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Petroleum, petrochemical and natural gas industries — External corrosion protection of risers by coatings and linings —

Part 1: Elastomeric coating systems-polychloroprene or EPDM

Industries du pétrole, de la pétrochimie et du gaz naturel — Protection de la corrosion externe des risers par revêtements et doublures —

Partie 1: Systèmes de revêtement élastomère-polychloroprène ou EPDM

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

A list of all parts in the ISO 18797 series can be found on the ISO website.

Introduction

This document is based on GSO 2273. This document defines the minimum technical requirements for the external corrosion protection of risers by coatings and linings based on elastomeric coating systems-polychloroprene, EPDM or equivalent elastomeric coatings that are employed in the oil and gas industry and provides technical guidance for developing local standards and specifications in order to ensure compliance in coating and lining material selection and performance with contract requirements.

Users of this document need to be aware that further or differing requirements can be needed for individual applications. This document is not limiting the contractor and/or manufacturer from proposing or company from accepting alternative engineering solutions for the individual application. This can be particularly applicable where there is innovative or developing technology. Where an alternative is proposed, the specification issuer needs to identify any deviations from this document and provide details.

This document does not incorporate any form of passive fireproofing requirements or any related compatibility issues. Any requirements with regards to passive fireproofing are to be addressed separately.

Petroleum, petrochemical and natural gas industries — External corrosion protection of risers by coatings and linings —

Part 1: Elastomeric coating systems-polychloroprene or EPDM

1 Scope

This document specifies the minimum requirements for materials selection, surface preparation, application, inspection, testing, qualification and acceptance criteria of external coating for steel risers pipes used in the splash zone, their field joints and clamps/guides, using an elastomeric protective coating based on polychloroprene, EPDM or equivalent. This is applicable for new construction and repair of applied pipes before installation. Maintenance requirements and field repairs are covered in ISO 18797-2.

This document also specifies the requirements for transportation, handling and storage of riser pipes before and after surface preparation and coating application.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 34 (all parts), *Rubber, vulcanized or thermoplastic — Determination of tear strength*

ISO 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 813, *Rubber, vulcanized or thermoplastic — Determination of adhesion to rigid substrate — 90 degree peel method* [alternative to ISO 814]

ISO 814, *Rubber, vulcanized or thermoplastic — Determination of adhesion to metal — Two-plate method* [alternative to ISO 813]

ISO 815-1, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 1: At ambient or elevated temperatures*

ISO 815-2, *Rubber, vulcanized or thermoplastic — Determination of compression set — Part 2: At low temperatures*

ISO 1431-1, *Rubber, vulcanized or thermoplastic — Resistance to ozone cracking — Part 1: Static and dynamic strain testing*

ISO 1817, *Rubber, vulcanized or thermoplastic — Determination of the effect of liquids*

ISO 2781, *Rubber, vulcanized or thermoplastic — Determination of density*

ISO 2812-2, *Paints and varnishes — Determination of resistance to liquids — Part 2: Water immersion method*

ISO 4649, *Rubber, vulcanized or thermoplastic — Determination of abrasion resistance using a rotating cylindrical drum device*

ISO 6502, *Rubber — Guide to the use of curemeters*

ISO 7619-1, *Rubber, vulcanized or thermoplastic — Determination of indentation hardness — Part 1: Durometer method (Shore hardness)*

ISO 8501-1:2007,[1)]*Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8502-2, *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 8502-3, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)*

ISO 8502-4, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 4: Guidance on the estimation of the probability of condensation prior to paint application*

ISO 8502-5, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 5: Measurement of chloride on steel surfaces prepared for painting (ion detection tube method)*

ISO 8502-6, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 6: Extraction of soluble contaminants for analysis — The Bresle method*

ISO 8502-9, *Preparation of steel substrate before application of paints and related products — Tests for the assessment of surface cleanliness — Part 9: Field method for the conductometric determination of water-soluble salts*

ISO 8503-2, *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 8503-4, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Stylus instrument procedure* [alternative to ISO 8503-5]

ISO 8503-5, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 5: Replica tape method for the determination of the surface profile* [alternative to ISO 8503-4]

ISO 10474:2013, *Steel and steel products — Inspection documents*

ISO 11126 (all parts), *Preparation of steel substrates before application of paints and related products — Specifications for non-metallic blast-cleaning abrasives*

ISO 21457, *Petroleum, petrochemical and natural gas industries — Materials selection and corrosion control for oil and gas production systems*

ISO 21809-3, *Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 3: Field joint coatings*

1) SSPC SP10 is equivalent to ISO 8501-1.

ISO 29601, *Paints and varnishes — Corrosion protection by protective paint systems — Assessment of porosity in a dry film* [alternative to ASTM D5162]

EN 10204:2004, *Metallic products — Types of inspection documents*

EN 12664, *Thermal performance of building materials and products — Determination of thermal resistance by means of guarded hot plate and heat flow meter methods — Dry and moist products of medium and low thermal resistance* [alternative to ISO 29601]

EN 14879-4:2007, *Organic coating systems and linings of protection of industrial apparatus and plants against corrosion caused by aggressive media — Part 4: Linings on metallic components*

API RP 5LW, *Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels* [alternative to API RP 5L1]

API RP 5L1, *Recommended Practice for Railroad Transportation of Line Pipe* [alternative to API RP 5LW]

ASTM D2084, *Standard Test Method for Rubber Property — Vulcanization Using Oscillating Disc Cure Meter*

ASTM D4285, *Standard Test Method for Indicating Oil or Water in Compressed Air*

ASTM D5162, *Standard Practice for Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates* [alternative to ISO 29601]

ASTM D5894, *Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal, (Alternating Exposures in a Fog/Dry Cabinet and a UV/Condensation Cabinet)*

SSPC-AB 2, *Cleanliness of Recycled Ferrous Metallic Abrasive*

SSPC-PA 2, *Procedure for Determining Conformance to Dry Coating Thickness Requirements*

SSPC-SP 1, *Solvent Cleaning*

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
atmospheric zone
areas of offshore structures and riser pipes that extend upward from the *splash zone* (3.18) up to top decks of the *platform* (3.12) which are exposed to sun, wind, sprays and rains

3.2
applicator
organization appointed by *contractor* (3.3)/*client* (3.4) to perform application of coatings/linings on riser pipes as per project procedures prepared in accordance with this document

3.3
contractor
organization appointed by the *client* (3.4) to perform the *works* (3.21) in accordance with this document

3.4
client
organization for which professional services are rendered or person that receives a product

3.5
dew point
temperature at which moisture in air will condense out on to a solid surface, like blast-cleaned metal surface or newly coated surfaces

3.6
dust
loose fine particulate matter present on a steel surface prepared for rubber lining, arising from blast cleaning or other grinding activities or from worksite environments

3.7
elastomeric coatings
flexible skins, permanently bonded to *risers* (3.15) and structures

Note 1 to entry: Elastomeric coatings are designed and developed to withstand aggressive environment or conditions affecting platform structures and risers in marine splash zones. These provide add-on durability to designed life to structures and risers in offshore environment, while providing resistance to seawater ingression, ozone oxidation, erosion and abrasion.

3.8
ethylene propylene diene monomer
EPDM
elastomeric compound or synthetic rubber applied as a protective coating on riser pipes in *splash zones* (3.18) to withstand erosion of riser pipe material caused by continuous exposure to seawater and wave actions

Note 1 to entry: EPDM provides resistance to outdoor and high temperature services in the range of -35 °C to 120 °C.

3.9
flash rusting
slight rust formation on a freshly blast-cleaned carbon steel surfaces due to humidity in air and if not painted within 4 h from start of blasting

3.10
holiday
discontinuity in a protective coating (cracks, pinholes, voids, etc.) that exhibits electrical conductivity when exposed to specific voltage

Note 1 to entry: Holiday also means a small defect in the lining that would permit corrosion of substrate under service conditions for which lining is designed. The term can be considered synonymous with cracks or mechanical damages occurring in rubber lining, while in services.

3.11
manufacturer
organization responsible for the manufacture of coating material(s)

3.12
platform
offshore structure used to accommodate oil and gas wells related production equipment, pipelines and living quarters

3.13
production batch
one loading capacity of the internal mixer used for preparing the mixed rubber prior to forming strip of sheet

3.14
polychloroprene
light yellow synthetic rubber compound obtained by polymerization of chloroprene

Note 1 to entry: Polychloroprene is commonly known as polychloroprene compound.

Note 2 to entry: Polychloroprene is applied as a protective coating on riser pipes in *splash zones* (3.18) and below to withstand erosion of riser pipe material caused by continuous exposure to seawater and wave actions. It provides resistance to outdoor and services temperature in the range of −35 °C to 90 °C.

3.15
riser
section of pipeline carrying crude/gas between ocean floor and upper decks of *platform* (3.12) on offshore structures

3.16
shore hardness
methods for determining the hardness of materials by means of durometer

3.17
site
lands and waters and other places on, under, in or through which the *works* (3.21) are to be carried out and any other lands, waters or places provided by the *client* (3.4) for the purposes of the contract together with any other places designated in the contract

3.18
splash zone
external surfaces of an offshore structure or pipeline that are, periodically wet and dry by the influence of the astronomical tides, winds and waves, the limits are as defined by the contract specifications

3.19
surface profile
micro-roughness of surface generally expressed as an average of height of highest peaks relative to lowest valleys sometime referred to as amplitude

3.20
vulcanization
curing of elastomeric materials by chemical reaction under heat and pressure to improve strength and elasticity of applied rubber lining

3.21
works
activities to be executed in accordance with the contract, as defined in the specified conditions and including both permanent and temporary activities

4 Abbreviated terms

µm	micrometer (microns)
ASTM	American Society for Testing and Materials
BS	British Standard
DFT	dry film thickness
HSE	health, safety and environment
GSO	Gulf Standardization Organization ITP
MS	method statement
MSDS	material safety data sheet
NACE	National Association of Corrosion Engineers
NPS	nominal pipe size

pphm	parts per hundred million
PPT	pre-production trial
PQT	procedure qualification trial
QA/QC	quality assurance/quality control
SSPC	Society for Protective Coatings

5 Pre-work requirements

5.1 General

5.1.1 All requirements in this document and the referenced documents shall be followed, except if they are modified or supplemented by project specification or datasheet.

5.1.2 The equipment, materials, consumables, spaces and stockpile areas that are necessary to carry out surface preparation, coating application, qualification testing, inspection and QA/QC shall be in accordance with this document and in a manner satisfactory to the client.

5.1.3 Surface preparation, priming, coating application, qualification testing/inspection and QA/QC works shall be carried out in a continuous sequence as per this document and as recommended by the manufacturers, unless otherwise specified by the client.

5.2 Health, safety and environmental (HSE)

5.2.1 All necessary health, safety and environmental (HSE) procedures shall be employed to protect the personnel and the surrounding environment during on-site/field works. The contractors shall submit their HSE manual for client's approval. The approved HSE procedures for the safe coating/lining processes shall be strictly followed.

5.2.2 All relevant international safety requirements, client's safety regulations for contractors and lifting equipment regulations shall be adhered, while performing coating and lining works.

5.2.3 Materials safety data sheets (MSDS) for all chemicals to be used within the client's operation areas shall be submitted to the client for review and approval. Health and safety precautions shall be clearly described on each materials container/package.

5.2.4 All wastes resulting from supply, preparation and application shall be contained, collected and properly disposed of in accordance with international/local environmental protection standards/regulations.

5.3 Qualification of coating/lining application and inspection personnel

5.3.1 The coating/lining operatives shall be competent to undertake the coating application, inspection/testing procedures and repair work. The qualification shall be obtained as agreed with the client or by demonstration at a procedure qualification trial (PQT) during pre-production trial (PPT).

5.3.2 Inspectors and applicator personnel carrying out the coating inspection shall be competent to carry out the requirements of this document. The applicator shall request the manufacturer of the coating/lining material(s) and equipment to provide technical assistance to the coating/lining operatives if necessary.

6 Materials

6.1 General requirements

6.1.1 The general requirements for the selection of materials for coating system and surface preparation shall be in accordance with ISO 21457. Materials proposed for coating of the riser pipe shall be tested by the product manufacturer and approved by the client before use. Non-conforming materials shall be rejected and replaced with approved materials. Test certificates shall be provided for all materials.

6.1.2 Identification of corrosion mechanism and parameter for evaluation when performing selection of materials for pipelines, piping related to transport and processing of hydrocarbon production including utility, injection system and wellheads shall be in accordance with ISO 21457.

NOTE ISO 21457 refers to materials that are generally available with properties that are known and documented. It also allows other materials to be evaluated and qualified for use.

6.1.3 Materials shall be of high quality, uniform in composition and free from all inclusions and foreign contaminants.

6.1.4 Materials shall not contain any asbestos/fibrous constituents, i.e. fibrous fillers or asbestos felt.

6.1.5 The contractor shall provide details of manufacturer, materials composition, technical specification, physical properties, data sheets and test certificates for all materials, prior to use, for the client's review and approval. The client has the right to request a complete performance test for any material used during the surface preparation and coating processes. The contractor and/or lining applicator shall select polychloroprene or EPDM compound, which is suitable for company specified characteristics and services and also select adhesive system, which will provide an adequate bond between rubber and riser pipe surface to ascertain designed life of services in seawater splash zone. Adhesive system shall depend upon the type of rubber compound and method of vulcanization.

6.1.6 The client shall at least provide the following characteristics of riser lines or pipe sections to be coated with polychloroprene or EPDM rubber:

a) nominal diameter;

b) wall thickness;

c) type of pipe joint;

d) design temperature (max-min);

e) operating temperature (max-min);

f) design pressure, service – seawater splash zone;

g) chemical analysis of seawater and designed service life of coating while indicating special site requirements.

6.1.7 Rubber compound and adhesive system shall be selected on the basis of previous project references and industry experience to ascertain that it is suitable for specified services. If this requirement could not be satisfied, appropriate testing shall be carried out as per manufacturer's recommendations. Where it is not possible to test sample elastomer lining in actual conditions, specified service conditions shall be simulated accurately.

6.1.8 Polychloroprene and EPDM coating as described in this document comprise the following coats or layers of coating materials:

a) 1st coat — primer coat that shall be compatible with the bonding agent and is bonded adequately to the steel substrate;

b) 2nd coat — bonding agent that shall be compatible with both the primer and the elastomer coating;

c) 3rd coat — tack cement rubber solution (rubber compound solution), if deemed necessary;

d) 4th coat — elastomeric coating material (polychloroprene or EPDM).

6.1.9 Elastomer compound and adhesive manufacturing facility and in-house testing laboratory shall be in compliance with the quality management system requirements.

6.1.10 The materials shall be compatible with each other to provide adequate bonding when vulcanized to enhance inbuilt chemical and physical properties as desired for corrosion protection of riser pipes in the splash zone.

6.1.11 Nylon tape to be wrapped temporarily over the elastomer coated pipe shall be of sufficient strength to withstand tension and secure coating tightly adherent to substrate. It shall also withstand autoclave temperatures during the vulcanization process.

6.1.12 The contractor/applicator shall provide the following to the client for review and approvals, well before entering into actual application of elastomer coating on specified surfaces:

a) name and number of elastomer compound;

b) test panels coated with proposed elastomer compound and vulcanized as a reference sample;

c) test certificate by in-house laboratory as well as client's designated external laboratory certifying qualification of polychloroprene and/or EPDM, meeting desired chemical and physical properties along with satisfaction of special considerations, if any.

6.1.13 Clearance for usage shall be obtained for coating materials to be used on riser pipes in seawater splash zone from local and international environment authorities governing or controlling marine pollution to specified norms.

6.1.14 On client's approval of selected elastomeric coating/lining, the applicator shall assess site requirements, prepare method statement (MS), inspection test plan (ITP) and quality assurance/quality control documentations and submit to the client for approval.

6.1.15 After approval of documents (as in 6.1.14), the applicator shall arrange for procedure qualification trial (PQT), demonstrating coating work to be carried out on automatic pipe coating machine and also by hand lay methods, while producing a test sample (as required in 6.1.12). The PQT shall be witnessed by the contractor, client and coating material manufacturer for approvals.

6.2 Material requirements

6.2.1 Polychloroprene elastomer coatings for risers shall be suitable for use in seawater, ambient air temperatures down to −35 °C and service temperatures of maximum +90 °C for the specified design life.

6.2.2 Ethylene propylene diene monomer (EPDM) elastomer coatings for risers shall be suitable for use in seawater, ambient air temperatures down to −35 °C and service temperatures of maximum +120 °C for the specified design life.

6.2.3 Other equivalent products shall comply with the material requirements specified within this document.

6.3 Materials packing, handling and storage

6.3.1 All materials shall be supplied in the manufacturer's original packaging in an undamaged condition to the plant/coating yard, clearly marked with the batch code, storage conditions, date of manufacture, shelf life and accompanied with the relevant batch certificate. The content of a batch certificate for different coating materials are shown in Annex A for reference.

6.3.2 All materials taken to worksite shall be stored in covered, cool, dry, well-ventilated areas and shall be kept clean, dry and free from any contaminants prior to and during application in addition to the manufacturer's recommendations. Any material that has been affected by the climate or contaminated in any way shall be rejected and replaced with approved materials.

6.4 Coating materials

6.4.1 All coating materials, in any one system, should originate from one client's approved manufacturer with his assurance that they are fully compatible with one another.

6.4.2 Bulk of coating materials shall be stored in air conditioned store rooms at temperature and under conditions as specified by material manufacturer as it should not be affected by climate or other factors. Coating materials found in unusable conditions shall be replaced by new stocks. Materials shall be used on first-in-first-out basis stock rotations. Expired material shall be quarantined and then disposed of as per HSE norms.

6.4.3 Elastomer coating materials shall be uniform in composition and free from contaminations.

6.4.4 The metal bonding agent and the elastomer bonding agent shall be those recommended by the polychloroprene rubber/EPDM manufacturers, or equivalent, as selected or developed for the environmental conditions and application process considered in this document.

6.4.5 The applied coating shall be resistant to oxidation, solar radiation, ozone, oil contamination and marine organisms. It shall be suitable and stable under applicable service temperature range. It shall be resistant to damage caused by twisting and flexing, exhibit outstanding physical toughness, resist degradation from UV, ozone and marine weather conditions and exhibit better fire retardant properties.

6.4.6 The applied coating shall be suitable for long-term use in offshore environments when immersed continuously in seawater (under the influence of cathodic protection), in the splash zone or in the atmospheric zone with moist conditions and salt laden air.

6.4.7 The applied coating shall be capable of preventing corrosion under the specified conditions. It shall have good resistance to mechanical damage and exhibit strong adhesion to steel.

6.4.8 The applied coating material shall have physical properties in accordance with those listed in Annex B. It shall be tested in accordance with 10.2. The applied coating shall have proven resistance to cathodic disbondment in accordance with the parameters set in Annex B.

6.4.9 If the client requests antifouling treatments to the surface of the coated riser pipe work, the contractor shall propose a compatible material required for antifouling, stating the application method and thickness of any treatment for client's approval. In most cases, the thickness of any treatment will be in addition to the minimum thickness specified for the elastomer coating.

6.4.10 Elastomeric coating manufacturer shall confirm compatibility of antifouling paints.

7 Bare pipes transportation, handling and storage

7.1 Transportation and handling of pipes

7.1.1 The contractor shall specify the proposed method for transportation, handling and storage of pipes for the client's approval. These requirements shall be in accordance with the relative clauses under API RP 5LW or API RP 5L1, unless otherwise specified.

7.1.2 All pipes shall be inspected at the time of loading and unloading. All damage to pipe existing at that time shall be reported. Damaged pipe shall be marked and kept separately until repaired, after which it can be coated.

7.1.3 The pipe shall be fitted with end caps to protect the pipe end bevels. These caps shall be maintained by the applicator until the pipe is withdrawn from its custody. Damaged or lost end caps shall be replaced. The applicator shall ensure that the pipes are returned to the contractor/client in the same condition as they were received.

7.1.4 At all times, for the purpose of loading, unloading and handling of pipe, the contractor shall use approved certified slings, spreader bars and protected pipe end hooks to the satisfaction of the client's lifting equipment regulations/standards. All slings, hooks, supports and skids shall be padded and suitable to prevent damage or deterioration of pipe and coating.

7.1.5 The contractor shall provide the client, prior to commencement of work, with all current load test certificates for each and every crane, fork lift truck, overhead gantry and all other lifting appliances (like slings, spreader bars, pipe hooks, etc.), in conjunction with all necessary procedures, to be used for the purposes of the work. This shall include all standby equipment as well.

7.1.6 Internal surfaces of riser pipe sections shall be cleaned and inspected to ensure that they are free of corrosion pitting. Internal surface severely corroded with pitting shall be rejected and replaced with new sections.

7.2 Storage of pipes

7.2.1 Prior to commencement of works, the applicator shall provide the client with full details of his proposed method of stock piling and storage areas for subsequent inspection and approval. The applicator shall obtain written approval from the client of his procedures prior to handling pipes as a minimum. Pipes should be stored in rows of width and spacing as per industry best practices.

7.2.2 Pipe identification shall be recorded upon receipt. Pipe identification shall be maintained by bonding an identification tag on each pipe at all times. The tag shall be stamped with the pipe number, length and intended riser location. To ensure better traceability of riser pipe sections, internal surfaces of pipe at ends shall be marked for further verifications.

8 Surface preparation

8.1 General

8.1.1 End caps shall be carefully removed when preparing the pipe for surface preparation and shall be retained for replacement when completing the coating process. Damaged or lost end caps during surface preparation shall be replaced. Both external and internal surfaces of each pipe shall be cleaned to remove non-adhesive mill scale/deposits.

8.1.2 The contractor shall submit a surface preparation procedure and details of equipment and materials that will be used in the process for the client's approval.

8.2 Pipe imperfections/damages removal

8.2.1 Before starting any surface preparation, pipes shall be inspected for general condition and the presence of defects/damage should be referred to the client's representative to establish whether they can be satisfactorily removed as an alternative to rejecting the pipe by the client.

8.2.2 All surface imperfections/defects that have arisen during fabrication and/or handling/transportation/storage, such as weld spatter, slivers, dents, gouges, flattening, etc., shall be removed by suitable methods approved by the client. The pipe surface to be coated shall be smooth, free of porosity, undercuts, cracks and cavities.

8.2.3 The contractor shall provide suitable isolated storage space for the handling of all pipes requiring repairs.

8.3 Contaminants removal

8.3.1 Prior to surface preparation, oil, grease and other contaminants shall be removed from the steel surface by means of a water-soluble degreasing agent/detergent, ensuring that the emulsified mixture is completely removed from the surface by washing or steam cleaning/rinsing with fresh potable water. The surface shall first dry before further surface preparation activities are carried out.

8.3.2 Heavy deposits of oil, grease and other fatty matter should initially be broken up, by appropriate solvent using clean rags, before the above procedure is adopted. Solvent cleaning shall be in accordance with SSPC-SP 1. Only solvents that do not leave any residues on the surface shall be used.

8.3.3 If degreaser chemicals are used to clean the riser pipe sections, no residue that can impair the bonding of the coating system shall be left. Degreaser chemicals shall have clearance for usage from local authorities governing or controlling pollution to specified standards.

8.4 Abrasive blast cleaning

8.4.1 Prior to blast cleaning, the pipe surface and ground area shall be checked for dryness. Dew point readings shall be taken before, during and after blasting operations. Pipe surface temperature shall be at least 3 °C above dew point, relative humidity shall be in the range of 5 % to 85 %, and substrate temperature shall be in the range of 10 °C to 50 °C.

8.4.2 Uniform pre-heating of the steel pipes shall be carried out, if necessary, to maintain dry surface prior to or during automatic abrasive blast cleaning, however, heating shall be controlled to prevent softening of plastic end caps. Pipe ends shall be plugged with end caps to prevent damage to the internal surface during blasting.

8.4.3 The compressed air used in the cleaning method shall be free of water and oil. The air supply shall be checked for water and oil contaminations in accordance with the procedure specified in ASTM D4285 prior to blast cleaning and regularly throughout blast cleaning operations.

8.4.4 Blasting materials shall be clean, dry and suitably stored to maintain excellent conditions prior to use. Expendable abrasives and those used for open blasting shall not be recycled. However, approved non-expendable abrasives for use in centrifugal type equipment may be re-used provided that cutting ability and systematic good quality control over the recycled abrasive are maintained in accordance with SSPC-AB 2.

8.4.5 The compressed air supply used for dry blast cleaning shall be of sufficient pressure and flow rate to enable rapid and efficient cleaning rates to be achieved. Blast cleaning shall be carried out at minimum nozzle air pressure of 7 barg (100 psig), as measured with a hypodermic needle gauge, at each blasting nozzle.

8.4.6 External surfaces shall be blast-cleaned by a client's approved type and brand of grit abrasives selected in accordance with ISO 11124 (all parts) and/or ISO 11126 (all parts). Abrasives shall be used to achieve a standard of surface cleanliness in accordance with ISO 8501-1:2007, Sa 3 or SSPC-SP 5/NACE No. 1. Every pipe shall be tested.

8.4.7 Abrasive blast cleaning shall produce an average peak-to-trough surface profile height (anchor pattern) of 50 µm to 100 µm, as specified by ISO 8503-2 or NACE RP0287, and as measured in accordance with ISO 8503-4 or ISO 8503-5. The particle size range of the abrasive used shall be selected to achieve the required surface profile height.

8.4.8 After blast cleaning, all residual particulate matter, dust and blasting materials shall be removed from both the exterior and the interior of the steel pipes by vacuum cleaning or using dry oil free compressed air before proceeding for further operations. The external surface shall be tested for residual dust particles using transparent self-adhesive tape in accordance with ISO 8502-3. A minimum acceptance standard of class 2 rating 2 shall apply. Every pipe shall be tested.

8.4.9 Abrasive blast-cleaned pipes shall be protected from wet or humid conditions. The cleaned surface shall be tested for condensation in accordance with ISO 8502-4. No pipe surface shall be allowed to flash rust prior to coating application. If flash rusting occurs, the pipe surface shall be blast-cleaned in accordance with 8.4. All prepared pipe surface, in any case, shall be coated within 4 h of blast cleaning.

8.4.10 Abrasive blast-cleaned surface shall be protected from salt/chloride. The blast-cleaned surface shall be tested for chloride contamination in accordance with ISO 8502-6 and ISO 8502-9. The acceptance criteria shall be maximum 20 mg/m^2 of soluble salt. At least one pipe per shift shall be tested.

8.4.11 Abrasive blast-cleaned pipe surface shall be inspected immediately for defects after blast cleaning. All revealed surface imperfections shall be referred to the client's representative for remedial action before coating application.

8.4.12 The blast-cleaned surface shall be tested for

a) remains of mill scales with slightly acidic copper sulfate solution in contrast colour,

b) remains of iron corrosion products,

c) laboratory determination of chlorides in accordance with ISO 8502-2, and

d) chloride content by ion detection tube method in accordance with ISO 8502-5.

8.4.13 Acceptance criteria for chloride salts shall be in the range of 10 mg/m^2 to 20 mg/m^2 or 1 µg/cm^2 to 2 µg/cm^2. One pipe per shift shall be tested, unless directed otherwise by the client.

8.4.14 After blast cleaning is completed, the ends of each length of pipe shall be masked off for a minimum length of 150 mm for field joints welding purposes.

8.4.15 Repairs to dent or pitting on blast-cleaned surface being accepted by the client within corrosion allowance shall be filled and levelled with compound compatible to elastomer coating above as well capable to withstand operating temperature of contained liquid or gas.

9 Coating application for risers

9.1 General

9.1.1 Risers for which polychloroprene or EPDM elastomer coating is specified shall be coated with minimum 12 mm thick coating in the splash zone area, as defined by the client.

9.1.2 At the time of coating application, all surfaces to be coated shall be checked to ensure conformance with the standard surface preparation specified in Clause 8. Any pipe, not conforming to the standard due to subsequent rusting/surface oxidation or contamination, shall be re-cleaned to meet the requirements of this document.

9.1.3 All surfaces to be coated shall be visually inspected for imperfection/defects that would impair the application or performance of the finished coatings. Any defects shall be brought to the attention of the client and the contractor shall take suitable remedial action.

9.1.4 All surfaces to be coated shall be dry and free from dust or any other contaminants immediately prior to the coating operation in conformance to the required level of surface preparation as stipulated in 8.4.

9.1.5 All coating materials to be used in coating operations shall be checked for conformance with 6.4 before coating application starts.

9.1.6 The temperature of steel surface to be coated shall not be less than 3 °C above the dew point and the relative humidity shall not exceed 85 %. Ambient temperatures for application shall conform to coating manufacturers' recommendations.

9.1.7 Prior to primer and adhesive application, the pipe surface and ground area in the shop shall be checked for dryness. Pipe surface temperature shall be at least 3 °C above dew point, relative humidity shall be less than 85 % and substrate temperature shall be in the range of 10 °C to 50 °C. Blast-cleaned pipes may be warmed, but not above 50 °C through autoclaves to prevent flash rusting, while waiting in for coating on automatic pipe coating conveyers.

9.1.8 The contractor shall maintain the identity of every pipe throughout the coating process.

9.1.9 The application process shall be designed to achieve a coating that is homogeneous and free of porosity, inclusions, delamination with specified adhesion throughout. The degree of cure should be consistent throughout the dry film.

9.1.10 The equipment and method used for surface preparations and elastomer coating application shall be in accordance with recommendations of the client or coating manufacturer, either on automatic pipe blasting and coating machine or by hand lay methods to obtain specified physical and chemical performance of elastomer coatings in splash zones.

9.2 Priming and coating on abrasive blast-cleaned surface

9.2.1 Abrasive blast-cleaned riser pipe sections for priming and adhesive applications shall be arranged on stands in a way that, overall surface is primed and applied with adhesive with no contact points for touch–up later ensuring 100 % adhesion base for subsequent elastomer coatings.

9.2.2 Blast-cleaned surfaces shall be primed within 4 h of cessation of blasting and before any visible rusting, discoloration or other surface contamination occurs. In case of any flash rust observed on the surface, the rust shall be removed by light sweep blast cleaning.

9.2.3 Immediately after blast cleaning and before any contamination of the surface or visible rusting occurs, the prepared surface shall be primed with a metal bonding agent as specified in 6.4. Any flash rusted surface shall be re-blasted as necessary and repainted.

9.2.4 Apply one coat of primer at DFT as per manufacturer recommendations and client agreement and allow it to dry completely. Coating area shall be well covered to prevent dust contaminations on coated surfaces.

9.2.5 The elastomer bonding agent (specified in 6.4) shall be applied over the primer (contaminants free) coating within the time period recommended by the coating material manufacturer, which usually depends on pipe temperature.

9.2.6 Within 2 h of bonding agent coating, one coat of tack cement rubber solution shall be applied at 60 µm to 75 µm and shall completely dry or follow product data sheet.

9.2.7 The coating system of primer, bonding agent and tack cement rubber solution (if applied) shall be applied by airless spray, brush or roller to produce an even thickness film of minimum 150 µm free of runs, sags, drips and holidays or missing.

9.2.8 The specified period between coatings will depend upon temperature of substrate pipe and shall be governed by the coating material manufacturer. In general, the pipe surface temperature shall be at least 5 °C above dew point, relative humidity shall be less than 85 % and substrate temperature shall be in the range of 10 °C to 50 °C. Blast-cleaned pipes may be warmed, but not above 50 °C.

9.2.9 All pipes having damaged or contaminated primer, bonding agent and tack cement rubber solution coating shall be re-blasted/cleaned and re-coated in accordance with this document and project specification.

9.3 Polychloroprene or EPDM application and vulcanization

9.3.1 Tack cement rubber solution, if applied, the pipe section shall be applied with elastomeric polychloroprene or EPDM coating either on automatic pipe coating machines or by hand laid application as directed by client. The manufacturer's recommendations shall be followed for the over coating interval between the adhesive application and elastomeric coating Polychloroprene or EPDM application.

9.3.2 Pipe sections coated with metal and elastomer-bonding agents shall be placed in a lathe permitting rotation and complete access to the area to be coated.

9.3.3 Adhesive applied and dried pipe sections shall be aligned perfectly on lathe fixed between headstock and tailstock to obtain even application of coating while pipe sections are rotate on lathe axis. The elastomer tape extruder unit/pressure sticker shall be carriage mounted to run parallel on rails. The relative speed of pipe to be coated and calendared rubber tape dispensing automatic machine shall be adjusted to obtain uniform thickness of elastomer coating on riser pipe sections.

9.3.4 The elastomer of polychloroprene or EPDM shall be extruded into a tape of specified dimension and applied on the pipe section by pressure sticking. The cold feed extruder with a variable pitch screw shall produce a continuous strip of fresh, warm uncured elastomer compound, which shall be wrapped spirally/helically on the rotating pipe section and then, firmly stuck using a pressure roller to avoid entrapment of air. The thickness of extruded tape shall be checked and the required total thickness of coating shall be obtained by repeating the coating process.

9.3.5 Applied elastomer coating on pipe section shall be checked visually for defects and tested for holidays at testing voltage of 1 kV per mm of coating thickness. Defects and holidays shall be repaired by

filling with uncured elastomer using pressure roller to ensure better adhesion without air entrapment. Holiday test and visual checks shall be repeated on repaired locations.

9.3.6 The overlap of each helix shall be at least 50 %. The approved specified overlap and tension shall be maintained throughout the application. The pipe surface shall be completely covered.

9.3.7 Defect free elastomer coating shall be secured in cylindrical form with a nylon tape (75 mm to 100 mm width) wrapped around with a 75 % overlap under normal tension by automatic coating machine. The tape tension and overlap shall be adjusted on automatic machine to get uniform wrapping. Nylon tapes shall be extended up to 150 mm beyond elastomer coating and double wrapped on ends to maintain tension on end coatings. Nylon tapes on ends shall be secured using adhesive tapes. Nylon tapes as well adhesive tape shall be capable to withstand vulcanization temperature in autoclave.

9.3.8 Elastomer coated riser pipes with nylon tape wrappings shall be put in the steam pressure autoclave for vulcanization within 24 h from completion of coating. Vulcanization is generally carried out at steam pressure of (4 ± 0,5) kg/cm^2 (range of 3,5 kg/cm^2 to 4,5 kg/cm^2) and temperature of (150 ± 5) °C (range of 145 °C to 155 °C) for about 3 h to 4 h or as per coating manufacturer's recommendation. After curing, the pipe shall be removed from the autoclave and cool to ambient temperature. The nylon tape wrapping shall be removed completely after the pipe has cooled to ambient temperature (usually not less than 3 h).

9.3.9 The thickness of the cured polychloroprene or EPDM coating shall be minimum 12 mm and maximum 14 mm unless otherwise specified by the client.

9.4 Manual coating application on clamps, guides, bolt holes, inner sections of flanges and pipe section used for modifications at worksites

9.4.1 If requested by the client, the contractor shall coat all clamps and guides using the required elastomer sheets. The material properties of the elastomer sheets shall be in accordance with 6.4.

9.4.2 Surface preparation of clamps and guides shall be in accordance with Clause 8.

9.4.3 Application of three coat adhesive system to the blast cleaned surface shall be in accordance with 8.2.

9.4.4 Calendared elastomer sheets of desired length, considering extra allowance for trimming shall be cut from bulk roll of synthetic rubber. The adhesive side shall be cleaned with recommended solvent and hand applied on subject sections manually starting from one edge to other and gradually removing entrapped air, using non-metallic rollers and suitable tools. Thickness of individual layers shall be in range of 3 mm to 5 mm and the number of coating layers shall depend upon the desired total thickness of coating.

9.4.5 Hand applied elastomer coating shall be checked for holidays and repaired in accordance with 9.3.5.

9.4.6 Defect-free elastomer coating shall be secured in on sections using nylon tapes in accordance with 9.2.5.

9.4.7 Vulcanization of coated sections shall be carried out in accordance with 9.3.8.

9.4.8 The contractor shall submit his detailed coating application method to the client for review and approval.

9.5 Coating application of field joints

9.5.1 The field joint coating shall be applied before installation in offshore. The field joints should be done on a barge before the installation or at an onshore location before taking up installation at offshore. It shall not be done on wet conditions. Edges of the existing coating shall be chamfered to approximately a 45° angle to allow an overlap of the uncured elastomer.

9.5.2 Suitable precautions shall be considered during site blast cleaning, priming and coating application to protect the prepared area from water, dust and any other contaminants. The temperature of the field joint working area shall be controlled such that the metal temperature of the pipe is below 45 °C or as per manufacturers' recommendations. Precautions shall be considered to protect surrounding shop applied coating from any damage or contamination.

9.5.3 Field joint area surface preparation shall be in accordance with Clause 8.

9.5.4 Field joint coating shall take place immediately after blast cleaning and before visible flash rusting occurs.

9.5.5 Polychloroprene or EPDM elastomer sheets shall be used for field application. The material properties shall be in accordance with 6.4.

9.5.6 Polychloroprene or EPDM shall be heated by an approved method to bring the material into workable condition. The sheet shall be applied to the joint edge and vigorously stitched down from the centre out to the edges. The joints shall be made flush with the existing coating. The material shall be applied to obtain the same thickness as the original factory applied coating.

9.5.7 Uncured polychloroprene or EPDM coated joint shall be tightly wrapped with nylon tape with a minimum of 50 % overlap that shall terminate a minimum of 150 mm over the factory-applied coating. Wetting of the tape to increase the tension, if required, is acceptable.

9.5.8 Electrical heating tapes shall be positioned over the joint followed by an insulation jacket. Cure shall be affected at a controlled temperature of (150 ± 5) °C. Timing for the cure shall only commence when the cure temperature has been reached. During curing, regular checks shall be made to ensure that the cure temperature is being maintained. The joint shall be heated for the required period to achieve a full cure. After curing is complete, the nylon tape shall be completely removed.

9.6 Coating repair

9.6.1 The contractor shall submit detailed procedures for coating repair to the client for approval, prior to the start of the repair work. The following procedures shall contain as a minimum:

a) repair of surface defects;

b) repair of holidays;

c) repair of under cured elastomer coating material;

d) removal of rejected coating and cleaning the pipe to the required standard for recoating;

e) testing to prove the effectiveness of the repairs.

9.6.2 The maximum area that may be repaired per coated pipe is 10 %. Pipes requiring larger total repairs shall be re-coated. Pipes having less than the specified minimum coating thickness shall be repaired. Records shall be kept of all repaired pipes and shall include the repair and test details. The contractor shall submit the details of materials, methods and equipment to be used for the repair, inspection and testing of defects to the client, for approval prior to the start of coating repair operations.

10 Inspection and testing

10.1 General

10.1.1 All coating materials shall be inspected/tested to ensure conformance with the requirements of this document. Samples of the coating materials, test certificates and coated sample plate shall be submitted to the client for approval prior to application.

10.1.2 Inspection and testing shall be performed at all stages of surface preparation to ensure conformance with Clause 8.

10.1.3 Inspection shall include a check to ensure that no materials have been deposited on the inside of each coated pipe.

10.1.4 Coating application shall be checked for compliance with the requirements of this document and the approved procedures.

10.2 Testing of elastomer properties

10.2.1 General

The manufacturer of the polychloroprene or EPDM elastomer material shall perform the tests described in 10.2.2 to 10.2.11. The tests shall use rubber samples taken from a production batch of the compound material and shall comply with the client accepted specified range. Annex B shows a summary of test methods, frequency of testing and acceptance criteria.

10.2.2 Cure and hardness

A sample from every production batch shall be tested for cure and hardness. The shore hardness for polychloroprene coating as measured by the standard penetrometer test shall be between 60A to 70A and 65A to 75A for EPDM. The test method shall be in accordance with ISO 7619-1.

10.2.3 Specific gravity

A sample from every production batch shall be tested for specific gravity (SG) in accordance with ISO 2781.

10.2.4 Rheological properties

A sample from every batch shall be tested in an oscillating disc rheometer in accordance with ASTM D2084. The rheometer curve (oscillating disc) produced shall be compared against a standard curve for acceptability.

10.2.5 Tensile strength, tear strength and elongation at break

The tests for tensile strength, tear strength and elongation at break shall be performed at certified testing machines. Samples from one in five production batches shall be tested for the following:

a) the minimum results for polychloroprene shall be

- 14 MPa for tensile strength in accordance with ISO 37,
- 35 N/mm for tear strength in accordance with ISO 34, and
- 400 % for elongation in accordance with ISO 37;

b) the minimum results for EPDM shall be

- 12 MPa for tensile strength in accordance with ISO 37,
- 25 N/mm for tear strength in accordance with ISO 34, and
- 350 % for elongation at break in accordance with ISO 37.

10.2.6 Compression set

Samples from one in 20 batches shall be tested for compression set for a period of 24 h at 70 °C. The compression set shall be a maximum of 25 %. This test shall be done in accordance with ISO 815.

10.2.7 Abrasion resistance

Samples from one in 20 batches shall be tested for abrasion resistance in accordance with ISO 4649. The test result shall not be more than 0,4 g/1 000 revolutions or as agreed by the client.

10.2.8 Ozone resistance

Sample from one in 20 batches shall be tested for ozone resistance. The polychloroprene or EPDM shall show no cracks or other detrimental effects. The test method shall be in accordance with ISO 1431-1.

10.2.9 Adhesion

Sample from one in 20 production batches shall be tested for adhesion in accordance with ISO 813 or ISO 814. The test results shall not be less than 12 N/mm.

10.2.10 Resistance to seawater

a) A sample from one in 20 production batches shall be tested for resistance to seawater.

b) Test samples shall be subjected to 28 d immersion at 177,8 cm (70 inch) seawater in accordance with ISO 1817. The testing conditions and acceptance criteria shall be as follows:

- test temperature shall be 85 °C for polychloroprene and 95 °C for EPDM;
- volume change shall be less than 5 %;
- testing shall show no evidence of cracking or splitting;
- change in hardness: ±5 units.

c) Client may decide to accept well-documented previous seawater trial of the same material instead of additional tests.

10.2.11 Thermal conductivity

When required by the client, a sample shall be taken from one in 20 production batches for thermal conductivity testing. The test result shall not be more than 0,30 W/m K. The test shall be done in accordance with EN 12664.

10.2.12 Vulcanization characteristics (rotorless curemeters)

a) This test shall be performed on every batch of uncured elastomer in accordance with ISO 6502. A standard curve shall be established to define the acceptance limits of the following parameters:

- M_L – minimum torque value;
- TS_x – time to 90 % cure;

— M_{HR} – maximum torque value.

b) Once a standard curve with the above parameters is established by the manufacturer and approved by the client, all subsequent curves shall fall within these limits.

10.2.13 Cathodic disbondment

This shall be determined in accordance with ISO 21809-3, Table 133 and Annex F, with designed product temperatures. The disbanded coating shall be less than 7 mm at 23°C and less than 10 mm at T_{max} limited to 95 °C for EPDM or Polychloroprene on either carbon steel or stainless steel substrates. ASTM G42 may be used as an alternative reference for testing at high temperatures only, subject to client approval or by agreement.

10.2.14 Volume resistivity

This shall be measured in accordance with ASTM D 257 and shall be a minimum of 10^8 Ω cm ($0{,}39 \times 10^8$ Ω in) for either elastomer.

10.3 Inspection/testing of coated pipes

10.3.1 Visual inspection

a) All coated steel pipes shall be visually inspected to ensure that the polychloroprene/EPDM coating has been applied in a manner representing high quality workmanship and that the material has cured adequately.

b) The coating shall be inspected for surface imperfections, lack of bond at joints and ends, voids, breaks, blisters, de-laminations, cuts, indentations or any other defects or apparent irregularities. Any visually detected defects shall be marked and brought to the attention of the client. Failure to satisfy the client acceptance criteria for integrity of the coating shall be grounds for rejection and recoating of all defective pipes.

10.3.2 Holiday detection

a) All coated pipes shall be subject to 100 % holiday detection using a suitable high voltage, high frequency holiday detector recommended by the coating manufacturer and approved by the client. Calibration of the holiday detector shall be at least twice per 8 h shift.

b) The test equipment shall produce a high frequency high voltage spark in accordance with ISO 29601. ASTM D5162 may be used as an alternative testing method.

c) The electrode used for testing shall be designed to ensure direct contact with the coating (no visible gaps) and provide complete coverage of the whole-coated pipe surface. The electrode shall be moved continuously over the surface of the coating at a speed not exceeding 100 mm/s.

d) The allowable holiday acceptance criteria for a coated pipe, to avoid complete rejection, shall be specified by the project specification and agreed by the client and the contractor. The basis for such acceptance criteria are defined in 11.1.

e) The contractor shall mark the allowable detected holidays for repair in accordance with his defect repair procedure based on Clause 11 and approved by the client. The defective areas shall be electrically re-tested after coating repair.

f) The contractor shall provide a holiday detection procedure for client's approval. The procedure shall be based on the above requirements. Any item not specified under this subclause shall be in accordance with ISO 29601, ASTM D5162 or NACE/SP 0188.

10.3.3 Thickness test

All coated pipes shall have a series of thickness measurements taken at random locations, on each pipe, in two different planes in accordance with SSPC-PA 2. This is to ensure compliance with the specified cured coating thickness. Any variation below the minimum specified shall be grounds for rejection by the client. The thickness of the polychloroprene or EPDM coating shall be minimum 12 mm and maximum 14 mm unless otherwise specified.

10.3.4 Adhesion (bond) test

a) Bond tests shall be performed on the cured coating to ensure that the adhesion is satisfactory. The adhesion or bond testing shall be measured in accordance with ISO 813 or ASTM D413 and ASTM D429 on every pipe. The strength of the bond shall be in excess of the tear strength of the Polychloroprene or EPDM coating such that, on tearing a section of bonded polychloroprene or EPDM from the steel, a coating of rubber shall still adhere of 100 % to the steel. The coating adhesion in this case shall be considered acceptable. The bond test area shall be repaired in accordance with client-approved procedures.

b) The presence of bare metal shall be considered to be due to bond failure and shall result in rejection of that complete pipe section by the client. The contractor shall re-coat all rejected pipes.

c) If coating adhesion is found not acceptable, the contractor shall test further pipes to establish the extent of adhesion failure. The bond test area shall be repaired in accordance with the client-approved procedures.

10.3.5 Hardness testing

Hardness testing shall be carried out in accordance with ISO 7619-1, Shore A durometer method on every pipe at a minimum of six locations in two different planes at regular intervals along the pipe. Results shall be quoted as Shore hardness on the A scale in degrees. The hardness shall be between 60A to 70A for polychloroprene and 65A to 75A for EPDM.

10.3.6 Ultrasonic inspection

Ultrasonic inspection using suitable certified equipment, approved by the client, shall be carried out on at least one pipe per cure over the entire coated area. There shall be no evidence of disbondment or porosity. The contractor shall provide his testing procedure for client's approval. No defects shall be permitted within 75 mm (3") from the end of the pipe coating. No more than two flaws detected by ultrasonic inspection may be repaired on any pipe. If the coated pipe selected for ultrasonic inspection shows defects that are cause for rejection, then the contractor shall test the five-coated pipes preceding and following the test pipe. If in any production batch the rejection rate is higher than 20 %, the action taken to assess the entire order shall be subject to the approval of the client.

10.3.7 Sound testing

Sound testing shall be carried out in accordance with EN 14879-4:2007, 9.4.5. At intervals not greater than 200 mm along the length of the pipe, the hammer shall be hand-held and impact onto the rubber-coated surface through a vertical height of at least 0,5 m with the additional acceleration. Locations that, by any change of sound, indicate a lack of bond shall be marked and checked by using ultrasonic inspection to verify the extent of any fault detected. If the ultrasonically inspected coated pipe shows defects/failures that give cause for rejection, then the contractor shall test five pipes preceding and following the test pipe. If further defects/failures are detected, then the entire production for the shift shall be checked and examined by the contractor and client.

10.3.8 Rejection

All coated pipes which are not satisfying the test results defined in 10.3.1 to 10.3.7, will be subject to client rejection.

10.4 Inspection and testing of field joint coating

Testing of the cured coating on every field joint shall include as a minimum, but not limited to, the following:

a) visual inspection in accordance with 10.3.1;

b) holiday detection in accordance with 10.3.2;

c) coating thickness in accordance with 10.3.3;

d) hardness testing in accordance with 10.3.6;

e) sound testing in accordance with 10.3.7.

10.5 Test reports and certificate of compliance

An inspection certificate according to ISO 10474:2013, type 3.1.B or according to EN 10204:2004, type 3.1, shall be issued by the applicator, unless specified by the client. Inspection certificate shall provide the results from the inspection and testing of the coated pipes in accordance with the requirements of this document and any other requirement specified by the client. If the client does waive the requirement for an inspection certificate, then the applicator should provide a certificate of compliance.

11 Coating damage/defect repair

11.1 Defect acceptance criteria

11.1.1 The allowable defect acceptance criteria for a coated pipe to avoid complete rejection shall be specified in the project specification and agreed by the client and contractor. This subclause provides guidelines that specify the basis for acceptance criteria.

11.1.2 Defects due to disbondment and porosity which are 4 000 mm^2 or less in area and are not within 75 mm of the end of the coating, should not be cause for rejection provided that:

a) for coated pipes of less than 200 mm outside diameter and 10 m or more in coated length, a maximum of four defects per pipe length are detected;

b) for coated pipes of greater than 200 mm outside diameter and 10 m or more in coated length, a maximum of six defects per pipe length are detected;

c) for coated pipes with less than 10 m of coated length, a lesser number of defects are detected in proportion to the allowances given in (a) and (b) above.

11.2 Repair procedures

The contractor shall submit his detailed defect repair procedures (for pipe section and field joint) for the client's approval. Repair procedures shall consider the following:

a) repair coating materials shall originate from the same manufacturer of the applied coating materials described in Clause 6;

b) irrespective of coating defect size or type, melt sticks shall not be used;

c) the area to be repaired shall be prepared, blast-cleaned and coated with bonding agents in accordance with Clause 8 and 9.2, respectively. The coating application shall take place immediately after blast cleaning and before visible re-rusting occurs;

d) for hand built repairs, an elastomer sheet of 6 mm maximum thickness shall be used to cover the repair area. Greater thickness shall be built up in more than one layer;

e) where mechanical damage is caused subsequent to delivery of pipe, on-site hand-built repairs may be carried out to reinstate the coating, if the extent of damage is minor and that does not require moving to the manufacturing facility;

f) the repaired area plus the sound coating shall be totally wrapped in case of pipes, or placed under a uniform pressure in case of clamps and guides, and then cured by a suitable method approved by the client.

12 Handling and stacking of coated pipes

12.1 At all times and until delivery to the site, coated pipes shall be handled, transported and stacked in such a manner that it avoids damage to or contamination of the pipe, pipe end and coating.

12.2 If specified in the client's order, the contractor shall submit details of the handling procedures. Such procedures shall include loading requirements where the contractor is responsible for loading. Coated pipes shall be handled and stacked as required by the relevant client's specification. During storage, the pipes shall be separated from each other with approved pads to the satisfaction of the client.

12.3 The requirements for lifting of pipe stacks during load out should be specified by the client.

12.4 Pipe that is damaged during handling shall be repaired in accordance with the requirements of the applicable pipe repair specification or standard.

12.5 Coating that is damaged after the holiday inspection (see 9.3.2) shall be repaired in accordance with 10.2.

12.6 Coated pipes shall have full encirclement separators around each length. Such separators shall be sized and located in order to prevent damage to the coating.

13 Quality requirements

13.1 The manufacturer/contractor should operate a quality management system to satisfy the requirements of this document, e.g. ISO 9001 or ISO/TS 29001, which is considered as guidance for sector requirements.

13.2 Prior to commencement of works, the contractor shall submit his QA/QC documentation for the client's approval. The documentation shall also include the details of surface preparation and coating application procedures to be used.

13.3 Sampling and testing of all materials supplied for coating operations shall be in accordance with this document and the plan agreed between the contractor and client. For each consignment of material, the contractor shall

a) submit samples of all materials and their test certificates, indicating that the materials comply with this document,

b) provide and maintain on, or close to the worksite, necessary laboratory equipment, testing and monitoring facilities to ensure good quality control and that all technical aspects of the work are in accordance with this document,

c) provide access to the client or designated representative to visit facilities to verify that the work is carried out in accordance with this document, and

d) incorporate, in his procedures, the completion of the standard client riser pipe coating progress chart as defined in Annex C.