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Oil and gas industries including lower carbon energy — Wet thermal insulation systems for pipelines and subsea equipment —

Part 1: Validation of materials and insulation systems

Industries du pétrole et du gaz, y compris les énergies à faible teneur en carbone — Systèmes d'isolation thermique en milieu humide pour conduites et équipements sous-marins —

Partie 1: Validation des matériaux et des systèmes d'isolation

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Foreword

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This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*, Subcommittee SC 2, *Pipeline transportation systems,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 12, *Oil and gas industries including lower carbon energy,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 12736-1, together with ISO 12736-2 and ISO 12736-3, cancels and replaces ISO 12736:2014.

The main changes are as follows:

— clearer delineation between validation and projects;

— introduction of material classes;

— modification of material property testing requirements, including detailed thermal conductivity testing requirements;

— introduction of additional long-term testing requirements;

— introduction of additional system testing requirements, including system interfaces;

— removal of project specific testing requirements;

— addition of requirement for risk-based analysis of the system long-term performance;

— modifications of the format and content requirements of the final validation dossier;

— addition of Annex A with guidance for using this document.

A list of all parts in the ISO 12736 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Oil and gas industries including lower carbon energy — Wet thermal insulation systems for pipelines and subsea equipment —

Part 1: Validation of materials and insulation systems

1 Scope

This document specifies requirements for the validation of wet thermal insulation systems applied to pipelines and subsea equipment in the oil and gas industry.

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

This document is not applicable to:

— maintenance works on existing installed wet thermal insulation systems;

— qualification for anti-corrosion coating;

— thermal insulation in the annulus of a steel pipe-in-pipe system.

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 34-1, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 1: Trouser, angle and crescent test pieces*

ISO 34-2, *Rubber, vulcanized or thermoplastic — Determination of tear strength — Part 2: Small (Delft) test pieces*

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

ISO 178, *Plastics — Determination of flexural properties*

ISO 179-1, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

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

ISO 604, *Plastics — Determination of compressive properties*

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

ISO 6721-1, *Plastics — Determination of dynamic mechanical properties — Part 1: General principles*

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

ISO 8302, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus*

ISO 11357-1, *Plastics — Differential scanning calorimetry (DSC) — Part 1: General principles*

ISO 11357-4, *Plastics — Differential scanning calorimetry (DSC) — Part 4: Determination of specific heat capacity*

ISO 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 12736-2, *Oil and gas industries including lower carbon energy — Wet thermal insulation systems for pipelines and subsea equipment — Part 2: Qualification processes for production and application procedures*

ISO 12736-3, *Oil and gas industries including lower carbon energy — Wet thermal insulation systems for pipelines and subsea equipment — Part 3: Interfaces between systems, field joint systems, field repairs, and pre-fabricated insulation*

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

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

ASTM D575, *Standard Test Methods for Rubber Properties in Compression*

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

3 Terms and definitions

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

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

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

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

3.1
agreed
specified in the purchase order

Note 1 to entry: To be discussed by the *system provider* (3.37) and *system purchaser* (3.38) with input from end user as required.

3.2
application procedure specification
APS
quality specification document, or group of specifications, describing procedures, method, equipment, tools, etc. used for *system* (3.35) application

3.3
batch
quantity of *material* (3.18) produced in a continuous manufacturing operation using raw materials of the same source or grade

3.4
blown foam
insulation *material* (3.18) formed by incorporating a gas phase into a polymer matrix

3.5
certificate of analysis
document provided by the manufacturer that indicates results of specific tests or analysis, including test methodology, performed on a specified lot of the manufacturer's product and corresponding conformity ranges

3.6
construction joint
interface (3.13) where both *systems* (3.35) are identical

3.7
cutback
length of item left uncoated at each end for joining purposes

Note 1 to entry: Welding is an example of joining purposes.

3.8
field joint
uncoated area that results when two pipe sections, or a pipe section and a *fitting* (3.9), with *cutbacks* (3.7) are assembled by welding or other methods

3.9
fitting
receptacle on a piece of *subsea equipment* (3.33), which interfaces to a *pipeline* (3.22)

3.10
high molecular weight precursor thermoset
material (3.18), which is a polymeric compound that remains malleable until application of sufficient heat to cause network formation and then does not flow upon reheating

EXAMPLE Butyl rubber.

3.11
inorganic syntactic foam
insulation *material* (3.18) formed by dispersing inorganic hollow particles within a polymer matrix

3.12
inspection and test plan
ITP
document providing an overview of the sequence of inspections and tests, including appropriate resources and procedures

3.13
interface
location where two *systems* (3.35) meet and affect each other

Note 1 to entry: A *field joint* (3.8) *system* (3.35) has two interfaces.

Note 2 to entry: In the case of multilayer *systems* (3.35), interfaces can be made up of multiple sub-interfaces.

3.14
jumper
short section of *pipeline* (3.22) that transfers fluid between two pieces of *subsea equipment* (3.33)

3.15
liquid precursor elastomeric thermoset
material (3.18), which is a polymeric compound with its glass transition below ambient temperature, that is produced via the combination of one or more components that can be pumped and flow as liquids and that react to create a crosslinked polymer that does not flow upon reheating

EXAMPLE Liquid precursor silicone rubber.

3.16
liquid precursor non-elastomeric thermoset
material (3.18), which is a polymeric compound with its glass transition above ambient temperature, that is produced via the combination of one or more components that can be pumped and flow as liquids and that react to create a crosslinked polymer that does not flow upon reheating

EXAMPLE Liquid epoxy.

3.17
mainline
portion of a *pipeline* (3.22) that is not a *field joint* (3.8)

3.18
material
polymeric compound applied to the *substrate* (3.34) protected or insulated in units of discrete thickness (layers) to build up a *system* (3.35)

3.19
material manufacturer
entity responsible for the manufacture of one or more *materials* (3.18) utilized in a *system* (3.35)

3.20
material maximum and minimum rated temperature
maximum and minimum temperature to which a particular *material* (3.18) can be continuously exposed, as per *system provider* (3.37) recommendation, during storage or in service as part of a *system* (3.35)

Note 1 to entry: For multi-layer systems, the material maximum rated temperature can be less than the *system maximum rated temperature* (3.36).

3.21
maximum rated pressure
maximum hydrostatic pressure to which the *system* (3.35) can be exposed, according to the *system provider* (3.37)

3.22
pipeline
flowline
tubular piping used to convey fluids

Note 1 to entry: Pipeline includes *jumpers* (3.14), *risers* (3.28) and *field joints* (3.8).

3.23
pre-fabricated insulation
section of stand-alone insulation, which is factory manufactured into its final form and then installed in the field by mechanically fastening or bonding to a corrosion protected structure

3.24
pre-production trial
PPT
series of tests performed immediately before the start of production, designed to demonstrate that the requirements of the *validated* (3.43) *system* (3.35), the *procedure qualification trial* (3.25) or both are achieved

Note 1 to entry: Requirements for PPT shall be as outlined in ISO 12736-2 or ISO 12736-3 and as *agreed* (3.1).

3.25
procedure qualification trial
PQT
series of tests designed to demonstrate that the *materials* (3.18), *system provider* (3.37), equipment and procedures can produce a *system* (3.35) in accordance with the *validation dossier* (3.44) and meet specific *project* (3.26) requirements

Note 1 to entry: Requirements for PQT shall be as outlined in ISO 12736-2 or ISO 12736-3 and as *agreed* (3.1).

3.26
project
scope of work *agreed* (3.1) upon contractually between *system purchaser* (3.38) and *system provider* (3.37)

3.27
R-lay
reel-lay
method of *pipeline* (3.22) installation in which long *stalks* (3.32) of pre-insulated pipes are pre-assembled by welding and application of *field joint* (3.8) *system* (3.35) onshore before being spooled onto large reels onboard the installation vessel, which then lays the pipes by unspooling the reel offshore

3.28
riser
vertical portion of a *pipeline* (3.22), including the bottom bend, arriving on or departing from an offshore surface installation

3.29
safety data sheet
SDS
DEPRACATED: material safety data sheet
document intended to provide workers and emergency personnel with procedures for handling and working with a *material* (3.18) utilized in the manufacture of the *system* (3.35) in a safe manner including physical data and first aid, etc.

Note 1 to entry: Physical data can include flash point and toxicity.

3.30
service life
specified period of use for a *system* (3.35) in service

3.31
solid/solid filled
insulation *material* (3.18) that systematically does not contain voids or hollow particles

3.32
stalk
continuous string of welded and *field joint* (3.8) coated pipe, which is prepared in readiness for pipe spooling onto a *R-lay* (3.27) barge

Note 1 to entry: A number of stalks will normally be required to make up a *pipeline* (3.22).

3.33
subsea equipment
components from a subsea production system, including subsea processing items and structures, meant to control hydrocarbons, not including *pipelines* (3.22)

EXAMPLE Valve, connector, manifold, christmas tree, flowline end termination.

3.34
substrate
surface to which a *material* (3.18) is applied or will be applied

3.35
system
all of the various *materials* (3.18) and the combination thereof, which can include layers of anti-corrosion, insulation, adhesive, and protective materials, as defined by cross-section to the underlying *substrate* (3.34) at a single point, which function together to act as a *wet thermal insulation* (3.45)

3.36
system maximum and minimum rated temperature
maximum and minimum temperature to which a particular *system* (3.35) can be continuously exposed, as per *system provider* (3.37) recommendation, during storage or in service

3.37
system provider
legal entity which is selling the applied *system* (3.35)

3.38
system purchaser
entity which is purchasing the applied *system* (3.35)

3.39
thermal conductivity
k-value
conductivity
heat flow through a unit length of *material* (3.18) under the influence of a thermal gradient

Note 1 to entry: Thermal conductivity is expressed in $W \cdot m^{-1} \cdot K^{-1}$.

3.40
thermoplastic
material (3.18), which is a polymeric compound that solidifies upon cooling and can flow and be reformed upon reheating

EXAMPLE Polypropylene.

3.41
tie-in field joint
connection of a *pipeline* (3.22) to a facility or *subsea equipment* (3.33), to other pipelines, or the connecting together of different sections of a single pipeline

3.42
U-value
overall heat transfer coefficient
rate of heat transfer from a reference surface under the influence of a thermal gradient

Note 1 to entry: U-value is expressed in $W \cdot m^{-2} \cdot K^{-1}$.

3.43
validation
demonstration of *material* (3.18) and *system* (3.35) performance during storage, handling and operation, within a specified envelope of use, as determined by the *system provider* (3.39)

3.44
validation dossier
collection of documentation and test reports, prepared in accordance with specific requirements, which provides detailed information on the proposed *system* (3.35), method of application, the *materials* (3.18) which form said *system* (3.35), and demonstration of *system* (3.35) performance

Note 1 to entry: Specific requirements are found in 7.6.

3.45
wet thermal insulation
system (3.35) that provides external corrosion protection and thermal insulation, and that is in direct contact with surrounding seawater

4 Symbols and abbreviated terms

4.1 Symbols

E_{kin}	impact energy (kinetic energy), expressed in joules
g	standard gravity, equivalent to 9,81 metres per seconds squared
H	pendulum height, expressed in metres
m_h	mass of hammer, expressed in kilograms
$Q_{ave,i}$	average value of heat flux transducers signals for sample *i*, where *i* = 1, 2, or 3, expressed in microvolts
Q_{lower}	lower plate heat flux transducer signal, expressed in microvolts
$Q_{Lower,Average}$	average lower plate heat flux transducer signal, expressed in microvolts
$Q_{Ref\ Mat\ ave}$	average value of heat flux transducers signals for reference material sample, expressed in watts per microvolts
$Q_{Ref\ Mat\ ave,i}$	average value of heat flux transducers signals for reference material sample *i*, where *i* = 1 or 2, and 1 is typically the thinner sample, expressed in watts per microvolts
Q_{upper}	upper plate heat flow, expressed in microvolts
$Q_{Upper,Average}$	average upper plate heat flow, expressed in microvolts
S_{Cal}	calibration factor, expressed in watts per microvolts
S_{Cal1}	single-thickness calibration factor, proportional factor between the electrical signal and heat flow, expressed in watts per microvolts
S_{Cal2}	two-thickness calibration factor, proportional factor between the electrical signal and heat flow, expressed in watts per microvolts
$S_{Cal,Lower}$	lower plate calibration factor, expressed in watts per microvolts
$S_{Cal,Upper}$	upper plate calibration factor, expressed in watts per microvolts
$\bar{R}_{ave}$	total average measured thermal resistance across all samples, expressed in metre square degrees kelvin per Watt
$R_{ave,i}$	average measured thermal resistance of sample *i*, where *i* = 1, 2, or 3, expressed in metre square degrees kelvin per Watt
R_{cal}	calibration contact resistance, expressed in metre square degrees kelvin per watt
$2R_{Cal,Lower}$	lower plate calibration contact resistance, expressed in metre square degrees kelvin per watt
$2R_{Cal,Upper}$	upper plate calibration contact resistance, expressed in metre square degrees kelvin per watt

$2R_{sample}$	contact resistance of the sample, expressed in metres square degrees kelvin per watt
ΔT	average temperature difference across the sample(s), expressed in degrees Celsius
T_{lower}	lower plate temperature, expressed in degrees Celsius
T_{upper}	upper plate temperature, expressed in degrees Celsius
$x_{ave,i}$	average measured thickness of sample i, where i = 1, 2, or 3, expressed in metres
$\bar{x}_{ave}$	total average measured thickness across all samples
$x_{Ref\ Mat\ ave}$	average thickness of the reference material sample, expressed in metres
$x_{Ref\ Mat\ ave,i}$	average thickness of reference material sample i, where i = 1 or 2, and 1 is typically the thinner sample, expressed in metres
$\lambda_{Ref\ Mat}$	thermal conductivity of the calibration reference material, expressed in watts per metre kelvin
$\lambda_{sampleA1}$	single thickness sample thermal conductivity, Test Type A1 specimen, expressed in watts per metre kelvin
$\lambda_{sampleA2}$	single thickness sample thermal conductivity, Test Type A2 specimen, expressed in watts per metre kelvin

4.2 Abbreviated terms

APS	application procedure specification
DMA	dynamic mechanical analysis
DSC	differential scanning calorimetry
ID	inner diameter
ITP	inspection and test plan
LVDT	linear variable differential transformer; linear variable displacement transformer; linear variable displacement transducer
OD	outer diameter
SI	International System of units
SST	simulated service test
QC	quality control
UV	ultraviolet