

Piping and equipment insulation

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Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are, as far as possible, intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF) and Federation of Norwegian Manufacturing Industries (TBL).

NORSOK standards are administered and published by Standards Norway.

Annex A is for information only.

Introduction

Revision 3 of this NORSOK standard is updated and partly rewritten based on industry experience over the last years.

NOTE Material standards: Relevant ASTM-standards are acceptable until European Standards (EN) are formally issued .

A new clause is added on piping penetrations and qualification of new products.

Test requirements for acoustic insulation have been updated in accordance with ISO 15665.

Thickness tables for insulation classes have been deleted from revision 3 of this NORSOK standard.

1 Scope

This NORSOK standard covers the minimum requirements for thermal, acoustic, personnel protection, fire protection and pipe penetration insulation of pipe work, equipment, vessels, tanks, valves, flanges etc. for offshore/onshore installations.

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

2 Normative and informative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements and guidelines of the standards referenced below.

2.1 Normative references

BS 5970:2001,	Optical Engineering Council Directive 67/548/EEC, Approximation of the laws, regulations and administrative provision relating to the classification, packaging and labelling of dangerous substances as modified and adapted to the technical progress
DNV Standard for Certification, EN 822,	2.9 Type Approval 8-471.19-1, Thermal insulating products for building applications – Determination of length and width
EN 823,	Thermal insulating products for building applications – Determination of thickness
EN 1604,	Thermal insulating products for building applications – Determination of dimensional stability under specified temperature and humidity conditions
EN 1608,	Thermal insulating products for building applications – Determination of tensile strength parallel to faces
EN 1609,	Thermal insulating products for building applications – Determination of short term water absorption by partial immersion
EN 12667,	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
EN 12939,	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
IACS UR S. 14.2.3,	Hose testing
IMO Resolution A.653 (16),	Recommendations on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials
IMO Resolution MSC 41 (64),	Interim standard for measuring smoke and toxic products of combustion for plastic piping in dry conditions (level 1 and 2)
IMO Resolution A.754 (18),	Recommendation on Fire Resistance Tests for “A”, “B” and “F” Class Divisions
ISO 37,	Rubber, vulcanized or thermoplastic – determination of tensile stress-strain properties
ISO 834,	Fire-resistance tests – Elements of building constructions – (all parts)
ISO 834-1,	Fire-resistance tests – Elements of building construction – Part 1: General requirements
ISO/TR 834-3,	Fire-resistance tests – Elements of building construction – Part: 3: Commentary on test method and test data application
ISO 5660-1,	Reaction-to-fire tests – Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method)
ISO 9364,	Continuous hot-dip aluminium/zinc-coated steel sheet of commercial, drawing and structural qualities ISO 15665, Acoustics - Acoustics insulation for pipes, valves and flanges (including Corrigendum 1) ISO 20340, Paints and varnishes – Performance requirements for protective paint system for offshore and related structures

Marine Equipment Directive, NORSOK S-002, NORSOK M-501, NS-EN 10215:1995,	Skipsutstyrsdirektivet Working Environment Surface Preparation and Protective Coating Continuously hot-dip aluminium-zinc (AZ) coated steel strip and sheet – Technical delivery conditions
NS-EN 12086, NS-EN 1363-1, NS-EN 1363-2, NS-EN ISO 1182, OTI 95634 PTIL "Innretningsforskriften", prEN 14303	Thermal insulating products for building applications Fire resistance tests - Part 1: General requirements Fire resistance tests - Part 2: Alternative and additional procedures Reaction to fire tests for building products - Non-combustibility test Jet Fire Resistance Test of Passive Fire Protection Materials
prEN 14304	Thermal insulation products for building equipment and industrial installations - Factory made mineral wool (MW) products - Specification
prEN 14305	Thermal insulation products for building equipment and industrial installations - Factory made flexible elastomeric foam (FEF) products - Specification
NS-EN ISO 12241	Thermal insulation products for building equipment and industrial installations - Factory made cellular glass (CG) products - Specification
NS-EN 13501-1	Thermal insulation for building equipment and industrial installations - Calculation rules (ISO 12241:1998)
NS-EN ISO 13787	Fire classifications of construction products and building elements-Part 1: Classification using data from reaction to fire test
prEN 14706	Thermal insulating products for building equipment and industrial installations-Determination of declared thermal conductivity
Insulation Handbook,	Thermal insulating products for building equipment and industrial installations-Determination of maximum service temperature Book 2 Sketches. Established by Statoil and Norsk Hydro, latest edition. www.statoil.com/tek/dvm/svg01757.nsf www.hydro.com

2.2 Informative references

None

3 Terms, definitions, abbreviations and insulation classes

For the purposes of this NORSOK standard, the following terms, definitions, abbreviations and insulation classes apply.

3.1 Terms and definitions

3.1.1

can

verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.2

company

operating company

3.1.3

functional specification

document that specifies the requirements expressed by features, characteristics, process conditions, boundaries and exclusions defining the performance of the product, process or service.

3.1.4

may

verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.5

shall

verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.6**should**

verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.1.7**technical specification**

document that prescribes technical requirements to be fulfilled by the product, process or service in order to comply with the functional specification

3.2 Symbols and abbreviations

AES	alkali earth silicate
AISI	American Iron and Steel Institute
ASTM	American Society for Testing and Materials
CG	cellular glass
CL	symbol of the declared level of soluble chlorides
DN	diameter nominal
DNV	Det Norske Veritas
EN	European Standard
FEF	flexible elastomeric foam
HSE	health, safety and environment
IACS	International Association of Classification Societies (e.g. DNV,)
IMO	International Maritime Organisation
IPS	insulation procedure specification
IPT	insulation procedure test
ISO	International Organization for Standardization
NS	Norsk Standard
OTI	Jet Fire Resistance Test of Passive Fire Protection Materials
P&ID	piping & instrument diagram
PTIL	Petroleumstilsynet
prEN	Draft European Standard
QC	quality control
ST	service temperature
WL(P)	symbol of the declared level of long term water absorption by partial immersion
WS	symbol of the declared level for short term water absorption

3.3 Insulation classes**Heat conservation****Class 1**

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

Cold medium conservation**Class 2**

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

Personnel protection**Class 3**

Surfaces with temperatures below -10 °C or above 70 °C and are confined to a distance of not more than 2,1 m vertically and 0,8 m horizontally away from walkways and normal working areas shall be guarded by screens. Insulation shall only be used where guards are not practical and for pipes with temperatures > 150 °C.

Frost protection**Class 4**

Insulation with or without heat tracing, to prevent freezing, solidification and inside condensation.

Fire protection**Class 5**

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. If no fire scenario or critical temperature is specified, the fire protection shall limit the temperature to 400 °C in a hydrocarbon fire situation lasting for 30 min according to ISO 834 (all parts).

Selected fire protection shall be documented based on relevant fire testing.

Acoustic insulation**Class 6, class 7 and class 8**

Acoustic insulation is specified in order to ensure that noise emission from piping and valves meets the area noise requirements for the working environment as given in NORSOK S-002. Based on documented insertion loss, each project may select the applicable class and select materials or combinations of materials to cover the required insertion loss at actual frequencies. This selection shall not conflict with any other requirement of this NORSOK standard, and company shall approve each combination.

The definition of the classes of acoustic insulation is as given in Clause 4 of ISO 15665. The 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 is to 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 is to 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 is to be in accordance with the definition given in ISO 15665 for class C. Valves and flanges shall be insulated.

External condensation and icing protection**Class 9**

The purpose is to prevent outside condensation on piping and equipment with operation temperatures below 20 °C.

4 General requirements

4.1 Introduction

General requirements for all insulation classes and details are given in this clause.

Surface preparation prior to insulation on piping, equipment, vessels, tanks, valves, flanges, pipe penetration, instrument tubing etc. to be according to NORSOK M-501.

All materials, or combination of materials and thicknesses, for insulation class 5, class 6, class 7 and class 8 shall be subject to relevant testing prior to use, see 7.6 and 10.1.

The insulation thickness shall be calculated in accordance with NS-EN ISO 12214, and based upon project requirements for heat loss, energy input etc.

Qualification procedure is stated in 10.3.1. IPS shall be taken into consideration in design phase.

Alternative insulation may be used if the proposed materials and methods satisfy the functional requirements in this NORSOK standard, see Clause 13. Approval by company is required.

Technical specifications and HSE data sheets for all materials shall be in Norwegian.

4.2 General design

Piping and equipment shall be insulated according to the insulation classes, operating temperature and insulation thickness defined in the P&ID, data sheets and IPS.

All insulation shall be covered with weather protection designed and installed to prevent ingress of water during normal operation throughout the project design life.

Insulation adjacent to flanges in piping and equipment shall be terminated to allow removal of bolts without damage to insulation. Minimum free space from the flange to the nearest part of the insulation shall be equal to the bolt length +25 mm. The termination of the weather protection shall be waterproof.

All design shall allow for necessary room for insulation and insulation jackets and preformed boxes, and minimum twice of required insulation thickness shall be incorporated for future variations and installations. This is, however, not relevant for penetrations.

Insulation systems shall be non-toxic and watertight.

When a rigid type of insulation is used, provision shall be made for longitudinal expansion and contraction.

4.3 Vessel insulation

Insulation of all vessels shall be supported on rings with a distance of 900 mm c/c installed on the vessel. Rings shall also be provided around nozzles above DN 200 mm. The rings shall be fastened to the vessel by lugs, welded to the vessel, see Insulation Handbook. The vessel supplier shall weld the lugs to the vessel.

Block insulation of CG shall be fastened with mechanically tightened metal bands and with bonding adhesive.

Insulation on vessel heads shall be fastened with bands spaced not more than 300 mm c/c. The bands shall be fixed to the fixing ring installed on the vessel.

Vessels of diameter 1 500 mm and smaller shall be insulated as piping.

4.4 Removable insulation of flanges and valves

Removable insulation for flanges and valves, like tailor made jackets or pre formed insulation boxes, shall be suitable for quick removal and reinstallation.

The cover shall be weather tight according to IACS UR S 14.2.3.

Tailor made jackets shall fit the actual valve/flange/equipment and secure minimum 100 mm overlap to incoming insulated pipe.

In the choice to use jackets or boxes close attention is to be paid to such as the geometry of the equipment, weather condition, mechanical impact, high pressure washing, use of chemicals, flare, available space and size etc.

Jackets shall have a design that allows frequent removal and reinstallation without taking damage. Insulation boxes for valves and flanges etc. in vertical lines shall have weather design on the upper part to avoid water ingress, see 9.1.23 in the Insulation Handbook.

Tailor made jackets shall not be used for class 2, class 3, and class 9, and valves and flanges above DN 400 and in weather exposed areas.

For valves above DN 900 in all classes except class 2 and class 9, insulation houses with inspection hatches and doors shall be used.

4.4.1 Surface material for jackets and boxes

Jacket surface material shall prevent water being absorbed by the insulation material. The material shall be suitable for use against design temperatures, and shall have an adequate wear resistance to withstand frequent handling and normal tear and wear. It shall be tested for flame spread according to IMO Resolution A.653 (16) equal to self-extinguishing properties and for smoke and toxic gases according to IMO Resolution MSC 41 (64).

In applications with temperatures above +230 °C materials suitable for the relevant temperatures shall be used.

Preformed insulation boxes, which shall be frequently removed for inspection or maintenance purposes, shall be provided with an inspection hatch with toggle latches and gasket between the hatch and the jacketing. The insulation shall be easily removable under the hatch. Inspection hatches shall be located where required by company and shall be indicated on the fabrication isometric.

Seams of jackets shall be watertight according to IACS UR S 14.2.3.

Preformed insulation boxes shall be made of stainless steel, AISI 316, or aluminium, AlMnI (AA 3103,) or equal. For class 5, stainless steel shall be used.

Jacketing for flanges and valves shall be formed such that it sheds water.
The materials used shall have documented resistance to deterioration by the applicable media.

4.4.2 Insulation materials for jackets and preformed boxes

Precautions shall be implemented in the design and fabrication of the insulation jackets and pre formed boxes to prevent the insulation material from sagging causing reduction of the insulation properties.

The insulation material shall not be combustible according to NS-EN ISO 1182.
Mineral wool or AES wool shall be totally wrapped in laminated alu-foil when used in insulation boxes.

4.4.3 Drainage

Tailor made jackets and preformed boxes shall be provided with drainage at its lowest point.
No drainage in boxes for class 2 and class 9. The drainage in class 5 shall be of certified/approved type.

4.4.4 Locking mechanism

The locking mechanism of the tailor made jackets shall be of the flap fastener type, minimum width 50 mm. Minimum width of overlap shall be 100 mm for jackets applied on valves/flanges larger than DN 80, and 50 mm for jackets applied on valves/flanges DN 80 and smaller.

Jackets for thermal-/acoustic insulation may be fastened to the pipe with nylon straps or equal, except in escape route areas where stainless steel bands shall be used.

For preformed boxes, adjustable excenter locks shall be used as locking mechanism, minimum size safe working load 900 N.

4.4.5 Accessories

All metal accessories shall be of stainless steel (AISI 316), except grommets for reinforced drain holes in tailor made jackets, which may be of brass.

4.4.6 Identification

Each removable part of an insulation cover shall be provided with an identification plate with the following information:

- vendor name;
- line number;
- tag number when relevant;
- cover number;
- design requirement (insulation class, fire requirements etc.).

The identification number system shall be easily read prior to and after installation.

The vendor shall identify each cover on drawings and store this information as retain documentation.
The identification plate shall be made of a material resistant to water and applicable medias.

4.5 Insulation of instrument and instrument tubing

For insulation of instruments, insulated cabinets with hinged doors shall be used. Instrument tubing (DN 10 mm to DN 32 mm) shall be insulated with FEF with factory-applied non-metallic jacketing for temperatures up to 100 °C. The non-metallic jacketing shall be in accordance with 5.9. Tubing sizes above 32 mm shall be insulated as piping.

For temperatures between 100 °C to 180 °C, mineral wool installed on distance holders and metallic or non-metallic jacketing shall be used. Above 180 °C, mineral wool and metallic jacketing can be used.

Surface temperature on heat tracing cables is to be checked prior to deciding material types for insulation of instrument tubing.

The FEF shall comply with prEN 14304 (see 5.4).

Fire protection of instrument tubing, see 7.5.

Surface protection of tubing shall be in accordance with NORSOK M-501.

4.6 Piping insulation

Insulation on long vertical pipe runs shall be supported with rings spaced on 3 600 mm maximum centres installed on the piping. Width of rings shall be half the thickness of the insulation material. On cold piping, insulation covering on rings shall be minimum 30 mm.

The rings shall be fastened to the piping as described in the Insulation Handbook.

4.7 Metallic jacketing

Longitudinal seams of metal jackets on horizontal or sloping pipelines shall be located maximum 60 degrees away from the lowest point of the circumference.

All seams on metallic jacketing shall be provided with a sealant in between the overlap.

Jacketing shall, as a general rule, be terminated with a fold and gasket to prevent water ingress. The termination shall be secured with bands. For removable insulation, the terminations shall be secured with toggle latches or band with toggle latches.

Metallic jacketing shall be built with a slope on top of vertical vessels.

Removable insulation covers shall be provided for removable vessels heads.

Sharp edges are not allowed.

The bottom heads of skirt-supported vessels may be covered with flat metallic jacketing.

For terminations where there are no risk of water ingress, e.g. on the underside of vertical installed valve/flange boxes, terminations without fold and gaskets is acceptable.

4.8 Non-metallic jacketing

For pipe insulation a non-metallic weather protection may be used instead of metallic jacketing for all classes except class 5. The non-metallic weather protection shall fulfil the material requirements in 5.9 and be verified with tests. Use of combustible non-metallic jacketing in enclosed areas shall be subject of approval in writing with regard to HSE aspects by company.

Application of non-metallic jacketing shall be done in accordance with vendor's recommendations and relevant part of the Insulation Handbook. Terminations against piping with a temperature above the maximum design temperature for the non-metallic jacketing shall be metallic jacketing with sufficient length to avoid overheating of the non-metallic jacketing.

It is recommended to apply aluminium foil between cellular glasses and non-metallic jacketing.

4.9 Heat tracing

Heat traced piping, flanges, valves and equipment shall be wrapped with minimum 0,045 mm aluminium foil prior to insulation to protect the heating cables and improve the heat distribution.

Where heating cables penetrate the jacketing, edge protection shall be provided to prevent damage to the cable. A permanent sealer shall be applied in order to prevent ingress of water.

4.10 Drains

For all insulation systems and insulation classes for piping and equipment (except for class 2, class 4^{*)} and class 9) there shall be minimum 10 mm diameter drain holes in all low points, and a minimum of one hole every 3 m on horizontal runs. Drain holes shall penetrate the whole insulation system. Necessary precaution shall be taken to avoid damage to the surface protection on the piping.

^{*)} Class 4 only on operating temperatures below ambient (20 °C).

Drains for class 5 shall be fire tested.

5 Materials

5.1 General

Insulation materials for classe 1, class 2, class 3, class 4 and class 9, shall consist of cellular glass up to normal operating temperature 180 °C. For class 3, insulation shall only be used where guards are not practical and with normal operating temperatures > 150 °C. Materials for class 5, class 6, class 7 and class 8 shall be cellular glass in combination with mineral wool or AES wool in accordance with Council Directive 67/548/EEC.

All insulation materials shall have a neutral pH value.

The materials shall not release toxic (see IMO Resolution MSC. 41 (64)) or corrosive gases when exposed to fire. No asbestos or asbestos products shall be used. No lead or lead products shall be used unless accepted by company.

In dry rooms with no sprinkler/deluge system, mineral wool may be used on pipes/vessels with a normal operating temperature above +40 °C. Indoor areas with regular water cleaning or testing of seawater deluge system are not considered dry.

For steam and exhaust pipe, mineral wool may be used with stainless steel jacketing. Mineral wool shall not be applied on stainless steel materials like AISI 316, duplex, 6Mo etc.

5.2 Cellular glass (CG)

CG shall conform to prEN 14305, with reaction to fire classification A1. In addition to requirements for all applications (see prEN14305, 4.2), properties specified in Table 1 for specific applications and other properties, if relevant, shall be declared:

Table 1 – Properties for applications

prEN 14305	Property	Requirement
4.3.2	Maximum ST (+)	Shall always be declared
4.3.3	Minimum ST (-)	Shall always be declared
4.3.4	Compressive strength	Shall always be declared
4.3.9	Water absorption	WL(P) and WS
4.3.10	Water vapour transmission/resistance	$\mu \geq 40\ 000$
4.3.11	Trace quantities of water soluble ions and the pH-value	CL: To be declared pH: neutral
D.5	Coefficient of thermal expansion	Shall always be declared

Declared thermal conductivity shall be equal to or better than given in Table 2 and Table 3:

Table 2 - CG pipe sections/bevelled lags for cold service

Thermal conductivity, λ_D								
Mean temp. °C	-170	-150	-100	-80	-50	-20	0	20
λ_D - W/Mk	0,018	0,020	0,025	0,027	0,032	0,034	0,040	0,042

Minimum thickness up to DN150 (6 in) shall be 30mm, above DN150, t 40mm.

Table 3 - CG pipe sections/bevelled lags for hot service

Thermal conductivity, λ_D					
Mean temp. °C	20	50	100	150	200
λ_D - W/mK	0,042	0,048	0,058	0,069	0,081

5.2.1 Bonding adhesive

For normal operating temperatures up to 140 °C adhesive shall be used for bonding of block insulation to vessels. When the adhesive cures it shall constitute a flexible bond that absorbs mechanical and thermal stress.

Bonding adhesive shall not be used above normal operating temperature of 140 °C.

5.2.2 Factory applied anti-abrasive coating

Anti-abrasive coating shall be used to prevent damage to cellular glass and painting. The anti-abrasive coating shall be completely dry before the insulation material is mounted.

The anti-abrasive coating shall be suitable for application at service temperatures.

The high temperature (120 °C to 180 °C) anti-abrasive coating shall be of high strength gypsum cement with inert mineral fillers applied on the inner surface of the insulation sections. When dry, the cement shall form a hard surface protection against abrasion.

The low temperature (<120 °C) anti-abrasive coating shall be a one-component acrylic based coating.

Amount of wet applied anti-abrasive coating shall be 0,75 kg/m².

5.3 Mineral wool

Mineral wool shall conform to prEN 14303, with reaction to fire classification A1. Properties specified in Table 4 shall be declared:

Table 4 - Properties

prEN14303	Property	Requirement
	Maximum ST (+)	Shall always be declared
4.3.2		
4.3.4	Water absorption, W _p	WS < 1,0 kg/m ²
4.3.6	Trace quantities of water soluble ions and the pH-value	CL: To be declared pH: neutral
C.3	Airflow resistivity	To be declared if necessary

Declared thermal conductivity shall be equal to or better than given in Table 5 and Table 6:

Table 5 - Mineral wool pipe sections/slabs/pipe section mats/bevelled lags

Thermal conductivity, λ _D									
Mean temp. °C	0	50	100	150	200	250	300	350	
λ - W/mK	0,033	0,038	0,044	0,051	0,061	0,073	0,087	0,103	

Table 6 - Mineral wool wired¹⁾ mats

Thermal conductivity, λ _D									
Mean temp. °C	50	100	150	200	250	300	350	400	
λ - W/mK	0,039	0,044	0,051	0,060	0,070	0,081	0,096	0,113	

¹⁾ Type of wire netting shall be stainless steel.

5.4 Flexible elastomeric foam (FEF)

FEF shall conform to prEN 14304.

Properties specified in Table 7 shall be declared:

Table 7 - Properties

prEN14304	Property	Requirement
4.3.2	Maximum ST (+)	Shall always be declared
4.3.3	Minimum ST (-)	Shall always be declared
4.3.4	Water absorption	WS
4.3.5	Water vapour transmission/resistance	$\mu \geq 7000$
4.3.6	Trace quantities of water soluble ions and the pH-value	CL: To be declared pH: neutral

Declared thermal conductivity shall be equal to or better than given in Table 8:

Table 8 - FEF tubes and sheets for cold and hot service

Thermal conductivity λ_D									
Mean temp. °C	-50	-30	-20	0	10	20	40	70	85
$\lambda - W/mK$	0,031	0,033	0,034	0,036	0,037	0,038	0,040	0,043	0,045

5.5 Alkali earth silicate (AES)

Properties specified in Table 9 shall be declared.

Table 9 - Properties

Property	Requirement	Test method
Length	Always declare nom. incl. tolerance	EN 822
Width	Always declare nom. incl. tolerance	EN 822
Thickness	Always declare nom. incl. tolerance	EN 823
Dimensional stability	Rel. dimensional changes < 1 %	EN 1604
Reaction to fire	Always declared	NS-EN 13501-1
Maximum ST (+)	Always to be declared	prEN 14706
Thermal conductivity, λ_D	Determined and verified in accordance with to NS-EN ISO 13787	EN 12667 or EN 12939
Tensile strength parallel to faces (handling property)	$\geq 2 \times$ weight of product	EN 1608
Water absorption	WS: to be declared	EN 1609
Trace quantities of water soluble ions and the pH-value	CL: To be declared pH: neutral	

Declared thermal conductivity shall be equal to or better than given in Table 10.

Table 10 - AES blankets/mats

Thermal conductivity, λ_D									
Mean temp. °C				200	250	300	400	500	600
$\lambda - W/mK$				0,06	0,07	0,08	0,10	0,13	0,16

5.6 Metallic foils and vapour barrier

Metallic foils used in connection with heat tracing shall be in accordance with 4.9.

Metallic foils, when used as vapour barrier shall be a strong, self-adhesive reinforced aluminium foil with total film thickness of minimum 0,045 mm.

5.7 Sealers and sealing tape

Joint sealers and sealing tape shall be permanently flexible through a relevant temperature range and shall be capable of withstanding repeated expansion and contraction.

5.8 Metallic jacketing

Metallic jacketing shall be stainless steel or sea water resistant aluminium-alloy. For fire protection the jacketing material shall be stainless steel.

Alu-zinc may be used as jacketing material for onshore projects providing company approval.

5.8.1 Stainless steel

Stainless steel metal jacketing shall be type AISI 316, 2B finish.

Stainless steel sheets for pipes and vessels up to DN 450 shall have a minimum thickness of 0,5 mm. For dimensions above DN 450 the minimum thickness shall be 0,7 mm.

5.8.2 Aluminium alloy

Aluminium alloy jacketing shall be type A1Mn1 (AA 3103) or equal.

Aluminium sheets for pipes and vessels up to DN 450 shall have a minimum thickness of 0,7 mm. For dimensions above DN 450, the minimum thickness shall be 1,0 mm.

5.8.3 Aluzinc

Aluzinc is to be evaluated on onshore project only.

Aluzinc jacketing shall be type hot dip coated steel with an alloy of zinc and aluminium to ISO 9364 or NS-EN 10215. Coating weight shall be 185 g/m².

Aluzinc sheets for pipes up to DN 300 shall have a minimum thickness of 0,6 mm. For dimensions above DN 300 the minimum thickness shall be 0,8 mm. Aluzinc sheets for vessels shall have a minimum thickness of 1,0 mm.

5.9 Non-metallic jacketing

Types of non-metallic weather jacketing shall be subject to company approval.

Requirements in Table 11, shall be fulfilled for non-metallic jacketing:

Table 11 - Requirements for non-metallic jacketing

Property	Test method	Requirement
Heat release	ISO 5660-1	Results to be given
Flame spread/Surface flammability	IMO Resolution A.653 (16)	Self extinguishing when exposed to 5 kW/m ²
Smoke and toxicity	IMO Resolution MSC 41 (64)	Smoke D _m = .1 Toxic fumes within limits specified in IMO Res MSC 41 (64)
Aging	ISO 20340 (4200 h)	Less than 70 % loss of lustre. The material shall maintain 90 % of its strength/elongation properties after the ageing test.
Tensile strength	ISO 37	≥ 6,9 MPa
Elongation at break	ISO 37	≥ 10 %
Water vapour transmission	NS-EN 12086	Min.μ: 50 000
Decomposition		The material shall not decompose at temperatures from -20 °C to 70 °C .

Based on tests results from fire characteristics the material can be subject to application restrictions. Any possible shrinkage or temperature unsuitability of the non-metallic jacketing shall be documented. The non-metallic jacketing shall be suitable for application at RH up to 90 % and down to +5 °C.

For factory applied non-metallic jacketing used on FEF on instrument tubing (see 4.5), the tensile strength shall be minimum 4 MPa, tear strength shall be minimum 5 N/mm² and elongation at break shall be minimum 150 %.

5.10 Perforated guards

Stainless steel perforated metal jacketing shall be of type AISI SS316, 2B finish, minimum 0,9 mm thickness, 5 mm hole diameter and 8 mm hole pitch.

Distance holders shall be made of polytetrafluoroethylene and may be used on pipes up to 101,6 mm (4 in). Minimum numbers of distance holders shall be three per circumferencial location. For larger dimensions, corrugated stainless steel metal jacketing shall be used.

Distance holders shall be installed with c/c maximum 300 mm.

5.11 Accessories

Vendor is to specify in IPS standard (material, dimension, type) regarding accessories such as rivets, adjustable excenter locks, bands, wires, clips, and breather springs etc.

All accessories shall be in AISI 316 materials.

Adjustable and lockable excenter locks shall have safe working load of minimum 900 N, and fastened with minimum two pop rivets.

Stainless steel wire for securing of insulation shall be 1 mm thick.

Steel banding and locking clips:

Equipment	Band width x thickness mm	Clips length x width x thickness mm
Piping and machinery	12 x 0,4	20 x 13 x 0,7
Vessels	19 x 0,4	20 x 20 x 0,7

6 Installation

The Insulation Handbook shall be used to secure a uniform and acceptable design of the insulation work.

Insulation contractor shall establish an IPS containing the parts of the Insulation Handbook, which are relevant for the project. Any deviation or addition to the Insulation Handbook shall be listed and included in this document. The document shall be subject to company approval in due time before commencement of the insulation work.

6.1 General

All insulation materials shall be stored in dry areas and all insulation work shall be performed in dry conditions.

The insulation materials and the external jacketing shall be installed in such a way that water does not enter the insulation material or between the insulation and the pipe/equipment surface during design life.

Surfaces to be insulated shall be clean and dry. The application of the insulation shall not be started before the mechanical completion certificate for coating has been issued. Surfaces to be insulated shall be treated in accordance with NORSOK M-501.

Discontinued insulation work shall be properly covered to avoid damage and keep the insulation clean and dry.

All insulation shall be installed with tightly fitted and staggered joints. Voids within the insulation are not acceptable.

If insulation work precedes testing of pipe work, welds and joints shall be left un-insulated to allow inspection during testing.

Insulation on valves shall leave the packing gland accessible, except for class 5 were company will specify the need for protection. Special attention shall be given for valves on cold systems.

To secure cellular glass pre-formed sections in place, adhesive glass fibre reinforced tape or stainless steel banding shall be used. Wire shall not be used.

Insulation shall be installed in such a way to make easily inspection, i.e. typical inspection points (tag plates, welds on doubling plates on vessels etc.).

6.2 Metallic jacketing

The crimps on jacketing shall have the following minimum dimensions depending on outside diameter (including insulation):

Up to 300 mm:	10 mm	5,0 mm radius
Between 300 mm and 600 mm:	13 mm	6,5 mm radius
Above 600 mm:	16 mm	8,0 mm radius

All jacketing seams shall be installed by "roof tile" principle and the application of joint sealer shall be inside the jacketing.

In cases where pop rivets are used, the rivet holes shall be predrilled prior to installation of jacketing. If pre-drilling is impossible, the length of the drilling bit shall not exceed 6 mm.

Metallic jacketing for vessel insulation shall be edge crimped and overlapped 75 mm on longitudinal and circumferential seams. For hot insulation with operating temperature above 180 °C, the overlap shall be 100 mm. Vessel jacketing shall be provided with bands on all overlap seams and support rings (400 mm c/c).

Head covers on vessels shall overlap shell covers by 100 mm.

On vessel jackets, breather springs shall be used on bands if required for expansion.

On vertical vessels and piping, "S" clips shall be used to keep the jacket sheets from sliding. Minimum four clips per seam.

Metallic jacketing shall be fastened with stainless steel bands. Only for difficult details such as bends, T-pieces etc. pop rivets (or equivalent) may be used.

Metallic jacketing for pipes and fittings shall be roller formed and edge crimped at longitudinal seams. Circumferential seams shall be crimped 50 mm from the edge wherever possible. Circumferential seams shall be overlapped minimum 50 mm longitudinal seams for outside diameters up to 150 mm shall be overlapped 30 mm and 50 mm above.

7 Hot service, fire protection and acoustic insulation

All material, or combination of materials, for insulation class 5, class 6, class 7 and class 8 shall be subject to relevant testing prior to use.

7.1 General

This clause describes the requirements for the following insulation classes:

Class 1:	Heat conservation
Class 3:	Personnel protection

Class 5: Fire protection
Class 6, class 7 and class 8: Acoustic insulation

7.2 Design

For heat conservation class 1, except for steam services or when otherwise specified, the following shall not be insulated:

- vessel man-way covers, nozzles and flanges;
- exchanger nozzles and flanges;
- valves and piping flanges;
- control valves, line valves and fittings, which are to be removed periodically;
- expansion and rotation joint, slide valves and similar equipment;
- steam traps.

7.3 Installation

The following requirements apply in addition to those in Clause 6.

7.3.1 Block insulation for vessels (cellular glass)

Insulation for vessel heads shall be curved blocks or standard flat blocks cut to fit.

For single layer and outer layer of multi layer insulation, banding shall be placed approximately 30 mm on each side of all butt joints with intermediate bands at a maximum of 300 mm centres. The inside layer of multi layer installations shall be banded at a maximum 450 mm centres.

7.3.2 Blanket insulation on vessels (AES wool/mineral wool)

Blanket insulation shall be applied as follows:

The last piece of insulation in each layer shall have a snug fit to make all joints tight. Contraction joints are not required for resilient insulation materials.

The edges of wired blankets shall be tied together with stainless steel wire.

7.3.3 Prefabricated pipe section insulation (cellular glass/mineral wool)

Prefabricated insulation shall be applied as follows:

Insulation pipe sections shall be tightly butted together and secured to pipe with glass fibre reinforced tape or stainless steel bands. For cellular glass joint sealer shall be used for temperatures up to +100 °C.

For multi layer systems of cellular glass only the outer layer shall have joint sealer.

Insulation shall be secured with bands over the outer layer at each side of radial joints and at the centre of each section.

Spacing of bands for the inner layer of multi layer insulation need only be sufficient to hold sections in place until the outer layer is secured.

To cover elbows and other irregular surfaces, sections may be cut and fitted in the field.

The calculated thickness may be adjusted up to the closest standard thickness given by the manufacturer.

7.3.4 Blanket insulation for piping (mineral wool/AES wool)

Blanket insulation shall be used for dimensions where pipe sections are not available.

Insulation joints shall be butted firmly together and secured with stainless steel wire or bands.

Insulation shall be secured with bands over the outer layer at each side of radial joints and at the centre of each section.

Fittings and flanges shall be insulated with blankets. Insulation shall be secured by wire or band.

Heat conservation and personnel protection with temperature > 180 °C mineral wool is to be used.

Necessary insulation thickness to be calculated in accordance to NS-EN ISO 12241 based on maximum temperatures and other process and safety requirements.

The calculated thicknesses may be adjusted up to the closest standard thickness given by the manufacturer. Double layer application shall generally be required for temperatures in excess of 400 °C for heat conservation, heat control etc, and in excess of 450 °C for personnel protection.

7.4 Steam service and exhaust lines

Steam Service and Exhaust lines will normally have an operating temperature enabling wet insulation to dry out. In such cases mineral wool may be used if accepted by company.

7.5 Class 5 Fire protecting

The purpose is to reduce the heat input and limit the temperature to an acceptable level on piping, vessels and equipment in a specified fire scenario or a hydrocarbon fire situation lasting for 30 min according to ISO 834 (all parts).

Required insulation thickness, and combination of insulating materials, shall be calculated based on relevant fire testing, and the following shall be taken into consideration:

- extrapolations of test results are not acceptable. New systems or combination of materials shall be subject to relevant fire tests prior to acceptance;
- type and duration of fire and explosion scenarios;
- properties of pipe work and vessel material (critical temperatures in piping materials);
- content of pipe work and vessel (critical temperature, operating temperature);
- depressurisation time for the exposed system;
- properties of the insulating material;
- only metallic jacketing shall be used on class 5, except on valves and flanges where removable jackets may be used.

If the fire scenario includes different exposures (e.g. Jet-fire and hydrocarbon-fire) the most stringent fire conditions shall be used for selecting/calculating the fire protection solution.

Selected fire protecting system (including any removable jackets or boxes) shall be tested and properly documented in accordance with one or more of the following test standards:

ISO 834	Fire resistance tests – Element of building constructions – (all parts)
IMO Resolution A.754(18)	Recommendation on Fire Resistance Tests for “A”, “B” and “F” Class Divisions.
OTI 95634	Jet Fire Resistance Test of Passive Fire Protection Materials

7.6 Guidelines for acoustic insulation

Pipe insulation within acoustic insulation classes, can be met by various combinations of insulation material and jacketing systems. Within the same installation one should try to limit the number of pipe insulation systems by choosing alternative that provide combinations of sufficient personnel protection, heat insulation, cold medium conservation, fire protection and noise insulation when and as required.

Valves and flanges shall be insulated where specified.

Guidelines for the choice of various layers of pipe insulation materials are given in Annex A.

All systems shall be tested and the insertion loss documented in accordance with the measurement procedure outlined in ISO 15665, Clause 10.

All materials shall also be tested and approved in the actual combination.

Existing system, which are tested in according with revision 2 of this NORSOK standard, are accepted.

The following applies to the materials:

- cellular glass as inner layer shall always be used for corrosion protection at operating temperature up to 180 °C;
- additional layers shall be mineral wool or AES wool;
- heavy synthetic sheets shall be $> 6 \text{ kg/m}^2$.

8 Cold service insulation

8.1 General

All insulation systems with operating temperatures below ambient (below 20 °C/BS 5970:2001, chapter 4.1.3), shall be insulated as cold service insulation.

This clause describes the requirements for the following insulation classes:

- Class 2: Cold medium conservation
- Class 4: Frost protecting ^{*)}
- Class 9: External condensation and icing protection

^{*)} For operating temperature above ambient (20 °C) vapour barrier shall not be used.

All cold insulation shall be provided with vapour barrier and shall have jacketing details as for class 2 insulation. Metallic foil joint overlaps shall be minimum 50 mm. It is of vital importance that the vapour barrier is smoothly and firmly applied to the insulation such that it forms a fully airtight layer.

On items with a complicated shape or narrow areas with poor access, etc., where a proper application of the aluminium foil cannot be obtained, a layer of mastic shall be applied on the outside of the insulation to ensure tightness of the vapour barrier. The mastic shall overlap the aluminium foil by at least 50 mm. Type of mastic shall be specified in IPS.

If pop-rivets or screws are used for fixation of jacketing, a 25 mm thick layer of mineral wool shall be applied outside the vapour barrier. The maximum length of pop rivets and screws shall be maximum 10 mm.

In cases where class 2 and class 9 is combined with insulation classes with an outer layer of AES of minimum 25 mm thickness, an additional layer of mineral wool is not required.

8.2 Vessel insulation

Where required, manholes shall be provided with removable covers of the same insulation thickness as the shell insulation. Covers shall be secured to the shell insulation and sealed to provide vapour tight joints.

8.3 Piping insulation

Valves, fittings and flanges shall be insulated with preformed pipe insulation. Sections shall be cut from standard blocks, fitted and secured with glass fibre reinforced tape or stainless steel bands.

In order to avoid frost formation or condensation on pipe supports, insulated prefabricated pipe supports shall be used.

8.4 Installation

The following requirements apply in addition to those in Clause 6:

- a smooth outer insulation surface must be obtained to provide an effective vapour seal;
- the outer layer vapour barrier used to seal all cold insulation prior to metal cladding shall be a laminated aluminium foil of minimum 45 μ . An additional layer of 25 mm mineral wool for protection of the vapour barrier shall be applied before installation of the metal jacketing;
- joint overlaps shall be minimum 50 mm. It is of vital importance that the vapour barrier is smoothly and firmly applied to the insulation such that it forms a fully airtight layer.

8.4.1 Block insulation for vessels

Joint sealer shall be applied on all block edges and in accordance with the manufacturer's recommendations.

Termination of insulation on all layers, including contact surfaces where removable insulation covers are installed, shall be vapour sealed.

Class 2, cold medium conservation insulation and insulation on other systems with operating temperatures below 20 °C (see BS 5970:2001, 4.1.3) shall be provided with a vapour barrier outside the outer layer of the cellular glass insulation.

8.4.2 Piping insulation

Prefabricated insulation of cellular glass shall be applied as follows:

- all joints of single layer and outer layer of multi layer insulation shall be applied with butt edges smeared with joint sealer before installation;
- anti-abrasive compound shall be applied to the inner bore and allowed to dry before application. Anti-abrasive compound, when required, shall be factory applied;
- bands or glass fibre reinforced tape shall be used to secure each layer of insulation, including the outer layer. Bands or tape shall be installed on 275 mm c/c, and at least 25 mm back from butt joints. Wire shall not be used;
- prefabricated flange and fitting covers shall be applied in the same manner as pipe insulation, except that non-removable joints shall be cemented with adhesive.

8.4.3 Valves and flanges

Due to the various shapes and design of valves and flanges, special attention shall be drawn towards the performance of the insulation work. The build-up of insulation shall be identical to the insulation on straight pipes. Where a perfect fit between the cellular glass insulation and the valve is not possible, the void shall be filled with mineral wool. All cut outs shall be properly sealed and completely airtight.

Insulation boxes shall have a neck a round pipe and fasten to box and secured around the pipe with band. Sharp edges are not accepted.

9 Combination of insulation classes

9.1 General

The guidelines below are given for insulation systems in cases where insulation shall serve more than one purpose.

Two digits in the line number on the P&ID will indicate the insulation class, and the insulation symbol will show insulation material and thickness.

Insulation class 1 will be shown as "01" etc. Insulation systems with combination of class 1 and class 5 shall be identified with the two digits "15" in the line number.

For combination classes containing acoustic insulation, flanges and valves are normally not insulated for class 6 and valves for class 7. Deviations to this shall be indicated on the P&IDs. Class 8 shall always be provided with insulation on flanges and valves.

Class 5 shall always be the outermost layer when combined with other classes.

9.2 Fire protecting (class 5) combined with heat conservation (class 1) and or acoustic insulation (class 6, class 7 and class 8)

Use class 5 fire proofing and relevant class for acoustic insulation builds up. Select the thickness from the insulation class with the greatest thickness. Stainless steel jacketing shall be used.

9.3 Acoustic insulation (class 6, class 7 and class 8) combined with heat conservation (class 1) or personnel protection (class 3)

Use acoustic insulation build up. Select the thickness from the insulation class with the greatest thickness.

9.4 Fire protecting (class 5) combined with cold service insulation (class 2, class 4 and class 9)

The following requirements apply:

- use cellular glass for the cold service and add a layer with the required thickness of accepted fire protection material. Stainless steel jacketing shall be used;
- a vapour barrier shall be applied outside the cellular glass layer, see 4.3.10 and 6.3.

9.5 Acoustic insulation (class 6, class 7 and class 8) combined with cold service insulation (class 2, class 4 and class 9)

Use acoustic insulation build-up, but add an outer layer of cold service insulation. The thickness of the acoustic insulation will allow a similar reduction in the thickness of the cold service insulation. However, minimum thickness of the cold service insulation shall be 30 mm.

A vapour barrier shall be applied outside the cellular glass layer, see 4.3.10 and 6.3.

10 Qualification requirements

10.1 Qualification of insulation system

The requirements for qualification prior to use are applicable to insulation class 5.

The fire resistance shall be decided in accordance with recognised standards and/or calculation models.

Tests shall be carried out on complete insulation system installed on a test piece on a relevant dimension.

The following shall identify the fire technical requirement relating to insulation materials:

- requirement in PTIL" Innretningsforskriften";
- for pool fire, the insulation system shall be qualified and the fire resistance shall be decided in accordance with recognised standards and/or calculation models, example.g. ISO 834 (all parts) or equivalent;
- insulation used for passive fire protection against a jet-fire shall be tested in according with OTI 95 634.

10.2 Qualification of personnel

10.2.1 Qualification of insulation fitters

Operators shall be qualified to tradesman level as insulation fitter or sheet metal worker.

The personnel shall have a relevant knowledge of health and safety hazard, use of protection equipment, insulation materials, application of insulation materials, insulation systems surface requirements, and how to avoid corrosion under insulation.

If not qualified to tradesman level, personnel shall be subject to a test in accordance with this NORSOK standard for classe 1, class 4 and class 5.

The test shall be supervised by a qualified supervisor and examined by qualified QC personnel. An examination certificate shall be issued if the candidate passes the test. Inspection personnel shall have access to site test procedures.

The test shall be carried out on a test piece, composed of a DN 100 pipeline containing at least one valve, two flanges, one T-piece, one trunnion support and one standard clamped support.

Both valve box and one flange shall be insulated with AISI 316 material to insulation class 5.

Alternatively a suitable location on the installed pipelines, which as a minimum consist of the same parts as described for the test piece, may be selected to which the IPT shall be carried out.

Each work team to consist of minimum 50 % workers qualified to tradesman level.

10.2.2 Qualification of supervisors, foremen and QC personnel

Personnel carrying out inspection or verification shall be qualified to tradesman level and shall be accepted as inspector by company.

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.

10.3 Qualification of procedures

10.3.1 Insulating procedure specification (IPS)

A detailed IPS based on the requirements of this NORSOK standard, and specific project requirements shall be approved by company prior to installation. The IPS shall as a minimum contain following documents:

- detailed sketches, which shows the system build-up for each insulation class to be used (also for combination of systems);
- all type of materials is to be used in the individual layer (product data sheet);
- all type of removable insulation covers for flanges and valves (detail drawings and necessary documentation);
- calculation of material thickness, (tables);
- inspection plan.

The qualified IPS shall be followed during all insulation work.

Following changes in the insulation application parameters requires the IPS to be re-qualified:

- any change of insulation material;
- change of system build-up;
- change type/manufacture of removable insulation covers.

10.3.2 Insulation procedure test (IPT)

An IPT shall be used to qualify all insulation procedures. A test piece (see 10.2.1 as applicable), alternatively a suitable location on the lines to be insulated, may be selected to which the IPT shall be performed. The IPT shall be qualified under realistic conditions likely to be present during insulation installation.

Inspection requirements for the IPT shall be as given in Clause 9 and the inspection plan in IPS.

11 Inspection and test

Work during production, at delivery and all other pertinent phases, shall be duly inspected and documented with inspection log. This log shall be available for the company.

Reasonable access to workshop and personnel for inspectors shall be allowed for.

Inspection shall be carried out at each stage of the work, but as a minimum before second layer and after installation of vapour barrier of multi layer insulation is applied and before jacketing is applied.

12 Sealing of pipe penetration

12.1 General

Penetrations in main fire divisions and H divisions to be thoroughly assessed.

Penetrations in fire divisions shall not reduce the integrity, stability or the temperature limitations of such divisions.

12.2 Testing

The following requirements apply:

- penetration sealing shall be tested for compliance with IMO Resolution A. 754 (18), Recommendation on Fire Resistance test for "A", "B" and "F" Class Divisions Appendix A. III;
- thermal exposure shall be in accordance with ISO 834-1/NS-EN 1363-1 for A (A0 & A60) rated penetrations and ISO/TR 834-3/NS-EN 1363-2 for H (H0, H60 and H120) rated penetrations;
- penetration sealing materials shall be tested for compliance with IMO Resolution A 653 (16), Recommendation on improved fire test procedures for flammability of bulkhead, ceiling and deck finish materials;
- penetration sealing materials shall be tested for compliance with IMO Resolution MSC. 41 (64), Interim standard for measuring smoke and toxic products of combustion.

12.2.1 Additional testing (if required)

The following requirements apply:

- jet fire testing according to "Jet-Fire Resistance Test of Passive Fire Protection Materials". Issued by Health and Safety Executive, UK report no. OTI 95 634;
- relevant explosion testing;
- weather tightness according to IACS UR S.14.2.3;
- water tightness according to DNV Standard for Certification, 2.9 Type Approval 8-471.19-1.

12.2.2 Type approval

Type approval certificate issued by a recognised classification society, or on behalf of, in accordance with the Marine Equipment Directive.

12.3 Installation

Penetration seals installed, including the materials and method of assembly, shall be equal to those used in the laboratory approval testing. Any deviations shall be highlighted on the project specific penetration dossier and approved by company.

Penetration seals shall be installed in the same orientation as tested. To be installed in both bulkhead and deck application, the penetration seal shall be tested in both type of divisions and, in addition, for both single pipe and multiple pipe penetrations.

The minimum and maximum size (length x width, cross sectional area or diameter) should be tested.

Installation of a penetration seal larger than the maximum size tested is not acceptable.

Penetration seals may be installed with a minimal separation distance, except seals that require insulation, as part of the approval shall be installed with sufficient separation distance to allow installation of appropriate amount of insulation.

Steel frame (sleeve) may be of carbon steel, galvanized steel or stainless steel regardless of type of steel used in laboratory test.

Steel frame (sleeve) that was welded to the test assembly shall be welded. When bolted to the test assembly it may be either bolted or welded.

Penetration seals may be installed with a greater thickness of sealant material.

Penetration seals shall be installed in the same manner and with the same type of insulation on the seal that was used in the laboratory fire test. However, the insulation applied to the bulkhead or deck being penetrated to make a fire division may be of any approved insulation.

Penetration seals that were tested with the sealing located entirely on the exposed/unexposed side shall be installed in the same way.

Steel frame (sleeve) that was tested symmetrically should be installed with approximately equal parts on each side of the division.

12.4 Drawings

Penetration seal manufacturer shall prepare typical installation drawings that show any required installation restrictions determined during the laboratory approval testing. These drawings shall be referenced on the type approval certificate. The seals shall be installed in accordance with these drawings. Drawings shall be included in the IPS/penetration dossier. The drawings should contain at least the following information:

- installation restrictions;
- minimum and maximum frame (sleeve) dimensions;
- installation symmetry;
- minimum and maximum pipe diameter;
- minimum distance between pipes (multiple);
- minimum distance between pipes and frame (sleeve);
- fire exposure side.

13 Qualification of new products

13.1 General

This clause lists additional requirements for testing and documentation for qualifying of new products developed for piping and equipment insulation purposes.

13.2 Testing

13.2.1 Testing of technical properties

All products shall be tested for technical properties by an external third party institute or accredited laboratory.

The test shall be relevant and in accordance with insulation classes described in this NORSOK standard.

Declaration of technical properties:

Property	Requirement	Test method
Length	Always declare nom. incl. tolerance	EN 822
Width	Always declare nom. incl. tolerance	EN 822
Thickness	Always declare nom. incl. tolerance	EN 823
Dimensional stability	Rel. dimensional changes < 1 %	EN 1604
Reaction to fire	Always declared	NS-EN 13501-1
Maximum ST (+)	Always to be declared	prEN 14706
Thermal conductivity, λ_D	Determined and verified in accordance with NS-EN ISO 13787	EN 12667 or EN 12939
Tensile strength parallel to faces (handling property)	$\geq 2 \times$ weight of product	EN 1608
Water absorption	WS	
Trace quantities of water soluble ions and the pH-value	CL: pH:	

13.2.2 Life cycle test

All products shall be tested for life cycle properties by an external third party Institute or accredited laboratory. The test shall be relevant and in accordance with the products strain and stress exposure and in relevance to products expected life cycle.

13.3 Documentation

The supplier shall prove that the products technical properties are in accordance with, and fulfil, requirements described for insulation classes in this NORSOK standard, or other specific project requirements.

The documentation shall be in written format, i.e. rapport, from an external third party Institute or accredited laboratory.

The supplier shall prove that the product has been tested for life cycle properties distinctly state evaluations above specified lifetime for the project.

13.3.1 Qualifying

To be able to supply products in accordance with this NORSOK standard, testing and documentation described in 13.2 and 13.3 shall be in compliance.

Annex A (Informative) Key data for insulation systems

Insulation class	Insulation Materials	Jacket Material	Other Comments / Build-up
Class 1 Heat conservation	Cellular glass Mineral wool at temp. higher than 180 °C	Stainless steel/al or non-metallic weather-proofing membrane	
Class 2 Cold service insulation	Cellular glass	Stainless steel/al or non-metallic weather-proofing membrane	Vapour barrier
Class 3 Personnel protection	Either class 1 to class 9 or perforated sheet metal guards	In accordance with classe 1 to class 9 as applicable	Perforated guards to be of stainless steel. If perforated guards is used, it shall be designed so that the jacket/guards temperature do not exceed 70 °C
Class 4 Frost proofing	Cellular glass	Stainless steel/al or non-metallic weather-proofing membrane	Vapour barrier
Class 5 Fire proofing	Cellular glass + AES - or mineral wool, when necessary	Stainless steel	Insulation materials are dependant on protection requirements, and shall be accepted in writing by client for each case
Class 6 Acoustic insulation	Cellular glass AES – or mineral wool heavy synthetic sheet	Stainless steel/al or non-metallic weather-proofing membrane	30 mm to 40 mm cellular glass + 25 mm wool + metallic jacketing (or aluminium foil + non-metallic jacketing)
Class 7 Acoustic insulation	Cellular glass AES – or mineral wool heavy synthetic sheet	Stainless steel/al or non-metallic weather-proofing membrane	30 mm to 40 mm cellular glass + 38 mm wool + heavy synthetic sheets + metallic jacketing (or aluminium foil + non-metallic jacketing)
Class 8 Acoustic insulation	Cellular glass AES – or mineral wool heavy synthetic sheet	Stainless steel/al or non-metallic weather-proofing membrane	30 mm to 40 mm cellular glass + 38 mm wool, + 2 x heavy synthetic sheets + 25 mm fibres + 2 x heavy synthetic sheets + metallic jacketing (or aluminium foil + non-metallic jacketing)
Class 9 External condensation	Cellular glass	Stainless steel/Al or non-metallic weather-proofing membrane	Vapour barrier

NOTE 1 Use of tape shall be subject to company approval.

NOTE 2 Jackets shall only be used in weather-protected areas.

NOTE 3 AES wool shall be used when acoustic insulation is combined with fire insulation.

NOTE 4 Insulation on systems with operating temperatures below 20 °C shall be provided with vapour barrier.

NOTE 5 For acoustic insulation, key data in the table above to be used as guide only. For existing test results, see revision 2 of this NORSOK standard.

