TTE Training Ltd.

Phase 2

Electrical Course Notes

E2-CN-007

Trace Heating

The purpose of Trace Heating

Trace heating is used to ensure that the contents of tanks, vessels pipes etc are available for use, at the correct temperature even under the most extreme ambient temperatures.

It is designed and installed on tanks and pipes to ensure a defined temperature, i.e. the heat input to the pipe will be controlled to ensure that the temperature of the pipe is maintained at the required temperature.

The secret is, in applying heat to the place where it is needed and nowhere else. Any heat that goes into the atmosphere represents wasted energy. The art lies in applying the necessary amount of heat (no more) to the appropriate location (nowhere else).

Trace heating generally falls into one of three areas:

- **Frost protection**, which protects water from freezing.
- **Temperature maintenance**, which holds pipes/tanks at a specific temperature.
- **Heat up**, which raises liquids etc to higher temperatures.

Freeze Protection

Every pipe or vessel is subject to heat loss when its temperature is greater than ambient temperature. Thermal insulation reduces the heat loss but does not eliminate it. Trace heating is used to replace the heat that is lost to atmosphere. If the heat replaced matches the heat lost, temperature will be maintained. An ambient temperature sensor can be used to energize the heating cable before the ambient temperature drops below freezing; 40°F is used as a standard.

For example, a 15mm copper water pipe 5°C with 25mm insulation in an ambient temperature of -15°C will lose 4.39 watts per metre. To prevent the pipe from freezing, much thicker insulation could be applied but this is both bulky and expensive. A trace heating system can supply the extra heat to prevent freezing. A thermostat is used to sense the ambient air temperatures and control the trace heating to maintain around 3 to 5°C in the pipe.

Methods of Trace Heating

Throughout industry, fluid (water, oil, etc) steam and electrical trace heating systems are widely used. All are intended for the same purpose of pipe and tank heating, but each is sometimes considered limited in its usefulness for some tracing applications.

Fluid Tracing

Fluid systems, which generally use water or oil as the heating fluid are very good systems and give good temperature control but are rather expensive since they require a jacketed pipe, or tank, a separate system to heat the fluid and pump/ pipe work to carry the heated fluid around the system.

Stream Tracing

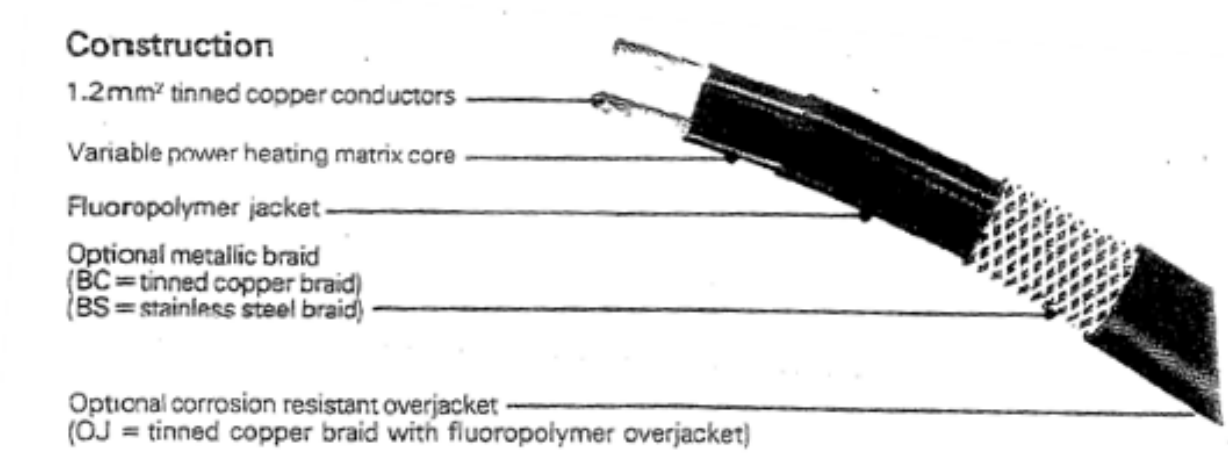
Steam tracing has been in use for many years and is a very good heating medium. However, it has several disadvantages, in that it can generally only provide temperature control between 105°C and 175°C, and it is very difficult to actually control the temperature, which makes it not ideal for temperature sensitive products. The other big problem with steam systems is that the maintenance and reliability of steam traps and valves can be difficult.

Electric Tracing

The use of electric tracing has, over the recent years become a very popular choice when installing a trace heating system. It is readily available and can be used to control the temperatures up to 550°C and can be used on both metallic and non-metallic pipe work / equipment. By using relatively simple controls the temperature can be maintained within very tight bands.

There are various types of trace heating cables, but the most popular type is the self-limiting cable. Which has a semi conductive core or matrix, that has a positive temperature coefficient (PTC) i.e., the higher the temperature the lower the heat output. This is the so-called self-limiting feature of the cable.

Construction of the self-limiting cable is shown below.



The cable can be purchased with various power (heat) outputs for example, 10W/m, 30W/m, 40W/m etc.

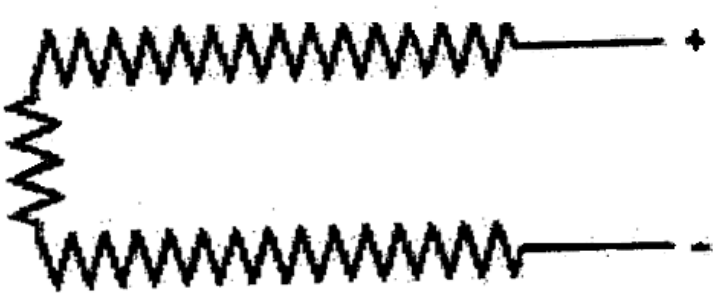
Temperature maintenance

Hot water service piping can also be traced, so that a circulating system is not needed to provide hot water at outlets. The combination of trace heating and the correct thermal insulation for the operating ambient temperature maintains a thermal balance where the heat output from the trace heating matches the heat loss from the pipe. Self limiting or regulating heating tapes have been developed and are very successful in this application.

A similar principle can be applied to process piping carrying fluids which may congeal at low temperatures, for example, tars or molten sulphur. Hit-temperature trace heating elements can prevent blockage of pipes.

Industrial applications for trace heating range from chemical industry, oil refineries, nuclear power plants, food factories. For example, wax is a material which starts to solidify below 70°C which is usually far above the temperature of the surrounding air. Therefore, the pipeline must be provided with an external source of heat to prevent the pipe and the material inside it from cooling down. Trace heating can also be done with steam, but this requires a source of steam and may be inconvenient to install and operate.

Different technologies of trace heating



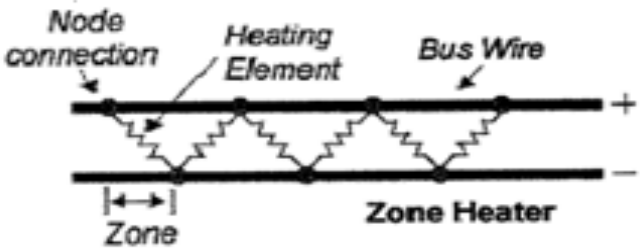
A series heating cable is made of a run of high-resistance wire, insulated and often enclosed in a protective jacket. It is powered at a specific voltage and the resistance of the wire creates heat. The downside of these types of heaters is that if they are crossed over themselves, they can overheat and burn out, they are provided in specific lengths and cannot be shortened in the field, also, a break anywhere along the line will result in a failure of the entire cable. The upside is that they are typically inexpensive (if plastic style heaters) or, as is true with mineral insulated heating cables, they can be exposed to very high temperatures. Mineral insulated heating cables are good for maintaining high temperatures on process lines or maintaining lower temperatures on lines which can get extremely hot such as high temperature steam lines.

Typically, series elements are used on long pipeline process heating, for example long oil pipelines and quay side of load pipes on oil refineries.

Constant Wattage "Zone"

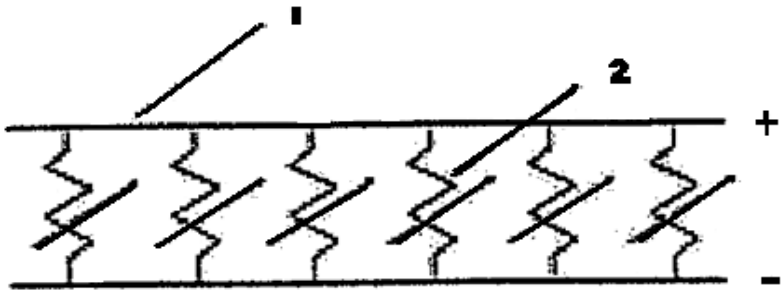
A constant wattage zone cable is made by wrapping a fine heating element around two insulted parallel bus wires, then on alternating sides of the conductors a notch is made in the insulation. The heating element is then normally soldered to the exposed conductor wire which creates a small heating circuit; this is then repeated along the length of the cable.

The benefits of this system over series elements is that should one small element fail then the rest of the system will continue to operate, a draw back of this system is that its length is limited to the notch distance, so when installing on site you normally have to install slightly beyond the end of the pipe work. It is still subject to overheating and burnout if overlapped, but this is generally bad practice to overlap when installing.



Self-Regulating Trace Heating

Self-regulating cable used two parallel bus wires which carry electricity but do not create heat. They are encased in a semi-conductive polymer. This polymer is loaded with carbon; as the polymer element heats, it allows less current to flow. There is then an inner jacket which separates the bus wires from the grounding braid. In commercial and industrial cables, an additional outer jacket of rubber or Teflon is applied. The benefits of this cable are the ability to cut to length in the field.



SR Cable. Bus wires (1), SR polymer (2)

Power supply and control

Trace heat cables may be connected to single phase or (in groups) to three-phase power supplies. Power is controlled either by a contactor or a solid-state controller. For self-regulating cable, the supply must furnish a large warm-up current if the system is switched on from a cold starting condition. The contactor or controller may include a thermostat if accurate temperature maintenance is required or may just shut off a freeze protection system in mild weather. Electrical heat tracing systems are required to have a residual current detection, (RCD) devices for personnel and equipment protection. As it is impossible to guarantee a sufficiently low earth loop impedance i.e. less than one ohm.

Control System

The supply: the three phase systems are fed via contactors similar to a three-phase motor ‘direct online’ starter which is controlled by a thermostat somewhere in the line. This ensures that the temperature is kept constant, and the line does not overheat or under heat.

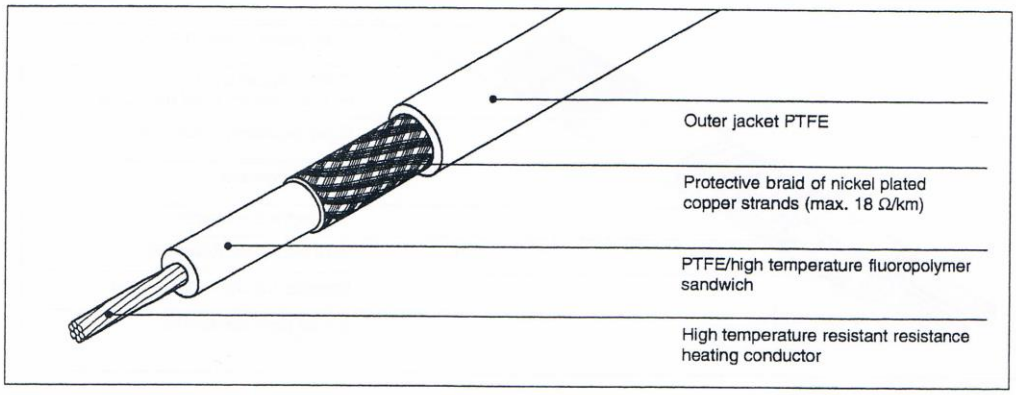
Boost: If a line becomes frozen because the heating was switched off then this may take some time to thaw out using trace heating. This thawing out is done on the three phase systems by using an ‘auto transformer’ to give a few more volts, and so amps, and make the trace heating elements a bit hotter. The boost system is usually on a timer and switches back to ‘normal’ after a set period.

Ⓔx Polymer insulated (PI) series resistance heating cable

XPI is a polymer insulated (PI) series heating cable, suitable for use in hazardous areas (ATEX, for gas and dust atmosphere). It has been designed for use in freeze protection and temperature maintenance applications of pipes, tanks and other equipment. XPI offers an economical solution for a wide variety of heat-tracing applications, in particular for pipe lengths beyond the maximum circuit lengths of parallel heating cables (e.g. 250 m).

The inner insulation is a sandwich construction of high temperature fluoropolymer and PTFE, the outer insulation is made of PTFE. This unique construction is very easy to terminate, highly flexible and makes XPI a very safe and reliable product. It provides highest chemical withstand and excellent mechanical strength, in particular at elevated temperatures. XPI heating cables can be used for temperatures up to 260°C (continuous) and 300°C (intermittent short-term exposure). XPI is easy to install and has printed meter-marks. Tyco Thermal Controls offers XPI heating cables in a very wide range of resistances, starting from 0.8 Ω/km up to 8000 Ω/km as well as a complete range of components for connection and splicing of the cables.

Heating cable construction



Application		
Area classification	Hazardous area, Zone 1 or Zone 2 (Gas) or Zone 21 or Zone 22 (Dust) Ordinary	
Chemical resistance	Organic and inorganic corrosives	
Approvals	System (heating units)	PTB 03 ATEX 1218X Ⓔx II 2 G/D EEx e II T6 to T2 IP 65 T 80°C...T 290°C
	Bulk cable	PTB 05 ATEX 1060 U Ⓔx II 2 G/D EEx e II T_p 260°C
	Temperature classification (T-rating) has to be established by using the principles of stabilised design or the use of a temperature limiting device. Use TraceCalc design software or contact Tyco Thermal Controls.	
Technical data		
Max. exposure temperature	260°C (continuous power off), 300°C (intermittent power off, max 1000 h)	
Min. installation temperature	–70°C	
Min. bending radius at –70°C	2.5 x cable diameter for cable diameter ≤ 6 mm 6 x cable diameter for cable diameter > 6 mm	
Max. power output	30 W/m (typical value, depending on application)	
Nominal voltage	Up to 450/ 750 V AC (U_0/ U)	
Min. impact resistance	4 Joule (as per EN 50019)	
Min. clearance	20 mm between heating cables	

IHT

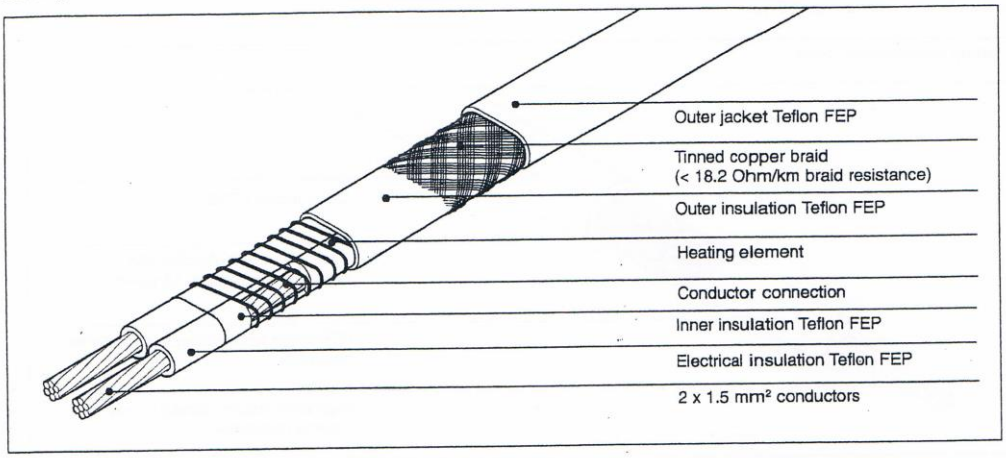
Constant wattage parallel circuit heating cable (for ordinary area use)

IHT is a parallel circuit, medium powered constant output tracer which can be cut to any length. IHT incorporates an FEP outer jacket which makes it ideal for use in chemically aggressive industrial applications.

It is designed for high temperature process maintenance applications in chemically aggressive environments such as animal fats.
It can be used also for freeze protection and the heating of pipelines, valves, pumps, containers etc.

It has twin conductors with extruded high quality Teflon FEP primary and inner insulation. The heating element is zone connected to the bus wires. FEP outer insulation, tinned copper overbraid and FEP outer jacket complete the construction.

Heating cable construction



	IHT/2/10-CT	IHT/2/20-CT	IHT/2/30-CT
Size	5.5 mm x 7.7 mm	5.5 mm x 7.7 mm	5.5 mm x 7.7 mm
Specification			
Nominal power output	10/12 W/m	20/24 W/m	30/36 W/m
Supply voltage (AC)	220-240 V	220-240 V	220-240 V
Area classification	Ordinary	Ordinary	Ordinary
Max. circuit length	120 m	90 m	75 m
Max. withstand temperature (power-off)	200°C	200°C	200°C
Max. work piece temperature (power on)	125°C	100°C	75°C
Min. installation temperature	–40°C	–40°C	–40°C
Min. bend radius	25 mm	25 mm	25 mm
Min. clearance	10 mm	10 mm	10 mm
Colour	White	Red	Green
Cold lead / heating zone length	1 m	1 m	1m

Raychem **QTVR**

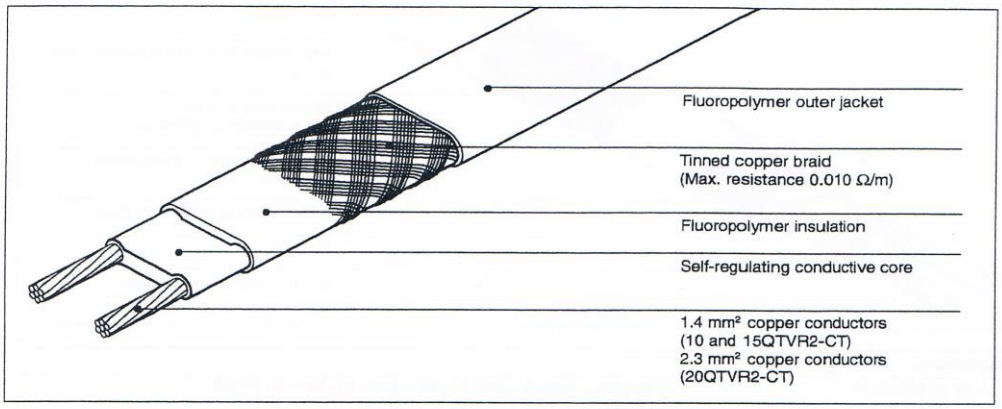
Self-regulating heating cable

Electrical heat-tracing for process temperature maintenance applications up to 110°C which are not subject to steam cleaning.

The QTVR family of self-regulating, parallel circuit heating cables is used for process temperature maintenance of pipes and vessels.

It can also be used for frost protection of large pipes and for applications requiring medium temperature exposure capability.

Heating cable construction



Application

Area classification	Hazardous, Zone 1, Zone 2 (Gas), Zone 21, Zone 22 (Dust) Ordinary
Traced surface type	Carbon steel Stainless steel Painted or unpainted metal
Chemical resistance	Organics and corrosives For aggressive organics and corrosives consult your local Tyco Thermal Controls Representative

Supply voltage

230 Vac (Contact your local Tyco Thermal Controls Representative for data on other voltages)

Approvals

The QTVR heating cables are approved for use in hazardous areas by PTB and Baseefa 2001 Ltd.

PTB 98 ATEX 1103 X
Ex II 2 G/D EEx e(m) II T4 IP66 T130°C

BAS98ATEX2337X
Ex II 2 GD EEx e II T4

The QTVR heating cables are approved by DNV for use on ships and mobile off shore units.
DNV Certificate No. E-6967
They are also VDE approved.

Specifications

Maximum exposure temperature (Continuous power on)	110°C
Temperature classification	T4 in accordance with European Standard EN 50 014
Minimum installation temperature	–60°C
Minimum bend radius	at 20°C: 13 mm at –60°C: 35 mm

Raychem **XTV**

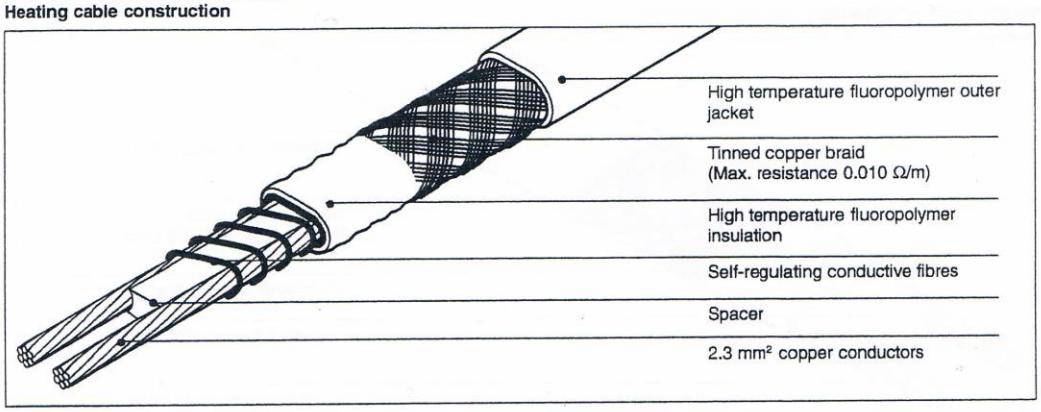
Self-regulating heating cable

Electrical heat-tracing for process temperature maintenance applications up to 120°C which may be subject to steam cleaning.

The XTV family of self-regulating, parallel circuit heating cables is used for process temperature maintenance of pipes and vessels.

It can also be used for frost protection of large pipes and for applications requiring high temperature exposure capability.

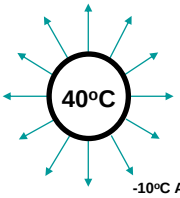
Heating cable construction



Application	
Area classification	Hazardous, Zone 1, Zone 2 (Gas), Zone 21, Zone 22 (Dust) Ordinary
Traced surface type	Carbon steel Stainless steel Painted or unpainted metal
Chemical resistance	Organics and corrosives For aggressive organics and corrosives consult your local Tyco Thermal Controls representative
Supply voltage	230 Vac (Contact your local Tyco Thermal Controls representative for data on other voltages)
Approvals	The XTV heating cables are approved for use in hazardous areas by PTB and Baseefa 2001 Ltd. PTB 98 ATEX 1105 X Ⓔx II 2 G/D EEx e(m) II T4/T3/250°C(T2) IP66 T130°C, T195°C, T250°C BAS98ATEX2336X Ⓔx II 2 GD EEx e II T3 and 240°C (T2) The XTV heating cables are approved by DNV for use on ships and mobile off shore units. DNV Certificate No. E-6968 They are also VDE approved.
Specifications	
Maximum exposure temperature (continuous power on)	120°C
Max. exposure temperature (intermittent power on and off)	215°C (20 bar saturated steam) Maximum cumulative exposure 1000 hours
Temperature classification	T2: 20XTV2-CT-T2 T3: 4XTV2-CT-T3, 8XTV2-CT-T3, 12XTV2-CT-T3, 15XTV2-CT-T3 in accordance with European Standard EN 50 014
Minimum installation temperature	–60°C
Minimum bend radius	at 20°C: 13 mm at –60°C: 51 mm

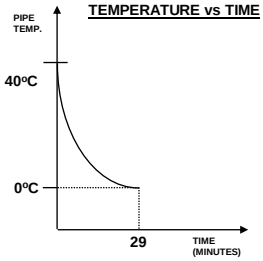
ILLUSTRATION

CASE 1 BARE PIPE

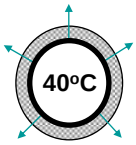


-10ºC AMBIENT

NET HEAT LOSS
529 WATTS / METRE

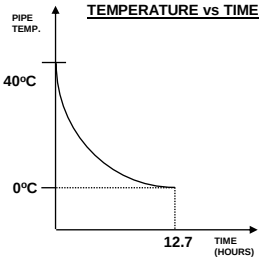


CASE 2 INSULATED PIPE (25mm FIBREGLASS)

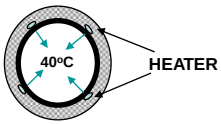


-10ºC AMBIENT

NET HEAT LOSS
21 WATTS / METRE

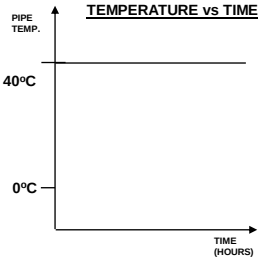


CASE 3 INSULATED & TRACED PIPE



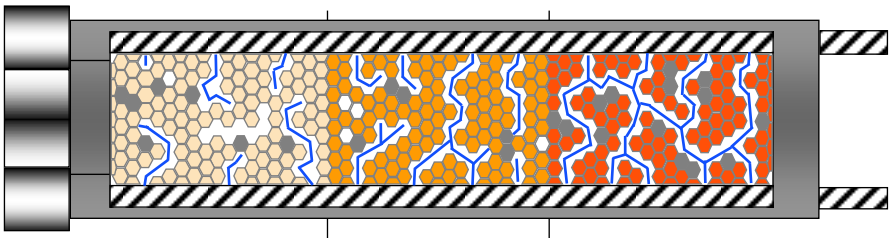
-10ºC AMBIENT

NET HEAT LOSS
NEGLIGABLE



OH6 T_HEAT.PPT 01/99 ALS

SELF-REGULATING HEATER TECHNOLOGY

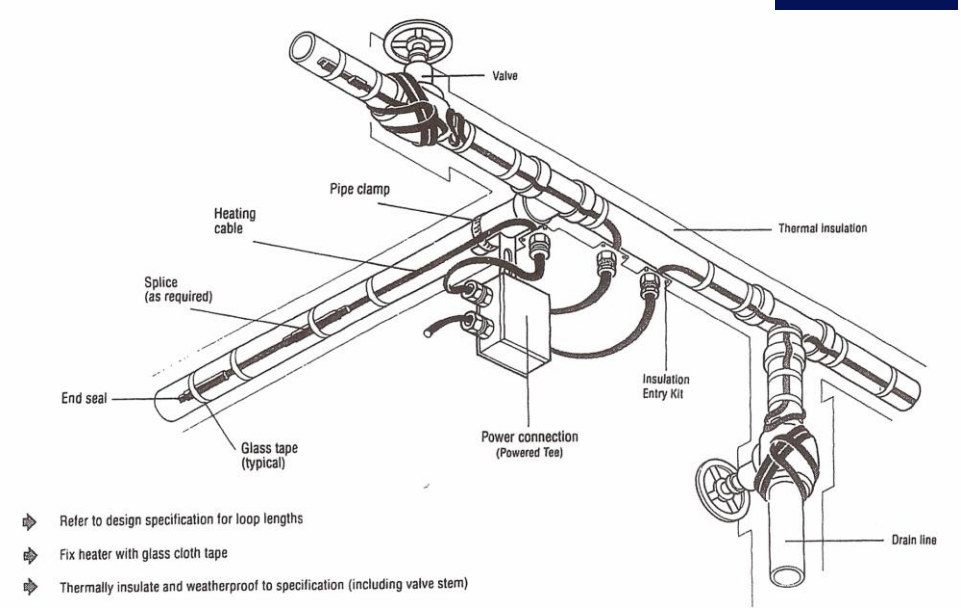


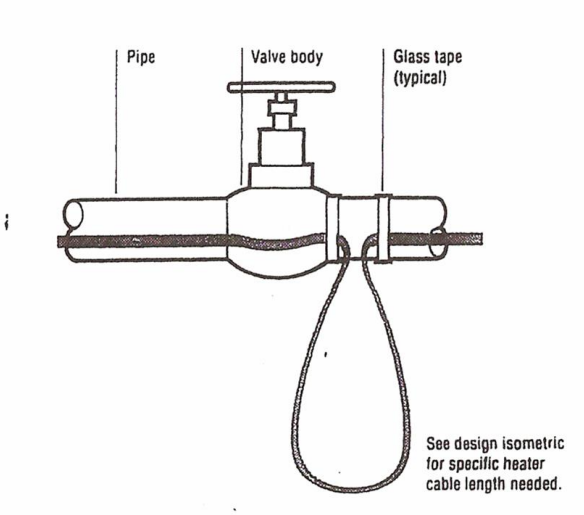
3. In hot sections, the core expansion disrupts almost of the electrical paths. With this high resistance to electrical flow, the power output is virtually zero.

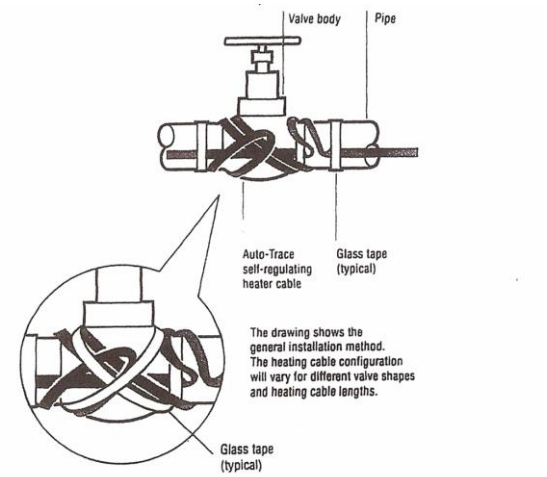
2. In warmer sections, the core expands microscopically, disrupting many electrical paths. The increased electrical resistance causes the heater to reduce its power output.

1. Where the heater is cold, the core contracts microscopically, creating many electrical paths through the conductive carbon. The flow of electricity through the core generates heat.

OH16A T_HEAT.PPT 01/99 ALS

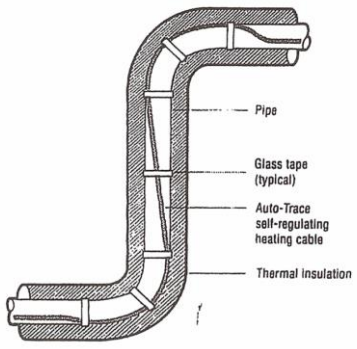

Valve
Pipe clamp
Heating cable
Thermal insulation
Splice (as required)
End seal
Glass tape (typical)
Power connection (Powered Tee)
Insulation Entry Kit
Drain line
Refer to design specification for loop lengths
Fix heater with glass cloth tape
Thermally insulate and weatherproof to specification (including valve stem)


Pipe
Valve body
Glass tape (typical)
See design isometric for specific heater cable length needed.



- Refer to design specification for loop length
- Fix with glass cloth tape
- Thermally insulate and weatherproof to specification (including valve stem)

Figure 4



- Fix heater to outside (long) radius of elbow
- Fix with glass cloth tape
- Thermally insulate and weatherproof to specification

INSTALLATION RECORD SHEET

CIRCUIT NO.								
INSTALLATION RECORDS FOR								
Circuit breaker number.								
Drawing reference number.								
Megger test before insulating (bypass thermostat if applicable). Reading								
Initial								
Date								
Megger test after insulating (bypass thermostat if applicable). Reading								
Initial								
Date								
Circuit voltage Panel								
Connection terminals								
Insulation completed and sealed. Initial								
Date								
Locations of under insulation components are marked on the insulating lagging. Initial								
Date								

REMARKS & COMMENTS

INSPECTION AND MAINTENANCE RECORD SHEET

CIRCUIT NO.								
MAINTENANCE CHECKS FOR				MONTH			YR.	
No signs of overheating, moisture, or corrosion, etc. Initial								
Date								
In connection systems Initial								
Heater and cable glands tight Connection terminals tight Earth connection tight Insulation in good condition Date								
Thermostats set properly and capillaries are protected Initial								
Date								
Megger test (bypass thermostat if applicable) Reading								
Initial								
Date								
Circuit voltage Panel								
Connection terminals								
All boxes and thermostats have been firmly closed Initial								
Date								
Locations of under insulation components are marked on the insulation lagging Initial								
Date								

REMARKS & COMMENTS