Chromalox®
PRECISION HEAT AND CONTROL

Engineering Specification for Electrical Heat-Tracing Systems

Contents

1.0 Scope

This specification covers the requirements for materials and support services for electric 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.

2.0 Codes, Approvals, and Standards

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

FM	Factory Mutual Research Corporation
IEEE 515	Institute of Electrical and Electronics Engineers
NEC	U.S. National Electric Code (NFPA 70)
NEMA	National Electrical Manufacturers Association
UL 746B	Underwriters' Laboratories, Inc.
ANSI	American National Standards Institute
CSA	Canadian Standards Association

3.0 Materials

3.1. Self-Regulating Heating Cables

All heat-tracing systems for use at temperatures up to a continuous exposure (maintain) of 250°F (121°C) and intermittent exposure temperature of 375°F (190°C) shall use a self-regulating heating cable.

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.
C) All cables shall be capable of passing a 1.6 kV dielectric test for one minute after undergoing a 10 ft-lb. impact (IEEE 515-1997 test 4.1.8)

3.1.1. Freeze Protection Systems 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 can be used directly on plastic or metallic pipes. Cables shall have a temperature identification number (T-rating) without the use of thermostats of the following.

Heating Cable	T-rating	Maximum Temperature
3 W/ft	T6	185°F (85°C)
5 W/ft	T6	185°F (85°C)
8 W/ft	T5	212°F (100°C)
10 W/ft	T4A	248°F (120°C)

B) The heating cable shall have a tinned copper braid with a resistance less than 8 mΩ/ft as determined by metallic covering conductivity test (IEEE 515-1997 test 4.1.13). The braid may be protected from chemical attack and mechanical abuse by an optional polyolefin or fluoropolymer outer jacket.

C) In order to provide rapid heat-up, and to prevent overheating of fluids and plastic pipe, the heating cable shall have the following minimum self-regulating indices:

Heating Cable	S.R. Index (W/°F)	S.R. Index (W/°C)
3 W/ft	-0.020	-0.036
5 W/ft	-0.045	-0.080
8 W/ft	-0.058	-0.104
10 W/ft	-0.071	-0.127

D) 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 facilitate longer circuit lengths and smaller breaker sizing. The heating cable shall have the following maximum inrush current at 50°F (10°C).

Heating Cable	Maximum Inrush @ time = 1 sec	Maximum Inrush @ time = 10 sec	Maximum Inrush @ time = 300 sec
3 W/ft, 120V	58 mA/ft	54 mA/ft	41 mA/ft
5 W/ft, 120V	155 mA/ft	128 mA/ft	66 mA/ft
8 W/ft, 120V	210 mA/ft	180 mA/ft	83 mA/ft
10 W/ft, 120V	432 mA/ft	319 mA/ft	123 mA/ft
3 W/ft, 240V	38 mA/ft	36 mA/ft	20 mA/ft
5 W/ft, 240V	92 mA/ft	80 mA/ft	33 mA/ft
8 W/ft, 240V	127 mA/ft	106 mA/ft	41 mA/ft
10 W/ft, 240V	281 mA/ft	205 mA/ft	62 mA/ft

F) 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 10 percent of rated power when energized and heated to 302°F (150°C) for 30 minutes. After this test, if the cable is allowed to cool to 50°F (10°C) and is reenergized, it must not have an increasing power output leading to thermal runaway.

G) In order to confirm 3.1B, the self-regulating heating cable shall maintain between 75 and 110 percent of its original power output after having been cycled 500 times between 50°F (10°C) and 150°F (65°C), allowing no more than 12 minutes of dwell time at each temperature.

H) The heating cable shall have the following third party approvals:

UL listed	Ordinary areas
CSA certified	Ordinary areas
	Class I, Division 2 groups A, B, C, D
	Class II, Division 2 groups F, G
FM approved	Ordinary areas
	Class I, Division 2 groups B, C, D
	Class II, Division 2 groups F, G
	Class III, Division 2

I) The heating cable shall be type SRL with continuous exposure (maintain) capability up to 150°F (65°C) and continuous exposure capability up to 185°F (85°C) with power off, as manufactured by Chromalox.

3.1.2. Process Temperature Maintenance with No Steam Exposure

A) The heating cable shall consist of two 14 AWG 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), without the use of thermostats, of the following:

Heating Cable	T-rating	Maximum Temperature
3 W/ft	T3	392 °F (200 °C)
5 W/ft	T3	392 °F (200 °C)
8 W/ft	T3	392 °F (200 °C)
10 W/ft	T2D	419 °F (215 °C)
15 W/ft	T2D	419 °F (215 °C)
20 W/ft	T2D	419 °F (215 °C)

B) The heating cable shall have a tinned copper braid with a resistance less than 8 mΩ/ft as determined by metallic covering conductivity test (IEEE 515-1997 test 4.1.13). The braid may be protected from chemical attack and mechanical abuse by an optional fluoropolymer outer jacket.

C) In order to provide rapid heat-up, and to prevent overheating of fluids, the heating cable shall have the following minimum self-regulating indices:

Heating Cable	S.R. Index (W/°F)	S.R. Index (W/°C)
3 W/ft	-0.010	-0.018
5 W/ft	-0.016	-0.029
8 W/ft	-0.022	-0.039
10 W/ft	-0.028	-0.050
15 W/ft	-0.042	-0.075
20 W/ft	-0.058	-0.104

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 200°F (93°C) and confirmed by the type test and published data sheets.

D) In order to facilitate longer circuit lengths and smaller breaker sizing. The heating cable shall have the following maximum inrush current at 50°F (10°C).

Heating Cable	Maximum Inrush @ time = 1 sec	Maximum Inrush @ time = 10 sec	Maximum Inrush @ time = 300 sec
3 W/ft, 120V	76 mA/ft	71 mA/ft	41 mA/ft
5 W/ft, 120V	94 mA/ft	89 mA/ft	66 mA/ft
8 W/ft, 120V	118 mA/ft	112 mA/ft	83 mA/ft
10 W/ft, 120V	266 mA/ft	231 mA/ft	124 mA/ft
15 W/ft, 120V	355 mA/ft	308 mA/ft	166 mA/ft
20 W/ft, 120V	430 mA/ft	365 mA/ft	208 mA/ft
3 W/ft, 240V	38 mA/ft	36 mA/ft	20 mA/ft
5 W/ft, 240V	47 mA/ft	45 mA/ft	33 mA/ft
8 W/ft, 240V	59 mA/ft	56 mA/ft	41 mA/ft
10 W/ft, 240V	133 mA/ft	115 mA/ft	62 mA/ft
15 W/ft, 240V	178 mA/ft	154 mA/ft	83 mA/ft
20 W/ft, 240V	215 mA/ft	183 mA/ft	104 mA/ft

E) In order to confirm 3.1B, the self-regulating heating cable shall retain at least 85 percent of its original power output after having been cycled between 70°F (21°C) and 375°F (190°C) for 3 weeks. Eight hours of dwell time at 70°F (21°C) and 16 hours of dwell time at 375°F (190°C) shall be conducted with a minimum test of 500 hours.

F) The heating cable shall have the following third party approvals:
UL listed Ordinary areas
CSA certified Ordinary areas

	Class I, Division 2 groups A, B, C, D
	Class II, Division 2 groups F, G
FM approved	Ordinary areas
	Class I, Division 2 groups B, C, D
	Class II, Division 2 groups F, G
	Class III, Division 2

G) The heating cable shall be type SRM/E with continuous exposure (maintain) capability up to 250°F (121°C) and continuous exposure capability up to 375°F (190°C) power off, as manufactured by Chromalox.

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, embedded in a self-regulating polymeric core that controls power output so that the cable has a temperature identification number (T-rating), without the use of thermostats, of the following:

Heating Cable	T-rating	Maximum Temperature
3 W/ft	T3	392 °F (200 °C)
5 W/ft	T3	392 °F (200 °C)
8 W/ft	T3	392 °F (200 °C)
10 W/ft	T2D	419 °F (215 °C)
15 W/ft	T2D	419 °F (215 °C)
20 W/ft	T2D	419 °F (215 °C)

B) The heating cable shall have a tinned copper braid with a resistance less than 8 mΩ/ft as determined by metallic covering conductivity test (IEEE 515-1997 test 4.1.13). The braid may be protected from chemical attack and mechanical abuse by an optional fluoropolymer outer jacket.

C) In order to provide rapid heat-up, and to prevent overheating of fluids, the heating cable shall have the following minimum self-regulating indices:

Heating Cable	S.R. Index (W/°F)	S.R. Index (W/°C)
3 W/ft	-0.010	-0.018
5 W/ft	-0.016	-0.029
8 W/ft	-0.022	-0.039
10 W/ft	-0.028	-0.050
15 W/ft	-0.042	-0.075
20 W/ft	-0.058	-0.104

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 200°F (93°C) and confirmed by the type test and published data sheets.

D) In order to facilitate longer circuit lengths and smaller breaker sizing. The heating cable shall have the following maximum inrush current at 50°F (10°C).

Heating Cable	Maximum Inrush @ time = 1 sec	Maximum Inrush @ time = 10 sec	Maximum Inrush @ time = 300 sec
3 W/ft, 120V	76 mA/ft	71 mA/ft	41 mA/ft
5 W/ft, 120V	94 mA/ft	89 mA/ft	66 mA/ft
8 W/ft, 120V	118 mA/ft	112 mA/ft	83 mA/ft
10 W/ft, 120V	266 mA/ft	231 mA/ft	124 mA/ft
15 W/ft, 120V	355 mA/ft	308 mA/ft	166 mA/ft
20 W/ft, 120V	430 mA/ft	365 mA/ft	208 mA/ft
3 W/ft, 240V	38 mA/ft	36 mA/ft	20 mA/ft
5 W/ft, 240V	47 mA/ft	45 mA/ft	33 mA/ft
8 W/ft, 240V	59 mA/ft	56 mA/ft	41 mA/ft
10 W/ft, 240V	133 mA/ft	115 mA/ft	62 mA/ft
15 W/ft, 240V	178 mA/ft	154 mA/ft	83 mA/ft
20 W/ft, 240V	215 mA/ft	183 mA/ft	104 mA/ft

E) In order to confirm 3.1B, the self-regulating heating cable shall retain at least 85 percent of its original power output after having been cycled between 70°F (21°C) and 375°F (190°C) for 3 weeks. Eight hours of dwell time at 70°F (21°C) and 16 hours of dwell time at 375°F (190°C) shall be conducted with a minimum test of 500 hours.

F) The heating cable shall have the following third party approvals:

UL listed	Ordinary areas
CSA certified	Ordinary areas
	Class I, Division 2 groups A, B, C, D
	Class II, Division 2 groups F, G
FM approved	Ordinary areas
	Class I, Division 2 groups B, C, D
	Class II, Division 2 groups F, G
	Class III, Division 2

G) The heating cable shall be type SRM/E with continuous exposure (maintain) capability up to 250°F (121°C) and continuous exposure capability up to 375°F (190°C) with power off, as manufactured by Chromalox.

3.1.4. Systems for Division 1 Hazardous (Classified) 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) A ground fault protection device set at 30 mA, with a nominal 100 ms response time, shall be used to protect each circuit.

B) The temperature identification number (T-rating) of the cable used shall comply with FM requirements as applicable.

C) 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 Division 1 locations.

D) The heating cable shall be HSRM-CT for maintain temperatures up to 250°F (121°C) and continuous exposure capability up to 375°F (190°C) with power off, as manufactured by Chromalox.

E) The heating cable shall have the following third party approvals:

FM approved	Class I, Division 1 groups B, C, D
	Class II, Division 1 groups E, F, G
	Class III, Division 1

F) For plastic pipe and vessel applications, the heating cable shall be HSRL-CT, for maintain temperatures up to 150°F (65°C) and continuous exposure capability up to 185°F (85°C) with power off, as manufactured by Chromalox.

3.2. Termination For Self-Regulating Heating Cables

A) All connection components used to terminate self-regulating 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 manufacture.

B) In order to keep connections dry, components shall be rated NEMA 4.

3.3. Mineral Insulated Cable Systems

All heat-tracing applications with continuous exposure (maintain) temperatures above 250°F (121°C) or intermittent exposure temperatures above 375°F (190°C) shall use factory-terminated, mineral insulated (MI) cables.

A) MI cable shall be magnesium oxide insulated with an Incoloy 825 sheath. The heated 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, etc. 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 temperatures, calculated according to the method outlined in IEEE Std 515-1997 section 6.4 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 cable tag containing the heating cable length, wattage, and voltage.

3.4. Thermostats and Contactors

A) Freeze protection systems shall operate using self-regulating control, the RTAS-X thermostat in ordinary and Division 2 hazardous areas, or the B121 thermostat in Division 1 hazardous areas.
B) Process temperature maintenance system shall operate using the RTBC-X thermostat in ordinary and Division 2 hazardous areas or the E121 thermostat in Division 1 hazardous areas.
C) Chromalox contactor type CONT shall be used where the heat tracing circuit current exceeds the thermostat switch rating. Contactor enclosure type NEMA 1, 4, or 7 shall be used according to enclosure location.

3.5. Control, Monitoring and Power Distribution Systems

A) For single loop applications, a UL listed microprocessor based temperature control, monitoring and power distribution system shall be used. The controller shall accept universal sensor inputs. The system shall be compatible with self-regulating and MI cables and shall have the following features.
   1) NEMA 4X fiberglass enclosure
   2) Supply voltage: (select: 120, 240 or 277 Vac single phase).
   3) Field power connection terminal block must accept universal sensor input for one circuit.
   4) Control must operate in 32-120°F (0-40°C) environments.
   5) Solid state relay rated 30A at 120°F (40°C) output.
   6) Optional RS-485 MODBUS® communications capable with interfacing with personal computers and PLC's.
   7) Low current alarm: 0-30A in 1A increments.
   8) Optional 5-100mA ground fault alarm trip.
   9) Process, deviation, band, high/low and latching/non-latching (manual/automatic reset) programmable temperature alarms.
   10) On/Off and PID control modes. PID mode must have one touch self-tuning feature such as Chromalox, 1600 series SMART button feature.
   11) Programmable Soft-Start-Timed Output Power Limit on Start-Up.

B) For multi-loop applications, a UL listed microprocessor based temperature control, monitoring and power distribution system shall be used. The sensors shall be of the type resistance temperature detector RTD (0 – 500 C/32 – 900 F) and shall be wired to the panel. The system shall be compatible with self-regulating and MI cables and shall have the following features.
   1) NEMA 4/12 enclosure.
   2) Supply voltage: (select: 120, 240 or 277 Vac single phase).
   3) The system must have a color touch screen operator interface.
   4) Field power connection terminal block and RTD input connection terminal block for (select: 8, 12 or 24 circuits).
   5) Select (32-120°F (0-40°C) operating environment without Cabinet Heater) (-40 – 120 F with Optional Cabinet heater).
   6) Mechanical Two-Pole Output Relays for each circuit rated 30 Amps .
   7) Select (Optional RS-485 MODBUS® communications for interfacing with personal computers and PLC's).
   8) The system must be capable of checking cable continuity without use of a monitor wire.
   9) Ground fault alarm must be adjustable between (25 – 500 mA).
   10) The system must have selectable capability for ground fault alarm only or ground fault and trip.
   11) The system must have Non-Latching, High/low programmable temperature alarms.
   12) The system must have Open Sensor Alarm with Programmable Open Sensor Output Setting (0 – 100%).
   13) The System must have capability to graphically display circuit currents.
   14) The system must have load managing start-up capability.
   15) The system must have programmable self-test capability from 0 to 720 hours with full system alarm capability including ground fault, high/low temp and continuity
   16) On/Off Control with adjustable Deadband (1 – 10)
   17) The system must be field programmable for °F or °C.
   18) The system must have capability for global programming of all setpoints and alarms.
   19) The system must have capability for graphic displays of Loop Status, Alarm conditions, Process Temperature, Setpoints, and Currents.
   20) The system must have one set of dry alarm contacts.
   21) The system must have selectable Hand/Off/Auto control modes.
   22) The system must have a control Loop Enable/Disable Feature.
   23) All features including temperature control, contactors, and power distribution must be contained in one enclosure.

24) The system must be modular in-design, such that individual components can be replaced in the field if necessary.
25) The system must be cUL approved.

C) Control, Monitoring and Power Distribution Systems shall be IntelliTrace HTLS /HTAS as supplied by Chromalox.

4.0 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 Chromatrace. 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) Uncontrolled pipe temperature at maximum ambient.

5.0 Field Support and Training

A) The material shipments shall include a detailed installation and maintenance manual for all products included in shipment.
B) The local vendor shall maintain qualified field service personnel to assist in installer training, system commissioning and basic troubleshooting.

Sales Reference PJ941

