in accordance with the procedure DIN 30670 (PE) or DIN 30678 (PP). PE coating samples shall be exposed at 100 °C for 200 days. PP coating samples shall be exposed at 140 °C for 100 days. The melt mass flow rate or the elongation at failure of the coating material shall be determined in accordance with ISO 1133 or ISO 527 respectively at the ageing intervals given in DIN 30670 (PE) or DIN 30678 (PP).

7.10 AGEING UNDER EXPOSURE TO LIGHT

The ageing of the coating under exposure to light shall be carried out in accordance with the procedure in DIN 30670. The melt mass flow rate, or the elongation at failure of the coating material shall be determined in accordance with ISO 1133 or ISO 527 respectively at the ageing intervals given in DIN 30670.

7.11 CATHODIC DISBONDING RESISTANCE

The cathodic disbonding resistance of the coating shall be tested as follows:

The test sample shall be free of holidays when tested in accordance with (7.3).

A sample of coated pipe shall be taken of sufficient length and with approximately the same diameter as the production pipe. The exact set-up of the test may depend on the diameter of the pipe.

A 6 mm hole shall be drilled in the coating, by means of a flat-faced mill. The hole shall not penetrate more than 0.5 mm into the pipe steel. The hole shall be at least 50 mm from any weld.

The sample shall be placed inside an electrolytic cell or an electrolytic cell shall be constructed on the pipe surface. All metallic parts other than the test defect shall be sealed from the electrolyte by means of a resin or other suitable compound. The volume of the cell shall be at least 250 ml.

The cell is filled with a 3 % sodium chloride solution.

An inert auxiliary electrode (e.g. platinum wire or mesh) shall be placed in the electrolyte, remote from the test defect.

A saturated calomel reference electrode (SCE) shall be placed in the electrolyte with the tip 10 mm from the test defect.

By means of a potentiostat, the electrochemical potential of the steel shall be polarised to -1500 ± 10 mV with respect to the SCE. This potential shall be maintained throughout the test.

The current required to maintain the potential shall be continuously recorded.

The duration of the test shall be 28 days, after which the sample shall be removed from the cell and examined. For quality control purposes, the 28-day test at 23 °C may be replaced by a shorter duration test at elevated temperature as stated in (4.3.8).

For tests at elevated temperatures, the temperature shall be controlled as follows:

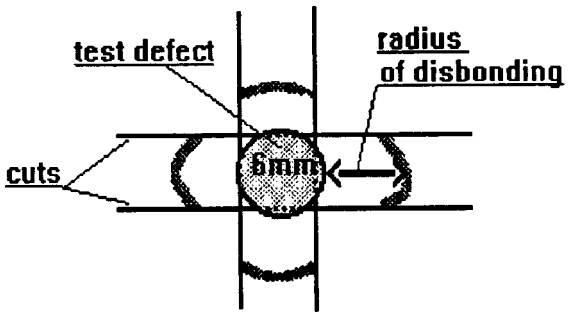
- When the sample is immersed in the cell, the solution, including the sample, shall be kept at the test temperature by the cell being placed in a thermostatically controlled water bath.
- When the cell has been constructed on the pipe sample, the steel sample shall be placed in a thermostatically controlled furnace or sand bath that also covers the top surface of the sample with at least 1 cm of sand. The furnace or bath shall be adjusted to maintain the required test temperature on the pipe surface in the test defect.
- During tests at elevated temperatures, suitable reflux coolers shall be used to prevent evaporation of the test electrolyte.

At the end of the test period, the sample shall be rinsed with fresh water and wiped dry.

Two cuts shall be made through the coating in the longitudinal direction of the pipe and two similar cuts shall be made in the circumferential direction, each pair of cuts being 5 mm apart and approximately following the tangent of the test defect. The length of the cuts shall extend to approximately 20 mm each side of the defect; see Figure 3.

By means of a knife, the strips of coating between the cuts shall be peeled from the pipe surface as far as possible, starting at the test defect. The distance over which the coating is detached and the metal is exposed, measured from the edge of the original test defect, shall be recorded for all four directions. The radius of disbonding shall be the arithmetic mean of the four measurements. A photograph of the test sample after testing, showing the disbonded area, should be included in the test report.

FIGURE 3 DETERMINATION OF THE RADIUS OF DISBONDING



7.12 DEGREE OF CURE OF FBE PRIMER

The degree of cure of the FBE primer shall be measured by means of differential scanning calorimetry in accordance with ASTM D 3418, to determine the glass transition temperature (Tg) and the enthalpy (Hr) of the curing of the powder.

For the samples of the applied coating, two scans shall be made to determine the glass transition temperatures Tg_1 and Tg_2, respectively. The degree of cure is related to the difference between Tg_1 and Tg_2, which shall be determined as:

$$\Delta Tg = Tg_2 - Tg_1$$

7.13 CONDUCTIVITY MONITORING OF BLASTING MATERIAL EXTRACTS

This method describes the procedure for monitoring the quality of the blasting material in machines that recycle the blasting material. An increased conductivity level may indicate that an ionic contaminant has been introduced into the blasting material from the pipe surface.

The procedure is as follows:

- measure a 100 ml volume of blasting material in a glass bottle;
- add 100 ml deionised or distilled water;
- cap the bottle and shake for 1 min;
- decant the water extract into another glass bottle;
- measure and record the conductivity of the water.

8. COATING REPAIR

The Contractor shall submit detailed procedures for coating repairs.

All coating repair procedures shall be qualified under both coating system (5.4) and Applicator qualification (6).

These procedures shall contain as a minimum:

- repair of surface defects;
- repair of pinholes, scratches and small defects (e.g. by means of a melt stick);
- removal of rejected coating and cleaning the pipe to the required standard for recoating;
- testing to prove the effectiveness of the repairs.

All pipes that have been repaired shall be fully re-examined in accordance with the quality control procedures (4.3).

Records shall be kept of all repaired pipes and shall include the repair and re-test details.

9. DOCUMENTATION

The Contractor shall keep accurate records of all relevant data of the coating process.

This documentation shall, as a minimum, consist of:

- copies of the coating system information as specified in (2);
- copies of qualification information as requested in (5);
- copies of, or reference to, all procedures for coating of the pipes;
- serial numbers of all pipes as given by the pipe Manufacturer (e.g. by copies of the pipe mill data sheets);
- serial numbers as given by the coating Applicator (if applicable) correlated with the Manufacturer's serial numbers;
- the order of coating, the day and shift of coating of each pipe;
- the batch numbers of the coating materials, the day and time of loading of each batch;
- serial numbers of rejected pipes and the reason for rejection;
- records of any repairs;
- the results of all quality control testing (4.3);
- records of temperatures during the coating process for each pipe, with the processing time of every tenth pipe marked on the temperature chart with the pipe number;
- names and signatures of the responsible persons for the coating process and quality control.

This documentation shall be submitted to the Principal after completion of the coating work, together with the testing and inspection instruments' calibration certificates.

10. HANDLING, STORAGE AND TRANSPORT OF BARE AND COATED PIPE

10.1 GENERAL

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.

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.

10.2 HANDLING OF PIPES

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

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.

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

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

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

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.

For handling of stainless steel pipes, transport equipment and conveyor shall be padded to prevent contact with carbon steel.

10.3 STORAGE AND STOCKPILING OF PIPES

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

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.

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

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.

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.

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.

10.4 TRANSPORT OF COATED PIPE

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

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

11. REFERENCES

In this DEP, reference is made to the following publications:

NOTES: 1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

2. The DEPs and most referenced external standards are available to Shell users on the SWW (Shell Wide Web) at http://sww.shell.com/standards.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.

AMERICAN STANDARDS

Recommended practice for railroad transportation of line pipe	API RP 5L1
Recommended practice for transportation of line pipe on barges and marine vessels	API RP 5LW

Issued by:
American Petroleum Institute
1220 L Street, N.W.
Washington, D.C.
USA

Standard guide for locating combustion test methods for polymeric materials	ASTM D 3418
Standard test method for impact resistance of pipeline coatings (falling weight test)	ASTM G 14

Issued by:
ASTM International
100 Barr Harbor Drive
West Conshohocken, PA 19428-2959
USA

GERMAN STANDARDS

Polyethylene coatings of steel pipes and fittings; requirements and testing	DIN 30670
Polypropylene coatings for steel pipes	DIN 30678

Issued by:
DIN Deutsches Institut fur Normung E.V. - English
Burggrafenstrasse 6
Berlin, Germany D-10787

INTERNATIONAL STANDARDS

Plastics – Determination of tensile properties	ISO 527
Plastics - Determination of the melt mass flow rate (MFR) and the melt volume flow rate (MVR) of thermoplastics	ISO 1133
Paints and Varnishes - Determination of film thickness	ISO 2808
Preparation of steel substrates before application of paints and related products - visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings	ISO 8501-1

Preparation of steel substrates before application of paints and related products - tests for the assessment of surface cleanliness - Part 2: Laboratory determination of chloride on cleaned surfaces	ISO 8502-2
Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 3: assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)	ISO 8502-3
Preparation of steel substrates before application of paints and related products - surface roughness characteristics of blast cleaned steel substrates - Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast cleaned surfaces	ISO 8503-1
Preparation of steel substrates before application of paints and related products - surface roughness characteristics of blast cleaned steel substrates Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel - comparator procedure	ISO 8503-2
Preparation of steel substrates before application of paints and related products - surface roughness characteristics of blast cleaned steel substrates Part 3: Methods for the calibration of ISO surface profile comparators and for the determination of surface profile - focusing microscope procedure	ISO 8503-3
Preparation of steel substrates before application of paints and related products - surface roughness characteristics of blast cleaned steel substrates Part 4: Methods for the calibration of ISO surface profile comparators and for the determination of surface profile - stylus instrument procedure	ISO 8503-4

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Geneva 20 Switzerland CH-1211

Copies can also be obtained from national standards organizations.