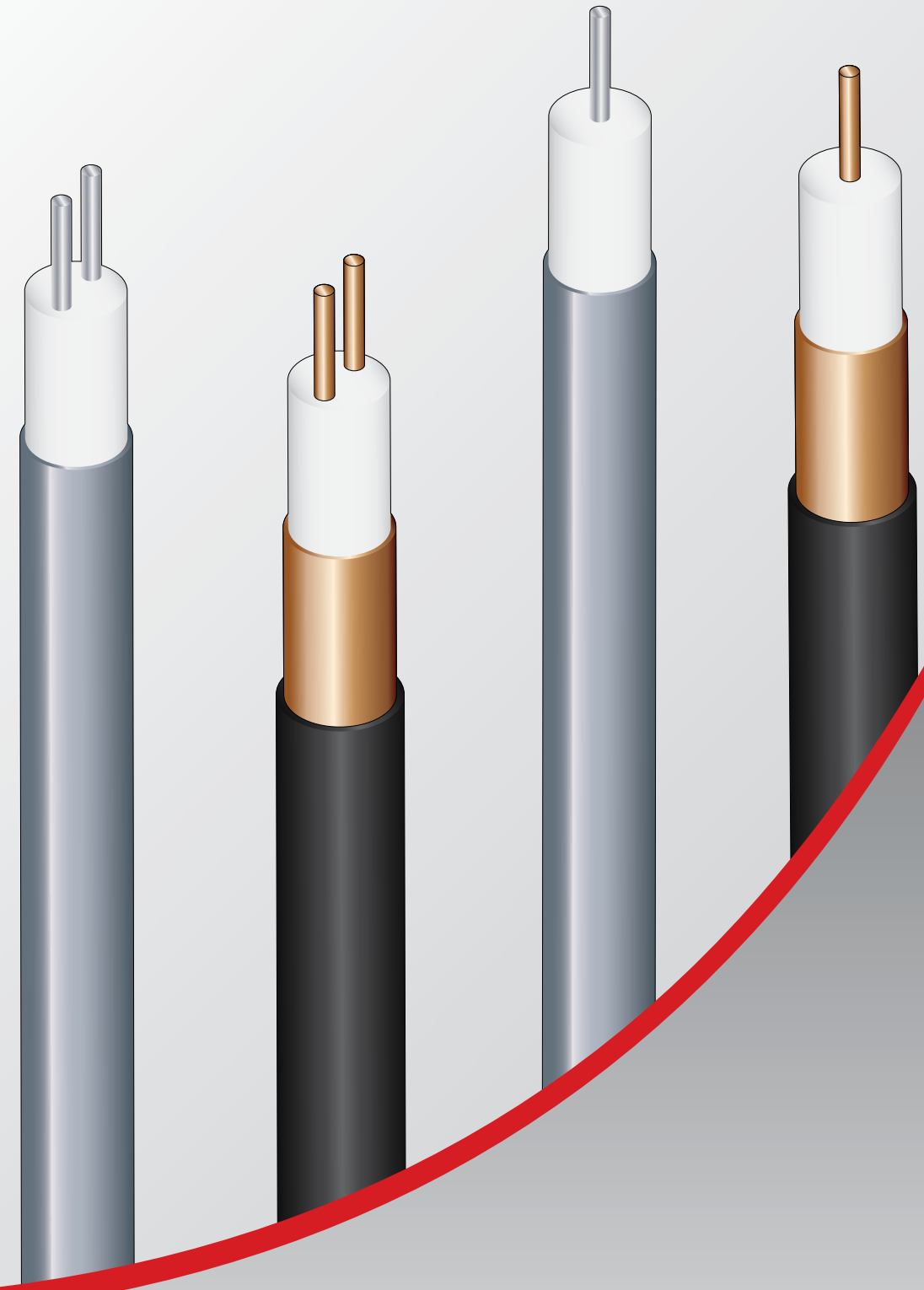
# MINERAL INSULATED HEATING CABLE

## HEAT TRACING SYSTEM INSTALLATION & MAINTENANCE



HEAT TRACE

The Heat Tracing Authority™

MINERAL INSULATED HEATING CABLE
HEAT TRACING SYSTEM INSTALLATION & MAINTANCE
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# *Mineral Insulated Heating Cable Heat Tracing Installation & Maintenance Description*

## 1. Scope

The following information refers to the installation methods, construction, maintenance requirements and recommendations for mineral insulated electric heat tracing cables, when fitted to pipelines and associated equipment.

## 2. Normative references

Mineral insulated cable specifications.
EN 60079-0, Explosive atmospheres - Part 0: Equipment – General requirements
EN 60079-1, Explosive atmospheres - part 1: Flameproof Enclosure “d” protection equipment
EN 60079-7, Explosive atmospheres - Part 7: increased safety “e” protection equipment
EN 60079-30-1, Explosive atmospheres - Part 30-1: Electrical resistance heat tracing – General and testing requirements
EN 60079-30-2, Explosive atmospheres - Part 30-2: Electrical resistance heat tracing – Application guide for design, installation and maintenance
IEEE 515, Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat tracing for Industrial Applications

## 3. Composition of heat tracing system of mineral insulated heating cables

A typical heat tracing system using MI heating cables includes the following components as illustrated below in **Figure 1**.

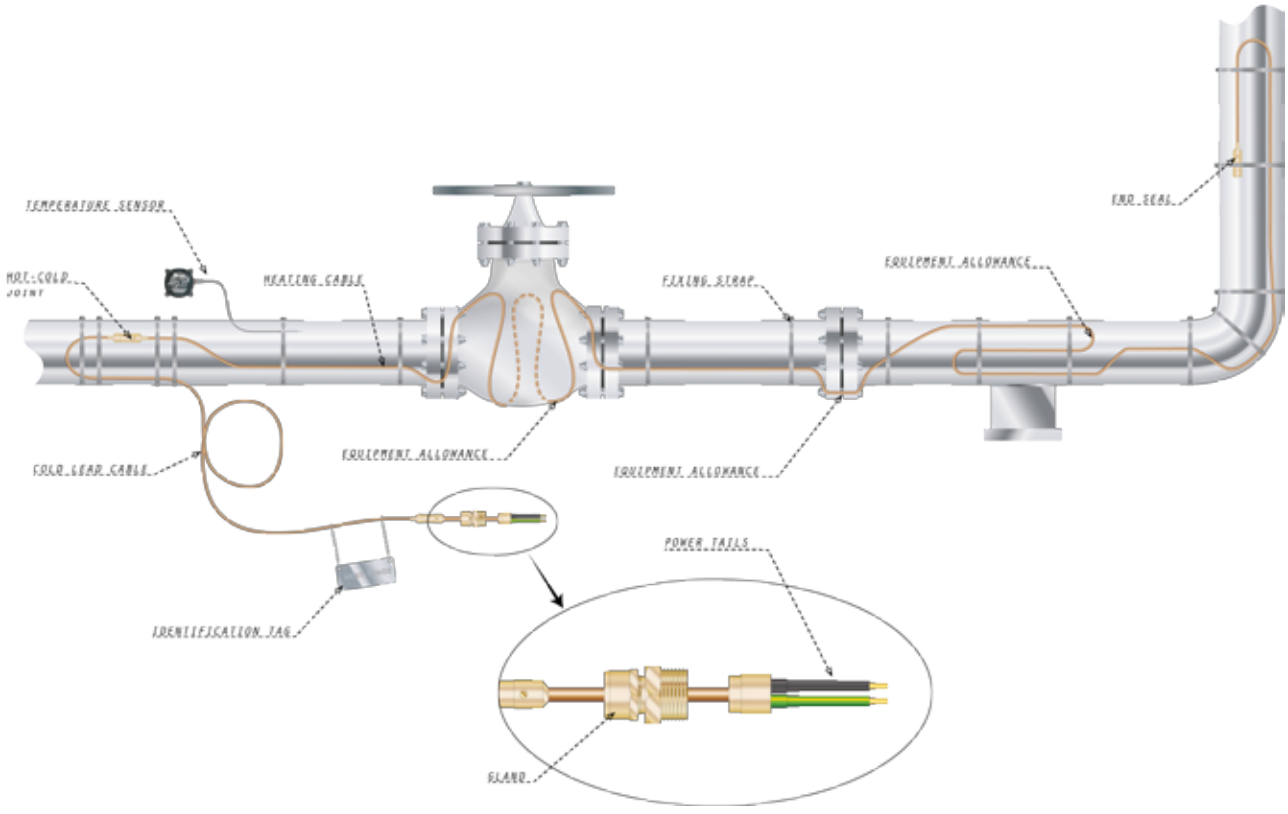



Figure 1 Example of heat tracing system using MI heating cables

MI heating cables are designed to give a specific power output based on the circuit requirements. The power output of the cable is determined by the heated length of the cable, the power supply voltage and the resistance of the heater conductor. The power connection cold leads and the remote end of the MI cable are usually pre-fabricated under factory conditions prior to delivery to site. With MI cables, once they are made it is not possible to alter the cable, or the supply voltage without affecting the heater’s power output.

***Caution: The finished heating cable cannot be altered or cut to suit the pipe.***

## 4. Type of MI heating units

The MI heating unit relates to type A, type B, type D and type E, as shown in figure 2. The type A and B is only suitable for the single-core mineral insulated heating cable. The type D and E is only suitable for the two-core mineral insulated heating cable.

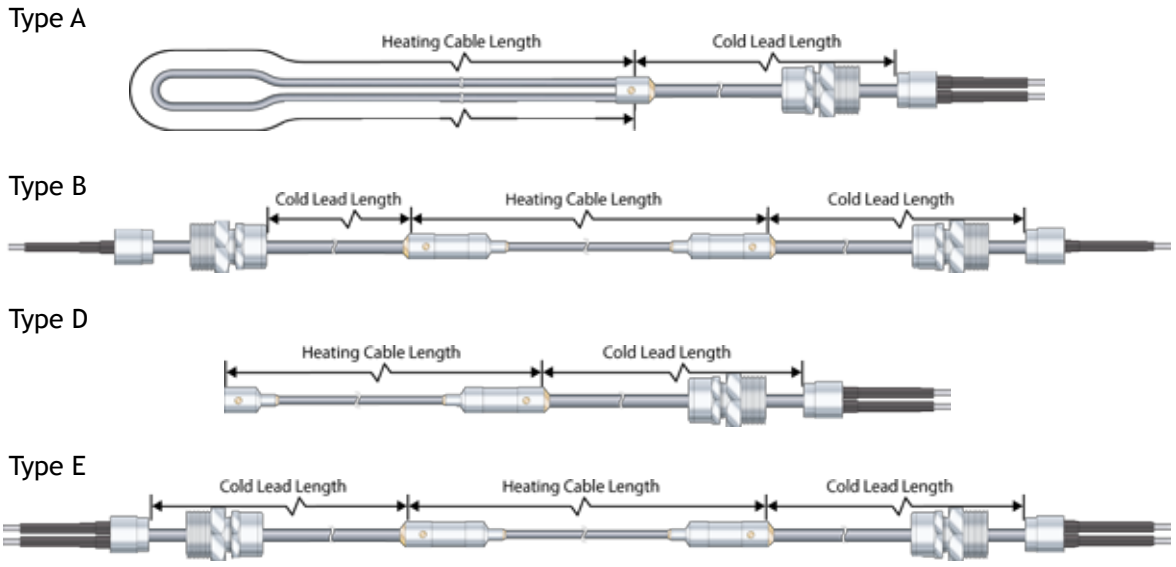



Figure 2 The type of MI heating units

The typical MI heating unit code contains the following symbols:
MSS-B 16N1000/12/4000/220/G 1/2"/ Ex

Hazardous area grade(1)
Gland thread specification.
Rated operating voltage, V.
Rated watts, W.
MI heating cable length (m).
MI heating cable specification.
MI heating unit structure type.
MI heating cable type.

***Note(1): If there is NO Ex mark on the cable the MI heating cable is only applicable to SAFE (non-HAZARDOUS) area use. If there is an Ex mark, the MI heating units can be used in relevant HAZARDOUS areas.***

***Caution: Ex mark means MI heating unit may be used in an explosive environment. The installer should verify the Excertification mark is shown on the label of the MI heating unit, to ensure that is suitable for use in HAZARDOUS areas.***

## 5. Information relating to IECEx & ATEX for MI heating cables

| | | |
|---|---|---|
| Certificate (MCU & MHC): | CML 18ATEX3388 | CML 18.0205 |
| Title: | MCU & MHC Mineral Insulated Heating Cable | |
| Certificate (MCN): | CML 18ATEX3389 | CML 18.0206 |
| Title: | MCN Mineral Insulated Heating Cable | |
| Certificate (MSS): | CML 18ATEX3390 | CML 18.0207 |
| Title: | MSS Mineral Insulated Heating Cable | |
| Certificate (MAL): | CML 18ATEX3391 | CML 18.0208 |
| Title: | MAL Mineral Insulated Heating Cable | |
| Marking: | Ex II 2 G D<br>Ex 60079-30-1 IIC T1 to T6 Gb<br>Ex 60079-30-1 IIIC T450°C to T85°C Db<br>*Refer to marking on cable for detail.* | |
| Standards | EN IEC 60079-0:2018<br>EN 60079-30-1:2017 | IEC 60079-0:2017<br>IEC/IEEE 60079-30-1:2015 |
| Installation Temperature | MCU, MCN, MSS & MAL<br>MHC | -80°C to 40°C<br>-25°C to 40°C |

Withstand Temperature

| Cable Type | Maximum Withstand Temperature |
|---|---|
| MAL | 800°C |
| MSS | 600°C |
| MCN | 400°C |
| MCU | 250°C |
| MHC | 90°C |

Non-metallic Materials

Magnesium Oxide

High-density polyethylene (MHC only)

Consider material performance with respect to the chemicals that may be present in the hazardous area.

## 6. Application areas

MI heating cables and heater units are widely used in areas where high temperature, high pressure, high radiation, or corrosive environments exist, and where high power density field, and electric heating or heating processes exist.

According to the professional cable selection and Ex certification approval, MI heating cables and units can be installed in SAFE area, or HAZARDOUS areas applications.

***Caution: It is prohibited for the heating cable assembly to be installed in an environment where explosive gas, or a vapour air mixture ignition temperature is below the marked temperature.***

## 7. Packing, transportation, handling, receiving, storage and handling for products

### 7.1 Packing

The packing of the products, can be a timber carton, cardboard box, or cable tray. The method of packing should be specified in the order, if not specified, usually the goods shall be packed in cardboard box.

### 7.2 Transportation and handling

When transporting and handling the Products, measures should be taken to ensure adequate protection from rainfall and moisture ingress, as well as protection from mechanical damage are in place to protect the products and the packaging.

### 7.3 Storage and handling

a) Check the packing list and product labels and ensure that they match the product type and quantity shown in the purchase order and that the correct products have been delivered. **Storage should not exceed 12 months.**

b) Check that the products received and the packaging are free from damage. Notify the carrier and the supplier accordingly if any damage is found.

c) Test MI heating cable, or MI heating unit conductor and check the insulation resistance and record the test data.

1) 300V MI heating cable or unit should use a 500Vdc insulation resistance meter instrument for testing, 600V MI heating element should using the 1000Vdc insulation resistance meter instrument.

2) The measured value of insulation resistance should not be less than 20MΩ.

d) Test the conductor DC resistance of MI cable or heating element, record the test data. The conductor shall not show any circuit break, and the measured value shall be within the prescribed tolerance.

### 7.4 Storage and handling

a) Products and components should be placed in dry indoor storage, centralised classification storage, and measures shall be taken to prevent mechanical damage of the products.

b) During the storage period, the products should be inspected once every three months. The appearance of the packaging should be complete, labelling should be complete, sealing capping should be tight. The metal sheath should not show any sign of corrosion.

c) Product storage environment temperature shall not be lower than -15°C and relative humidity should be less than 85%.

d) Distribution of materials should be in accordance with the requirements, in order to avoid any unnecessary handling and accidental damage.

## 8. Heating system installation

### 8.1 General

a) Technical specifications should be carefully read before the heating system is installed. Pre-installation checks must be carried out in accordance with the manufacturer's instructions. We further recommend that heating system performance should be checked after installation and test readings recorded accordingly. Acceptance of the systems performance will depend on the correct installation of the product and associated ancillaries.

b) The heating system installation should be carried out in compliance with the requirements of the system design specification, together with EN 60079-30-2, IEEE 515 and any other national and local applicable laws and standards.

c) Heating system installation and commissioning personnel should be suitably qualified electricians and ideally have experience in installing electric heat tracing systems. The installation should be implemented under the supervision of a qualified electrician. In hazardous areas, the installation and the supervising electrician should have successfully completed the necessary training for working in hazardous / gas explosive environments where the heat tracing system is located. Only trained personnel can perform special key work, such as the connection to the power supply and/or terminal installation.

d) Heating system installation shall be in accordance with the approved system design drawings. Any major construction should be notified to the designer and written consent obtained and filed accordingly.

e) Heating system should be installed on all pipelines and pipeline accessories after pressure test. Insulation materials are only to be installed and completed after the electric heating tracing installation has passed test.

f) All the heating surface coatings or fittings should be compatible with the operating conditions of the heat tracing system.

g) Heating system installation should be installed in coordination with the pipeline, insulation materials and instruments design, to ensure the complete system is in accordance with the approved system plan.

h) Measurement of MI unit insulation resistance and DC resistance of the conductor shall be done prior to installation and again after installation, before preservation material construction and after its completion, and before the system commissioning. Test requirements shall be in accordance with the implementation of the clauses of this specification: 7.3 c) and 7.3 d).

i) MI heating unit grounding wire must be connected with the grounding terminal of equipment, and provide reliable grounding/earthing.

### 8.2 Installation temperature

The lowest temperature for MI heating cable installation is:

1) HDPE outer sheath MI heating cable: -25°C;

2) Copper and copper nickel alloy and stainless steel sheath MI heating cable: -80°C

### 8.3 Bending radius

a) Copper and copper nickel alloy sheath and HDPE jacket heating cable minimum bending radius during installation see **Table 1**.

b) For stainless steel, Inconel or 825 alloy sheathed heating cable minimum bending radius during installation see **Table 2**.

**Table 1 Bending Radius of Copper and Copper Nickel Alloy Sheath and HDPE Jacketed Heating Cables**

| O.D. of Heating cable, D/mm | D<7 | 7≤D<12 | 12≤D<15 | D≥15 |
|---|---|---|---|---|
| Minimum bending radius, Rmin/mm | 2D | 3D | 4D | 6D |

**Table 2 Bending Radius of Stainless Steel, Inconel or 825 alloy Sheath Heating Cables**

| O.D. of Heating cable, D/mm | D<5 | 5≤D<10 | 10≤D<15 | D≥15 |
|---|---|---|---|---|
| Minimum bending radius, Rmin/mm | 3D | 4D | 6D | 10D |

## 8.4 Installation preparation

a) Preparation should be carried out according to the design documents before installation, and check all the items listed below.

b) A routine examination of all electric heating equipment, should be carried out, including confirmation of product type, technical documents and material quantity. The installer should check all the heating cable and components, in order to verify the product type, product and packaging label, rated power, rated voltage, number and characteristics are in accordance with the approved system design. The installation instructions, the certificate or declaration of compliance with professional institutions required, should also be validated.

c) Any sharp protrusions, such as welding slag, spatter, cement, etc., should be removed from the pipe surface and its accessories before installing the heat tracing.

d) Check that the installed system matches the design drawings, such as pipe diameter, pipe length, containers, valves, flanges and pipe numbers. If equipment requiring heating changes, it may be necessary to adjust the heating cable and check the heat tracing material list again.

e) Tests should be carried out before installation, check and record according to **Table 3**.

1) Check if heat tracing devices are damaged or not. Carry out the final check for continuity and insulation. Measurment of insulation resistance must be carried out in accordance with the provisions of 7.3.c).

2) Temperature controller should be tested to ensure proper calibration, including, but not limited to, set point, temperature and temperature range of operation.

3) Check whether the control cabinet certificate and test records are complete. Check that the control cabinet is not damaged.

## 8.5 Alternative components

Components of the tracing system can be substituted provided that substitutes meet the following conditions:

a) For explosive gas environment with electric heating system, it is prohibited to replace any special components with similar alternative components, unless the replacement is a part of the explosion-proof certificate;

b) Other components can be used for any replacement components;

c) Heating system distribution components can be replaced with any other applicable components recognized by professional organizations.

## 8.6 Determine the power point locations

Before installation the heating system installer should determine the power point positions. Junction boxes should be installed where the heater unit penetrates through the insulating layer position, and consideration should be taken of potential pipeline expansion and its possible influence, to ensure that the heating unit is not damaged.

**Table 3 Check Before Installation**

| No | Item | Note |
|---|---|---|
| 1 | Is the workpiece fully erected & tested & all temporary supports removed? Is the surface to be heated free from sharp edges, weld spatter and rough surfaces? | Any welding or pressure testing after the installation of a heat tracing cable could damage the device. |
| 2 | Is the surface upon which the heat tracer is to be applied normal steel, or non-metallic? | If the surface is of polished stainless steel, very thin-walled pipe, or non-metallic, special precautions may be necessary. |
| 3 | Do the items to be heated correspond in size, position, etc., with the system design? | A suitable line numbering system may be of assistance. |
| 4 | Has it been specified that metallic foil be installed before the application of the heat tracer? | This may be used to aid heat distribution. |
| 5 | Has it been specified that metallic foil be installed after the application of the heat tracer? | This may be used to prevent insulation from surrounding the heat tracer or to aid heat distribution. |

| | | |
|---|---|---|
| 6 | Can flow of product under normal or abnormal conditions reach temperatures greater than those that the heat tracer can withstand? | This would normally be covered in the design stage; however, further discussion with staff at the plant may show that incorrect or out-of-date information has been used. |
| 7 | Is the heat tracing system's most recent documentation (working drawings, designs, and instructions) available? | No change shall be contemplated without reviewing the heat tracing system documentation, as careful calculations are necessary to ensure safe operation. |
| 8 | Can the pipes or surfaces to be heated expand and contract so as to cause stress on any part of the heat tracing installation? | In this case precautions are necessary to avoid damage. |
| 9 | Can sensors of temperature controllers be affected by external influences? | An adjacent heating circuit could affect the sensor. |
| 10 | Is the heat tracer to be spiralled or zig-zagged onto the workpiece, according to the design? | Check design loading per unit length of pipe (or surface area) to determine if spiral or zig-zag application is necessary. |
| 11 | Are cold leads, when fitted, suitable for contact with the heated surface? | If the cold lead is to be buried under the insulation, it has to be able to withstand the temperature. |
| 12 | Is the pipework hung from a pipe rack? | In this case, special precautions are required to ensure the weatherproofing of the insulation at points of suspension. |
| 13 | Does pipework have its full complement of supports? | The addition of any intermediate supports at a later stage could damage the heating system. |
| 14 | Are sample lines/bleed lines, etc., installed at the plant but not shown on drawings? | These could obstruct or prevent the fitting of the heat tracer, and a review of the heat tracing system documentation may be necessary. |
| 15 | Are other parameters used in the design of the equipment, such as pipe supports, specified by the design documentation? | Pipe supports not included at the system design stage may result in insufficient heat due to additional losses from supports. |
| 16 | Are the heat tracers, controllers, junction boxes, switches, cable glands, etc., suitable & certified for the hazardous area classification and the environmental conditions and are they protected against corrosion and the ingress of liquids and particulate matter? | |

## 8.7 Heat tracer installation

### 8.7.1 Installation requirements

a) MI heating cable, or units, should be placed in vertical or horizontal line planes. When using MI heating cable in any formation on the ground, care should be taken not to bend the cable beyond the recommended min radius. Care should also be taken not to pull the cable for a long distance over the ground as friction is likely to cause damage.

b) Unless there are special provisions in the general design, on heated objects, the hot to cold joint should be installed first, as a starting point for the heating cable installed on the heated object. After the hot to cold heating cable joints, the heating cable shall be kept straight with the necessary spacing. When the cable is laid parallel and straight enough, the fixing distance is 200-300mm; when cable is installed with a spiral, the fixing spacing should not exceed 2000mm. In the elbow, flange and other piping accessories, the number of fixing points should be increased accordingly.

***Caution: Both ends of the joint shall be fixed on to the workpiece. It is prohibited to bend the heating cable within 5cm of any joint, or it may damage the welding joint seal.***

c) When heating cable is required to be laid closely on the hot surface, in order to achieve the best effect of heat conduction, in difficult close contact places, such as valves, flanges, etc., it is appropriate to use heat conducting materials such as metal, foil, thermally conductive compounds, etc., to assist with heat transfer.

d) During installation process, if heating cable has a hanging loop , it can be corrected by careful use of a wood or rubber hammer, or it can also be held in place by suitable fixing tape.

e) Heating cable may be fixed on the outside of a pipe, or fixed to a wire mesh on the outer wall of a container, or cast into the low-temperature metal pieces , or pouring in concrete, or soaked in the liquid medium to achieve more effective heat conduction.

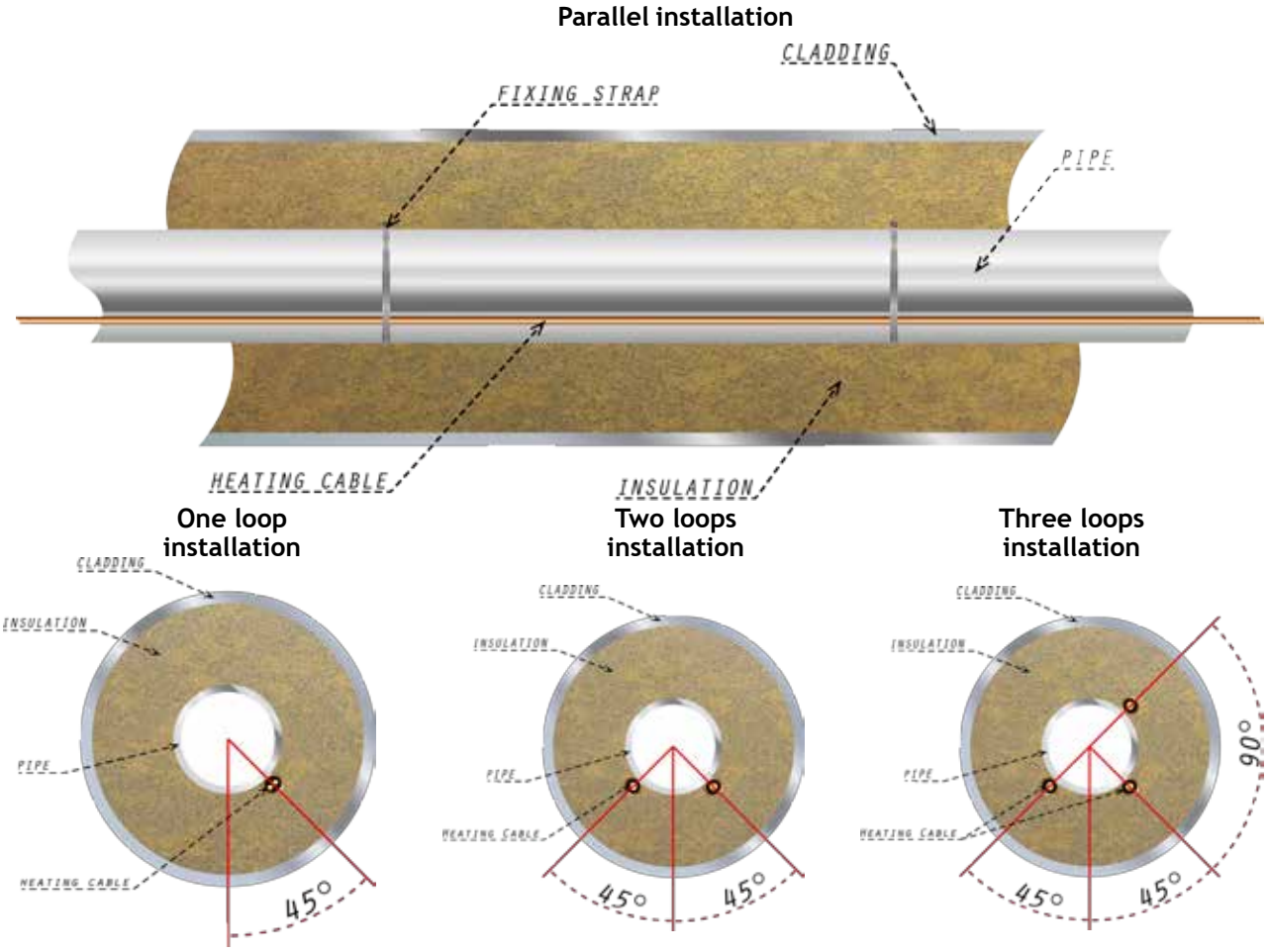



Figure 3 Heating cable installed parallel on pipeline

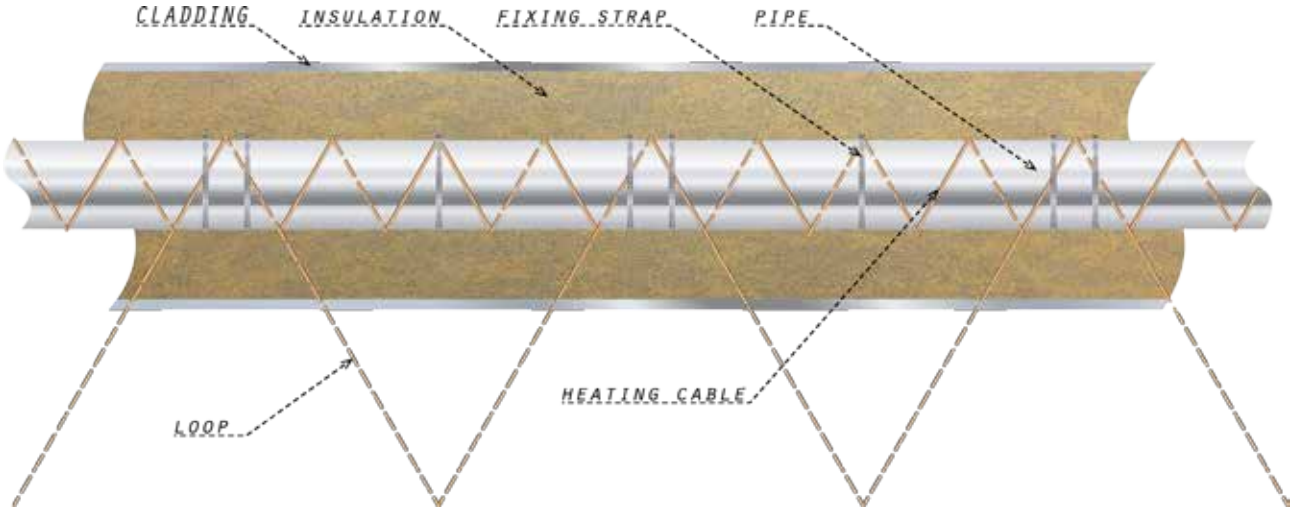



Figure 4 Heating cable installed spirally on pipeline

f) Heating cable fixing materials can be tie wires, tie tapes, or hose clamps. The selection should be matched with the mechanical strength of the heating cable sheath material and consider the mutual electrochemical corrosion. We recommend the following binding materials:

1) Copper sheathed heating cable can be used with: bare copper wires, heat resistant glass fibre ropes, or glass fibre tapes;
2) HDPE outer sheath heating cable can be used with: extruded plastic protective layer wire and heat-resistant glass fibre ropes or glass fibre tapes;
3) Copper nickel alloy or stainless steel sheathed heating cable: can use stainless steel material soft tie wire, tie belt, hose clamps or heat-resistant glass fibre rope, or glass fibre tape.

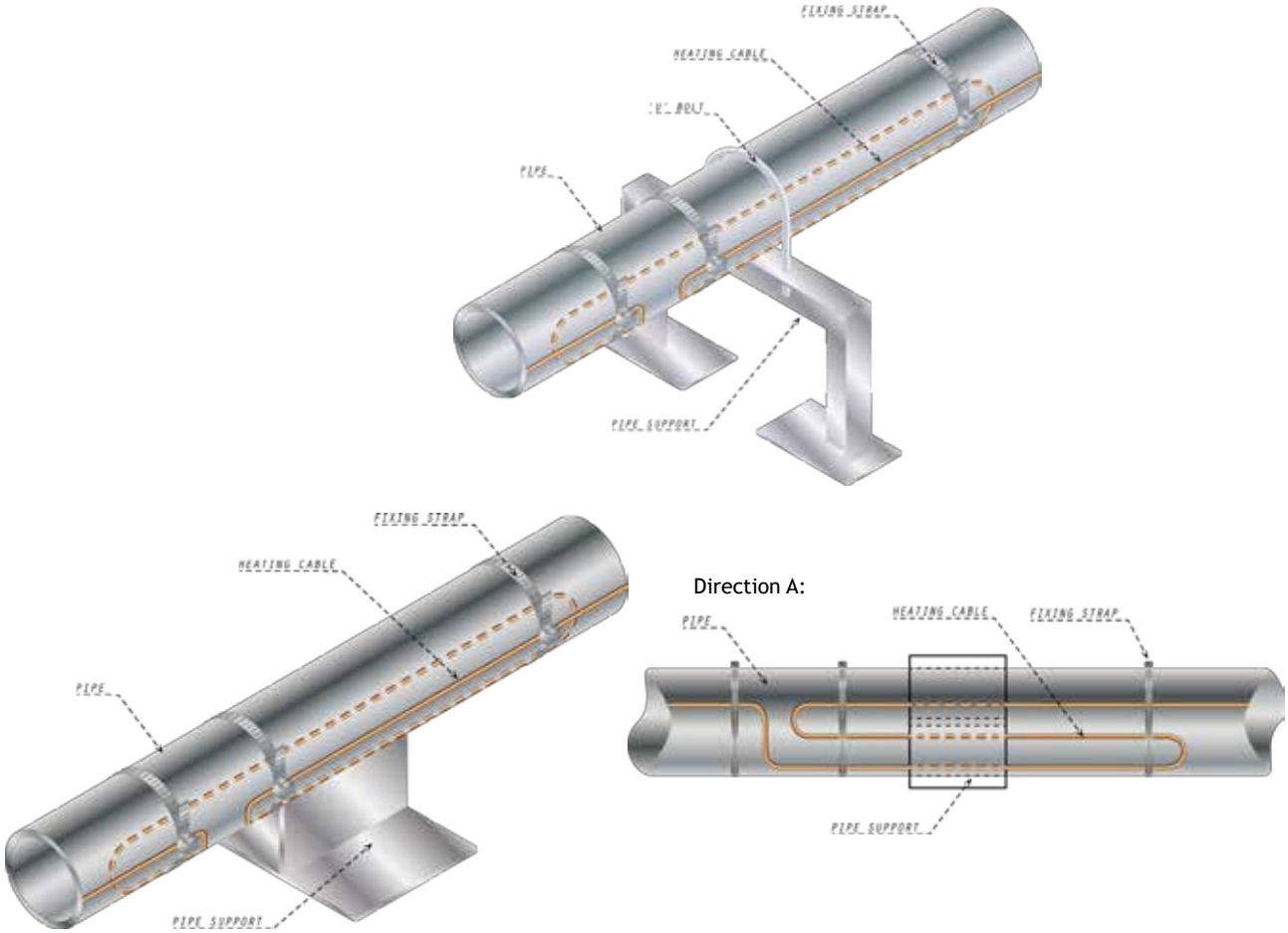



**Figure 5 The heating cable installed on pipe support**

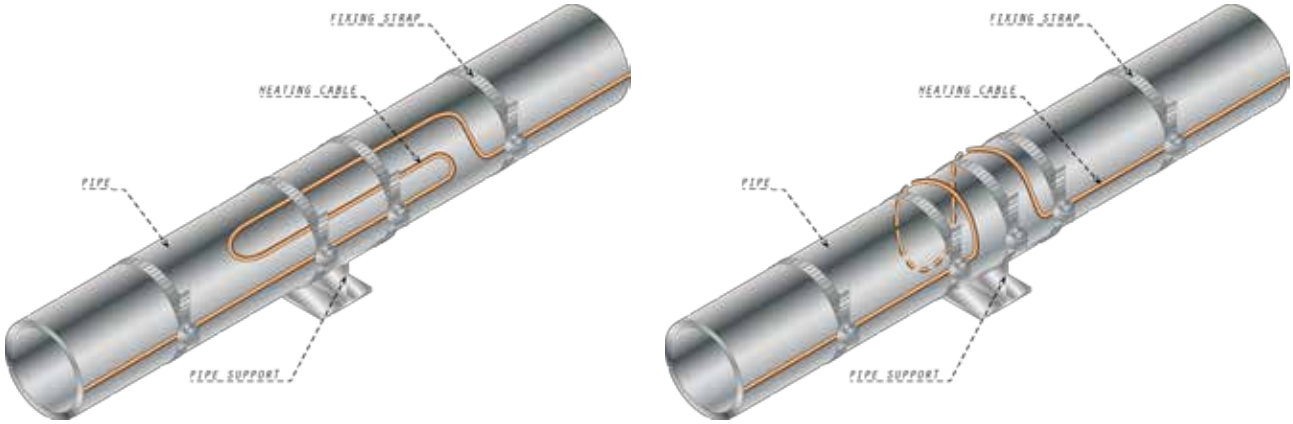



**Figure 6 The heating cable installed on pipe support bracket**

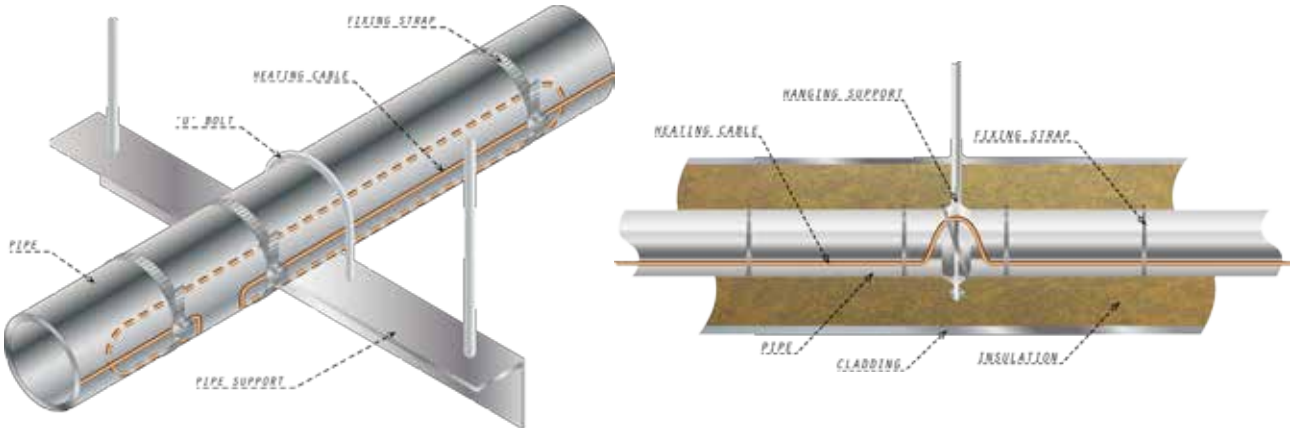



**Figure 7 The heating cable installed on pipe hanger**

g) When installing MI heating cable the cables must not be overlapped. If, after laying the MI heating cable there is excess cable, the excess shall be carefully arranged in parallel and must not be overlapped on itself.

h) A single core MI heating cable can generate a magnetic field in the conductor that can cause an induced voltage in the metal sheath of the cable, and/or a metal junction box. To overcome this issue the MI heating cable should be a looped circuit eg: a twin core MI cable, or a two cable circuit, so that the cables cancel out the magnetic fields generated with each conductor and eliminates any induced voltage.

i) MI heating unit cold lead end will not produce appreciable heat, usually relying on a lagging entry kit that should include a watertight seal to prevent rainwater entering the thermal insulation material.

j) Once MI heating cable or units have been installed, it prohibited to carry out any further welding operations. If the plant owner does require partial disassembly, replacement and re-welding, they should be made aware of the risk to the heating installation. Before re-welding, the heating system, including all heaters and associated components must be removed to free up enough space for the construction. The removed heating cable and components should be kept secure in a weatherproof enclosure and protected from damage until construction is completed. A technically qualified heat tracing engineer should carry out full pre-installation testing and evaluation prior to the heating system being re-installed by suitably experience heat tracing installation engineer. All test reading should be recorded and filed accordingly and any abnormal readings relayed to the heat tracing system designer.

### 8.7.2 Installation on the pipeline

Methods of laying heating cable consist of mainly parallel and spiral installation. The installation process should avoid twisting, over-lapping, bridging contact or under acute stamping. The heater bending radius should be in conformity with the manufacturer's recommendations. On metal pipes the MI heating cable may be straight traced or spiralled on to the pipe. For plastic pipes and plastic coated pipe the heating cable should be spiralled on to the pipe.

a) Parallel installation

The heating cable may be laid in a single or multiple parallel lay; any loop can be a single or double loop. Heating cable should ideally be installed at around the 5o'clock or 7o'clock position on the pipe. Heating cables laid in parallel with a plurality of interval should be uniform, as shown in **Figure 3**.

b) Spiral installation

It can be the single spiral, single double helix, or segmented reverse spiral, as shown in **Figure 4**. Before installing, first mark the spiral pitch distance on the pipeline and equipment and begin the installation from the power point end of the cable.
Keep the heating cable spiral in a tight state when installed, if it appears to be too short or too long at the end of heating circuit, adjust the spiral pitch to compensate. However, ensure that the minimum power per metre of pipe shall not be less than the system design requirements.

### 8.7.3 Installation on pipeline accessories

When the heating cable is installed on valves, flanges, elbows, supports, filters, pumps or other pipeline accessories, the length of cable installed should be implemented according to the provisions itemised in Table 4 , to compensate for the additional heat loss and for easy disassembly and maintenance.

a) Support, bracket, hanger

When installing on a support bracket, or hanger, the bend in the heating cable should be fixed with fixing tape and cable bend should not exceed the stated minimum bending radius. For a length of cable installed on a support bracket and hanger, the thermal insulation materials and thickness should comply with the system design requirements. A pipe hanger with a single point suspension, does not require consideration of an additional installation allowance. If U type pipe hanger is employed, the heating cable shall be on the inner side of the U type pipe clamp. See **Figure 5**, **Figure 6** and **Figure 7**.

**Table 4 Typical Pipeline Accessories Heating Cable Installation Margin (pipe length, converted to metres)**

| Nominal diameter | | Valve type | | | Threaded flange | Orifice flange | Pipe support | Check valve | Pump |
|---|---|---|---|---|---|---|---|---|---|
| inch | mm | screwed or welded | flange connection | butterfly valve | | | | | |
| ½ | 15 | 0.15 | 0.31 | 0 | 0.15 | 0.45 | 0.50 | 0.10 | 0.60 |
| ¾ | 20 | 0.23 | 0.46 | 0 | 0.15 | 0.45 | 0.50 | 0.18 | 0.90 |
| 1 | 25 | 0.31 | 0.61 | 0.31 | 0.15 | 0.45 | 0.50 | 0.26 | 1.20 |
| 1¼ | 32 | 0.46 | 0.61 | 0.31 | 0.18 | 0.50 | 0.50 | 0.31 | 1.20 |
| 1½ | 40 | 0.46 | 0.72 | 0.46 | 0.18 | 0.50 | 0.50 | 0.41 | 1.20 |
| 2 | 50 | 0.61 | 0.76 | 0.61 | 0.18 | 0.50 | 0.40 | 0.56 | 1.50 |
| 2½ | 65 | 0.69 | 0.91 | 0.69 | 0.18 | 0.50 | 0.40 | 0.64 | 1.80 |
| 3 | 80 | 0.76 | 1.07 | 0.76 | 0.18 | 0.50 | 0.40 | 0.71 | 2.00 |
| 4 | 100 | 1.22 | 1.52 | 0.91 | 0.25 | 0.65 | 0.40 | 1.02 | 3.00 |
| 5 | 125 | 1.52 | 1.83 | 0.91 | 0.25 | 0.65 | 0.40 | 1.32 | 4.00 |
| 6 | 150 | 2.13 | 2.44 | 1.07 | 0.25 | 0.65 | 0.30 | 1.93 | 4.50 |
| 8 | 200 | 2.90 | 3.35 | 1.22 | 0.28 | 0.68 | 0.30 | 2.70 | 6.50 |
| 10 | 250 | 3.81 | 4.27 | 1.22 | 0.28 | 0.68 | 0.20 | 3.51 | 8.50 |
| 12 | 300 | 4.57 | 5.03 | 1.52 | 0.41 | 0.81 | 0.20 | 4.02 | 10.00 |
| 14 | 350 | 5.49 | 5.94 | 1.68 | 0.43 | 0.98 | 0.15 | 4.94 | 11.50 |
| 16 | 400 | 6.55 | 7.01 | 1.83 | 0.55 | 1.10 | 0.10 | 5.05 | 14.00 |
| 18 | 450 | 7.77 | 8.23 | 1.98 | 0.55 | 1.10 | - | 6.27 | 16.50 |
| 20 | 500 | 8.69 | 9.14 | 2.13 | 0.68 | 1.33 | - | 7.19 | 18.50 |
| 24 | 600 | 10.36 | 10.87 | 2.44 | 0.81 | 1.51 | - | 8.76 | 22.00 |
| 30 | 750 | 12.19 | 12.80 | 3.05 | 0.98 | 1.68 | - | 10.89 | 25.50 |
| 36 | 900 | 14.02 | 14.63 | 3.66 | 1.36 | 1.96 | - | 12.52 | 30.00 |

***Note:***

1) *For the installation allowance for heating cables installed on pipeline accessories, each accessory in the table above shows the required equivalent length of heating cable, relative to the nominal diameter of the pipe. In multiple heating systems, the length of each heating cable on the pipeline accessories is for equivalent length of the pipeline. Where the same heating loop includes a number of pipeline accessories, the installed power should be converted to correspond with the length of a separate pipeline.*

2) *The nominal pressure of the valve in the table is 2.0MPa and below. If the installation has a higher nominal pressure valve installation, please make contact with the heat tracing design engineering team, or valve product manufacturer/ supplier, as a higher pressure valve will be larger and will require more heat compensation*

b) Flange

When the heating cable is spiralled on the pipe, the spiral direction through the flange is reversed, as shown in **Figure 8**. Heating cables fitted across the flange connection may be terminated in junction box, or with an electric plug and socket device, or other such connecting accessories, to allow complete removal of the heater during flange disconnection. The voltage level of any connecting attachment should match with the heating cable voltage level. The rated current should be greater than the working current of the heating cable.

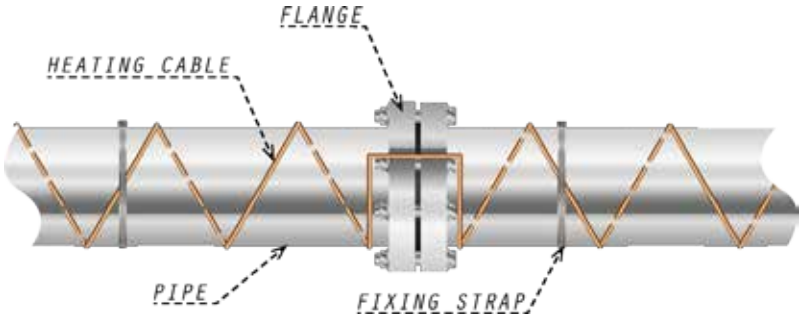



**Figure 8 The heating cable installed on the flange**

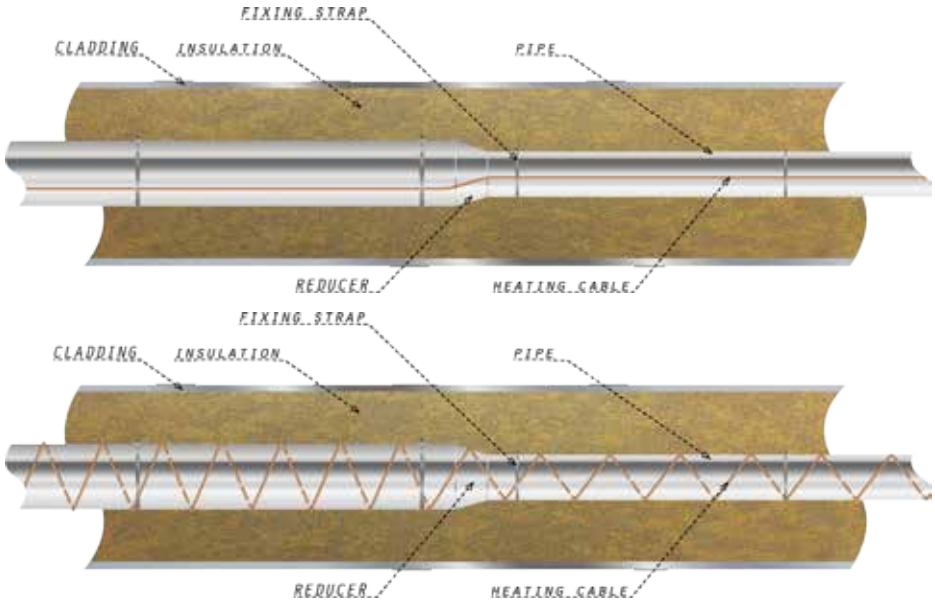



**Figure 9 The heating cable installed on the reducing joint**

c) Reducing joint

The cable should be fixed at cable bends and at each reducing joint end. The rest in straight sections shall be fixed according to the straight pipes spacing. As shown in **Figure 9**.

If the heating cable is installed on a reducing joint with spiral winding, the pitch dimension of the spiral shall be adjusted accordingly to ensure the installed power output meets the pipe diameter requirements.

d) Elbow

As a parallel line installation the heat tracing cable should be installed along the bends outer convex and fixed at both ends and the middle of the elbow. As a spiral winding installation, the bend convex spiral pitch shall be consistent with straight pipe spiral spacing. On concave bends spiral spacing will less than the convex spiral spacings. As shown in **Figure 10**.

e) Pipe head

The installation length of the cable at the pipeline ends shall comply with the system design requirements. The spiral winding pitch at pipeline ends should be in accordance with the designed pipeline length. As shown in **Figure 11**.

f) Pipe tee

A linear heating cable parallel installation on the pipe tee as shown in **Figure 12**. On a spiral installation on a pipe T, the spiral pitch should comply with the system design requirements. If the heating cable is installed using a T splice connection, the T splice must comply with the system design requirements.

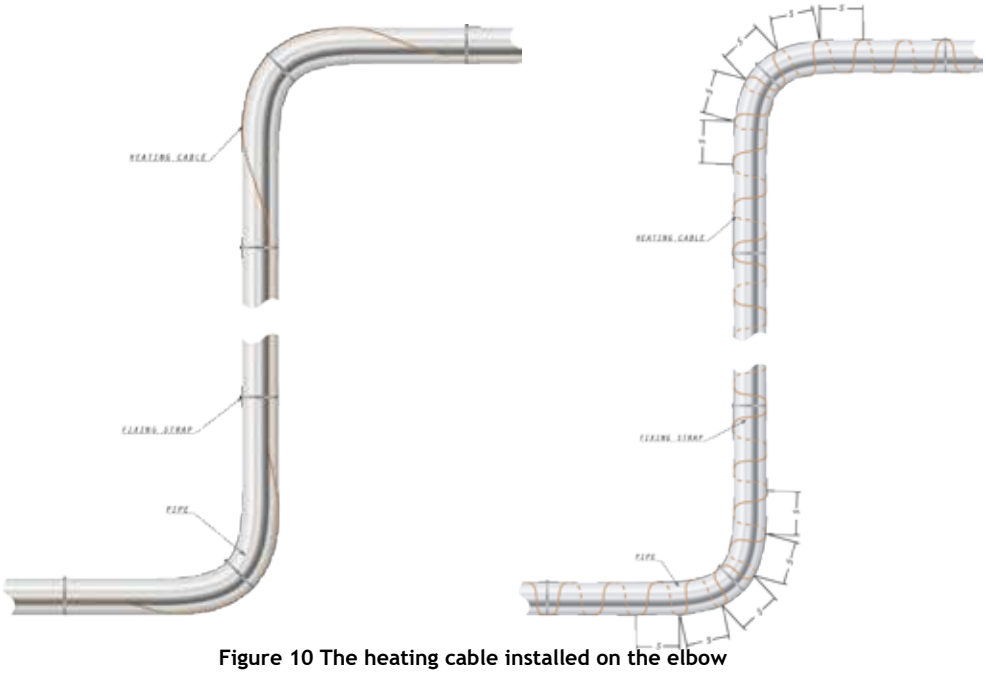


Figure 10 The heating cable installed on the elbow

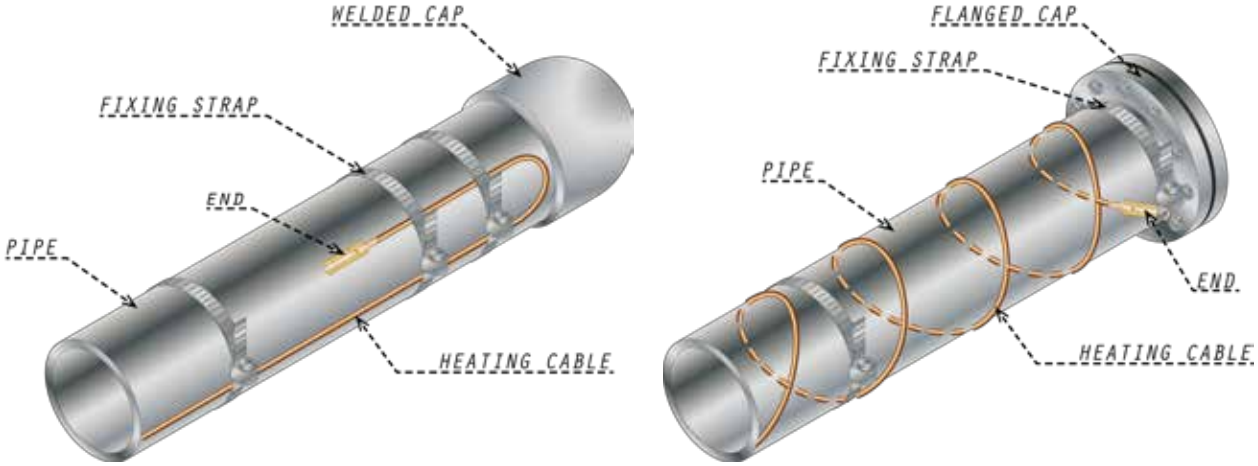
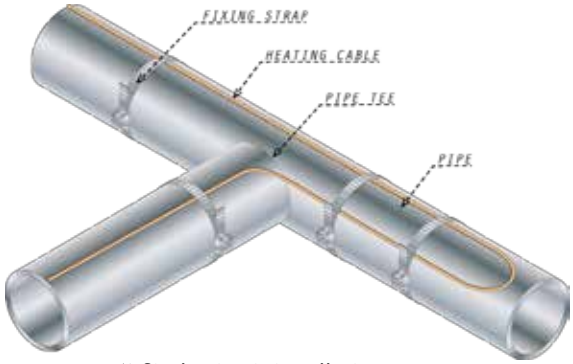
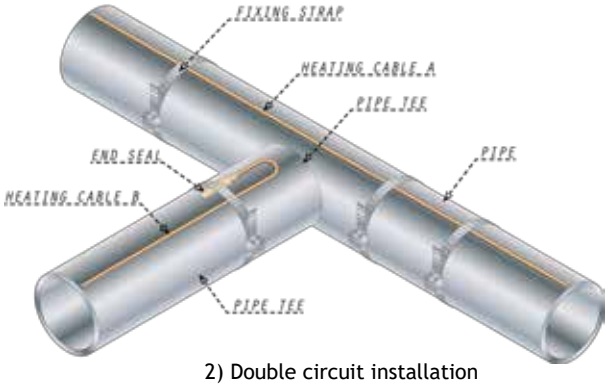


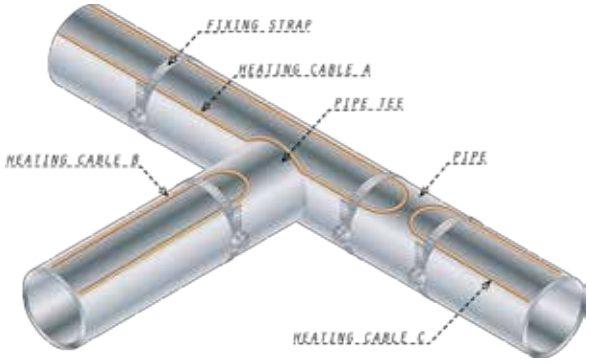

Figure 11 The heating cable installed on the pipe head




1) Single circuit installation




2) Double circuit installation




3) Three circuit installation

Figure 12 The heating cable shown installed at the pipe tee

g) Valve

The cable installation method on a valve is shown in **Figure 13**. It is suitable for pipeline straight tracing or spiralling.
Heating cables on a valved pipe may be terminated in junction boxes, or with an electric plug and socket device, or other such connecting accessories, to allow complete removal of the heater during valve removal for replacement and/or maintenance. The voltage level of any connecting attachment should match with the heating cable voltage level. The rated current should be greater than the working current of the heating cable.
The cable should be cross lashing fixed on the valve, the installation length and any bending radius should meet the system design requirements.

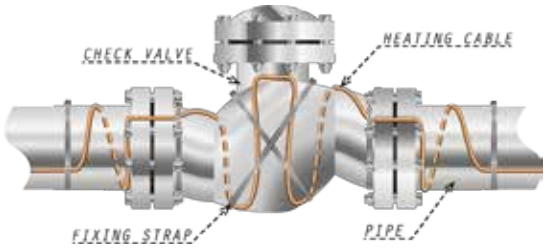
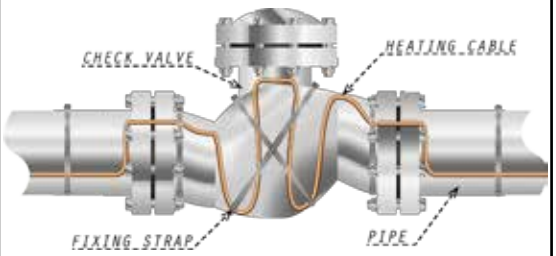
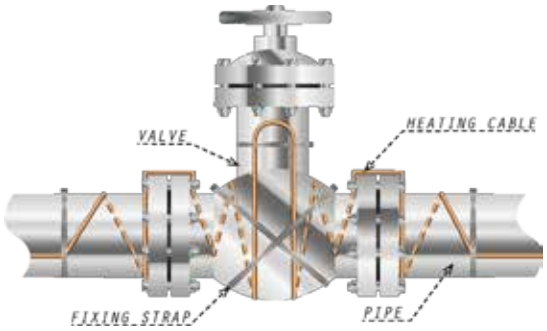
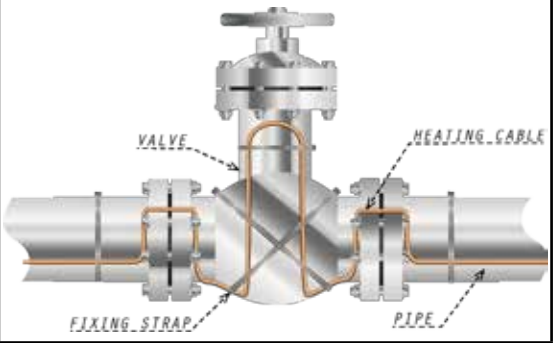
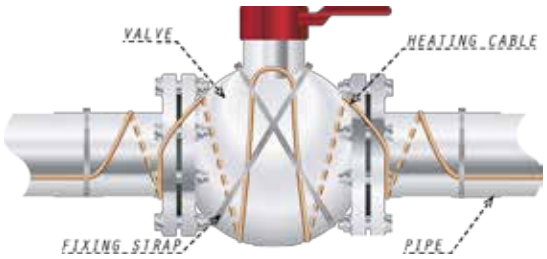
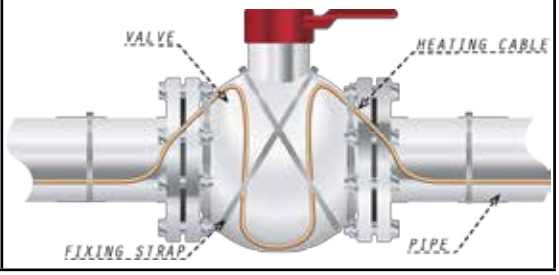
| Valve | Single circuit installation | Double circuit installation |
|---|---|---|
| Check Valve |  |  |
| Flange gate valve |  |  |
| Ball valve |  |  |

**Figure 13 The heating cable installed on the valve**

h) Pump

The pump body can adopt an independent heat tracing system, or heating cables on the pump/pipe connection part can be mounted via a junction box, or electric plug and socket device. When such connecting accessories are used, the voltage level of the connecting attachment must match that of the heating cable voltage level. The rated current should be greater than the working current of the heating cable.

The heat tracing cable installed on a pump body can either use aluminum adhesive tape or heat transfer compound. Alternatively, a wire mesh can be fixed on the pump body and the heating cables tied to the mesh with cable ties, as shown in **Figure 14**. The length of the heating cable that is installed on the pump body should comply with the system design requirements.

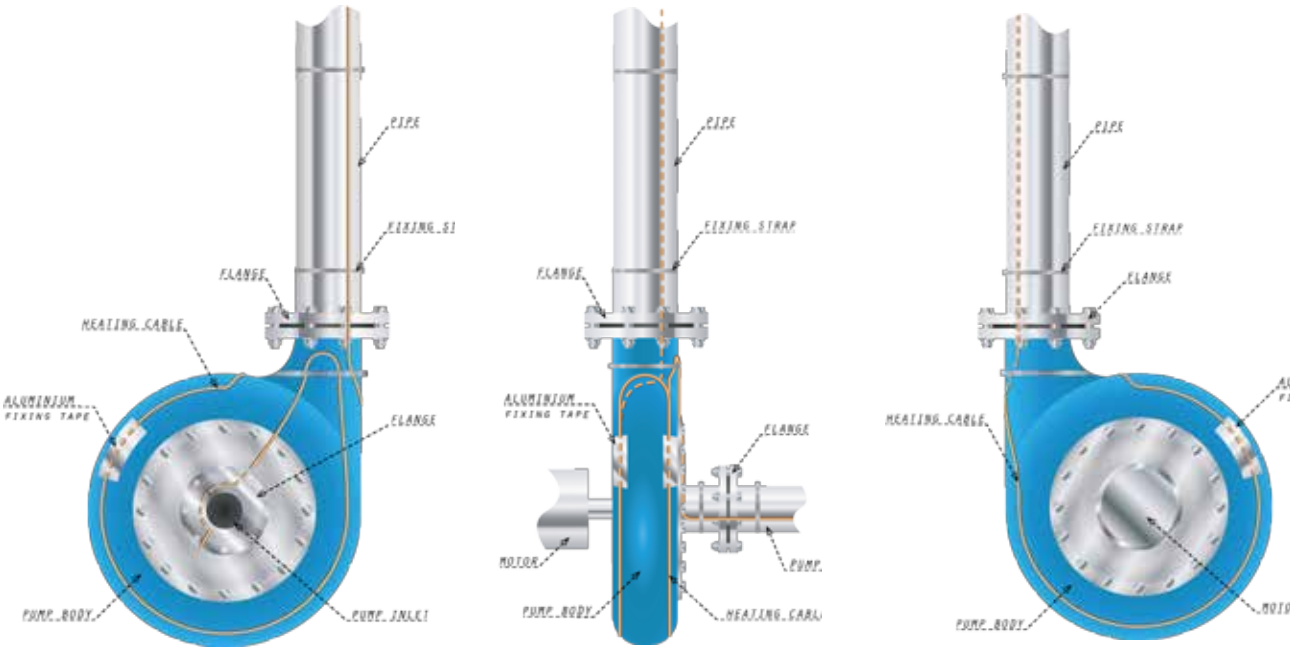



**Figure 14 The heating cable installed on the pump**

i) Filter

The heating cable installed on the filter is as shown in **Figure 15**. The heating cables can be mounted with a junction box, or an electric plug and socket device. With such connecting accessories, the voltage level of connecting attachment should match the heating cable voltage level. The rated current should be greater than the working current of the heating cable.

The heating cable fixing and the installation length should comply with the system design requirements.

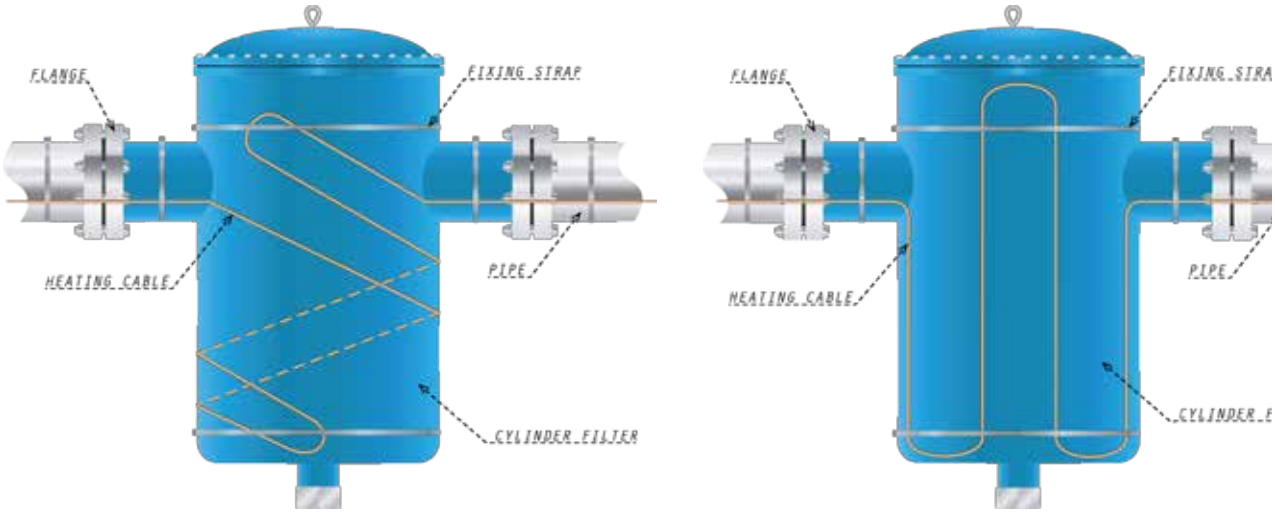



**Figure 15 The heating cable installed on the filter**

j) Instrument tube, or expansion pipe

As shown in **Figure 16**, the heating cables can be mounted with a junction box, or electric plug and socket device. With such connecting accessories, the voltage level of the connecting attachment must match with heating cable voltage level. The rated current should be greater than the operating current of the heating cable. It is prohibited to fix the heating cable as it passes over an expansion joint. The heating cable length for the installation shall comply with the system design requirements.

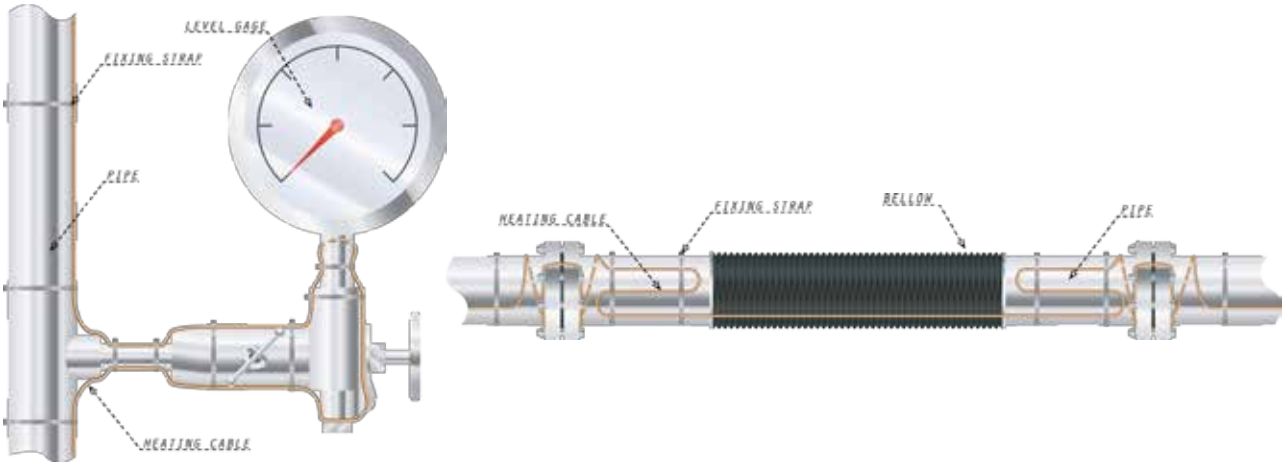



**Figure 16 heating cable installed on instrument tube or expansion bellow**

## 8.8 Junction box installation

An MI heating unit junction box should be designed as a special type. The level of protection should be suitable to meet the installation environment. The installation site shall be selected as follows:

a) to avoid rain and snow accumulation; to avoid accumulation of dangerous substances;

b) is convenient for inspection and maintenance and does not affect the other processes;

c) to be close to the heated object, within the scope of the cold lead cable length.

The junction box should be installed securely and should be fixed on a wall or floor bracket, or directly on the pipe using a fixed bracket on pipes up to 65°C.

When installed in hazardous areas, the junction box should be certified accordingly to meet the relevant National and International Standards requirements; the temperature T Class and the correct IP level of protection must meet the requirements of the local environment at the site. The cable entry into the junction box should use a suitably rated Ex entry gland. The gland should be screwed into the junction box and tightened to completely seal the entry. Any unused junction box entry should be sealed with a suitably rated blanking plug.

## 8.9 The installation of monitoring equipment

### 8.9.1 The installation of sensors

Sensors should be suitably rated in accordance with site requirements. Temperature sensors should not be located where they can be influenced by external heat radiation, solar heat radiation, adjacent process heating temperatures, or close to nearby heated buildings, or in the region of any local heat source. Ambient temperature sensors should be positioned in the most exposed position local to the heat tracing system. If the installation environment is classed as hazardous, the chosen sensor must be suitably rated with Ⓔx certified mark.

The sensor shall be placed at the point where pipelines and associated heat tracing is in good contact. The sensor shall be protected to avoid thermal insulation layers and secured to the surface to be heated. Care should be taken not to damage any capillary tubes, thermocouple cables, or RTD signal cables and not to twist wires or damage the sensor, in order to avoid incorrect readings error.

Surplus capillary tubes can be laid in the insulation layer, except if the total length is more than 1m.
The heat preservation layer on the capillary tube exit from the JB, the thermocouple, or RTD signal wires, should be moisture proof, waterproof and rainproof as they exit from the JB.

### 8.9.2 Controller box installation

Except in special circumstances (during installation or control operation) the controller box cover, door or lid should be kept closed before, during and after installation. If necessary, the controller should be set to the required temperature. A function test should be carried out by adjusting the value of the temperature setting, until the controller displays the required temperature. A control box installed in hazardous areas shall be certified accordingly and show the Ex certification mark.

## 9. Insulation system installation

### 9.1 General requirements

**9.1.1** Prior to the thermal insulation system installation, the owners, project supervisor, thermal insulation contractor's supervisor at the site, should be invited to examine and check the heat tracing installation quality and witness the electrical heating function test, in order to verify the correct operation of the heat tracing system. Also, to verify with the person responsible for the thermal insulation, that any records and test data for the MI heating cable, operating under normal conditions and power supply voltage, are transferred to the installation records, together with information relating to any part of the heating system concealed from view. This will complete the stage construction records accordingly.

**9.1.2** During the thermal insulation construction process, thermal insulation construction personnel have the responsibility to carry out full protection of thermal system components (with heater, temperature sensor, junction boxes, etc.) for safety. The electric drill and drill bit used for installation of thermal insulation outer cladding shall be fitted with a suitable drill bit depth stop kit, giving a finite drill bit depth measurement, in order to avoid unnecessary mechanical damage to the heating system beneath the insulation. Thermal insulation construction personnel shall be responsible for any damage caused during the thermal insulation installation.

### 9.2 Preparation before installation

Insulation construction must be carried out after installation of each part of the heating system immediately, in order to provide mechanical and climatic protection. Thermal insulation material before installation, should be according to the specification requirements of 7.3c) and 7.3d) for detecting and recording the insulation resistance.

Before the installation of thermal insulation materials, the contractor should coordinate with the heating system installation units and construction units to confirm the following inspection:

a) Check the insulation material type, diameter and thickness of thermal insulation material design selection values are consistent;

b) During the storage, handling and installation processes, the installer should install temporary climate protection layers to avoid moisture ingress into the insulation layer, and all thermal insulation materials should be sealed in a layer beneath any climate protection.

### 9.3 The installation of insulation materials

Insulation material shall be applied to all parts of the pipeline and equipment, including valves, flanges, bracket, elbow, T piece and other accessories. If expansion joints or corrugated pipes are used in the system, the surface of the insulation layer should not restrict the equipment or affect the heat tracing system.

In order to ensure the heated equipment is adequately insulated and completely covered, insulation materials may be oversized. Other matters that need to be considered:

a) Between pipe and the pipe bracket, the system should retain sufficient space for installation of thermal insulation materials.

b) Confirm that the thickness of thermal insulation matches the system design requirements. Ensure that the heating cable is NOT embedded into the insulating material, otherwise it will lead to an increase in the cable sheath temperature. If the insulation thickness specified is not correct, use a thicker insulation layer that will meet the system design requirements.

c) All heater insulation entry kits should be sealed to prevent moisture from entering. The heater outlet from the pipe should be considered in advance and, as far as possible, exit from the thermal insulating layer in the lower 180 degree sector of the pipe.

d) The thermal Insulation layer should be cut close to fittings to avoid any gap and to stagger any overlap when installing, to ensure minimum heat loss to the pipe and any in-line fittings.

e) Thermal insulation construction should be meticulous, so as not to damage the heating system. The heat exchanger, temperature sensors and other devices shall not be in a staggered position.

f) On the flanges, valves and other accessories, or other equipment, with irregular shapes, when laying heating cables give consideration to the use of metal foil, to avoid trapping the heater in the insulation layer.

g) Stainless steel sheathed heaters should avoid using high halogen content insulation materials. The thermal insulation thickness and material should be recorded.

### 9.4 The installation of metal protective layer

Where thermal insulation cladding/metal protective layers are used, special attention should be paid to exposed sharp edges, so they are not in direct contact with the heater cable, or associated components.

Critical areas are:

a) Flange: metal products should be trimmed, exposed surface of insulation materials should be of a suitable non-absorbent material.

b) Valve: prefabricated insulating jacket should remain length allowance, and installed in the metal housing near the pipe

c) Elbow and T junction: avoid installing straight section metal protecting layer at an elbow or T junction, as this may damage the heating system. Elbows should use metal protecting layers with rolled edges.

Protective metal cladding over the thermal insulation that overlap should use appropriate sealants. When using screws, or self-tapping fasteners, care should be taken to ensure that all drills and screws used cannot penetrate the insulation materials and damage the heat tracing system installed below. The metal outer cladding should carry additional warning labels indicating the presence of electric heat tracing beneath the thermal insulation.

### 9.5 Site (construction site) circuit insulation resistance testing

After thermal insulation construction is completed, in accordance with the requirements of section 7.3.c, all electric heat tracing circuits should undergo an insulation resistance test, the measured value of which should not be less than 5MΩ.

## 10. Commissioning

### 10.1 Checks before commissioning

Before commissioning, the heat tracing commissioning record, as itemised in **Table 5**, should be completed accordingly.

### 10.2 Function test and completion documents

After the completion of thermal insulation installation, together with the installation completion of distribution and control systems, commissioning should be carried out in accordance with the details shown in table 4 to complete the commissioning records.

#### 10.2.1 Function test

This test should check the following functions:

a) Run all power supply branch circuits to verify that the current is normal. The temperature control device may require a temporary bypass;

b) Verify the effectiveness of any circuit monitoring or alarm circuits. The contactor may need to be bypassed;

c) Complete the entries in the heating each circuit debugging record (**Table 5**). This will clearly record all the testing and debugging data;

d) According to Clause 9.5, record the measured value from each insulation resistance test;

e) Record the applied voltage and running current for each circuit for 5 minutes. The pipeline temperature shall be recorded according to the system design requirements;

f) Verify that any alarm and monitoring system operates in accordance with the system requirements and achieves the desired effect;

g) Verify that the thermostat setting calibration has been completed and passed inspection and that the temperature controller is set at the correct value.

#### 10.2.2 Completion documents

a) Design and test file:

1) Directory;

2) The heating circuit and the power connection point, joints and T splices, terminals, and temperature sensor, piping schematis;

3) For containers show the heating arrangement and layout;

4) List of pipe and insulation materials;

5) Heater single loop length;

6) Calculation and data size;

7) List of materials;

8) Installation instructions;
9) Construction scheme;
10) Temperature sensor installation manual;
11) Commissioning record (**Table 5**);
12) Temperature measurement curve;
13) Installation certificate.

b) Circuit diagram or list:
1) Wiring and circuit diagram or list;
2) Terminal wiring diagram, switch device list;
3) Installation instructions.

c) Others
1) Individual equipment technical specification and instruction manual
2) Functional diagram agreed by design engineer
3) The explosive gas environment equipment certificate issued by certification organization.

## 11. Preventative maintenance/Fault finding.

### 11.1 General requirements

The heating system maintenance period should be no more than a year, the implementation of maintenance projects according to Table 6. In a very harsh environment, or places where there is a corrosion or mechanical damage risk, should increase the maintenance frequency and employ a more detailed inspection. The increase of maintenance frequency should be determined according to the user or owner experience.

All the maintenance operations should be recorded in the log (as shown in **Table 6**) and stored in a file system.

### 11.2 Common faults and solution

MI heating cable and electric heating unit has a long service life, some faults may usually occur after the production maintenance, for example:

- after inspection of electrical equipment, the protective seal does not adequately re-seal the enclosure
- Ingress of moisture to the junction box
- damage due to process piping and equipment disassembly, repair, welding, improper operation of replacement equipment
- thermal Insulation layer damage makes the insulation layer absorb moisture, especially where the pipeline and equipment are subject to high temperature operation, corrosion damage prone to hot and humid environments.

MI heating cable and unit fault and solution:

a) Heating cable not heating, circuit protection switch tripping and system not energised. Turn on the power supply to the circuit carry out 1000V megger test, measuring between the conductor and metal sheath, if insulation resistance is zero, determine if the fault is the conductor and the sheath of short circuit.

b) Heating cable not heating, no tripping of circuit protection switch. Turn on the power supply to the circuit and carry out 1000V megger test, measuring between the conductor and metal sheath insulation, if the power bridge measuring DC resistance of conductor is infinite, check for a continuity fault, or break, in the conductor circuit.

After determining the heat tracing cable is damaged, replace the heating circuit with spare cable. Damaged heat tracing cable should be promptly returned to the supplier/manufacturer for repair or re-supply.

## 12. Maintenance

### 12.1 General requirements

After determining the cause of any circuit fault, the circuit should be repaired or replaced as required. If it is determined that the heating tracing failure is a potential manufacturing fault, the heater should be replaced and the damaged heater returned to manufacturer for inspection and testing. On-site maintenance shall only be done under the following conditions:

a) Do not make repairs to failed certified equipment. Any repair made to certified equipment in hazardous areas shall be carried out in strict accordance with the instructions contained in the list of professional certification;

b) When replacing faulty heaters or ancillary equipment, ensure that the design and operational characteristics of heaters and equipment, such as mechanical strength and waterproof performance are retained;

c) Maintenance methods should follow the recommendations as shown in the heating system files and use the recommended materials and tools;

d) The implementation of maintenance work should not cause local risk;

e) Maintenance personnel training should be carried out according to the standard clause 8.1.3.

The replacement of components shall be subject to the provisions of clause 8.5 of this specification.

### 12.2 Feasibility analysis of heater electrical maintenance

#### 12.2.1 Mechanical damage

If the MI heating system has never been connected to an electrical supply previously and mechanical damage has caused an electrical insulation failure, due to conductor disconnection or moisture in the joint, it may be able to be repaired.

If the fault is found only after electrical connection and the damaged area is very small, visually inspect for one (1) metre on either side of the fault and test to confirm that the integrity of the electrical insulation on either side of the fault location is not affected.

#### 12.2.2 Damage caused by corrosion

If the damage is caused by corrosion and if the damaged area is very small, it may be possible to repair the damage.

If corrosion damage is found in more than one area, or if the damaged area is large, the heating system should be replaced.

#### 12.2.3 Damage caused by overheating

If the damaged area is very small, it may be able to be repaired.

If it is suspected that the fault is as a result of the design problem, the system and the design should be re-evaluated with the designer.

### 12.3 Heating system repair maintenance requirements

**12.3.1** After removal of damaged parts, it should be ensured that the heating performance is within the scope of its original design, and is not affected following re-installation after repair.

**12.3.2** For any replacement/repair, only materials and parts recommended by the designer and manufacturer should be used and the replacements shall be subject to the provisions of clause 8.5.

**12.3.3** Repair should be carried out in strict accordance with the process provided by the manufacturer, using the recommended materials and tools.

**12.3.4** Any repair should ensure that heating system's metal sheath grounding integrity and continuity is confirmed.

**12.3.5** The repaired heating system shall be tested again before re-installation based on the requirements of 9.5.

## 13. MI heating cable and component life related remarks

MI heating cable and components are usually employed in high temperature operations and are is not suitable for frequent disassembly and assembly. So, operation of equipment requiring frequent disassembly of internal components will increase the risk of damage to the process equipment. Heating systems should therefore be designed as an independent MI heating cable loop. Owners should also be advised of the recommended spare parts that should be carried for the maintenance of the equipment.

The heating equipment insulation outer layer should maintain a good waterproof protection, to ensure against the sudden rain. After the completion of any repairs, the waterproof function must be restored to its original condition.

***Caution: If the heating equipment thermal insulation fails, it will directly affect the process medium temperature and at the same time may also damage the MI heating cable in its running condition. If the thermal insulation layer is exposed to rain, moisture, or humid conditions, this could produce electro-chemical corrosion and reduce the corrosion-proof and mechanical properties of the MI heating cable, which will directly affect the MI heating cable's service life.***

## Table 4 Pre-commissioning Check and Heat Tracer Installation Record

| | | | |
|---|---|---|---|
| Location: | System: | Project No.: | Reference drawing(s): |
| Line No.: | Heat tracer No.: | Area classification: | Temperature classification: |
| Panel No.: | Location: | Circuit No.: | Circuit amp/voltage: |
| Heat Tracer manufacturer: | Heat tracer model: | Heat tracer wattage unit length/voltage rating: | |
| Verify certification marking: | | | |
| MegOhm meter manufacturer/model: | | Voltage setting: | Accuracy/full scale: |
| Megohm meter date of last calibration: | | | |
| Multi-meter manufacturer/model: | Ohm setting: | Accuracy/full scale: | |
| **HEAT TRACE TESTING** | Test value/remarks: | Date: | Initials: |
| Note: Minimum acceptable insulation resistance shall be 20 MΩ. The test voltage is 1000Vd.c. | | | |
| 1 Receipt of material on reel: | | | |
| Continuity test on reel: | | | |
| Insulation resistance test on reel: | | | |
| 2 Piping completed (approval to start heat tracer installation) | | | |
| 3 After installation | | | |
| 4 Heat tracer installed (approval to start thermal insulation installation) | | | |
| Heat tracer correctly installed on pipe, vessel or equipment. | | | |
| Heat tracer correctly installed at valves, pipe supports, and other heat sinks. | | | |
| Components correctly installed and terminated (power, tee-end seal). | | | |
| Installation agrees with manufacturer's instructions and circuit design. | | | |
| 5 Thermal insulation installation complete | | | |
| Continuity test: | | | |
| Insulation resistance test: | | | |
| **SYSTEM INSPECTED** | | | |
| 6 Marking, tagging and identification complete. | | | |
| 7 Heat tracer effectively earthed. | | | |
| 8 Temperature controls properly installed and set points verified. | | | |
| 9 Junction boxes all certified and closed. | | | |
| 10 Thermal insulation weather tight (all penetrations sealed). | | | |
| 11 End seals, covered splices marked on insulation outer cladding. | | | |
| 12 Drawings, documentation marked as-built. | | | |
| Performed by: | | Company: | Date: |
| Witnessed by: | | Company: | Date: |
| Accepted by: | | Company: | Date: |
| Approved by: | | Company: | Date: |

## Table 5 Heat Tracing Commissioning Record

| | | | |
|---|---|---|---|
| Location: | System: | Project No.: | Reference drawing(s): |
| Line No.: | Heat tracer No.: | Area classification: | Temperature classification: |
| Panel No.: | Location: | Circuit No.: | Circuit amp/voltage: |
| Heat Tracer manufacturer: | Heat tracer model: | Heat tracer wattage unit length/voltage rating: | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Verify certification marking: | | | | | | | |
| **Verify certification marking:** | | | | | | | |
| **HEAT TRACER INFORMATION** | | | | | | | |
| Heat tracer total design length: | | | Heat tracer total installed length: | | | | |
| Thermal insulation type: | | | Thermal insulation thickness: | | | | |
| Workpiece maintain temperature: | | | Maximum workpiece temperature: | | | | |
| **HEAT TRACER TESTING (data from heat tracer installation record)** | | | | | | | |
| Electrical resistance (continuity) test, in ohms: | | | | | | | |
| Electrical insulation resistance test, in megohms: | | | | | | | |
| Test ambient temperature: | | | | | | | |
| PERFORMANCE DATA | Volts a.c. | | Current in amperes | | | | |
| | Panel | Field | Single-phase | Three-phase | | | |
| | | | Line | A phase | B phase | C phase | Neutral |
| Start-up | | | | | | | |
| After 5min | | | | | | | |
| After 4h | | | | | | | |
| Ambient temperature at time of test: | | | | | | | |
| Workpiece temperature at beginning of test: | | | After 4h | | | | |
| Calculated watts per unit length (V × A/m): | | | After 4h | | | | |
| TEMPERATURE CONTROL: type | | | | | | | |

| | | | |
|---|---|---|---|
| Heat tracer controller: | Ambient sensing: | Workpiece sensing: | Temperature set point: |
| High limit controller: | Type: | Location: | Temperature set point: |
| Heating controls calibrated: | | | |
| Heating controls operation verified: | | | |
| ALARMS/MONITORING TYPE: | | | |
| Temperature: | High setting: | Low setting: | Operation verified: |
| Heat tracer current: | High setting: | Low setting: | Operation verified: |
| Residual current: | | Setting | Operation verified: |
| Loss of voltage: | | | Operation verified: |
| Other | | | Operation verified: |
| RCD PROTECTION TYPE: | | | |
| Setting: | Measured current: | Tested in operation: | |
| Performed by: | | Company: | Date: |
| Witnessed by: | | Company: | Date: |
| Accepted by: | | Company: | Date: |
| Approved by: | | Company: | Date: |

## Table 6 Maintenance Schedule and Log Record

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Location system: | | System: | | | Reference drawing(s): | | |
| **CIRCUIT INFORMATION** | | | | | | | |
| Heat tracer No.: | | Circuit length: | | | Breaker panel No.: | | |
| Power connection: | | Design voltage: | | | Breaker pole(s) No.: | | |
| Tee connection: | | | | Residual current protection (type): | | | |
| Splice connection: | | | | Residual current trip setting: | | | |
| Heating controller | | | | | | | |
| **VISUAL** | | | | | | | |
| Panel No. | Circuit No. | | | | | | |
| | Date | | | | | | |
| | Initial | | | | | | |
| Thermal insulation | | | | | | | |
| Damaged insulation/lagging | | | | | | | |
| Water seal good | | | | | | | |
| Insulation/lagging missing | | | | | | | |
| Presence of moisture | | | | | | | |
| Heating system components | | | | | | | |
| Enclosures, boxes sealed | | | | | | | |
| Presence of moisture | | | | | | | |
| Signs of corrosion | | | | | | | |
| Heat tracer lead discolouration | | | | | | | |
| Heating and/or high limit controller | | | | | | | |
| Operating property | | | | | | | |
| Controller set point | | | | | | | |
| **ELECTRICAL** | | | | | | | |
| Insulation resistance testing (bypass controller if applicable) | | | | | | | |
| Test voltage | | | | | | | |
| Megger value, MΩ | | | | | | | |
| Heat tracer supply voltage | | | | | | | |
| Value at power source | | | | | | | |
| Value at field connection | | | | | | | |
| Heat tracer circuit current reading | | | | | | | |
| Amps reading at 2 min to 5 min | | | | | | | |
| Amps reading after 15 min | | | | | | | |
| Ground-fault current | | | | | | | |
| Comments and actions | | | | | | | |
| Performed by: | | | | Company: | | Date: | |
| Approved by: | | | | Company: | | Date: | |

NOTES:

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