Appendix K: Engineering Specification for Electrical Heat-Tracing Systems

Contents

1 Scope

This specification covers the requirements of materials and support services for heat-tracing systems supplied by the vendor. Neither the supply of the materials related to the connection of the power supply nor the installation of the entire system is part of this specification.

2 Codes, Approvals, and Standards

The electric heat-tracing system shall conform to this specification. It shall be designed, manufactured, and tested in accordance with the applicable requirements of the latest edition of the following codes and standards.

ANSI	American National Standards Institute
CEC	Canadian Electrical Code
CSA	CSA International
FM	FM Approvals
IEC	International Electro-Mechanical Commission
IEEE	Institute Of Electrical and Electronics Engineers
ITS	Intertek Testing Services (Intertek ETL SEMKO)
NEC	U.S. National Electrical Code (NFPA 70)
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
UL	Underwriters' Laboratories, Inc.

3 Electric Heat Trace System Materials

3.1 Self-Regulating Heating Cables

All heat-tracing applications with continuous exposure (maintain) temperatures from 150°F (65°C) to 250°F (121°C) or intermittent exposure temperatures from 185°F (85°C) to 420°F (215°C) shall use self-regulating cables.

A. Self-regulating heating cable shall vary its power output relative to the temperature of the surface of the pipe or the vessel. The cable shall be designed such that it can be crossed over itself and cut to length in the field.
B. Self-regulating heating cable shall be designed for a useful life of 20 years or more with "power on" continuously, based on the following useful life criteria:
   1. Retention of at least 75 percent of nominal rated power after 20 years of operation at the maximum published continuous exposure (maintain) temperature.
   2. Retention of at least 90 percent of nominal rated power after 1000 hours of operation at the maximum published intermittent exposure temperature. The testing shall conform to UL 746B, IEC 216-1 Part 1.
C. A warranty against manufacturing defects for a period of 10 years shall be available.
D. All cables shall be capable of passing a 2.5 kV dielectric test for one minute (ASTM 2633) after undergoing a 0.5 kg-m impact (BS 6351, Part 1, 8.1.10).

3.1.1 FREEZE-PROTECTION SYSTEMS

A. The heating cable shall consist of two 16 AWG or larger nickel-plated copper bus wires, embedded in a self-regulating polymeric core that controls power output so that the cable can be used directly on plastic or metallic pipes. Cables shall have a temperature identification number (T-rating) of T6 (185°F or 85°C) without use of thermostats.
B. A ground-fault protection device set at 30 mA, with a nominal 100-ms response time, shall be used to protect each circuit.
C. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a modified polyolefin or fluoropolymer outer jacket.
D. In order to provide rapid heat-up, to conserve energy, and to prevent overheating of fluids and plastic pipe, the heating cable shall have the following minimum self-regulating indices:

Table K.1 Minimum Self-Regulating Indices

Heating cable	S.R. index (W/°F)	S.R. Index (W/°C)
3 W/ft	0.038	0.068
5 W/ft	0.060	0.108
8 W/ft	0.074	0.133
10 W/ft	0.100	0.180

The self-regulating index is the rate of change of power output in watts per degree Fahrenheit or watts per degree Celsius, as measured between the temperatures of 50°F (10°C) and 100°F (38°C) and confirmed by the type test and published data sheets.

E. In order to ensure that the self-regulating heating cable does not increase power output when accidentally exposed to high temperatures, resulting in thermal runaway and self-ignition, the cable shall produce less than 0.5 watts per foot (1.64 watts per meter) when energized and heated to 350°F (177°C) for 30 minutes. After this test, if the cable is reenergized, it must not have an increasing power output leading to thermal runaway.
F. In order to confirm 3.1B, the self-regulating heating cable shall retain at least 90 percent of its original power output after having been cycled 300 times between 50°F (10°C) and 210°F (99°C), allowing at least six minutes of dwell time at each temperature.

G. The heating cable shall be Raychem® BTV-CT or BTV-CR self-regulating heater, with continuous exposure (maintain) capability up to 150°F (65°C) and intermittent exposure capability up to 185°F (85°C), as manufactured by Tyco Thermal Controls.

3.1.2 PROCESS TEMPERATURE MAINTENANCE WITH NO STEAM EXPOSURE

A. The heating cable shall consist of two 16 AWG or larger nickel-plated copper bus wires, embedded in a self-regulating polymeric core that controls power output so that the cable has a temperature identification number (T-rating) of T4 (275°F or 135°C) without use of thermostats.
B. A ground-fault protection device set at 30 mA, with a nominal 100-ms response time, shall be used to protect each circuit.
C. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in a type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
D. In order to confirm 3.1B, the self-regulating heating cable shall retain at least 90 percent of its original power output after having been cycled 300 times between 50°F (10°C) and 300°F (150°C), allowing at least six minutes of dwell time at each temperature.
E. The heating cable shall be Raychem QTVR-CT self-regulating heater, for continuous and intermittent exposure capability up to 225°F (110°C), as manufactured by Tyco Thermal Controls.

3.1.3 FREEZE PROTECTION AND PROCESS TEMPERATURE MAINTENANCE WITH STEAM EXPOSURE

A. The heating cable shall consist of two 14 AWG nickel-plated copper bus wires, separated by a fluoropolymer spacer and helically wrapped with a self-regulating fluoropolymer fiber that controls power output so that the cable has an unconditional temperature identification number (T-rating) of T2C (446°F or 230°C) or lower without use of thermostats.
B. A ground-fault protection device set at 30 mA, with a nominal 100-ms response time, shall be used to protect each circuit.
C. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in a type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
D. In order to confirm 3.1B, the self-regulating heating cable shall retain at least 90 percent of its original power output after having been cycled 300 times between 50°F (10°C) and 450°F (232°C), allowing at least six minutes of dwell time at each temperature.
E. The heating cable shall be Raychem XTV-CT self-regulating heater, for continuous exposure (maintain) capability up to 250°F (121°C) and intermittent exposure capability up to 420°F (215°C or 250 psi steam), as manufactured by Tyco Thermal Controls.

3.1.4 SYSTEMS FOR DIVISION 1 HAZARDOUS LOCATIONS

The following requirements shall apply in addition to the criteria specified in paragraph 3.1.1, 3.1.2, or 3.1.3.

A. The self-regulating heating cable shall be specifically FM Approved or CSA Certified for use in Division 1 locations.
B. A ground-fault protection device set at 30 mA, with a nominal 100 ms response time, shall be used to protect each circuit.
C. The temperature identification number (T-rating) of the cable used shall comply with FM and CSA requirements as applicable.
D. Connection methods used with the cable shall be compatible and approved as a part of the system manufactured and supplied by the heating cable vendor for use in the Division 1 location.
E. For plastic pipe and vessel applications, the heating cable shall be Raychem HBTV-CT or Raychem BTV-CT self-regulating heaters, with continuous exposure capability up to 150°F (65°C) and intermittent exposure capability up to 185°F (85°C), as manufactured by Tyco Thermal Controls.
F. The heating cable shall be Raychem HQTV-CT or Raychem QTVR-CT self-regulating heaters, for continuous and intermittent exposure capability up to 225°F (110°C), as manufactured by Tyco Thermal Controls.
G. The heating cable shall be Raychem HXTV-CT or Raychem XTV-CT self-regulating heaters, for continuous exposure (maintain) capability up to 250°F (121°C) and intermittent exposure capability up to 420°F (215°C or 250 psi steam), as manufactured by Tyco Thermal Controls.

3.1.5 TERMINATIONS FOR NONHAZARDOUS AND HAZARDOUS CLASS 1, DIV 2 LOCATIONS

A. All connection components used to terminate heating cables, including power connectors, splices, tees, and connectors shall be approved for the respective area classification and approved as a system with the particular type of heating cable in use. Under no circumstances shall terminations be used which are manufactured by a vendor other than the cable manufacturer.
B. In order to keep connections dry and corrosion resistant, components shall be constructed of nonmetallic, electrostatic, charge-resistant, glass-filled, engineered polymer enclosure rated NEMA 4X. The component stand shall allow for up to four inches (100 mm) of thermal insulation.
C. Terminals shall be spring clamp wire connection type to provide reliable connection, maintenance-free operation, and ease of reentry.
D. Heating cable terminations shall use cold-applied materials and shall not require the use of a heat gun, torch, or hot work permit for installation.
E. Components shall be rated to a minimum installation temperature of –40°F (–40°C), minimum usage temperature of –75°F (–60°C), and maximum pipe temperature of 500°F (260°C).
F. The component system shall be Raychem JBM-100-L-A connection kit complete with integral LED power indicating light to serve as complete power, splice, or tee connection for up to three Raychem BTV, QTVR, or XTV industrial parallel heating cables as manufactured by Tyco Thermal Controls.

3.2 Power-Limiting Heating Cables

Heat-tracing applications with continuous exposure (maintain) temperatures from 250°F (121°C) to 455°F (235°C) or power-off exposure temperatures from 420°F (216°C) to 500°F (260°C) shall use power-limiting cables. Continuous exposure (maintain) temperatures are based on wattage and voltage used; consult with vendor for specific cable temperature limits. Applications below 500°F (260°C) continuous exposure, power-off, shall consider power-limiting cables if more than one run of self-regulating heating cable is required.

The decision between self-regulating heating cable and power-limiting heating cable shall be made considering the need for a T-rating that is not dependent on the specific application (this is provided by self-regulating heating cables) and the number of runs of heat tracing required for the application. In some applications power-limiting heaters can use fewer runs due to higher power output at higher temperatures.

A. Power-limiting heating cable shall use a metallic heating element that varies its power output relative to the temperature of the surface of the pipe or the vessel. The cable shall be a parallel-zoned heating cable with a positive temperature coefficient heating element spirally wound around a flexible glass fiber core. The cable shall be designed such that it can be crossed over itself one time and cut to length in the field.
B. A ground-fault protection device set at 30 mA, with a nominal 100-ms response time, shall be used to protect each circuit.
C. Maximum heating cable sheath temperature, per either the FM or CSA method of calculation, shall be submitted with the bid or design for all Division 1 and Division 2 applications.
D. The power-limiting heating cable shall have 12 AWG copper bus wires.
E. A warranty against manufacturing defects for a period of 10 years shall be available.
F. All cables shall be capable of passing a 2.5 kV dielectric test for one minute (ASTM 2633) after undergoing a 0.5 kg-m impact (BS 6351, Part 1, 8.1.10).
G. The heating cable shall be Raychem VPL-CT power-limiting heater, with continuous exposure (maintain) capability of 300°F (150°C) to 455°F (235°C), depending on power output required, and intermittent exposure capability up to 500°F (260°C), as manufactured by Tyco Thermal Controls.

3.2.1 TERMINATIONS FOR NONHAZARDOUS AND HAZARDOUS CLASS 1, DIV 2 LOCATIONS

A. All connection components used to terminate heating cables—including power connectors, splices, tees, and connectors—shall be approved for the respective area classification and approved as a system with the particular type of heating cable in use. Under no circumstances shall terminations be used which are manufactured by a vendor other than the cable manufacturer.
B. In order to keep connections dry and corrosion resistant, components shall be constructed of nonmetallic, electrostatic, charge-resistant, glass-filled, engineered polymer enclosure rated NEMA 4X. The component stand shall allow for up to four inches (100 mm) of thermal insulation.
C. Terminals shall be spring clamp wire connection type to provide reliable connection, maintenance-free operation, and ease of reentry.
D. Heating cable terminations shall use cold-applied materials and shall not require the use of a heat gun, torch, or hot work permit for installation.
E. Components shall be rated to a minimum installation temperature of –40°F (–40°C), minimum usage temperature of –75°F (–60°C), and maximum pipe temperature of 500°F (260°C).
F. The component system shall be Raychem JBM-100-L-A connection kit complete with integral LED power indicating light to serve as complete power, splice, or tee connection for up to three Raychem VPL industrial parallel heating cables as manufactured by Tyco Thermal Controls.

3.3 Mineral Insulated Heating Cable Systems

All heat-tracing applications with continuous exposure (maintain) temperatures above 300°F (150°C) to 455°F (230°C), depending on power output required, or intermittent exposure temperatures above 500°F (260°C) shall use factory-terminated, mineral insulated (MI) cables.

A. MI heating cable shall be magnesium oxide insulated, with copper or alloy conductors and an Incoloy 825 sheath. The heating section of the cable shall be joined to a cold lead also made of Incoloy 825.
B. Each cable shall be factory-terminated to the required length, consisting of the lengths required for the pipe or equipment, plus an allowance for areas of additional heat loss

such as valves, flanges, fittings, supports, and the like, plus a reasonable excess to allow for field variations. The cold lead section shall be seven feet long unless otherwise specified.

C. Maximum heating cable sheath temperature, per either the FM or CSA method of calculation, shall be submitted with the bid or design for all Division 1 and Division 2 applications.
D. Each cable shall be shipped with the catalog number marked on the outside of the package, and a permanent metallic cable tag containing the heating cable length, wattage, voltage, and current draw. If the cable has been designed for a hazardous location, the tag shall also indicate the area classification and heat-tracing circuit number.
E. A warranty against manufacturing defects for a period of 10 years shall be available.
F. The heating cable shall be Pyrotenax® brand Alloy 825 MI, mineral insulated heating cable with a maximum application temperature for the heating units of 1022°F (550°C) and a maximum exposure temperature for the heating cable of 1200°F (650°C), as manufactured by Tyco Thermal Controls.

3.4 Electrical Tank Heating Pads

A. The tank wall, to which the panel is to be fixed, shall be prepared according to panel manufacturer's instructions.
B. Panels shall be flexible so that they are easily fastened to the surface of the tank to be heated.
C. Panels shall be suitable for maintaining the tank wall temperature at specified temperature continuously without degrading or changing output characteristics of the panel.
D. Resistance heating elements shall be between flexible insulating layers, with a continuous operating rating of at least 200°F (93°C) and a short-term withstand rating of at least 366°F (186°C), to insulate electrically and provide mechanical protection for the heating elements. Elements shall be constant resistance.
E. Panels shall have an integrated thermostat to be used for over-temperature protection, but an additional primary control thermostat must be used.
F. All heater circuits are required to be protected with a 30 mA ground-fault protection device (GFPD).
G. For metallic tanks, supplied watt density (at 240 volts) shall be 1.9 watts/sq inch with a T-rating of T2C.
H. For plastic tanks, supplied watt density (at 240 volts) shall be 0.6 watts/sq inch with a T-rating of T4A.
I. A stainless steel ground plain on the external surface of the panel shall be supplied to provide a ground path as required by the National Electrical Code section 427-22.
J. Vendor shall supply a stainless steel junction box. Cold leads shall be Teflon-coated 14 AWG copper leads contained within liquid-tight, flexible conduit for added protection.
K. Mounting instructions and all required materials for fastening panels to the tank wall are to be furnished. Means other than thermal insulation are to be provided to hold panels in position. In addition to the specified tank heater the following materials are required: Raychem RHS Installation Kit (P/N 844869), DigiTrace® 910 controller or equivalent, BCK-35 clamp kit (P/N C77215) or equivalent, Thomas and Betts 5232 conduit fitting, and 5302 sealing ring or agency approved equivalent.
L. Nonhazardous and hazardous location approvals for Class I, Division 2 Groups B, C, D, Class II Division 1 and 2 Groups E, F, G and Class III shall be existing on all heating elements.
M. Installation and operation instructions shall be provided in hard copy and available on a 24-hour accessible Internet site. Installation instructions shall be Raychem Tank Heater (H55207) instructions.
N. A Megger test at 2500 Vdc shall be performed on installation and once a year.
O. The panels shall be Raychem RHS tank heaters as supplied by Tyco Thermal Controls.

3.5 Longline Systems

A. *Self-Regulating, Two-Wire Geometry, Freeze Protection (500–2000 feet)*. For freeze protection applications, without high temperature exposure, up to 2000 feet, a two-wire self-regulating heater is often the best choice.

1. The heating cable shall consist of two 10 AWG nickel-plated copper bus wires embedded in a self-regulating polymeric core that controls power output so that the cable can be used directly on plastic or metallic pipes. The cables shall have a temperature identification number (T-rating) of T6 (185°F or 85°C) without use of thermostats.
2. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in a type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
3. The heating cable shall be Raychem LBTV2-CT for lengths of 500–1125 feet and SLBTV-CT for lengths of 1125–2000 feet, with continuous exposure capability up to 150°F (65°C) and intermittent exposure capability up to 185°F (85°C), as manufactured by Tyco Thermal Controls.

B. *Self-Regulating, VL Geometry, Freeze Protection (1000–12,000 feet)*. For freeze protection applications, without steam exposure, above 2000 feet up to 12,000 feet a self-regulating freeze protection heater in a VL geometry is often the best choice.

1. The heating cable shall consist of two 10 AWG nickel-plated copper bus wires embedded in a self-regulating polymeric core, plus three additional 10 AWG nickel-plated copper bus wires. The cable shall be able to be connected directly to a 3-phase, 4-wire, 480 Vac or 600 Vac source.
2. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in a type test (ASTM, B193, Sec. 5). The braid shall be protected from mechanical abuse by a modified polyolefin outer jacket or from mechanical abuse and chemical attack by a fluoropolymer outer jacket.
3. The heating cable shall be Raychem VLBTV2-CT self-regulating heater, with continuous exposure capability up to 150°F (65°C) and intermittent exposure capability up to 185°F (85°C), manufactured Tyco Thermal Controls.

C. *Self-Regulating, VL Geometry, Freeze Protection and Process Temperature Maintenance with Steam Exposure (1000–6000 feet)*. For process temperature maintenance and freeze protection with steam exposure, a self-regulating process temperature maintenance heater in a VL geometry is often the best choice.

1. The heating cable shall consist of two 14 AWG nickel-plated copper bus wires separated by a fluoropolymer spacer and helically wrapped with a self-regulating fluoropolymer fiber, plus three additional 14 AWG nickel-plated copper bus wires. The cable shall be able to be connected directly to a 3-phase, 4-wire, 480 Vac or 600 Vac source.
2. The heating cable shall have a tinned copper braid with a resistance less than the heating cable bus wire resistance as determined in a type test (ASTM, B193, Sec. 5). The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
3. The heating cable shall be Raychem VLKTV2-CT self-regulating heater, with continuous exposure capability up to 300°F (150°C) and intermittent exposure capability up to 420°F (215°C) or 250 psi steam as manufactured by Tyco Thermal Controls.

D. *Constant-Wattage Series Resistance, Freeze Protection and Process Temperature Maintenance up to 482°F (250°C) with Steam Exposure (500–12,000 feet).* For process temperature maintenance and freeze protection with steam exposure, a constant wattage series resistance heater is often the best choice, particularly when more than one run of self-regulating heater is needed.

1. The heating cable shall be a series resistance constant wattage heater. It shall consist of one or two copper conductors or copper alloy conductors insulated with high temperature heavy-walled fluoropolymer.

2. The heating cable shall have a tinned or nickel-plated copper braid to provide a ground path. The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
3. The heating cable shall be constant wattage Raychem SC, with continuous exposure capability up to 400°F (204°C), Raychem SC/H with continuous exposure capability up to 482 °F (250°C), or SC/F with continuous exposure capabilities up to 195°F (90°C) as manufactured by Tyco Thermal Controls.

E. *Constant-Wattage, Mineral Insulated (MI), Series Resistance, Freeze Protection and Process Temperature Maintenance from 482°F (250°C) to 1022°F (550°C) with Steam Exposure (5,000–10,000).* A constant wattage Alloy 825 series resistance heater is often the best choice for high temperature, longline, and corrosion resistant applications.
1. MI cable shall be magnesium oxide insulated, with copper or alloy conductors and an Incoloy 825 sheath. The heating section of the cable shall be joined to a cold lead also made of Incoloy 825.
2. Each cable shall be factory-terminated to the required length, consisting of the lengths required for the pipe or equipment, plus an allowance for areas of additional heat loss, such as valves, flanges, fittings, supports, and the like, plus a reasonable excess to allow for field variations. The cold lead section shall be seven feet long unless otherwise specified.
3. Maximum heating cable sheath temperature, per either the FM or CSA method of calculation, shall be submitted with the bid or design for all Division 1 and Division 2 applications.
4. Each cable shall be shipped with the catalog number marked on the outside of the package, and a permanent metallic cable tag containing the heating cable length, wattage, voltage, and current draw. If the cable has been designed for a hazardous location, the tag shall also indicate the area classification and heat-tracing circuit number.
5. A warranty against manufacturing defects for a period of 10 years shall be available.
6. The heating cable shall be Pyrotenax® brand Alloy 825 MI mineral insulated heating cable with a maximum application temperature for the heating units of 1022°F (550°C) and a maximum exposure temperature for the heating cable of 1200°F (650°C), as manufactured by Tyco Thermal Controls.

F. *Skin-Effect Tracing Systems, Circuit Lengths up to 15 Miles, Freeze Protection and Process Temperature Maintenance up to 392°F (200°C), with or without Steam Exposure.* For very long lines, process temperature maintenance and freeze protection, skin-effect tracing is usually the best choice.
1. The heating system shall consist of an electrically insulated, temperature-resistant conductor with high-temperature, heavy-walled fluoropolymer insulation installed inside a heat tube and connected to the tube at the far end.
2. The heat tube shall be ferromagnetic and thermally coupled to the carrier pipe that is being traced.
3. The design must be completed by the system manufacturer.
4. The installation should be supervised by the system manufacturer.
5. The heat-tracing system shall be Tracer® STS (Skin-Effect Tracing System) longline heating system as manufactured by Tyco Thermal Controls.

3.6 Heat-Trace Panels

3.6.1 GROUP HEAT-TRACING CIRCUIT CONTROL

A. For freeze protection or group control process-temperature maintenance systems, distribution panels shall consist of an enclosure, including a panelboard with ground-fault protection devices (30mA trip level).
B. The panels shall provide ground-fault alarm capabilities.
C. If more than one circuit is required, a main contactor shall be used.
D. The panels shall operate with ambient-sensing or proportional ambient-sensing controllers.

E. The panels shall be capable of remote temperature monitoring and alarming of individual heat-tracing circuits.
F. The panels shall be CID2 approved for hazardous locations with Z-purge.
G. The panels shall be capable of providing audible and visible alarms.
H. The panel shall be the DigiTrace HTPG heat-tracing panel as manufactured by Tyco Thermal Controls.

3.6.2 INDIVIDUAL HEAT-TRACING CIRCUIT CONTROL

A. For individual control process temperature maintenance systems, distribution panels shall consist of an enclosure, including a panelboard with ground-fault protection devices (30mA trip level).
B. The panels shall provide ground-fault alarm capabilities.
C. Circuits shall be switched by individual contactors operated by line-sensing controllers.
D. The panels shall be capable of remote temperature monitoring and alarming of individual heat-tracing circuits.
E. The panels shall be CID2 approved for hazardous locations with Z-purge.
F. The panels shall be capable of providing audible and visible alarms.
G. The panel shall be the DigiTrace HTPI heat-tracing panel as manufactured by Tyco Thermal Controls.

3.7 Control and Monitoring Systems

All control and monitoring systems shall be capable of communicating with a host PC for central programming, status review, and alarm annunciation. All systems shall include, but not be limited to, the following:

A. Alarm limits and setpoint temperatures shall be programmable from the central monitoring and control panel in °F and °C. The system shall include an alphanumeric display with multilanguage support and password protection or lockable cabinet to prevent unauthorized access to the system.
B. The system shall be switched by an external solid-state or mechanical relay with a minimum rating of 30 Amps.
C. The system shall be capable of assigning one or more RTDs to a circuit to monitor temperature. The controller shall be capable of one RTD to control the heater circuit and a second RTD for another control point or to measure sheath temperature of a heater for high temperature cutout (NGC-30 doesn't support).
D. The system shall monitor temperature, voltage, and line current to the systems.
E. The system shall monitor ground-fault current and offer the option of alarm only or alarm and trip if the ground fault exceeds the selectable level.

3.7.1 MULTIPOINT, DISTRIBUTED ARCHITECTURE CONTROL AND MONITORING DEVICES

A. The system shall be field-mounted and shall have FM or CSA (or equivalent) approval for Class I, Division 2, Groups A, B, C, D when using a solid-state switching device or using electromechanical relays and a Z-purge system.
B. The panel shall be complete with individual heat tracing circuit controller cards (5 heat-trace circuits per card), control contactors, power transformers (adjacent to each panel), space heaters, or panel cooling system as required.
C. The control and monitoring system shall be rack mounted and have option to include integral power distribution panels.
D. The system shall provide a touch screen User Interface Terminal, mounted on the panel, to display monitoring, fault and status information as well as heat-tracing circuit configuration capability. A version of the User Interface Terminal shall be approved for use in Class I Division 2 environments as required. A remote mountable version of the User Interface Terminal shall be available if locating the User Interface Terminal remotely from the panel is desired.

E. The system shall be capable of using resistance temperature detectors (RTDs) that are wired directly to the central monitoring systems or to a remote RTD module that communicates with the central monitoring system over a twisted pair. Up to four RTDs sensor inputs for each circuit shall be available for a variety of combinations of temperature control, monitoring and alarming.

F. The system shall be compatible with all types of heating cables and capable of performing the following functions:

1. Controlling and monitoring pipe temperatures.
2. Providing real-time temperature and alarm log readouts.
3. Providing alarms in the event of low or high pipe temperature, low or high heater current, high ground-fault current, ground-fault trip, relay failure, and sensor failure.
4. Providing remote alarm annunciation.
5. Interfacing with personal computers and DCS systems.

G. The system shall provide three isolated solid-state alarm relays or dry contact relays on the User Interface Terminal and 1 isolated solid state alarm relay or a dry contact relay on each control board for alarm annunciation back to a Distributed Control System (DCS). The 3 alarm relays on the User Interface Terminal shall be user programmable to indicate on any alarm or any combination of available alarms. Each of the three alarm relays shall be independently programmable.

H. There shall be a means to upload heat-tracing circuit configuration and fault threshold information into the control and monitoring system.

I. Electrical code-approved ground-fault detection equipment shall be integral to the controller to simplify installation and reduce total cost.

J. The system shall allow up to four (4) RTD temperature inputs per heat tracing circuit for monitoring, control and fault indication.

K. The system shall support currents up to 60 Amps and voltages up to 600 V.

L. The system shall provide the user with the option of line-sensing control with a user selectable dead band, ambient sensing, proportional ambient sensing (PASC), power limiting and proportional (SSRs only) control modes.

M. The control and monitoring system shall have a network-ready option to provide communication to a host

N. The system shall be able to accept additional temperature inputs from the DigiTrace RMM2 Remote Monitoring Module. The system shall allow these additional inputs to be assigned to any circuit within the control panel.

O. Enclosure types shall be NEMA 12 (paint steel, indoor installation), NEMA 4/3R (painted steel outdoor installation), or NEMA 4X/3RX (stainless steel for corrosion resistance and protection from moisture).

P. System shall have a USB port connection for easy upgrades of User Interface software and to download design parameters.

Q. PC running Windows™-based DigiTrace Supervisor software for central programming, status review, and alarm annunciation. The Control and Monitoring Systems shall support the ModBus® RTU communications protocol and be supplied complete with Ethernet, RS-485 and RS-232 communications interface capability.

R. The system shall be the DigiTrace NGC-30 heat-tracing control and monitoring system, as manufactured by Tyco Thermal Controls.

3.7.2 MULTIPOINT SINGLE CIRCUIT CONTROL AND MONITORING SYSTEMS - RACK MOUNTED

A. The system shall have FM or CSA (or equivalent) approval for Class I, Division 2, Groups A, B, C, D when using a solid-state switching device or using electromechanical relays and a Z-purge system.

B. The system shall provide an isolated solid-state alarm relay for alarm annunciation back to a Distributed Control System (DCS).

C. Electrical code-approved ground-fault detection equipment shall be integral to the controller to simplify installation and reduce total cost.

D. Multipoint single circuit control and monitoring systems shall be rack mounted complete with integral power distribution panels.
E. The panel shall be complete with individual heat-tracing circuit controller cards (1 per heat trace circuit), control contactors, circuit breakers, power transformers (adjacent to each panel), space heaters, or panel cooling system as required.
F. The control and monitoring system shall support a minimum of 2 temperature monitoring inputs per heat tracing circuit for monitoring, control and fault indication.
G. The control and monitoring system shall allow a single Heat Trace Controller card to be removed and replaced while all remaining circuits continue to operate normally.
H. The Control and Monitoring System shall be network-ready to provide communication to a host PC running Windows™- based DigiTrace Supervisor software for central programming, status review, and alarm annunciation. The Control and Monitoring System shall support the ModBus RTU or ASCII communications protocol and be supplied complete with RS-232, RS-485 or Ethernet communications interface capability.
I. The Control and Monitoring System shall have an option to use a handheld programmer for local monitoring, fault reporting and parameter programming of the system.
J. The system shall be the DigiTrace T2000 heat-tracing control system, as manufactured by Tyco Thermal Controls.

3.7.3 MULTICIRCUIT MULTIPOINT DISTRIBUTED-ARCHITECTURE CONTROL AND MONITORING SYSTEM WITH POWER LINE CARRIER COMMUNICATIONS

A. The control and monitoring system shall be capable of controlling heat-tracing circuits with line-sensing control, ambient-sensing control, or proportional ambient-sensing control (PASC).
B. The system shall be capable of using resistance temperature detectors (RTDs) that are:
   1. Wired directly to the central monitoring systems
   2. Wired to a remote module that communicates with the central monitoring system over a twisted pair
   3. Wired to a temperature transmitter that communicates to a remote module over the bus wires of the heater (power-line carrier technology).
C. The non-power line carrier part of the system shall be compatible with all types of heating cables and capable of performing the following functions:
   1. Monitoring and controlling pipe temperatures.
   2. Providing real-time temperature and alarm log readouts.
   3. Providing alarms in the event of low or high pipe temperature, or in case of sensor failure.
   4. Providing remote alarm annunciation.
   5. Interfacing with personal computers and DCS systems.
D. The system shall be capable of utilizing power line carrier technology that uses the heating cable bus wires and power distribution wiring for communication, thus eliminating additional field instrument/sensor wiring. Temperature transmitters shall monitor heating cable continuity and temperature at any point along the heat-tracing circuit, including teed-off heating segments and the end of the circuit.
E. For temperature monitoring, the power line carrier system shall use resistance temperature detectors (RTDs) wired directly to the power-line carrier temperature transmitters. Electrical isolation between the plant environment and the system shall be provided by dedicated, shielded, heat-tracing isolation transformers and filters.
F. The power line carrier part of the system shall be compatible with all types of parallel heating cables and capable of performing the following functions:
   1. Monitoring and controlling pipe temperatures.
   2. Monitoring heating cable continuity and ground leakage current (via 5GF-C circuit cards).

3. Providing alarms in the event of low or high pipe temperatures, loss of heating cable continuity, loss of panel power, loss of service voltage to the heating cable, sensor failure, or microprocessor failure.
4. Providing time-stamped temperature and alarm log readouts.
5. Performing self-diagnostic routines for commissioning and troubleshooting.
6. Interfacing with DCS systems.

G. For temperature monitoring without power line carrier technology the system shall use resistance temperature detectors (RTDs) that are wired to the central monitoring and control panel or to a remote module that communicates with the central monitoring and control system via a twisted pair. For temperature control the system shall use on-off control methods with contactors addressed through the central monitoring and control panel.

H. The system shall use on-off control methods to maintain temperatures of heat-tracing circuits. Process temperature control shall be accomplished using contactors addressed through the central monitoring and control panel. The contactors shall be grouped into a common NEMA 12, 4 or 4X-rated enclosure. Ambient temperature control and proportional ambient sensing control (PASC) shall be controlled by the central monitoring and control panel which will energize or de-energize heat-tracing circuits.

I. The control and monitoring system shall be the DigiTrace 200NI/200NG monitoring and control system as manufactured by Tyco Thermal Controls.

3.7.4 SINGLE- OR DUAL- POINT CONTROL AND MONITORING DEVICES

A. The system shall be field-mounted and shall have FM or CSA approval for Class I, Division 2, Groups A, B, C, D when using a solid-state switching device.

B. The system shall provide the user with the option of line-sensing control with a user selectable dead band, ambient sensing, proportional ambient sensing, and power limiting control modes.

C. The system shall provide an isolated solid-state alarm relay or a dry contact relay for alarm annunciation back to a Distributed Control System (DCS).

D. Electrical code-approved ground-fault detection equipment shall be integral to the controller to simplify installation and reduce total cost.

E. Enclosure type shall be NEMA 4X fiberglass reinforced plastic (FRP) or stainless steel for corrosion resistance and protection from moisture.

F. The control and monitoring systems shall have a may be network-ready option to provide communication to a host PC running Windows™-based DigiTrace Supervisor software for central programming, status review, and alarm annunciation. DigiTrace Control and Monitoring Systems shall support the ModBus® RTU or ASCII communications protocol and be supplied complete with RS-232, RS-485 communications interface capability.

G. The system shall be the DigiTrace 910 or DigiTrace 920 heat-tracing control system, as manufactured by Tyco Thermal Controls.

3.8 Thermostats and Contactors

A. Freeze protection systems shall operate using self-regulating control or with the DigiTrace AMC-1A or DigiTrace AMC-F5 thermostat and the DigiTrace E104-100A or DigiTrace E304-40A contactor in nonhazardous locations, and DigiTrace AMC-1H thermostat with Digitrace E307-40A contactor in hazardous locations, as supplied by Tyco Thermal Controls.

B. Process temperature maintenance systems shall operate using self-regulating control or with DigiTrace AMC-1B thermostat and DigiTrace E104-100A or DigiTrace E304-40A contactor in nonhazardous locations and DigiTrace E507S-LS or DigiTrace RAYSTAT-EX-03-A thermostats and DigiTrace E307-40A contactor in hazardous locations, as supplied by Tyco Thermal Controls.

4 Engineering

A. The vendor shall be given a line list from which to design and estimate a complete heat-tracing system. The bid package shall also include area layout and orthographic drawings.

C. The vendor shall provide a detailed design utilizing standard heat-tracing design software, such as Tyco Thermal Controls TraceCalc® Pro design software or equal. At minimum, the design must provide the following:
   1. Circuit identification number
   2. Maintain temperature
   3. Line size and insulation
   4. Heat loss for pipe, valves, and supports
   5. Amount and type of heating cable required
   6. Spiral requirements
   7. Heating cable service voltage
   8. Heating cable power output at the maintain temperature
   9. Minimum and maximum maintain temperature vs. minimum and maximum ambient temperatures
   10. Circuit breaker and transformer sizing

K. The vendor shall provide heat-tracing isometric drawings at the buyer's request, using either hard copy or machine-readable CAD inputs.

5 Testing

A. Factory inspections and tests for self-regulating, power limiting, series constant wattage and constant wattage (MI) heater cables shall include but are not limited to the following:
   1. Testing shall be done per the latest IEEE Std. 515 test section and applicable manufacturer's standards.
   2. In the field, all heater cables shall be meggered. The following separate field megger readings shall be taken on each self-regulating and each M.I. heater cable:
      a. Heater cable shall be meggered when received at jobsite before installation.
      b. Heater cable shall be meggered after installation, but before insulation is applied.
      c. Heater cable shall be meggered after insulation has been installed.
   3. All three of the above field megger readings shall be greater than 20 megohms. Otherwise, the heater cable is not acceptable and shall be replaced.
   4. Field megger tests shall be recorded for each heater cable, and certified reports shall be submitted to the user.

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