

ENGINEERING SPECIFICATION FOR ELECTRICAL HEAT-TRACING SYSTEMS

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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 requirements stated in the applicable CSA, FM, IEEE and UL standards and US National and Canadian Electrical Codes.

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 300°F (150°C) or intermittent exposure temperatures from 185°F (85°C) to 482°F (250°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 60216-1.
- C. A warranty against manufacturing defects for a period of 10 years shall be available.
- D. All cables shall be capable of passing a 2.2 kV dielectric test for one minute after undergoing a 1.0 kg-0.7 m impact (IEC/IEEE 60079-30-1:2015, clause 5.1.5.1).

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 wire with a cross-sectional area being equal to or greater than conductor cross-sectional area. 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 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. 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 nVent.

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 wire with a cross-sectional area being equal to or greater than conductor cross-sectional area. The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
- D. 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 nVent.

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 wire with a cross-sectional area being equal to or greater than conductor cross-sectional area. The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
- D. The heating cable shall be RAYCHEM XTV-CT or KTV-CT self-regulating heater, for continuous exposure (maintain) capability up to XTV: 250°F (121°C), KTV: 300°F (150°C) and intermittent exposure capability up to 482°F (250°C or 250 psi steam), as manufactured by nVent.

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 nVent.
- 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 nVent.
- 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 482°F (250°C or 250 psi steam), as manufactured by nVent.

3.1.5 Terminations for nonhazardous And hazardous class I, div 2 locations

- A. All connection kits 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, connection kits shall be constructed of nonmetallic, electrostatic, charge-resistant, glass-filled, engineered polymer enclosure rated TYPE 4X. The connection kit 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 connection kit 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 nVent.

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 2.2 kV dielectric test for one minute after undergoing a 1.0 kg-0.7 m impact (IEC/IEEE 60079-30-1:2015, clause 5.1.5.1).
- 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 nVent.

3.2.1 Terminations for nonhazardous And hazardous class I, div 2 locations

- A. All connection kits 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, connection kits shall be constructed of nonmetallic, electrostatic, charge-resistant, glass-filled, engineered polymer enclosure rated TYPE 4X. The connection kit stand shall allow for up to four inches (100 mm) of thermal insulation.
- C. Terminals shall be the 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 connection kit 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 nVent.

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 Alloy 825 sheath. The heating section of the cable shall be joined to a cold lead also made of Alloy 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 approved engineering design software, shall be submitted with the bid or design for all Division 1 (Zone 1) and Division 2 (Zone 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. 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 RAYCHEM (Alloy 825), 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 nVent.

3.4 ELECTRICAL TANK HEATING PADS

- A. The tank wall, to which the panel is to be fixed, shall be prepared according to the 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 the 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 200°F (93°C) and a short-term withstand rating of 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 844869-001), RAYCHEM 910 controller or equivalent, BCK-35 clamp kit (P/N C77215-000) 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 exist 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 during installation and once a year.
- O. The panels shall be RAYCHEM RHS tank heaters as supplied by nVent.

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 the use of thermostats.
 - 2. The heating cable shall have a tinned copper braid wire with a cross-sectional area being equal to or greater than conductor cross-sectional area. The braid shall be protected from chemical attack and mechanical abuse by a fluoropolymer outer jacket.
 - 3. The heating cable shall be RAYCHEM LBT2V-CT for lengths of 500–1125 feet and SLBT2V-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 nVent.

- 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 wire with a cross-sectional area being equal to or greater than conductor cross-sectional area. The braid shall be protected from chemical attack and mechanical abuse 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 by nVent.
- 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 wire with a cross-sectional area being equal to or greater than conductor cross-sectional area. 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 nVent.
- 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, two or three or three 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 nVent.
- 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 feet. 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 Alloy 825 sheath. The heating section of the cable shall be joined to a cold lead also made of Alloy 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 approved engineering design software, shall be submitted with the bid or design for all Division 1 (Zone 1) and Division 2 (Zone 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. 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 RAYCHEM XMI (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 nVent.
- F. Skin-Effect Heat-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 required.
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 RAYCHEM STS (Skin-Effect Heat-Tracing System) as manufactured by nVent.

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 RAYCHEM HTPG heat-tracing panel as manufactured by nVent.

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 RAYCHEM HTPI heat-tracing panel as manufactured by nVent.

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. One RTD can be applied 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.
- D. The system shall monitor temperature, voltage, and line current to the systems. (NGC-40 does not support voltage monitoring).
- 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 CONTROL AND MONITORING SYSTEMS FOR SINGLE AND MULTI- CIRCUIT APPLICATIONS

GENERAL

- A. The system shall have FM, UL, CSA, ETL (or equivalent) approval for Class I, Division 2, Groups A, B, C, D and Class I, Zone 2, Group IIB+H2 when using a solid-state switching device or using electromechanical relays and a Z-purge system.
- B. Enclosure types shall be TYPE 12 (painted steel, indoor installation), TYPE 4/3R (painted steel, outdoor installation), or TYPE 4X/3RX (stainless steel, outdoor installation) as required by project specification.
- C. Field mounted switch racks (skid assemblies) shall be available in various configurations. They shall integrate a distribution transformer dedicated to the heating system, a power distribution panel board suitable for the area classification and a heat trace control panel. The entire switch rack shall be factory assembled, tested, and approved by FM, UL, CSA, ETL (or equivalent).
- D. The system shall use 3-wire 100-ohm platinum Resistance Temperature Detectors (RTDs) for temperature sensing.
- E. The system shall allow multiple RTD temperature inputs per heat tracing circuit for monitoring, control and fault indication. Each sensor shall be configurable for control, monitoring or high temperature cut-out or combinations thereof.
- F. The system shall provide the following control mode options: On/Off Control with a user selectable dead band, Proportional Ambient Sensing Control (PASC), Always On and Always Off. For controllers utilizing Solid State output Relays (SSRs), Proportional (PID) Control with configurable power limiting shall also be available.
- G. The controllers shall support single and 3 or 4 wire 3-phase heating loads of up to 60 Amps and 600 VAC with ground-fault detection.
- H. Ground-fault (GF) detection equipment approved to UL1053 shall be integral to the controller. The GF feature shall provide independent alarm and trip settings.
- I. Each control module shall provide an individual fail-safe dry-contact alarm relay that may be connected to an external annunciator.
- J. For controllers utilizing SSRs, a soft-start feature shall be available to ramp the output from 0-100% over time to reduce heater inrush currents.
- K. The controller shall be capable of testing the heating circuit at a user defined interval. The test shall terminate immediately upon detection of any unsafe condition (GF, High Temperature) and generate the appropriate alarms.

SYSTEM

- A. 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.
- B. The system shall support an optional touch screen user interface (UI) mounted on the panel to display circuit status, monitoring data and fault information as well as provide heat-tracing circuit configuration capability. A version of the UI shall be approved for use in Class I Division 2/Zone 2 environments as required. A remote mountable version of the UI shall be available if locating the user interface remotely from the panel is desired.
- C. The UI shall not be used for basic heat trace control functions. Primary heat trace control shall be performed independently by the control modules.
- D. The UI shall have three form-C alarm relays that may be configured to alarm by type.
- E. The system shall be capable of updating UI operating software in the field.
- F. The system shall support Modbus RTU/TCP communications protocols and be supplied complete with RS-232, RS-485 and Ethernet communications interface capability. Fiber-optic interfaces, and pre-packaged communications converters and repeaters shall be available as options.
- G. Devices with multiple communications ports shall support simultaneous connections to external devices and automatically synchronize status and configuration information across all ports.
- H. The heat trace vendor shall offer Windows®- based supervisor software for central programming, monitoring, and alarm annunciation. The supervisory software shall support a client-server architecture allowing multiple simultaneous users and workstations, and be capable of integrating all system data into a central database. All information shall be available from any workstation and the software shall provide full user permissions and grouped access features.

SINGLE/DUAL CIRCUIT CONTROLLERS

- A. The single and dual-point controllers shall allow up to two hardwired RTD inputs per circuit.
- B. The controller shall monitor heater voltage and support high and low voltage alarming.
- C. The system shall be the RAYCHEM 910 or RAYCHEM 920 heat-tracing control system, as manufactured by nVent.

MULTI-CIRCUIT PANELS

- A. The multi-point panels shall have the option to include integral power distribution.
- B. The multi-point panels shall be capable of using RTDs that are wired directly to the internal control or expansion modules. The system shall allow up to four RTD inputs to be assigned to any circuit within the control panel. Expansion of the number of RTDs shall not result in a loss of the number of available heating circuits in the panel.
- C. The multi-point panels shall support external field mounted RTD multiplexing modules and allow the temperatures to be assigned to any circuit within the control panel. RTD multiplexing modules shall be capable of being installed at a distance of up to 1200m (4000ft) from the control panel without additional equipment.
- D. The multi-point control modules shall provide dry contact alarm relays.
- E. The controller shall have the option to monitor heater voltage and support high and low voltage alarming.
- F. The system shall be the RAYCHEM NGC-30 heat-tracing control system, as manufactured by nVent.

3.7.2 SINGLE POINT CONTROL AND MONITORING SYSTEMS FOR SINGLE CIRCUIT AND MULTI-CIRCUIT APPLICATIONS

GENERAL

- A. The system shall have FM, UL, CSA, ETL (or equivalent) approval for Class I, Division 2, Groups A, B, C, D and Class I, Zone 2, Group IIB+H2 when using a solid-state switching device or using electromechanical relays and a Z-purge system.
- B. Enclosure types shall be TYPE 12 (painted steel, indoor installation), TYPE 4/3R (painted steel, outdoor installation), or TYPE 4X/3RX (stainless steel, outdoor installation) as required by project specification.
- C. Field mounted switch racks (skid assemblies) shall be available in various configurations. They shall integrate a distribution transformer dedicated to the heating system, a power distribution panel board suitable for the area classification and a heat trace control panel. The entire switch rack shall be factory assembled, tested, and approved by FM, UL, CSA, ETL (or equivalent).
- D. The control solution shall provide single, dedicated, independent control modules for each heat tracing circuit to deliver the highest level of heat management system reliability.
- E. The system shall use 3-wire 100-ohm platinum Resistance Temperature Detectors (RTDs) for temperature sensing.
- F. The system shall allow multiple RTD temperature inputs per heat tracing circuit for monitoring, control and fault indication. Each sensor shall be configurable for control, monitoring or high temperature cut-out or combinations thereof.
- G. The system shall provide the following control mode options: On/Off Control with a user selectable dead band, Proportional Ambient Sensing Control (PASC), Always On and Always Off. For controllers utilizing Solid State output Relays (SSRs), Proportional (PID) Control with adaptive power limiting shall also be available.
- H. Each control module shall provide one digital input that may be configured for various functions such as forcing the controller output on or off.
- I. The controllers shall support single and 3 or 4 wire 3-phase heating loads of up to 60 Amps and 600 VAC with ground-fault detection.
- J. For controllers utilizing SSRs, Circuit Breaker Limiting and Switch Limiting features for protection of circuit breakers and SSR relay outputs shall be available.
- K. Ground-fault (GF) detection equipment approved to UL1053 shall be integral to the controller. The GF feature shall provide independent alarm and trip settings.
- L. Each control module shall provide an individual fail-safe dry-contact alarm relay that may be connected to an external annunciator.
- M. For controllers utilizing SSRs, an adaptive soft-start feature shall be available to ramp the output from 0-100% over time to reduce heater inrush currents.
- N. The controller shall be capable of testing the heating circuit at a user defined interval. The test shall terminate immediately upon detection of any unsafe condition (GF, High Temperature) and generate the appropriate alarms.

SYSTEM

- A. 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.
- B. The system shall support an optional touch screen user interface (UI) mounted on the panel to display circuit status, monitoring data and fault information as well as provide heat-tracing circuit configuration capability. A version of the UI shall be approved for use in Class I Division 2/Zone 2 environments as required. A remote mountable version of the UI shall be available if locating the user interface remotely from the panel is desired.
- C. The UI shall not be used for heat trace control. All heat trace control shall be performed independently by the control modules.
- D. The system shall be capable of updating UI operating software and controller firmware in the field.

- E. The system shall support Modbus RTU/TCP communications protocols and be supplied complete with RS-232, RS-485 and Ethernet communications interface capability. Fiber-optic interfaces, and pre-packaged communications converters and repeaters shall be available as options.
- F. Devices with multiple communications ports shall support simultaneous connections to external devices and automatically synchronize status and configuration information across all ports.
- G. The heat trace vendor shall offer Windows®- based supervisor software for central programming, monitoring, and alarm annunciation. The supervisory software shall support a client-server architecture allowing multiple simultaneous users and workstations, and be capable of integrating all system data into a central database. All information shall be available from any workstation and the software shall provide full user permissions and grouped access features.
- H. The system shall provide load shedding capabilities that may be initiated by external devices. Multiple load shedding zones shall be supported, allowing select groups of controllers to be put into load shedding mode.
- I. The load shedding command shall be periodically broadcast on the network. The controller shall manage the load shedding mode and automatically revert to normal operation should the load shedding commands fail to be broadcast.
- J. The Controllers shall provide a fail-safe load shedding mode to ensure that pipe temperatures do not drop below acceptable levels even during load shedding events.

SINGLE/DUAL CIRCUIT CONTROLLERS

- A. The single and dual-point controllers shall allow up to two hardwired RTD inputs per circuit.
- B. The controller shall monitor heater voltage and support high and low voltage alarming.
- C. The system shall be the RAYCHEM 910 or RAYCHEM 920 heat-tracing control system, as manufactured by nVent.

MULTI-CIRCUIT PANELS

- A. The multi-point panels shall consist of DIN rail mountable control and monitoring modules. Panels shall have the option to include integral power distribution.
- B. The multi-point panels shall be capable of using RTDs that are wired directly to the internal control or expansion modules. The system shall allow up to eight RTD inputs to be assigned to any circuit within the control panel. Expansion of the number of RTDs shall not result in a loss of the number of available heating circuits in the panel.
- C. The multi-point panels shall support external field mounted RTD multiplexing modules and allow the temperatures to be assigned to any circuit within the control panel. RTD multiplexing modules shall be capable of being installed at a distance of up to 1200m (4000ft) from the control panel without additional equipment.
- D. The multi-point control modules shall provide dry contact relays. Alarming shall be software configurable on an individual circuit, group, or panel basis, rather than hard-wired.
- E. For three phase circuits, the controllers shall monitor and report the current for each phase (L1, L2 and L3) individually. High and low line current alarm threshold set points shall be independently programmable for each phase.
- F. The system shall be the RAYCHEM NGC-40 heat-tracing control system, as manufactured by nVent.

3.7.3 POWER LINE CARRIER COMMUNICATIONS (PLI) OPTION FOR RAYCHEM NGC-30 CONTROL SYSTEMS (This specification is intended as an addendum to Section 3.7.1 which covers the NGC-30 Control System)

- A. The system shall be capable of utilizing power line carrier (PLI) technology that uses the heating cable bus wires and power distribution wiring for communication, thus eliminating additional field instrument/sensor wiring.
- B. The PLI system shall consist of a PLI modules located in the Control System panel which communicates with field mountable connectors as follows:
 1. RAYCHEM Smart End Seal (SES) kits
 2. RAYCHEM Smart Power Connection (SPC) kits
- C. The NGC-30 system with PLI shall be fitted with electromechanical relays for heat-tracing circuit on/off control.

- D. The NGC-30 system with PLI shall have FM, UL or CSA (or equivalent) approval for Class I, Division 2, Groups A, B, C, D when using electromechanical relays and a Z-purge system.
- E. The PLI field mountable connectors shall have FM, UL or CSA (or equivalent) approval for Class I, Division 2, Groups A, B, C, D for use in hazardous locations.
- F. Temperature transmitters shall monitor temperature at any point along the heat-tracing circuit, including teed-off heating segments and the end of the circuit and may provide the option for line continuity monitoring and reporting.
- G. For temperature monitoring with the PLI technology, the system shall use resistance temperature detectors (RTDs) wired directly to the PLI temperature transmitters. The PLI temperature transmitters shall communicate to a PLI Module located in the NGC-30 panel over the power distribution wires and bus wires of the heater.
- H. The Control system shall also support temperature monitoring in addition to the PLI system. The Control system shall use resistance temperature detectors (RTDs) that are wired directly to the monitoring and control panel or to a remote module (RMM2) that communicates with the central monitoring and control system via RS-485 twisted pair wiring. The system shall allow these additional inputs to be assigned to any circuit within the control panel.
- I. Electrical isolation between the plant environment and the system shall be provided by dedicated, shielded, heat-tracing isolation transformers and front end filters.
- J. The system shall provide a touch screen User Interface Terminal, to display monitoring, fault and status information of the PLI system as well as configuration capability.
- K. The PLI part of the system shall be compatible with the following types of heating cables:
 - 1. RAYCHEM Self-Regulating heating cables
 - 2. RAYCHEM VPL heating cables (using SPC kits only)
 - 3. RAYCHEM SC heating cables
 - 4. RAYCHEM MI heating cables (using SPC kits only)
- L. The system shall be the RAYCHEM NGC-30 heat tracing control & monitoring system with PLI option as manufactured by nVent.

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 TYPE 4X fiberglass reinforced plastic (FRP) or stainless steel for corrosion resistance and protection from moisture.
- F. The control and monitoring systems shall have a network-ready option to provide communication to a host PC running Windows®-based RAYCHEM Supervisor software for central programming, status review, and alarm annunciation. RAYCHEM 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 RAYCHEM 910 or RAYCHEM 920 heat-tracing control system, as manufactured by nVent.

3.8 THERMOSTATS AND CONTACTORS

- A. Freeze protection systems shall operate using self-regulating control or with the RAYCHEM AMC-1A or RAYCHEM AMC-F5 thermostat and the RAYCHEM E104-100A or RAYCHEM E304-40A contactor in nonhazardous locations, and RAYCHEM AMC-1H thermostat with RAYCHEM E307-40A contactor in hazardous locations, as supplied by nVent.
- B. Process temperature maintenance systems shall operate using self-regulating control or with RAYCHEM AMC-1B thermostat and RAYCHEM E104-100A or RAYCHEM E304-40A contactor in nonhazardous locations and RAYCHEM E507S-LS or RAYCHEM RAYSTAT-EX-03-A thermostats and RAYCHEM E307-40A contactor in hazardous locations, as supplied by nVent.

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.
- B. The vendor shall provide a detailed design utilizing standard heat-tracing design software, such as nVent 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
- C. 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. Insulation resistance shall be measured from heating device conductors to metallic braid, metallic sheath, or other equivalent electrically conductive material with a 500 Vdc test voltage. However, it is strongly recommended that higher test voltages be used—mineral insulated trace heaters should be tested at, but not exceed, 1000 Vdc, and polymeric insulated trace heaters should be tested at 2500 Vdc.
 - 2. In the field, all heater cables shall be tested for insulation resistance. The following separate field megohmmeter readings shall be taken on each cable:
 - a. When received at jobsite before installation
 - b. After installation, but before insulation is applied
 - c. After insulation has been installed
 - 3. The readings obtained shall satisfy the minimum acceptable readings per IEEE Std 515-2011 otherwise the heater cable is not acceptable and shall be replaced.

It is strongly recommended that the manufacturer's minimum recommended IR values be observed as tabulated below:

Source	Manufacturer			IEEE515-2011
Cable Type	Self- Regulating/ Power- Limiting	Constant Wattage (Polymer)	Constant Wattage (MI)	All
IR Values (Megohms)	Recommended Minimum IR Value			Absolute Minimum Acceptable
On Receipt	1000	100	100	20
After Insulation	1000	100	20	20
After Insulation	1000	100	20	5
Start Up/ Commissioning	1000	100	10	5

Note: Insulation resistance readings should be recorded promptly at each of the different stages after the cable has been received, installed, insulated and commissioned.

4. Field megohmmeter tests shall be recorded for each heater cable, and certified reports shall be submitted to the user.
5. Adverse weather conditions such as high humidity can influence measuring equipment/ test leads/ connections and appropriate steps should be taken to avoid false insulation resistance readings.

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