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Petroleum and natural gas industries — Wet thermal insulation coatings for pipelines, flow lines, equipment and subsea structures

Industries du pétrole et du gaz naturel — Revêtements pour isolation thermique humide de canalisations, lignes d'écoulement et structures sous-marines

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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).

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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 WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

Introduction

Users of this International Standard are advised that further or differing requirements can be required for individual applications.

Petroleum and natural gas industries — Wet thermal insulation coatings for pipelines, flow lines, equipment and subsea structures

1 Scope

This International Standard defines the minimum requirements for qualification, application, testing, handling, storage and transportation of new and existing wet thermal insulation systems for pipelines, flowlines, equipment and subsea structures in the petroleum and natural gas industries. The purpose of these systems is to provide external corrosion protection and thermal insulation.

This International Standard is applicable to wet thermal insulation systems submerged in seawater.

This International Standard is not applicable to thermal insulation in the annulus of a steel pipe-in-pipe system.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 62, *Plastics — Determination of water absorption*

ISO 178, *Plastics — Determination of flexural properties*

ISO 527 (all parts), *Plastics — Determination of tensile properties*

ISO 813, *Rubber, vulcanized or thermoplastic — Determination of adhesion to a rigid substrate — 90 degree peel method*

ISO 844, *Rigid cellular plastics — Determination of compression properties*

ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

ISO 1133 (all parts), *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics*

ISO 1172:1996, *Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content — Calcination methods*

ISO 1183 (all parts), *Plastics — Methods for determining the density of non-cellular plastics*

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

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

ISO 2808:2007, *Paints and varnishes — Determination of film thickness*

ISO 2811-1, *Paints and varnishes — Determination of density — Part 1: Pyknometer method*

ISO 2884 (all parts), *Paints and varnishes — Determination of viscosity using rotary viscometers*

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3219, *Plastics — Polymers/resins in the liquid state or as emulsions or dispersions — Determination of viscosity using a rotational viscometer with defined shear rate*

ISO 4590, *Rigid cellular plastics — Determination of the volume percentage of open cells and of closed cells*

ISO 4624, *Paint and varnishes — Pull-off test for adhesion*

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

ISO 4897, *Cellular plastics — Determination of the coefficient of linear thermal expansion of rigid materials at sub-ambient temperatures*

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 7822:1990, *Textile glass reinforced plastics — Determination of void content — Loss on ignition, mechanical disintegration and statistical counting methods*

ISO 8301, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Heat flow meter apparatus*

ISO 8501-1, *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 8502-3, *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 8503-1, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces*

ISO 11357 (all parts), *Plastics — Differential scanning calorimetry (DSC)*

ISO 14896, *Plastics — Polyurethane raw materials — Determination of isocyanate content*

ISO 15711, *Paints and varnishes — Determination of resistance to cathodic disbonding of coatings exposed to sea water*

ISO 21809-1:2011, *Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 1: Polyolefin coatings (3-layer PE and 3-layer PP)*

ISO 21809-3:2008, *Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 3: Field joint coatings*

EN 253, *District heating pipes — Preinsulated bonded pipe systems for directly buried hot water networks — Pipe assembly of steel service pipe*

ASTM D4060, *Standard test method for abrasion resistance of organic coatings by the taber abraser*

3 Terms and definitions

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

3.1
applicator
company which undertakes the coating application in accordance with the provisions of this International Standard

3.2
certificate of analysis
batch certificate issued by the manufacturer

Note 1 to entry: It is a document that contains the results of tests performed by the manufacturer.

3.3
conformity certificate
certificate of conformity issued by the manufacturer

3.4
cool down time
time taken for a fluid contained within a pipeline to reach a pre-determined temperature from specific start temperatures (internal and external) when fluid flow is stopped

3.5
cutback
uncoated area defined in terms of length at the ends of each pipe which is required to prevent damage to the coating system when the pipe sections are welded together

3.6
end of life
condition of parameter of interest at the end of the service life

3.7
end user
company that owns and/or operates the production system

3.8
equipment
components other than pipelines and flowlines through which fluid flows from the well to the processing facility

EXAMPLE Valve, manifold, christmas tree.

3.9
field joint
uncoated area that results when two pipe sections, or a pipe section and a fitting with coating cutbacks, are assembled by welding

3.10
field joint coating
coating applied after two pipe sections with coating cutbacks have been assembled, by welding, in the field or a fabrication site

3.11
field joint designer
company that proposes the field joint system for qualification in accordance with this International Standard

3.12
flowline
pipe that transfers fluid from an oil or gas well to the riser foot of a processing facility

3.13
heat transfer coefficient
U-value
rate of heat transfer from a reference surface under the influence of a thermal gradient

Note 1 to entry: Expressed in $W.m^{-2}.K^{-1}$.

3.14
insulation system
specific combination of pre-treatment, anti-corrosion coating, insulation and protective outer sheath to achieve the corrosion protection and insulation properties as described in this International Standard

3.15
layer
materials applied to the surface to be insulated in units of discrete thickness to build up the insulation system

3.16
manufacturer
company responsible for the manufacture of coating materials

3.17
material data sheet
form containing data regarding the physical and mechanical properties of a particular material used in the coating process including guidelines and recommendations for its processing and use

3.18
material safety data sheet
form intended to provide workers and emergency personnel with procedures for handling and working with the material in a safe manner including physical data such as flash point, toxicity, first aid

3.19
maximum rated pressure
external pressure for which the insulation layers are designed, according to the system supplier

3.20
maximum and minimum rated temperature
conditions for which the insulation layers are designed, according to the system supplier

3.21
pipeline
pipe that transfers fluid from a processing or storage facility to another location be it another processing facility, refinery, chemical plant or end user

3.22
PI tape
precision vernier periphery tape that allows the direct and accurate measurement of the diameter of tubular objects without the need for callipers or micrometers

3.23
pre-production test
PPT
series of tests performed immediately before the start of production, designed to demonstrate that the requirements of a previously qualified coating system are achieved, as outlined in this International Standard and as outlined by the purchaser

3.24
procedure qualification test
PQT
series of tests designed to demonstrate that the coating materials, coating applicator, coating equipment and coating procedure can meet the requirements as outlined in this International Standard and as outlined by the purchaser

3.25
purchaser
company responsible for providing the product order requirements

3.26
service life
specified period of use of the insulation coating in service

3.27
stalk
continuous string of welded and field joint coated pipe, which is prepared in readiness for pipe spooling onto a reel lay barge

Note 1 to entry: A number of stalks will normally be required to make up a flowline or pipeline.

3.28
stalk tie-in
weld connection followed by field joint coating, which is completed between stalks during pipe spooling

3.29
subsea structure
structural foundation or template for the positioning, support and protection of various items of production equipment

EXAMPLE Manifolds, trees.

3.30
syntactic foam
insulation material formed by dispersing hollow particles within a polymer matrix

Note 1 to entry: Polyurethane, epoxy, phenolic and PP, silicone are examples of polymers.

3.31
system supplier
company that proposes the insulation system for qualification in accordance with this International Standard

3.32
thermal conductivity
k-value
ability of a material to conduct heat, generally quantified in terms of the heat flow through a unit length of material under the influence of a standardized temperature difference

Note 1 to entry: Expressed in $W.m^{-1}.K^{-1}$.

3.33
unit of production
quantity of three layer polypropylene coated pipes, at the same stage in the coating sequence, where the final insulation thickness is built up by multiple application of the constituent layers

Note 1 to entry: The constituent layers are the insulation layers and the top coat.

4 Abbreviated terms

3LPP	three layer polypropylene
4LPP	four layer polypropylene
APS	application procedure specification
CD	cathodic disbondment
CP	cathodic protection
DMA	dynamic mechanical analysis
DSC	differential scanning calorimetry
FBE	fusion bonded epoxy
FJC	field joint coating
GSPP	glass syntactic polypropylene
GSPU	glass syntactic polyurethane
HDPE	high density polyethylene
ID	internal diameter
ITP	inspection and test plan
MFR	melt flow rate
OD	outer diameter
PE	polyethylene
PP	polypropylene
PU	polyurethane
RH	relative humidity
SPU	syntactic PU
UV	ultraviolet

5 General recommendations and requirements

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

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 International Standard. It shall be permissible for the purchaser to make any investigation necessary in order to have assurance of compliance by the applicator and to reject any material and/or coating that does not comply.

6 Qualification dossier

6.1 General

A qualification dossier of the proposed insulation system in accordance with this clause shall be presented by the system supplier for review, when requested by purchaser. The requirements of this clause shall apply to all layers present in the insulation system. The content of such a dossier shall be in accordance with 6.2 and 6.3.

Historical data may be included in this qualification dossier and will be subject to review and approval by purchaser.

6.2 Content of qualification dossier

The system supplier shall provide qualification documentation which shall include the following as a minimum.

a) System summary:

   1) description of the insulation system tested;

   2) maximum rated temperature and pressure;

   3) minimum and maximum temperature guidelines for storage, handling, installation and corresponding recommendations.

b) Insulation system materials:

   1) material or layer technical data sheet and material safety data sheet;

   2) recommended shelf life and storage instructions;

   3) material, or layer when applicable, conformity certificate and material certificate of analysis from the manufacturer with the following information:

      i) product name and manufacturer;

      ii) manufacturing plant;

      iii) date of manufacture;

      iv) batch number;

      v) properties to be tested with every batch and corresponding conformity ranges;

      vi) date of issue;

      vii) signature of authorized personnel (with name and function);

   4) test data for each individual layer, in accordance with Clause 7.

c) As applied coating: qualification data for the application process, in accordance with Clause 9.

d) Full scale testing: test data for the complete system as applied, in accordance with Clause 8.

6.3 Anti-corrosion coating documentation

The purpose of this International Standard is not to define a proper qualification program for anti-corrosion coating. The wet insulation system supplier can select any anti-corrosion coating suitable for the maximum rated temperature of its insulation system and with which the system will pass the qualification requirements of this International Standard.

If the anti-corrosion coating selected by the end user is different from the one used by the system supplier for qualification, both parties shall agree on a test program to ensure that anti-corrosion coating and wet insulation are compatible up to the maximum rated temperature of the insulation system.

7 Layer test requirements

7.1 General

Each layer of the insulation system or each insulation material shall be tested as specified in this clause.

Table 1 specifies general properties to be tested for each layer where applicable.

Table 2 specifies properties to be tested on a case by case basis by agreement with the purchaser.

Each property measurement shall be documented along with the acceptance criteria for use in Clause 9.

Requirements for the qualification of repair materials shall be by agreement.

Table 1 — General properties

Layer property	Test specification	Test temperature 23°C ± 2°C	Maximum rated temperature	Minimum rated temperature
Thermal conductivity	ISO 8301	✓	✓	
Specific heat capacity	ISO 11357	✓	✓	
Hydrostatic compressive behaviour	Annex A	✓	✓	
Water absorption	ISO 62, ISO 1817[a]	✓	✓	
Density	ISO 1183	✓		
Tensile properties	ISO 527, ISO 37[b]	✓	✓	✓
Hardness	ISO 868	✓		
DSC	ISO 11357-2	Temperature range		
DMA	N/A	Temperature range		

[a] ISO 1817 for elastomers.

[b] ISO 37 for elastomers.

Table 2 — Specific properties

Material property	Test specification	Test temperature 23°C ± 2°C	Maximum rated temperature	Minimum rated temperature
Compressive strength	ISO 844	✓	✓	✓
Abrasion resistance	ASTM D 4060 / ISO 4649 [a]	✓		
Coefficient of linear thermal expansion	ISO 4897		✓	✓
UV resistance	See 7.2.5			

[a] ISO 4649 for elastomers

7.2 Ageing tests

7.2.1 General

The purpose of the ageing tests is to estimate the thermal, chemical and mechanical stability for the material's service life. The tests shall account for:

— all expected ageing phenomena, (including thermal and chemical ageing);

— the failure mechanism of the insulation material,

— any water absorption and pressure effects.

For certain materials, physical changes can produce results in tensile testing that are not indicative of chemical change. In such cases additional testing may be performed in order to explain and to understand the extent and criticality of these physical changes. This may include the use of general and material specific analysis techniques that lie outside of this specification. The results of such investigative work shall be included in the test dossier.

End of life properties should be determined and considered based on relevant application specific acceptance criteria. These shall be defined and explained by the system supplier with the ageing test results.

For each individual layer (or material) available in a range of density, the ageing tests are required only for one density, provided the data in Table 1 are documented for the relevant range of density.

In order to estimate the potential degradation of an insulation system due to wet ageing, two tests shall be performed:

— determination of the water absorption kinetic of each layer in the insulation system (7.2.2);

— determination of the degradation of the thermo-mechanical properties of each layer due to water ageing (7.2.3).

Ageing tests are not required for anti-corrosion and adhesive layers.

An optional full insulation system ageing test may be carried out in accordance with 7.2.4 to verify the long term behaviour.

7.2.2 Water absorption kinetic test

The objective shall be the determination of the end of life, through thickness, water profile.

Ageing media shall be either fresh water or seawater. Artificial seawater, if used, shall be prepared in accordance with ISO 15711.

The test shall be performed as follows:

— four temperatures:

  — 4°C;

  — maximum rated temperature minus 30°C;

  — maximum rated temperature minus 15°C;

  — maximum rated temperature (as defined in 6.2);

— duration: 1 year;

— pressure: maximum rated pressure (as defined in 6.2);

— 5 samples of each size per ageing temperature;

— sample sizes for ageing tests shall be (50 x 50 x 4) mm and (50 × 50 × 8) mm. Moulded samples should be used whenever possible;

— weighing intervals: 1, 2 weeks and 1, 3, 6 and 12 months. After removal from water, samples shall be dried with a clean dry cloth or filter paper and weighed. These six data points shall be reported on a graph and the absorption kinetic (diffusion coefficient and saturation) of the material(s) shall be determined. The test media shall be replaced at each sampling interval.

NOTE 1 Using the classical diffusion law (Fick), these data allow (knowing the through thickness temperature profile) an estimation of the end of life through thickness water profile of the structure (see detailed guidance as information in Annex K).