Employer
SAKO BRNO A.S.

Project
High-efficient combined heat and power facility utilizing renewable sources (OHB II - line K1)

Date
February 2021

PART III, APPENDIX 14.4
INSULATION AND CLADDING FOR PROCESS

SAKO

RAMBØLL

PART III, APPENDIX 14.4
INSULATION AND CLADDING FOR PROCESS

Project name	**High-efficient combined heat and power facility utilizing renewable sources (OHB II - line K1)**
Version	**1**
Date	**2021-02-25**
Documentation	**Procurement documentation – Part III – Employer's Requirements**

Ramboll
Hannemanns Allé 53
DK-2300 Copenhagen S
Denmark

T +45 5161 1000
F +45 5161 1001
www.ramboll.com/energy

Rambøll Danmark A/S
DK reg.no. 35128417

CONTENTS

1. GENERAL

The insulation work shall, unless otherwise stated in the technical conditions, be in accordance with:

- EN/ISO 12241: Thermal insulation for building equipment and industrial installations – Calculation rules.
- EN 823: Thermal insulating products for building applications – Determination of thickness.

All parts covered by the scope of Works shall be first-rate with regard to materials as well as construction and execution of the works. Insulation material damaged in any way may not be used.

2. INSULATION REQUIREMENTS

The insulation of installations shall be dimensioned considering energy loss, surface temperature, and condensate.

In general, insulation thickness and insulation work shall be determined based on an overall optimisation of the Line and heat loss or cooling loss costs.

Applied insulation thickness and K-values for the relevant parts (pipe diameters, vessels, plane surfaces, etc.) shall be stated at the specific temperatures.

2.1 Specific insulation requirements for hot installations

All installations having a surface temperature above 40°C under continuous maximum load shall be insulated and the following minimum requirements for dimensioning of thermal insulation shall be conformed with:

- The surface temperature must never exceed 45 °C at an ambient temperature of 25 °C.
- The surface temperature must never exceed 55 °C at an ambient temperature of 40 °C or lower.

The ambient temperature will be measured 1.5 m from the surface in stationary air. Any non-compliance to this requirement shall be stated in the Contractor's Proposal.

2.2 Specific insulation requirements for cold installations

All installations having a surface temperature lower than the dew point temperature (condense formation) at minimum load shall be insulated to prevent condensation.

The insulation shall be designed in such a way that the exterior surface temperature at the vapour barrier is always higher than the surrounding air dew point temperature.

2.3 Exceptions to insulation requirements

Some exceptions to the requirements could be accepted by the Employer, e.g. for fibre-reinforced plastic scrubbers and turbine lubrications oil system. Exceptions shall be agreed with the Employer and personnel safety shall be taken care.

3. NOISE AND VIBRATIONS

The cladding and its support structure shall be designed in order to minimize possible resonance phenomena.

4. SHIELDING AGAINST SCALDING

The insulation works shall include shielding against scalding in systems where condensation of steam/cooling of condensate is desired.

All piping where cooling is desired, e.g. for the online sampling system for water/steam cycle, shall be covered by perforated steel piping to protect against scalding. The dimensioning of the perforated steel piping shall be done so that the surface requirements stated in section 2 are complied with.

Components in which condensation may be necessary for functioning, e.g. steam traps, shall have steel mesh enclosures to protect against scalding. These enclosures shall be equipped with spring locks to allow for easy dismounting without the use of tools. The dimensioning of the enclosure shall be done so that the surface requirements stated in section 2 are complied with.

5. MATERIALS

5.1 Insulation material

1. Pipes

   t ≤ 250 °C: Laminated mat, pipe insulation
   t > 250 °C: Wire mesh mat, pipe insulation

2. Vessels and plane surfaces

   t ≤ 250 °C: Plate batts, laminated mat
   t > 250 °C: Fire batts, wire mesh mat

3. Condensate insulation, insulation of cold pipes/cooling pipes

   Insulation with a flexible, diffusion proof steam barrier, e.g. Armaflex (natural rubber).

   Thermal bridges at pipe supports and the like shall be minimized.

   Application of stainless-steel piping for cold media shall be considered if technically possible.

   Solutions with mineral wool or polystyrol pipe insulation can be used but requires an effective steam barrier and an effective mechanical protection.

5.2 Steam Barrier

Cold installations shall be equipped with steam barrier with minimum steam diffusion.

5.3 Cladding

All insulation cladding shall comply with the below-mentioned dimensional requirements to protect the insulation material and a possible steam barrier against damage. All claddings shall be in a colour specified by the Employer.

1. *Pipes and round ducts*
   Corrugated aluminium plates shall be used to the extent possible for all pipes and round ducts. Corrugated plastic-coated galvanized steel plates can only be used in exceptional cases and upon approval by the Employer. In case aluminium plates are used, the following minimum thicknesses apply.

Cladding diameter	Alu-plate
0 - 350 mm	0.88 mm
350 - mm	1.00 mm

2. *Larger plane surfaces, boiler, square ducts, tanks, containers, etc.*
   The cladding shall be bolt-on plastic coated galvanized strengthened plate, e.g. corrugated or cassette solution complying with the common demands for rigidity and mechanical

strength. Alternatively, corrugated aluminium plates may be used, however this has to be approved upon by the Employer.

The plates must have a thickness of at least 0.7 mm.

Final choice and design of cladding shall be determined together with the Employer at a later stage. Key criteria for the choice will be high quality concerning finish, durability, mechanical strength, easy cleaning appropriate for the aggressive environment at the actual location in the plant.

For outside installations, special attention shall be made to the corrosion class of cladding material and fasteners (bolts, rivets etc.).

6. EXECUTION

6.1 Insulation

6.1.1 GENERAL

All insulation work shall be carried out in such a way, that the designed insulation value remains effective throughout the technical lifetime of the plant.

The applied insulation materials shall be able to bear its own weight and be resistant towards the vibrations, which occur in the installation, preventing permanent deformations and/or holes in the insulation material.

The insulation material shall be situated close to the part to be insulated, and cracks in butts or joints may not occur. If multi-layer insulation is used, the butts and joints shall be offset.

If the insulation material is thicker than 60 mm and pipe insulation is not used, the insulation shall be carried out with offset joints.

Plate claddings can normally not rest on the actual insulation material but shall be equipped with distance holders between cladding and installation. Insulation workers are not allowed to perform weldings on vessels or pipes, unless this is specifically agreed with the Employer. Only certified welders are allowed to perform weldings on vessels or pipes (see Appendix A14.1 *Welding and Inspection of Pressurized Parts*).

Cladding and insulation shall be close fitting, so that any air gap between cladding and insulation is minimized.

Installation parts, which due to operational causes can be expected to need repairs or checks, shall be insulated in such a way, that the dismounting/mounting of the insulation is easy, e.g. with sewed insulation mats.

Insulation and cladding around valves, dampers, compensators, measuring equipment, inspection hatches, or where there is a possibility of routine inspection shall be designed to ensure easy dismounting and be in a robust construction. At places where frequent dismounting becomes important, the cladding shall be furnished with spring locks.

At inspection hatches the cladding shall be led all the way to the container/duct wall in an angle of approximately 45 degrees.

At least 2 weeks prior to start of the installation, the detailed design shall be approved by the Employer.

6.1.2 RECTANGULAR DUCTS AND PLANE SURFACES

Minimum allowed insulation mat thickness is 75 mm. In situations, such as small pipes, limited space etc., a thinner mat thickness may be used, however this has to be approved upon by the Employer. The insulation is mounted directly on the duct sides.

In case of double-layer insulation, at least one layer of the insulation shall be mounted outside rib stiffenings and similar. All insulation in multi–layer insulation shall be with offset joints.

The insulation shall be fastened on plane duct sides and surfaces with Ø4.19 mm reinforcement pins, minimum 4 per m². On the underside of ducts and downward turned surfaces at least 6 Ø4.19 mm reinforcement pins per m² shall be used.

On outside horizontal duct and component surfaces the insulation shall be fastened with minimum 4 Ø4.19 mm reinforcement pins per m².

Reinforcement pins may not be used on inside horizontal surfaces of ducts and component surfaces.

On rib stiffenings and similar with necessary deformation of the insulation around a given steel profile, a suitable number of reinforcement pins shall be mounted to ensure that the insulation can be deformed and fastened as required.

The insulation work must be carried out in such a way that the individual batts are firmly fixed at their individual planes. No open cracks may occur between the individual batts, and a possible shaping of the individual batts may be considered.

The locking devices for the reinforcement pins may not cause cracks in the insulation.

6.2 Plate cladding

6.2.1 TUBES, CYLINDRICAL DUCTS AND COMPONENTS

Transverse joints in plate cladding shall be carried out with effective overlapping. Enlargement in the plate claddings axial direction caused by temperature fluctuations should be distributed on a suitable number of expansion joints.

The plate cladding and its assemblies shall be water-repellent preventing washing water, rainwater, and similar from penetrating the insulation.

The plates shall be faultless and without damages. Major damages will cause rejection. A temporary mounting with a later replacement may be required.

In places where aluminium and steel components are joined, the Contractor shall carry out the joints in such a way that galvanic corrosion is avoided.

The Contractor shall ensure that possible differential movements between the cover plates and the construction behind these in connection with temperature fluctuations are absorbed:

1. Distance holder
   Distance holders between plate cladding and pipe shall be placed with a maximum distance of 1 m for horizontal pipes and 2 m for vertical pipes in places where there is a possibility of exterior influence.

   Suggestions with design sketches of distance rings with steel legs and insulation tape at different temperatures are shown in Sketches no. 1, 2 and 3. Should the Contractor propose another design for distance holders, this shall be approved by the Employer.

Only in special circumstances, distance holders can be left out. These circumstances are small (<300 mm) horizontal pipes that are mounted in such a way that there is no risk of exterior damage. Exemptions to be agreed with the Purchaser.

2. Bends
Bends shall be designed with a number of segments dependent on pipe dimension and insulation thickness in accordance with the Sketches no. 4, 5, and 6.

3. Valves
Packing boxes, hand wheels, actuators and possible valve lubrication points must be fully accessible and located outside the insulation.
Finishing of pipe insulation to fittings shall be designed with end cladding.

Valve insulation thickness shall be the same as on the pipe, on which the valve is mounted.

4. Weld-in valves
Insulation claddings on weld-in valves with a dimension less than DN 80 shall be designed with spring locks.

Piping insulation at valves shall be finished 100 mm outside the welds under consideration to welding control. The principle of insulation is shown in Sketch no 7.

5. Flanged valves
All insulation claddings on flanged valves shall be designed with spring locks.
The principle of insulation is shown in Sketch no 8.

6. Flange joint
At flange joints in pipe systems, the cladding shall be designed with detachable claddings with spring locks.

7. Pipe fittings
Generally, the outer dimensions of the plate cladding shall follow the installations under consideration to insulation thickness ensuring that the insulation is continuous. All transitions shall be smooth.

8. Finishing with end cladding
In places where detachable claddings are required, the piping insulation shall be finished with end cladding.

Detachable insulation claddings resting on the piping insulation shall also be designed with end cladding. The end cladding shall be fastened on the detachable claddings.

9. Cut-outs
Cut-outs in plate claddings for pipe hangers, pipe saddles, fix points, etc. shall be designed as small as possible and in such a way that the insulation material is not visible nor introduce risk of injury when touched (e.g. finger cuts). If these requirements cannot be met, the plate cladding shall be designed with special tightening rosettes etc.

10. Recesses
If it becomes necessary to use recesses (bypass) in the insulation due to insufficient design, e.g. pipe crossings, galleries, or structures, there should be paid due attention to pipe

movements, and the recesses shall be designed with tight-fitting plate cladding. The contractor shall make use of high-performance insulation material where recesses will otherwise result in non-compliance with the temperature requirements described in section 2.

11. Instrument and tap branches
Instrument and tap branches and other branches, which need no further insulation, shall be provided with rosettes to make a tight fitting around the cut-outs and to cover the cut in the plate cladding.

If instruments or other equipment, which cannot be fixed on the outside of the insulation, is mounted, the plate claddings shall be provided with an inward turned conical rosette.

12. Pumps
Insulation of pumps shall be designed for demounting and equipped with spring locks. There shall be free access to packing boxes.

13. Vessels
The plate cladding shall be fastened to the distance rings with flat bars. Distance rings shall be fastened to the vessel with welded knobs, clamping bands, or similar fastening methods.

For vessel diameters smaller than 3 m, 25 x 2.5 mm bar iron shall be used. For greater diameters, 30 x 3 mm bar iron shall be used.

In places, where outer additional loads can occur, e.g. in the form of ladders placed on the insulation or where it is possible to walk on the insulation, the distance holders of the insulation cladding and the plate cover shall be designed to withstand this.

Generally, the insulation cladding should follow the vessel ends, but for smaller vessels or where special conditions apply, the contractor may install plane or conic ends.

14. Cladding overlaps
For all non-horizontal pipes/planes, cladding overlaps shall be top down, so that any water leakage cannot seep into the insulation material.

6.2.2 SQUARE DUCTS AND PLANE SURFACES

1. General
The same as stated in Section 6.2.1.

2. Design
Plate cladding including supports shall be designed in such a way that permanent deformations on the cladding are avoided at the following assumed loads:

Top sections	:	1.0 kN on 0.1 x 0.1 m
Side sections	:	0.5 kN on 0.1 x 0.1 m

7. INSPECTION OF INSULATION WORK

7.1 Inspections by the Contractor

Throughout the insulation work process, the Contractor shall supervise all installations to make sure that the work is carried out according to the requirements and the correct materials are used.

Inspection of the insulation shall be carried out according to the below mentioned requirements.

7.1.1 INSPECTION OF THE EXECUTION OF WORK

Inspections during the execution of work shall ensure that the prescribed materials and insulation thickness are used. Additionally, the inspections shall ensure that the work is carried out in accordance with the present technical conditions.

7.1.2 MEASUREMENT OF INSULATION THICKNESS OR OUTSIDE DIMENSIONS

If the arithmetic mean of the measurements is less than the stated value, and single measurements differ more than 15 % from the arithmetic mean, the insulation work may be rejected.

7.1.3 MEASUREMENTS OF THE SURFACE TEMPERATURE OF THE FINISHED INSULATION DURING OPERATION.

With reference to section 2, the surface temperature should not exceed 45 °C at a surrounding temperature of 25 °C. If measurements during operation show that the surface temperature generally exceeds 45 °C or sporadically (at distance holders) exceeds 50 °C, the insulation work will be rejected.

7.2 Inspections by the Employer

The scope of inspection by the Employer will be spot testing and will be carried out on the Employer's request and at the Employer's expense.

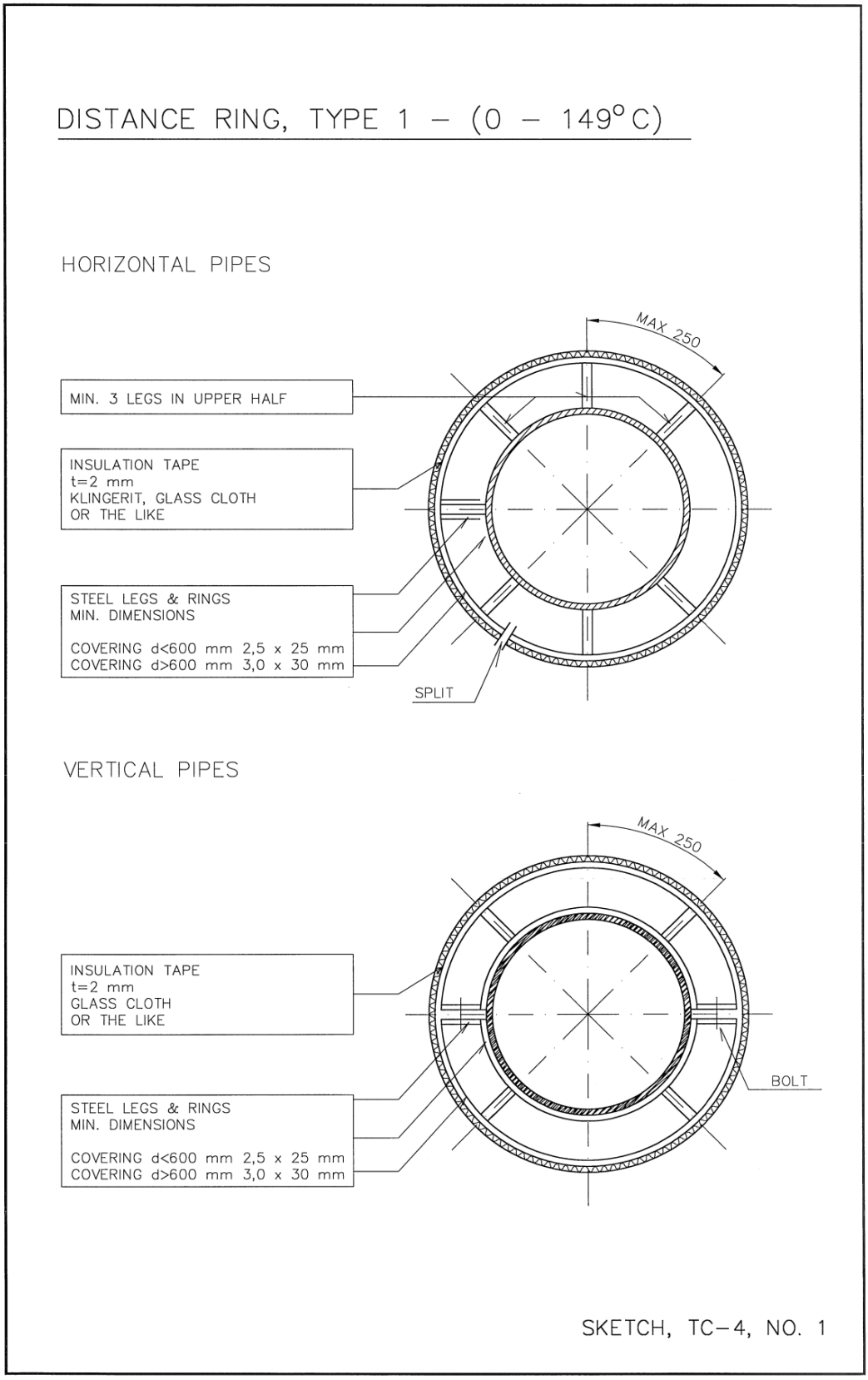
This inspection does not exempt the Contractor from carrying out the required inspection by the Contractor.

During the Warranty period, the Employer has the possibility of having a thermovision report carried out to check if the insulation is intact and is in accordance with the Employer's requirements. If the inspection shows that the insulation has been damaged in any way, e.g. forming of cavities etc., the Contractor should correct these damages. The work shall be done at the Contractor's expense.

If the inspection shows any lacks concerning insulation thickness or surface temperature, the Contractor must cover all expenses for all repairs as well as a re-inspection.

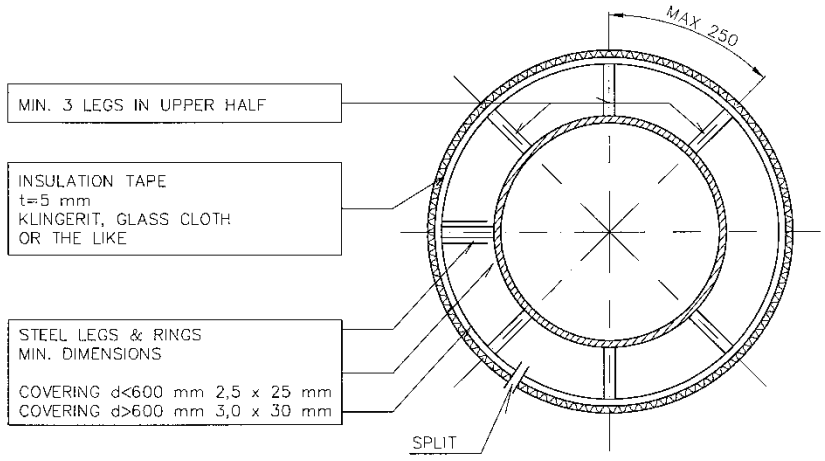
Additionally, the Contractor must repair all detected defects and damages in the scope of Contract Object at the Contractor's expense.

8. SKETCHES

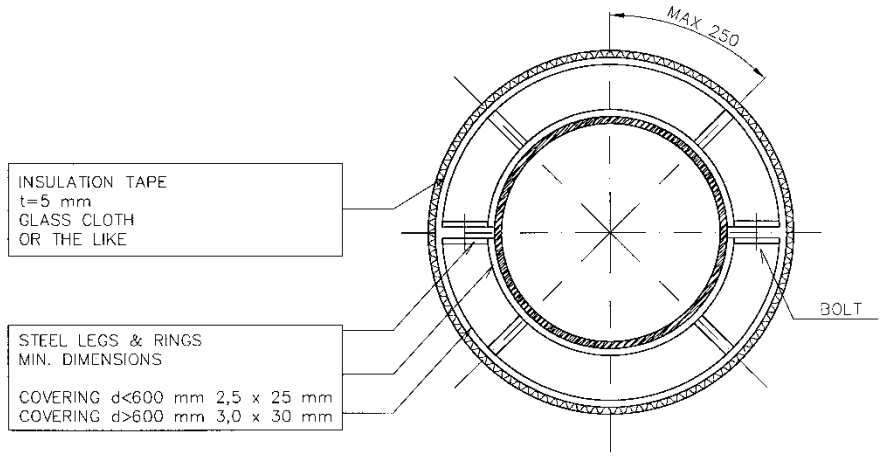

DISTANCE RING, TYPE 1 – (0 – 149°C)
HORIZONTAL PIPES
MAX. 250
MIN. 3 LEGS IN UPPER HALF
INSULATION TAPE
t=2 mm
KLINGERIT, GLASS CLOTH
OR THE LIKE
STEEL LEGS & RINGS
MIN. DIMENSIONS
COVERING d<600 mm 2,5 x 25 mm
COVERING d>600 mm 3,0 x 30 mm
SPLIT
VERTICAL PIPES
MAX. 250
INSULATION TAPE
t=2 mm
GLASS CLOTH
OR THE LIKE
STEEL LEGS & RINGS
MIN. DIMENSIONS
COVERING d<600 mm 2,5 x 25 mm
COVERING d>600 mm 3,0 x 30 mm
BOLT
SKETCH, TC–4, NO. 1

DISTANCE RING, TYPE 2 – (150 – 399°C)

HORIZONTAL PIPES



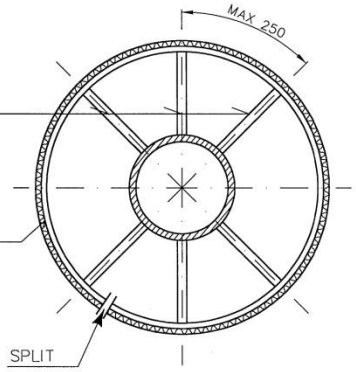
VERTICAL PIPES



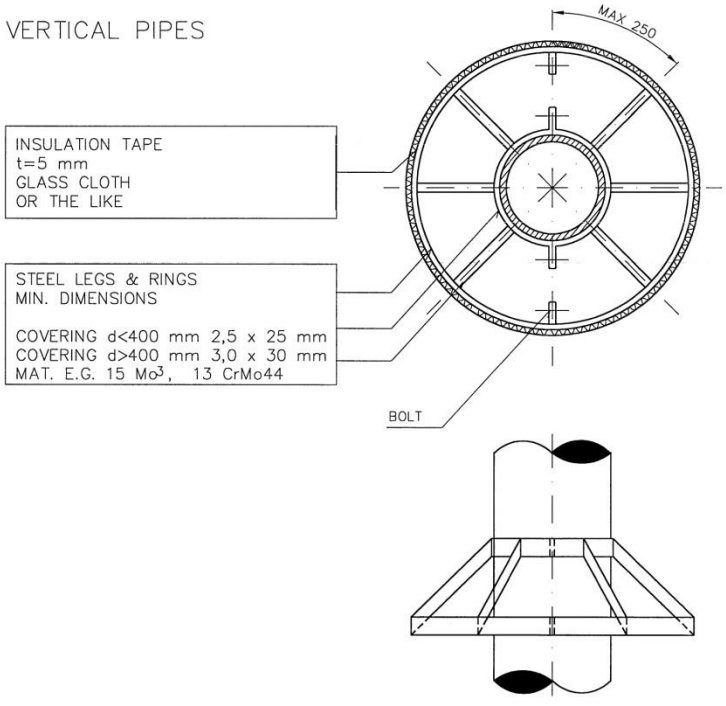
SKTECH, TC–4, NO. 2

DISTANCE RING, TYPE 3 – (400 – 600° C)

HORIZONTAL PIPES

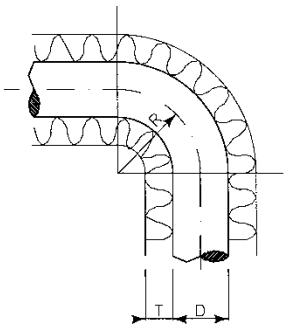


VERTICAL PIPES



SKETCH, TC–4, NO. 3

90° PIPE BENDS, R=1.5 x D

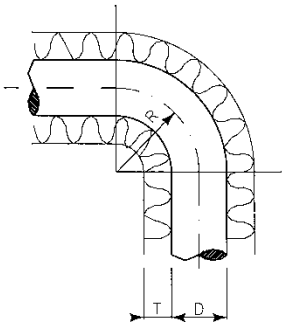


NO. OF SHEETS FOR A 90° BEND									
OUTS. DIAM.	INSULATION THICKNESS, T IN mm								
	30	60	90	120	150	180	210	240	270
17.2	4	4	4	4	4				
21.3	4	4	4	4	4				
26.9	4	4	4	4	4				
33.7	4	4	4	4	4				
42.4	4	4	4	4	4				
48.3	4	4	4	4	4				
60.3	4	4	4	4	4	5			
76.1	4	4	4	4	4	5			
88.9	4	4	4	4	4	6			
114.3	4	5	5	6	6	7			
139.7	4	5	6	7	7	8			
168.3	5	5	6	7	7	8			
219.1	5	6	7	7	8	9			
273.0	5	6	8	8	9	10			
323.9	6	7	9	9	10	10			
355.6	7	8	9	9	10	10			
406.4	8	9	9	9	10	10			
508.0	10	10	10	10	10	11			
(620)	12	12	12	12	12	12			

BENDS < 90°ARE ROUND UP TO A COMPLETE NUMBER OF SHEETS

SKETCH, TC-4, NO. 4

90° PIPE BENDS, R=3.0 x D

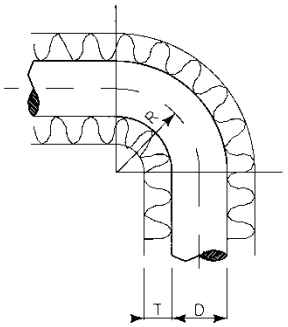


NO. OF SHEETS FOR A 90° BEND									
OUTS. DIAM.	INSULATION THICKNESS, T IN mm								
	30	60	90	120	150	180	210	240	270
17.2	4	4							
21.3	4	4							
26.9	4	5	5						
33.7	5	5	5	5					
42.4	5	5	6	6					
48.3	5	5	6	6	6				
60.3	5	5	6	6	6				
76.1	6	6	6	6	7				
88.9	6	6	6	7	7	7			
114.3		7	7	7	7	8			
139.7		7	7	8	8	9			
168.3		7	7	9	9	10			
219.1		8	8	9	9	10	10		
273.0		9	9	9	10	10	11		
323.9		10	10	10	10	11	11	12	
355.6		10	10	10	11	11	12	12	
406.4		10	10	10	11	11	12	12	
508.0	12	12	12	12	12	12	12	12	
(620)	12	12	12	12	12	12	12	12	12

BENDS < 90°ARE ROUND UP TO A COMPLETE NUMBER OF SHEETS

SKETCH, TC-4, NO. 5

90° PIPE BENDS, R=5.0 x D



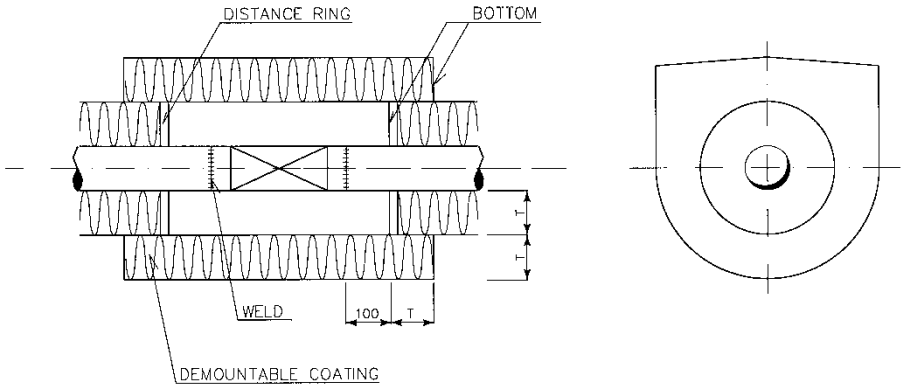
NO. OF SHEETS FOR A 90° BEND									
OUTS. DIAM.	INSULATION THICKNESS, T IN mm								
	60	90	120	150	180	210	240	270	300
17.2									
21.3									
26.9									
33.7									
42.4									
48.3									
60.3									
76.1	7								
88.9	8	8							
114.3	9	9	9						
139.7	9	9	9	11	11				
168.3	10	10	11	11	11	11			
219.1	10	11	11	11	11	12			
273.0	10	11	11	11	12	13			
323.9		11	12	12	12	13			
355.6		11	12	12	13	13			
406.4			12	12	13	15			
508.0				13	14	15	15	15	
(620)				14	15	15	15	15	15

BENDS < 90°ARE ROUND UP TO A COMPLETE NUMBER OF SHEETS

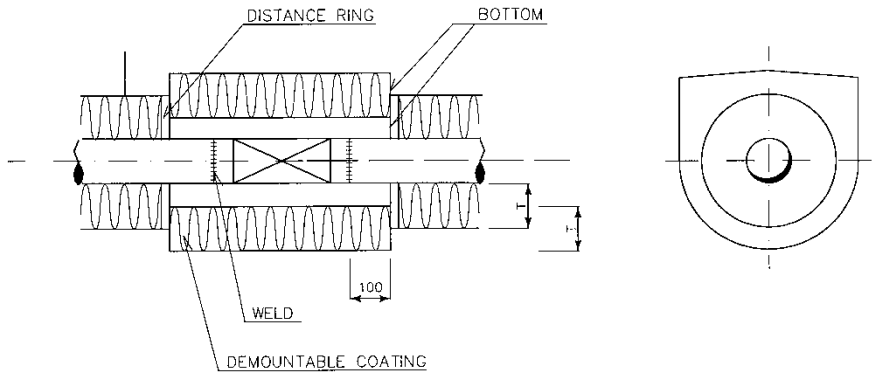
SKETCH, TC-4, NO. 6

WELDING VALVE

EXAMPLE 1



EXAMPLE 2



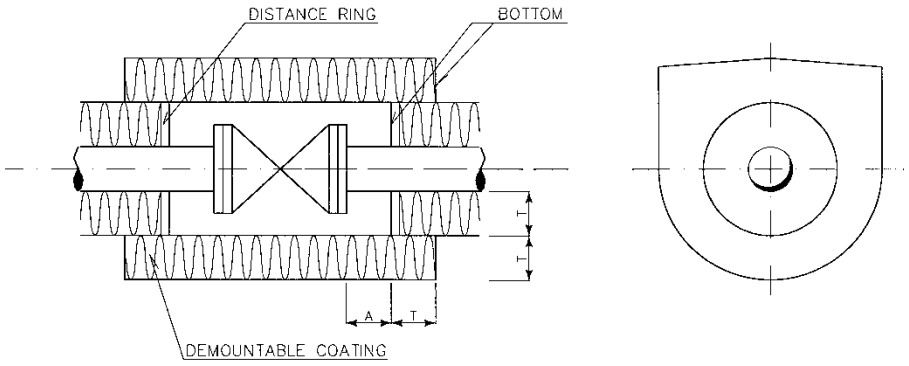
VALVE < Dn 80 COATING WITH SCREWS

VALVE > Dn 80 COATING WITH SNAP-ACTION LOCKS

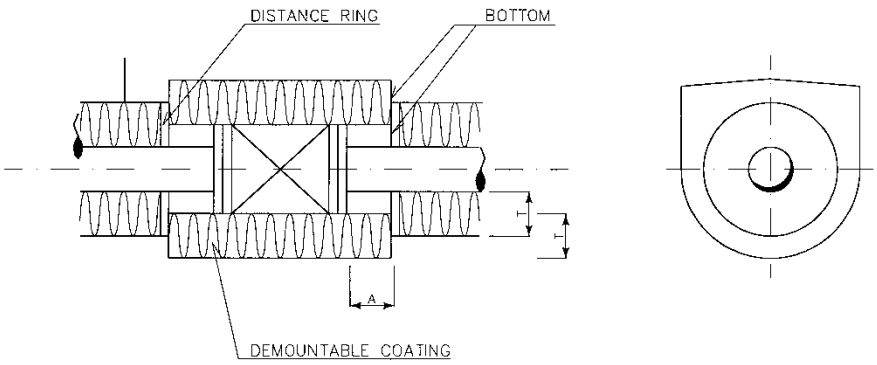
SKETCH, TC-4, NO. 7

FLANGE VALVE

EXAMPLE 1



EXAMPLE 2



VALVE < Dn 80 COATING WITH SCREWS

VALVE > Dn 80 COATING WITH SNAP-ACTION LOCKS

Dn	20	40	50	80	100	150	200	250	300	350	400	500	600
Dn	80	90	90	100	110	125	145	155	165	190	195	200	210

SKETCH, TC-4, NO. 8