HEAT TRACE™
SETTING THE STANDARDS LEADING THE WAY

The Heat Tracing Authority™

Design, Installation and Maintenance Manual

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Industrial Electric Heat Tracing Systems

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SYSTEM DESIGN

Introduction

Each heat tracing application imposes unique demands on the designer to achieve the desired performance in a safe manner. Heat tracing, systems comprise heating cables and ancillary items which necessarily interface with other system components such as thermal insulation and the electrical supply items which will power the system. The overall system is the integration of these component parts and so the values of these interfaced items have to be known and controlled in order to design a system that will perform as required, and do so safely.

Aspects of Safety are regulated by IEC 60519-1, 'Safety in installations for Electroheating and electromagnetic processing' – Particular requirements for electrical resistance trace heating systems for industrial and commercial applications.

The Design, Installation, Commissioning and Maintenance of electric heat tracing systems shall conform to all IEC requirements for the use of electrical equipment and with the requirements of the relevant heat tracing standard, usually either IEC 62395 Electrical resistance trace heating systems for industrial and commercial applications or IEC 60079-30 Explosive atmospheres - electrical resistance trace heating. Consideration shall be given to the maintenance of the system and process equipment, to energy efficiency, and to testing of the installed system for operational satisfaction and safety.

Note:

A copy of any Heat Trace ATEX certificate or any other approvals certificate can be provided on request.

When designing a heat tracing system for use in explosive gas atmospheres, additional constraints are imposed due to the requirements and classification of the area under consideration.

The heat tracing selection shall consider the determination of the maximum possible system temperature (usually the heater outer sheath temperature) under worst case conditions as specified in IEC 62395 or 60079-30. This temperature may be reduced, for example, through adjustments to the system parameters, for instance by the use of multiple tracers to reduce the power produced per unit length. The excess of installed power over and above the heating duty requirements, and the way in which heat tracers are applied, installed and operated shall not be the cause, even under worst-case conditions, of any unacceptable risk.

Competence

The design of electrical resistance trace heating systems shall be overseen by persons knowledgeable of trace heating following the design methodology for explosive atmospheres as specified by the manufacturer.

Thermal insulation

The selection, installation and maintenance of thermal insulation is a key component in the performance of an electrical heat tracing system. The type and thickness of the insulation must be as specified in the design documentation.

The thermal insulation system is normally designed to prevent the majority of heat losses. The heat tracing system compensates for the remaining losses. Therefore, problems with thermal insulation will have a direct impact on the overall system performance.

Selection of heat tracer

For a particular application, there are some basic design characteristics that shall be reviewed to determine the choice of trace heater(s). These are as follows:-

a) The maximum withstand temperature of the heat tracers shall be greater than the maximum possible work piece temperature (which may be greater than the normal operating temperature) and must be greater than the maximum maintain temperature.

b) Heat tracers should be suitable for operation in the environmental conditions specified, for example, a corrosive atmosphere or a low ambient temperature.

c) For hazardous locations, heat tracers must be certified for use in the particular explosive gas atmosphere.

For any application, there is a maximum allowable power density at which a heat tracer can be used without damaging either the work piece or its contents. This is particularly critical in certain cases, such as with lined pipes, vessels containing caustic soda or with heat-sensitive materials. The maximum allowable power density shall be recorded in the system documentation. Multiple tracing or spiralling of a single heat tracer may be required.

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Site-fabricated heaters

Site-fabricated heat tracers are permissible provided that:

- - installation personnel are competent in the special techniques required.
- - heat tracers pass the field (site work) test requirements.
- - heat tracers are correctly marked in accordance with the heat tracing standards.

Maximum temperature determination

It is important that the maximum sheath temperature of the heat tracer is determined for all applications to ensure safety from overheating. Some examples are:

a) Applications such as non-metallic piping where the maximum temperature of the heat tracer may exceed the maximum withstand temperature of the pipe material, the thermal insulation, or other components of the system;

b) Applications that are not thermostatically controlled or have ambient sensing control, and that have potentially high heater sheath temperatures at equilibrium;

c) Critical applications where a high degree of process temperature accuracy is required;

In determining the maximum sheath temperature it should be assumed that the controlling thermostat has failed in the 'on' position. The determined maximum heater sheath temperature must not exceed the high limit temperature for the application. This high limit temperature may, for example, be the maximum withstand temperature of the heater, a process temperature limit, or, if in a hazardous area, the Temperature Class of the hazard.

There are three ways of protecting the heat tracing system from exceeding the high-limit temperature:-

1. The use of inherently temperature-safe heat tracers (self-regulating trace heaters having a PTC characteristic) that can never exceed the high limit temperature. Heat tracing standards refer to this as the product classification method.

2. A stabilised design. Here the designer calculates the maximum possible work piece temperature, from which he determines the relative heat tracer sheath temperature, ensuring that it always remains below the high limit temperature.

or

3. A temperature control system.

When multiple heat tracers (especially on pipes with different flow conditions) are grouped together under a single surface-sensing temperature control device, each design condition shall be analysed as a stabilised design.

Inherently temperature-safe heat tracers (PTC characteristic)

Heat tracers that significantly reduce power with an increase in temperature may be deemed inherently temperature-safe if their power output is practically zero at a sheath temperature less than the maximum withstand temperature of the heater. Thus, in most applications further temperature limiting control measures are not necessary, provided that this sheath temperature is also below any other high limit temperature, such as the maximum allowable process temperature, or the T- class if the application is in an hazardous location. However, temperature controls may be utilised for energy efficiency purposes.

It should be noted that ALL Heat Trace's range of self-regulating heating cables are Inherently Temperature-Safe (IT-S) and rarely require temperature controls to ensure temperature safety.

Note:

Clearly, Inherently Temperature-Safe (IT-S) heat tracers provide the SAFEST form of temperature-safe protection and should ALWAYS be selected as a first option from a safety standpoint, as IT-S neither relies on a designer's calculations, nor the reliability of a temperature controller.

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Stabilised design (Fixed condition)

Stabilised design is based on the principle of determining the maximum work piece and heat tracer surface temperatures under a worst-case set of conditions. This is a calculation of the equilibrium conditions that occur when the heat input equals the system heat loss. The worst-case set of conditions include:-

1. maximum ambient temperature, (+40°C unless otherwise specified);
2. still air;
3. minimum value for the thermal conductivity of the thermal insulation;
4. no temperature control (or temperature controller failed in the 'on' condition);
5. the trace heater is operated at its stated operating voltage plus 10%;
6. the heat tracer is assumed to be operating at the upper limit of the manufacturing tolerance,
   or at the minimum specific resistance for series heat tracers.
7. the heater is not in contact with the work piece
   (an air gap exists between them).

It will be appreciated that a stabilised design is a complex calculation. The relationship between the work piece and heater sheath temperatures depends on heater geometry, and calculations should not be undertaken by persons inexperienced in the subject.

However, Heat Trace's Evolution Design program automatically carries out stabilised design calculations for every line, and advises when temperature controls are necessary for temperature safety;

Note;

Safety from a stabilised design relies on the accuracy and correctness of the calculations of a designer. Therefore a stabilised design carries more risk than an inherently temperature-safe heat tracing system, but less risk than a system relying on a correctly designed, installed and maintained temperature control system. Again, Heat Trace's IT-S self-regulating tracers should ALWAYS be selected as a first option, with stabilised design as a second option

Controlled design

Occasionally, although it is the least safe form of temperature safety protection, a controlled design cannot be avoided. The major concerns with this form of temperature protection are:-

- - is the sensor located at the hottest point in the circuit?
- - what happens if the sensor is moved or becomes detached? e.g. for maintenance purposes.
- - what happens if the sensor wires are cut, or the sensor fails?
- - does the control system for complex piping sections cater for all flow patterns?

For a controlled design, a temperature limiter/ control device must prevent the trace heater from exceeding the high-limit temperature by typically sensing:-

a) the temperature of the work piece or other application components; or

b) parameters other than temperature, such as current.

Whilst heat tracing standards permit the direct sensing of the heater sheath, this practice is NOT recommended by Heat Trace, due to the potential of a dangerous situation occurring when the sensor, without the knowledge of the user, becomes detached from the outer sheath.

Therefore, the sensor should always be fixed to the work piece. Heat Trace's Evolution software will advise the set-point temperature required in order to ensure that the sheath temperature does not exceed the high limit temperature.

The temperature limiter/control system shall open the circuit if a malfunction occurs in the sensor or the limiter/control device. Specific requirements for controlled designs are found in heat tracing standards IEC 62395 and IEC 60079-30-1. A Zone 1 hazardous area requires a second controller (called a limiter) that requires manual re-setting.

A control and monitoring system shall be used that meets the application requirements of these standards. It should be appropriate to the application considerations for various process types according to the degree of criticality and process temperature accuracy.

Such control and monitoring equipment may provide, control of temperature to ensure that high-limit temperatures are not exceeded, monitoring of the heat tracing circuit for faults, over-current protection and residual current protection and isolation. It is essential that any additional requirements for particular applications, specified by the heat tracing system designer for the system, also fully meet operational and safety requirements.

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Location of Temperature sensors

The number and location of sensors are determined by the requirements of the process design criteria.

- Sensors should be positioned at points that are representative of the maintain temperature.
- Where two or more heat tracing cables meet or join, sensors should be mounted 1m to 1.5 m from the junction.
- If a heat tracing circuit includes both piping and in-line heat sinks or heat sources, the sensor should be located on a section of pipe in the system approximately 1m to 1.5m from the in-line heat sinks or heat sources.
- Where a pipeline heating circuit runs through areas with different ambient temperatures (such as inside and outside a heated building), two sensors and associated controls may be required to control pipeline temperatures properly.
- In complex piping systems, the material flow patterns must be evaluated for all possible circumstances before selecting the number and sensor locations. It is often necessary to fit controls to each section of equipment that can experience variable flow patterns.
- The temperature sensor for control should be located to avoid direct temperature effects from the heat tracer. The sensor should be securely mounted to ensure good thermal contact with the work piece.
- The temperature sensitivity of certain process materials and certain types of piping materials may warrant both a control and high-limit temperature device. The control sensor should be located at least 90° around the circumference from the trace heater. The high-limit sensor may be located immediately adjacent to the control sensor with a set point at the material or system maximum allowable temperature, minus a safety margin.

INSPECTIONS

Receiving materials

Upon receipt of heat tracing components, a general inspection should be conducted including a confirmation of the correct type and quantities of materials and documentation. All heat tracers should be checked to verify catalogue type, product and package markings, power rating, voltage rating, quantity and special characteristics. In addition, receipt of installation instructions and, as appropriate, certificates or declarations of conformity should be verified. The supplier of the heat tracing system should provide Heat Trace's specific instructions for the trace heaters and the various types of system components. Instructions for components and trace heaters suitable and intended for unclassified and explosive gas atmospheres use shall be clearly identified.

Pre-installation testing

The following tests shall be performed and documented on a pre-installation checklist and record similar to that of Table 1. This shall also be used to determine whether the heat tracing design matches the installation conditions.

a) Heat tracers shall be visually checked for damage. Continuity and insulation checks should be made as a final check. Insulation resistance should be measured.

b) Individual controls shall be tested to ensure correct calibration including, but not limited to, set points, operating temperature range and span.

c) Vendor fabricated and assembled control panels shall include documentation certifying that all wiring, layout and functions are correct and have been tested. Upon receipt of the control panels at the work site, a general inspection shall be made to also confirm that no damage has occurred in transit.

Note: 'Claims under warranty will not be considered if the acceptance and commissioning report is not filled completely and signed'.

Visual examination

The heat tracer shall be completely free of physical damage. Connections pre-assembled at the factory must be sufficiently rugged to withstand normally expected conditions during installation.

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Insulation resistance test

Insulation resistance shall be measured from trace heater conductors to metallic braid, metallic sheath, or other equivalent electrically conductive material with a minimum 500 V d.c. test voltage. However, it is strongly recommended that higher test voltages be used – mineral insulated heat tracers should be tested at, but not exceeding, 1000 V d.c., and polymeric insulated heat tracers should be tested at 2500 V d.c. The measured insulation resistance shall not be less than 20 MΩ.

Component substitution

Components of a heat tracing system may be substituted if the following conditions are met:

a) components specifically listed in the supplier's installation or maintenance instructions shall not be substituted with similar parts unless the components are part of the certification;

b) other components specified in the supplier's installation or maintenance instructions may be substituted with any suitably rated component;

c) components that are part of a wiring system that supplies power to the heat tracer may be substituted with any suitably rated component acceptable to the authority having jurisdiction.

Determination of power supply location

The power supply location shall be determined prior to installation of the trace heating. The junction boxes shall be mounted in such a way that the trace heater cannot suffer damage between the point at which it emerges from the insulation and the point of entry into the junction box.

Installation of heat tracers

The heat tracer should not be folded, twisted, or allowed to overlap, cross or touch itself unless this is specifically permitted in the Heat Trace's instructions. Attention should be given to the minimum bending radii and minimum installation temperature stated in the product data sheets. Note that Heat Trace's range of self-regulating tracer cables will NOT be heat damaged by overlapping, although, as a principle, overlapping is not recommended.

In the installation of heat tracing systems, only genuine Heat Trace approved components may be used. Otherwise the system certification may be compromised.

Connections and terminations

It is essential that all heat tracers are terminated correctly. Connections and terminations completed at the work site should carefully follow Heat Trace's instructions. Factory terminated equipment should be inspected to ensure that such terminations are complete, properly tagged and/or marked in conformity to IEC 62395 or IEC 60079-30-1, as appropriate. It is important for the installer to review the certifications, the temperature ratings of the connections and terminations, and their suitability for the operating conditions.

'Longline' series resistance heat tracers, intended for site termination, should be checked before installation to ensure that the installed lengths correspond to the design length and loading. When mineral insulated or Constant Power heat tracers (AHT) are terminated at the job site, the cut ends should be sealed immediately to prevent any moisture ingress. For parallel circuit heat tracers, the total circuit length should not exceed Heat Trace's recommendations.

Termination can be made using approved Heat Trace termination kits or, with written authorisation of the manufacturer, any suitably certified type termination kit, which fully isolate, insulate and seal the conductive cores.

Connection kits

The connection kits of a heat tracers should be securely fitted in accordance with Heat Trace's instructions, protected to prevent physical damage and positioned to prevent the ingress of water, or other contaminants, that could adversely affect its use or suitability.

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PRE-INSTALLATION CHECKS

Table 1 - Pre-installation checks

	Items to be checked	Remarks
1	Is the workpiece fully erected and tested and 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 trace heater could damage the device
2	Is the surface upon which the trace heater is to be applied normal steel or non-metallic?	If the surface is of polished stainless steel, very thin-walled or non-metallic, special precautions may be necessary
3	Do the items to be heated correspond in size, position, etc. with the design?	It is sometimes difficult to be sure that the correct workpiece is being heated. A suitable line numbering system may be of assistance
4	Has it been specified that metallic foil be installed before the application of the trace heater??	This may be used to aid heat distribution
5	Has it been specified that metallic foil be installed after the application of the trace heater?	This may be used to prevent insulation from surrounding the trace heater or to aid heat distribution
6	Can flow of product under normal or abnormal conditions reach temperatures greater than those that the trace heater 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 trace heating system most recent documentation (working drawings, designs, and instructions) available?	No change shall be contemplated without reviewing the trace heating system documentation, as careful calculations are necessary to ensure safe operation
8	Can pipes or surfaces expand and contract so as to cause stress on any part of the trace heating 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 trace heater to be spiralled or straight traced onto the workpiece, according to the design?	Check design loading per unit length of pipe (or surface area) to determine if spiral 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 intermediate supports at a later stage could damage the heating system
14	Are sample lines/bleed lines, etc. at the plant but not on drawings?	These could obstruct or prevent the fitting of the trace heater, and a review of the trace heating 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?	More or less lengths of trace heater may be required than was called for in the design. This may require for redesign of the circuit.
16	Are the trace heaters, controllers, junction boxes, switches, cable glands, etc., suitable for the area classification and the environmental conditions and are they protected as necessary against corrosion and the ingress of liquids and particulate matter?	If the trace heater design does not meet the intended application, the circuit must be redesigned and the system documentation must be updated.

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Junction boxes

Heat tracing circuits shall be connected into boxes that are certified for the appropriate methods of protection, and that have suitable ingress protection. Junction boxes should be located as closely as possible to the heat tracer exit point while allowing for any work piece expansion. Junction box lids should not be left open at any time.

Cold leads

Checks should be made to ensure that the joints are waterproof, where applicable, and the bond to earth is valid. Cold leads, if used, should always emerge from the surrounding thermal insulation in such a way that ingress of water or other contaminants is not possible e.g. by the use of Heat Trace's DESTU sealed termination units. Cold leads should be protected where they exit through thermal insulation.

Cold leads shall only be fitted or modified on site in strict accordance with Heat Trace's instructions and conditions of use, as specified by the certifications. Where cold leads have been jointed to metal sheathed heat tracers by means of soldering or brazing, neither the heat tracer nor the cold lead should be bent near a brazed joint.

Heat tracer entries and glands

Seals and/or glands supplied with heat tracers shall be appropriately certified. Glands shall be fully screwed into the box and compression applied to provide a complete seal. Unused entries shall be blanked off with suitable plugs. If unthreaded entries are used, the entry size shall provide sufficient clearance for the threaded section of the gland, with the gland locknut tightened against a compressible sealing washer to seal the gland in the enclosure.

Conductor terminations should not be completed until after all other connections and the end termination have been assembled and the circuit insulation resistance test has been carried out.

Earthing requirements

Earthing requirements include the following:

a) The outer metallic covering or metallic braid of the trace heater shall be bonded to the earthing system to provide for an effective ground path.

b) In applications where the primary ground path is dependent on the metallic covering or metallic braid, the chemical resistance of the material shall be considered if exposure to corrosive vapours or liquids might occur.

Jointing, splicing and modifications

Jointing, splicing and modifications to the heat tracer shall be carried out on site only in strict accordance with Heat Trace's instructions. Note that any such work on heat tracers in explosive gas atmospheres may invalidate the explosive gas atmospheres certification.

Particular attention should be paid to any modifications to heat tracers where any change in unit length will alter the power density of the heat tracer and affect the sheath temperature. Modifications shall be recorded in the system documentation.

End terminations

The end termination of a heat tracer shall be securely fitted in accordance with Heat Trace's instructions and protected to avoid mechanical damage and the ingress of water or other contaminants that may adversely affect its use or suitability.

Conductor terminations

Terminals shall be of sufficient size and rating to accept the conductors, which may be solid or stranded wires or foils. Care should be taken in stripping back insulation to avoid damaging the conductors.

Crimp or compression type connectors and ferrules shall be of the correct size and of an approved type for the conductor concerned. Compression tools shall be suitable for the specific types of fittings and be in good condition.

Heat tracers that have been installed and not terminated shall be sealed to prevent ingress of moisture and shall be protected from damage pending completion of the termination.

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STANDARD CABLE INSTALLATION PROCEDURE

Persons involved in the installation and testing of electric trace heating systems shall be suitably trained in all special techniques required. Installation shall be carried out under the supervision of a qualified person.

De-energise circuits before installation or servicing.

Electrical Supply Points

Locate all electrical supply points (and where applicable, any splice connection points) and site the components into the location where the heaters will be terminated. Any associated thermostatic controls or sensors should also be fixed and, if appropriate, interwired to the power supply unit. Fittings normally are mounted onto predrilled Heat Trace pipe mounting brackets or to any other firm surface within 0.5m of the termination (design) point.

Spiral Pitch

If the heater is to be spiralled onto the pipe then follow the circuit route, marking off the required spiral pitch with a piece of chalk. It may help to apply string or cord to the specified spiral ratio and note the resultant spiral pitch before applying the heaters. If the same pitch is commonly in use then a stick or rod marked with the spiral pitch may be a useful gauge.

Cable Installation

Follow the specific termination instructions. Generally they suggest cutting a zonal tracer close to an electrical zone connection which will be just visible through the basic tracer sheath. Series heaters must equal the design length when installed. Starting adjacent to the supply point, anchor the tracer to the surface with fixing tape at the next electrical connection (zonal tracers) or approximately 0.75 metre distant with other types, leaving the remainder of the tracer freely suspended for making off the terminations.

Cable Fixing

Spiral or straight trace as indicated on the drawings, following any instructions indicating which side of the heater should be on the heated surface. Apply straight tracers to the lower half of the pipe if possible, keeping away from the underside of flanges and other joints which might leak fluids onto the tracers in service. (See Fig 1).

Keep the tracer reeled up as far as possible and apply under SLIGHT tension. Fix straight traced heaters every 300mm (12”) with 1.5 turns of fixing tape. It is recommended that an expansion allowance for all nominally straight traced heaters is allowed. This is achieved by a turn around the pipe at regular intervals, or by special expansion conduits applied to larger pipes. In no case should fixings be applied at more frequent intervals than the 300mm recommended in most standards, eg. wrapping fixing tape in a continuous close spiral over the tracer is not good practice and may result in expansion failures near the mid-point of the circuit. It is sufficient to fix spirally applied heaters at 2m (6ft) intervals.

Heaters normally are only spiralled at a maximum ratio of 1.5:1. Greater ratios are better achieved by straight tracing multiple heaters unless otherwise specified by the system designer. (See Fig 2).

To achieve maximum heat transfer from the heater to the surface to be heated, we strongly recommend the use of over foil with Aluminium fixing tape. In particular with 31 FSLe, 40 FSR, 60 FSEw and all cables over 75 W/m.

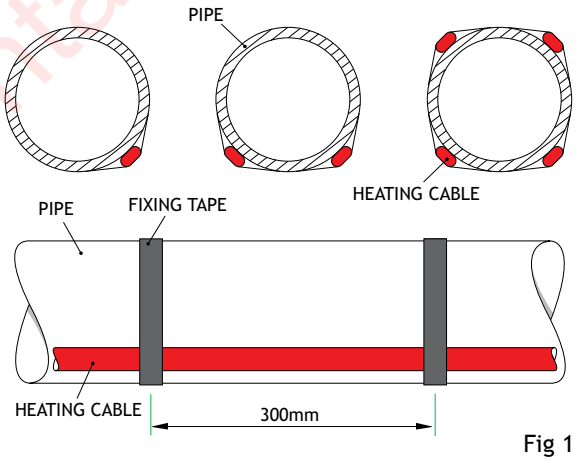
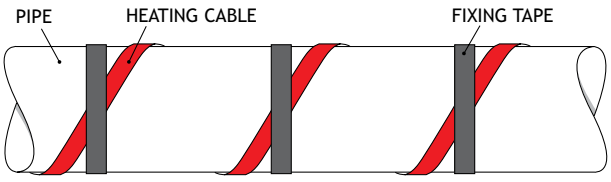


Fig 1



NOTE: REFER TO SYSTEM DESIGN INFORMATION FOR HEATER SPIRAL PITCH

Fig 2

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Flanges

At flanged joints, ties should be positioned on either side and close to the flanges to ensure maximum surface contact. To avoid mechanical damage during future servicing of the line fitting, and to cater for additional heat losses, allow sufficient slack, generally as a small loop over the flange, to permit attention to the flange packings. To avoid damage from leakage do NOT pass the tracer over the flange at the 6 o'clock position. (See Fig 3).

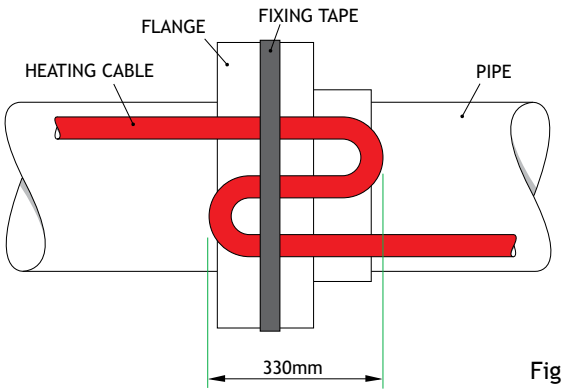

Fig 3

Valves

If valves are not to be provided with separate heaters then allow sufficient extra heater to cover the additional losses. Appropriate allowances are suggested in IEC 62395 'Electrical resistance trace heating systems for industrial and commercial applications' or may be marked on the system drawings. Heat tracers should be "reverse spiralled" at fittings to permit future withdrawal of the fitting for service. (See Fig 4).

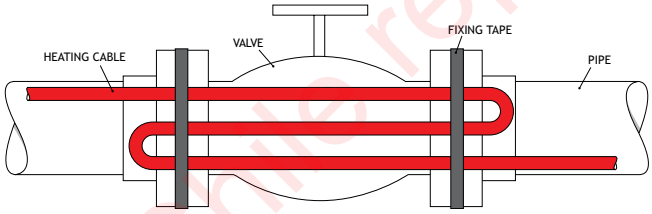

Fig 4

Heating cable should always follow the long radius at bends. (See Fig 5).

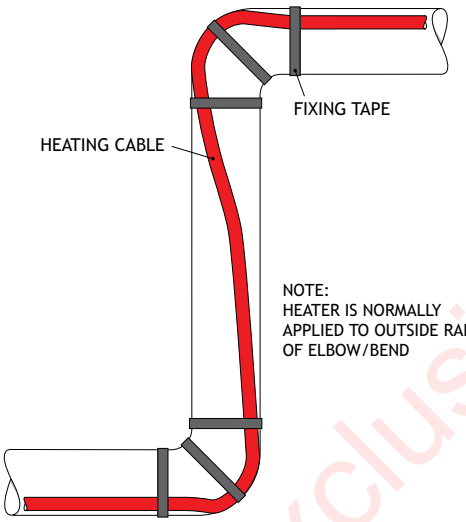

Fig 5

Cable Terminations

Terminate the tracers and fit the end seals in strict accordance with the product specific instructions.

Do NOT connect the conductors of a parallel circuitry heater together as this will result in a short circuit.

Protect all cable ends from moisture, damage or other interference if they are to be left exposed for an extended period of time.

Splice Connections

To facilitate the removal of spool pieces or fittings without disturbing the tracer scheme, parallel circuitry tracers may be cut at flanges, filters, pumps, etc. and a splice connection made off into a suitable junction box.

Note:

It may be possible to use this technique with series heaters by substituting lengths of suitably sized hook-up cable to a maximum total of 5% of the original circuit length.

Tee Branches

At 'Tee' branches the tracer may be cut and the three sections from each branch may be spliced together using a splice kit (if available) or termination kits and a 'Tee' connection box. Alternatively, it may be more convenient to run the heater through the Tee position and provide an independent heater for the branch.
(See Fig 6).

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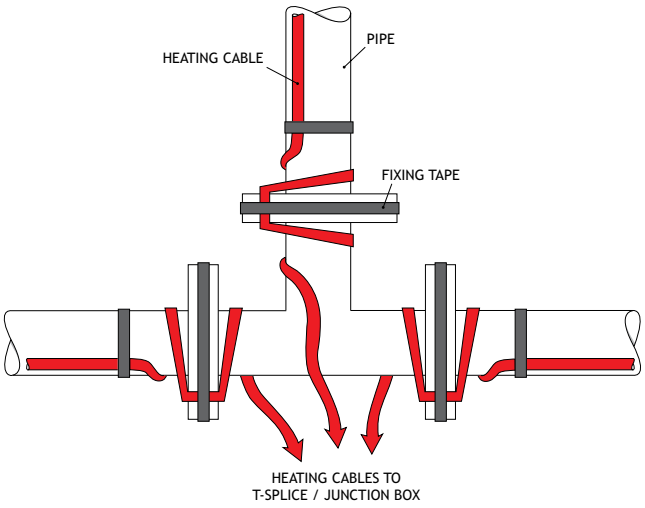

Fig 6

Plastic Pipework

Plastic piping will always use low power heaters, usually applied over a metallic foil carrier and/or fixed with an adhesive backed metallic foil tape.

Sensor Location

Position the sensor of the thermostat or other controller on the heated surface within 100mm of the heater using fixing tape, special adhesive backed aluminium fixing tape, or heat resistant clips. The temperature sensor should not be in direct contact with the heater unless the heated surface is plastic when it should be placed immediately adjacent to the heater. Set the thermostat or other controller to the design operating temperature specified in the system drawings or documentation. (See Fig 7).

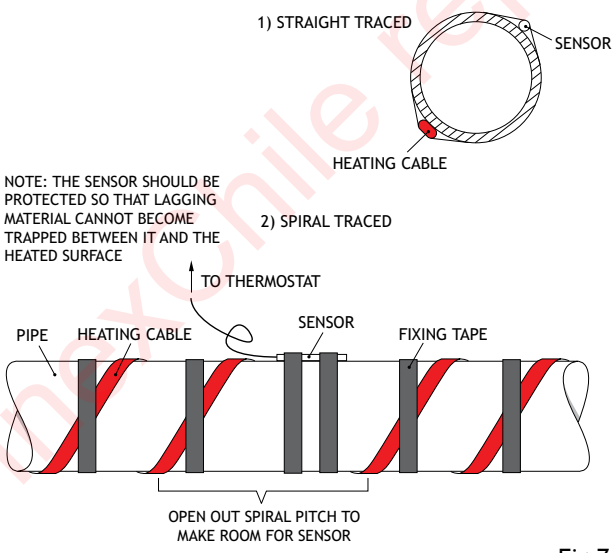

Fig 7

Fittings

Typical application of heat tracing at fittings:

Heater installation on strainers (See Fig 8)

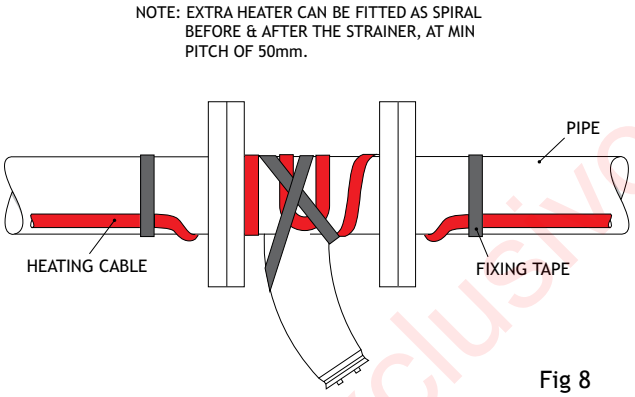

Fig 8

Heater installation on Pipe supports (See Fig 9)

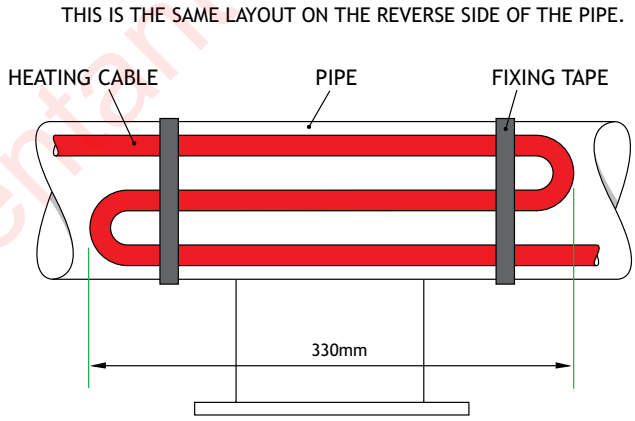

Fig 9

Heater installation on Pumps (See Fig 10)

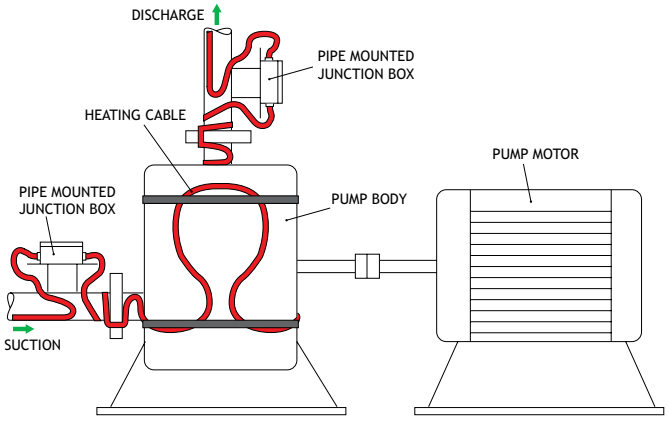

Fig 10

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INSTALLATION PROCEDURE FOR LLR CABLES

Electrical supply points

Locate all electrical supply points (and where applicable, any splice connection points) and site the components into the location where the heaters will be terminated. Any associated thermostatic controls or sensors should also be fixed and , if appropriate, interwired to the power supply unit. Fittings normally are mounted onto pre-drilled Heat Trace pipe mounting brackets or to any other firm surface within 1.0m of the termination (design) point.

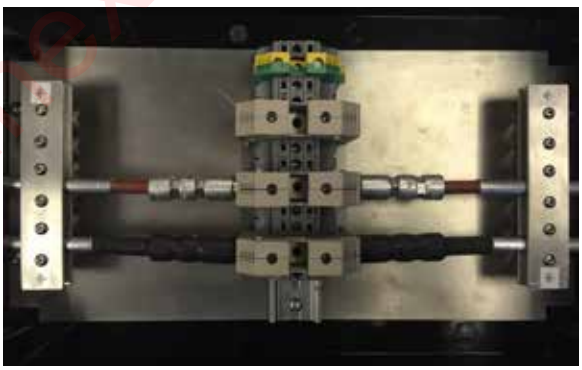
Spiral pitch

It is not recommended that LLR cables are spiralled.

Cable installation

Follow the specific termination instructions. The LLR cable can be terminated in several ways, three of these use an ‘in line splice joint, the joint can comprise of either a sonic welded joint, cold welded joint or a compression joint, the joint is then filled with silicone. The splice joint is as shown below.

The other termination method is on low power output LLR to terminate directly into the power/ star or intermediate junction boxes; this is done via a crimping method as shown in the picture below.



Cable Fixing

Straight trace as indicated on the drawings below, following any instructions indicating which side of the heater should be on the heated surface. Apply straight tracers to the lower half of the pipe if possible, keeping away from the underside of flanges and other joints which might leak fluids onto the tracers in service. (See Fig 11).

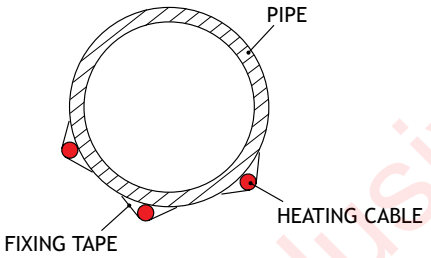


Fig 11

Keep the tracer reeled up as far as possible and apply under SLIGHT tension. Fix straight traced heaters every 300mm (12”) with 2 turns of fixing tape. It is recommended that an expansion allowance for all nominally straight traced heaters is allowed. This is achieved by special expansion conduits applied to larger pipes. In no case should fixings be applied at more frequent intervals than the 300mm recommended in most standards, eg. wrapping fixing tape in a continuous close spiral over the tracer is not good practice and may result in expansion failures near the mid-point of the circuit.

Sensor Location

Position the sensor of the thermostat or other controller on the heated surface within 100mm of the heater using fixing tape, special adhesive backed aluminium fixing tape, or heat resistant clips. The temperature sensor should not be in direct contact with the heater unless the heated surface is plastic when it should be placed immediately adjacent to the heater. Set the thermostat or other controller to the design operating temperature specified in the system drawings or documentation. (See Fig 12).

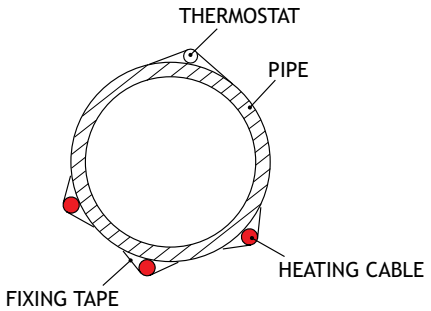


Fig 12

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Flanges

At flanged joints, ties should be positioned on either side of the flanges. To avoid mechanical damage during future servicing of the line fitting, and to cater for additional heat losses, allow sufficient slack, and install over the flange in an ‘S’ method as shown below, the bending must be via the approved Heat Trace Ltd bending device. The Trace is to be installed as shown below.

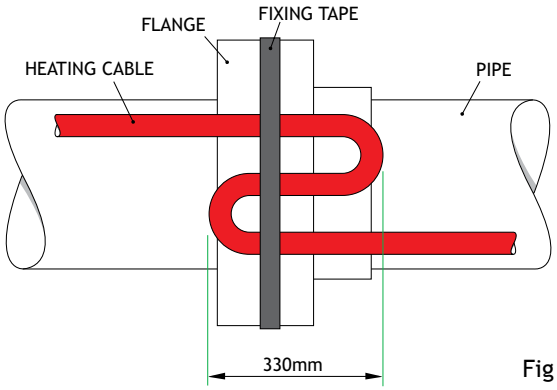

Fig 13

Valves

If valves are not to be provided with separate heaters then allow sufficient extra heater to cover the additional losses. Appropriate allowances are suggested in IEC 62395 ‘Electrical resistance trace heating systems for industrial and commercial applications’ or may be marked on the system drawings. LLR cable should use the ‘S’ method as shown below.

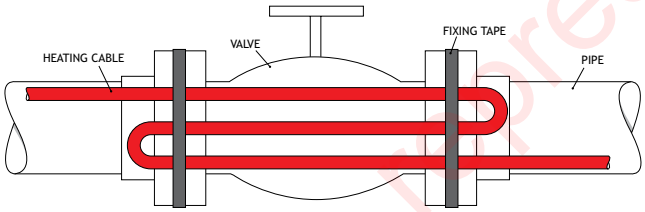

Fig 14

Bending Ratio’s

The bending ratio of LLR cable is shown in the tabe below. All bending should be carried out using the Heat Trace Ltd approved bending device.

Cable Type	Diameter ‘D’	10D	Round up to nearest 5mm
HTS1F-AR-A 1.7	6.1	61	65mm
HTS1F-AR-A 3.1	6.6	66	70mm
HTS1F-AR-A 7.1	7.6	76	80mm
HTS1F-AR-A 12.6	8.6	86	90mm
HTS1F-AR-A 19.6	9.6	96	100mm
HTS1F-AR-A 28.3	10.6	106	110mm
HTS1F-AR-A 40	14.9	149	150mm
HTS1F-AR-A 60	16.5	165	165mm

Heating cable should always follow the long radius at bends. (See Fig 15).

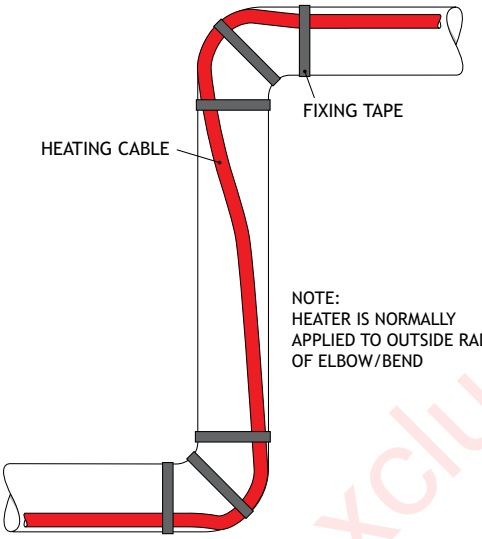

Fig 15

Heater installation on Pipe supports (See Fig 16)

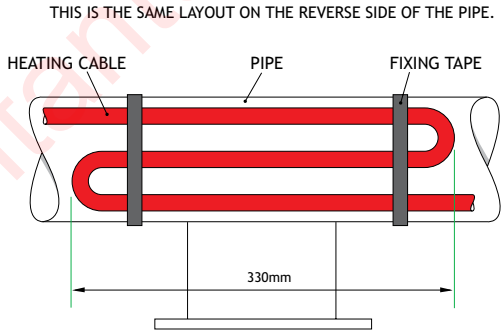

Fig 16

Cable Terminations

Terminate the tracers and ends into junction boxes in strict accordance with the product specific instructions and documentation.

Protect all cable ends from moisture, damage or other interference if they are to be left exposed for an extended period of time.

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Electrical Connections

Complete the electrical connections into the termination units. Ensure that any inter-connecting cabling between thermostats and power supply units is complete (see ELECTRICAL SUPPLY POINTS above).

Note:

Electrical hook-ups, and interwiring of heat tracing components are often the responsibility of the main electrical contractor and so may not be within the scope of the heat tracing installation.

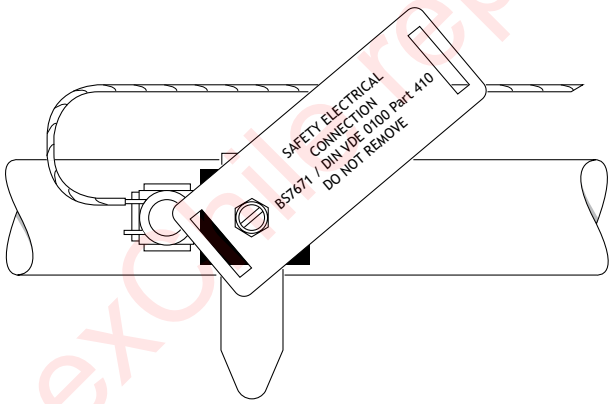
Earthing / Bonding

Before putting into service, earthing/bonding must be in accordance with BS7671, or DIN VDE 0100 Part 410. Check that appropriate provision is made for all extraneous metalwork, such as external metal braids, or mounting plates, to be connected to the installation's main earthing terminal or that they are bonded to protective conductors.

Particular attention should be paid to bonding the sheaths of mineral insulated, metal sheathed cables because, under fault conditions, heavy earth currents from associated installations could be present.

Note:

A label must be firmly attached in a visible position at every point of connection of every conductor which bonds extraneous conductive parts.
(See Fig 17)



EARTH CONNECTION WARNING NOTICE

Fig 17

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Control and monitoring

Verification of equipment suitability

The selected limiters, controllers, thermostats, sensors, and related devices shall meet the requirements of the overall system with regard to the service temperature, the IP (ingress protection) rating, and the method of protection. The certification of heat tracing systems may prescribe the use of specific components. In these cases it is mandatory to use only parts specified by Heat Trace.

Sensor considerations

General sensor installation

The sensor should be installed and positioned in accordance with Heat Trace's instructions. The control sensor should not be situated in areas of external radiant heat, solar gain, process heat discharge or close to a heated building. Care should be exercised to ensure that the sensor can sense appropriate temperature conditions within a trace heated zone and away from the end of a pipe or a pipe support. Ambient temperature-sensing controllers should be sited in the most exposed position for the installation.

The sensor should be strapped in good thermal contact with the work piece or equipment and protected so that thermal insulation cannot be trapped between the sensor and the heated surface. Care should be taken not to damage the capillary tube, thermocouple or RTD leads, or to distort the sensor and thereby cause calibration error.

Where direct temperature sensing of the flowing medium is required, the sensor should be located in thermowells at suitable positions, for example above potential sludge levels in vessels.

Excess capillary tube may be run under the thermal insulation unless the overall length exceeds 1m, in which case, the volume of the capillary may be sufficient to adversely affect equipment calibration.

Care should be taken to ensure that the capillary tube, thermocouple or RTD leads emerge from the thermal insulation in a manner that will not allow the ingress of moisture.

In many cases the sensor location is defined during the system design phase. Considerations for sensor placement are defined above.
The following sections describe installation considerations for specific installation methods.

Sensor installation for temperature controllers

The sensor for the temperature controller is installed onto the surface of the work piece or equipment in a position that will provide a temperature that is representative of the overall circuit. As illustrated in Figure 12, the sensor shall be positioned so that it is not influenced by the temperature of the trace heater, or other factors, such as heat sinks and/or solar gain.

Sensor installation for temperature limiting device

Where temperature limiters are required to ensure temperature safety, the sensor is installed onto the surface of the work piece, or equipment, in a position that will provide a temperature representative of the overall circuit. In order to ensure that the safety temperature controller can accurately react to the maximum trace heater surface temperature, particular attention must be paid to the location, method of attachment and set point. This method of sensor installation is based on the known relationship between the equipment temperature and the heater sheath temperature at a given power output. Typical temperature limiting sensor installation is indicated in Figure 18.

It is important that the controller is set so that the heater sheath temperature does not exceed the high-limit temperature under worst-case conditions (e.g. voltage +10 %, heater at upper limit of manufacturing power tolerance, heater out of contact with the work piece/equipment, high ambient, no external convection). Heat Trace's Evolution software will enable this set-point temperature to be defined.

Fig 18

Typical installation of control sensor and sensor for temperature limiting control.

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Controller operation, calibration and access

Set-point values of the temperature controllers and, where unavoidable for the temperature safety of the system, safety temperature limiters, shall be reviewed during commissioning. Temperature limiters must be tamper-proof.

The temperature control device and sensor loop shall be calibrated at the commissioning stage. The controller shall be set to the required temperature and re-calibrated from the factory setting if necessary. A function check shall be made by adjusting the temperature setting until the controller is seen to energize the heat tracer.

All measured data shall be documented.

Thermal insulation

General

The selection and application of the thermal insulation are key elements in the installation of an electric heat tracing system. The thermal insulation is normally designed in such a way that it largely compensates the heat losses of the heating system. Consequently, problems with the insulation have a direct effect on the performance of the system as a whole. Minimisation of energy dissipation reduces the running costs, improves the system characteristics and enhances the system's heating capacity. Installation of thermal insulation shall conform to all applicable national standards and local regulations.

Preparatory work

Precautions must be taken to protect heat tracers from mechanical damage and moisture intrusion after they have been installed and prior to the application of thermal insulation. Before starting the installation of thermal insulation, it is recommended that the site engineering department establishes a liaison between the heat tracing installer and the thermal insulation contractor, so that the thermal insulation is applied as soon as possible after the installation and testing of heat tracers.

The following checks and procedures should be confirmed:-

a) Verify that the type, inside diameter, and thickness agree with the values used in the selection of the heat tracer(s). If the insulation thickness differs from the specification, it may not be possible to meet the required system performance.

b) For thermal insulation, temporary weather protection should be provided during storage, handling and installation to avoid the risk of moisture being trapped under the weather-protective coating or jacket.

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Distribution wiring and branch circuits

The branch circuit wiring of each heat tracing circuit requires an over-current protective device. The size and type of distribution wiring, and the ratings of the branch circuit protective devices should be based on heater start-up currents and their duration at the minimum temperature the heat tracing device may experience.

Earth-fault protective device

An appropriate earth fault protective device shall be provided, with a sensitivity of 30mA, 30ms, unless otherwise specified.

Earth fault equipment protection is required for each circuit.

Circuit protective device

It is necessary to check that:

- - the protective device is sized correctly to the rated current (at initial and detailed inspections);

- - the protective device is certified to all applicable national and international requirements and to the requirements for the appropriate method of protection.

Tagging/Identification

Permanent tagging and identification shall be completed as follows and shall be verified for compliance with the marking requirements of IEC62395-1 or 60079-30-1, as appropriate:

a) Branch circuit breaker
b) Monitor and alarm apparatus
c) Heat tracer power connection
d) Circuit number and set-point for each temperature controller.

Marking shall be carried out for each heat tracing circuit, on the respective junction box.

Testing

Trace heater circuit insulation resistance test

Test procedures shall be conducted on all heat tracer circuits after installation.

Necessary modifications

The heat tracing systems are subjected to checking of the maximum surface temperature. If the temperatures measured deviate from the admissible surface temperatures, or from the design figures, corrective measures shall be taken and the system shall be modified.

Field (site work) circuit insulation resistance tests shall be conducted on all heat tracer circuits after installation, with the requirement that the measured insulation resistance shall not be less than 20 MΩ, except that MI trace heaters shall not be less than 5 MΩ.

Visual inspection

The visual inspection shall ensure that:

a) no moisture can penetrate the insulation as a result of weathering (correct position of overlaps or lock beading);

b) sliding connections (or similar) on weather cladding are sufficiently flexible to absorb any expansion movement;

c) the screws selected for fastening the weather cladding are short enough to exclude any possibility of damage to heat tracers or to temperature sensors;

d) the entry cut-outs in the weather cladding for trace heaters, temperature sensors, etc., are dimensioned so they ensure that contact is impossible. This is especially relevant in the case of branches, where the cladding must be cut sufficiently wide;

e) the cladding joints and thermal insulation entries are properly sealed with an elastic, non-hardening sealant that is resistant to chemical attack and decay, and is dimensionally stable.

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Commissioning

Pre-commissioning check

The pre-commissioning checklist given in Table 2 should be completed and retained. The trace heating system parameters in table 3 shall be verified during commissioning.

Functional check and final documentation

The heat tracing system(s) shall be commissioned after the thermal insulation has been installed and the electrical distribution is completed. The heat tracer commissioning record given in Table 3 shall be completed and retained.

The following functional checks should be carried out:

a) Close all branch circuits and verify proper current. A temporary bypass may be required for the temperature control device.
b) Verify that monitor or alarm circuits are operable. A bypass may be required at field contacts.
c) Complete the heat tracer commissioning record (Table 3) for each circuit. This shall clearly document all testing and commissioning data.
d) Record the electrical insulation resistance values for each measurement taken.
e) Record the applied voltage and resulting current after 5 minutes of energisation, together with the work piece temperature, if required.
f) Verify that the alarm and monitor components operate as intended.
g) Verify that the calibration check at the temperature controller set-point has been performed and the controller has been set at this value.

Testing after commissioning

It is recommended that the insulation resistance of the entire branch circuit, after the thermal insulation is complete, should not be less than 5 MΩ. If the value is below 5 MΩ, verify that integrity of the heating device has not been compromised. If required, the operation of each electric heating device should be checked by applying rated voltage and recording current and pipe temperature at steady-state conditions. Time should be allowed for the current to stabilize, as the start-up current is sometimes higher than the operating current.

Instructions for maintenance/repair or modification

Caution: consult the trace heating system documentation prior to maintenance/repair/modification.
After maintenance/repair/modification, test the operation of the earth-fault device of each affected circuit.
In the event of an earth fault or over current interruption, the device shall not be reset until the cause of the trip has been investigated by qualified personnel.
Upon completion of maintenance/repair/modification, the insulation resistance of the trace heater shall be measured and recorded after installation and shall not be less than 20MΩ, except that MI trace heaters shall not be less than 5MΩ (or higher values if specified by Heat Trace Ltd).

Final documentation

Adequate and uniform documentation of the electric heat tracing circuits is an essential precondition for economical maintenance of this equipment. This is especially important to facilitate rapid troubleshooting in the event of circuit problems. It also provides the basis for simpler, faster and less costly handling of any desired modifications and expansions by a specialist for electric heat tracing systems.

The documentation of each heating circuit of a heat tracing system shall include the following elements:

a) Design and testing documentation:
   1) Table of contents
   2) Piping layout showing the heat tracing circuits and the location of power points, connections, splices, tees, remote end terminations and temperature sensors for control and limitation
   3) For vessels: layout of the heat tracing
   4) Maximum work piece temperature and insulation type, size and thickness.
   5) Individual circuit length of heat tracers
   6) Calculation and dimensioning data
   7) Material list
   8) Trace heater installation instructions
   9) Heater cabling plan
   10) Description of and installation instructions for temperature sensors
   11) Heater commissioning record (Table 3)
   12) Temperature profile measurement
   13) Installation certificate
   14) Maximum ambient temperature
   15) Trace ratio

b) Circuit diagrams or lists:
   1) Wiring and circuit diagrams or lists
   2) Terminal connection diagrams, switchgear with parts list
   3) Installation instructions

c) Other:
   1) Technical descriptions and instruction manuals for the individual pieces of equipment
   2) Functional diagram - as agreed with the system design engineer
   3) Certificates from a certification agency for explosive gas atmosphere equipment, where appropriate.

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Table 2 - Pre-commissioning Checklist

Location:	System:	Project number:	Reference drawing(s):
Line number:	Heater number:	Area classification:	Temperature classification:
Panel number:	Location:	Circuit number:	Circuit amp/voltage:
Heater manufacturer:	Heater model:	Heater wattage unit length/voltage rating:	
Megohm meter date of last calibration:		Voltage setting:	Accuracy/full scale:
Megohm meter manufacturer/model:			
Multimeter manufacturer/model:	Ohm setting:	Accuracy/full scale:	

HEATER TESTING	Test value/remarks:	Date:	Initials:
NOTE Minimum acceptable insulation resistance shall be 20 MΩ. Minimum acceptable test voltage is 500 V d.c. However, 1,000 V d.c. recommended for MI, 2,500 V d.c. for polymeric cables.			
1 Receipt of material on reel			
Continuity test on reel			
Insulation resistance test on reel			
2 Piping completed (approval to start heater installation)			
3 After installation			
4 Heater installed (approval to start thermal insulation installation)			
Heater correctly installed on pipe, vessel or equipment			
Heater correctly installed at valves, pipe supports, 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 (see IEC 60079-30-1)			
7 Heater 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:

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Table 3 - Heater commissioning record

Location:	System:	Project number:	Reference drawing(s):
Line number:	Heater number:	Area classification:	Temperature classification:
Panel number:	Location:	Circuit number:	Circuit amp/voltage:
Heater manufacturer:	Heater model::	Heater wattage unit length/voltage rating:	

HEATER INFORMATION:						
Heater total design length:		Heater total installed length:				
Thermal insulation type:		Thermal insulation thickness:				
Normal pipe temperature:		Maintain pipe temperature:				
HEATER TESTING: (data from heater installation record)						
Electrical resistance (continuity) test in ohms:						
Electrical insulation resistance test in Megohm:						
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 10 min						
After 4 h						
Ambient temperature at time of test:						
Pipe temperature at beginning of test:		After 4 h:				
Calculated watts per unit length (V x A/m):		After 4 h:				
TEMPERATURE CONTROL: type						
Heater controller	**Ambient sensing**	**Pipe sensing**	**Temperature setpoint**			
High limit controller	**Type**	**Location**	**Temperature setpoint**			
Heating controls calibrated						
Heating controls operation verified						
ALARMS/MONITORING: type						
Temperature:	High setting:	Low setting:	Operation verified			
Heater 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:				

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Cable Markings: Self-Regulating

Product	Certificate No.	Markings
FSS	**Sira 02ATEX3072**	Ⓔx II 2GD
		Ex e IIC T3 Gb Applicable for products rated up to 75W/m and 277 V max
		Ex tb IIIC T200°C Db IP67
		Ex e IIC T2 Gb Applicable for products rated above 75 W/m and for nominally rated 230 V products powered up to a maximum 277V.
		Ex tb IIIC T300°C Db IP67
FSR	**Sira 02ATEX3070**	Ⓔx II 2GD
		Ex e IIC T6 Gb Applicable for products rated up to 40 W/m and for nominally rated 230V products up to 31 W/m powered up to a maximum 277V.
		Ex tb IIIC T85°C Db IP67
		Ex e IIC T4 Gb Applicable for products rated above 40 W/m and for nominally rated 230V products above 31 W/m powered up to a maximum 277 V.
		Ex tb IIIC T135°C Db IP67
FSE	**Sira 02ATEX3076**	Ⓔx II 2GD
		Ex e IIC T4 Gb
		Ex tb IIIC T135°C Db IP67
FSEw	**Sira 12ATEX3114**	Ⓔx II 2GD
		Ex e IIC T4 Gb Applicable for nominally rated 230 V products up to 45W/m powered up to a maximum 277V
		Ex tb IIIC T135°C Db IP67
		Ex e IIC T3 Gb Applicable for nominally rated 230 V products above 45W/m powered up to a maximum 277V
		Ex tb IIIC T200°C Db IP67
FSM	**Sira 02ATEX3075**	Ⓔx II 2GD
		Ex e IIC T6 Gb
		Ex tb IIIC T85°C Db IP67
FSLe	**Sira 02ATEX3074**	Ⓔx II 2GD
		Ex e IIC T6 Gb Applicable for products rated up to 31 W/m powered at their nominal voltage and up to 25 W/m for nominally 230 V rated products powered up to 277V.
		Ex tb IIIC T85°C Db IP67
		Ex e IIC T4 Gb Applicable for products rated above 31 W/m powered by their nominal voltage and above 25 W/m for nominally 230 V rated products powered up to 277V.
		Ex tb IIIC T135°C Db IP67
FLV	**Sira 12ATEX3115**	Ⓔx II 2GD
		Ex e IIC T6 Gb Applicable for products rated up to 31 W/m
		Ex tb IIIC T85°C Db IP67
		Ex e IIC T4 Gb Applicable for products rated above 31 W/m
		Ex tb IIIC T135°C Db IP67
FLVw	**Sira 12ATEX3113**	Ⓔx II 2GD
		Ex e IIC T6 Gb Applicable to cables with a rating less than 40 W/m used at up to 30 Vmax.
		Ex tb IIIC T85°C Db IP67
		Ex e IIC T4 Gb Applicable to cables with a rating above 40 W/m used at up to 30 Vmax.
		Ex tb IIIC T135°C Db IP67
FSU	**Sira 04ATEX3012**	Ⓔx II 2GD
		Ex e IIC T3 Gb Applicable for products rated up to and including 75W/m and 277 V max
		Ex tb IIIC T200°C Db
		Ex e IIC T2 Gb Applicable for products rated above 75W/m and for nominally rated 230V products powered to a maximum 277V.
		Ex tb IIIC T300°C Db
FSUw	**Sira 13ATEX3126**	Ⓔx II 2GD
		Ex e IIC T3 Gb Applicable for products rated up to and including 75W/m and 277 V max
		Ex tb IIIC T200°C Db
		Ex e IIC T2 Gb Applicable for products rated above 75W/m and for nominally rated 230V products powered to a maximum 277 V
		Ex tb IIIC T300°C Db
FS+	**CML 18ATEX3154**	Ⓔx II 2GD
		Ex e IIC T3 Gb Applicable for products rated up to 75W/m and 277 V max
		Ex tb IIC T200°C Db
		Ex e IIC T2 Gb Applicable for products rated above 75W/m and for nominally rated
		Ex tb IIIC T300°C Db 230 V products powered up to a maximum 277 V.
		IP66/67

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Cable Markings: Constant Wattage & LongLine

Product	Certificate No.	Markings
PHT	**CML 17ATEX3169**	Ⓔx II 2GD
		Ex e IIC T* Gb
		Ex tb IIIC T*°C Db IP67
		Ta=-40°C ≤Ta≤ +285°C
AHT	**Sira 02ATEX3079**	Ⓔx II 2GD
		Ex e IIC T* Gb
		Ex tb IIIC T#°C Db
		T* and T#°C (see schedule)
MTFJ	**Sira 02ATEX3077**	Ⓔx II 2G
		EEx e II T (see schedule)
HTS1F	**Sira 17ATEX2136X**	Ⓔx II 2 GD
		Ex 60079-30-1 IIC T* Gb (see product description)
		Ex 60079-30-1 IIIC T*°C Db (see product description)
HTS3FM	**Sira 17ATEX3163X**	Ⓔx II 2 GD
		Ex 60079-30-1 IIC T* Gb (see product description)
		Ex 60079-30-1 IIIC T*°C Db (see product description)
LLR	**CML 15ATEX3113X**	Ⓔx II 2G D
		Ex 60079-30-1 IIC T* Gb
		Ex 60079-30-1 IIIC T**°C IP67
LLR-HV	**CML 15ATEX3112X**	Ⓔx II 2GD
		Ex 60079-30-1 IIC T* Gb
		Ex 60079-30-1 IIIC T**°C Db IP67
HTS	**Sira 03ATEX3291**	Ⓔx II 2G
		EEx e II T*
SkinTrace	**CML 17ATEX3155**	Ⓔx II 2GD
		Ex 60079-30-1 IIC T* Gb
		Ex 60079-30-1 IIIC T*°C Db IP67
		Ta=-40°C to +200°C

NOTES:

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Design, Installation & Maintenance Manual

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HTDIMM 010 03/19
Issue 15

HEAT TRACE™
SETTING THE STANDARDS LEADING THE WAY

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