

Published: 2018-12-23

Language: English

Piping and equipment insulation

ICS: 75.180.01, 913.12, 13.220.99, 29.080

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Foreword

NORSOK M-004:2018 was adopted as NORSOK Standard 2018-12-23.

NORSOK M-004:2018 supersedes NORSOK R-004 Rev. 3, August 2006.

NORSOK is an acronym for the competitive position of the Norwegian continental shelf and comprise petroleum industry standards in Norway. The collaboration initiative in 1993 between the authorities and the petroleum industry initiated the development of NORSOK standards.

Reducing the project execution time and developing and operating cost for petroleum installations on the Norwegian shelf was the target.

The intention for the Petroleum industry is to develop and use standards providing good technical and cost-effective solutions to ensure that the petroleum resources are exploited and managed in the best possible way by the industry and the authorities. The industry will actively contribute to the development and use of international standards in the global market.

The NORSOK standards shall:

- bridge the gap based on experiences from the Norwegian continental shelf where the international standards are unsatisfactorily;
- replace oil company specifications where possible;
- be available as references for the authorities' regulations;
- be cost effective; and
- promote the Norwegian sector as an attractive area for investments and activities.

Developing new NORSOK standards and regular maintenance of existing standards shall contribute to maintain the competitiveness both nationally and internationally for the Norwegian petroleum industry.

The NORSOK standards are developed by experts from the Norwegian petroleum industry and approved according to the consensus principles as laid down by the guidelines given in NORSOK A-001 N directive.

The NORSOK standards are owned by the Norwegian Oil and Gas Association, the Federation of Norwegian Industries and the Norwegian Shipowners' Association. They are managed and published by Standards Norway.

Historically, piping and equipment insulation has been under the formal responsibility of NORSOK EG R Mechanical. Due to transfer of responsibility from NORSOK EG R Mechanical to NORSOK EG M Materials, the standard is re-issued as NORSOK M-004:2018, edition 1.

The re-issuance of the standard also reflects a major revision and update of the standard itself. The update is based on industry experience over the last years.

The major changes are listed as follows:

- the standard has been re-structured and rewritten.
 - o Qualification requirements are included in a separate section.
 - o Material requirements are included in a separate section.
 - o Design engineering requirements are included in a separate section.
 - o Installation and inspection requirements are included in a separate section.
- criteria for fire testing has been aligned with requirements in S-001 and best practise in the industry;

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- a sketch showing test piece for site test has been included as Annex C (informative annex);
- material data sheets for insulation materials, incl. GRP cladding, have been established and included as Annex D (normative);
- all references to relevant international standards have been reviewed and changed where convenient. Several changes are made;
- requirements for aerogel insulation materials have been included;
- requirements for polymer-based fire protection have been included;
- temperature definitions applicable for assessing personnel protection, material selection and vapour barrier are added;
- IPT requirements have been deleted;
- in general, selection criteria and selection possibilities are included in tables where convenient, and not as free text;
- reference to “Insulation Handbook” is removed.

Annex A and C are informative. Annex B and D are normative.

Introduction

NORSOK M-004:2018 has been established by a working group nominated by NORSOK EG M (expert group for materials). The working group was represented by insulation suppliers, engineering and fabrication contractors, institutes and operators. The standard has been established based on consensus and covers Norwegian Petroleum industry requirements.

The standard shall be used by the onshore and offshore Norwegian Petroleum industry. The standard specifies good technical and cost-effective solutions.

The standard is relevant for:

- insulation suppliers – providing insulation systems complying with the standard;
- certification bodies, test laboratories – personnel qualifications and insulation system testing and qualifications;
- engineering and fabrication contractors – detail engineering and facilitating of insulation systems;
- operators – purchasing and maintenance of insulation systems.

The standard covers insulation for piping and equipment for the following insulation purposes:

- thermal purposes;
- fire protection;
- acoustic protection;
- personnel protection.

Additionally, the standard covers penetration seals through cellar decks, bulkheads, etc., for fire protection and explosion purposes.

Corrosion under insulation (CUI) is a major challenge for onshore and offshore installations. In all life cycle phases, it is important to have high focus on how to minimize CUI, from design to decommission.

NORSOK M-004 has strong relationship to NORSOK C-002, NORSOK M-001, NORSOK M-501, NORSOK S-001 and NORSOK S-002. Where this standard refers to these standards, this standard shall be read and understood in conjunction with these standards.

The corresponding annexes A and C are informative. Annexes B and D are normative.

Normative text contains the requirements of the standard. Informative text is only guidance to the reader. All text in foreword, introduction and notes is informative text. Note to entries in section 3 and annexes to the document may be either normative or informative.

The bibliography lists standards, norms, laws, regulations and other literature that may be relevant to the use of this document.

Piping and equipment insulation

1 Scope

This NORSOK standard covers the minimum requirements for insulation of pipes, equipment, vessels, tanks, valves, flanges, instrument tubing and penetrations for offshore/onshore installations. This standard covers thermal insulation, personnel protection, fire protection and acoustic protection.

This standard is not intended for subsea installation.

This NORSOK standard does not cover refractory or HVAC (heating, ventilation and air condition) related items.

2 Normative references

The following referenced documents contain text which fully or in part is part of the requirements in the document. For dated references, only the edition cited applies. For undated references, the latest edition of the cited document applies (including amendments).

NORSOK C-002,	<i>Architectural components and equipment</i>
NORSOK M-001,	<i>Material selection</i>
NORSOK M-501,	<i>Surface preparation and protective coating</i>
NORSOK S-001,	<i>Technical Safety</i>
NORSOK S-002,	<i>Working environment</i>
ISO 37,	<i>Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties</i>
ISO 178,	<i>Plastics- Determination of flexural properties</i>
ISO 527,	<i>Plastics- Determination of tensile products</i>
ISO 834,	<i>Fire-resistance tests – Elements of building constructions – (all parts)</i>
ISO 5660-1,	<i>Reaction-to-fire tests – Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)</i>
ISO 8497,	<i>Thermal insulation – Determination of steady-state thermal transmission properties of thermal insulation for circular pipes</i>
ISO 9364,	<i>Continuous hot-dip aluminium/zinc-coated steel sheet of commercial, drawing and structural qualities</i>
ISO 9865,	<i>Textiles – Determination of water repellency of fabrics by the Bundesmann rain shower test</i>
ISO 12944-9,	<i>Paints and vanishes – Corrosion protection of steel structures by protective paint systems – Part 9: Protective paint systems and laboratory performance test methods for offshore and related structures</i>
ISO 15665,	<i>Acoustics – Acoustics insulation for pipes, valves and flanges (including Corrigendum 1)</i>

ISO 20340:2009,	<i>Paints and varnishes – Performance requirements for protective paint system for offshore and related structures</i>
ISO 22899-1,	<i>Determination of the resistance to jet fires of passive fire protection materials – Part 1: General requirements</i>
ISO 80079-36,	<i>Explosive atmospheres – Part 36: Non-electrical equipment for explosive atmospheres – Basic method and requirements</i>
EN 822,	<i>Thermal-insulating products for building applications – Determination of length and width</i>
EN 823,	<i>Thermal-insulating products for building applications – Determination of thickness</i>
EN 1363-2,	<i>Fire resistance test. Alternative and additional procedures</i>
EN 1604,	<i>Thermal-insulating products for building applications – Determination of dimensional stability under specified temperature and humidity conditions</i>
EN 1608,	<i>Thermal-insulating products for building applications – Determination of tensile strength parallel to faces</i>
EN 1609,	<i>Thermal insulating products for building applications – Determination of short-term water absorption by partial immersion</i>
EN 10346,	<i>Continuously hot-dip coated steel flat product for cold forming</i>
EN 12086,	<i>Thermal insulating products for building applications – Determination of water vapour transmission properties.</i>
EN 12667,	<i>Thermal performance of building materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Products of high and medium thermal resistance</i>
EN 12939,	<i>Thermal performance of building materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Thick products of high and medium thermal resistance</i>
EN 13468,	<i>Thermal insulating products for building equipment and industrial installations – Determination of trace quantities of water-soluble chloride, fluoride, silicate, sodium ions and pH</i>
EN 13471:2001,	<i>Thermal insulating products for building equipment and industrial installations – Determination of the coefficient of thermal expansion</i>
EN 13472,	<i>Thermal insulating products for building equipment and industrial installations – Determination of short-term water absorption by partial immersion of preformed pipe insulation</i>
EN 13501-1:2007+A1	<i>Fire classifications of construction products and building elements – Part 1: Classification using data from reaction to fire test</i>
EN 14303,	<i>Thermal insulation products for building equipment and industrial installations – Factory made mineral wool (MW) products – Specification</i>
EN 14304,	<i>Thermal insulation products for building equipment and industrial installations – Factory made flexible elastomeric foam (FEF) products – Specification</i>
EN 14305,	<i>Thermal insulation products for building equipment and industrial installations – Factory made cellular glass (CG) products – Specification</i>
EN 14706,	<i>Thermal insulating products for building equipment and industrial installations – Determination of maximum service temperature</i>
EN 14707,	<i>Thermal insulating products for building equipment and industrial installations – Determination of maximum service temperature for preformed boxes</i>

EN 60332-1-1	Tests on electrical and optical fibre cables under fire conditions – Part 1-1 Tests for vertical flame propagation for a single insulated wire or cable – Apparatus
EN 60332-1-2	Tests on electrical and optical fibre cables under fire conditions – Part 1-2 Tests for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame
EN 60332-1-3	Tests on electrical and optical fibre cables under fire conditions – Part 1-3 Tests for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles
EN ISO 12241,	<i>Thermal insulation for building equipment and industrial installations – Calculation rules</i>
EN ISO 13787,	<i>Thermal insulation products for building equipment and industrial installations – Determination of declared thermal conductivity</i>
ASTM C-201,	<i>Standard Test Method for Thermal Conductivity of Refractories</i>
ASTM C1728,	<i>Standard Specification for Flexible Aerogel Insulation</i>
ASTM-E662,	<i>Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials</i>
DNVGL-CP-0165,	<i>Cable and pipe penetrations</i>
IACS UR S14,	<i>Testing procedures of watertight compartments</i>
IMO 2010	<i>FTP Code Part 1 Non- combustibility test</i>
IMO 2010	<i>FTP Code Part 2 Smoke and toxicity test</i>
IMO 2010	<i>FTP Code Part 3 Test for "A", "B" and "F" Class Divisions</i>
IMO 2010	<i>FTP Code Part 5 Test for surface flammability</i>
NES 713,	<i>Toxicity Test Apparatus</i>

Regulations

Marine Equipment Directive, Directive No. 2014/90/EU

PSA, The Facilities Regulations (Innretningsforskriften)

PSA, Technical and Operational Regulations (Teknisk og operasjonell forskrift for landanlegg)

EC, Regulations No. 1272/2008

3 Terms and definitions

In this document, the following terms and definitions apply.

3.1

shall (requirement)

expression in the content of a document conveying objectively verifiable criteria to be fulfilled and from which no deviation is permitted if compliance with the document is to be claimed

Note 1 to entry: Requirements are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.2 Table 3.

3.2

should (recommendation)

expression in the content of a document conveying a suggested possible choice or course of action deemed to be particularly suitable without necessarily mentioning or excluding others

Note 1 to entry: Recommendations are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.3 Table 4.

Note 2 to entry: In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but it is not prohibited.

3.3

may (permission)

expression in the content of a document conveying consent or liberty (or opportunity) to do something

Note 1 to entry: Permissions are expressed using the verbal forms specified in ISO/IEC Directives Part 2 clause 7.4 Table 5.

3.4

can (possibility and capability)

1: expression in the content of a document conveying expected or conceivable material, physical or causal outcome.

2: expression in the content of a document conveying the ability, fitness, or quality necessary to do or achieve a specified thing

Note 1 to entry: Possibility and capability is expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.5 Table 6.

3.5 temperature definitions

Normal operating temperature: temperature during normal operation, including normal variations.

Maximum operating temperature: maximum temperature including plant operation at unstable condition. Unstable condition includes start-up/ shutdown, control requirements and process upsets.

Ambient temperature; temperature of the air surrounding the product to be insulated. The product might be a pipe, valve, vessel, etc.

In this standard, the following temperature definitions applies:

- personnel protection: **normal operating temperature, T_n** , shall be used for evaluation of the need for personnel protection;
- vapour barrier: **normal operating temperature, T_n** , shall be used for evaluation of the need for vapour barrier.

Material selection: **maximum operating temperature, T_m** , shall be used for insulation and cladding material selection.

3.6

indoor

mechanically ventilated rooms

3.7

Company

operating company, normally a company, ship/rig owner, contractor or subcontractor that is responsible for the facility

3.8**Insulation Class 1: Heat conservation**

The purpose is to reduce heat losses and to maintain temperatures for the efficient operation of the process.

3.9**Insulation Class 2: Cold medium conservation**

The purpose is to maintain low temperature and control heat input to the process.

3.10**Insulation Class 3: Personnel protection**

Protection of personnel from surfaces with temperatures below -10 °C or above 70 °C in normal operating conditions.

3.11**Insulation Class 4: Frost protection**

Insulation to prevent freezing, precipitation and inside condensation.

3.12**Insulation Class 5 and F: Fire protection**

The purpose is to reduce the heat input and secure that the temperature on piping, vessels and equipment is below the specified critical temperature when exposed to the specified fire scenario for the actual area of installation. Class F is used only for protection of pressurized flange connections if adjoining piping or equipment is not insulated, otherwise Class 5 alone shall be used.

3.13**Insulation class 6, 7 and 8; Acoustic insulation**

Acoustic insulation is specified in order to ensure that noise emission from piping, valves, flanges and equipment meets the area noise requirements for the working environment. The definition of the classes of acoustic insulation is as given in ISO 15665, Clause 4. This standard specifies the minimum insertion loss for each class related to the diameter of the pipe on which it is to be applied.

Class 6

Minimum insertion loss shall be in accordance with the definition given in ISO 15665 for class A. Valves and flanges shall be insulated when and as required by Company.

Class 7

Minimum insertion loss shall be in accordance with the definition given in ISO 15665 for class B. Flanges to be insulated. Valves to be insulated when and as required by Company.

Class 8

Minimum insertion loss shall be in accordance with the definition given in ISO 15665 for class C. Valves and flanges shall be insulated.

3.14**Insulation Class 9: External condensation and icing protection**

The purpose is to prevent outside condensation on piping and equipment with normal operating temperatures below ambient.

4 Symbols and abbreviations

For this document, the following symbols and abbreviations apply.

AG	Aerogel
AES	Alkali Earth Silicate
ASTM	American Society for Testing and Materials
CG	Cellular Glass
CL	symbol of the declared level of soluble chlorides
CUI	Corrosion under insulation
c/c	centre/centre
DN	Diameter Nominal
EG M	Expert Group Materials
EG R	Expert Group Mechanical
EVA	Ethylene-Vinyl Acetate
FEF	Flexible Elastomeric Foam
FROSIO	Faglig Råd for Opplæring og Sertifisering av Inspektører innen Overflatebehandling
GRP	Glass fibre Reinforced Polyester
HSE	Health, Safety and Environment
IACS	International Association of Classification Societies (e.g. DNVGL, Lloyds, TÜV)
IMO	International Maritime Organisation
IPS	Insulation Procedure Specification
ISO	International Organization for Standardization
ITP	Inspection and Test Plan
MW	Mineral Wool
OD	Outer Diameter of Cladding
P&ID	Piping & Instrument Diagram
PBFP	Polymer Based Fire Protection
PSA	Petroleum Safety Authority (Petroleumstilsynet – PTIL)
EN	European Standard
QC	Quality Control
ST	Service Temperature
T _n	Normal operating temperature
T _m	Maximum operating temperature
W _{lp}	symbol of the declared level of long-term water absorption
W _p	symbol of the declared level for short-term water absorption
pH	potential of Hydrogen
RH	Relative Humidity

5 Qualification requirements

5.1 Qualification of personnel

5.1.1 Qualification of insulation fitters

All operators shall be qualified. For each work team, minimum 50 % workers shall be qualified to tradesman level. Operators shall be qualified to tradesman level as insulation fitter. The remaining operators shall as minimum be qualified by a theoretical examination and practical site test, as given below. The test scheme shall be subject to Company approval. Company is entitled to be present during the test. Notification shall be sent min five working days in advance. Insulation contractors shall have a list of personnel that have passed the test, and this shall be available for the Company. The site test shall be carried out for each Contract or Project and shall reflect the actual scope of work.

Guidance note: If agreed by Company, the site test can be omitted provided documented relevant site test.

Prior to the theoretical examination test, the unskilled/semi-skilled operators shall have undergone relevant theoretical training, e.g. by class lessons.

The theoretical examination test shall demonstrate relevant knowledge of health and safety hazard, use of protection equipment, insulation materials, application of insulation materials, insulation systems surface requirements, how to avoid corrosion under insulation and prevent ingress of moisture.

The practical test shall be supervised by a qualified supervisor and examined by qualified QC personnel.

The test shall be carried out with project specific insulation classes and materials according to IPS, on relevant parts of the test piece in Annex C.

An examination certificate, with photo identification, shall be issued if the candidate passes the theoretical examination test and the practical test.

The theoretical training, examination and practical test shall be documented. Inspection personnel shall have access to training, examination and practical test procedures.

5.1.2 Qualification of supervisors, foremen and QC personnel

Personnel carrying out inspection or verification shall be qualified FROSIO Inspector level III, within insulation. FROSIO Inspector level II, may carry out the inspection work under the supervision of an inspector level III.

Supervisors and foremen shall be qualified to tradesman level and shall have documented minimum 3 years' experience with insulation work corresponding to work described in this standard.

All QC- and supervision personnel shall be familiar with the requirements in this NORSOK standard.

5.2 Qualification of insulation system

The insulation systems for the following applications shall be tested, documented and when required Type Approved/certified prior to any use:

- Class 5 and F: The selected fire protection system shall be tested and documented as described in Sec. 5.2.1;
- Class 6, 7 and 8: All materials shall be tested, and documented as described in Sec. 5.2.2;