

NORSOK STANDARD

COMMON REQUIREMENTS
PIPING AND EQUIPMENT INSULATION

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Please note that whilst every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.

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1 FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and remove unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and are jointly issued by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered by NTS (Norwegian Technology Standards Institution).

The purpose of this industry standard is to replace the individual oil company specifications for use in existing and future petroleum industry developments, subject to the individual company's review and application.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of this standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

2 SCOPE

This standard covers the minimum requirements for thermal, acoustic, personnel protection and fireproofing insulation of pipework and equipment for offshore installations.

3 NORMATIVE REFERENCES

ASTM-C552	Cellular Glass Block and Pipe Thermal Insulation.
ASTM-C592	Ceramic Fibre Blanket Insulation for Pipes and Vessels.

4 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

Shall	Shall is an absolute requirement which shall be followed strictly in order to conform with the standard.
Should	Should is a recommendation. Alternative solutions having the same functionality and quality are acceptable.
May	May indicates a course of action that is permissible within the limits of the standard (a permission).
Can	Can-requirements are conditional and indicates a possibility open to the user of the standard.

Insulation classes

Class 1 Heat conservation

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

Class 2 Cold medium conservation

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

Class 3 Personnel protection

Surfaces operating at temperatures above 70°C or below -10°C and accessible from normal working areas and access ways shall be guarded by screens to a height of 2100mm above the walking level. The protection shall be confined to a distance of not more than 0.8m horizontally from access walkways and normal working areas. Insulation shall only be used where guards are not practical.

Class 4 Frost proofing

The purpose is to prevent freezing, solidification and condensation.

Class 5 Fire proofing

The purpose is to reduce the heat input and pressure build up in vessels and piping in a fire situation.

Class 6 Acoustic insulation - 10dB

Reduction of noise in the area 500-2000Hz by 10dB.

Class 7 Acoustic insulation - 20dB

Reduction of noise in the area 500-2000Hz by 20dB.

Class 8 Acoustic insulation - 30dB

Reduction of noise in the area 500-2000Hz by 30dB.

Class 9 External condensation and icing protection

The purpose is to prevent condensation on piping and equipment with operation temperatures below ambient.

For combination of insulation classes see clause 8.

4.2 Abbreviations

ASTM	American Society for Testing and Materials
AISI	American Iron and Steel Institute
P&ID	Process & Instrument Diagram

5 GENERAL REQUIREMENTS**5.1 Introduction**

General requirements for thermal insulation (hot and cold) are given in this clause. Specific requirements for hot service and acoustic insulation are stated in clause 6, and cold service insulation in clause 7.

Alternative insulation may be used if the proposed materials and methods satisfy the functional requirements in this specification. Approval is necessary.

5.2 Design

5.2.1 General

Piping and equipment shall be insulated according to the insulation class, operating temperature and insulation thickness stated in the P&ID and Data sheets .

All insulation shall be covered with weather proofing (jacketing) designed and installed to prevent ingress of water and oil at normal operation during the 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 jacketing shall be equal to the bolt length +25mm. The termination of the jacketing shall be weathertight.

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

5.2.2 Vessel insulation

Insulation of vertical vessels shall be supported on rings installed on the vessel.

Block insulation shall be fastened with mechanically tightened metal bands or with bonding adhesive.

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

Vessels of diameter 1500mm and smaller shall be insulated as piping.

5.2.3 Insulation of flanges and valves

Removable insulation for flanges and valves, except for fire proofing and acoustic insulation shall be deluge proof and tailor made.

The insulation shall withstand removal/reinstallation (e.g. to obtain access for inspection purposes) at relevant locations at least twice a year over the design life without losing its properties.

5.2.4 Insulation of instrument and instrument tubing

For insulation of instruments, insulated cabinets with hinged doors shall be used. Instrument tubing may be insulated with Vidoflex or equivalent or with Vidofinish or equivalent.

5.2.5 Piping insulation

Insulation on long vertical pipe runs shall be supported on rings spaced on 6400mm maximum centres installed on the piping. Width of rings shall be minimum 1/3 of and maximum 12mm less than the insulation thickness.

5.2.6 Metallic jacketing

Flat heads are not allowed on top of vertical vessels.

Removable insulation covers shall be provided for vessels heads which are removable. The bottom heads of skirt supported vessels may be covered with flat metallic jacketing.

Jacketing for flanges and valves shall be formed such that it sheds water.

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

All seams on metal jacketing shall be sealed with tape.

Insulation systems for flanges and valves for all classes shall have a low point drain.

For all horizontal piping and equipment there shall be made drain holes in low point with a minimum distance of 3m between each hole when specified.

5.2.7 *Non metallic jacketing*

For insulated piping for all classes except class 5 (fire protection) non metallic jacketing may be used.

5.3 *Materials*

5.3.1 *General*

Materials for classes 1, 2, 3, 4, 6 and 9 shall consist of cellular glass. Materials for class 5, 7 and 8 shall consist of ceramic fibre and cellular glass.

Insulation material shall be non-combustible, non-toxic and water-repellent. The materials shall not release toxic or corrosive gases when exposed to fire. No asbestos or asbestos products shall be used.

5.3.2 *Ceramic fibres*

Ceramic fibre blankets shall be manufactured from aluminio-silicate fibres, with an average fibre length of approximately 100mm.

The density shall be within 95-130kg/m³. The material shall withstand temperatures up to 1100°C. For protection against jet fires high duty fibres that withstand temperatures above 1100°C shall be considered.

5.3.3 *Sealers, Tape*

Joint sealers shall be permanently flexible through a temperature range from -90°C to 200°C and shall be capable of withstanding repeated expansion and contraction without cracking and with minimum shrinkage.

Sealing tape for sealing of metal jacketing joints shall be Densit FK10 or equivalent.

5.3.4 *Cellular glass*

Cellular glass insulation block and pre-formed pipe sections shall conform to ASTM C552 and be suitable for temperatures from -260°C to 430°C. The density shall be 120 kg/m³ + 10%. Cellular glass shall have anti abrasive coating compatible with the process line temperature.

To secure cellular glass pre-formed sections in place, adhesive glass fibre reinforced tape or stainless steel banding shall be used.

5.3.5 *Metallic jacketing*

Metallic jacketing shall be stainless steel or Al-alloy. For fire protection the jacketing material shall be stainless steel.

1. Stainless steel

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

Stainless steel sheets for pipes and vessels up to outside diameter 1200mm without insulation shall have a thickness of 0.5mm. For outside diameter above 1200mm the thickness shall be 0.7mm.

2. Aluminium alloy

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

Aluminium sheets for pipes and vessels up to outside diameter 1200mm shall have a thickness of 0.7mm. For outside diameter above 1200mm the thickness shall be 0.9mm.

5.3.6 *Non metallic jacketing*

The materials used for non metallic jacketing shall be Scotch 3M type 52CPT or equivalent. Other types may be used on approval.

5.3.7 *Bonding adhesive*

For temperatures up to 140°C adhesive shall be a two component urethane modified bitumen adhesive for bonding cellular glass to vessels.

5.3.8 *Accessories*

Vendor to specify his standard (material, dimension, type) regarding accessories such as rivets, toggle latches, bands, wires, clips, breather springs etc. Approval is required.

5.4 *Installation*

5.4.1 *General*

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

Surfaces to be insulated shall be clean and dry. No commencement of the application of insulation shall be made until a mechanical completion certificate for coating has been issued.

Surfaces with not finished insulation system shall be properly covered to avoid damage.

Single layer insulation shall be applied with longitudinal joints staggered. In double-layer applications, joints of the outer layer shall be staggered with respect to the inner layer joints. All insulation shall be installed with the joints tight. Voids within the insulation are not acceptable.

If insulation work precedes testing of pipework, welds and joints shall be left uninsulated to allow inspection during testing.

Welding on any surface to be insulated shall not be carried out without prior approval.

Insulation on valves shall leave the packing gland accessible.

5.4.2 *Metallic jacketing*

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

Up to 300mm:	10mm	5mm radius
Between 300mm and 600mm:	13mm	6.5mm radius
Above 600mm:	16mm	8mm radius

All jacketing seams shall be sealed by roof tile principle and the application of sealing tape (tape inside jacketing).

Metal jacketing for vessel insulation shall be edge crimped and overlapped 75mm on longitudinal and circumferential seams.

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

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 4 clips per seam.

Metal jacketing shall be fastened with bands (Band-It or equivalent). Only for difficult details as bends, T-pieces etc. Pop rivets (or equivalent) may be used.

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

6 HOT SERVICE INSULATION

6.1 General

This clause describes the requirements for the following insulation classes:

- Class 1, Heat conservation.
- Class 3, Personnel protection.
- Class 5, Fire proofing.
- Class 6, 7 and 8, Acoustic insulation.

6.2 Design

Guidance for the choice of insulation thicknesses for heat conservation and personnel protection is for cellular glass given in table 1. If a specific temperature has to be maintained, the thickness of the insulation material in question has to be specified in each case. Thickness of fire protection is specified by the safety discipline and stated in the P&ID.

The following equipment shall not be insulated for heat conservation class 1 except for steam services or when otherwise specified:

1. Vessel manway covers, nozzles and flanges.
2. Exchanger nozzles and flanges.
3. Valves and piping flanges.
4. Control valves, line valves and fittings that are to be removed periodically.
5. Expansion and rotation joints, slide valves and similar equipment.
6. Steam traps.

Flanges operating at temperatures above 450°C shall be insulated and protected with sheet metal jacketing.

6.3 Installation

The following requirements apply additional to those in clause 5.4:

6.3.1 Block insulation for vessels

Blanket insulation for vessels:

1. Insulation for vessel heads shall be curved blocks or standard flat blocks cut to fit.
2. For single layer and outer layer of multi layer shall insulation, banding shall be placed approximately 30mm on each side of all butt joints with intermediate bands at a maximum of 300mm centres. The inside layer of multi layer installations shall be banded on at a maximum 450mm centres.
3. When banding is not practical on irregular surfaces, insulation shall be secured with stainless steel wire.

6.3.2 Blanket insulation on vessels

Blanket insulation on vessels:

1. 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.
2. The meeting edges of blankets shall be tied together with stainless tie wire.

6.3.3 Prefabricated pipe section insulation

Prefabricated insulation shall be applied as follows:

1. Insulation pipe sections shall be used according to Manufacturer's standard production. Insulation pipe section shall be tightly butted together and secured to pipe with stainless steel wire or bands.
2. Insulation shall be secured with bands over the outer layer at each side of radial joints and at the centre of each section.
3. Spacing of wire or bands for the inner layer of multi layer insulation need only be sufficient to hold sections in place until the outer layer is secured.
4. To cover elbows and other irregular surfaces, sections may be cut and fitted in the field.

6.3.4 Blanket insulation for piping

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

1. Insulation joints shall be butted together firmly and secured with stainless steel wire or bands.
2. Insulation shall be secured with bands over the outer layer at each side of radial joints and at the centre of each section.

3. Fittings and flanges shall be covered with cut block insulate or blankets. Insulation shall be secured by wire or band.

6.4 Guidance for insulation thicknesses

Table 1 applies to Heat conservation (class 1) and personnel protection (class 3)

Material: Cellular glass

Table 1. Thicknesses in millimetres for cellular glass.

Nominal diameter mm	Maximum operating temperatures °C							
	100	150	200	250	300	350	400	420
20	30	30	30	30	50	50	50	50
25	30	30	50	50	50	50	50	50
32	30	30	50	50	50	50	50	50
50	30	30	50	50	50	50	80	80
65	30	30	50	50	50	80	80	80
80	30	50	50	50	50	80	80	80
100	50	50	50	50	50	80	80	100
150	50	50	50	50	80	80	80	100
200	50	50	50	50	80	80	80	100
250	50	50	50	50	80	80	100	100
300	50	50	50	50	80	80	100	100
350	50	50	50	50	80	80	100	100
400	50	50	50	50	80	80	100	100
450	50	50	50	50	80	80	100	100
500	50	50	50	50	80	80	100	100
600	50	50	50	50	80	80	100	100
Above 600 and flat surface	50	50	80	80	100	100	100	150

The material thickness given above are guidelines only. They shall be adjusted up to the closest standard thickness given by the manufacturer. Thicknesses of 80mm and above can be built up in two layers if required.

6.5 Guidelines for acoustic insulation

For Class 6 acoustic insulation, 10dB, insulation shall be 50mm cellular glass with jacketing. Valves and flanges shall be insulated when specified.

For Class 7 acoustic insulation, 20dB, insulation shall be 50mm cellular glass against pipe and 25mm thick synthetic ceramic fibre mat under metal jacketing. Valves and flanges shall be insulated when specified.

For Class 8 acoustic insulation, 30dB, insulation shall be 50mm cellular glass against pipe and 50mm thick synthetic ceramic fibre mat with two layers of lead sheets 0.5 mm thick between the cellular glass and the ceramic fibres. Valves and flanges shall be insulated when specified.

7 COLD SERVICE INSULATION

7.1 General

This clause describes the requirements for the following insulation classes:

- Class 2, Cold medium conservation.
- Class 4, Frost proofing.
- Class 9, External condensation and icing protection.

7.2 Design

7.2.1 General

If specific temperature has to be maintained for process reasons, the thickness of the insulation has to be specified in each case.

Where heat tracing cable penetrates metal jacketing, edge-protection type Flexiform GT5/AA or equivalent shall be applied to the edges of the jacketing.

7.2.2 Vessel insulation

Where required, manways 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.

7.2.3 Piping insulation

Valves and fittings shall be insulated with preformed pipe insulation. Lags shall be cut from standard blocks, fitted and wired in place. Alternatively, tailor made jackets may be used.

Flanges shall be insulated with the same insulation thickness as the thickness on adjoining pipe run, vessel, machinery or fitting.

In order to avoid frost formation or condensation on pipe supports, insulated prefabricated pipe supports shall be used so that thermal bridges are avoided.

7.3 Installation

The following requirements apply additional to those in clause 5.4: A smooth outer insulation surface must be obtained to provide an effective vapour seal.

7.3.1 Block insulation for vessels

Block insulation for vessels:

1. All block edges shall be buttered with a thin coat of joint sealer when single layer insulation and the outer layer of a multi layer insulation is applied. The remaining joints shall be left dry, except where vapour seals or contraction joints are required,
2. Termination of insulation on all layers, including contact surfaces where removable insulation covers are installed, shall be vapour sealed.

7.3.2 Piping insulation

Prefabricated insulation of cellular glass shall be applied as follows:

1. All joints of single layer and outer layer of a multi layer insulation shall be applied with butt edges buttered with joint sealer before installation.
2. Anti-abrasive compound shall be applied to the inner bore and allowed to dry before application. Anti abrasive compound when required, is preferred factory applied.
3. 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 275mm centres, and at least 25mm back from butt joints.
4. Prefabricated flange and fitting covers shall be applied in the same manner as pipe insulations, except that non-removable joints shall be cemented with adhesive.

7.3.3 Guidance for insulation thicknesses

- Frost proofing, Class 4 piping and equipment with heat tracing:
 - Thickness (mm) of insulation for piping and equipment shall be:
 - 30mm up to and including nominal diameter 200 mm.
 - 50mm above 200mm and flat surface.
- Frost proofing, Class 4 piping and equipment without heat tracing:
 - Thickness (mm) of insulation for piping and equipment shall be:
 - 40mm up to and including nominal diameter 80mm.
 - 30mm above 80mm and flat surface.

Table 2 applies to cold service insulation, class 2 and 9, and condensation protection.

Thickness in millimetre for cellular glass.

Material: Cellular glass

Table 2. Thickness in millimetres for cellular glass.

Nominal diameter mm	Minimum temperatures °C									
	5	0	-10	-20	-30	-40	-50	-60	-70	-80
25	30	30	50	60	60	75	75	90	90	100
32	30	50	50	60	75	75	75	90	100	100
50	30	50	50	60	75	90	90	100	100	100
65	50	50	50	60	75	90	90	100	100	125
80	50	50	60	75	75	100	100	100	125	125
100	50	50	60	75	75	100	100	100	125	125
150	50	50	60	75	90	100	100	125	125	125
200	50	50	75	75	90	100	125	125	125	150
250	50	50	75	75	100	100	125	125	150	150
300	50	50	75	75	100	100	125	125	150	150
350	50	50	75	75	100	100	125	125	150	150
400	50	50	75	75	100	100	125	125	150	150
450	50	50	75	75	100	100	125	150	150	150
500	50	75	75	75	100	100	125	150	150	150
600	50	75	75	75	100	100	125	150	150	175

The material thickness given above are guidelines only. They shall be adjusted up to the closest standard thickness given by the manufacturer. Thicknesses of 100mm and above can be built up in two layers if required.

8 COMBINATION OF INSULATION CLASSES

Below guidelines 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 5 can be identified with the two digits 15 in the line number or other project specific combinations.

Fire proofing (5) combined with Heat conservation (1) or Personnel protection (3) or Acoustic insulation (6, 7 & 8).

Use class 5 Fire protection but select the thickness from the insulation class with the greatest thickness. Lead sheets to be used if required for acoustic reasons.

Acoustic insulation (6, 7 & 8) combined with Heat conservation (1) or Personnel protection (3).

Use class 6 or 7 Acoustic insulation but select the thickness from the insulation class with the greatest thickness.

Fire Proofing (5) combined with cold service insulation (2, 4 and 9).

Use cellular glass for the cold service and add a layer with the required thickness of ceramic fibre wool as fire protection. A vapour barrier outside the fire protection to be included to reduce intrusion of water/vapour into the fire protection.

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

Use class 6 or 7 acoustic insulation, 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 30mm.

9 INSPECTION AND TEST

Work during production, at delivery and all other pertinent phases, shall be duly inspected.

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 of multi layer insulation is applied and before jacketing is applied.