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Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems —

Part 5: External concrete coatings

Industries du pétrole et du gaz naturel — Revêtements externes des conduites enterrées ou immergées utilisées dans les systèmes de transport par conduites —

Partie 5: Revêtements externes en béton

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, 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.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

This second edition cancels and replaces the first edition (ISO 21809-5:2010), which has been technically revised.

A list of all parts in the ISO 21809 series can be found on the ISO website.

Introduction

It is necessary that users of this document be aware that further or differing requirements might be needed for individual applications. This document is not intended to inhibit a vendor from offering or the purchaser from accepting alternative equipment or engineering solutions for the individual application. This can be particularly applicable if there is innovative or developing technology. If an alternative is offered, it is the responsibility of the vendor to identify any variations from this document and provide details.

Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems —

Part 5: External concrete coatings

1 Scope

This document specifies the requirements for qualification, application, testing and handling of materials required for the application of reinforced concrete coating externally to either bare pipe or pre-coated pipe for use in pipeline transportation systems for the petroleum and natural gas industries as defined in ISO 13623.

The external application of concrete is primarily used for the negative buoyancy of pipes used in buried or submerged pipeline systems and/or for the mechanical protection of the pipe and its pre-coating.

This document is applicable to concrete thicknesses of 25 mm or greater.

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 1920-5, *Testing of concrete — Part 5: Properties of hardened concrete other than strength*

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

ISO 16120-2, *Non-alloy steel wire rod for conversion to wire — Part 2: Specific requirements for general purpose wire rod*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

EN 197-1, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*

EN 206-1, *Concrete — Part 1: Specification, performance, production and conformity*

EN 450-1, *Fly ash for concrete — Part 1: Definition, specifications and conformity criteria*

EN 934-2, *Admixtures for concrete, mortar and grout — Part 2: Concrete admixtures — Definitions, requirements conformity, marking and labelling*

EN 1008, *Mixing water for concrete — Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*

EN 10080, *Steel for the reinforcement of concrete — Weldable reinforcing steel — General*

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

EN 10244-2, *Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 2: Zinc or zinc alloy coatings*

EN 12390-2, *Testing hardened concrete — Part 2: Making and curing specimens for strength tests*

EN 12390-3, *Testing hardened concrete — Part 3: Compressive strength of test specimens*

EN 12390-7, *Testing hardened concrete — Part 7: Density of hardened concrete*

EN 12504-1, *Testing concrete in structures — Part 1: Cored specimens — Taking, examining and testing in compression*

EN 12620, *Aggregates for concrete*

EN 13055-1, *Lightweight aggregates — Part 1: Lightweight aggregates for concrete, mortar and grout*

EN 13263-1, *Silica fume for concrete — Part 1: Definitions, requirements and conformity criteria*

ACI 308.1-98, *Standard specification for curing concrete*

ASTM A641, *Standard specification for zinc-coated (galvanized) carbon steel wire*

ASTM A810, *Standard specification for zinc-coated (galvanized) steel pipe winding mesh*

ASTM A1064, *Standard specification for carbon-steel wire and welded wire reinforcement, plain and deformed, for concrete*

ASTM C31, *Standard practice for making and curing concrete test specimens in the field*

ASTM C33, *Standard specification for concrete aggregates*

ASTM C39, *Standard test method for compressive strength of cylindrical concrete specimens*

ASTM C40, *Standard test method for organic impurities in fine aggregates for concrete*

ASTM C42, *Standard test method for obtaining and testing drilled cores and sawed beams of concrete*

ASTM C128, *Standard test method for density, relative density (specific gravity) and absorption of fine aggregate*

ASTM C150, *Standard specification for Portland cement*

ASTM C171, *Standard specification for sheet materials for curing concrete*

ASTM C172, *Standard practice for sampling freshly mixed concrete*

ASTM C309, *Standard specification for liquid membrane-forming compounds for curing concrete*

ASTM C330, *Standard specification for lightweight aggregates for structural concrete*

ASTM C331, *Standard specification for lightweight aggregates for concrete masonry units*

ASTM C332, *Standard specification for lightweight aggregates for insulating concrete*

ASTM C494, *Standard specification for chemical admixtures for concrete*

ASTM C595, *Standard specification for blended hydraulic cements*

ASTM C617, *Standard practice for capping cylindrical concrete specimens*

ASTM C618, *Standard specification for coal fly ash and raw or calcined natural Pozzolan for use in concrete*

ASTM C637, *Standard specification for aggregates for radiation-shielding concrete*

ASTM C642, *Standard test method for density, absorption, and voids in hardened concrete*

ASTM C989, *Standard specification for slag cement for use in concrete and mortars*

ASTM C1157, *Standard performance specification for hydraulic cement*

ASTM C1176, *Standard practice for making roller-compacted concrete in cylinder molds using a vibrating table*

ASTM C1240, *Standard specification for silica fume used in cementitious mixtures*

ASTM C1435, *Standard practice for molding roller-compacted concrete in cylinder molds using a vibrating hammer*

ASTM C1602, *Standard specification for mixing water used in the production of hydraulic cement concrete*

ASTM C1604, *Standard test method for obtaining and testing drilled cores of shotcrete*

ASTM D2216, *Standard test methods for laboratory determination of water (moisture) content of soil and rock by mass*

ASTM D4643, *Standard test method for determination of water (moisture) content of soil by microwave oven heating*

ASTM D4959, *Standard test method for determination of water content of soil by direct heating*

ASTM D6176, *Standard practice for measuring surface atmospheric temperature with electrical resistance temperature sensors*

3 Terms and definitions

For the purposes 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
aggregate
fine and coarse granular material such as sand, crushed stone, iron blast furnace slag, magnetite, ilmenite, or hematite used with a cement medium to form concrete or mortar

3.2
anode
sacrificial metallic attachment that is electrically connected to the steel pipe

3.3
applicator
company that undertakes the coating application in compliance with the provisions of this document

3.4
cementitious material
inorganic material or a mixture of inorganic materials that sets and develops strength by chemical reaction with water by formation of hydrates and is capable of doing so under water

3.5
compression wrap process
process by which the concrete mix is discharged into a coating head and applied in a continuous helical strip with pressure onto a rotating pipe

3.6
compressive strength
maximum compressive stress at the point of failure

3.7
concrete admixture
material, other than *aggregate* (3.1), water, cement or *supplementary cementitious material* (3.33), or fibre reinforcement, that is added as an ingredient to the concrete mix or one of its components, to enhance or modify the properties of the concrete or application process

3.8
concrete coated pipe weight
weight of the concrete coated pipe in air after the concrete *cutback* (3.13) has been completed

3.9
core
cylindrical specimen of a specific or designated diameter drilled from hardened concrete coating to be tested in compression or examined petrographically

3.10
cover
distance between the surface of the reinforcement and the outer surface of the concrete

3.11
cube
specimen of specific dimensions prepared from fresh concrete to be tested in compression

3.12
curing
action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and (if applicable) pozzolanic reactions to occur so that the required properties of the mix can develop

3.13
cutback
length of pipe left without concrete coating at each end

3.14
cylinder
cylindrical specimen prepared from fresh concrete to be tested in compression

3.15
electrical isolation
absence of electrical continuity between the steel pipe and reinforcement

3.16
field specimen
cores (3.9), *cubes* (3.11), *cylinders* (3.14), prisms or *in situ* specimens taken from the hardened concrete coating

3.17
form process
pump process
process by which the concrete mix is poured into a mould on a stationary pipe

3.18
gap
annular separation between the concrete coating and the underlying substrate

3.19
holiday
pre-coating (3.25) discontinuity that exhibits electrical conductivity when exposed to a specific voltage

3.20
impact resistance
resistance of concrete coating against interference and accidental loads

3.21
impingement process
process by which the concrete is discharged at high velocity onto a rotating pipe

3.22
mix design
unique blend of *aggregates* (3.1), cement, water, and *supplementary cementitious materials* (3.33) and/or admixtures that will result in a concrete mix

3.23
negative buoyancy
weight of the concrete coated pipe less the positive buoyancy of the concrete coated pipe when considered as a closed *cylinder* (3.14) immersed in the service environment

3.24
pi tape
tape used to measure the diameter of the concrete coated pipe

3.25
pre-coating
any coating or coating system applied to the external surface of the steel pipe prior to the application of the concrete coating

3.26
purchaser
company responsible for providing the product order requirements

3.27
reclaimed concrete
concrete that is reintroduced into the mix and does not require processing before reuse

3.28
recycled concrete as aggregate
concrete that has been reprocessed for use as *aggregate* (3.1)

3.29
shear resistance
resistance against relative displacement (movement) along the interface between the concrete coating and the underlying *pre-coating* (3.25)

3.30
slip form process
process whereby the concrete is applied to a vertical pipe by means of a slip form mould

3.31
specific gravity
ratio of mass of a volume of material to the mass of an equal volume of distilled water at a stated temperature

3.32
steel reinforcement
bars, wires, fibres, or strands, which are embedded in the concrete coating in such a manner that the reinforcement and the concrete act together in resisting forces

3.33
supplementary cementitious material
SCM
natural or man-made siliceous or siliceous and aluminous materials that can be used to either partially substitute Portland cement or increase the total content of *cementitious material* (3.4) in concrete mixes to improve the strength and durability of concrete

EXAMPLE Fly ash, ground granulated blast furnace slag, silica fume, calcined shale or metakaolin.

3.34
supplier
provider or manufacturer of supplies or materials used in the application of concrete coating

3.35
test report
document that provides the quantitative test results for tests conducted in accordance with the requirements of this document

4 Symbols and abbreviated terms

4.1 Symbols

D_b bare pipe diameter (mm)

D_c average concrete coated pipe diameter (mm)

t_c concrete thickness (mm)

t_p pre-coating minimum thickness (mm)

4.2 Abbreviated terms

AWG American wire gauge

SCM supplementary cementitious materials

5 General requirements

5.1 Rounding

Unless otherwise stated in this document, to determine conformance with the specified requirements, observed or calculated values shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in compliance with ISO 80000-1:2009, Annex B, Rule A.

NOTE For the purposes of this provision, the rounding method of ASTM E29 is equivalent to ISO 80000-1:2009, Annex B, Rule A.

5.2 Compliance with this document

A quality system and an environmental management system should be applied to assist compliance with the requirements of this document.

NOTE ISO/TS 29001 gives sector-specific guidance on quality management systems and ISO 14001 gives guidance on the selection and use of an environmental management system.

The applicator shall be responsible for complying with all of the applicable requirements of this document. It shall be permissible for the purchaser or end user to make any investigation necessary in

order to be assured of compliance by the applicator and to reject any material and/or concrete coating that does not comply.

6 Information supplied by the purchaser

6.1 General information

The purchase order shall include the following information:

a) the number of this document and year of publication (i.e., ISO 21809-5:2017);

b) pipe quantity, outside diameter, wall thickness, minimum and maximum individual pipe lengths, type and thickness of pre-coating;

c) bare pipe standard or specification designation, e.g. ISO 3183, or pre-coated pipe standard or specification designation, e.g. ISO 21809-2;

d) concrete coating thickness, density or specific gravity or negative buoyancy and compressive strength;

e) applicable project specifications;

f) reinforcement type, standard and cross-sectional area percentages;

g) concrete coating cutback length and tolerances for each pipe end;

h) pre-coating inspection and repair requirements;

i) markings to be applied to the concrete coated pipe;

j) frequency of concrete coating density test during coating production (see Table 2).

6.2 Additional information

The purchase order shall indicate which of the following provisions apply for the specific order item:

a) plant inspection by the purchaser;

b) additional tests, types and frequency;

c) handling procedures;

d) storage procedures;

e) requirement for applicator to submit details of the facilities and the methods to be used for yard storage;

f) waiver of test reports;

g) other special requirements, e.g. impact resistance, shear resistance for tension transfer on the pipe lay vessel;

h) anode location area.

7 Materials

7.1 Pipe

The supply of bare or pre-coated pipe to be concrete coated shall conform to the pipe and pre-coating standards or specifications that are specified in the purchase order.

IMPORTANT — Pre-coated steel pipe might not necessarily have a surface condition that is appropriate for the application of concrete coating. Remediation of the bare steel pipe or pre-coating may therefore be required.

7.2 Cement

The applicator shall use cement that is:

a) certified by the supplier to be in compliance with the requirements of ASTM C150, ASTM C595, ASTM C1157 or EN 197-1;

b) identified with the following information on the certification and/or delivery documents for each shipment of cement:

   — cement producer's name and location,

   — product description including type and classification of cement, and

   — year and month of production;

c) handled, transported and stored prior to use, in compliance with the cement manufacturer's recommendations and in compliance with the applicable standards;

d) no more than 6 months from the date of manufacture for bulk cement or 3 months from date of manufacture for bagged cement, unless it is retested and proven to be in compliance with the original standard.

NOTE Cement stored in a warm, humid environment for an extended period of time could possibly lose significant properties.

For submerged service conditions using concrete mixes containing Portland cement as the only cementitious material, the tricalcium aluminate (C_3A) content of the cement shall be less than or equal to 10,0 %. For all other service conditions, the tricalcium aluminate content limit is not applicable.

For submerged service conditions using concrete mixes containing Portland cement as the only cementitious material, the alkali content shall not exceed 0,6 %, if potentially reactive aggregates are used.

7.3 Supplementary cementitious materials

If approved by the purchaser, the applicator shall use SCMs that are:

a) certified by the supplier to be in compliance with the requirements of ASTM C618, ASTM C989, ASTM C1240, EN 450-1 or EN 13263-1;

b) identified with the following information on the certification and/or delivery documents for each shipment of SCMs:

   1) SCM producer's name and location,

   2) product description including type and classification of SCM, and

   3) year and month of production;

c) handled, transported and stored prior to use, in compliance with the SCM supplier's recommendations and in compliance with the applicable standard;

d) within time limits stated in the applicable standard, unless it is retested and proven to be in compliance with the original standard.

NOTE SCMs stored in a warm, humid environment for an extended period of time could possibly lose significant properties.

7.4 Aggregate — Fine and coarse

The applicator shall use fine or a combination of fine and coarse aggregates that are:

a) certified by the supplier to be in compliance with the requirements of ASTM C33 or EN 12620;

b) identified with the following on the certification and/or delivery documents for each source of aggregate:

   1) aggregate supplier's name and location,

   2) product description including gradation, and

   3) qualification standard or specification;

c) stored in such a condition as to prevent contamination and shall remain in compliance with the applicable standard.

The applicator shall verify that the aggregate received meets the above requirements.

7.5 Heavyweight aggregate

If required, the applicator shall use heavyweight aggregate with an oven-dried density higher than 3 000 kg/m^3, such as iron ore or other dense material, that is:

a) certified by the supplier to be in compliance with the requirements of ASTM C637 or EN 12620;

b) identified with the following on the certification and/or delivery documents for each shipment of heavyweight aggregate:

   1) heavyweight aggregate supplier's name and location,

   2) product description including gradation,

   3) chemical composition, and

   4) density;

c) suitable in size for the application process and achieves the required concrete coating properties;

d) stored in such a condition as to prevent contamination and shall remain in compliance with the applicable standard.

The applicator shall verify that the aggregate received meets the above requirements.

7.6 Lightweight aggregate

If required, the applicator shall use lightweight aggregate with an oven-dried density lower than 2 000 kg/m^3, such as expanded or sintered clay, shale, slate, perlite, slag, sintered fly ash, natural pumice, volcanic cinders or industrial cinders, that is:

a) certified by the supplier to be in compliance with the requirements of ASTM C330, ASTM C331, ASTM C332 or EN 13055-1;

b) identified with the following on the certification and/or delivery documents for each shipment of lightweight aggregate:

   1) lightweight aggregate supplier's name and location,

   2) product description including gradation,

   3) chemical composition, and

4) density;

c) suitable in size for the application process and achieves the required coating properties;

d) stored in such a condition as to prevent contamination and shall remain in compliance with the applicable standard.

The applicator shall verify that the aggregate received meets the above requirements.

7.7 Recycled concrete as aggregate

The use of recycled concrete is acceptable if processed from current or previous concrete coating projects to achieve an aggregate suitable in size for the application process. The use of this aggregate in combination with new aggregates shall achieve the required concrete coating properties stated in Table 1 and Table 2.

Every 100 m^3 of processed recycled concrete shall be tested for:

a) moisture in compliance with ASTM D4643;

b) cleanliness in compliance with ASTM C40;

c) particle size in compliance with ASTM C33 or EN 12620;

d) density in compliance with ASTM C128.

The percentage of recycled concrete used as aggregate shall not exceed 10 % by weight unless agreed with the purchaser.

NOTE Percent mass fraction is commonly called “weight percent” in USC units.

7.8 Water

Water used in the production of concrete shall comply with ASTM C1602 or EN 1008. Water that is potable does not require testing for compliance.

7.9 Steel reinforcement

The concrete coating shall be reinforced by steel bars tied or welded to form cages or by wire mesh steel. Steel bars shall comply with ASTM A1064 or EN 10080. Wire mesh reinforcement shall comply with ASTM A1064 or ISO 16120-2. Zinc coated wire mesh shall comply with ASTM A810 or EN 10244-2.

The applicator shall request and retain certificates for each shipment. The certificates shall contain the information required in the aforementioned standards.

7.10 Concrete admixtures

The use and types of concrete admixtures shall be agreed on with the purchaser and shall comply with ASTM C494 or EN 934-2. Concrete admixtures containing added chlorides shall not be used.

7.11 Reclaimed concrete

The use of reclaimed concrete is acceptable only when the material is reintroduced via a conveyance system into the process within 30 min of initial mixing with water.

8 Concrete mix

The concrete ingredients shall be homogeneously mixed according to the applicator's mix design to predetermined proportions based on the concrete density and compressive strength necessary to achieve the requirements of the purchase order.

Each time the source of aggregate, water or cement changes, and that change necessitates a modification of the mix design or if the mix design changes for any other reason, the applicator shall verify by testing that the new mix design results in a concrete coating that meets the purchase order requirements.

The applicator shall have a documented process control system to ensure continuity of the produced mix.

For submerged service conditions using concrete mixes containing Portland cement as the only cementitious material, the water to cement ratio in the concrete mix shall be equal to or less than 0,40 and the minimum cement content shall be 400 kg/m^3 of the concrete mix.

For all other service conditions using concrete mixes containing Portland cement as the only cementitious material, the water to cement ratio in the concrete mix shall be equal to or less than 0,45 and the minimum cement content shall be 350 kg/m^3 of the concrete mix.

For all service conditions using concrete mixes containing SCMs, the water to cement ratio in the concrete mix may be equal to or lower than concrete mixes containing only Portland cement to achieve equivalent or higher compressive strengths.

9 Coating application

9.1 Qualification

A qualification test in accordance with Table 1 shall be performed prior to the start of concrete coating production. Three test pipes representative of the requirements of the purchase order and agreed on with the purchaser shall be concrete coated and test results shall be in compliance with Table 1.

If a result for density, compressive strength or water absorption does not meet the requirements of Table 1, retesting shall be carried out in accordance with 11.3.

If a result for other test parameters does not meet the requirements of Table 1, retesting may be done in agreement with the purchaser.

NOTE This qualification test represents one pipe diameter coated with one thickness and one density of concrete.

If existing documentation from previous projects using the same application process, application equipment and materials demonstrates compliance with the requirements of Table 1, the purchaser may accept this documentation and waive the qualification test requirement.

Documents for qualification shall include:

a) concrete coating materials;

b) pipe outside diameter;

c) type of pre-coating applied;

d) concrete coating thickness;

e) steel reinforcement;

f) mix design;

g) concrete coating application and curing procedures;

h) inspection and test plan;

i) measurement, testing procedures and results;

j) procedure for testing shear resistant material, if applicable, which shall be provided by the applicator;

k) procedure for testing impact resistance, if applicable, which shall be provided by the applicator;

l) repair materials and procedures;

m) handling and storage procedures;

n) anode installation procedure, if applicable.

Table 1 — Qualification test requirements

Property	Subclause	Test method	Requirements	Tolerance	Frequency qualification
Pre-concrete coated pipe length	9.1	N/A	N/A (for informational purposes)	N/A (for informational purposes)	Each pipe
Concrete coating thickness[a]	11.2.1	11.2.1	As stated in purchase order	±6 mm	Ten measurements on each pipe
Pre-concrete coated pipe weight in air	11.2.3	Measurement	As stated in purchase order	N/A (for informational purposes)	Each pipe
Concrete coated pipe weight in air	11.2.4	Measurement	As stated in purchase order	$^{+7,5}_{-5}$ %	Each pipe
Concrete coating density[a]	11.2.5	ASTM C642 EN 12390–7	As stated in purchase order	±5 %	Each pipe
Concrete coating cutback length	9.6	Measurement	As stated in purchase order	±25 mm	Each end of each pipe
Reinforcement placement	9.5.5	9.5.5	As stated in 9.5.5	As stated in 9.5.5	Each pipe
Reinforcement electrical isolation	9.5.5.1	9.5.5.1	9.5.5.1	As stated in 9.5.5.1	Each pipe
Reinforcement overlap	9.5.5.2 9.5.5.3	11.2.2	9.5.5.2 9.5.5.3	9.5.5.2 or 9.5.5.3, as applicable	Each pipe
Preparation of compressive strength specimens from fresh concrete	11.2.6.1	ASTM C31 ASTM C172, ASTM C1176, ASTM C1435, or EN 12390–2	N/A	N/A	One set of three specimens
Preparation of compressive strength specimens from hardened concrete	11.2.6.2	ASTM C42, ASTM C617, ASTM C1604, or EN 12504–1	N/A	N/A	One set of three visually acceptable specimens per pipe

[a] If the applicator has calculated the thickness and density of the concrete coating from the specific gravity or negative buoyancy stated in the purchase order, then the results shall be approved by the purchaser prior to the qualification test.

[b] For qualification, the method of testing compressive strength shall be agreed on between the purchaser and the applicator. Cores shall not be taken if the concrete thickness is less than 40 mm.

[c] Hardened concrete coating field specimens that have achieved a minimum compressive strength of 15 MPa shall be tested in compliance with Annex A for water absorption.

[d] Shear resistance and/or impact resistance qualification testing shall be conducted if specified in the purchase order.

Table 1 *(continued)*

Property	Subclause	Test method	Requirements	Tolerance	Frequency qualification
Compressive strength[b]	11.2.6	ASTM C39, ASTM C42, ASTM C1604, EN 12390–3	As stated in purchase order	As stated in purchase order	All specimens
Water absorption[c]	11.2.7	Annex A	Not to exceed 5 %	None	One test on one pipe
Shear resistance[d]	N/A	Annex B	As stated in purchase order	As stated in purchase order	As stated in purchase order
Impact resistance[d]	11.2.8	Purchase order	As stated in purchase order	As stated in purchase order	As stated in purchase order
Environmental conditions	9.3	ASTM D6176	9.3	For informational purposes only	Once on the day of qualification

[a] If the applicator has calculated the thickness and density of the concrete coating from the specific gravity or negative buoyancy stated in the purchase order, then the results shall be approved by the purchaser prior to the qualification test.

[b] For qualification, the method of testing compressive strength shall be agreed on between the purchaser and the applicator. Cores shall not be taken if the concrete thickness is less than 40 mm.

[c] Hardened concrete coating field specimens that have achieved a minimum compressive strength of 15 MPa shall be tested in compliance with Annex A for water absorption.

[d] Shear resistance and/or impact resistance qualification testing shall be conducted if specified in the purchase order.

9.2 Application of concrete coating

Concrete coating shall be applied by any one of the following processes:

a) compression (wrap) process;

b) impingement process;

c) form and/or pump process;

d) slip form process.

9.3 Environmental conditions

Coating application shall take place only under the following conditions:

a) pipe, pre-coating, reinforcement and concrete mix temperature shall be within the range of +3 °C to +35 °C;

b) air temperature in the immediate vicinity of the concrete coating application process shall be within the range of +3 °C to +43 °C.

If the conditions for coating fall outside those given in a) and b), then the applicator shall present a procedure for the protection of the concrete coating to the purchaser for approval.

9.4 Pipe

9.4.1 Pre-coated pipe

The surface of the pre-coated pipe shall be free from dirt, mud, oils or any deleterious material which would prevent the application of the concrete coating in compliance with this document.

If the pre-coating plant is connected directly to the concrete coating plant by a conveyor system, then additional testing for holidays of the pre-coated pipe is not required prior to the application of the concrete coating.

If the pre-coated pipe has been handled or placed in stockpile, then all pipes shall be tested for holidays in compliance with the original pre-coating standard. Holidays shall be repaired as agreed with the purchaser.

If concrete coating has been removed for any reason, then the pre-coated pipe shall be tested for holidays in compliance with the original pre-coating standard. Holidays shall be repaired as agreed with the purchaser.

9.4.2 Bare pipe

The surface of the bare pipe shall be free from dirt, mud, oils, loose scale or any deleterious material which would prevent the application of the concrete coating in compliance with this document.

9.5 Steel reinforcement

9.5.1 General

Steel reinforcement shall be provided to limit spalling and control cracking of the concrete coating.

The reinforcement provided shall be a cage, welded wire mesh, woven wire mesh or a combination thereof. The type of reinforcement to be used shall be stated in the purchase order.

The reinforcement shall be free from oil, grease, dirt or other deleterious material.

The minimum amount of the steel reinforcement shall be 0,4 % circumferentially and 0,06 % longitudinally of the cross-sectional area of the concrete coating.

9.5.2 Cage reinforcement

Cage reinforcement shall be in the form of spirally wound cages, having a continuous hoop bar with a number of straight longitudinal bars evenly spaced around the spiral and tied or welded at each bar intersection. Alternatively, the continuous hoop bar may be replaced by single circumferential hoops.

The material used shall be in compliance with EN 10080 or ASTM A1064. The welding of the materials shall result in a steel cage in compliance with EN 10080 or ASTM A1064.

The diameter of the circumferential and longitudinal bars shall be calculated from the requirements of the purchase order or the requirements of 9.5.1. The minimum diameter of the reinforcement used for cages shall be 5 mm.

9.5.3 Welded wire mesh reinforcement

The reinforcement shall be applied by a method that provides continuity of the reinforcement.

The welded wire mesh used shall be galvanized and shall conform to ASTM A1064, ASTM A641 and ASTM A810 or ISO 16120-2.

The diameter of the circumferential and longitudinal wires shall be calculated from the requirements of the purchase order or the requirements of 9.5.1. The minimum diameter of the reinforcing wire shall be 1,5 mm.

9.5.4 Woven wire mesh reinforcement

The reinforcement shall be applied by a method that provides continuity of the reinforcement.

Woven wire mesh reinforcement shall conform to ASTM A810.

The minimum diameter of the woven wire mesh shall be 1,15 mm (AWG 17).

9.5.5 Reinforcement placement

9.5.5.1 General

The reinforcement shall be a minimum of 10 mm from the surface of the pre-coating or bare pipe and shall have a minimum of 10 mm concrete cover. The reinforcement shall not protrude beyond the end of the concrete coating cutback unless otherwise agreed between applicator and the purchaser.

The reinforcement shall be electrically isolated from the pipe and the pre-coating. This isolation shall be tested twice per production shift with a calibrated instrument. The resistance shall be greater than 10 000 Ω.

If more than one layer of reinforcement is used, there shall be a minimum spacing of 5 mm between layers (excluding the overlap area).

9.5.5.2 Cage reinforcement

The reinforcement shall be positioned within the middle third of the concrete coating.

Cages shall be rigidly held concentric to the pipe at the correct location by electrically insulating plastic, synthetic resin or concrete spacers.

Spacers shall have flush bases to prevent indentation into the pre-coating.

If multiple sections are required to achieve continuous reinforcement, the overlap between the longitudinal bars shall be a minimum of 200 mm with a minimum distance between circumferential reinforcement of 25 mm. Overlapping bars shall be mechanically connected as necessary to maintain continuity.

9.5.5.3 Woven or welded wire mesh reinforcement

A minimum of one layer of reinforcement shall be used. Additional layers of reinforcement may be necessary to meet the purchase order requirements or the percentage requirements of 9.5.1.

The longitudinal overlap shall be a minimum of 12 mm as measured from wire to wire.

9.6 Concrete cutback

The ends of the concrete coating shall be shaped 60° to 90° to the axis of the pipe.

The ends and inside of the pipe shall be free of concrete debris.

The concrete cutback length shall be measured from each end of each pipe to the start of the concrete coating and shall meet the requirements of Table 2.

9.7 Anode installation

If anodes are to be installed after the application of the concrete coating, pipes assigned for anode installation shall have a section of concrete removed of such a length as to accommodate an anode +100 mm minimum and at the location as agreed in the purchase order.

If anodes are installed prior to the application of the concrete coating, the reinforcement shall be a minimum distance of 15 mm from each end of the anode.

The anode shall not come into contact with the concrete coating reinforcement.

10 Curing methods

The concrete coating shall be cured by one or a combination of the following methods:

a) water fogging or misting (in compliance with ACI 308.1-98);

b) liquid membrane or sheet materials (in compliance with ASTM C309 or ASTM C171);

c) steam.

It shall be demonstrated that the steam curing process has no deleterious effects on the concrete coating.

Whichever method is used, the concrete coating shall remain moist and above a temperature of 0 °C as measured on the concrete coating until a minimum compressive strength of 15 MPa is achieved as tested from samples taken from the concrete coated pipe.

11 Inspection and testing

11.1 General

During concrete coating production, quality control tests shall be carried out in accordance with Table 2 to demonstrate compliance with the purchase order and/or this document. If a test result does not meet the requirements of Table 2, retesting shall be carried out in accordance with 11.3.

Acceptance of non-conforming coatings shall be at the purchaser's option.

Inspection, measurement and test equipment shall be calibrated to a standard at a frequency that ensures the integrity of the inspections, measurements and tests. The calibration records shall include all information required to trace the calibration to the applicable standard, including reference to the unique identification of the standard.

Records of all calibrations shall be maintained by the applicator and shall be available for review.

Table 2 — Production quality control

Property	Clause/ Subclause	Test method	Requirements	Tolerance	Frequency
Aggregates	7.4, 7.5, 7.6	ASTM C33 EN 12620	Applicator's purchase order to supplier	Applicator's purchase order to supplier	Twice per week
Recycled aggregates	7.7	As in 7.7	Applicator's values	Applicator's values	Each 100 m^3 of processed material
Water content	8	ASTM D4643 or ASTM D4959 or ASTM D2216 or suitable alternative	Applicator's mix design	Applicator's mix design	Minimum of one every 2 h of production
Cement content and water/cement ratio	8	EN 206–1	Applicator's mix design	Applicator's mix design	Minimum of one every 2 h of production
Concrete coating thickness	11.2.1	11.2.1	Purchase order	+6 mm, each measurement	Three measurements on each pipe
Concrete coating density	11.2.5	11.2.5	Purchase order	±5 %	As stated in the purchase order
Concrete coating cutback length	9.6	Measurement	Purchase order	±25 mm	Each end of each pipe

[a] Test frequency may be relaxed, if agreed to by the purchaser.

Table 2 *(continued)*

Property	Clause/ Subclause	Test method	Requirements	Tolerance	Frequency
Concrete coated pipe weight in air	11.2.4	11.2.4	Purchase order	$^{+7,5}_{-5}$ % for each individual pipe; $^{+5}_{-2,5}$ % for rolling 25 consecutive pipe average	Each pipe
Reinforcement electrical isolation	9.5.5.1	9.5.5.1	9.5.5.1	As stated in 9.5.5.1	Twice per production shift
Reinforcement location	9.5.5	11.2.2	9.5.5.2 9.5.5.3	As stated in 9.5.5.1	Once per production day per pipe size or concrete thickness
Reinforcement overlap	9.5.5.2 9.5.5.3	11.2.2	9.5.5.2 9.5.5.3	As stated in 9.5.5.1	Once per production shift per pipe size or concrete thickness
Preparation of compressive strength test specimens from fresh concrete	11.2.6.1	ASTM C31, ASTM C172, ASTM C1176, ASTM C1435, or EN 12390–2	N/A	N/A	A set of three test specimens from the first 50 m^3, then each 150 m^3 thereafter, or three test specimens at least twice per production shift, whichever is more frequent[a]
Preparation of compressive strength test specimens from hardened concrete	11.2.6.2	ASTM C42, ASTM C617, ASTM C1604, or EN 12504–1	Not applicable on concrete thicknesses less than 40 mm	N/A	A set of three visually acceptable test specimens from one pipe every 25 pipes coated
Compressive strength	11.2.6	ASTM C39, ASTM C42, ASTM C1604 or EN 12390–3	Purchase order	Purchase order	All test specimens
Water absorption	11.2.7	Annex A	Not to exceed 5 %	None	Minimum of once per production shift, test specimens as in Annex A
Environmental conditions	9.3	9.3	9.3	As stated in 9.3	Each day at the start of production

[a] Test frequency may be relaxed, if agreed to by the purchaser.

11.2 Test procedures

11.2.1 Concrete coating thickness — Diameter measurement

The outside diameter of the concrete coated pipe shall be measured using a pi tape or other appropriate diameter measurement method approved by purchaser. Each coated pipe shall have a minimum of three equally spaced measurements along the length of the pipe.

The average of the three diameter measurements shall be used to calculate the concrete coating thickness, t_c, using Formula (1):

$$t_c = [(D_c) - (D_b + t_p + t_p)]/2 \quad (1)$$

where

t_c is the concrete thickness (mm);

D_c is the average concrete coated pipe diameter (mm);

D_b is the bare pipe diameter (mm);

t_p is the pre-coating minimum thickness (mm).

The minimum pre-coat thickness may be determined by reviewing the project records of the pre-coating process or by measuring a pre-coated pipe representative of the pipe to be concrete coated. Agreement shall be reached with the purchaser on the method of pre-coating measurement.

If the calculated concrete thickness does not meet the requirements of Table 1 or Table 2, as applicable, the pipe shall be stripped and recoated.

11.2.2 Placement of reinforcement

A section of freshly applied concrete approximately 75 mm × 200 mm shall be removed from the first pipe of each day's production down to the pre-coating. During the removal process, the applicator shall ensure the integrity of the original placement of the reinforcement.

Inspection of the exposed area shall confirm that the reinforcement is positioned and the overlap is as required in the purchase order. The exposed area shall be repaired by trowelling or otherwise packing a mix of like material.

If the wire is not positioned correctly, the pipe shall be rejected, stripped of the concrete coating and recoated. Each pipe following the rejected pipe shall be inspected in this manner until the position of the reinforcement is accepted. All rejected pipes shall be stripped and recoated.

Alternative test methods shall be subject to agreement with the purchaser prior to production.

11.2.3 Pre-concrete coated pipe weight in air

If required by the purchase order, the pre-coated steel pipe shall be weighed prior to the application of concrete coating using a weighing device that is calibrated to an accuracy of ±0,5 % of the calibration weight. The calibration weight shall be representative of the anticipated production weights.

11.2.4 Concrete coated pipe weight in air

Each concrete coated pipe shall be weighed as it is removed from the coating machine, but after concrete cutback completion, using a weighing device that is calibrated to an accuracy of ±0,5 % of the calibration weight. The calibration weight shall be representative of the anticipated production weights. The method of weighing the pipe shall be specified by the applicator in the manufacturing procedure.

Weight adjustment by recoating shall be performed within the first 30 min of cement coming into contact with water, provided the increased girth measurement meets the requirements of Table 1 or Table 2.

Weight adjustment by scraping and/or scabbling shall be performed, provided there is no damage to the concrete coating and the decreased girth measurement meets the requirements of Table 1 or Table 2.

The weight of each pipe joint shall be permanently recorded on the inside or outside of the pipe as specified in the purchase order by any method agreed on with the purchaser. The weight of each concrete coated pipe shall also be recorded on the applicator's records.

If the measured weight and girth measurement do not meet the requirements of Table 1 or Table 2, as applicable, the pipe shall be rejected, stripped and recoated.

11.2.5 Concrete coating density

The density of the hardened concrete shall be determined in accordance with ASTM C642 or EN 12390-7.

If the result does not meet the requirements of Table 1 or Table 2, as applicable, retesting shall be performed in accordance with 11.3.

11.2.6 Compressive strength

11.2.6.1 Preparation of specimens from fresh concrete

Specimens shall be prepared from the fresh mix in compliance with ASTM C31, ASTM C172, ASTM C1176, ASTM C1435 or EN 12390-2. Preparation of specimens shall commence within 15 min after the concrete has been discharged from the mixing unit.

NOTE The standard methods of concrete consolidation by rodding or internal vibration, as described in ASTM C31 or EN 12390-2, might not be practical for low-moisture-content concrete mixes. Consolidation using vibrating table or vibrating hammer, as specified in ASTM C1176 and ASTM C1435, could possibly be more suitable.

11.2.6.2 Preparation of specimens from hardened concrete

Specimens shall be prepared from hardened concrete in compliance with ASTM C42, ASTM C1604 or EN 12504-1. Specimens from hardened concrete shall not be taken from concrete thicknesses less than 40 mm. The core shall have a minimum diameter of 29 mm.

The cores shall be drilled at three locations along the pipe body: between 1 m and 2 m from each end and within the middle 2 m. The specimens shall be visually inspected for obvious defects, such as voids, wire overlap, bars, cracks, dimensional irregularities or any other deleterious defects. Specimens with obvious defects shall be discarded.

A core having a maximum length of less than 95 % of its diameter before capping or a length less than its diameter after capping or end preparation shall not be tested. The maximum acceptable length of the core after capping or end preparation is 120 % of its diameter. The maximum thickness of the capping material, if used, shall be 3 mm.

Unbonded caps shall not be used.

11.2.6.3 Testing of specimens from hardened concrete

Specimens shall be tested in compliance with ASTM C39 or EN 12390-3. The test method used, including the conditioning of the specimens, shall be recorded.

NOTE Specimens tested dry or as-received could possibly have a higher compressive strength than specimens that are fully saturated for the same concrete coating.

If the result does not meet the requirements of the purchase order, as applicable, retesting shall be performed in accordance with 11.3.

11.2.7 Water absorption

Hardened concrete coating specimens that have achieved a minimum compressive strength of 15 MPa shall be tested in accordance with Annex A.

If the results do not meet the requirements of Table 1 or Table 2, as applicable, retesting shall be performed in accordance with 11.3.

11.2.8 Impact resistance

If an impact resistance test is required by the purchase order for coating qualification, an impact test procedure that is applicable to the service conditions shall be specified.

NOTE DNV-RP-F111 contains a methodology that can be used for impact testing for both offshore and onshore pipelines.

If the result does not meet the requirements of Table 1, the purchaser shall have the right to require additional tests.

11.2.9 Shear resistance

If a shear resistance test is required by the purchase order, the test procedure in Annex B shall be used. If the result does not meet the requirements of Table 1, the purchaser shall have the right to require additional tests.

11.2.10 Visual inspection

The finished concrete coating shall be visually inspected and any damaged areas and cracks shall be repaired in accordance with Clause 12.

11.3 Retesting

Retesting following a failed test shall only be permitted for density, compressive strength or water absorption tests.

If a test fails to conform to the specified requirements, either

a) the test that fails shall be repeated using the spare samples taken from the originally tested area of the affected pipe, or

b) all pipe coated after the previous acceptable test and prior to the next acceptable test shall be stripped and recoated in accordance with the requirements of Table 2.

If the retested sample conforms to the specified requirements of Table 2, then the coated pipe represented by that sample shall be accepted.

If the retest fails to conform to the specified requirements of Table 2, either

a) all pipe coated after the previous acceptable test and prior to the next acceptable test shall be stripped and recoated in accordance with the requirements of Table 2, or

b) subject to the approval of the purchaser. Further retesting may be performed to determine which pipes coated after the previous acceptable test are acceptable. Pipes that are not acceptable shall be stripped and recoated in accordance with the requirements of Table 2.

11.4 Test results

Regardless of any waiver of test reporting specified in the purchase order, the results of all tests required in 11.2 and 11.3 shall be retained and available to the purchaser on request.

12 Repair of concrete coated pipe

12.1 General

Damaged areas and cracks in the hardened concrete coating shall be repaired as stated in 12.2 and 12.3. The repair procedure and the repair materials shall be compatible with the applied coating. Repair work shall be performed with qualified materials and in compliance with procedures approved by the purchaser.

12.2 Damaged areas

The repair of damaged areas on the surface of the concrete coating shall conform to the following requirements.

a) Exposed reinforcement on the external circumferential surfaces of the concrete coating is not acceptable and shall be repaired.

b) Individual damaged areas less than 1 000 cm^2, which have sustained less than 25 % reduction in the concrete coating thickness, shall be acceptable and shall not require repair.

c) Individual damaged areas that have sustained a reduction in the concrete coating thickness greater than 25 % or involving a surface area between 1 000 cm^2 and 3 000 cm^2 shall be repaired.

d) For damaged areas larger than described in c), the purchaser shall have the right to reject the pipe or damage shall be repaired, if approved by the purchaser.

e) If the aggregated damage areas exceed 10 % of the total concrete coating surface, the concrete shall be entirely removed and the pipe recoated.

12.3 Cracks

The following cracks shall be repaired:

— longitudinal cracks over 30 cm in length and more than 0,3 mm in width;

— circumferential cracks shall be repaired, if they exceed 1,6 mm in width and extend more than 180° around the circumference of the pipe.

Cracks smaller than defined above do not require repair.

12.4 Gaps

Gaps between the bare or pre-coated pipe and the concrete coating in excess of 1,5 mm, extending more than 150 mm from the beginning of the concrete cutback, that have a length of more than 60° around the circumference of the pipe and which remain for at least 24 h after the pipes have been taken out of stockpile shall be repaired.

Precautions shall be taken to prevent any permanent deformation or loss of friction during coating, curing and handling.

12.5 Stripping

Concrete coating that fails to meet the requirements of the purchase order or this document shall be stripped in compliance with the applicator's procedure that has been approved by the purchaser.

13 Markings

Concrete coated pipe shall be legibly marked in compliance with the requirements of the purchase order.

14 Handling and storage

Concrete coated pipe shall be handled and stored in a manner that avoids damage to the pipe, coating or any ancillary additions to the pipe such as anodes. If specified in the purchase order, the applicator shall submit details of the handling and storage procedures; such procedures shall include load-in and load-out requirements where the applicator is responsible for load-in or load-out.

Concrete coated pipes with anodes installed shall be stockpiled in a manner that avoids:

— direct contact with other anodes;

— damage to the anode by any other means.

Concrete coating that is damaged after application shall be repaired in accordance with the requirements of Clause 12.

If specified in the purchase order, the applicator shall submit details of the facilities and the methods to be used for yard handling and storage.

15 Test reports and inspection documents

Unless specified otherwise in the purchase order, an inspection certificate 3.1 in accordance with ISO 10474 (or type 3.1 in accordance with EN 10204) shall be issued by the applicator, which provides the results from the inspection and testing of the coated pipes in accordance with the requirements of this document and any other requirements specified in the purchase order. If, however, in the purchase order, the purchaser does waive the requirement for an inspection certificate, then the applicator should provide a declaration of compliance with the order "2.1" in accordance with ISO 10474 (or a declaration of compliance with the order "type 2.1" in accordance with EN 10204).

Annex A
(normative)

Water absorption test

A.1 General

This test method describes the procedure to be used to determine the water absorption of concrete coated pipe using hardened concrete field specimens.

A.2 References

Test methods for the determination of the density of hardened concrete shall be in accordance with EN 12390-7 and ISO 1920-5 .

A.3 Equipment

The equipment shall consist of the following:

A.3.1 Digital balance, having a capacity of 500 g or more and sensitive to 0,1 g or less.

A.3.2 Wire brush.

A.3.3 Waterproof permanent marker.

A.3.4 Paper towels.

A.4 Field specimens

Hardened concrete field specimens shall be taken from concrete coating which has achieved a minimum compressive strength of 15 MPa. Anode cut-out areas may be used for field specimens.

The specimens shall be free of visible cracks, fissures or damaged edges. No end preparation is necessary other than the removal of any foreign material, if necessary.

A minimum of either

— three acceptable field specimens from one pipe, or

— one acceptable field specimen from each of three pipes

shall be used to determine the water absorption of the concrete coating.

A.5 Procedure

Visually inspect as-received specimens for cracks, fissures or shattered edges. Clean up any loose material with a wire brush, if necessary. Discard defective specimens.

Identify each specimen with a permanent waterproof marker. Record the following information: coating date, pipe number and specimen number.

Each specimen shall be dried using paper towels upon arrival in the site laboratory to remove the water from the field specimen cutting process. Weigh each specimen and record the mass as the dried mass in air, m_A.

Immerse each specimen in water for a minimum of 24 h (maximum 28 h). Remove each specimen from the water, towel off surface moisture and weigh. Record the mass as the 24 h saturated mass in air, $m_{s,\,24}$.

Place each specimen back in the water for a further period of 24 h (maximum 28 h). Remove the specimen, towel off surface moisture and weigh. Record the mass as the saturated surface mass in air, $m_{s,\,48}$.

The density of the test water shall be recorded and reported to the purchaser.

A.6 Calculation procedure

The water absorption is calculated as given in Formula (A.1) for the 24 h water absorption, A_{24}, expressed as a percentage mass fraction or as given in Formula (A.2) for the 48 h water absorption, A_{48}, expressed as a percentage mass fraction:

$$A_{24} = (m_{s,\,24} - m_A) / m_A \times 100 \quad \text{(A.1)}$$

$$A_{48} = (m_{s,\,48} - m_A) / m_A \times 100 \quad \text{(A.2)}$$

where

m_A is the dried mass in air, expressed in grams;

$m_{s,\,24}$ is the mass of the 24 h saturated sample, expressed in grams;

$m_{s,\,48}$ is the mass of the saturated surface sample, expressed in grams.

NOTE Common industry practice is to write Formulae (A.1) and (A.2) as follows:

A calculation is made by subtracting the "dried weight in air" from the "saturated surface weight in air" and dividing that result by the "weight in air". This answer, expressed as a percentage, is the "percent water absorption".

24-h water absorption, % = (B − A)/A × 100

48-h water absorption, % = (C − A)/A × 100

where

A is the "dried weight in air" specimen (grams);

B is the "24-hour saturated weight in air" after 24 h (grams);

C is the "saturated surface weight in air" after 48 h (grams).

A.7 Results

The following information shall be recorded:

— pipe identification;

— type of specimen(s) tested and test result(s);

— acceptance criteria and pass/fail status for both the 24 h and 48 h tests;

— test method;

— date of test;

— technician.

Annex B
(normative)

Shear resistance test

B.1 General

The purpose of this test is to determine the interface shear transfer strength between the concrete coating and the underlying pre-coating.

B.2 Specimen details

The concrete coated pipe to be tested shall be taken from one production pipe for shear resistance testing. Agreement shall be reached with the purchaser on the lengths of the prepared test specimens.

NOTE This qualification test represents one pipe diameter with one type of pre-coating and one thickness and density of concrete coating.

B.3 Test procedure

The test specimens shall be tested either in a laboratory or in the field using a test apparatus capable of applying a uniform axial tension load in the steel pipe to push the concrete coating along the pipe. Measures shall be taken to avoid localized failure of the concrete coating where the loading is applied.

The specified maximum load, the rate of loading, the duration of the sustained load and the temperature of the steel pipe shall be agreed on with the purchaser.

The load shall be uniformly increased until either the specified load has been reached, widespread slippage has occurred or the concrete coating has failed.

The magnitude of the applied load and the displacement of the concrete coating relative to the steel pipe shall be continuously recorded until the end of the test.

B.4 Results

The following information shall be recorded:

— pipe identification;

— test specimen dimensions, including length;

— test method;

— specified shear transfer strength;

— magnitude and duration of the applied load and the displacement of the concrete coating;

— temperature of test specimen;

— acceptance criteria, pass/fail status;

— date of test;

— technician;

— any additional information requested by the purchaser.

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[5] ISO/TS 29001, *Petroleum, petrochemical and natural gas industries — Sector-specific quality management systems — Requirements for product and service supply organizations*

[6] ASTM E29, *Standard practice for using significant digits in test data to determine conformance with specifications*

[7] DNV-RP-F111, *Interference between trawl gear and pipelines*

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