 Linde AG Linde Engineering Division	Insulation for Standard Air Separation Plants for Non-Oxygen-Carrying Components		LINDE STANDARD LS 151-18 Part 1
Orig.: TME/Schwerdtfeger	Checked: TME/Rübel	Appr.: TAW-N/Alekseeva	Page 1 of 27

Replaces Issue 09.2005

Dimensions in mm

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1 Scope

This Linde Standard (LS) applies to the design and execution of insulation work on standard air separation plants for components with an oxygen content of < 70 % and operating temperatures of +5°C to +350°C, which are insulated with elastomeric foam or with mineral fibrous insulation materials.

LS 151-18 comprises Parts 1 and 2. It applies to contracts, where Linde carries out the detail engineering. The valid, relevant subject-specific standards and guidelines are the basis for the application. Prior to planning it is necessary to check, based on the contract, if this standard can be applied unamended. Company-specific restrictions or extensions shall be taken into consideration during the design and execution of the insulation work. The standard shall be supplemented in cases of deviating requirements or a project-related specification shall be compiled.

For the insulation of oxygen-carrying components (oxygen content ≥ 70 %), the LS series LS 151-07 applies.

This LS does not release the executing company from the obligation of carrying out the insulation commensurate to the state-of-the-art. If the Contractor can offer insulation systems, which have advantages compared to the specified insulation systems, these corresponding suggestions shall be submitted in writing. These suggestions shall contain:

- a precise description of the insulation systems
- the designation of the insulation materials to be used
- design and execution of the insulation systems
- a cost comparison

2 Normative references

This standard contains provisions which, through undated references in this text, constitute provisions of other publications. The normative references are cited at the respective part in the text and the publications are listed below. Issues valid at the time of placement of order shall govern.

ISO 1481	Slotted pan head tapping screws
ISO 15665	Acoustics - acoustic insulation for pipes, valves and flanges
EN ISO 9000	Quality management systems - fundamentals and vocabulary
EN ISO 1478	Tapping screw thread
EN ISO 15983	Open end blind rivets with break pull mandrel and protruding head - A2/A2
EN 10327	Continuously hot-dip coated strip and sheet of low carbon steels for cold forming - Technical delivery conditions
DIN 4102-1	Fire behaviour of building materials and building components - Part 1: Building materials; concepts, requirements and tests
LS 151-07 (all parts)	Specification for the insulation of oxygen bearing plant components
LS 151-18 Part 2	Insulation for standard air separation plants for non-oxygen-carrying components - products and producer

3 General

3.1 Types of Insulation / Insulation Thicknesses

The required insulation system (type, thickness) is shown in P&I diagrams, isometric drawings, equipment datasheets, piping- and instrumentation lists. The description of the insulation type is shown in Table 1.

For insulation thickness see tables 1 to 5.

Table 1: Insulation type, description and insulation thickness

Insulation type	Operating temperature, °C	Insulation thickness ¹⁾	Short description	Insulation material/ specification
E	+5 - +85	see Tab.2 + 20	Condensate prevention/Alternating temperature insulation	Elastomeric foam with air ventilation / metal cladding
EE	+5 - +85	see Tab.2 + 20	Condensate prevention/Alternating temperature insulation and electrical tracing	Elastomeric foam with air ventilation / metal cladding
ES	+5 - +85	see Tab.2+3 + 20 + 5 ²⁾	Condensate prevention/Alternating temperature insulation with acoustic insulation	Elastomeric foam with air ventilation without/with anti boom material / metal cladding
EES	+5 - +85	see Tab.2+3 + 20 + 5 ²⁾	Condensate prevention/Alternating temperature insulation with acoustic insulation and electrical tracing	Elastomeric foam with air ventilation without/with anti boom material / metal cladding
WM	+15 - +200	see Tab.4 + 20	Heat-/Alternating temperature insulation for molecular sieve system	Mineral fibre aluminium faced (lamella mat) vapour-tight with air ventilation / metal cladding
S	+15 - +350	50	Acoustic insulation	Mineral fibre with anti boom material / metal cladding
W	+15 - +350	see Tab.4	Heat insulation	Mineral fibre / metal cladding
WE	+15 - +350	see Tab.4	Heat insulation with electrical tracing	Mineral fibre / metal cladding
WS	+15 - +350	see Tab.4	Heat insulation with acoustic insulation	Mineral fibre with anti boom material / metal cladding
WES	+15 - +350	see Tab.4	Heat insulation with electrical tracing and acoustic insulation	Mineral fibre with anti boom material / metal cladding
PP	+60 - +350	see Tab.5	Personnel protection	Mineral fibre / metal cladding

¹⁾ The insulation thickness is the addition of the thickness taken from the suitable table + air ventilation (only insulation types E, EE) + anti boom material (only ES, EES)

²⁾ The larger value from table 2 and 3 shall be used

Table 2: insulation thickness — insulation type E, EE, ES, EES
(free of condensate at medium temperature 10°C and free convection without wind)

Ambient temperature	Relative humidity				
	≤ 60 %	65 %	70 %	75 %	80 %
25°C	19	19	19	19	38
30°C	19	19	19	38	38
35°C	19	19	38	38	38
40°C	19	38	38	38	38

Table 3: insulation thickness — insulation type ES, EES
(insertion loss for octavos in dB acc. to ISO 15665)

Insulation thickness ¹⁾	Anti boom material	Frequency, Hz							
		63	125	250	500	1000	2000	4000	8000
19	0	-3,0	3,0	3,8	9,6	14,4	23,3	29,6	40,1
19	2,3	-4,0	6,2	6,2	11,8	21,5	25,1	34,7	37,4
38	2,3	1,3	7,0	8,3	18,0	21,7	30,3	42	53,1
64	2,3	-2,1	4,0	6,3	16,9	25,1	35,8	53,1	52,5

¹⁾ For this application only examined products acc. to LS 151-18 P2, table 2 are permitted
Note: in case of higher requirements for noise insulation special design shall be specified by TME

Table 4: insulation thickness — insulation type W, WM, WE, WES, WS*

DN ¹⁾	Operating temperature, °C				
	≤ 150	200	250	300	350
≤ 50	40	50	50	60	80
100	50	60	80	80	100
200	80	80	100	120	120
400	100	120	120	140	150
600	100	120	140	150	170
900	120	130	150	170	190
≥ 1200	150	170	190	220	240

* insulation thickness > 50mm

¹⁾ The insulation thickness of not listed DN shall be interpolated and rounded up accordingly (10mm steps).

Table 5: insulation thickness — insulation type PP

DN ¹⁾	Operating temperature, °C				
	≤ 150	200	250	300	350
≤ 50	30	40	50	60	60
100	30	40	60	60	80
200	40	50	60	80	100
400	40	60	80	100	120
600	40	60	80	100	120
900	40	60	80	100	120
≥ 1200	40	60	80	100	120

¹⁾ The insulation thickness of not listed DN shall be interpolated and rounded up accordingly (10mm steps).

3.2 Documentation

3.2.1 Pre-Documentation

Before beginning the work, the Contractor shall compile a documentation on all the materials envisaged for use and the documentation shall be submitted to Company for review. The insulation work shall only be begun when the material documentation has been reviewed and approved.

This documentation shall contain the following information:

- product description and technical datasheets
- safety datasheets.

3.2.2 Final Documentation

A documentation folder shall be compiled by the Contractor and shall contain

- all documents in accordance with 3.2.1
- consistency declarations (the fitted material matches the documents in the documentation)

The final documentation shall be handed over to Company at the time of the mechanical completion at the latest.

3.3 Quality Assurance

The general work cycle of the insulation work, quality assurance and quality control are set out in a Quality Assurance Program on the basis of EN ISO 9000. This program is compiled project-related by the Contractor and agreed with Company. The following measures shall be included:

- Responsibility;
- QA test steps with description;
- Acceptance procedure;
- Relevant documents (regulations, acceptance sheet).

4 Materials

4.1 General

- Exclusively, new and unused materials shall be used.
- The materials shall be provided with all the required designations.
- The materials, which require certification in accordance with the respective national regulations, shall be approved and meet the certification conditions. The proof shall be supplied by the Contractor.
- All required datasheets, process guidelines, safety datasheets, test certificates and manufacturer regulations shall be provided with the materials.

4.2 Delivery and Storage

All materials shall be protected professionally for transport and intermediate storage until assembly, taking the relevant regulations into consideration. It shall be noted that

- the insulation materials shall be stored in accordance with the manufacturer's specifications and legal regulations;
- the metal sheets shall be stored that damage and corrosion are avoided.

If the functionality of the materials has been damaged as a result of transport or storage or its appearance is impaired, the material shall not be used.

4.3 Material Deviations

In case materials are used, that deviate in quality or their technical data from the specified material, the deviation shall be explained and a detailed description of the deviating data or characteristics shall be submitted.

This material shall only be used after review and approval by Company.

4.4 Supporting Structures & Spacer Ring Constructions

Metallic supporting structures and spacer ring structures shall be manufactured from hot-dip galvanised flat steel ($\geq 30 \times 3\text{mm}$) in accordance with Figures A.13 and A.14.

Spacer ring structures made of elastomeric foam strips shall be $\geq 50\text{mm}$ wide and $\geq 19\text{mm}$ thick, see Figure A.2.

4.5 Insulation Materials

4.5.1 General

Only authorised or equivalent insulation materials shall be used. The insulation materials shall at least fulfil the following requirements (until and including 4.5.3).

For operating temperatures > 200°C, only insulation materials of Fire Classification A (see DIN 4102-1) shall be used.

The minimum requirements for insulation materials are shown in Tables 6 and 7.

Table 6: Minimum requirements on insulation materials

Insulation material	Apparent density, kg/m ³	Operating temperature, °C	Additional properties
Mineral fibre mat	≥ 80	≤ 510	<ul style="list-style-type: none"> • noncombustible, fire classification A (DIN 4102-1) • hydrophobic • chloride content < 6 ppm • stable in structure, decay- and vermin - resistant • dimensionally stable • age-resisting
Mineral fibre preformed sections	≥ 110	≤ 450	
Lamella mat	≥ 40	≤ 240	
Elastomeric foam	≥ 60	≤ 85 (sheets) ≤ 105 (hoses)	<ul style="list-style-type: none"> • As above, but B1/B2 (see DIN 4102-1) ; • moisture resistance factor ≥ 4000

Table 7: Minimum requirements on thermal conductivity (nominal values), W/(m K)

Insulation material	Mean temperature t _m , °C						
	50	100	150	200	250	300	400
Mineral fibre mat	0,045	0,052	0,061	0,074	0,088	0,106	0,129
Mineral fibre preformed sections	0,042	0,048	0,057	0,068	0,081	0,097	-
Lamella mat	0,043	0,055	0,069	0,086	0,105	-	-
Elastomeric foam	0,041	-	-	-	-	-	-

4.5.2 Mineral Fibre Insulation Materials

The mineral fibre insulation materials used shall meet the relevant insulation material standards and fit for purpose. Depending on the requirements:

- Mineral fibre wired mats
- Mineral fibre lamella mats
- Mineral fibre preformed sections and mouldings
- Loose mineral fibres

shall be used.

4.5.3 Elastomeric Foam Insulation Materials

The elastomeric foams used shall meet the relevant insulation material standards and be fit for purpose. Depending on the requirements:

- Elastomeric foam hoses
- Elastomeric foam sheets
- Elastomeric foam mouldings
- Elastomeric foam butts

shall be used.

The use of elastomeric foam sealing straps is **not** permitted.

4.6 Fastening Means for Insulation Materials

4.6.1 Fastening means for mineral fibre mats are:

- Bands
- Mat hooks
- Binding wire

Table 8: Minimum dimensions of fastening means

Fastening means	Maximum gap	Minimum dimension		
		Plastic	Steel zinced	Stainless steel
Bands	300	13 x 0,5	16 x 0,5	16 x 0,5
Mat hooks	150	-	Ø 2,0 x 115	Ø 1,5 x 115
Binding wire	160	-	Ø 0,65	Ø 0,5

4.6.2 Fastening Means for Elastomeric Foams

Elastomeric foam insulation materials are exclusively fastened/bonded with authorised mountings in accordance with manufacturer regulations (Assembly Manual of the Insulation Material Manufacturer).

4.7 Cladding

Aluminium-zinc (ca. 55% aluminium, ca. 45% zinc) coated steel plate of low carbon steels for cold forming shall be used for cladding, for example, material No. 1.0226 + AZ185 in accordance with EN 10327.

4.7.1 Self Tapping Screws and Blind Rivets

4.7.1.1 Screws for the joint of the cladding

For all sorts of cladding, self tapping screws made of stainless steel, in accordance with ISO 1481 Forms C or F, with washers made of stainless steel and galvanised weather and ozone-resistant EPDM (Elastomeric foam end pieces) shall be used. The use of blind rivets made of stainless steel is only permitted in exceptional cases and after prior approval by the local site insulation supervisor.

4.7.1.2 Joints in difficult to access points and lever fastenings.

Where access to overlaps is difficult (e.g. removal coverings of taps) as well as for clamp lever fastenings and hinges shall be used only blind rivets with protruding head acc. to EN ISO 15983. Only rivets made from stainless steel (A2) shall be used (rivet including mandrel).

4.7.2 Sealing Material

Materials in accordance with Table 9 shall be used for sealing. The sealing material shall be non precipitation-hardening, chemically neutral, decay-, deformation-, ageing- and UV-resistant. It shall be bonded to the metal cladding all-over and permanently.

Table 9: Sealing and associated insulation material

Pos.	Sealing	Insulation material
A	In-between seam overlaps	Permanently elastic sealing band on a polyisobutylene basis or equivalent; minimum dimension 20mm x 2mm
B	Seams Taps Breather hole Uninsulated penetration	Adhesive tape on a aluminium-bitumen or butyl basis minimum dimension 50mm x 0,6mm Aluminium – coating, minimum 0,05mm
C	Uninsulated penetration with expansion	Permanently elastic sealing compound on a butyl-caoutchouc basis or equivalent, overall thickness minimum 0,8mm.
D	Barrier for pipes with operating temperatures ≤ 93°C	Fibre strengthened Mastic compound: minimum 2,0mm

4.7.3 Aluminium Foils

Aluminium foils shall be used for electrically traced pipes and equipment for the protection of the tracing cables and for better heat distribution at the object. Minimum thickness required is 0,1mm.

4.8 Additional Materials for the Acoustic Insulation

The outer cladding of all acoustic insulation is fitted on the inside with anti boom material. The anti boom material shall have a weight per unit area of $\geq 4,8 \text{ kg/m}^2$.

5 Execution

If the Contractor has reservations concerning the insulation specification, he shall inform Company of this before submission of the offer in writing.

5.1 Beginning of the Insulation Work

In principle insulation work shall only be started after release in writing by the local site insulation supervisor of Company.

The Contractor shall review the relevant preliminary work for the construction discipline before the beginning of the insulation work.

The cleaning of oil and dirt of the surfaces to be insulated is included in the scope of work and services of the contractor.

5.2 Supporting Structures & Spacer Ring Constructions

5.2.1 Supporting Structures for the Insulation with Fibre Insulation Materials

No spacer ring constructions are required for

- Pipes up to DN100 with an insulation thickness of up to 50mm,
- Pipes, which are insulated with mineral fibre preformed sections.

In the support area of metallic spacer points, coated components shall be protected by sheet metal strip or plugshoes against damage (see Figure A.14).

The distance of the spacers at the bearing ring shall be $\leq 250\text{mm}$. At least three metallic spacers per bearing ring are required.

The maximum distance for supporting constructions amounts to 950mm. For elbows, adaptors, and other fittings with lengths of $> 500\text{mm}$, supporting constructions shall be fitted at both ends. For uninsulated elbows with an outer radius of $> 700\text{mm}$ additional supporting constructions shall be used.

5.2.2 Spacer Ring Constructions for Insulation with Elastomeric Foam Insulation Materials

Spacer ring constructions for horizontally and vertically arranged components $< \text{DN}500$ made of elastomeric foam strips, $\geq 19\text{mm}$ thick and $\geq 50\text{mm}$ wide shall be radially bonded to the elastomeric foam insulation material in intervals of $\leq 450\text{mm}$.

For horizontal components $\geq \text{DN}500$, additionally to the radially located elastomeric foam strips in the upper vertex area, a further elastomeric foam strip shall be bonded axially (run of the component) all-over the elastomeric foam insulation material; strip dimensions $\geq 19\text{mm}$ thick and $\geq 50\text{mm}$ wide (see Figure A.2).

For the air ventilation of the metal cladding and to avoid the accumulation of moisture, a gap shall be left at the lower bottom point of $\geq 30 - 50\text{mm}$ in the supporting construction.

5.3 Insulation

5.3.1 General

Mineral fibre mats shall always be joined together without any gaps. For multilayer applications, the arrangement shall be joint and splice staggered.

5.3.2 Insulation with Mineral Fibre Mats (see Figure A.12)

Insulation thicknesses $> 120\text{mm}$ shall be carried-out double-layered.

For horizontal vessels and pipes, the mineral fibre mats shall be arranged without horizontal buttjoints.

Mineral fibre mats (without wire mesh) shall be fastened using four straps per meter.

Buttjoints of wired mats shall be stitched together with wire (at least three stitches overlapping on both sides) or linked using mat hooks.

For components with a diameter of $\geq 700\text{mm}$, the mats shall be fastened additionally with at least 2 straps per mat width.

5.3.3 Insulation with Elastomeric Foams

Plates, batts, hoses and form pieces made from cross-linked elastomeric foams shall be bonded completely and sealed tightly at all buttjoints. For this purpose, the insulation material manufacturer's licensed original bonding agent shall be used.

After installing the elastomeric foam, interim acceptance of all joints of the elastomeric foam insulation material shall be carried out, prior to the installation of the spacer ring construction and the cladding.

The insulation work with elastomeric foam shall be performed in accordance with the installation guideline of the elastomeric foam manufacturer.

To avoid moisture transport under the insulation system for piping, every 2 m and at all end pieces a barrier shall be carried out (see Figure A.7).

This applies in particular to the following areas:

- Penetrations
- Insulation ends
- Valves, flanges
- Supports of vessels
- Buttjoint area for piping insulation

The elastomeric foam insulation material shall be glued completely and to the full surface over a length of $\geq 150\text{mm}$ per connection to the component to serve as barrier.

5.3.4 Insulation Design with Lamella Mats and Air Ventilated Metal Cladding for Insulation Type WM (molecular sieve system)

Sketches see Figures A.9, A.10 and A.11

All component parts shall initially be insulated with lamella mats, alternatively for piping with aluminium faced preformed sections. At branches, the component with the smaller geometric dimension shall be insulated first; second the component with the larger geometric dimension.

The lamella mats shall be installed and fastened without any gaps. The longitudinal joints shall be taped with adhesive tape additionally. All joints shall be sealed vapour-tight by using aluminium adhesive tape accurately.

After installation of the lamella mats, interim acceptance for the insulation (matting) shall be carried out in order to ensure the construction guarantees the function of the vapour barrier.

5.4 Cladding

5.4.1 General

The cladding shall consist of aluminium zinc coated steel plate.

The cladding shall be installed immediately after the installation of the insulation materials. During assembly, all open points shall be protected with appropriate means against moisture ingress.

The metal cladding shall be prefabricated corresponding to the piping conduit and shall be equipped with swages at the circumferential and longitudinal joints. The use of industrially prefabricated sheet metal parts is permitted.

On horizontal pipes, the seams shall be arranged in the lower sector (4 - 8 o'clock), for less accessible points in the positions 2 - 10 o'clock. The seams shall be staggered, with the exception of the elbows.

All rims, edges, swages, overlaps, penetrations and sheet metal separators shall be formed to avoid ingress of rainwater and, where appropriate, sealed.

Required cut outs in the metal cladding (e.g. for measuring taps or pipe supports) shall be cut out adequate, provided with blanks (at gaps with more than 2mm) and/or with rain deflectors and shall be sealed permanently - elastic.

Longitudinal joint overlaps shall be tightened with self tapping screws. Screws shall be placed at regular intervals and with at least 6 screws per meter. Pop rivets and straps shall only be used with the prior written approval of the local site insulation supervisor of Company. The maximum distance between the straps shall be 300mm.

Minimum dimensions for sheet metal thickness, overlaps and joint agents depend on the circumference of the metal cladding, see Table 10.

Table 10: Minimum dimensions

Scope of sheet metal jacket	Aluminium- zinc - plate	Overlap		Means of connection	
		Longitudinal joint	Circumferential joint	Tapping screw ¹⁾	Rivets ²⁾
up to 400	0,5	30	50	4,2 x 9,5	Ø 3,2
> 400 – 800	0,6	40	50	4,2 x 9,5	Ø 3,2
> 800 – 1200	0,7	50	50	4,2 x 9,5	Ø 3,2
> 1200 – 2000	1	50	50	4,2 x 9,5	Ø 4,0
> 2000	1	50	50	4,8 x 13	Ø 4,8
¹⁾ acc. EN ISO 1478 made of stainless steel					
²⁾ acc. EN ISO 15983					

Is insulation specified with air ventilation, an air gap of 19mm shall be carried out between the insulation and the sheet metal cladding (see Figures A.1, A.4 and A.9).

To ensure ventilation and drainage of the air gap, at least 4 openings per meter Ø min. 10mm shall be carried out for horizontally components at the lowest point. These can be produced by drillings or lip-shaped edges (however, 20mm wide). The drillings shall be carried out by using taper-drill from the sheet metal internal side. For vertical piping, these openings are not necessary.

5.4.2 Pipes

Insulation end pieces are carried out as put into swages or as end caps (folded in edges). For sloped and vertical piping, the upper ends shall be designed as rain deflectors. If necessary, the ends shall be sealed (see Figures A.4, A.10 and A.16).

For ends in the area of uninsulated flanges and operating temperatures $\geq 250^{\circ}\text{C}$, a glass fibre tape 50 x 3mm shall be installed as a thermal decoupling arrangement between the end and the pipe. A sheet metal strip, 50 x 0,6mm, shall be placed on the glass fibre band so that the end can neither damage the glass fibre tape nor the pipe (see Figures A.10 and A.15).

The expansion compensation on piping is carried out by expansion joints; these shall preferably be arranged in the area of pipe supports.

5.4.3 Elbows

The cladding of the elbows shall be performed in segments and corresponding to the elbow shape. The elbow segments shall be fitted together by swages. The size of the swages shall be dimensioned to absorb heat expansions (see Figure A.3).

5.4.4 Valve and Flange boxes

Blind flanges from drains and vents and manholes shall only be insulated after specific release by the Commissioning Manager and/or the local site insulation supervisor of Company.

The metal cladding of insulated flanges, fittings, manholes or other installations shall be executed as removable covers with self-locking snap-on fastener.

For the insulation types E, EE, ES, EES and WM, the insulation materials shall be fitted vapour-tight to the component in accordance with the installation guidelines of the manufacturer. The metal cladding shall be assembled with appropriate rain deflectors over the insulation material in a self-supporting manner (see Figures A.5 and A.6).

Covers shall be installed aligned waterproof to the adjoining cladding; e.g. manholes and taps covers shall be provided with an edge of at least 15mm in width, screwed and sealed to the cladding.

For vertically arranged covers, the upper front side shall be made as a rain deflector with slope of at least 3° . This also applies to vertical taps on horizontally tap covers.

Individual cover parts shall be linked together with self-installed snap-on lever fastenings and shall not be heavier than 25 kg. Cover parts $\geq \text{DN}500$ shall be provided with two handles each.

Horizontal covers shall get 4 drain/vent openings per meter ($\text{Ø} \geq 10\text{mm}$) at the lowest point. The drillings shall be carried out by using a taper-drill (prior assembly) from the metal cladding internal side.

Covers for insulation types W, WE, WS, WES, S and PP shall be lined with wired mats and fastened to the cover by using pins.

5.4.5 Condensate Collectors and Steam Distributors

Collectors and distributors shall be carried out in the same way as specified for the piping (see 5.4.2) and the covers (see 5.4.4)

5.4.6 Vessels and Tanks

The work shall be carried out, to the extent applicable, in accordance with 5.4.2. Shape changes caused by temperature, statics and dynamics shall be accounted for in the construction.

Assembly joints in the cladding shall be covered with blanks. The overlap shall be at least 30mm.

The insulation of the equipment/vessel taps is a part of the equipment/vessel insulation. The insulation of flanges and valves is part of the piping insulation.

The cladding of the equipment/vessel heads shall be carried out corresponding to the equipment/vessel shape.

Sections in the metal cladding shall be provided with blanks and rain deflectors, as far as required, and shall be sealed.

Longitudinal Expansion of the equipment shall be compensated for by expansion joints.

Expansion joints shall be installed in the area of the support rings.

The design of vertical vessel insulation of the various insulation types is stated in Figures A.8, A.11 and A.17.

5.5 Sealing

If there is a risk of moisture penetration of any kind, the metal cladding shall be completely and permanently sealed.

The sealing of the joints shall be carried out by inserting sealing straps/materials in the swages or in the overlap.

Sealing from outside shall only be carried out, if this exception is founded and approved by the local site insulation supervisor of Company. This approval shall be given in writing.

5.6 Electrical Tracing

The insulation work shall only be carried out after release by the local site insulation supervisor of Company (submission of an acceptance sheet for the electrical tracing).

Prior to starting insulation work, the tracing cable to the component shall be mounted and equipped with grommets for the cladding (screwed cable glands/plastic sleeves) (is not part of the scope of the Contractor). The position of the cable penetrations shall be determined.

The Contractor shall use the already to the tracing cable attached grommet and install it at the cladding. The grommets shall be sealed with appropriate sealing materials properly and permanently.

Grommets shall be used in accordance with Figure A.18.

To achieve better heat distribution at the pipe, components and tracing cable shall be wrapped in aluminium foil.

Immediately after completion of the installation, Company shall repeat the function test of the electrical tracing cable. With a negative result, the insulation shall be removed, the fault corrected and then the insulation shall be restored.

If the design makes extremities necessary, contact or damage of the tracing cable shall be excluded. For the protection of the tracing cable, the inner radius of the ends shall be protected accordingly (cut-proof sealing strap/metallically protected execution).

The insulation cladding shall be labelled on the outside, e.g. with an identification sign with the words "electrical tracing" by the Contractor. The signs do are not included in the scope of supply of the Contractor.

5.7 Personnel Protection Insulation

Uninsulated, warm components with an operating temperature $> 60^{\circ}\text{C}$ shall get personnel protection insulation to avoid injuries as a result of unintended contact if they

- are above movement areas or service gangways up to a height of 2,5 m
- and/or have a lateral gap of $\leq 0,5$ m to ladders and service gangways

The work shall be carried out as heat insulation (W) with insulation thicknesses as per Table 5 (PP).

Revision: table 1 added, table 3 new, standard changed for global manufacturing

Previous Issues: 07.2005, 09.2005

Responsible department for the technical content: TME

LS-Class 2: for project specific use

Refer to protection notice ISO 16016

Annex A (normative)

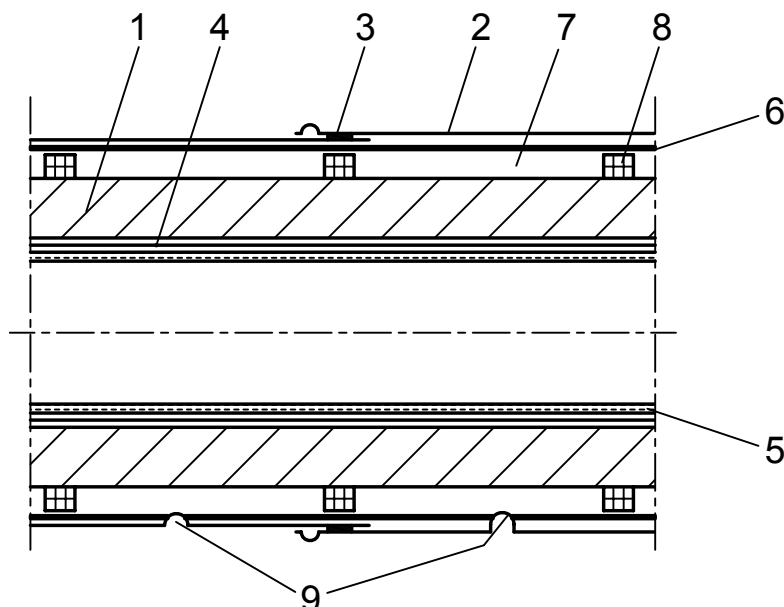
Design of insulation. Figures

A.1 Overview

Table A.1: Index of detail design drawings

Figure	Insulation type	Description
A.1	E, ES, EE, EES	Insulation design
A.2	E, ES, EE, EES	Spacer Ring Construction
A.3	E, ES, EE, EES	Elbow insulation
A.4	E, ES, EE, EES	End piece insulation, horizontal, vertical
A.5	E, ES, EE, EES	Flange insulation
A.6	E, ES, EE, EES	Valve insulation
A.7	E, ES, EE, EES	Vessel insulation horizontal
A.8	E, ES, EE, EES	Vessel insulation vertical, bottom end
A.9	WM	Insulation design
A.10	WM	End piece insulation, horizontal, vertical
A.11	WM	Vessel insulation vertical, bottom end
A.12	W, WE, WS, WES, S, PP	Insulation design
A.13	W, WE, WS, WES, S, PP	Spacer ring construction, for Insulation type W, PP: VT > 200°C
A.14	W, WE, PP	Spacer ring construction, VT ≤ 200°C
A.15	W, WE, WS, WES, S	Design pipes, valves, flanges
A.16	W, WE, WS, WES, S	End pieces insulation, horizontal, vertical
A.17	W, WE, WS, WES, S	Vessel insulation vertical, bottom end
A.18	all	Electrical tracing: grommet for heating cable

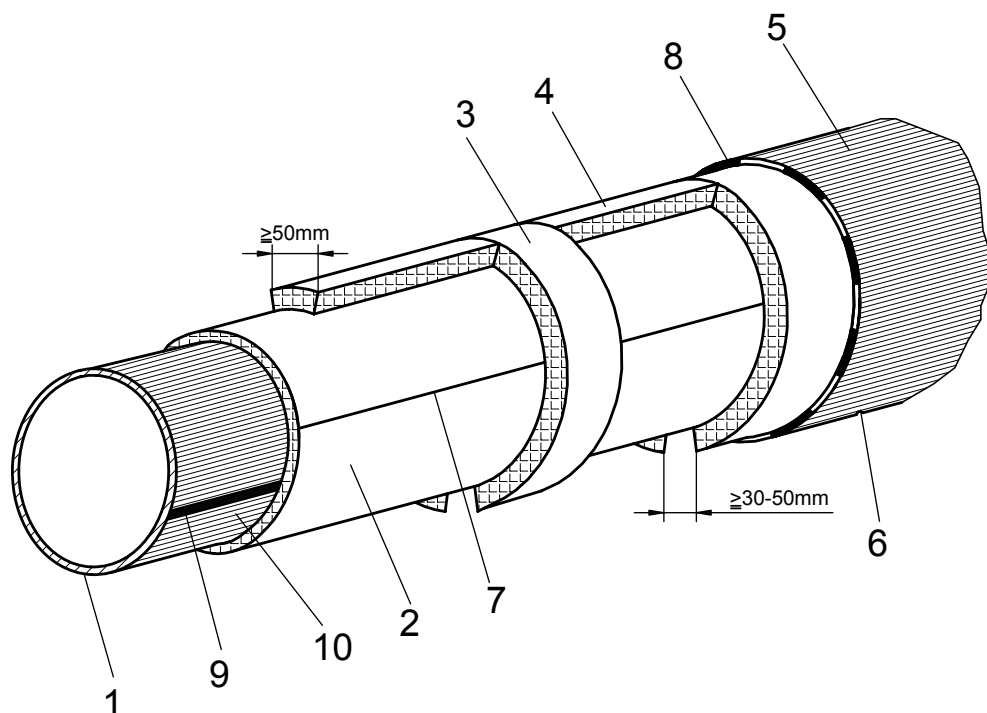
A.2 Insulation type E,ES, EE, EES



Key

- | | |
|---|--|
| 1 Insulation material: elastomeric foam | 6 Anti boom material (only ES, EES) |
| 2 Metal cladding | 7 Air ventilation 19mm |
| 3 Sealing | 8 Spacer ring construction: elastomeric foam |
| 4 Aluminium foil (only EE, EES) | 9 Ventilation/drainage opening $\varnothing > 10\text{mm}$ |
| 5 Electrical tracing (only EE, EES) | |

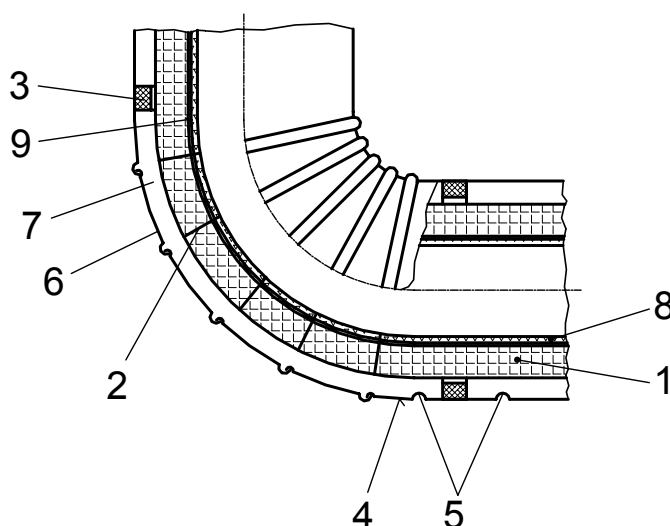
Figure A.1: Principle sketch Insulation design E, ES, EE, EES



Key

- | | |
|---|--|
| 1 Component | 6 Ventilation/drainage opening $\varnothing > 10\text{mm}$ |
| 2 Insulation material: elastomeric foam | 7 Cutting edge elastomeric foam – adhesion joint, glued completely |
| 3 Spacer ring construction: radial (elastomeric foam, 19mm thick) | 8 Anti boom material (only ES, EES) |
| 4 Spacer ring construction axial (elastomeric foam, 19mm thick) (only DN > 500) | 9 Electrical tracing (only EE, EES) |
| 5 Metal cladding | 10 Aluminium foil (only EE, EES) |

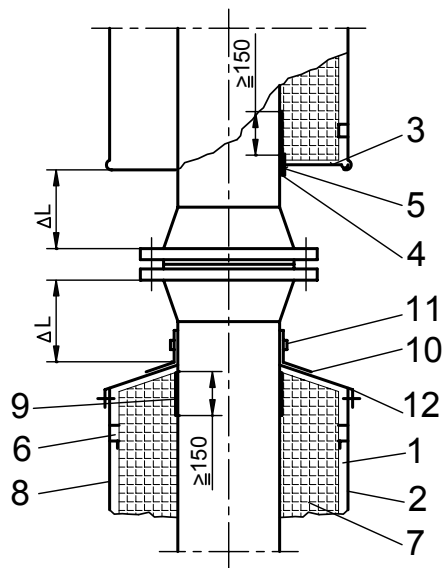
Figure A.2: Principle sketch Spacer Ring Construction E, ES, EE, EES



Key

- | | |
|--|-------------------------------------|
| 1 Insulation material: elastomeric foam | 6 Anti boom material (only ES, EES) |
| 2 elastomeric foam – adhesion joint, glued completely | 7 Air ventilation |
| 3 Spacer ring construction: elastomeric foam (19mm thick) | 8 Electrical tracing (only EE, EES) |
| 4 Metal cladding | 9 Aluminium foil (only EE, EES) |
| 5 Ventilation/drainage opening $\varnothing > 10\text{mm}$ | |

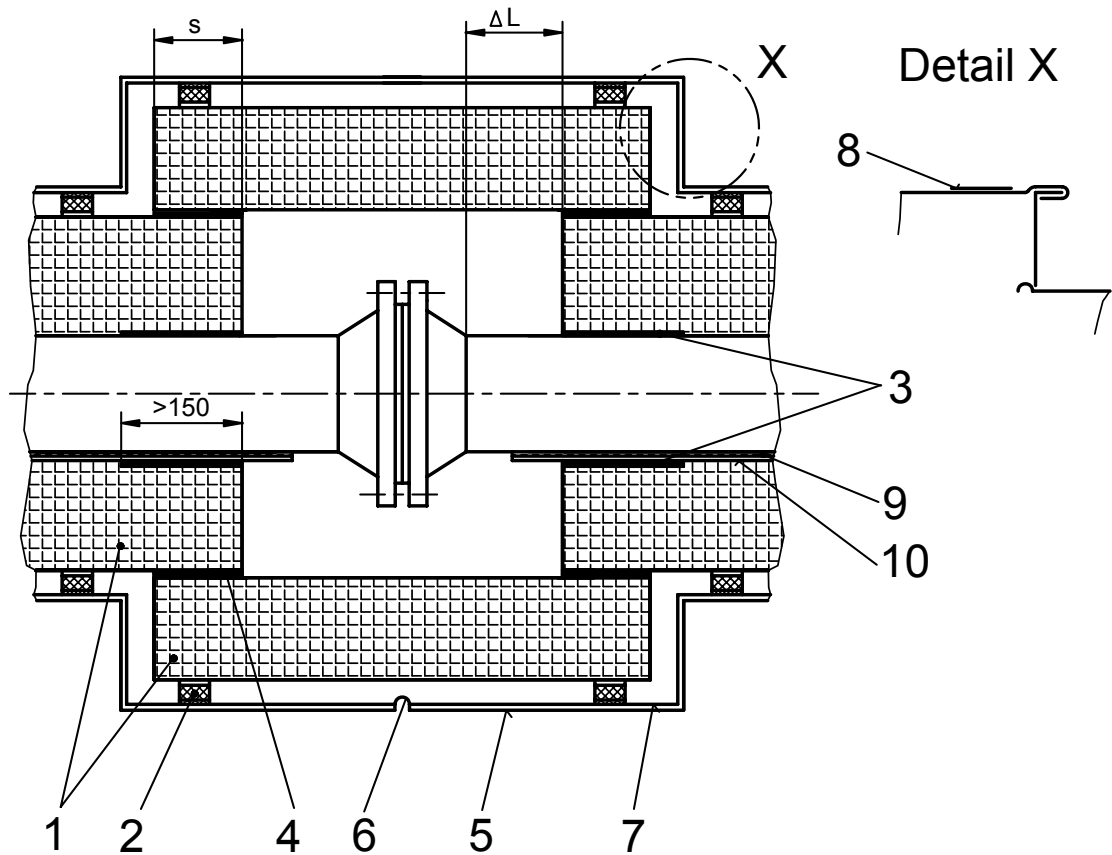
Figure A.3: Principle sketch Elbow insulation E, ES, EE, EES



Key

- | | |
|--|---|
| 1 Air ventilation | 8 Anti boom material (only ES, EES) |
| 2 Metal cladding | 9 Adhesion joint, glued completely (barrier) |
| 3 Extremity | 10 Rain deflector |
| 4 Alu-bitumen adhesive | 11 Strap |
| 5 Sheet metal strip | 12 Edge with Edge Profile |
| 6 Spacer ring construction: elastomeric foam | $\Delta L = \text{bolt length} + 20\text{mm}$ |
| 7 Insulation material: elastomeric foam | |

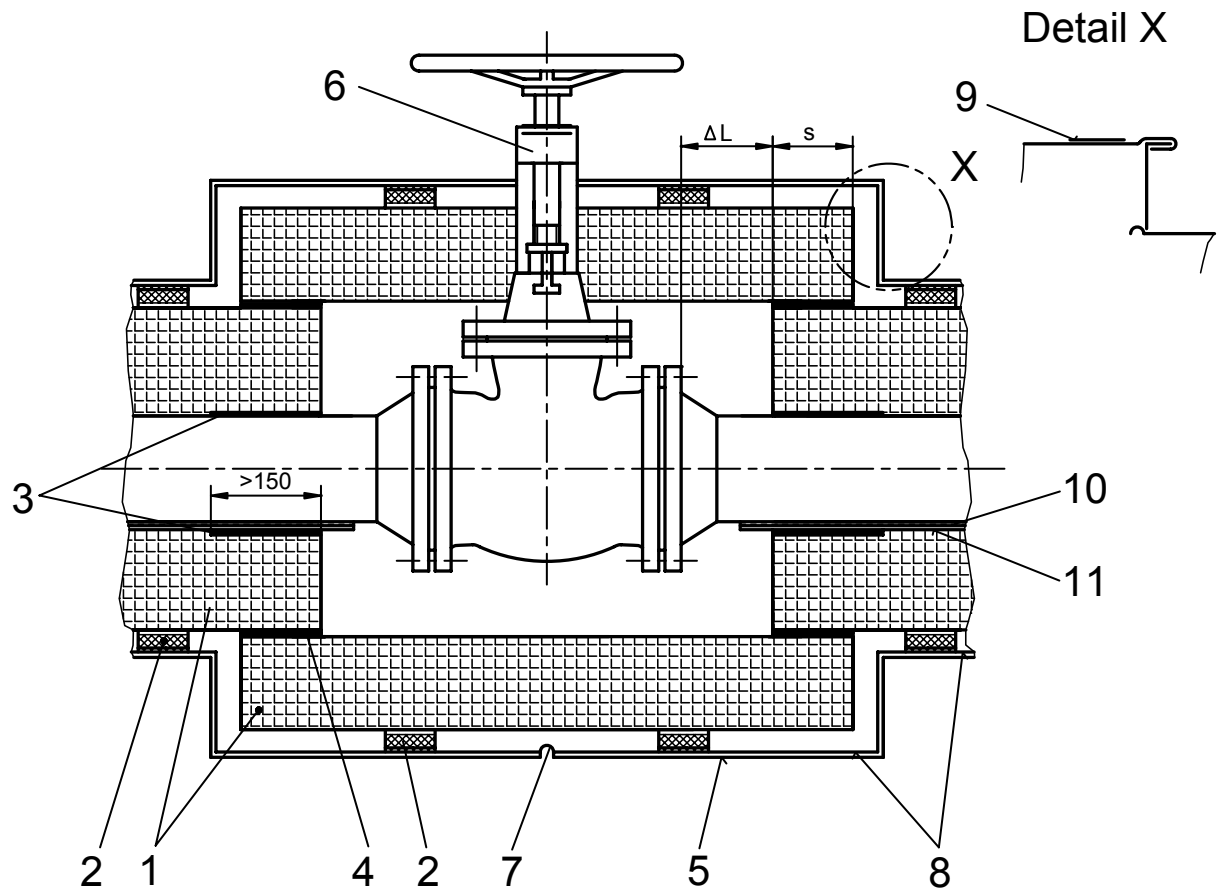
Figure A.4: Principle sketch End piece insulation, horizontal, vertical E, ES, EE, EES



Key

- | | |
|--|-------------------------------------|
| 1 Insulation material: elastomeric foam | 7 Anti boom material (only ES, EES) |
| 2 Spacer ring construction: elastomeric foam (19 mm thick) | 8 Strap with snap-on fastener |
| 3 Adhesion joint, glued completely (barrier) | 9 Electrical tracing (only EE, EES) |
| 4 Adhesion joint of overlap, glued completely | 10 Aluminium foil (only EE, EES) |
| 5 Metal cladding | s = insulation thickness |
| 6 Ventilation/drainage opening $\varnothing > 10\text{mm}$ | ΔL = bolt length + 20mm |

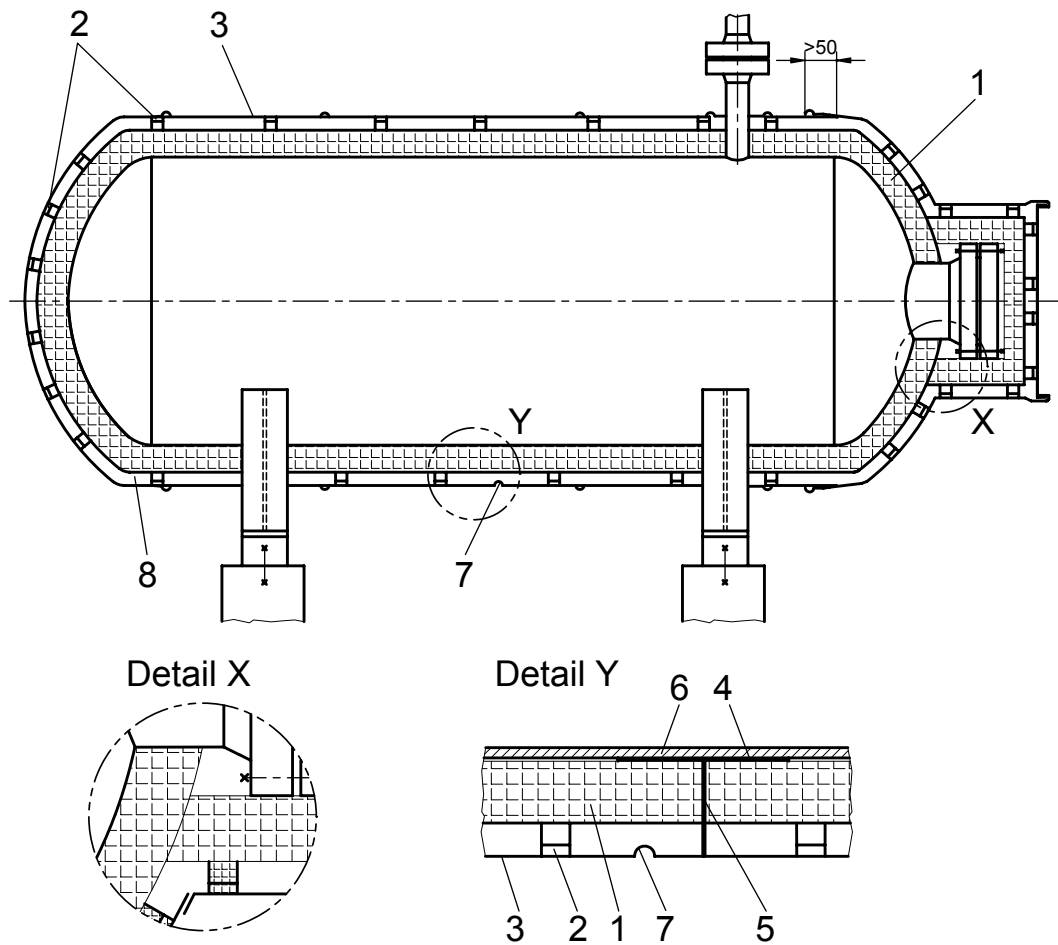
Figure A.5: Principle sketch Flange insulation E, ES, EE, EES



Key

- | | |
|--|--------------------------------------|
| 1 Insulation material: Elastomeric foam | 8 Anti boom material (only ES, EES) |
| 2 Spacer ring construction: elastomeric foam (19mm thick) | 9 Strap with snap-on fastener |
| 3 Adhesion joint, glued completely (barrier) | 10 Electrical tracing (only EE, EES) |
| 4 Adhesion joint of overlap, glued completely | 11 Aluminium foil (only EE, EES) |
| 5 Metal cladding | s = insulation thickness |
| 6 Easy to access stuffing box | ΔL = bolt length + 20mm |
| 7 Ventilation/drainage opening $\varnothing > 10\text{mm}$ | |

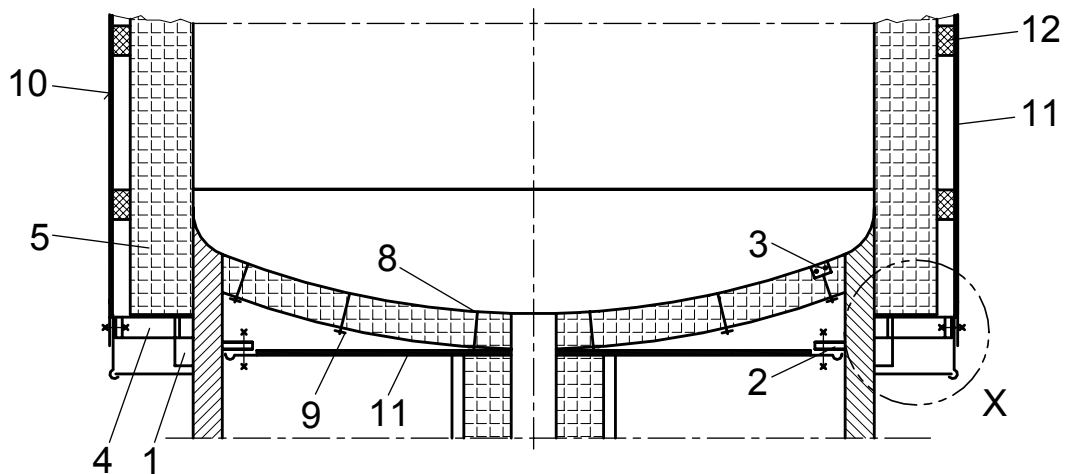
Figure A.6: Principle sketch Valve insulation E, ES, EE, EES



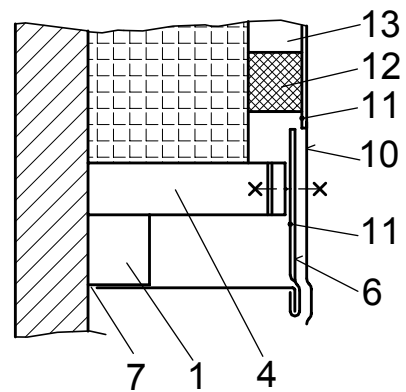
Key

- | | |
|--|--|
| 1 Insulation material: elastomeric foam | 6 Component |
| 2 Spacer ring construction: elastomeric foam (19mm thick) | 7 Ventilation/drainage opening $\varnothing > 10\text{mm}$ |
| 3 Metal cladding | 8 Air ventilation |
| 4 Adhesion joint, glued completely (barrier) $\geq 150\text{mm}$ | 9 Anti boom material (only ES, EES) |
| 5 Elastomeric foam seam, glued completely | |

**Figure A.7: Principle sketch Vessel insulation horizontal, E, ES, EE, EES
(Shown without tracing)**



Detail X

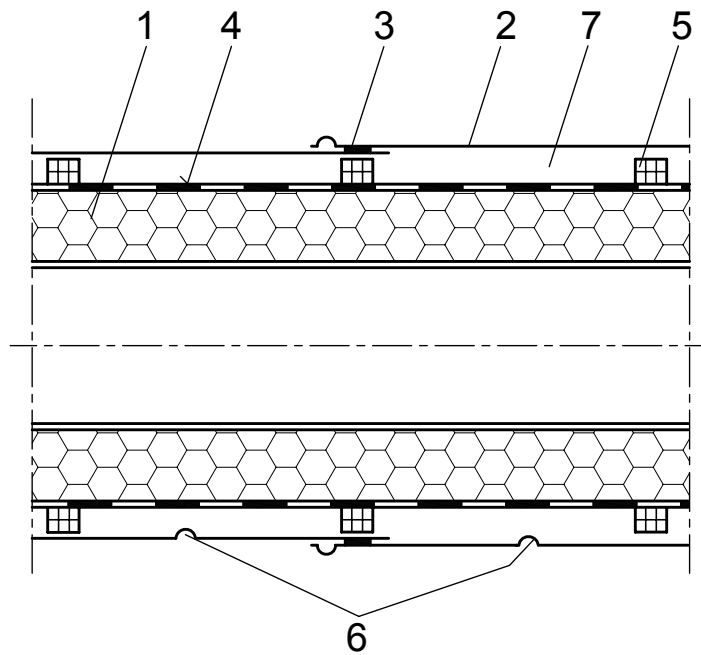


Key

- | | |
|--|---|
| 1 Mounting (neps) for supporting structure | 8 Pin \varnothing 3mm (min. 6 pieces/m ² , provided by client) |
| 2 Mounting for cladding | 9 Clip |
| 3 Alternative mounting to fix pins | 10 Metal cladding |
| 4 Supporting structure | 11 Anti boom material (only ES, EES) |
| 5 Insulation material: elastomeric foam | 12 spacer ring construction: elastomeric foam (19 mm thick) |
| 6 End -frame, folded | 13 Air ventilation |
| 7 Circumferential gap 3 – 5mm | |

Figure A.8: Principle sketch Vessel insulation, bottom end, E, ES, EE, EES
(Shown without tracing)

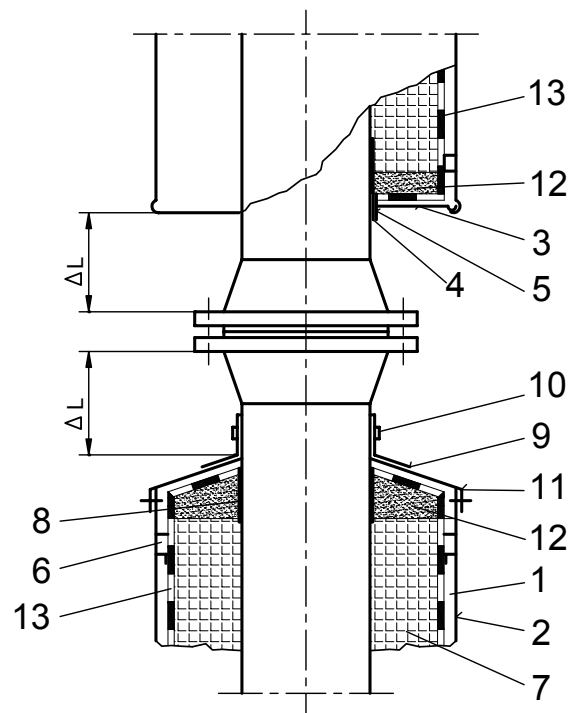
A.3 Insulation type WM



Key

- | | |
|--|--|
| 1 Insulation material: mineral fibre aluminium faced (Lamella mat) | 4 Vapour barrier (aluminium facing) |
| 2 Cladding | 5 Spacer ring construction: elastomeric foam (19 mm) |
| 3 Sealing | 6 Ventilation/drainage opening $\varnothing > 10\text{mm}$ |
| | 7 Air ventilation 19 mm |

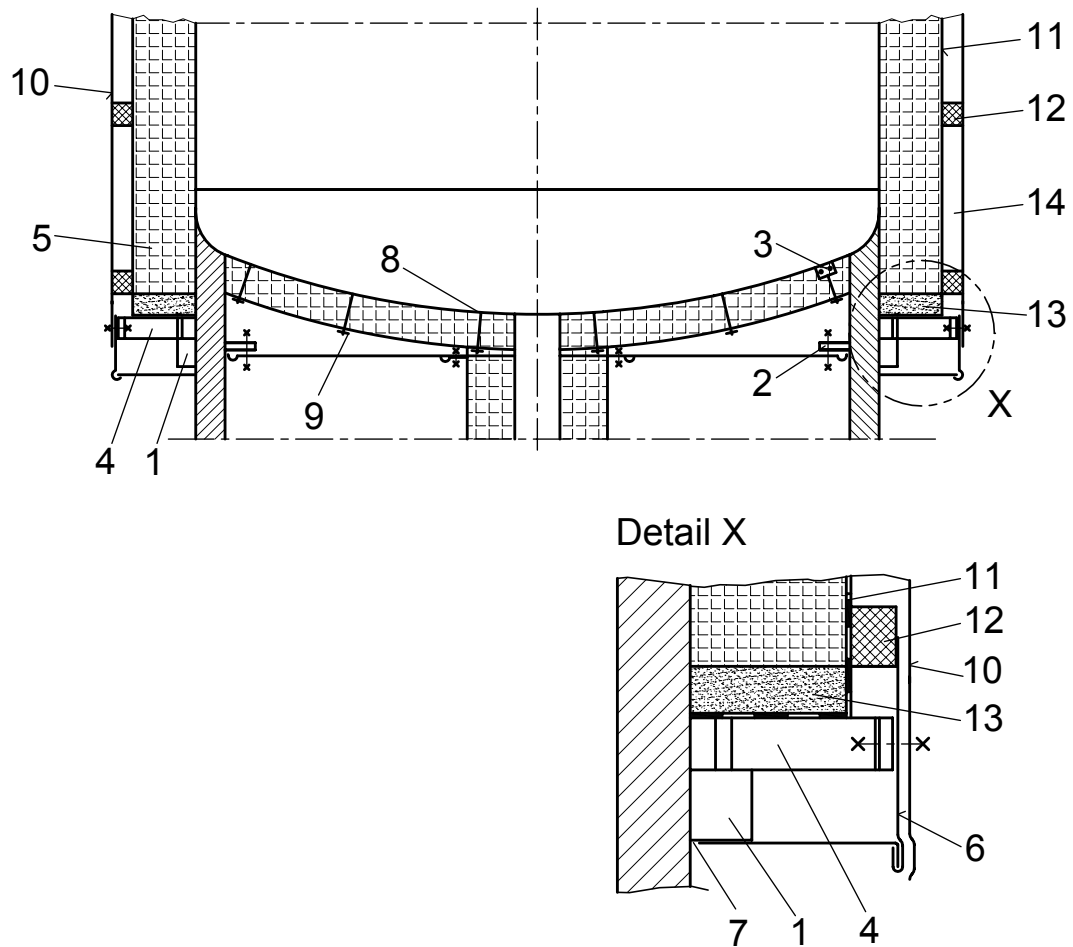
Figure A.9: Principle sketch Insulation design WM



Key

- | | |
|--|------------------------------------|
| 1 Air ventilation | 8 Adhesion joint, glued completely |
| 2 Metal cladding | 9 Rain deflector |
| 3 Extremity | 10 Strap |
| 4 Alu-bitumen adhesive | 11 Edge with Edge Profile |
| 5 Sheet metal strip | 12 Closed end: elastomeric foam |
| 6 Spacer ring construction: elastomeric foam | 13 Vapour barrier |
| 7 Insulation material: mineral fibre aluminium faced | ΔL = bolt length + 20mm |

Figure A.10: Principle sketch End piece insulation, horizontal, vertical, WM
Used for uninsulated, vertical flanges and horizontal end pieces (upper part of drawing)

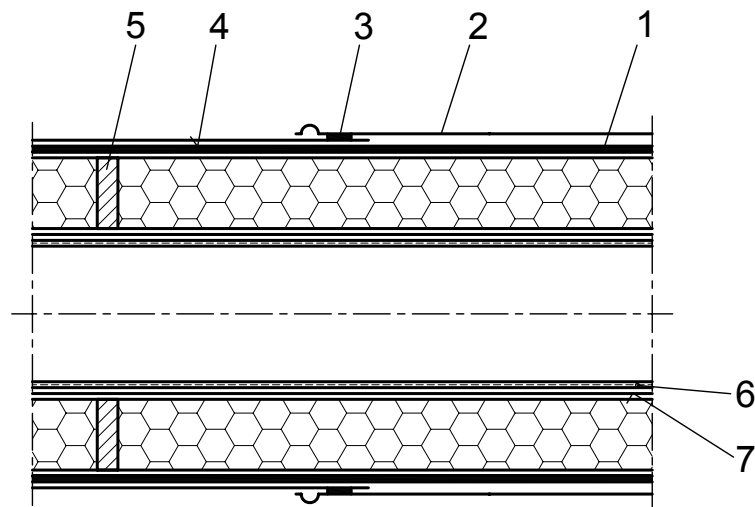


Key

- | | |
|--|--|
| 1 Mounting (neps) for supporting structure | 8 Pin \varnothing 3 mm (min. 6 pieces/m ² , provided by client) |
| 2 Mounting for cladding | 9 Clip |
| 3 Alternative mounting to fix pins | 10 Metal cladding |
| 4 Supporting structure | 11 Vapour barrier |
| 5 Insulation material: mineral fibre | 12 Spacer ring construction: elastomeric foam |
| 6 End -frame, folded | 13 Closed - end: elastomeric foam (19mm thick) |
| 7 Circumferential gap 3 – 5mm | 14 Air ventilation |

Figure A.11: Principle sketch Vessel insulation, bottom end, WM

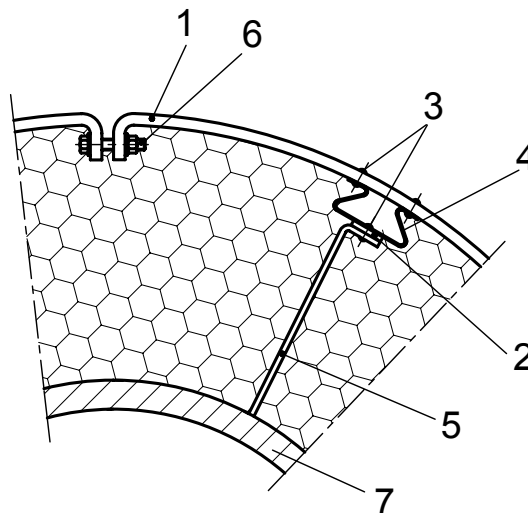
A.4 Insulation type W, WE, WS, WES, S, PP



Key

- | | |
|--|-------------------------------------|
| 1 Insulation material: mineral fibre | 5 Spacer ring construction |
| 2 Cladding | 6 Electrical tracing (only WE, WES) |
| 3 Sealing | 7 Aluminium foil (only WE, WES) |
| 4 Anti boom material (only S, WS, WES) | |

Figure A.12: Principle sketch Insulation design W, WE, WS, WES, S, PP

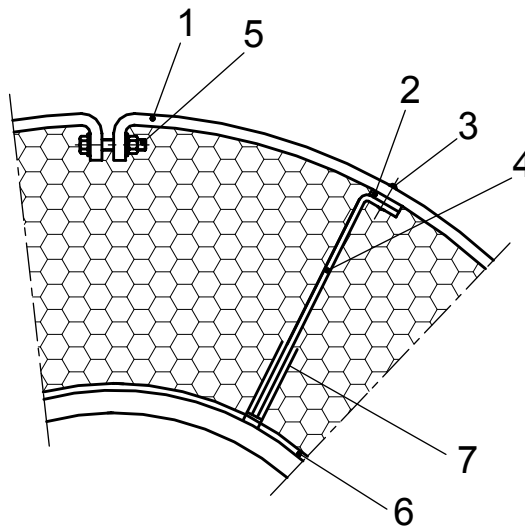


Key

- | | |
|---------------------------------------|-----------------------|
| 1 Thrust ring | 5 Spacer |
| 2 Heat insulation layer | 6 Holding – down bolt |
| 3 Rivet $\varnothing \geq 5\text{mm}$ | 7 Component |
| 4 Omega clip | |

Figure A.13: Principle sketch Spacer ring construction (W, PP, if VT > 200°C)

A.5 Insulation type W, WE, PP

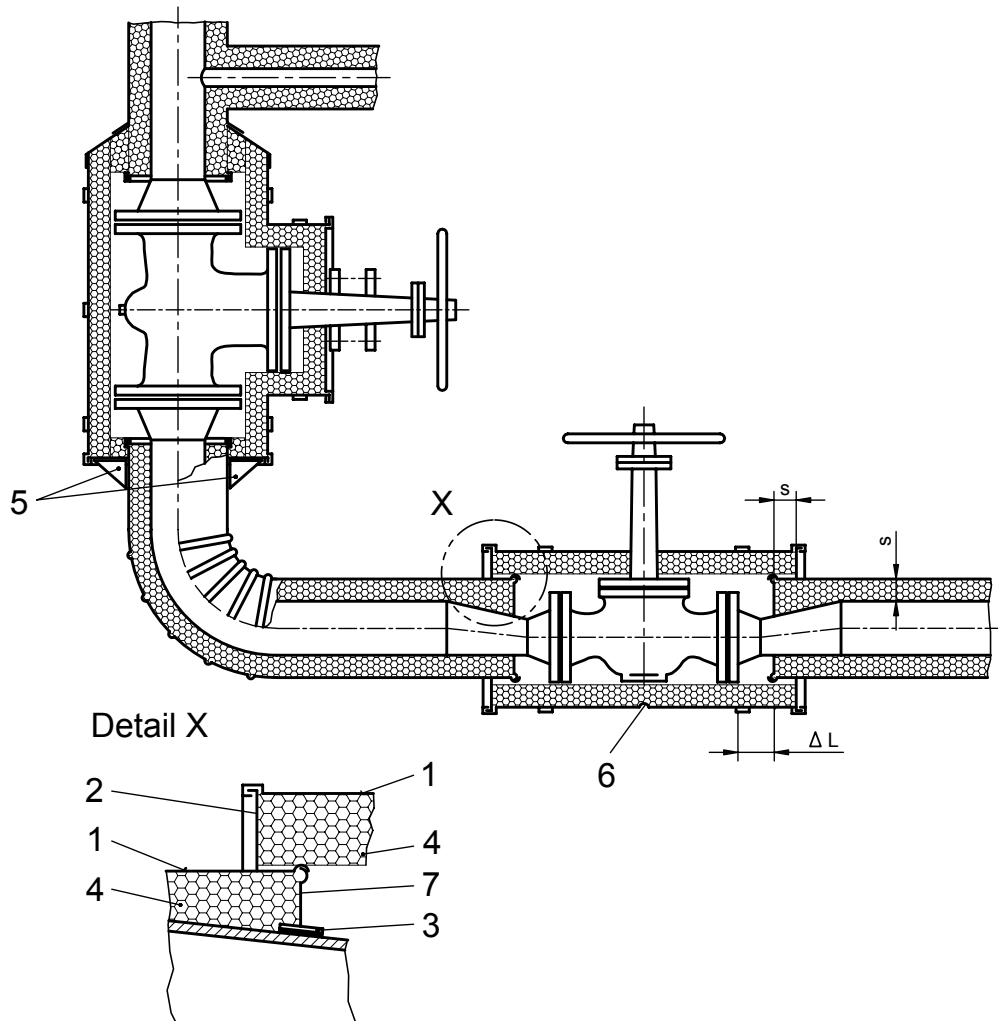


Key

- | | |
|--|---|
| 1 Thrust Ring | 5 Holding down bolt |
| 2 Heat insulation layer | 6 Protection sheet metal strip (applies only to coated components), or alternative 7. |
| 3 Rivet $\varnothing \geq 5\text{mm}$ | 7 Plugshoes (applies only to coated components) |
| 4 Standard Spacer (bevelled and notched) | |

Figure A.14: Principle sketch Spacer ring construction (W, WE, PP, if VT $\leq 200^\circ\text{C}$)

A.6 Insulation type W, WE, WS, WES, S

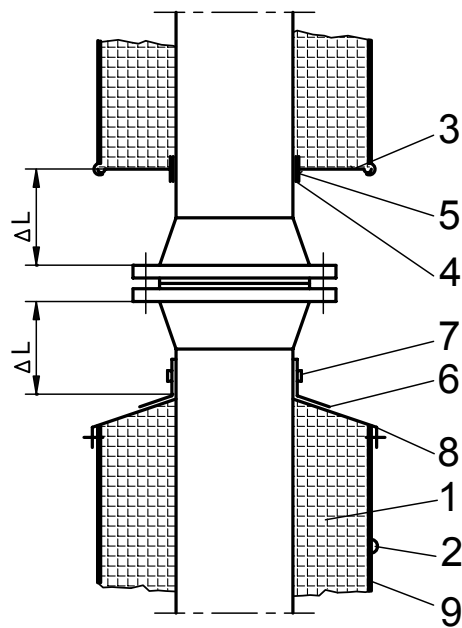


Key

- 1 Metal cladding
- 2 End cap with rolled in extremity
- 3 Glass fabric tape with metal sheet straps
- 4 Insulation material: Elastomeric foam
- 5 Support for removable covering

- 6 Ventilation/drainage opening $\varnothing > 10\text{mm}$
- 7 Engaged extremity (approved for Pipe work)
- s = insulation thickness
- ΔL = bolt length + 20mm

Figure A.15: Principle sketch Design pipes, valves, flanges W, WE, WS, WES, S

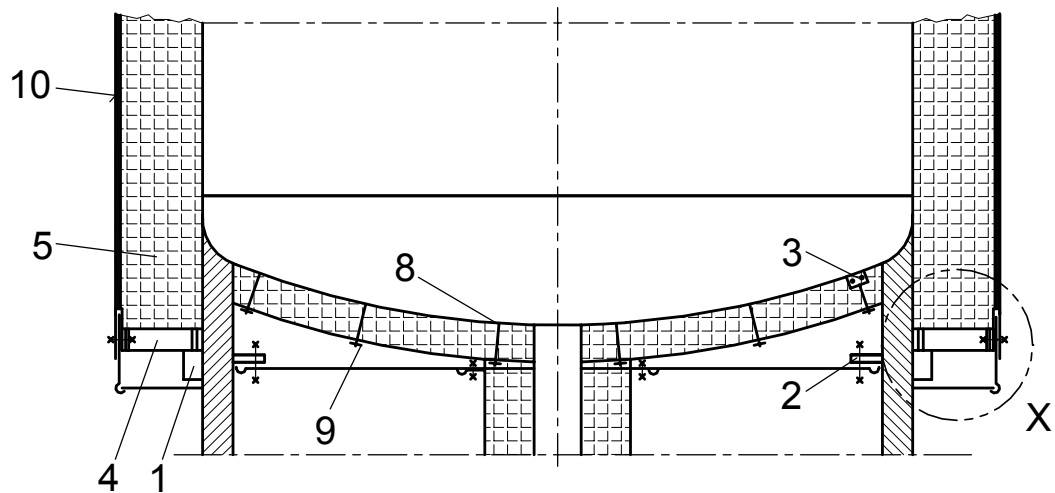


Key

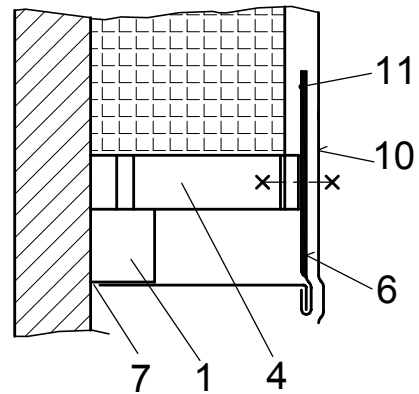
- 1 Insulation material: mineral fibre
- 2 Metal cladding
- 3 Extremity
- 4 Glass fabric tape
- 5 Sheet metal strip

- 6 Rain deflector
- 7 Band
- 9 Sound absorbing material (only WES, WS, S)
- ΔL = bolt length + 20mm
- s = insulation thickness

Figure A.16: Principle sketch End pieces insulation, W, WE, WS, WES, S (upper part of drawing) (shown without tracing)



Detail X

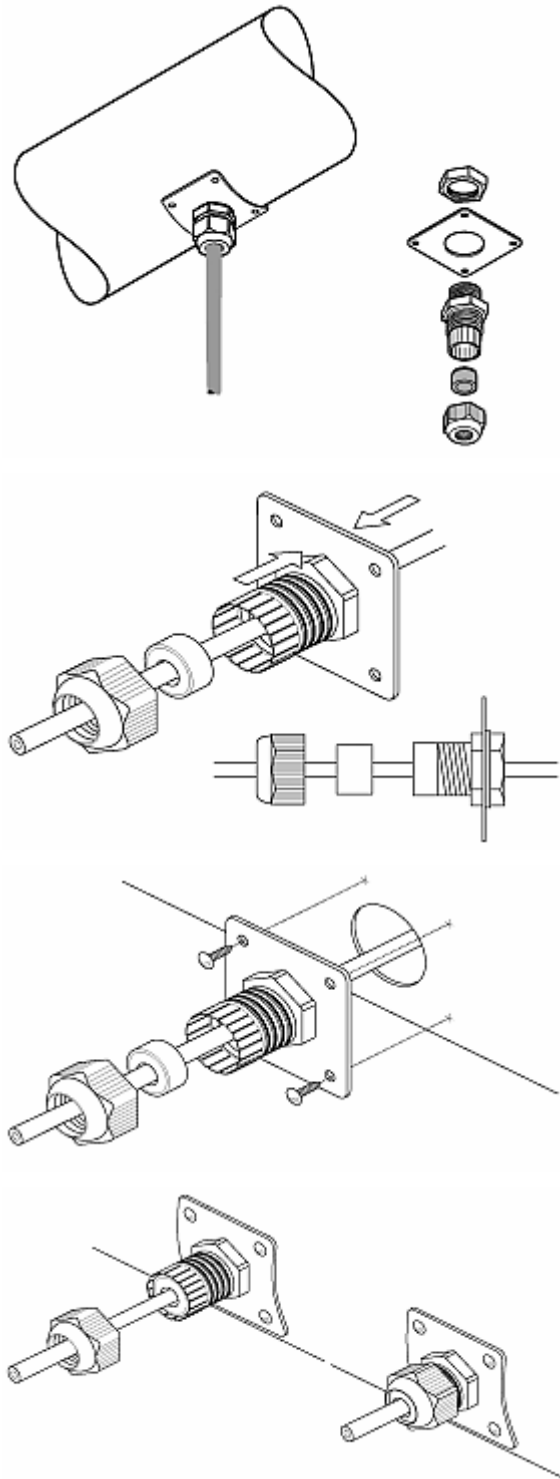


Key

- | | |
|--|---|
| 1 Mounting (Neps) for supporting structure | 7 Circumferential gap 3 – 5mm |
| 2 Mounting for cladding | 8 Pin \varnothing 3mm (min. 6 pieces/m ² , provided by client) |
| 3 alternative cladding to fix pins | 9 Clip |
| 4 Supporting structure | 10 Metal cladding |
| 5 Insulation material: mineral fibre | 11 Anti boom material (only WES, WS, S) |
| 6 End-frame, folded | |

Figure A.17: Principle sketch Vessel insulation bottom end, W, WE, WS, WES, S

A.7 Electrical tracing: Grommet for heating cable



Unscrew backnut from gland body.

Position locknut, fixing plate, grommet and gland components on the heating cable in the order shown.

Tighten locknut securely onto gland body.

Secure the fixing plate to the cladding with self-tapping screws, pop rivets or equivalent. Seal with suitable sealant.

Position grommet in the gland body. Ensure it is seated squarely. Tighten backnut securely onto gland body leaving one full thread showing.

Figure A.18: Electrical tracing – grommet for heating cable for all types of insulation