Raychem

COMMERCIAL HEAT TRACING

PRODUCTS AND SERVICES

@PentairThermal

THERMAL MANAGEMENT

WWW.PENTAIRTHERMAL.COM

THERMAL MANAGEMENT

We provide quality solutions for winter safety, comfort and performance to building and infrastructure design, construction, operation and maintenance professionals. From pipe freeze protection to maintaining fluid temperatures and melting snow, detecting leaks or heating floors, you can rely on Thermal Management solutions and services for greater safety, comfort and performance.

THE HEART OF OUR SOLUTIONS

As the inventor of self-regulating heat tracing in 1970, our Raychem brand is recognized for technical leadership in the industries we serve. The cable delivers the right amount of heat exactly when and where it is needed. As the temperature drops, more heat is produced. Conversely, as the temperature rises, less heat is produced. But there are many more benefits:

- The smart cables can be overlapped without any risk of overheating.
- The heating cables can be cut to length 'in the field'. This means additional flexibility when plans do not correspond to the "real life" situation on site.

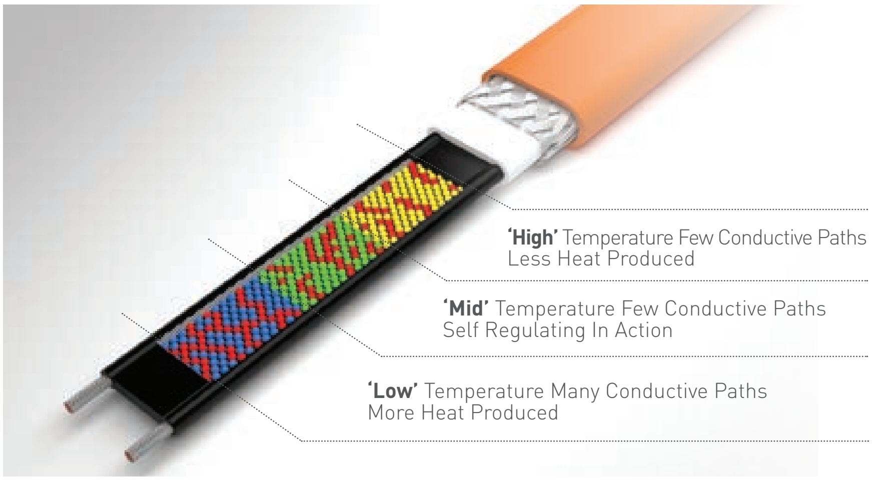
Our mineral insulated heating cables and wiring have led the industry for more than 75 years. Able to withstand extreme, harsh environments, our cables provide the most reliable heat-tracing solution for high-temperature applications.

Raychem

SELF-REGULATING TECHNOLOGY — RIGHT AMOUNT OF HEAT

At higher temperatures, the polymer expands, reducing the number of paths – thereby reducing the power output of the cable. At low temperatures, there are many conductive paths, allowing higher level of current to flow between the bus wires.

Producing the 'right amount of heat' saves you money with no wasted energy.



TESTED AND QUALIFIED

- Thermal Management's range of heating systems are tested to the most stringent industry standards to ensure maximum reliability and performance for our customers.

FM APPROVED UL LISTED SA

ROBUST CONSTRUCTION

- Long service life assured through modified polyolefin or fluorpolymer insulation and jacket materials.

LIFE EXPECTANCY

- Extensive scientific testing and field history prove that when properly installed and maintained the self-regulating cables are expected to work for many decades.

IT'S MORE THAN A CABLE!

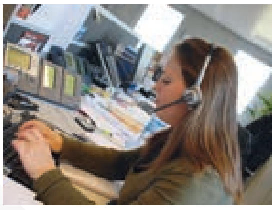
The combination of a self-regulating heating cable and **smart control** system allows for dynamic management of the heating cable's power output dependent on parameters such as ambient temperature and moisture. These will help you comply with today's building regulations on energy savings. A complete Raychem system can result in energy savings of up to 80%!

Additionally, Raychem **connection systems** have been designed and configured to be fully compatible with our heating cables. The RayClic connection system cuts installation time by 80%.

CUSTOMER SERVICE AND TECHNICAL SUPPORT TEAMS

Thermal Management offers a set of tools and services that aim to simplify the professional´s life. Not only do we offer the best quality products, we also support them with unrivalled services.

- Customer service agents to answer your questions
- Fast order handling & shipment
- Free documentation service
- On demand" technical advice



- Designs and quotations
- Direct support to specifiers and installers
- Training support upon request
- Complete after-sale service
- For non-standard applications, our team can assist you in finding the right heating solution Call 1-800-545-6258

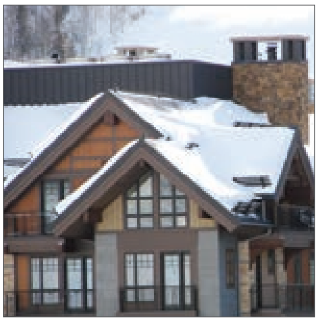
BEST PRODUCT SELECTION, DESIGN TOOLS AND INTEGRATED SERVICES EXPERTS

Thermal Management offers the widest range of heat tracing products for safety, comfort, and performance applications for commercial construction. To compliment this, we offer a full-suite of intuitive designer tools to make it easy to create optimal heat-trace designs for your specific applications (see pg 22).

Most importantly, we are the heat-trace experts and the leading full-service integrator for heat management systems. Our Integrated Services team partners with you to address all types of projects, from buildings to complex infrastructure, to optimize solutions that enhance safety, comfort and performance.

Pipe Freeze Protection

Flow Maintenance



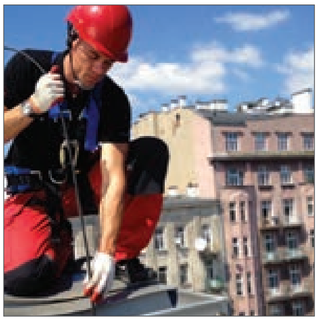
Roof & Gutter De-Icing

Surface Snow Melting

Freezer Frost Heave Prevention

Floor Heating

Hot Water Temperature Maintenance



Integrated Services

PROTECT PIPES

Unprotected pipes

Water lines and fire protection lines can freeze and burst when exposed to cold temperatures. Raychem systems help you prevent this.

PIPE FREEZE PROTECTION OF WATER LINES

Raychem pipe freeze protection systems are flexible and easy to attach to the exterior of the pipe to keep pipes from freezing, bursting, and causing water damage. XL-Trace systems can add a precise level of heat to prevent water pipes from freezing.

XL-Trace System

PIPE FREEZE PROTECTION OF FIRE PROTECTION LINES

Raychem XL-Trace fire sprinkler freeze protection systems can freeze protect aboveground and buried supply pipes, fire standpipes, branch lines and branch lines containing sprinklers when run in areas subject to freezing. XL-Trace is c-CSA-us Certified for use on fire suppression systems under CSA C22.2 No. 130-03 for Canada and IEEE 515.1-2005 for the US.

Flow in grease waste and fuel oil lines is hindered when pipes get below the temperature at which the viscosity inhibits fluid flow. Raychem systems help you protect pipes.

Unprotected pipes

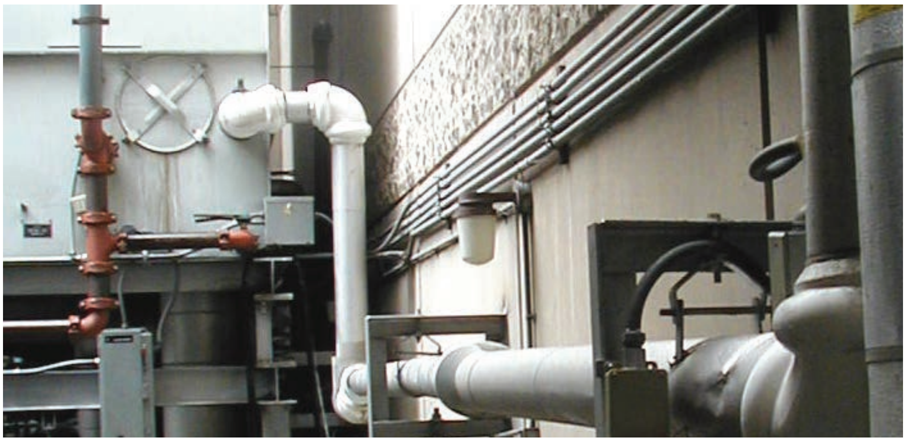
GREASE WASTE FLOW MAINTENANCE

Raychem XL-Trace grease waste flow maintenance systems is designed to maintain a 110°F (43°C) fluid temperature to keep the Fat, Oil, Grease mixture (FOG) in suspension from the kitchen to the grease interceptor. By maintaining flow in even the most demanding commercial kitchens, this system can reduce costs associated with maintenance and down-time.

XL-Trace System

FUEL OIL MAINTENANCE

Raychem XL-Trace fuel oil flow maintenance systems can maintain #2 fuel oil lines above the temperature at which the viscosity inhibits fluid flow.



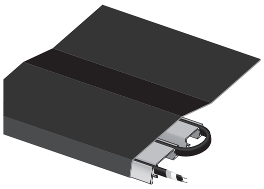
PROTECT ROOFS, GUTTERS AND WINDOWS

Unprotected roof and gutters

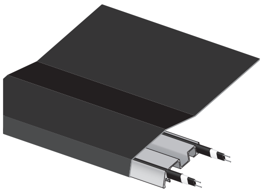
Ice dams can form on roofs, in gutters, and downspouts preventing water from properly draining which can result in water damage. Heavy icicles can fall and cause serious injury. Standing water can leak through to interior walls and furnishings. Raychem systems help you protect roofs, gutters, and downspouts.

ROOF & GUTTER DE-ICING – RIM

Raychem Roof Ice Melt (RIM) System is the premier, highest performing, aesthetically elegant roof & gutter de-icing solution ideal for new construction or renovation of residential or commercial buildings. The system consists of metallic panels that embed self-regulating heat tracing cable to provide high power output.
RIM system with 3 runs of cable is ideal for heavy snow load areas. RIM2 system with 2 runs of cable is ideal for light to moderate snow load areas.



RIM System



RIM2 System

ROOF & GUTTER DE-ICING – ICESTOP

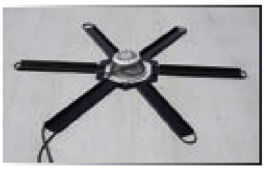
Raychem IceStop is an advanced, high performing, specified roof & gutter de-icing solution ideal for commercial buildings in light to heavy snow load areas. It can be cut to length for easy installation in plastic, copper, steel, or aluminum gutters, and on flat or pitched roofs, valleys and overhangs. The low operating temperature of the heating cable also makes it safe for use on modern membrane roofs.

IceStop System

Ice dams can also form on and around roof drains preventing water from properly draining which can result in water damage. Window condensation can result in a build up of mold/mildew, causing health hazards and potential damage to the delicate artifacts, like those found in libraries and museums. Raychem systems help you protect roof drains and windows.

RIM DRAINTRACE

Raychem RIM-DrainTrace (RIM-DT) is a complete solution to trace roof drains. It includes Raychem IceStop heating cable, connection kits and pre-cut RIM panels for a fast, reliable, and elegant system to keep your roof drain free of snow and ice.



RIM-DrainTrace

WINDOW MULLION HEATING

Raychem Window Mullion Heating (WMH) is a complete heating solution designed to be installed in window frames. The system utilizes high wattage self-regulating cable installed in an engineered aluminum tray assembly offering efficient, high performance heat that keeps your windows free of frost and moisture.

Window Mullion Heating

PROTECT SURFACES

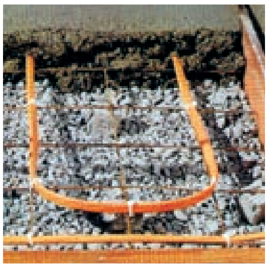

Unprotected surfaces

When snow and ice accumulates on outdoor concrete and asphalt surfaces, they can become slippery, unusable, and unsafe for people and vehicles.

Proven, reliable, and efficient, Raychem snow melting systems keep sidewalks, stairways, driveways, parking garage ramps, loading docks, store entryways, and other areas free of snow and ice during even the worst weather conditions.

SURFACE SNOW MELTING – ELECTROMELT


ElectroMelt System


ElectroMelt System

The Raychem ElectroMelt system for concrete surfaces incorporates a rugged cut-to-length self-regulating heating cable that reduces heat output automatically as the pavement warms. It is ideal as an off-the-shelf solution and for smaller areas.

SURFACE SNOW MELTING – MI


MI System


Raychem MI System

The Raychem MI system for concrete, asphalt, and pavers, incorporates a rugged copper mineral insulated cable protected by a high density polyethylene outer jacket that provides constant power output. It offers higher voltages, high output, and 3-phase power, making it ideal for large areas.

When snow and ice accumulates on paved surfaces or suspended surfaces, like stairs, walkways and catwalks, they become unsafe for people. Safety becomes even more of a concern when these unsafe condition affect critical access areas such as evacuation routes, ADA accessibility, and so on. Raychem systems help you protect surfaces.

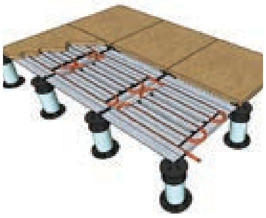
SMART TIP

Contact us at
1-800-545-6258

Our Integrated Services team can assist you with cable layout design for your requirements.

PEDESTAL MOUNTED HEATING

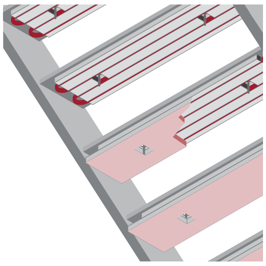
Raychem Pedestal Mounted Paver Heating (PMPH) is a complete snow melting solution designed to be installed under the pedestal mounted pavers. The system utilizes high wattage self-regulating cable installed in an engineered aluminum tray assembly offering efficient, high performance snow melting that keeps your pedestal mounted pavers free of snow and ice.



Pedestal Mounted Heating

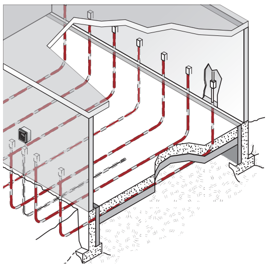
SUSPENSION MOUNTED HEATING

Raychem Suspension Mounted Heating (SMH) is a complete snow melting solution designed to be installed under suspended metal surfaces such as stairs, walkways and catwalks. The system utilizes high wattage self-regulating cable installed in an engineered aluminum tray assembly offering efficient, high performance snow melting that keeps your suspended surfaces free of snow and ice.



Suspension Mounted Heating

PROTECT FREEZERS



Freezer frost heave example

Inside cold rooms and freezers, subfreezing temperatures cause heat to be lost from the soil under the floor. As the soil freezes, capillary action draws water into the frozen areas where the water forms a concentrated ice mass. As the ice mass grows, it heaves the freezer floor and columns, causing damage. Raychem freezer frost heave prevention systems can prevent this problem.

FREEZER FROST HEAVE PREVENTION - RAYSOL

RaySol System

RaySol cut-to-length self-regulating heating cables provide long circuit lengths, higher heat output, and are durable enough to be embedded in concrete, making it ideal in preventing heaving in soils under freezers, refrigerated warehouses, and cold rooms. RaySol is ideal for smaller areas.

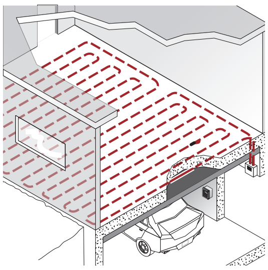
FREEZER FROST HEAVE PREVENTION - MI

MI System

HDPE jacketed copper sheathed heating cables provide higher voltages, high output, 3-phase power, small profile, and are durable enough to be embedded in concrete, making it ideal in preventing heaving in soils under freezers, refrigerated warehouses, and cold rooms. MI is ideal for larger areas.

REPLACE HEAT LOSS

Floors over non-heated areas such as garages, or loading docks lose heat through the floor insulation over a cold space. Raychem heat loss solutions can prevent this problem.



heat loss replacement example

HEAT LOSS REPLACEMENT - RAYSOL

RaySol cut-to-length self-regulating heating cables provide long circuit lengths, higher output, and are durable enough to be embedded in concrete, making it ideal to eliminate the chill felt from the heat lost through floors over non-heated areas such as skywalks, cantilevered roofs, garages, or loading docks. Also works as a radiant space heating solution. RaySol is ideal for smaller areas.

RaySol System

HEAT LOSS REPLACEMENT - MI

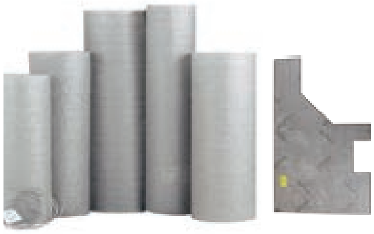
HDPE jacketed copper sheathed heating cables provide higher voltages, high output, 3-phase power, small profile, and are durable enough to be embedded in concrete, making it ideal to eliminate the chill felt from the heat lost through floors over non-heated areas such as skywalks, cantilevered roofs, garages, or loading docks. Also works as a radiant space heating solution. MI is ideal for larger areas.

MI System

ENJOY THE COMFORT YOU DESERVE

FLOOR HEATING - NUHEAT

Nuheat electric floor heating systems are an ideal room-specific heat source option for both new construction or renovation projects. These easy-to-install systems can be installed under tile, stone, laminate and engineered wood floors.



NUHEAT CUSTOM & STANDARD MAT SYSTEM

Pre-built like an electric blanket, Nuheat mats are available in standard sizes or can be custom built to precisely fit any room with curves or angles. It is the easiest and quickest system to install. Nuheat custom mats can be manufactured in 3 days. Standard mats are available in over 70 standard off-the-shelf square and rectangular sizes. Voltage: 120 V or 240 V

NUHEAT CABLE SYSTEM

Offering the ultimate in installation flexibility, Nuheat cable is perfect where on-site adjustments are required. Coupled with newly redesigned cable guides and a low-profile cold lead, adding heated floors to your renovation or new construction project has never been easier. Over 30 kit sizes; largest 120 V covers 120 sq ft and largest 240 V covers 240 sq ft.

NUHEAT MEMBRANE

NUHEAT MEMBRANE by Progress Profiles is a tile underlayment and uncoupling system that is specifically designed to embed and hold the industry-leading Nuheat cable floor heating system. The low profile of the membrane reduces the stress caused by differential movement between the tile layer and the substrate which can lead to tile cracking. Flexible cable spacing and wattage output of 10, 12, or 15 watts per sq ft makes it suitable for comfort heating or primary heat source applications.

NUHEAT MESH SYSTEM

The Nuheat mesh system is heating cable woven into an adhesive-backed fiberglass mesh with patented mesh bands to hold the heating cable in place. The modifiable solution is simple to roll-out and can be customized on the job site to fit any room shape. Standard off-the-shelf mesh available in 13 sizes for 120 V, and 19 sizes for 208/240 V.

SMART TIP

Nuheat Electric Floor Heating Systems offer an entirely maintenance-free heating alternative—with no cold spots. Industry leading 25-year Total Care warranty applies. See www.nuheat.com for more information.

ENJOY INSTANT HOT WATER

Conventional recirculation systems in large commercial buildings can lead to high energy costs and wasted water. Raychem has a smart alternative for meeting Plumbing Code that saves water and energy.

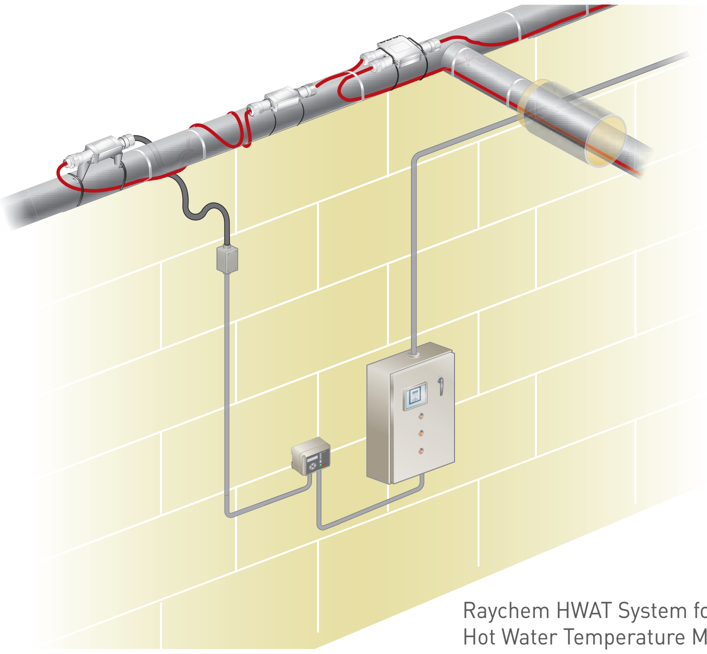
HOT WATER TEMPERATURE MAINTENANCE

Raychem's Hot Water Temperature Maintenance (HWAT) system is a better way to meet Plumbing Code that saves water, energy, and can be used in concert with, or instead of, conventional designs. It is a simple, smart performance alternative to complex recirculation systems.

HWAT heating cables are attached to hot-water supply pipes to compensate for heat loss and maintain hot water temperature throughout the building, while eliminating the need for return piping and associated equipment.

This simplified design improves performance, reduces installation costs, and takes up less building space. More importantly, HWAT system saves energy, water, and requires less maintenance which significantly reduces building operating costs. When properly installed and maintained, HWAT heating cables have a service life in excess of 40 years.

HWAT System



Raychem HWAT System for
Hot Water Temperature Maintenance

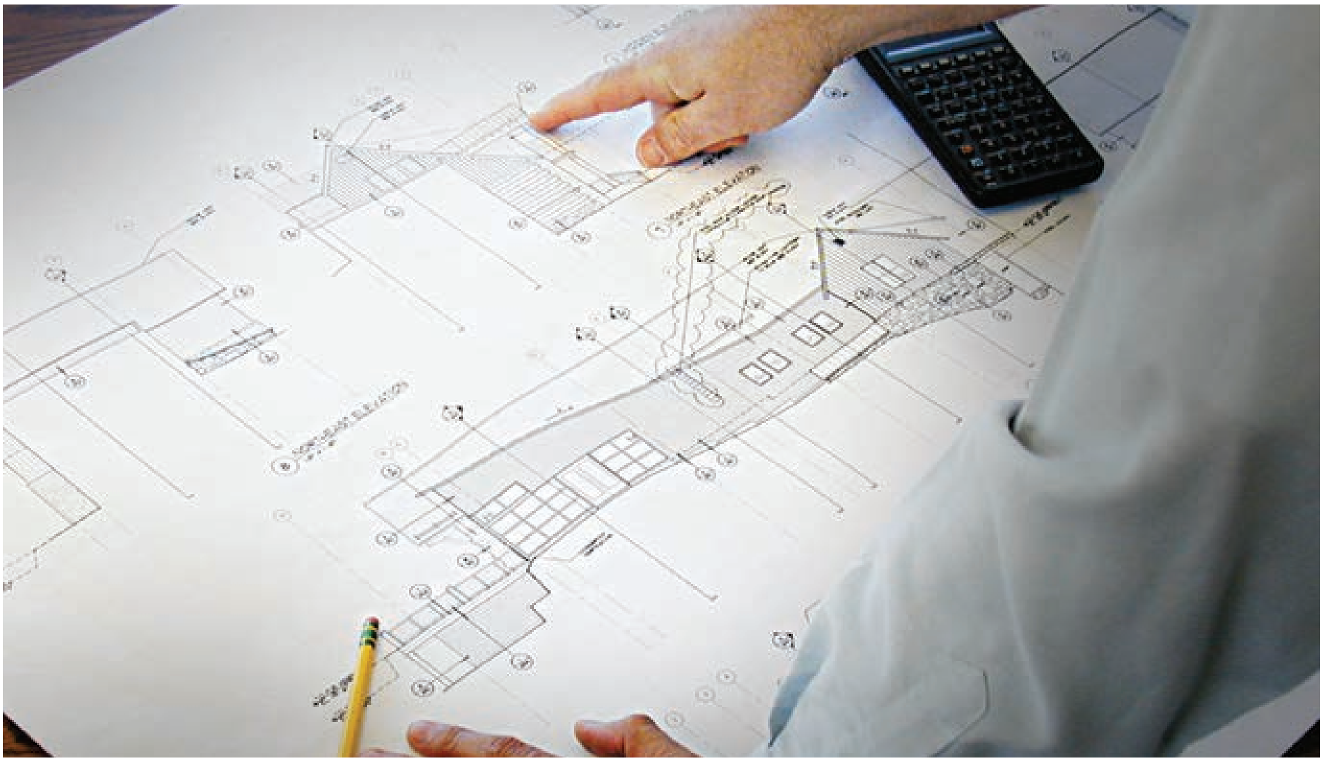
SMART TIP

For HWAT design assistance, please refer to the Hot Water Temperature Maintenance Product Selection and Design Guide (H57538)

HWAT System

INTEGRATED SERVICES

The Thermal Management Integrated Services team of experts partner with you to address all types of projects, from **buildings** to complex **infrastructure**, to ensure optimized solutions to enhance safety, comfort and performance.



PROPOSALS & ESTIMATES

- Support architects, engineers, and contractors to develop Electric Heat Trace (EHT) scope, review EHT applications, and outline required engineering deliverables
- Provide detailed proposal for requested Scope of Work incuding Engineering, Products, Construction, and/or Field Support Services

ENGINEERING & DESIGN

- Create custom layout drawings for EHT applications
- On-site field engineering and design for heat trace applications
- Design custom heat trace systems with optimized performance

PROJECT MANAGEMENT

- Manage heat trace projects for design, supply and/or installation services
- Manage materials—procurement, buy-outs, deliveries on site

Beyond front end assistance of proposals, engineering and design, the Integrated Services team can be there every step of the way through contruction and installation, to commissioning and post installation services.

CONSTRUCTION / INSTALLATION

- Installation of heat trace products
- Installation of power distribution and control wiring
- On-site supervision of installation

FIELD SUPPORT SERVICES

- Commissioning & Start-up Assistance
- Troubleshooting & Repair
- Audits
- Training

CHOOSE INTEGRATED SERVICES TO ...

- Provide CUSTOM SOLUTIONS to meet your needs
- Help you REDUCE RISK
- Be the SINGLE POINT OF CONTACT for your project needs
- Optimize the right system for your building or infrastructure.

Visit our web site at **www.pentairthermal.com**
or contact us at **1-800-545-6258**

COMMERCIAL HEATING PRODUCTS

SELF-REGULATING HEATING CABLES

Raychem self-regulating heating cables consist of two parallel conductors embedded in a conductive polymer heating core. The core is radiation-cross linked to ensure long-term reliability. The self-regulating heating cable automatically adjusts power output to compensate for temperature changes. Producing the 'right amount of heat' saves you money with no wasted energy.

SELF-REGULATING HEATING CABLES

XL-Trace

Pipe Freeze Protection and Flow Maintenance

IceStop

Roof and Gutter De-Icing

ElectroMelt

Surface Snow Melting and Anti-Icing

RaySol

Heat-Loss Replacement and Freezer Frost Heave Prevention

HWAT

Hot Water Temperature Maintenance

CONNECTION KITS AND ACCESSORIES

Raychem power, splice, tee, end seal kits, and accessories are vital parts of the heat-tracing system.

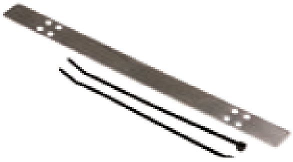
The RayClic connection kits have been designed and configured to be fully compatible with our XL-Trace, IceStop, and HWAT heating cables, and cuts installation time by 80%.

RayClic-PC Power Connection

GMK-RC Roof Clip

RayClic-LE Lighted End Seal

GM-RAKE Hanger Bracket



MINERAL INSULATED HEATING CABLES

Raychem mineral insulated heating cables consist of a single or dual conductor surrounded by magnesium oxide insulation, a solid copper sheath, and an extruded high density polyethylene jacket. The mineral insulated series-type technology provides a reliable and constant heat source that is ideal for surface snow melting, anti-icing, floor heating, and freezer frost heave prevention.

COPPER MI HEATING CABLES

Roof and Gutter De-Icing, Heat Loss Replacement

HDPE JACKETED COPPER MI HEATING CABLES

Roof and Gutter De-Icing, Surface Snow Melting, Anti-Icing, Freezer Frost Heave Prevention

ALLOY 825 MI HEATING CABLES

Surface Snow Melting, Anti-Icing

CONTROL & MONITORING PRODUCTS

ADVANCED CONTROLLERS & POWER DISTRIBUTION

ADVANCED CONTROLLERS

Our microprocessor-based controllers provide accurate control and feedback for critical heat-tracing applications, including freeze protection for sprinkler piping systems. HWAT-ECO and C910-485 are single-point controllers, whereas the ACS-30 is a multi-point control platform.

HWAT-ECO

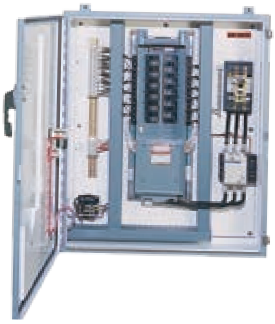
C910-485

ACS-30

POWER DISTRIBUTION

Raychem dedicated HTPG and SMPG power-distribution panels reduce costly field wiring and controller costs. Available for heat tracing, surface snow melting, anti-icing, and roof and gutter de-icing applications. The HECS control system is specifically designed to work with RIM roof ice melt systems and can utilize multiple sensors to provide zone control for better energy efficiency.

HTPG



SMPG

HECS

SNOW CONTROLLERS & THERMOSTATS

SNOW CONTROLLERS AND SENSORS

ETI® snow controllers automatically energize snow melting, and roof and gutter de-icing systems when both precipitation and low temperature are detected. The controllers work with the aerial, pavement-mounted, and gutter snow sensors.

PD-PRO

GF-PRO

APS-4C

CIT-1

SIT-6E

GIT-1

ELECTRONIC AND MECHANICAL THERMOSTATS

The EC-TS and ECW-GF are ambient or line sensing thermostats and provide accurate temperature control for pipe freeze protection and flow maintenance applications. They can control a single heat tracing circuit or as a pilot control of a contactor switching multiple heat-tracing circuits.

Our mechanical thermostats, like the AMC-F5 or AMC-1A, provide simple on/off control for pipe freeze protection applications. They can control a single heat tracing circuit or as a pilot control of a contactor switching multiple heat-tracing circuits.

EC-TS

ECW-GF

AMC-F5

AMC-1A

FLOOR HEATING THERMOSTATS

Our floor heating thermostats are suitable for all Nuheat floor heating systems and include built-in GFCI protection:

Signature (WiFi-enabled programmable touchscreen) Works with Nest

Home (programmable touchscreen)

Element (non-programmable)

CONTROLLER APPLICATION MATRIX

		GENERAL APPLICATIONS											
		Least Desirable →											→ Most Desirable
		Element	Home	Signature	AMC-F5	AMC-1A	AMC-1B	SST-2	EC-TS	ECW-GF	HTPG	C910-485	ACS-30
Application	Pipe Freeze Protection				✔	✔	✔	✔	✔	✔	✔	✔	✔
	Pipe Flow Maintenance						✔		✔	✔		✔	✔
	Fire Mains, Sprinkler Lines											✔	✔
	Roof & Gutter - IceStop								✔	✔			✔
	Roof & Gutter - RIM												
	Surface Snow Melting										✔		✔
	Freezer Frost Heave/Heat Loss									✔	✔	✔	✔
	Floor Heating - Nuheat	✔	✔	✔									
	Domestic Hot Water												
# of Circuits	120 V	1	1	1	1	1	1	1	1	1	54	1	5+
	208 V	1	1	1	1	1	1	1	1	1	26	1	5+
	240 V	1	1	1	1	1	1	1	1	1	20	1	5+
	277 V				1	1	1	1	1	1	26	1	5+
	480 V												5+
	Minimum Setpoint	50°F	50°F	50°F	40°F	15°F	25°F	40°F	30°F	32°F		0°F	
	Maximum Setpoint	104°F	104°F	104°F	40°F	140°F	325°F	40°F	110°F	200°F		200°F	
	Power Distribution										✔		
	Max Amps/Circuit	15	15	15	22	22	22	30	30	30	50	30	30
	30 mA GFPD												
	Hold On Timer (hours)	1hr to indefinite	1hr to indefinite	1hr to indefinite									
Controls Based on	Ambient Temp	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Line Temp				✔		✔	✔	✔	✔		✔	✔
	Moisture										✔		✔
	Proporational (PASC)											✔	✔
	Sensor Length (feet)	15	15	15	2.5	0	9	20	25	25		0-4500	0-4500
Additional Sensor Input Req'd	RTD											✔	✔
	CIT-1										✔		
	GIT-1										✔		
	SIT-6E										✔		
	External										✔	✔	✔
	Max # Sensors								1	1	1	2	5+
	Optional Remote Control									✔			
BMS Tie-In	Contacts							✔		✔	Optional	✔	✔
	AC relay											✔	
	Smart											✔	✔
Alarms	High Voltage											✔	✔
	Low Volage (Loss of Power)							✔		✔		✔	✔
	Low Temp									✔		✔	✔
	High Temp									✔		✔	✔
	GF Monitoring	✔	✔	✔				✔				✔	✔
	GF Trip	✔	✔	✔				✔		✔	Optional	✔	✔
	Hi Amp Draw											✔	
	Low Amp Draw											✔	
	Sensor Failure	✔	✔	✔				✔		✔		✔	✔
	Auto-Cycle											✔	✔

		HOT WATER APP	SNOW MELTING APPLICATIONS								
			Least Desirable → Most Desirable								
		HWAT-ECO	LCD-8	ASD	APS-3C	PD-PRO	GF-PRO	APS-4C	SC-40	HECS	SMPG
Application	Pipe Freeze Protection										
	Pipe Flow Maintenance										
	Fire Mains, Sprinkler Lines										
	Roof & Gutter - IceStop		✓		✓	✓	✓	✓	✓		✓
	Roof & Gutter - RIM			✓						✓	
	Surface Snow Melting		✓		✓	✓	✓	✓	✓		✓
	Freezer Frost Heave/Heat Loss										
	Floor Heating - Nuheat										
	Domestic Hot Water	✓									
# of Circuits	120 V		1	4 or 8	1	1	1			18	
	208 V	1	1	4 or 8	1	1	1	1	1	18	18
	240 V	1	1	4 or 8	1	1	1	1	1	18	
	277 V			4 or 8		1	1	3	3	18	18
	480 V			4 or 8				1	1	18	9
	Minimum Setpoint	105°F	38°F	−150°F	38°F	38°F	38°F	38°F		−150°F	
	Maximum Setpoint	140°F	38°F	150°F	38°F	38°F	38°F	38°F		150°F	
	Power Distribution									✓	✓
	Max Amps/Circuit	24	16	30	24	30	30	40	40	40	50
	30 mA GFPD						✓	✓	✓	✓	✓
	Hold On Timer (hours)		0–5		0–10	0–8	0–8	0–10	0–10		0–10
Controls Based on	Ambient Temp		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Line Temp										
	Moisture		✓		✓	✓	✓	✓	✓		✓
	Proporational (PASC)										
	Sensor Length (feet)	13-328		15						15	
Additional Sensor Input Req'd	RTD			✓						✓	
	CIT-1				✓	✓	✓	✓			✓
	GIT-1				✓	✓	✓	✓			✓
	SIT-6E				✓	✓	✓	✓			✓
	External	Optional			Optional			Optional	APS-40		Optional
	Max # Sensors			1	6	22		6		2	6
	Optional Remote Control				RCU-3	RCU-3	RCU-4	RCU-4			RCU-3
BMS Tie-In	Contacts										
	AC relay	✓									
	Smart										
Alarms	High Voltage										
	Low Volage (Loss of Power)	✓									
	Low Temp	✓									
	High Temp	✓									
	GF Monitoring										
	GF Trip						✓	✓	✓	✓	Optional
	Hi Amp Draw										
	Low Amp Draw	✓									
	Sensor Failure	✓									✓
	Auto-Cycle										

DESIGNER'S TOOLBOX

VISIT WWW.PENTAIRTHERMAL.COM

Our website provides all the latest tools and information you need to design, select, and purchase a complete system for any commercial heating application. Browse and find the most up-to-date product brochures, data sheets, design guides and installation instructions.

Use our web-based design programs to help with your projects.

Visit our web site at
www.pentairthermal.com
or contact us at
1-800-545-6258.

DESIGN TOOLS

AUTODESK SEEK, BIM & TRACE-IT

Autodesk® Seek is a search engine that enables architects, engineers, and other design professionals to quickly discover, preview, and download our BIM files and product specifications for use in Autodesk Revit® or AutoCAD®. For more information, visit http://seek.autodesk.com, and search on Thermal Management.

Trace-It is a software add–in for Autodesk Revit that allows users to design Raychem heat trace within their Revit model. To download Trace-It, go to http://apps.auotdesk.com, and type in Trace-It.

ACS-30 Program Integrator

The ACS-30 Program Integrator is a utility used on Microsoft Windows PCs that allows the user to easily set up circuit databases—providing invaluable help for commissioning the heating cable control system.

TraceCalc For Buildings

TraceCalc Pro For Buildings is an intuitive, easy-to-use, online design tool that lets users create simple or complex heat-tracing designs for pipe freeze protection and flow maintenance applications. Projects can have multiple applications, circuits, and pipe segments.

Once users enter parameters, the system generates a complete bill of material with the appropriate heating cables, circuit lengths, power requirements, connection kits and accessories—which can be used to request a quote online.

Roof & Gutter Calculator

Roof & Gutter Calculator is an on-line, easy-to-use design tool that lets users enter design parameters for a roof & gutter de-icing project.

Once users enter parameters, the system generates a complete bill of material with the appropriate heating cables, circuit lengths, power requirements, connection kits and accessories—which can be used to request a quote online.

SnoCalc

SnoCalc is an on-line, easy-to-use design tool that lets users enter design parameters for a surface snow melting project.

Once users enter parameters, the system generates a complete bill of material with the appropriate heating cables, circuit lengths, power requirements, connection kits and accessories—which can be used to request a quote online.

BEFORE YOU SPECIFY OR BUY, WEIGH THE FACTS

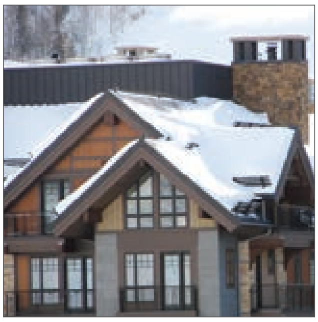
Thermal Management offers the most complete line of heating technologies and services.

As the inventors of Raychem heat-tracing products, with more than **1.75 billion feet** installed worldwide, we are the preferred brand by engineers and installers for all applications.

Whether you need **products**, **design tools**, or **project assistance from our Integrated Services experts**, rely on the proven heating solutions leader for optimized systems to enhance the safety, comfort, and performance of your building or infrastruture projects.


Pipe Freeze Protection


Flow Maintenance

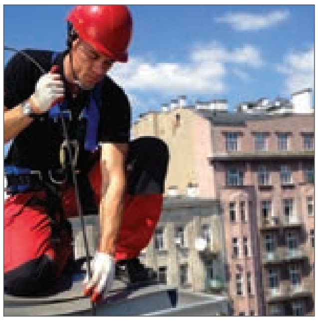

Roof & Gutter De-Icing


Surface Snow Melting


Freezer Frost Heave Prevention


Floor Heating


Hot Water Temperature Maintenance


Integrated Services

DESIGN GUIDES

This section provides individual design guides for Thermal Management Commercial Heating products. These design guides are also available in .pdf format on our web site at www.pentairthermal.com

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Raychem

PIPE FREEZE PROTECTION AND FLOW MAINTENANCE — XL-TRACE SYSTEM

This step-by-step design guide provides the tools necessary to design a Raychem XL-Trace pipe freeze protection or flow maintenance system. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

This design guide presents Thermal Management' recommendation for designing an XL-Trace pipe freeze protection and flow maintenance system for the following applications:

- Freeze protection of general water piping (aboveground and buried)
- Flow maintenance of waste lines (aboveground and buried)
- Flow maintenance of fuel lines (aboveground)

This guide does **not** cover applications in which any of the following conditions exist:

- Hazardous locations, as defined in the national electrical codes
- Pipe temperature other than specified in Table 1 on page 5
- Pipe maintenance temperatures above 150°F (65°C)
- Supply voltage other than 120 V or 208–277 V

For designing XL-Trace pipe freeze protection system for fire sprinkler piping, please refer to the XL-Trace System for Fire Sprinkler Freeze Protection Design Guide (H58489).

If your application conditions are different, or if you have any questions, contact your Thermal Management representative or call (800) 545-6258.

How to Use this Guide

This design guide presents Thermal Management's recommendations for designing an XL-Trace pipe freeze protection or flow maintenance system. It provides design and performance data, electrical sizing information, and application configuration suggestions. Following these recommendations will result in a reliable, energy-efficient system.

OTHER REQUIRED DOCUMENTS

This guide is not intended to provide comprehensive installation instructions. For complete XL-Trace pipe freeze protection and flow maintenance system installation instructions, please refer to the following additional required documents:

- XL-Trace System Installation and Operation Manual (H58033)
- Additional installation instructions are included with the connection kits, thermostats, controllers, and accessories

If you do not have these documents, you can obtain them from the Thermal Management web site at www.pentairthermal.com.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system connection kits could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING:** To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

Thermal Management’ standard limited warranty applies to all products.

An extension of the limited warranty period to ten (10) years from the date of installation is available if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

The XL-Trace system provides freeze protection and flow maintenance for aboveground and buried pipe applications. The XL-Trace system is based on self-regulating heating cable technology. Thermal Management offers the option of three self-regulating heating cables with the XL-Trace system: 5XL, 8XL, and 12XL (208–277 V only) for applications using 120 and 208–277 V power supplies. The cable’s output is reduced automatically as the pipe warms, so there is no possibility of failure due to overheating.

An XL-Trace system includes the heating cable, power connection, splice, tee connections, controls, contactors, power distribution panels, accessories, and the tools necessary for a complete installation.

XL-Trace Applications

Identify which of the standard XL-Trace applications below pertain to your installation. Proceed to the appropriate design sections that follow.

TABLE 1 XL-TRACE APPLICATIONS

Application	Description	Specific application requirements
Pipe freeze protection		
General water piping	Freeze protection (40°F [4°C] minimum) of insulated, metal or plastic water piping	“Aboveground piping” on page 8 “Buried piping,” page 9
Flow maintenance		
Grease waste lines	Flow maintenance (110°F [43°C] minimum) for insulated grease waste lines	“Aboveground piping” on page 11 “Buried piping” on page 12
Fuel lines	Flow maintenance (40°F [4°C] minimum) for insulated metal piping containing #2 fuel oil	“For aboveground piping only,” page 13

Note: If your application does not fit these guidelines, contact your local Thermal Management representative or call (800) 545-6258.

Self-Regulating Heating Cable Construction

Raychem XL-Trace self-regulating heating cables are comprised of two parallel nickel-plated bus wires in a cross-linked polymer core, a tinned copper braid, and a fluoropolymer or polyolefin outer jacket. These cables are cut to length, simplifying the application design and installation.

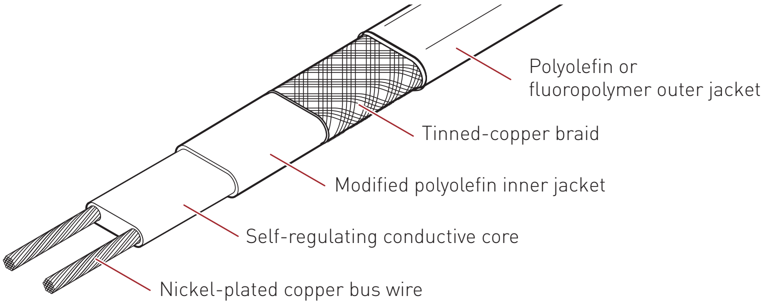
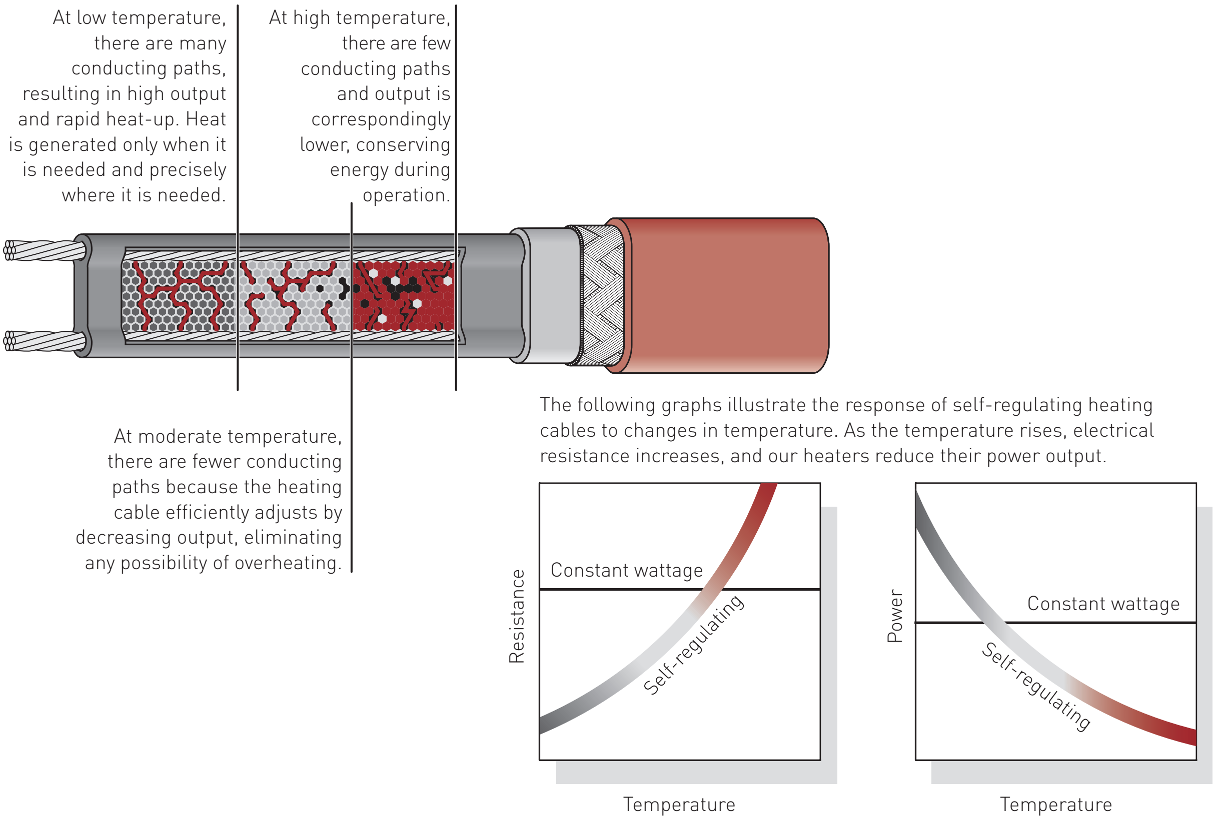


Fig. 1 XL-Trace heating cable construction

With self-regulating technology, the number of electrical paths between bus wires changes in response to temperature fluctuations. As the temperature surrounding the heater decreases, the conductive core contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core.

As the temperature rises, the core expands microscopically. This expansion increases electrical resistance and the number of electrical paths decreases. The heating cable automatically reduces its output.



At low temperature, there are many conducting paths, resulting in high output and rapid heat-up. Heat is generated only when it is needed and precisely where it is needed.

At high temperature, there are few conducting paths and output is correspondingly lower, conserving energy during operation.

At moderate temperature, there are fewer conducting paths because the heating cable efficiently adjusts by decreasing output, eliminating any possibility of overheating.

The following graphs illustrate the response of self-regulating heating cables to changes in temperature. As the temperature rises, electrical resistance increases, and our heaters reduce their power output.

Fig. 2 Self-regulating heating cable technology

PIPE FREEZE PROTECTION APPLICATIONS

A pipe freeze protection system is designed to maintain the pipe temperature at a minimum of 40°F (4°C) to prevent freezing.

Typical Pipe Freeze Protection System

A typical pipe freeze protection system includes the XL-Trace self-regulating heating cables, connection kits, ambient temperature control, and power distribution.

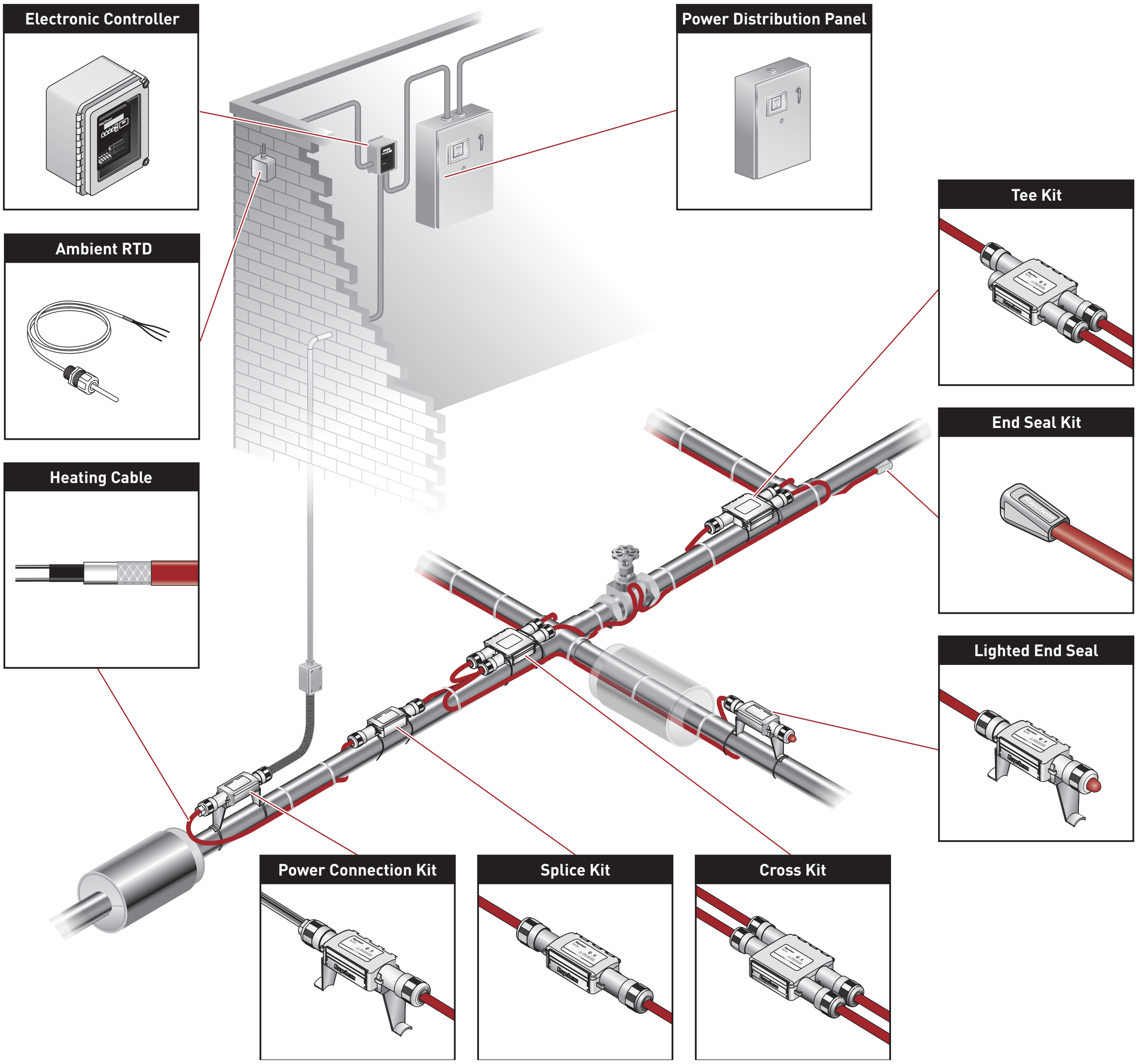


Fig. 3 Typical XL-Trace pipe freeze protection system

General Water Piping

General water piping is defined as metal or plastic water piping located in nonhazardous locations.

ABOVEGROUND PIPING

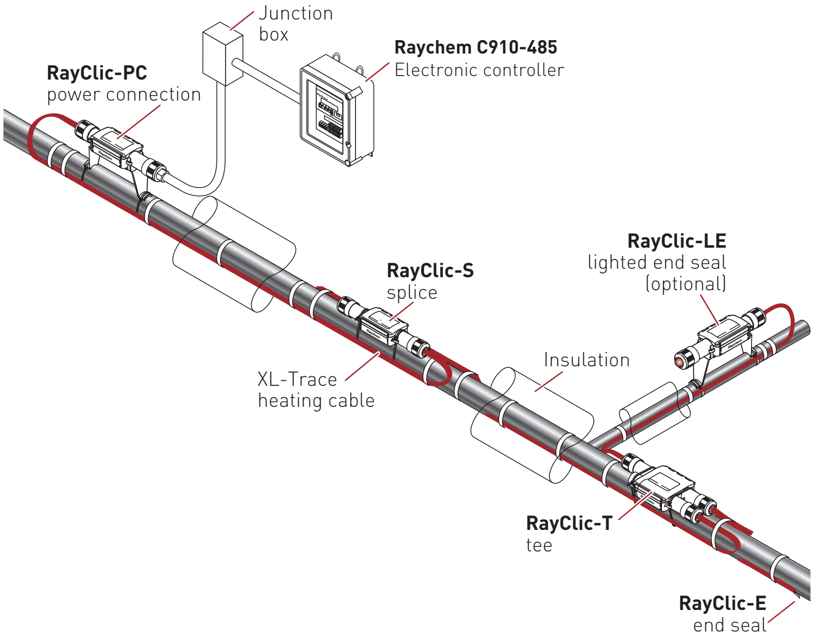


Fig. 4 Typical aboveground piping system

Application Requirements

The system complies with Thermal Management requirements for aboveground general water piping when:

- The heating cable is permanently secured to insulated metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- A 30-mA ground-fault protection device (GFPD) is used.
- The heating cable is installed per manufacturer's instructions with approved Raychem connection kits. See Table 13 on page 29 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Other Required Documents" page 15.

Approvals

UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

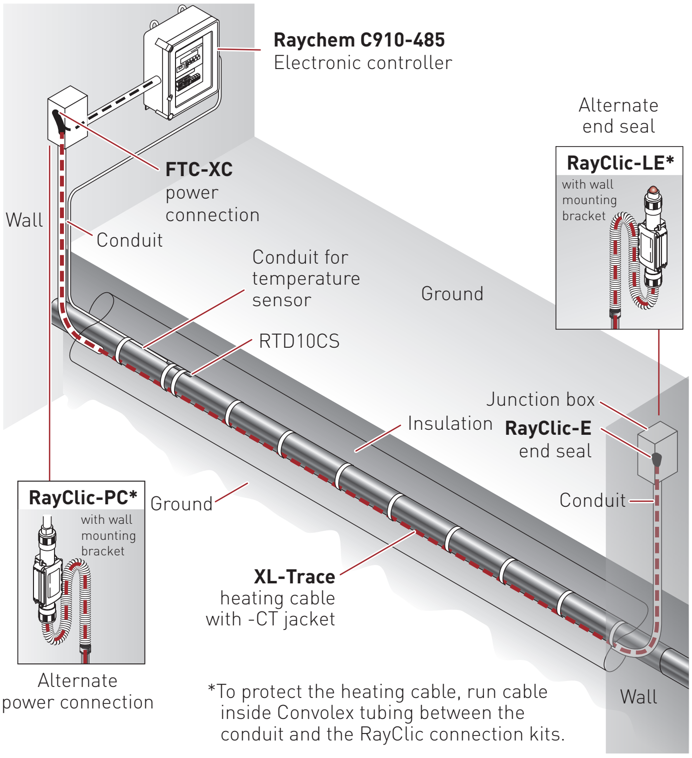
LISTED APPROVED

5XL1-CR, -CT 8XL1-CR, -CT
5XL2-CR, -CT 8XL2-CR, -CT

-W C US

5XL1-CR, -CT 8XL1-CR, -CT 12XL2-CR, -CT
5XL2-CR, -CT 8XL2-CR, -CT

BURIED PIPING



*To protect the heating cable, run cable inside Convolex tubing between the conduit and the RayClic connection kits.

Fig. 5 Typical buried piping system

Application Requirements

The system complies with Thermal Management requirements for use on buried insulated metal or plastic pipe when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape or to plastic pipes using AT-180 aluminum tape.
- The pipeline is buried at least 2-feet deep.
- All heating cable connections (power, splice, tee, and end termination) are made above-ground. No buried or in-conduit splices or tees are allowed.
- The heating cable has a fluoropolymer outer jacket (-CT).
- The power connection and end seal are made in UL Listed and CSA Certified junction boxes above grade.
- The heating cable is protected from the pipe to the power connection box in UL Listed and CSA Certified water-sealed conduit (minimum 3/4-inch diameter) suitable for the location.
- A 30-mA ground-fault protection device (GFPD) is used.
- Closed-cell, waterproof thermal insulation with fire-retardant, waterproof covering is used.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 15 on page 31 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Pipe Heat Loss Calculations," page 15.

Approvals

UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

LISTED	APPROVED		C US -W	
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

FLOW MAINTENANCE APPLICATIONS

A flow maintenance system is designed to maintain cooking grease waste lines and #2 fuel oil lines above the temperature at which the viscosity inhibits fluid flow.

Typical Flow Maintenance System

A typical flow maintenance system includes the XL-Trace self-regulating heating cables with a fluoropolymer outer jacket, connection kits, line-sensing temperature control and power distribution.

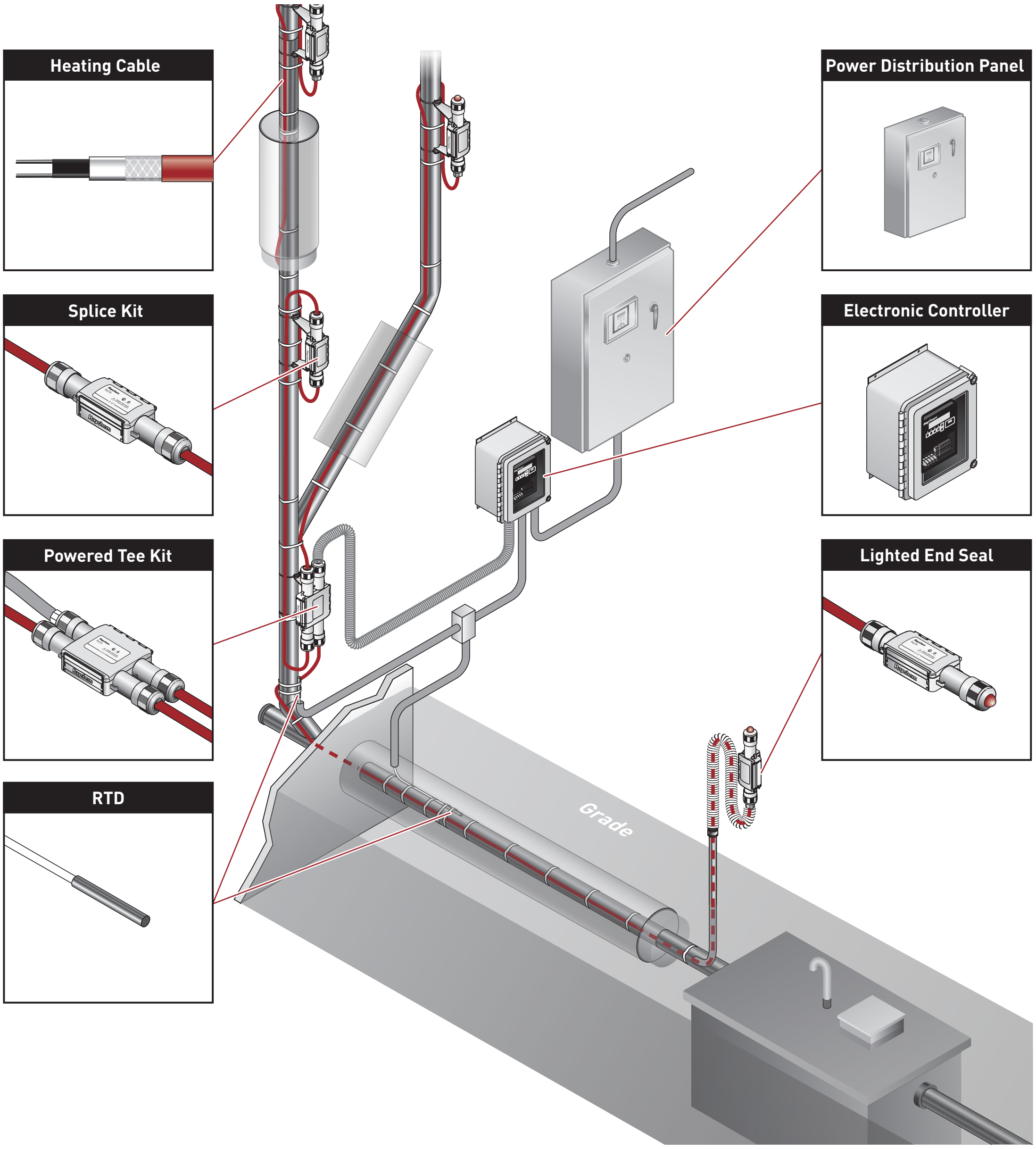


Fig. 6 Typical XL-Trace flow maintenance system

Grease Waste Lines

Grease waste lines are defined as piping used for the disposal of waste oils and fats created in the cooking process. Typical applications include grease waste lines from commercial restaurants. A grease-line flow maintenance system is designed to maintain a 110°F (43°C) minimum fluid temperature.

ABOVEGROUND PIPING

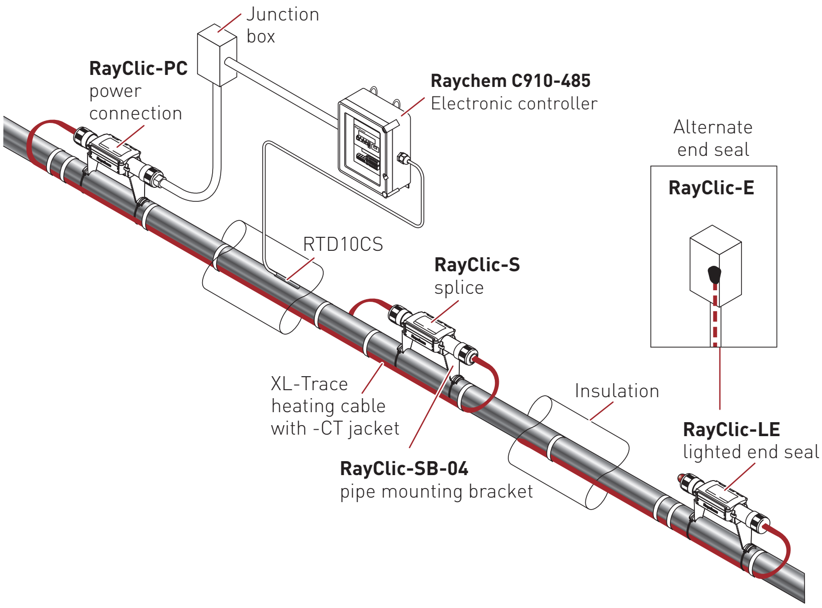


Fig. 7 Typical aboveground piping system

Application Requirements

The system complies with Thermal Management requirements for aboveground grease waste lines when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- The heating cable must have a fluoropolymer outer jacket (-CT).
- A 30-mA ground-fault protection device (GFPD) is used.
- Tees and splices are installed using pipe mounting brackets, not in direct contact with piping.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 13 on page 29 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

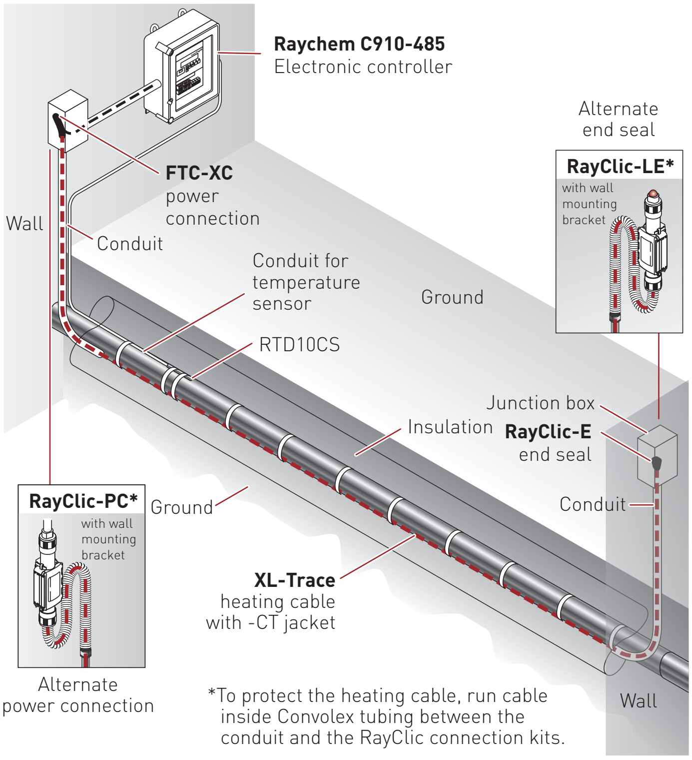
See "Pipe Heat Loss Calculations," page 15.

Approvals

XL-Trace systems (-CT only) are UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

UL LISTED	FM APPROVED	C US -W		
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

BURIED PIPING



*To protect the heating cable, run cable inside Convolex tubing between the conduit and the RayClic connection kits.

Fig. 8 Typical buried grease waste line

Application Requirements

The system complies with Thermal Management requirements for buried grease waste lines when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- The heating cable must have a fluoropolymer outer jacket (-CT).
- The pipeline is buried at least 2-feet deep.
- All heating cable splices or tees are made aboveground. No buried or in-conduit splices or tees are allowed.
- The power connection and end seal are made in UL Listed and CSA Certified junction boxes above grade.
- The heating cable is protected from the pipe to the power connection box in UL Listed and CSA Certified conduit (minimum 3/4-inch diameter) suitable for the location.
- A 30-mA ground-fault protection device (GFPD) is used.
- Closed-cell, waterproof thermal insulation with fire-retardant, waterproof covering is used.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 15 on page 31 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Heating Cable Catalog Number" on page 19.

Approvals

XL-Trace systems (-CT only) are UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

LISTED	APPROVED	c US -W		
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

Fuel Lines

Fuel lines are defined as those carrying #2 fuel oil. A fuel line flow maintenance system is designed to maintain a 40°F (4°C) minimum fluid temperature to maintain flow.

FOR ABOVEGROUND PIPING ONLY

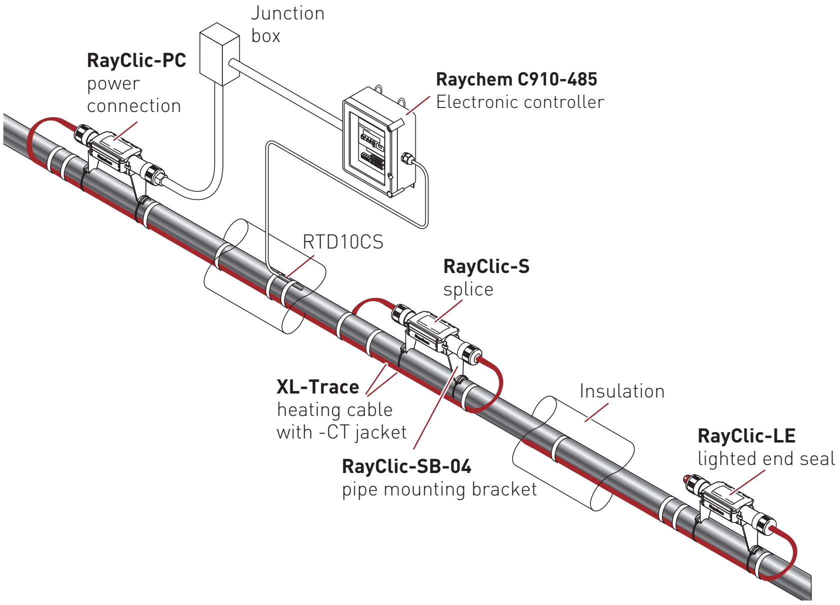


Fig. 9 Typical aboveground piping system

Application Requirements

The system complies with Thermal Management requirements for aboveground #2 fuel oil piping when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape or to plastic pipes using AT-180 aluminum tape.
- The heating cable must have a fluoropolymer outer jacket (-CT).
- Tees and splices are installed using pipe mounting brackets, not in direct contact with piping.
- A 30-mA ground-fault protection device (GFPD) is used.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 13 on page 29 and the XL-Trace System Installation and Operation Manual (H58033).

Cable Selection

See "Pipe Heat Loss Calculations," page 15.

Approvals

XL-Trace systems (-CT only) are UL Listed, FM Approved, and c-CSA-us Certified for nonhazardous locations.

UL LISTED	FM APPROVED
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT

c CSA us		
5XL1-CT 5XL2-CT	8XL1-CT 8XL2-CT	12XL2-CT

PIPE FREEZE PROTECTION AND FLOW MAINTENANCE DESIGN

This section details the design steps necessary to design your application. The examples provided in each step are intended to incrementally illustrate the project parameter output for two sample designs from start to finish. As you go through each step, use the "XL-Trace System Pipe Freeze Protection and Flow Maintenance Design Worksheet," page 38, to document your project parameters, so that by the end of this section you will have the information you need for your Bill of Materials.

TraceCalc Pro

TraceCalc Pro for Buildings is an online design tool available to help you create simple or complex heat-tracing designs for pipe freeze protection or flow maintenance applications. It is available at http://www.pentairthermal.com.

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Design Step by Step

Your system design requires the following essential steps.

1 Determine design conditions and pipe heat loss

2 Select the heating cable

3 Determine the heating cable length

4 Determine the electrical parameters

5 Select the connection kits and accessories

6 Select the control system

7 Select the power distribution

8 Complete the Bill of Materials

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 1 Determine design conditions and pipe heat loss

Collect the following information to determine your design conditions:

- XL-Trace application (from Table 1)
- Location
  - Indoors
  - Outdoors
  - Aboveground
  - Buried
- Maintain temperature (T_M)
- Maximum system temperature (T_{MAX})
- Minimum ambient temperature (T_A)
- Pipe diameter and material
- Pipe length
- Thermal insulation type and thickness
- Supply voltage

Example: Pipe Freeze Protection – Water Piping

Location	Aboveground, outdoor
Maintain temperature (T_M)	40°F (4°C)
Maximum system temperature (T_{MAX})	80°F (27°C)
Minimum ambient temperature (T_A)	–20°F (–29°C)
Pipe diameter and material	2-inch plastic
Pipe length	300 ft (91 m)
Thermal insulation type and thickness	1-inch fiberglass
Supply voltage	120 V

Example: Pipe Freeze Protection – Grease Waste Line

Location	Buried
Maintain temperature (T_M)	110°F (43°C)
Maximum system temperature (T_{MAX})	125°F (52°C)
Minimum ambient temperature (T_A)	50°F (10°C) (soil temperature)
Pipe diameter and material	4-inch metal
Pipe length	200 ft (61 m)
Thermal insulation type and thickness	1-inch rigid cellular urethane
Supply voltage	208 V

PIPE HEAT LOSS CALCULATIONS

To select the proper heating cable you must first determine the pipe heat loss. To do this you must first calculate the temperature differential (ΔT) between the pipe maintain temperature and the minimum ambient temperature.

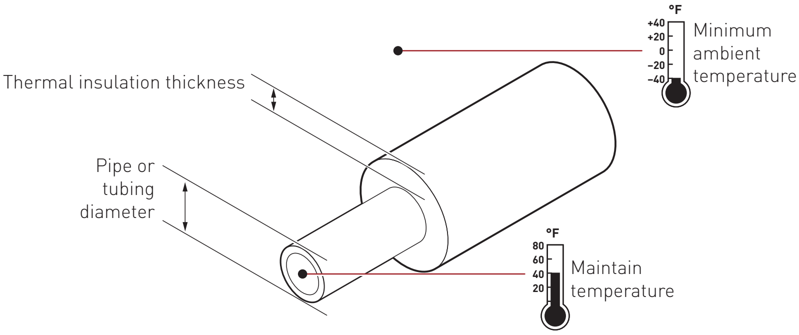


Fig. 10 Pipe heat loss

Calculate temperature differential ΔT

To calculate the temperature differential (ΔT), use the formula below:

$\Delta T = T_M - T_A$

Example: Pipe Freeze Protection – Water Piping

T_M	40°F (4°C)
T_A	–20°F (–29°C)
	ΔT = 40°F – (–20°F) = **60°F**
	ΔT = 4°C – (–29°F) = **33°C**

Example: Flow Maintenance – Grease Waste Line

T_M	110°F (43°C)
T_A	50°F (10°C)
	ΔT = 110°F – (50°F) = **60°F**
	ΔT = 43°C – (10°C) = **33°C**

Determine the pipe heat loss

Match the pipe size, insulation thickness, and temperature differential (ΔT) from Table 2 to determine the base heat loss of the pipe (Q_B).

Example: Pipe Freeze Protection – Water Piping

Pipe diameter	2 inch
Insulation thickness	1 inch
ΔT	60°F (33°C)

Heat loss (Q_B) for 60°F must be calculated through interpolation between ΔT at 50°F and ΔT at 100°F from Table 2. For difference between the ΔT of 50°F and the ΔT of 100°F:

$Q_{B\text{-}50}$	3.2 W/ft (from Table 2)
$Q_{B\text{-}100}$	6.8 W/ft (from Table 2)
ΔT interpolation	ΔT 60°F is 20% of the distance between ΔT 50°F and ΔT 100°F
$Q_{B\text{-}60}$	Q_B-50 + [0.20 x (Q_B-100 – Q_B-50)] = 3.2 + [0.20 x (6.8 – 3.2)] = 3.9 W/ft
Pipe heat loss (Q_B)	**3.9 W/ft @ T_M 40°F (12.9 W/m @ T_M 4°C)**

Example: Flow Maintenance – Grease Waste Line

Pipe diameter	4 inch
Insulation thickness	1 inch
ΔT	60°F (33°C)

Q_B for 60°F must be calculated through interpolation between ΔT at 50°F and ΔT at 100°F from Table 2. For difference between the ΔT of 50°F and the ΔT of 100°F:

$Q_{B\text{-}50}$	5.4 W/ft (from Table 2)
$Q_{B\text{-}100}$	11.2 W/ft (from Table 2)
ΔT interpolation	ΔT 60°F is 20% of the distance between ΔT 50°F and ΔT 100°F
$Q_{B\text{-}60}$	Q_B-50 + [0.20 x (Q_B-100 – Q_B-50)] = 5.4 + [0.20 x (11.2 – 5.4)] = 6.6 W/ft
Pipe heat loss Q_B	**6.6 W/ft @ T_M 110°F (21.5 W/m @T_M 43°C)**

Compensate for insulation type and pipe location

The base heat loss is calculated for a pipe insulated with thermal insulation with a k-factor ranging from 0.2 to 0.3 BTU/hr–°F-ft²/in (fiberglass or foamed elastomer) in an outdoor, or buried application. To get the heat loss for pipes insulated with alternate types of thermal insulation and for pipes installed indoors, multiply the base heat loss of the pipe (Q_B) from Step 3 by the insulation multiple from Table 4 and the indoor multiple from Table 3 to get the corrected heat loss:

$Q_{CORRECTED}$ = Q_B x Insulation multiple x Indoor multiple

Example: Pipe Freeze Protection – Water Piping

Location	Aboveground, outdoor
Thermal insulation thickness and type	1-inch fiberglass
Pipe heat loss Q_B	3.9 W/ft @ T_M 40°F (12.9 W/m @ T_M 4°C)
$Q_{CORRECTED}$	3.9 W/ft x 1.00 x 1.00 = **3.9 W/ft @ T_M 40°F (12.9 W/m @ T_M 4°C)**

Example: Flow Maintenance – Grease Waste Line

Location	Buried
Thermal insulation type and thickness	1-inch rigid cellular urethane
Pipe heat loss Q_B =	6.6 W/ft @ T_M 110°F (21.5 W/m @ T_M 43°C)
$Q_{CORRECTED}$ =	6.6 W/ft x 0.6 x 1.00 = **4.0 W/ft @ T_M 110°F (13.1 W/m @ T_M 43°C)**

TABLE 2 PIPE HEAT LOSS (Q_B) FOR OUTDOOR OR BURIED PIPE (W/FT) FOR 1/2 TO 3-1/2 INCHES

Insulation thickness (in)	(ΔT)		Pipe diameter (IPS) in inches								
	°F	°C	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2
0.5	20	11	1.0	1.2	1.4	1.6	1.8	2.2	2.5	3.0	3.4
	50	28	2.5	2.9	3.5	4.1	4.6	5.5	6.5	7.7	8.6
	100	56	5.2	6.1	7.2	8.6	9.6	11.5	13.5	16.0	18.0
	150	83	8.1	9.5	11.2	13.4	14.9	17.9	21.1	25.0	28.1
1.0	20	11	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.7	1.9
	50	28	1.6	1.9	2.2	2.5	2.8	3.2	3.8	4.4	4.9
	100	56	3.4	3.9	4.5	5.2	5.8	6.8	7.8	9.1	10.2
	150	83	5.3	6.1	7.0	8.2	9.0	10.6	12.2	14.2	15.9
1.5	20	11	0.5	0.6	0.7	0.8	0.8	1.0	1.1	1.3	1.4
	50	28	1.3	1.5	1.7	1.9	2.1	2.4	2.8	3.2	3.6
	100	56	2.8	3.1	3.5	4.0	4.4	5.1	5.8	6.7	7.4
	150	83	4.3	4.8	5.5	6.3	6.9	8.0	9.1	10.5	11.6
2.0	20	11	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1
	50	28	1.1	1.3	1.4	1.6	1.8	2.0	2.3	2.6	2.9
	100	56	2.4	2.7	3.0	3.4	3.7	4.2	4.8	5.5	6.0
	150	83	3.7	4.2	4.7	5.3	5.8	6.6	7.5	8.5	9.4
2.5	20	11	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0
	50	28	1.0	1.2	1.3	1.4	1.6	1.8	2.0	2.3	2.5
	100	56	2.2	2.4	2.7	3.0	3.3	3.7	4.2	4.7	5.2
	150	83	3.4	3.7	4.2	4.7	5.1	5.8	6.5	7.4	8.1
3.0	20	11	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9
	50	28	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.0	2.2
	100	56	2.0	2.2	2.4	2.7	2.9	3.3	3.7	4.2	4.6
	150	83	3.1	3.4	3.8	4.3	4.6	5.2	5.8	6.6	7.1
4.0	20	11	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.7
	50	28	0.9	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.8
	100	56	1.8	2.0	2.1	2.4	2.5	2.9	3.2	3.5	3.8
	150	83	2.8	3.0	3.4	3.7	4.0	4.4	4.9	5.5	6.0

Note: Multiply the W/ft heat loss values by 3.28 for W/m.

TABLE 1.2 CONTINUED PIPE HEAT LOSS (Q_B) FOR OUTDOOR OR BURIED PIPE (W/FT) FOR 4 TO 20 INCHES

Insulation thickness (in)	(ΔT)		Pipe diameter (IPS) in inches								
	°F	°C	4	6	8	10	12	14	16	18	20
0.5	20	11	3.8	5.3	6.8	8.4	9.9	10.8	12.2	13.7	15.2
	50	28	9.6	13.6	17.4	21.4	25.2	27.5	31.3	35.0	38.8
	100	56	20.0	28.4	36.3	44.6	52.5	57.4	65.2	73.0	80.8
	150	83	31.2	44.3	56.6	69.6	81.9	89.5	101.7	113.8	126.0
1.0	20	11	2.1	2.9	3.7	4.5	5.3	5.8	6.5	7.3	8.0
	50	28	5.4	7.5	9.4	11.5	13.5	14.7	16.6	18.6	20.5
	100	56	11.2	15.6	19.7	24.0	28.1	30.6	34.7	38.7	42.8
	150	83	17.5	24.3	30.7	37.4	43.8	47.8	54.1	60.4	66.7
1.5	20	11	1.5	2.1	2.6	3.2	3.7	4.0	4.5	5.0	5.5
	50	28	3.9	5.3	6.7	8.1	9.4	10.2	11.5	12.9	14.2
	100	56	8.1	11.1	13.9	16.8	19.6	21.3	24.0	26.8	29.5
	150	83	12.7	17.3	21.6	26.2	30.5	33.2	37.5	41.8	46.1
2.0	20	11	1.2	1.7	2.1	2.5	2.9	3.1	3.5	3.9	4.3
	50	28	3.1	4.2	5.2	6.3	7.3	7.9	8.9	9.9	10.9
	100	56	6.6	8.8	10.9	13.1	15.2	16.5	18.6	20.7	22.8
	150	83	10.2	13.8	17.0	20.5	23.8	25.8	29.0	32.3	35.5
2.5	20	11	1.1	1.4	1.7	2.1	2.4	2.6	2.9	3.2	3.5
	50	28	2.7	3.6	4.4	5.2	6.1	6.6	7.4	8.2	9.0
	100	56	5.6	7.4	9.1	10.9	12.6	13.7	15.3	17.0	18.7
	150	83	8.7	11.6	14.2	17.0	19.7	21.3	23.9	26.5	29.1
3.0	20	11	0.9	1.2	1.5	1.8	2.0	2.2	2.5	2.7	3.0
	50	28	2.4	3.1	3.8	4.5	5.2	5.6	6.3	7.0	7.6
	100	56	4.9	6.5	7.9	9.4	10.8	11.7	13.1	14.5	15.9
	150	83	7.7	10.1	12.4	14.7	16.9	18.3	20.5	22.6	24.8
4.0	20	11	0.8	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3
	50	28	2.0	2.5	3.1	3.6	4.1	4.4	5.0	5.5	6.0
	100	56	4.1	5.3	6.4	7.5	8.6	9.3	10.3	11.4	12.4
	150	83	6.4	8.3	10.0	11.8	13.4	14.5	16.1	17.8	19.4

Note: Multiply the W/ft heat loss values by 3.28 for W/m.

TABLE 3 INDOOR PIPE HEAT LOSS MULTIPLES

Fiberglass thickness (in)	Indoor multiple
0.5	0.79
1	0.88
1.5	0.91
2	0.93
2.5	0.94
3	0.95
4	0.97

TABLE 4 INSULATION HEAT LOSS MULTIPLES

k factor at 50°F (10°C) (BTU/hr–°F-ft^2/in)	Insulation multiple	Examples of preformed pipe insulation
0.1–0.2	0.6	Rigid cellular urethane (ASTM C591)
0.2–0.3	1.0	Glass fiber (ASTM C547) Foamed elastomer (ASTM C534)
0.3–0.4	1.4	Cellular glass (ASTM C552) Mineral fiber blanket (ASTM C553)

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 2 Select the heating cable

To select the appropriate XL-Trace heating cable for your application, you must determine your cable supply voltage, power output, and outer jacket. Once you select these, you will be able to determine the catalog number for your cable.

HEATING CABLE CATALOG NUMBER

Before beginning, take a moment to understand the structure underlying heating cable catalog numbers. You will refer to this numbering convention throughout the product selection process. Your goal is to determine the catalog number for the product that best suits your needs.

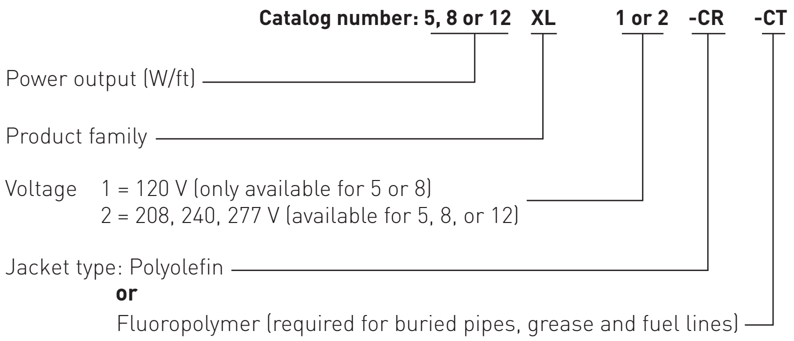


Fig. 11 Heating cable catalog number

Select the heating cable from Fig. 12 that provides the required power output to match the corrected heat loss for your application. Fig. 12 shows the power output for the heating cables on metal pipe at 120/208 volts. To correct the power output for other applied voltage or plastic pipes multiply the power output at the desired maintain temperature by the factors listed in Table 5. If the pipe heat loss, $Q_{CORRECTED}$, is between the two heating cable power output curves, select the higher-rated heating cable.

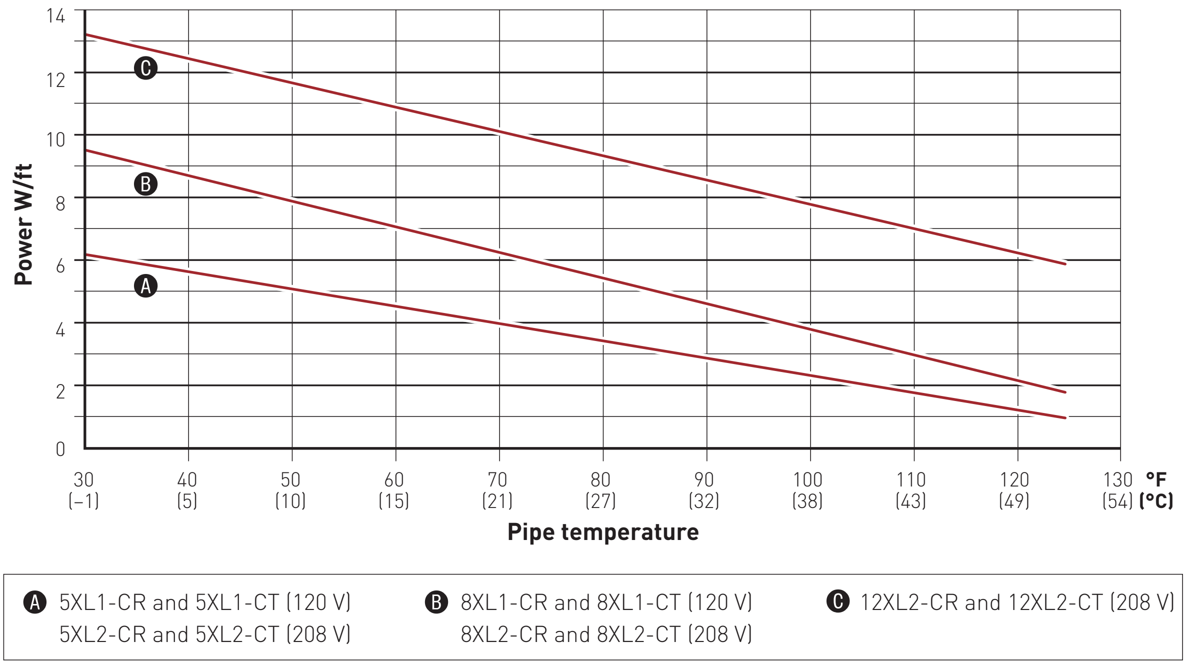


Fig. 12 Heating cable power output on metal pipe

TABLE 5 POWER OUTPUT CORRECTION FACTORS

Voltage correction factors	5XL1	8XL1	5XL2	8XL2	12XL2
120 V	1.00	1.00	–	–	–
208 V	–	–	1.00	1.00	1.00
240 V	–	–	1.12	1.12	1.14
277 V	–	–	1.29	1.27	1.30
Plastic pipe correction factor (With AT-180 Aluminum tape)	0.75	0.75	0.75	0.75	0.75

Confirm that the corrected power output of the heating cable selected is greater than the corrected pipe heat loss ($Q_{CORRECTED}$). If $Q_{CORRECTED}$ is greater than the power output of the highest-rated heating cable, you can:

- Use two or more heating cables run in parallel
- Use thicker insulation to reduce heat loss
- Use insulation material with a lower k factor to reduce heat loss

Example: Pipe Freeze Protection – Water Piping

Pipe maintain temperature (T_M)	40°F (4°C) (from Step 1)
$Q_{CORRECTED}$	$Q_{CORRECTED}$ = 3.9 W/ft @ T_M 40°F (13.1 W/m @ T_M 4°C)
Supply voltage	120 V (from Step 1)
Pipe material	Plastic (from Step 1)
Select heating cable:	Q_B = 3.9 W/ft @ T_M 40°F (from Step 1) 5XL1= 5.6 W/ft @ 40°F (from Fig. 12)
Supply voltage correction factor	1.00 (from Table 5)
Pipe material correction factor	Plastic = 0.75 (from Table 5)
Corrected heating cable power	5.6 W/ft x 1.00 x 0.75 = 4.2 W/ft
Selected heating cable	**5XL1**

Example: Flow Maintenance – Grease Waste Line

Pipe maintain temperature (T_M)	110°F (43°C) (from Step 1)
$Q_{CORRECTED}$	3.9 W/ft @ T_M 110°F (13.1 W/m @ T_M 43°C)
Supply voltage	208 V (from Step 1)
Pipe material	Metal (from Step 1)
Select heating cable:	Q_B = 3.9 W/ft @ T_M 110°F (from Step 1) 12XL2= 7.0 W/ft @110°F (from Fig. 12)
Supply voltage correction factor	1.00 (from Table 5)
Pipe material correction factor	Metal = 1.00
Corrected heating cable power	7.0 x 1.00 x 1.00 = 7.0 W/ft
Selected heating cable	**12XL2**

CONFIRM EXPOSURE TEMPERATURE RATING FOR THE HEATING CABLE

Refer to Table 6 to verify that the maximum system temperature does not exceed the exposure temperature of the selected heating cable.

TABLE 6 HEATING CABLE TEMPERATURE RATINGS

	5XL1	5XL2	8XL1	8XL2	12XL2
Maximum maintain temperature (T_M)	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)
Maximum exposure temperature (T_{EXP})	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)	185°F (85°C)

Example: Pipe Freeze Protection – Water Piping

Maximum system temperature (T_{MAX})	80°F (27°C) (from Step 1)
Selected heating cable	5XL1 (from previous step)
Maximum heating cable exposure temperature (T_{EXP})	150°F (65°C) (from Table 6)
$T_{MAX} < T_{EXP}$	**Yes**

Example: Flow Maintenance - Grease Waste Line

Maximum system temperature (T_{MAX})	125°F (52°C) (from Step 1)
Selected heating cable	12XL2 (from previous step)
Maximum heating cable exposure temperature (T_{EXP})	185°F (85°C)(from Table 6)
$T_{MAX} < T_{EXP}$	**Yes**

SELECT OUTER JACKET

Select the appropriate heating cable outer jacket for the application. Jacket options are:

-CR	Compatible with most XL-Trace applications
-CT	Required for buried pipe freeze protection and for grease and fuel line flow maintenance; may be used in other XL-Trace applications for improved mechanical strength and chemical resistance.

Example: Pipe Freeze Protection – Water Piping

Selection: 5XL1-CR

Example: Flow Maintenance - Grease Waste Line

Selection: 12XL2-CT

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 3 Determine the heating cable length

In Step 2 you selected the appropriate heating cable and the number of runs of heating cable required for the pipe. Multiply the length of the pipe by the number of heating cable runs for the heating cable length.

Heating cable length = Pipe length x No. heating cable runs

Additional heating cable will be required for heat sinks and connection kits. Use Table 7 and Table 8 to determine the additional footage required for heat sinks (valves, flanges, and pipe supports). You will determine the additional heating cable for connection kits in Step 5. Round up fractional lengths to ensure heating cable lengths are sufficient.

Total heating cable length required = (Pipe length x No. heating cable runs) + Additional heating cable for heat sinks (valves, pipe supports, and flanges)

TABLE 7 ADDITIONAL HEATING CABLE FOR VALVES

Pipe diameter (IPS) (inches)	Heating cable (feet (meters))	
1/2	0.8	(0.24)
3/4	1.3	(0.4)
1	2.0	(0.6)
1-1/4	3.3	(1.1)
1-1/2	4.3	(1.3)
2	4.3	(1.3)
3	4.3	(1.3)
4	4.3	(1.3)
6	5.0	(1.5)
8	5.0	(1.5)
10	5.6	(1.7)
12	5.9	(1.9)
14	7.3	(2.2)
18	9.4	(2.9)
20	10.5	(3.2)

TABLE 8 ADDITIONAL HEATING CABLE FOR PIPE SUPPORTS AND FLANGES

Support	Additional cable
Pipe hangers (insulated)	No additional heating cable
Pipe hangers noninsulated and U-bolt supports	Add 2x pipe diameter
Welded support shoes	Add 3x the length of the shoe
Flanges	**Add 2x pipe diameter**

Note: For applications where more than one heating cable is required per foot of pipe, this correction factor applies for each cable run.

Example: Pipe Freeze Protection – Water Piping

Pipe length	300 ft (91 m) (from Step 1)
Pipe diameter	2-inch plastic (from Step 1)
Number of heating cable runs	1 (from Step 2)
Valves	3 gate valves
	4.3 ft x 3 gate valves = 12.9 ft (3.9 m)
Pipe supports	5 pipe hangers with U-bolts
	2-inch pipe diameter = 2 / 12 = 0.17 ft
	[0.17 ft pipe diameter x 2] x 5 pipe supports
	= 1.7 ft (0.5 m)
Flanges	0
Total heating cable for heat sinks	12.9 ft (3.9 m) + 1.7 ft (0.5 m) = 14.6 ft (4.4 m)
	Rounded up to 15 ft (5 m)
Total heating cable length required	300 ft (91 m) x 1 run + 15 ft = **315 ft (96 m) of 5XL1-CR**
	(**Note:** AT-180 Aluminum tape is required for installing heating cable on plastic pipe.)

Example: Flow Maintenance – Grease Waste Line

Pipe length	200 ft (61 m) (from Step 1)
Pipe diameter	4-inch metal (from Step 1)
Number of heating cable runs	1 (from Step 2)
Valves	2 gate valves
	[4.3 ft x 2 gate valves] x 1 run = 8.6 ft (2.6 m)
Pipe supports	2 non-insulated hangers
	4-inch pipe diameter = 4 /12 = 0.33 ft
	[(0.33 ft pipe diameter x 2) x 2 pipe supports] x 1 run = 1.3 ft (0.4 m)
Flanges	2
	4-inch pipe diameter = 4 /12 = 0.33 ft
	[(2 x 0.33 ft (pipe diameter)) x 2 flanges] x 1 run
	= 1.3 ft (0.4 m)
Total heating cable for heat sinks	8.6 ft (2.6 m) + 1.3 ft (0.4 m) + 1.3 ft (0.4 m)
	= 11.2 ft (2.2 m)
	Rounded up to 12 ft (3 m)
Total heating cable length required	200 ft x 1 run + 12 ft = **212 ft (65 m) of 12XL2-CT**

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 4 Determine the electrical parameters

To determine the electrical requirements for your application, you must determine the number of circuits and calculate the transformer load.

DETERMINE NUMBER OF CIRCUITS

To determine the number of circuits, you need to know:

- Total heating cable length
- Supply voltage
- Minimum start-up temperature

Use Table 9 to determine the maximum circuit length allowed. If the total heating cable length exceeds the maximum circuit length for the expected start-up temperature, more than one circuit will be required.

$$\text{Number of circuits} = \frac{\text{Heating cable length required}}{\text{Maximum heating cable circuit length}}$$

Important: Select the smallest appropriate ground-fault circuit breaker size.

⚠ **WARNING:** To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

TABLE 9 MAXIMUM CIRCUIT LENGTH IN FEET

		40°F / 110°F Maintain*											
Start-up temperature (°F)	**CB size (A)**	**5XL1**	**8XL1**	**5XL2**			**8XL2**			**12XL2**			
		120 V	**120 V**	**208 V**	**240 V**	**277 V**	**208 V**	**240 V**	**277 V**	**208 V**	**240 V**	**277 V**	
–20°F	15	101	76	174	178	183	131	138	146	111	114	117	
	20	134	101	232	237	245	175	184	194	148	151	156	
	30	201	151	349	356	367	262	276	291	223	227	234	
	40	270	201	465	474	478	349	368	388	297	303	312	
0°F	15	115	86	199	203	209	149	157	166	120	122	126	
	20	153	115	265	271	279	199	209	221	160	163	168	
	30	230	172	398	406	419	298	314	331	239	244	252	
	40	270	210	470	490	530	370/399	390/420	420/443	319	326	336	
20°F	15	134	100	232	237	244	173	182	192	126	129	133	
	20	178	133	309	315	325	231	243	257	169	172	177	
	30	270	200	464	473	488	346	365	385	253	258	266	
	40	270	210	470	490	530	370/462	390/486	420/513	340/349	344	355	
40°F	15	160	119	278	283	292	206	217	229	142	145	150	
	20	214	159	370	378	390	275	290	306	190	194	200	
	30	270	210	470	490	530	370/416	390/438	420/462	285	291	300	
	40	270	210	470	490	530	370/554	390/584	420/616	340/398	360/406	380/419	
50°F (buried)	15	–	–	–	–	–	228	240	254	152	155	160	
	20	–	–	–	–	–	304	320	338	203	207	213	
	30	–	–	–	–	–	457	481	507	304	310	320	
	40	–	–	–	–	–	609	641	676	405	414	427	
65°F (indoors grease)	15	–	–	–	–	–	272	286	302	169	172	178	
	20	–	–	–	–	–	362	381	402	225	230	237	
	30	–	–	–	–	–	543	572	603	338	345	356	
	40	–	–	–	–	–	610	660	720	430	460	490	

* When maximum circuit length is listed in:
- black type, the value is for applications with a 40°F maintain
- red type, the value is for applications with a 110°F maintain

TABLE 10 MAXIMUM CIRCUIT LENGTH IN METERS

		4°C / 43°C Maintain*										
Start-up temperature (°C)	**CB size (A)**	**5XL1**	**8XL1**	**5XL2**			**8XL2**			**12XL2**		
		120 V	**120 V**	**208 V**	**240 V**	**277 V**	**208 V**	**240 V**	**277 V**	**208 V**	**240 V**	**277 V**
–29°C	15	31	23	53	54	56	40	42	44	34	35	36
	20	41	31	71	72	75	53	56	59	45	46	48
	30	61	46	106	108	112	80	84	89	68	69	71
	40	82	61	142	145	149	106	112	118	90	92	95
–18°C	15	35	26	61	62	64	45	48	51	36	37	38
	20	47	35	81	83	85	61	64	67	49	50	51
	30	70	52	121	124	128	91	96	101	73	74	77
	40	82	64	143	149	162	113/122	119/128	128/135	97	99	102
–7°C	15	41	31	71	72	74	53	56	59	39	39	41
	20	54	41	94	96	99	70	74	78	51	52	54
	30	82	61	141	144	149	106	111	117	77	79	81
	40	82	64	143	149	162	113/141	119/148	128/156	104/106	105	108
4°C	15	49	36	85	86	89	63	66	70	43	44	46
	20	65	48	113	115	119	84	88	93	58	59	61
	30	82	64	143	149	162	113/127	119/134	128/141	87	89	91
	40	82	64	143	149	162	113/169	119/178	128/188	104/121	110/124	116/128
10°C (buried grease)	15	–	–	–	–	–	70	73	77	46	47	49
	20	–	–	–	–	–	93	98	103	62	63	65
	30	–	–	–	–	–	139	147	155	93	95	98
	40	–	–	–	–	–	186	195	206	124	126	130
18°C (indoors grease)	15	–	–	–	–	–	83	87	92	52	53	54
	20	–	–	–	–	–	110	116	123	69	70	72
	30	–	–	–	–	–	166	174	184	103	105	108
	40	–	–	–	–	–	186	201	220	131	140	149

* When maximum circuit length is listed in:

- black type, the value is for applications with a 4°C maintain
- red type, the value is for applications with a 43°C maintain

Example: Pipe Freeze Protection – Water Piping

Total heating cable length	315 ft of 5XL1-CR (from Step 3)
Supply voltage	120 V (from Step 1)
Minimum start-up temperature	–20°F (–29°C) (from Step 1)
Number of circuits	315 ft / (201 ft max CL) = 1.6 circuits
	Round up to 2 circuits

Example: Flow Maintenance – Grease Waste Line

Total heating cable length	223 ft of 12XL2-CT (from Step 3)
Supply voltage	208 V (from Step 1)
Minimum start-up temperature	50°F (10°C) (from Step 1)
Number of circuits	223 ft / 304 ft = 0.7 circuits
	Round up to 1 circuit

DETERMINE TRANSFORMER LOAD

Transformers must be sized to handle the load of the heating cable. Use the following tables to calculate the total transformer load.

TABLE 11 TRANSFORMER SIZING (AMPERES/FOOT)

Minimum start-up temperature (°F)	5XL1	8XL1	5XL2			8XL2			12XL2		
	120	120	208	240	277	208	240	277	208	240	277
–20	0.119	0.159	0.069	0.067	0.065	0.092	0.087	0.082	0.108	0.106	0.102
0	0.105	0.139	0.060	0.059	0.057	0.080	0.076	0.072	0.100	0.098	0.095
20	0.090	0.120	0.052	0.051	0.049	0.069	0.066	0.062	0.095	0.093	0.090
40	0.075	0.101	0.043	0.042	0.041	0.058	0.055	0.052	0.084	0.083	0.080
50	–	–	–	–	–	0.053	0.050	0.047	0.079	0.077	0.075
65	–	–	–	–	–	0.044	0.042	0.040	0.072	0.070	0.067

TABLE 12 TRANSFORMER SIZING (AMPERES/METER)

Minimum start-up temperature (°C)	5XL1	8XL1	5XL2			8XL2			12XL2		
	120	120	208	240	277	208	240	277	208	240	277
–20	0.391	0.521	0.226	0.221	0.215	0.301	0.286	0.270	0.354	0.347	0.336
–18	0.343	0.457	0.198	0.194	0.188	0.264	0.251	0.238	0.329	0.322	0.312
–7	0.294	0.394	0.170	0.166	0.161	0.227	0.216	0.205	0.311	0.305	0.296
4	0.246	0.331	0.142	0.139	0.135	0.191	0.181	0.172	0.276	0.271	0.263
10	–	–	–	–	–	0.172	0.164	0.155	0.259	0.254	0.246
18	–	–	–	–	–	0.145	0.138	0.130	0.233	0.228	0.221

Use Table 11 or Table 12 to determine the applied voltage and the maximum A/ft (A/m) at the minimum start up temperature to calculate the transformer load as follows:

$$\frac{\text{Max A/ft at minimum start-up temperature x Heating cable length (ft) x Supply voltage}}{1000} = \text{Transformer load (kW)}$$

Example: Pipe Freeze Protection – Water Piping

Total heating cable length	315 ft of 5XL1-CR (from Step 3)
Minimum start-up temperature	–20°F (–29°C) (from Step 1)
Circuit breaker sizing	30 A

$$\frac{\text{Max A/ft at –20°F x Total feet x Supply voltage}}{1000} = \text{(0.119 A/ft x 315 ft x 120 V) / 1000}$$

Transformer load (kW) **= 4.5 kW**

Example: Flow Maintenance – Grease Waste Line

Total heating cable length	212 ft of 12XL2-CT (from Step 3)
Supply voltage	208 V
Minimum start-up temperature	50°F (10°C) (from Step 1)

$$\frac{\text{Max A/ft at 50°F} \times \text{Total feet} \times \text{Supply voltage}}{1000} = (0.079\text{ A/ft} \times 212\text{ ft} \times 208\text{ V}) \,/\, 1000$$

Transformer load (kW) **= 3.5 kW**

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 5 Select the connection kits and accessories

All XL-Trace systems require a power connection and end seal kit. Splice and tee kits are used as required. Use Table 13 on page 29 (for aboveground applications) and Table 15 on page 31 (for buried applications) to select the appropriate connection kits.

Note Add extra cable on your Bill of Materials for power connections, tees, and end seals. See Table 13 on page 29, Table 15 on page 31, and Table 16 on page 32 for more information.

⚠ **WARNING:** Approvals and performance are based on the use of Thermal Management-specified parts only. Do not substitute parts or use vinyl electrical tape.

ABOVEGROUND PIPING

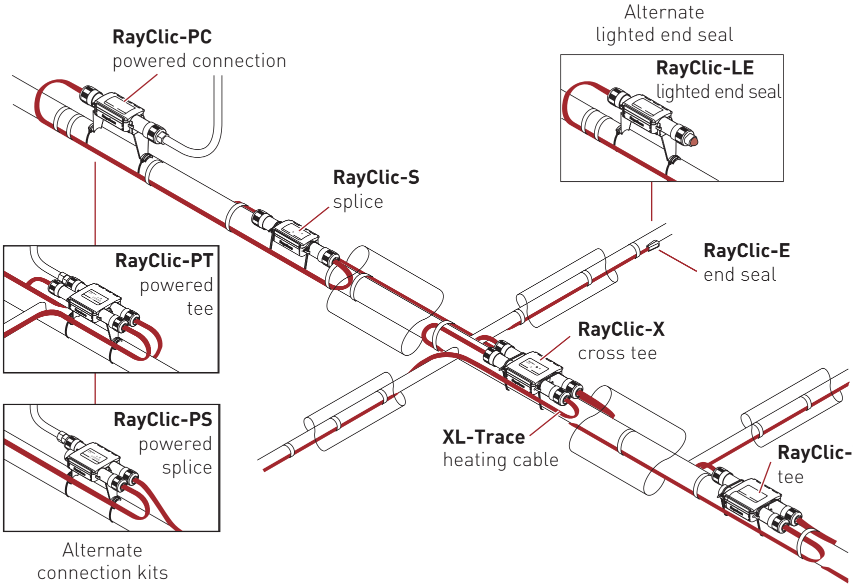


Fig. 13 RayClic connection system

Use the following table for general piping, and grease waste and fuel lines. Develop a bill of materials from the connection kits listed in this table.

Note Connection kits must be off the pipe when installed on grease waste, fuel oil, or pipes exceeding 150°F (65°C).

TABLE 13 CONNECTION KITS AND ACCESSORIES FOR ABOVEGROUND PIPING

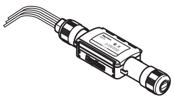
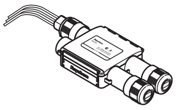
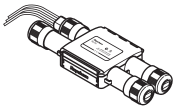
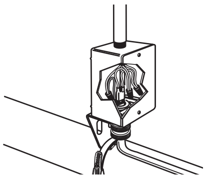
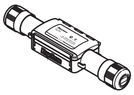
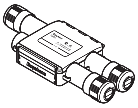
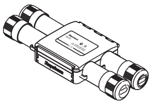
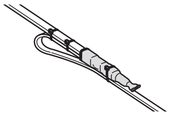
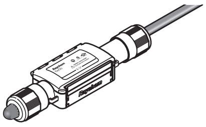
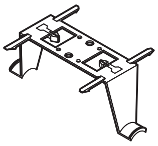
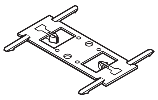
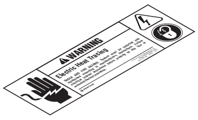
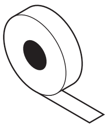
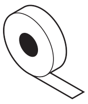
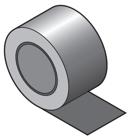
	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Connection kits					
	RayClic-PC	Power connection and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	2 ft (0.6 m)
	RayClic-PS	Powered splice and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	4 ft (1.2 m)
	RayClic-PT	Powered tee and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	6 ft (1.8 m)
	FTC-P[2]	Power connection and end seal kit **Note:** FTC-P is required for circuits requiring 40 A circuit breakers.	1	1 per circuit	2 ft (0.6 m)
	RayClic-S	Splice used to join two sections of heating cable	1	As required	2 ft (0.6 m)
	RayClic-T	Tee kit with end seal; use as needed for pipe branches	1	As required	2 ft (0.6 m)
	RayClic-X	Cross connection to connect four heating cables	1	As required	8 ft (2.4 m)
	FTC-HST[3]	Low-profile splice/tee; use as needed for pipe branches	2	As required	3 ft (0.9 m)
	RayClic-LE	Lighted end seal (RayClic-SB-04 pipe mounting bracket included)	1	Alternate end seal	2 ft (0.6 m)
	RayClic-E	Replacement end seal	1	Additional end seal	0.3 ft (0.1 m)

TABLE 13 CONNECTION KITS AND ACCESSORIES FOR ABOVEGROUND PIPING

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Accessories					
	RayClic-SB-04	Pipe mounting bracket. Required for mounting the kits off the pipe for exposure temperatures greater than 150°F (65°C) and for grease and fuel line splices and tees.	1	As required	–
	RayClic-SB-02	Wall mounting bracket	1	As required	–
	ETL	"Electric Traced" label (use 1 label per 10 feet of pipe)	1	1 label per 10 feet (3 m) of pipe	–
	GT-66	Glass cloth adhesive tape for attaching heating cable to pipe at 40°F (4°C) or above.	66 ft (20 m)	See Table 14	–
	GS-54	Glass cloth adhesive tape for attaching heating cable to pipe above –40°F (–40°C).	54 ft (20 m)	See Table 14	–
	AT-180	Aluminum tape. Required for attaching heating cable to plastic pipe (use 1 foot of tape per foot of heating cable).	180 ft (55 m)	1 ft/ft (0.3 m/m) of heating cable	–

[1] Allow extra heating cable for ease of component installation.

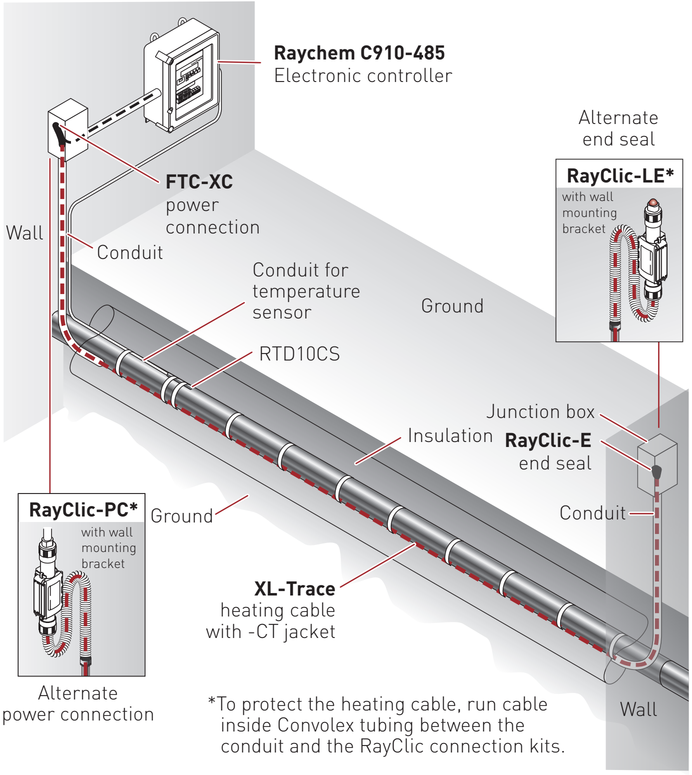
[2] Junction box not included.

[3] One RayClic-E end seal is required for each FTC-HST used as a tee kit.

TABLE 14 QUANTITY OF GLASS CLOTH ADHESIVE TAPE REQUIRED (ATTACH AT 1-FOOT INTERVALS)

Pipe size (in)	<2	3	4	6	8	10
Feet of pipe per GT-66 roll	60 (18 m)	50 (15 m)	40 (12 m)	25 (8 m)	20 (6 m)	15 (5 m)
Feet of pipe per GS-54 roll	49 (15 m)	41 (13 m)	33 (10 m)	20 (6 m)	16 (5 m)	12 (4 m)

BURIED PIPING



*To protect the heating cable, run cable inside Convolex tubing between the conduit and the RayClic connection kits.

Fig. 14 Typical buried piping system

Use the following for buried water piping and grease waste lines. Note that all connections must be aboveground and that no splices/tees are allowed. Develop a bill of materials from the connection kits in this table.

TABLE 15 CONNECTION KITS AND ACCESSORIES FOR BURIED PIPING

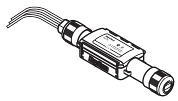
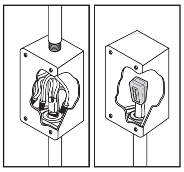
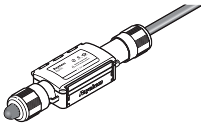
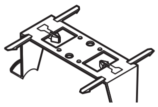
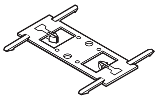
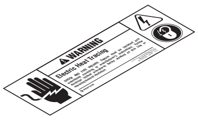
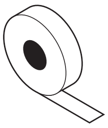
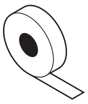
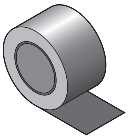
	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
	RayClic-PC	Power connection and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	2 ft (0.6 m)
	FTC-XC	The FTC-XC power connection and end seal kit is for use with XL-Trace heating cable that is run through conduit to a junction box. Materials for one power connection and end seal is included in the kit. **Note:** FTC-XC is required for circuits requiring 40 A circuit breakers.	1	1 per circuit	2 ft (0.6 m)
	RayClic-LE	Lighted end seal (RayClic-SB-04 pipe mounting bracket included)	1	Alternate end seal	2 ft (0.6 m)
	RayClic-E	Replacement end seal	1	Additional end seal	0.3 ft (0.1 m)

TABLE 15 CONNECTION KITS AND ACCESSORIES FOR BURIED PIPING

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Accessories					
	RayClic-SB-04	Pipe mounting bracket	1	As required	–
	RayClic-SB-02	Wall mounting bracket	1	As required	–
	ETL	"Electric Traced" label (use 1 label per 10 feet of pipe)	1	1 label per 10 feet (3 m) of pipe	–
	GT-66	Glass cloth adhesive tape for attaching heating cable to pipe at 40°F (4°C) or above.	66 ft (20 m)	See Table 16	–
	GS-54	Glass cloth adhesive tape for attaching heating cable to pipe above –40°F (–40°C).	54 ft (20 m)	See Table 16	–
	AT-180	Aluminum tape. Required for attaching heating cable to plastic pipe (use 1 foot of tape per foot of heating cable).	180 ft (55 m)	1 ft/ft (0.3 m/m) of heating cable	–

[1] Allow extra heating cable for ease of component installation.

TABLE 16 QUANTITY OF GLASS CLOTH ADHESIVE TAPE REQUIRED (ATTACH AT 1-FOOT INTERVALS)

Pipe size (in)	**<2**	**3**	**4**	**6**	**8**	**10**
Feet of pipe per GT-66 roll	60 (18 m)	50 (15 m)	40 (12 m)	25 (8 m)	20 (6 m)	15 (5 m)
Feet of pipe per GS-54 roll	49 (15 m)	41 (13 m)	33 (10 m)	20 (6 m)	16 (5 m)	12 (4 m)

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step ❻ Select the control system

Temperature controls save energy by ensuring that the system is energized only when necessary. Thermal Management offers a wide variety of monitoring and control options, including:

- Electronic thermostats provide higher accuracy of the heating cable circuit with thermistor sensors and built-in ground-fault protection.
- Electronic controllers provide superior accuracy with RTD temperature sensors, built-in ground-fault protection, monitoring and alarm output.
- Modbus® protocol communication over RS-485 system is supported using Raychem ProtoNode multi-protocol gateways.

Note: Grease waste flow maintenance requires line sensing controllers such as the Raychem ECW-GF, C910-485, or the ACS-30.

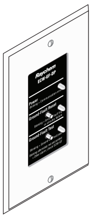
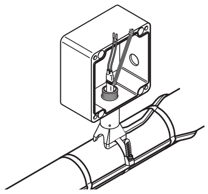
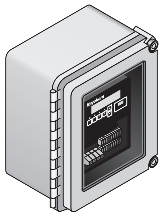
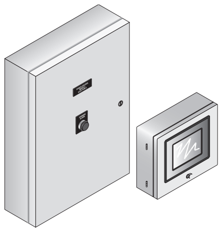
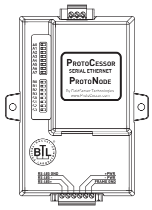
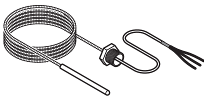
Use the following table to identify the control system suitable for your application. Contact your Thermal Management representative or contact Thermal Management directly at (800) 545-6258 for more information.

TABLE 17 TEMPERATURE CONTROL OPTIONS

	Electronic thermostat	Electronic controllers	
		Single-point	Multipoint
Application	ECW-GF	C910-485	ACS-30
Ambient sensing	x	x	x
Line sensing	x	x	x
Buried pipe	x	x	x
Sensor	Thermistor	RTD*	RTD*
Sensor length	35 ft	multiple options	multiple options
Set point range	32°F to 200°F (0°C to 93°C)	–76°F to 1058°F (–60°C to 570°C)	"
Enclosure	NEMA 4X	NEMA 4X	"
Deadband	2°F to 10°F (2°C to 6°C)	3°F (1.6°C)	"
Enclosure limits	–40°F to 140°F (–40°C to 60°C)	–40°F to 140°F (–40°C to 60°C)	"
Switch rating	30 A	30 A	"
Switch type	DPST	DPST	"
Electrical rating	100–277 V	100–277 V	"
Approvals	c-UL-us	c-CSA-us	"
Ground-fault protection	30 mA fixed	20 mA to 250 mA	"
Alarm outputs			"
AC relay	2 A at 277 Vac	100–277 V, 0.75 A max.	"
Dry contact relay	2 A at 48 Vdc	48 Vac/dc, 500 mA max.	"

* not included with unit

TABLE 18 CONTROL SYSTEMS

	Catalog number	Description
Electronic Thermostats and Accessories		
	ECW-GF	The ECW-GF electronic controller provides accurate temperature control with integrated 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor for line, slab or ambient sensing temperature control, and is housed in a NEMA 4X rated enclosure. The controller features an AC/DC dry alarm contact relay.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	FTC-PSK	The FTC-PSK pipe stand and power connection kit is for use with XL-Trace heating cables. The stand is designed specifically for the Raychem ECW-GF electronic controllers and is compatible with other junction boxes that have 1 inch NPT entries, threaded or non-threaded. Materials for one power connection and end seal are included in the kit.
Electronic Controllers and Sensors		
	C910-485	The C910-485 is a compact, full-featured microprocessor-based single-point heat-trace controller. The C910-485 provides control and monitoring of electrical heat-tracing circuits for both freeze protection and temperature maintenance, and can be set to monitor and alarm for high and low temperature, high and low current, ground-fault level, and voltage. The Raychem C910-485 controller is available with an electromechanical relay (EMR) for use in ordinary areas. The C910-485 comes with an RS-485 communication module.
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in commercial freeze protection and flow maintenance applications. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers. The ProtoNode-RER is for BACnet® or Metasys® N2 systems.
	RTD-200 RTD3CS RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD3CS: temperature sensor with a 3-ft (0.9 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 7 Select the power distribution

Once the heating cable circuits have been defined, you must select how to provide power to them. Power to the XL-Trace heating cables can be provided in several ways: directly through the temperature control, through external contactors, or through HTPG power distribution panels.

SINGLE CIRCUIT CONTROL

Heating cable circuits that do not exceed the current rating of the selected temperature control device shown in Table 18 can be switched directly (see Fig. 15).

GROUP CONTROL

If the current draw exceeds the switch rating, or if the controller will activate more than one circuit (group control, an external contactor must be used (see Fig. 15 on page 35).

Large systems with many circuits should use an HTPG power distribution panel. The HTPG is a dedicated power-distribution, control, ground-fault protection, monitoring, and alarm panel for freeze protection and broad temperature maintenance heat-tracing applications. This enclosure contains an assembled circuit-breaker panelboard. Panels are equipped with ground-fault circuit breakers with or without alarm contacts. The group control package allows the system to operate automatically in conjunction with an ambient-sensing thermostat, individual electronic, or duty cycle controller.

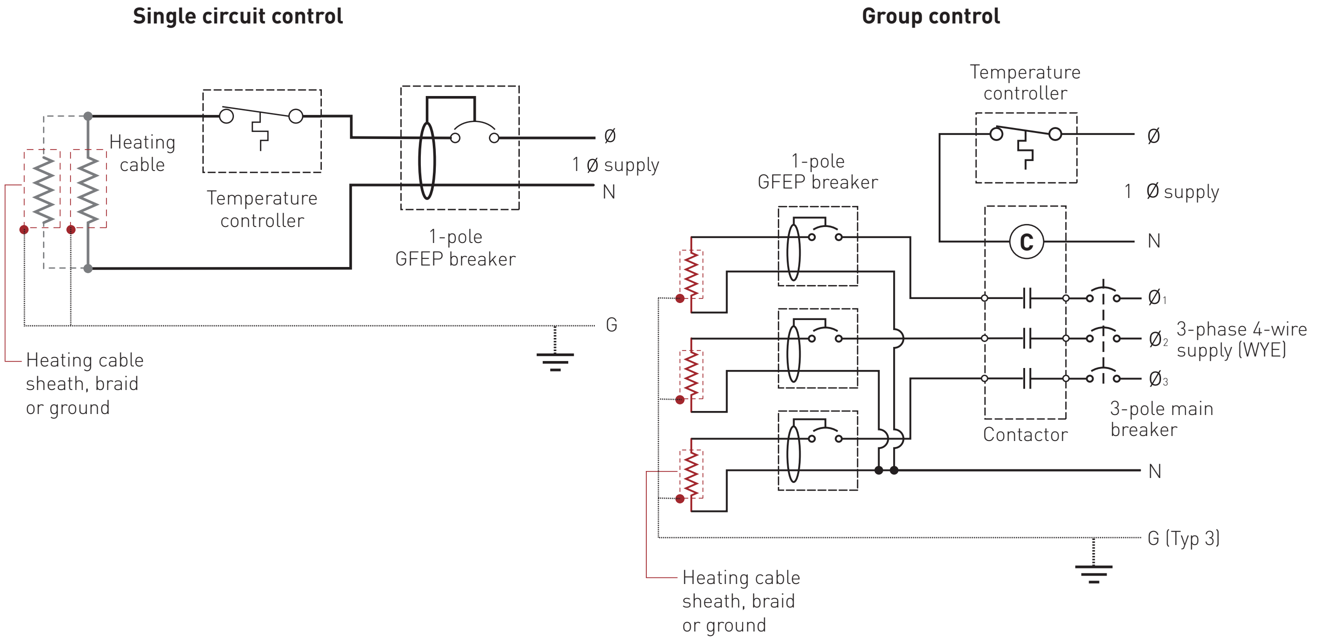
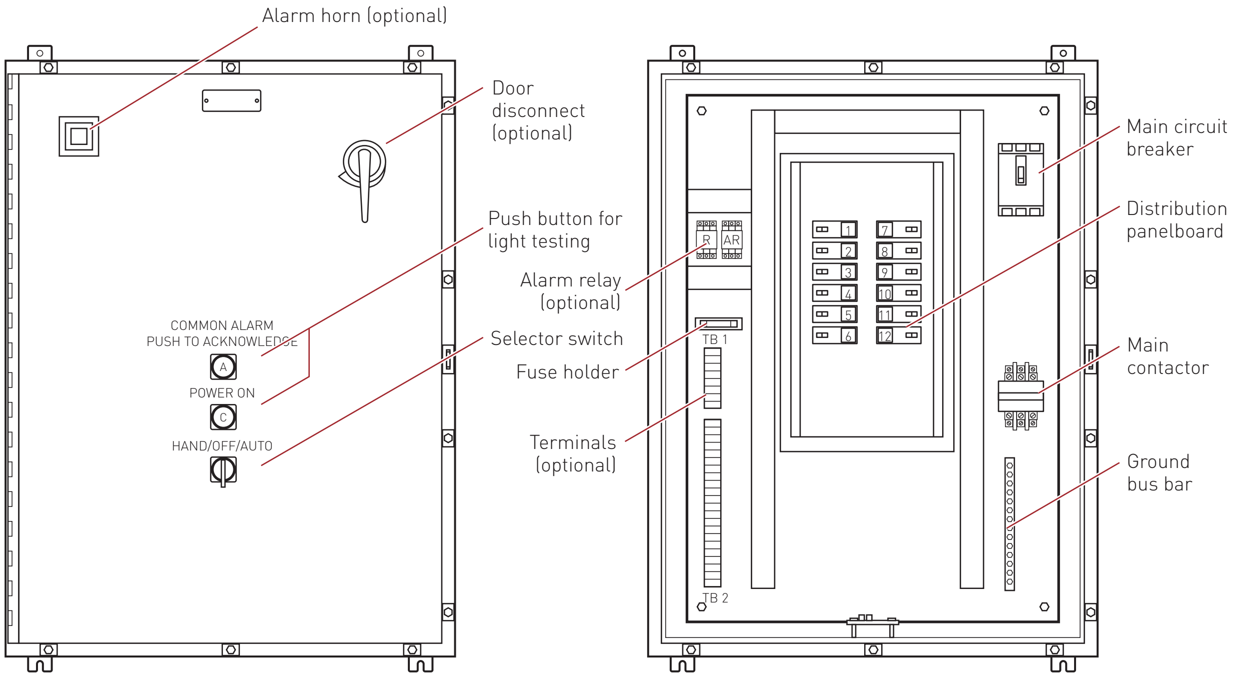


Fig. 15 Single circuit and group control



Alarm option shown above

Fig. 16 HTPG power distribution panel

Three-phase, 4 wire supply (Wye)

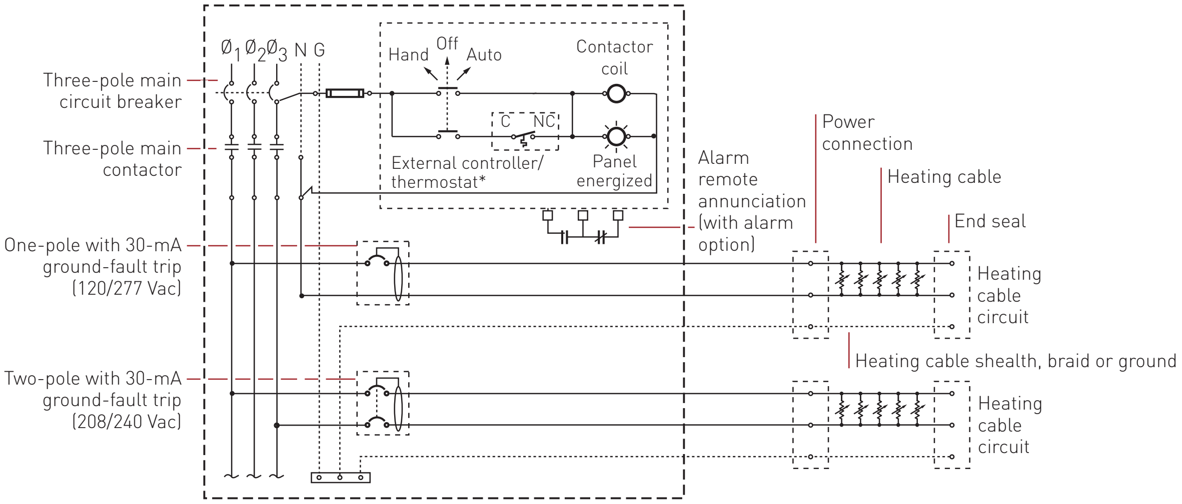
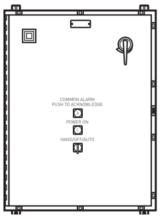


Fig. 17 HTPG power schematic

TABLE 19 POWER DISTRIBUTION

	Catalog number	Description
Power Distribution		
	HTPG	Heat-tracing power distribution panel with ground-fault and monitoring for group control.

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Select the power distribution
8. Complete the Bill of Materials

Step 8 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details necessary complete your Bill of Materials.

XL-TRACE SYSTEM PIPE FREEZE PROTECTION AND FLOW MAINTENANCE DESIGN WORKSHEET

Step 1 Determine design conditions and pipe heat loss

Design conditions

XL-Trace application	Location		Maintain temp. (T_M)	Max. system temp. (T_{MAX})	Min. ambient temp. (T_A)	Pipe diameter and material		Pipe length	Thermal insulation type and thickness	
Pipe freeze protection										
☐ Water piping	☐ Indoors ☐ Outdoors	☐ Aboveground ☐ Buried	______	______	______	____ in	☐ Metal ☐ Plastic	____ ft (m)	☐ Fiberglass ☐ ________	___ in
Flow maintenance										
☐ Grease waste lines	☐ Indoors ☐ Outdoors	☐ Aboveground ☐ Buried	______	______	______	____ in	☐ Metal ☐ Plastic	____ ft (m)	☐ Fiberglass ☐ ________	___ in
☐ Fuel lines	☐ Indoors ☐ Outdoors	☐ Aboveground ☐ Buried	______	______	______	____ in	☐ Metal ☐ Plastic	____ ft (m)	☐ Fiberglass ☐ ________	___ in
Example: **✔ Water piping**	**✔ Aboveground** **✔ Outdoor**		**40°F**	**80°F**	**–20°F**	**2 in**	**✔ Plastic**	**300 ft**	**✔ Fiberglass**	**1 in**

Pipe heat loss

Calculate temperature differential ΔT

Pipe maintain temperature (T_M) ____________ °F (°C)

Ambient temperature (T_A) ____________ °F (°C)

____________ – ____________ ————————→ = ____________

T_M T_A **ΔT**

Example: Pipe Freeze Protection – Water Piping

Pipe maintain temperature (T_M) 40 °F (from Step 1) °F

Ambient temperature (T_A) –20 °F (from Step 1) °F

40 °F – –20 °F ————————→ = **60 °F**

T_M T_A **ΔT**

Determine the pipe heat loss: See Table 2 for the base heat loss of the pipe (Q_B). If the ΔT for your system is not listed, interpolate between the two closest values.

Q_{B-50} ΔT1 ________ W/ft (W/m)

Q_{B-100} ΔT2 ________ W/ft (W/m)

Q_B ________ W/ft (W/m)

Pipe diameter ________ in

Insulation thickness ________ in

ΔT ________ °F (°C)

Q_{B-50} ________ W/ft (W/m)

Q_{B-50} ________ W/ft (W/m)

Example: Pipe Freeze Protection – Water Piping

Pipe diameter	2 in
Insulation thickness	1 in
ΔT	60°F
Q_{B-50}	3.2 W/ft
Q_{B-100}	6.8 W/ft
ΔT interpolation	ΔT 60°F is 20% of the distance between ΔT 50°F and ΔT 100°F $Q_{B-50} + [0.20 \times (Q_{B-100} - Q_{B-50})]$
Q_{B-60}	$3.2 + [0.20 \times (6.8 - 3.2)] = 3.9$ W/ft
Pipe heat loss (Q_{B-60})	**3.9 W/ft @ T_M 40°F**

Compensate for insulation type and pipe location

See Table 2 for the pipe heat loss (Q_B). If the ΔT for your system is not listed, interpolate between the two closest values.
See Table 3 for indoor multiple
See Table 4 for insulation multiple

Location ______________

Insulation thickness and type ______________

Q_B ______________ W/ft (W/m)

Insulation multiple ______________

Indoor multiple (if applicable) ______________

$$\frac{\underline{\qquad\qquad}}{Q_B} \times \frac{\underline{\qquad\qquad}}{\text{Insulation multiple}} \times \frac{\underline{\qquad\qquad}}{\text{Indoor multiple (if applicable)}} = Q_{CORRECTED}$$

Example: Pipe Freeze Protection – Water Piping

Location Aboveground, indoor

Thermal insulation thickness and type 1-in fiberglass

Q_B 3.9 W/ft @ T_M 40°F

Insulation multiple 1.00

Indoor multiple N/A

$$Q_{CORRECTED} = \frac{3.9\ \text{W/ft}}{Q_B} \times \frac{1.00}{\text{Insulation multiple}} = \mathbf{3.9\ W/ft\ @\ T_M\ 40°F}$$

Step ❷ Select the heating cable

Power output data: See Fig. 12
Power output correction factors: See Table 5
Heating cable temperature ratings: See Table 6

Pipe maintain temperature (T_M) ____________ (from Step 1)

Corrected heat loss ($Q_{CORRECTED}$) ____________ (from Step 1)

Supply voltage ____________ (from Step 1)

Pipe material (metal or plastic) ____________ (from Step 1)

XL-Trace application (water, fuel oil, or greasy waste) (from Step 1)

Pipe freeze protection: general water piping, sprinkler piping ____________

Flow maintenance: greasy waste lines, fuel lines ____________

Maximum system use temperature (T_{MAX}) ____________ (from Step 1)

Heating cable selected ____________ (from Step 1)

Power at T_M (120/208 V) ____________

Power output correction factor ____________ (from Step 1)

Plastic pipe correction factor ____________

____________	x	____________	=	____________
Power at rated V factor		Plastic pipe correction factor		Corrected power

Is the heating cable power output ($P_{CORRECTED}$) ≥ the corrected heat loss? ☐ Yes ☐ No

If No, then design with additional runs of heating cable or thicker thermal insulation.

Example: Pipe Freeze Protection – Water Piping

Maintain temperature (T_M) 40°F

Corrected heat loss ($Q_{CORRECTED}$) 3.9 W/ft @ T_M 40°F

Supply voltage 120 V

Pipe material (metal or plastic*) plastic
(*AT-180 aluminum tape required for installing heating cable on plastic pipes)

Q_B = 3.9 W/ft @ T_M 40°F
Select curve C: 5XL1 = **5.6 W/ft @ 40°F**
Power output correction factor: 120 V = 1.00
Pipe material correction factor: Plastic = 0.75
Corrected heating cable power: 5.6 @/ft x 1.00 x 0.75 = **4.2 W/ft**
Select: **5XL1**
Maximum system temperature (T_{MAX}): 80°F
Maximum heating cable exposure temperature (T_{EXP}): 150°F
$T_{MAX} < T_{EXP}$: Yes

Select outer jacket

☐ -CR
☐ -CT

Example: Pipe Freeze Protection – Water Piping

5XL1-CR

Step 3 Determine the heating cable length

For additional heating cable allowance for valves: See Table 7.
For additional heating cable allowance for pipe supports and flanges: See Table 8.

Heat sinks

________	→	________	x	________	=	________
Type of valves		How many		Additional heating cable		**Total heating cable for valves**
________	→	________	x	________	=	________
Type of pipe supports		How many		Additional heating cable *2-in pipe diameter = 0.17 ft		**Total heating cable for pipe supports**
________	→	________	x	________	=	________
Type of flanges		How many		Additional heating cable		**Total heating cable for flanges**

Total heating cable for heat sinks: ________

↓

Total heating cable length

(________	x	________)	+	________	=	________
Pipe length		Number of heating cable runs		Additional cable for valves, pipe supports, and flanges		**Total heating cable length required**

Example:

Heat sinks

Gate valves	→	3	x	4.3 ft	=	**12.9 ft**
Type of valves		How many		Additional heating cable		**Total**
Pipe hangers noninsulated and U-bolt supports	→	5	x	(0.17 ft* x 2 = 0.34 ft)	=	**1.7 ft**
Type of pipe supports		How many		Additional heating cable *2-in pipe diameter = 0.17 ft		**Total**
n/a	→	0	x	0	=	**0 ft**
Type of flanges		How many		Additional heating cable		**Total**

Total: **14.6 ft rounded up to 15 ft**

↓

Total heating cable length

(300 ft	x	1)	+	15 ft	=	**315 ft**
Pipe length		Number of heating cable runs		Additional cable for valves, pipe supports, and flanges		**Total heating cable length required**

Step 4 Determine the electrical parameters

Determine maximum circuit length and number of circuits

See Table 9 and Table 10.

Total heating cable length required ____________

Supply voltage: ☐ 120 V ☐ 208 V
☐ 240 V ☐ 277 V

Circuit breaker size: ☐ 15 A ☐ 20 A
☐ 30 A ☐ 40 A

Minimum start-up temperature ____________

Maximum circuit length ____________

____________ / ____________ = ____________

Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Example:

Total heating cable length required 315 ft of 5XL1-CR

Supply voltage: ☑ 120 V ☐ 208 V
☐ 240 V ☐ 277 V

Circuit breaker size: ☐ 15 A ☐ 20 A
☑ 30 A ☐ 40 A

Minimum start-up temperature –20°F

Maximum circuit length 201 ft

315 ft / 201 ft = **1.6 circuits, round up to 2**

Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Determine transformer load

See Table 11 and Table 12.

____________ x ____________ x ____________ / 1000 = ____________

Max A/ft at minimum start-up temperature x Heating cable length x Supply voltage / 1000 = **Transformer load (kW)**

Example:

0.119 A/ft x 315 ft x 120 V / 1000 = **4.5 kW**

Max A/ft at minimum start-up temperature x Heating cable length x Supply voltage / 1000 = **Transformer load (kW)**

Step 5 Select the connection kits and accessories

See Table 13.

Connection kits – Aboveground	Description	Quantity	Heating cable allowance
☐ RayClic-PC	Power connection and end seal	________	____________
☐ RayClic-PS	Power splice and end seal	________	____________
☐ RayClic-PT	Powered tee and end seal	________	____________
☐ FTC-P	Power connection and end seal	________	____________
☐ RayClic-S	Splice	________	____________
☐ RayClic-T	Tee kit with end seal	________	____________
☐ RayClic-X	Cross connection	________	____________
☐ FTC-HST	Low-profile splice/tee	________	____________
☐ FTC-PSK	Pipe stand and power connection kit	________	____________
☐ RayClic-LE	Lighted end seal	________	____________
☐ RayClic-E	Extra end seal	________	____________

Connection kits – Buried	Description	Quantity	Heating cable allowance
☐ RayClic-PC	Power connection and end seal	________	____________
☐ FTC-XC	Power splice and end seal	________	____________
☐ RayClic-LE	Lighted end seal	________	____________
☐ RayClic-E	Extra end seal	________	____________

Accessories – Aboveground and buried	Description	Quantity
☐ RayClic-SB-04	Pipe mounting bracket	________
☐ RayClic-SB-02	Wall mounting bracket	________
☐ ETL	"Electric-Traced" label	________
☐ GT-66	Glass cloth adhesive tape	________
☐ GS-54	Glass cloth adhesive tape	________
☐ AT-180	Aluminum tape (for plastic pipes)	________

____
Total heating cable allowance for connection kits

____________ + ____________ = ____________

Total heating cable length + Total heating cable allowance for connection kits = **Total heating cable length required**

Step 6 Select the control system

See Table 18.

Thermostats, controllers and accessories	Description	Quantity
☐ ECW-GF	Electronic thermostat with 25-ft sensor	______
☐ ECW-GF-DP	Remote display panel for ECW-GF	______
☐ C910-485	Microprocessor-based single-point heat-tracing controller	______
☐ ACS-UIT2	ACS-30 user interface terminal	______
☐ ACS-PCM2-5	ACS-30 power control panel	______
☐ ProtoNode-RER	Multi-protocol gateway	______
☐ RTD3CS	Resistance temperature device	______
☐ RTD10CS	Resistance temperature device	______
☐ RTD-200	Resistance temperature device	______
☐ RTD50CS	Resistance temperature device	______

Step 7 Select the power distribution

See Table 19.

Power distribution	Description	Quantity
☐ HTPG	Heat-tracing power distribution panel for group control	______

Step 8 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

FIRE SPRINKLER SYSTEM FREEZE PROTECTION — XL-TRACE SYSTEM

This step-by-step design guide provides the tools necessary to design a Raychem XL-Trace fire sprinkler freeze protection system. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

This design guide presents Thermal Management' recommendations for designing an XL-Trace pipe freeze protection system for fire sprinkler piping. It provides design and performance data, control options, electrical sizing information, and application configuration suggestions. This guide does not give information on how to design your fire protection system.

This guide does **not** cover applications in which any of the following conditions exist:

- Hazardous locations, as defined in national electrical codes
- Supply voltage other than 120 V or 208–277 V

If your application conditions are different, or if you have any questions, contact your Thermal Management representative or call (800) 545-6258.

How to Use this Guide

This design guide takes you step by step through designing a freeze protection system for fire suppression piping. Following these recommendations will result in a reliable, energy-efficient system.

OTHER REQUIRED DOCUMENTS

This guide is not intended to provide comprehensive installation instructions. For complete system installation instructions, please refer to the following additional required documents:

- XL-Trace System Installation and Operation Manual (H58033)
- Additional installation instructions are included with the connection kits, controllers, and accessories

If you do not have the above documents, you can obtain them from the Thermal Management web site at www.pentairthermal.com.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system connection kits could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

✎ This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING:** To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

Thermal Management’ standard limited warranty applies to all products.

10 YEAR Product warranty

An extension of the limited warranty period to ten (10) years from the date of installation is available if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

The XL-Trace system is designed to freeze protect aboveground and buried supply pipes, fire standpipes, branch lines and branch lines containing sprinklers when run in areas subject to freezing.

Thermal Management offers the option of three self-regulating heating cables with the XL-Trace system; 5XL, 8XL, and 12XL for applications using 120 V and 208–277 V power supplies. The XL-Trace system is based on self-regulating heating cable technology whereby the heating cable's output is reduced automatically as the pipe warms; eliminating the possibility of sprinkler system overheating.

An XL-Trace system includes the heating cable, power connection, splice, tee connections, controls, power distribution panels, accessories, and the tools necessary for a complete installation.

Approvals

NFPA 13 (Standard for the Installation of Sprinkler Systems) allows Listed electrical heat tracing to freeze protect fire suppression systems including supply lines, standpipes and branch lines containing sprinklers. XL-Trace is c-CSA-us Certified for use on fire suppression systems under CSA C22.2 No. 130-03 for Canada and IEEE 515.1-2005 for the US. The system covered in this manual includes supply lines, stand pipes, branch lines and sprinkler heads.

Self-Regulating Heating Cable Construction

Raychem XL-Trace self-regulating heating cables are comprised of two parallel nickel-plated bus wires in a cross-linked polymer core, a tinned copper braid, and a fluoropolymer or polyolefin outer jacket. These cables are cut to length, simplifying the application design and installation.

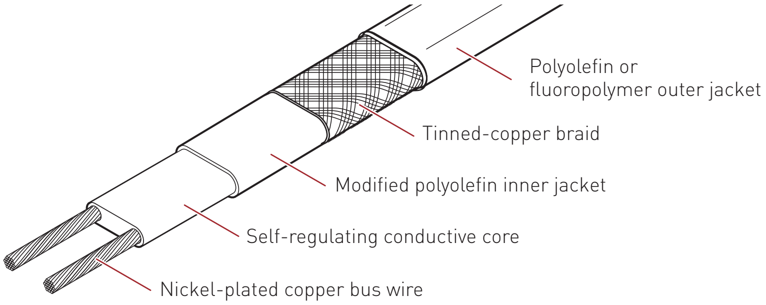
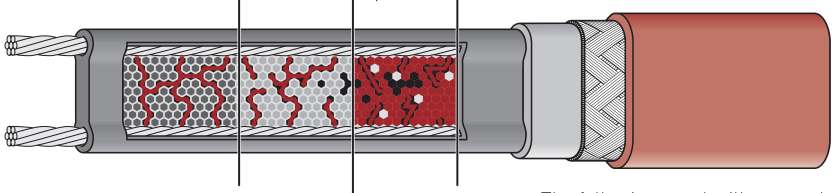


Fig. 1 XL-Trace heating cable construction

With self-regulating technology, the number of electrical paths between bus wires changes in response to temperature fluctuations. As the temperature surrounding the heater decreases, the conductive core contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core.

As the temperature rises, the core expands microscopically. This expansion increases electrical resistance and the number of electrical paths decreases. The heating cable automatically reduces its output.



At low temperature, there are many conducting paths, resulting in high output and rapid heat-up. Heat is generated only when it is needed and precisely where it is needed.

At high temperature, there are few conducting paths and output is correspondingly lower, conserving energy during operation.

At moderate temperature, there are fewer conducting paths because the heating cable efficiently adjusts by decreasing output, eliminating any possibility of overheating.

The following graphs illustrate the response of self-regulating heating cables to changes in temperature. As the temperature rises, electrical resistance increases, and our heaters reduce their power output.

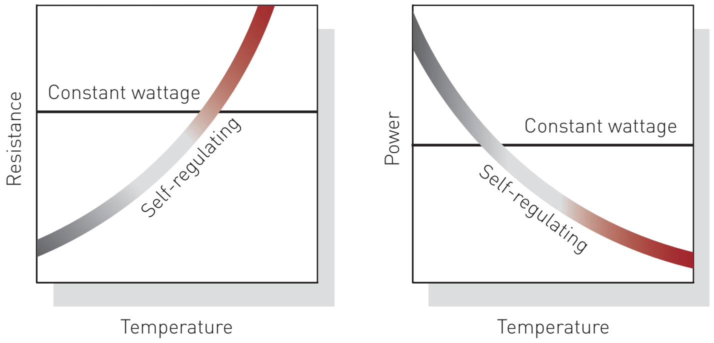


Fig. 2 Self-regulating heating cable technology

FIRE SUPPRESSION SYSTEM FREEZE PROTECTION APPLICATIONS

A freeze protection system is designed to maintain water temperature at a minimum of 40°F (4°C) to prevent fire suppression piping from freezing.

Typical Pipe Freeze Protection System

A typical freeze protection system includes the XL-Trace self-regulating heating cables, connection kits, temperature control, and power distribution.

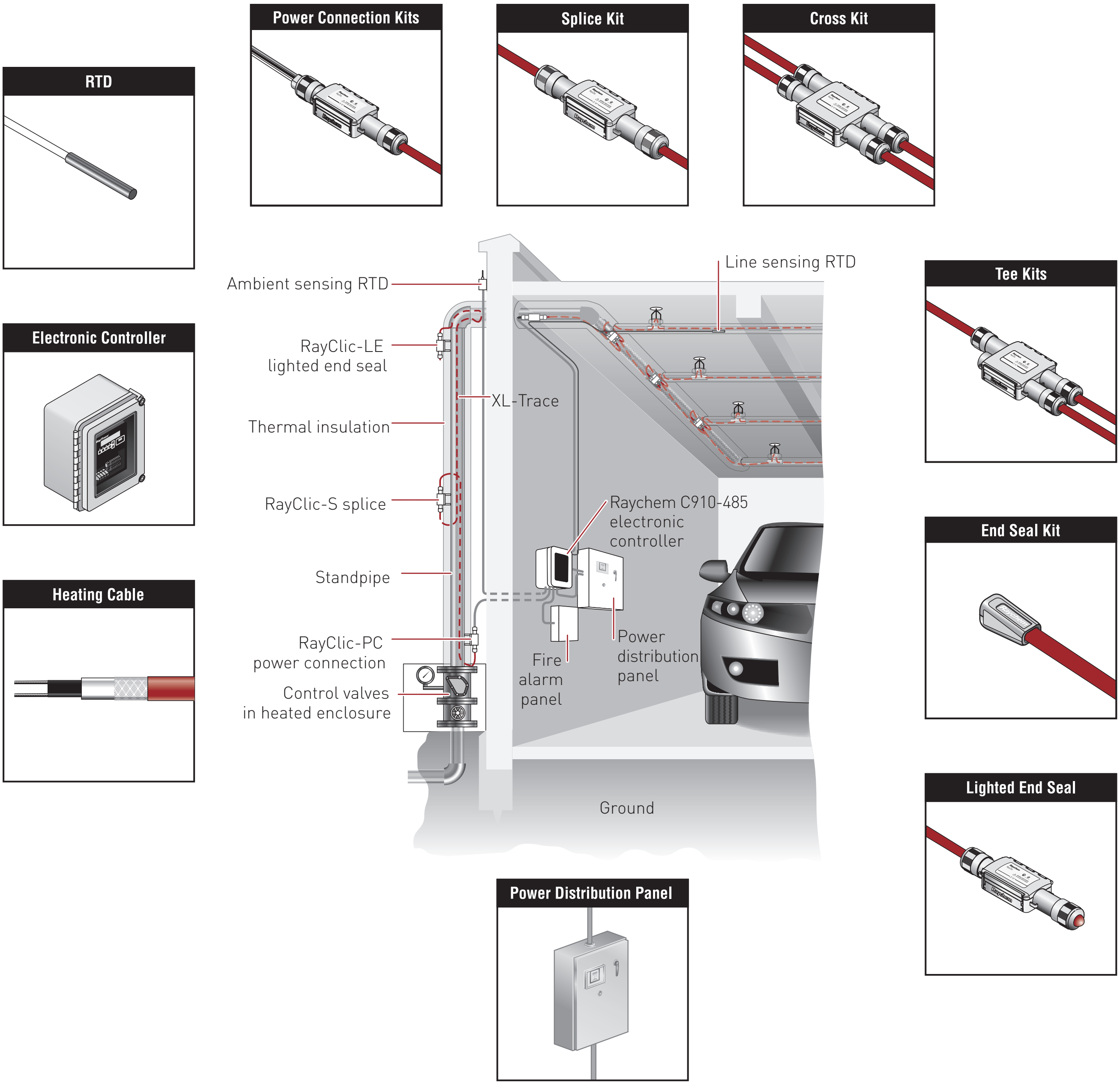


Fig. 3 Typical XL-Trace pipe freeze protection system

Fire Supply Lines

XL-Trace is designed to maintain fire supply lines at 40°F (4°C) in areas subject to freezing.

ABOVEGROUND SUPPLY PIPING

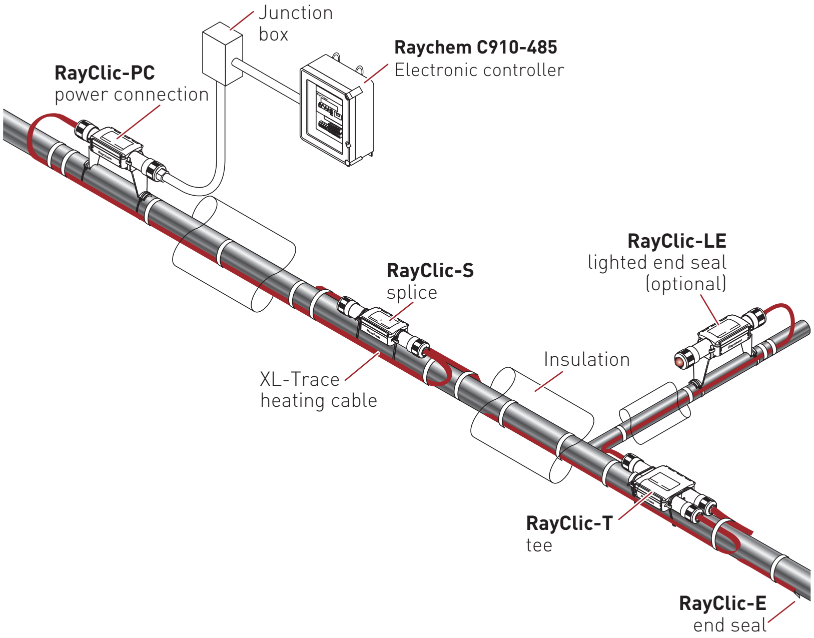


Fig. 4 Typical aboveground supply piping system

Application Requirements

The system complies with Thermal Management requirements for aboveground general water piping when:

- The heating cable is permanently secured to insulated metal pipes with GT-66 glass tape or to plastic pipes using AT-180 aluminum tape.
- Raychem C910-485 or ACS-30 controllers with integrated ground-fault protection and alarm contacts are used and are connected to a fire control panel.
- The heating cable is installed per manufacturer's instructions with approved Raychem connection kits. See Table 11 on page 71 and the XL-Trace System Installation and Operation Manual (H58033).

Approvals

UL Listed and c-CSA-us Certified for nonhazardous locations.

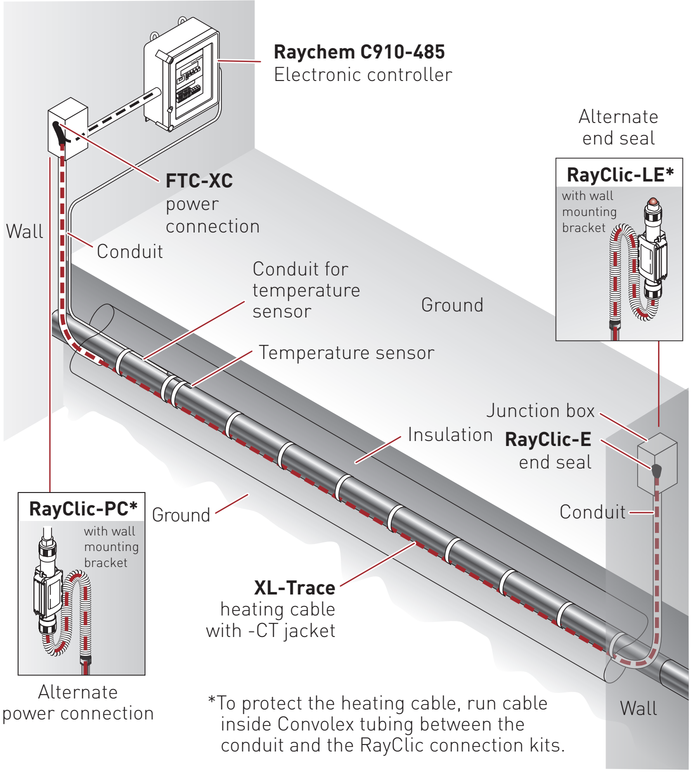
LISTED

5XL1-CR, -CT 8XL1-CR, -CT
5XL2-CR, -CT 8XL2-CR, -CT

C US

5XL1-CR, -CT 8XL1-CR, -CT 12XL2-CR, -CT
5XL2-CR, -CT 8XL2-CR, -CT

BURIED PIPING



*To protect the heating cable, run cable inside Convolex tubing between the conduit and the RayClic connection kits.

Fig. 5 Typical buried piping system

Application Requirements

The system complies with Thermal Management requirements for use on buried insulated metal or plastic pipe when:

- The heating cable is permanently secured to insulated metal pipes with GT-66 glass tape or to plastic pipes using AT-180 aluminum tape.
- The pipeline is buried at least 2-feet deep.
- The heating cable has a fluoropolymer outer jacket (-CT).
- All heating cable connections (power, splice, tee, and end termination) are made aboveground. No buried or in-conduit splices or tees are allowed.
- The power connection and end seal are made in UL Listed and CSA Certified junction boxes, or RayClic connection kits, above grade.
- The heating cable is protected from the pipe to the power connection box in UL Listed and CSA Certified water-sealed conduit (minimum 3/4-inch diameter) suitable for the location.
- Raychem C910-485 or ACS-30 controllers with integrated ground-fault protection and alarm contacts are used and are connected to a fire control panel.
- Closed-cell, waterproof thermal insulation with fire-retardant, waterproof covering approved for direct burial is used.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 13 on page 73 and the XL-Trace System Installation and Operation Manual (H58033).

Approvals

UL Listed and c-CSA-us Certified for nonhazardous locations.

LISTED

5XL1-CT	8XL1-CT
5XL2-CT	8XL2-CT

-W C US

5XL1-CT	8XL1-CT	12XL2-CT
5XL2-CT	8XL2-CT	

Sprinkler Standpipes

XL-Trace is designed to maintain fire suppression system standpipes at 40°F (4°C) in areas subject to freezing.

FOR ABOVEGROUND STANDPIPES

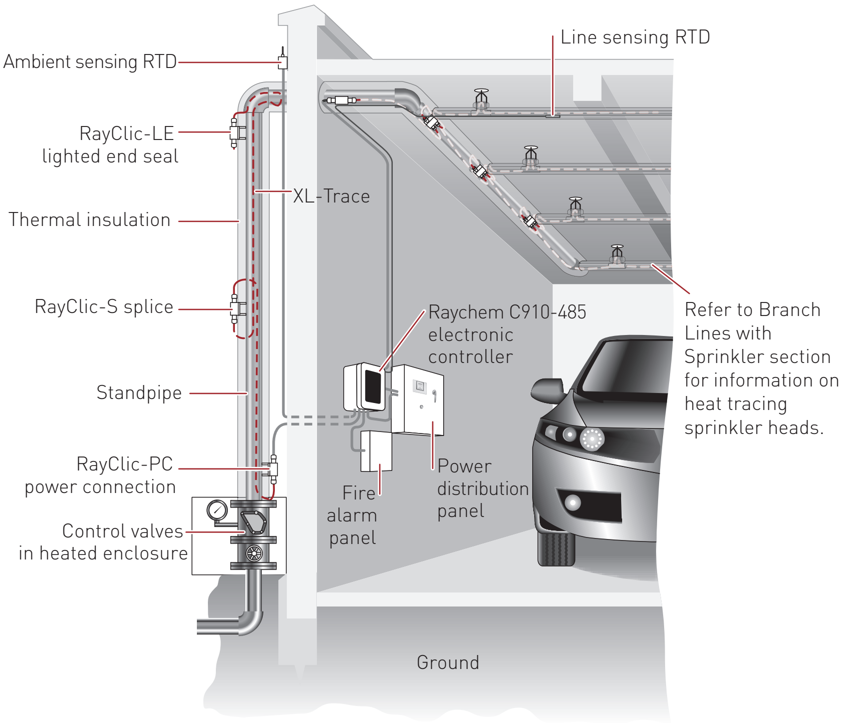


Fig. 6 Standard sprinkler standpipe heating system layout

Application Requirements

The system complies with Thermal Management requirements for freeze protection of sprinkler system piping when:

- The heating cable is permanently secured to insulated metal pipes with GT-66 glass tape or to plastic pipes using AT-180 aluminum tape.
- Schedule 5, 10, 20, or 40 steel sprinkler standpipe up to and including 20 inches in diameter is used.
- UL Listed fiberglass or closed cell flame-retardant insulation with weatherproof cladding is used.
- Raychem C910-485 or ACS-30 controllers with integrated ground-fault protection and alarm contacts are used and are connected to a fire control panel.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 11 on page 71 and the XL-Trace System Installation and Operation Manual (H58033).

Approvals

UL Listed and c-CSA-us Certified for nonhazardous locations.

UL LISTED		c CSA us -W		
5XL1-CR, -CT	8XL1-CR, -CT	5XL1-CR, -CT	8XL1-CR, -CT	12XL2-CR, -CT
5XL2-CR, -CT	8XL2-CR, -CT	5XL2-CR, -CT	8XL2-CR, -CT	

Branch Lines with Sprinklers

XL-Trace is designed to maintain branch lines containing sprinklers at 40°F (4°C) in areas subject to freezing.

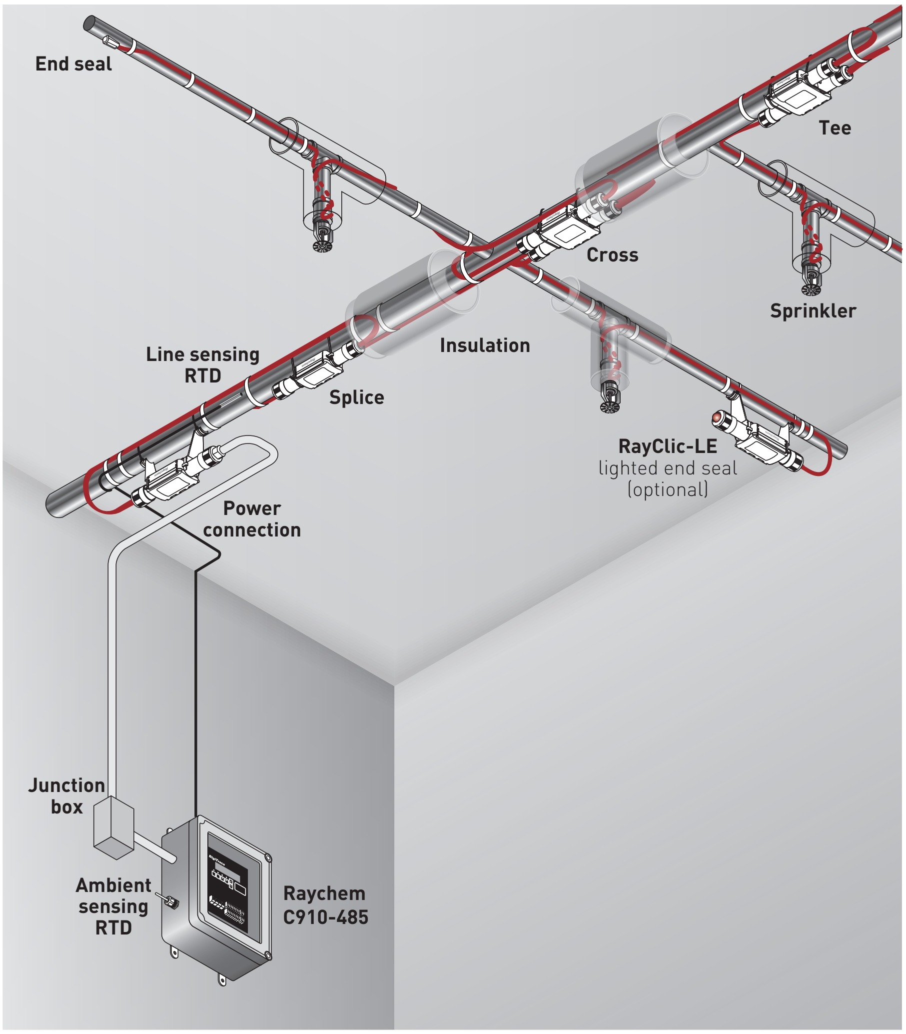


Fig. 7 Typical fire suppression system for branch lines with sprinklers

Application Requirements

The system complies with Thermal Management requirements for fire suppression branch lines with sprinklers when:

- The heating cable is permanently secured to metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- Raychem C910-485 or ACS-30 controllers with integrated ground-fault protection with alarm contacts are used and are connected to a fire control panel.
- The sprinkler design accounts for the sprinkler shadow created by the outer diameter of the thermal pipe insulation.
- Closed-cell, waterproof thermal insulation with fire-retardant, waterproof covering is used.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 13 on page 73 and the XL-Trace System Installation and Operation Manual (H58033).
- Additional heating cable is installed to compensate for sprinkler heads, sprigs, valves and pipe supports as detailed in the Table 6 on page 66 of this document and the XL-Trace System Installation and Operation Manual (H58033).

Approvals

c-CSA-us Certified for use in U.S. and Canada in nonhazardous locations.

5XL1-CR, -CT	8XL1-CR, -CT
5XL2-CR, -CT	8XL2-CR, -CT

Freezer Application

XL-Trace is designed to keep condensate in dry sprinklers from freezing and may be installed in freezers located in areas subject to freezing.

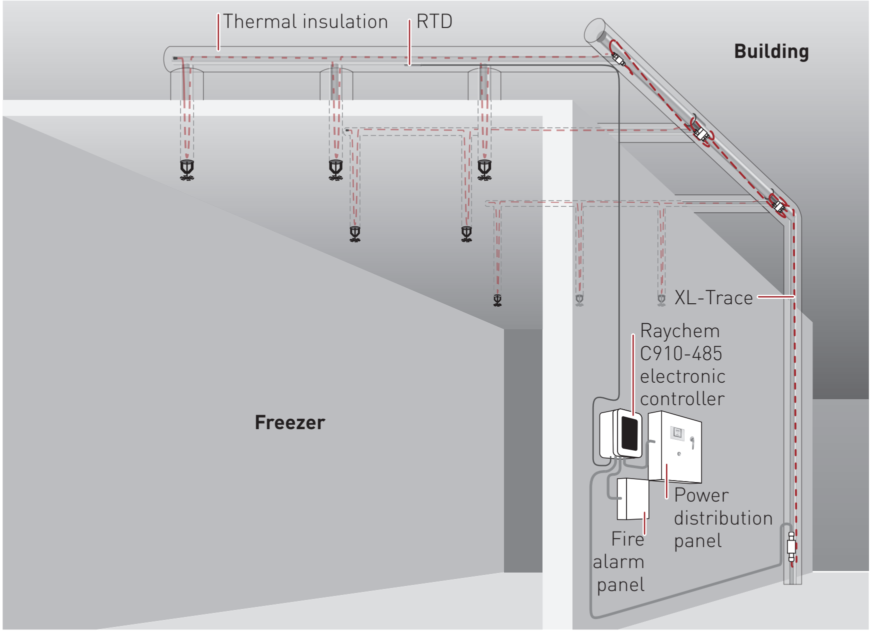


Fig. 8 Typical fire suppression system for freezer applications

Application Requirements

The system complies with Thermal Management requirements for fire suppression systems for freezer applications when:

- The system is for freezer and freezer within a freezer applications.
- The heating cable is permanently secured to metal pipes with GT-66 glass tape, or to plastic pipes using AT-180 aluminum tape.
- Raychem C910-485 or ACS-30 controllers with integrated ground-fault protection and alarm contacts are used and are connected to a fire control panel.
- Closed-cell, waterproof thermal insulation with fire-retardant, waterproof covering is used for pipes and sprigs in areas subject to freezing.
- The sprinkler design accounts for sprinkler shadow created by the outer diameter of the thermal pipe insulation.
- The heating cable is installed per manufacturer's instructions with approved Thermal Management connection kits. See Table 13 on page 73 and the XL-Trace System Installation and Operation Manual (H58033).
- Additional heating cable is installed to compensate for sprinkler heads, sprigs, valves and pipe supports as detailed in the Table 6 on page 66 of this document and the XL-Trace System Installation and Operation Manual (H58033).

Approvals

c-CSA-us Certified for use in U.S. and Canada in nonhazardous locations.

5XL1-CR, -CT	8XL1-CR, -CT
5XL2-CR, -CT	8XL2-CR, -CT

FIRE SUPPRESSION SYSTEM FREEZE PROTECTION DESIGN

This section details the design steps necessary to design your application. The examples provided in each step are intended to incrementally illustrate the project parameter output for two sample designs from start to finish. As you go through each step, use the "XL-Trace System Fire Sprinkler System Freeze Protection Design Worksheet," page 78, to document your project parameters, so that by the end of this section you will have the information you need for your Bill of Materials.

TraceCalc Pro for Buildings is an online design tool available to help you create simple or complex heat-tracing designs for pipe freeze protection or flow maintenance applications. It is available at http://www.pentairthermal.com.

Design Step by Step

Your system design requires the following essential steps.

1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Step 1 Determine design conditions and pipe heat loss

Collect the following information to determine your design conditions:

- Location
  - Indoors
  - Outdoors
  - Aboveground
  - Buried
- Maintain temperature (T_M)
- Minimum ambient temperature (T_A)
- Pipe diameter and material
- Pipe length
- Thermal insulation type and thickness
- Supply voltage

Example: Fire Standpipe

Location	Aboveground, outdoors
Maintain temperature (T_M)	40°F (4°C)
Minimum ambient temperature (T_A)	–20°F (–29°C)
Pipe diameter and material	10-inch metal
Pipe length	50 ft (16.4 m)
Thermal insulation type and thickness	1 1/2-inch fiberglass
Supply voltage	208 V

Branch Line with Sprinkler

Location	Indoors
Maintain temperature (T_M)	40°F (4°C)
Minimum ambient temperature (T_A)	0°F (–18°C)
Pipe diameter and material	1-inch metal
Pipe length	200 ft (61 m)
Thermal insulation type and thickness	1/2-inch closed-cell foamed elastomer
Supply voltage	208 V

PIPE HEAT LOSS CALCULATIONS

To select the proper heating cable you must first determine the pipe heat loss. To do this you must first calculate the temperature differential (ΔT) between the pipe maintain temperature and the minimum ambient temperature.

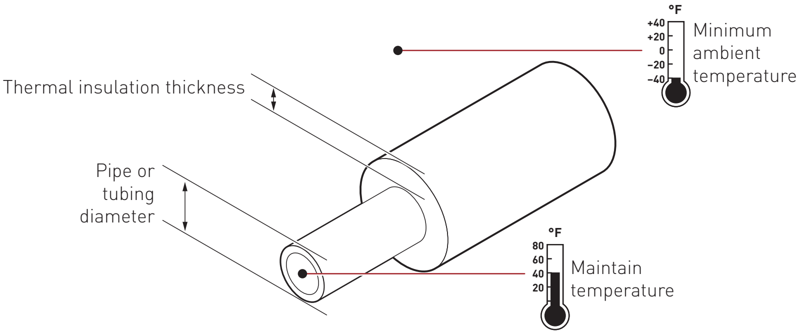


Fig. 9 Pipe heat loss

Calculate temperature differential ΔT

To calculate the temperature differential ΔT), use the formula below:

$\Delta T = T_M - T_A$

Example: Fire Standpipe

T_M	40°F (4°C)
T_A	–20°F (–29°C)

$\Delta T = 40°F - (-20°F) =$ **60°F**

$\Delta T = 4°C - (-29°C) =$ **33°C**

Example: Branch Line with Sprinkler

T_M	40°F (4°C)
T_A	0°F (-18°C)

$\Delta T = 40°F - (0°F) =$ **40°F**

$\Delta T = 4°C - (-18°C) =$ **22°C**

Determine the pipe heat loss

Match the pipe size, insulation thickness, and temperature differential (ΔT) from Table 1 on page 61 to determine the base heat loss of the pipe (Q_B).

Example: Fire Standpipe

Pipe diameter	10 inch
Insulation thickness	1 1/2 inch
ΔT	60°F (33°C)

Heat loss (Q_B) for 60°F must be calculated through interpolation between ΔT at 50°F and ΔT at 100°F from Table 1. For difference between the ΔT of 50°F and the ΔT of 100°F:

Q_{B-50}	8.1 W/ft (from Table 1)
Q_{B-100}	16.8 W/ft (from Table 1)
ΔT interpolation	ΔT 60°F is 20% of the distance between ΔT 50°F and ΔT 100°F
Q_{B-60}	$Q_{B-50} + [0.20 \times (Q_{B-100} - Q_{B-50})] = 8.1 + [0.20 \times (16.8 - 8.1)] = 9.8$ W/ft
Pipe heat loss (Q_B)	**9.8 W/ft @ T_M 40°F (32.1 W/m @ T_M 4°C)**

Example: Branch Line with Sprinkler

Pipe diameter	1 inch
Insulation thickness	1/2 inch
ΔT	40°F (22°C)

Q_B for 40°F must be calculated through interpolation between ΔT at 20°F and ΔT at 50°F from Table 1. For difference between the ΔT of 20°F and the ΔT of 50°F:

Q_{B-20}	1.4 W/ft (from Table 1)
Q_{B-50}	3.5 W/ft (from Table 1)
ΔT interpolation	ΔT 40°F is 67% of the distance between ΔT 20°F and ΔT 50°F
Q_{B-40}	$Q_{B-50} + [0.67 \times (Q_{B-50} - Q_{B-20})] = 1.4 + [0.67 \times (3.5 - 1.4)] = 2.8$ W/ft
Pipe heat loss Q_B	**2.8 W/ft @ T_M 40°F (9.2 W/m @ T_M 4°C)**

Compensate for insulation type and pipe location

The base heat loss is calculated for a pipe insulated with thermal insulation with a k-factor ranging from 0.2 to 0.3 BTU/hr–°F–ft^2/in (fiberglass or foamed elastomer) in an outdoor, or buried application. To get the heat loss for pipes insulated with alternate types of thermal insulation and for pipes installed indoors, multiply the base heat loss of the pipe (Q_B) from Step 3 by the insulation multiple from Table 3 on page 62 and the indoor multiple from Table 2 on page 62 to get the corrected heat loss:

$Q_{CORRECTED} = Q_B \times$ Insulation multiple x Indoor multiple

Example: Fire Standpipe

Location	Aboveground, outdoors
Thermal insulation thickness and type	1 1/2-inch fiberglass
Pipe heat loss Q_B	9.8 W/ft @ T_M 40°F (32.1 W/m @ T_M 4°C)
$Q_{CORRECTED}$	9.8 W/ft x 1.00 x 1.00 = **9.8 W/ft @ T_M 40°F (32.1 W/m @ T_M 4°C)**

Example: Branch Line with Sprinkler

Location	Aboveground, indoors
Thermal insulation type and thickness	1/2-inch closed cell foamed elastomer
Pipe heat loss Q_B =	2.8 W/ft @ T_M 40°F (9.2 W/m @ T_M 4°C)
$Q_{CORRECTED}$ =	2.8 W/ft x 1.0 x 0.79 = **2.20 W/ft @ T_M 410°F (7.3 W/m @ T_M 4°C)**

TABLE 1 PIPE HEAT LOSS (Q_B) FOR OUTDOOR OR BURIED PIPE (W/FT) FOR 1/2 TO 3-1/2 INCHES

Insulation thickness (in)	(ΔT)		Pipe diameter (IPS) in inches								
	°F	°C	1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	3-1/2
0.5	20	11	1.0	1.2	1.4	1.6	1.8	2.2	2.5	3.0	3.4
	50	28	2.5	2.9	3.5	4.1	4.6	5.5	6.5	7.7	8.6
	100	56	5.2	6.1	7.2	8.6	9.6	11.5	13.5	16.0	18.0
	150	83	8.1	9.5	11.2	13.4	14.9	17.9	21.1	25.0	28.1
1.0	20	11	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.7	1.9
	50	28	1.6	1.9	2.2	2.5	2.8	3.2	3.8	4.4	4.9
	100	56	3.4	3.9	4.5	5.2	5.8	6.8	7.8	9.1	10.2
	150	83	5.3	6.1	7.0	8.2	9.0	10.6	12.2	14.2	15.9
1.5	20	11	0.5	0.6	0.7	0.8	0.8	1.0	1.1	1.3	1.4
	50	28	1.3	1.5	1.7	1.9	2.1	2.4	2.8	3.2	3.6
	100	56	2.8	3.1	3.5	4.0	4.4	5.1	5.8	6.7	7.4
	150	83	4.3	4.8	5.5	6.3	6.9	8.0	9.1	10.5	11.6
2.0	20	11	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1
	50	28	1.1	1.3	1.4	1.6	1.8	2.0	2.3	2.6	2.9
	100	56	2.4	2.7	3.0	3.4	3.7	4.2	4.8	5.5	6.0
	150	83	3.7	4.2	4.7	5.3	5.8	6.6	7.5	8.5	9.4
2.5	20	11	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9	1.0
	50	28	1.0	1.2	1.3	1.4	1.6	1.8	2.0	2.3	2.5
	100	56	2.2	2.4	2.7	3.0	3.3	3.7	4.2	4.7	5.2
	150	83	3.4	3.7	4.2	4.7	5.1	5.8	6.5	7.4	8.1
3.0	20	11	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	0.9
	50	28	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.0	2.2
	100	56	2.0	2.2	2.4	2.7	2.9	3.3	3.7	4.2	4.6
	150	83	3.1	3.4	3.8	4.3	4.6	5.2	5.8	6.6	7.1
4.0	20	11	0.3	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.7
	50	28	0.9	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.8
	100	56	1.8	2.0	2.1	2.4	2.5	2.9	3.2	3.5	3.8
	150	83	2.8	3.0	3.4	3.7	4.0	4.4	4.9	5.5	6.0

Note: Multiply the W/ft heat loss values by 3.28 for W/m.

TABLE 1 CONTINUED PIPE HEAT LOSS (Q_B) FOR OUTDOOR OR BURIED PIPE (W/FT) FOR 4 TO 20 INCHES

Insulation thickness (in)	(ΔT)		Pipe diameter (IPS) in inches								
	°F	**°C**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**
0.5	20	11	3.8	5.3	6.8	8.4	9.9	10.8	12.2	13.7	15.2
	50	28	9.6	13.6	17.4	21.4	25.2	27.5	31.3	35.0	38.8
	100	56	20.0	28.4	36.3	44.6	52.5	57.4	65.2	73.0	80.8
	150	83	31.2	44.3	56.6	69.6	81.9	89.5	101.7	113.8	126.0
1.0	20	11	2.1	2.9	3.7	4.5	5.3	5.8	6.5	7.3	8.0
	50	28	5.4	7.5	9.4	11.5	13.5	14.7	16.6	18.6	20.5
	100	56	11.2	15.6	19.7	24.0	28.1	30.6	34.7	38.7	42.8
	150	83	17.5	24.3	30.7	37.4	43.8	47.8	54.1	60.4	66.7
1.5	20	11	1.5	2.1	2.6	3.2	3.7	4.0	4.5	5.0	5.5
	50	28	3.9	5.3	6.7	8.1	9.4	10.2	11.5	12.9	14.2
	100	56	8.1	11.1	13.9	16.8	19.6	21.3	24.0	26.8	29.5
	150	83	12.7	17.3	21.6	26.2	30.5	33.2	37.5	41.8	46.1
2.0	20	11	1.2	1.7	2.1	2.5	2.9	3.1	3.5	3.9	4.3
	50	28	3.1	4.2	5.2	6.3	7.3	7.9	8.9	9.9	10.9
	100	56	6.6	8.8	10.9	13.1	15.2	16.5	18.6	20.7	22.8
	150	83	10.2	13.8	17.0	20.5	23.8	25.8	29.0	32.3	35.5
2.5	20	11	1.1	1.4	1.7	2.1	2.4	2.6	2.9	3.2	3.5
	50	28	2.7	3.6	4.4	5.2	6.1	6.6	7.4	8.2	9.0
	100	56	5.6	7.4	9.1	10.9	12.6	13.7	15.3	17.0	18.7
	150	83	8.7	11.6	14.2	17.0	19.7	21.3	23.9	26.5	29.1
3.0	20	11	0.9	1.2	1.5	1.8	2.0	2.2	2.5	2.7	3.0
	50	28	2.4	3.1	3.8	4.5	5.2	5.6	6.3	7.0	7.6
	100	56	4.9	6.5	7.9	9.4	10.8	11.7	13.1	14.5	15.9
	150	83	7.7	10.1	12.4	14.7	16.9	18.3	20.5	22.6	24.8
4.0	20	11	0.8	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.3
	50	28	2.0	2.5	3.1	3.6	4.1	4.4	5.0	5.5	6.0
	100	56	4.1	5.3	6.4	7.5	8.6	9.3	10.3	11.4	12.4
	150	83	6.4	8.3	10.0	11.8	13.4	14.5	16.1	17.8	19.4

Note: Multiply the W/ft heat loss values by 3.28 for W/m.

TABLE 2 INDOOR PIPE HEAT LOSS MULTIPLES

Fiberglass thickness (in)	Indoor multiple
0.5	0.79
1	0.88
1.5	0.91
2	0.93
2.5	0.94
3	0.95
4	0.97

TABLE 3 INSULATION HEAT LOSS MULTIPLES

k factor at 50°F (10°C) (BTU/hr–°F–ft^2/in)	Insulation multiple	Examples of preformed pipe insulation
0.1–0.2	0.6	Rigid cellular urethane (ASTM C591)
0.2–0.3	1	Glass fiber (ASTM C547) Foamed elastomer (ASTM C534)
0.3–0.4	1.4	Cellular glass (ASTM C552) Mineral fiber blanket (ASTM C553)

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Step 2 Select the heating cable

To select the appropriate XL-Trace heating cable for your application, you must determine your cable supply voltage, power output, and outer jacket. Once you have selected these, you will be able to determine the catalog number for your cable.

HEATING CABLE CATALOG NUMBER

Before beginning, take a moment to understand the structure of the heating cable catalog numbers. You will refer to this numbering convention throughout the product selection process. Your goal is to determine the catalog number for the product that best suits your needs.

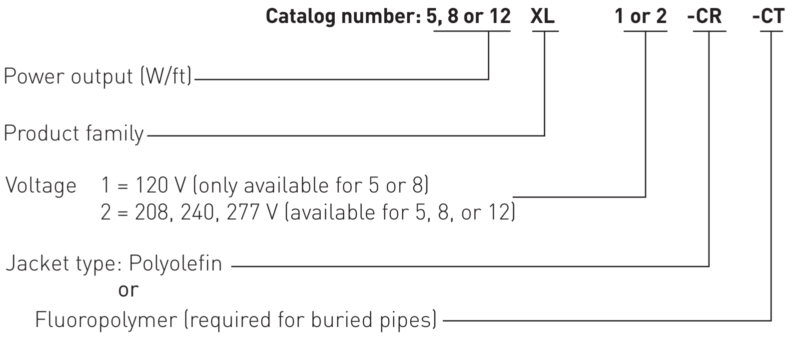


Fig. 10 Heating cable catalog number

Select the heating cable from Fig. 11 that provides the required power output to match the corrected heat loss for your application. Fig. 11 shows the power output for the heating cables on metal pipe at 120/208 volts. To correct the power output for other applied voltage or plastic pipes multiply the power output at the desired maintain temperature by the factors listed in Table 4 on page 64. If the pipe heat loss, $Q_{CORRECTED}$, is between the two heating cable power output curves, select the higher-rated heating cable.

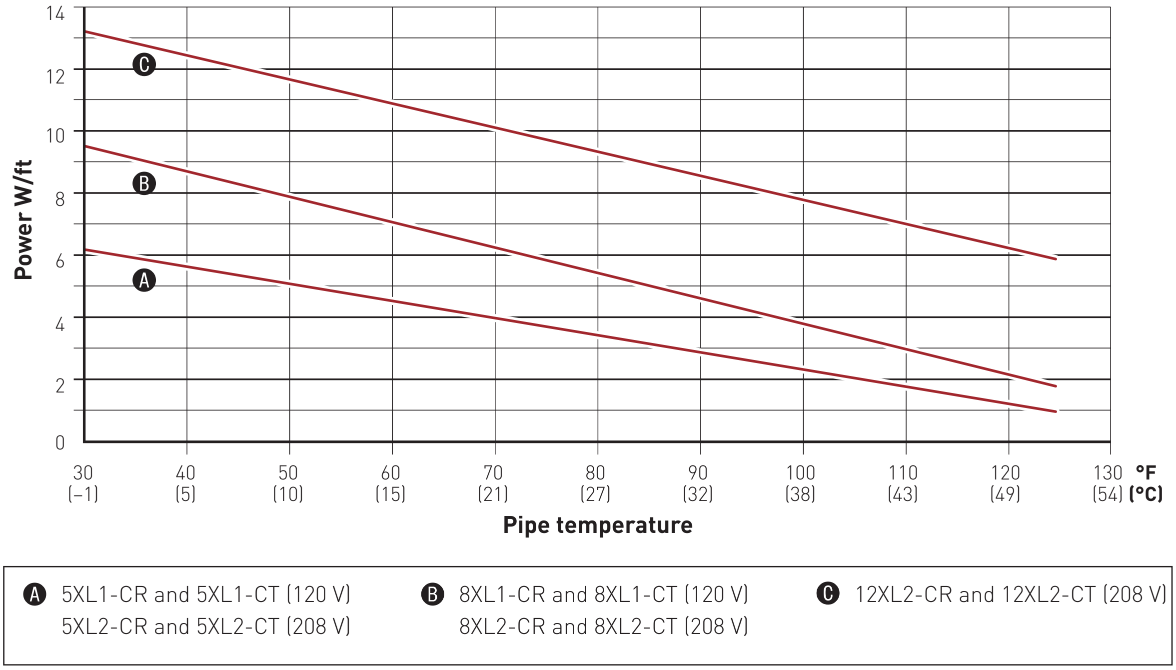


Fig. 11 Heating cable power output on metal pipe

TABLE 4 POWER OUTPUT CORRECTION FACTORS

Voltage correction factors	**5XL1**	**8XL1**	**5XL2**	**8XL2**	**12XL2**
120 V	1.00	1.00	–	–	–
208 V	–	–	1.00	1.00	1.00
240 V	–	–	1.12	1.12	1.14
277 V	–	–	1.29	1.27	1.30
Plastic pipe correction factor (With AT-180 Aluminum tape)	0.75	0.75	0.75	0.75	0.75

Confirm that the corrected power output of the heating cable selected is greater than the corrected pipe heat loss ($Q_{CORRECTED}$). If $Q_{CORRECTED}$ is greater than the power output of the highest-rated heating cable, you can:

- Use two or more heating cables run in parallel
- Use thicker insulation to reduce heat loss
- Use insulation material with a lower k factor to reduce heat loss

Example: Fire Standpipe

Pipe maintain temperature (T_M)	40°F (4°C) (from Step 1)
$Q_{CORRECTED}$	$Q_{CORRECTED}$ = 9.8 W/ft @ T_M 40°F (32.1 W/m @ T_M 4°C)
Supply voltage	208 V (from Step 1)
Pipe material	Metal (from Step 1)
Select heating cable	$Q_{CORRECTED}$ = 9.8 W/ft @ T_M 40°F (from Step 1) 12XL2 = 12.4 W/ft @ 40°F (from Fig. 11)
Supply voltage correction factor	1.00 (from Table 4)
Pipe material correction factor	Metal = 1.00 (from Table 4)
Corrected heating cable power	9.8 W/ft x 1.00 x 1.00 = 9.8 W/ft
Selected heating cable	**12XL2**

Example: Branch Line with Sprinkler

Pipe maintain temperature (T_M)	40°F (4°C) (from Step 1)
$Q_{CORRECTED}$	2.8 W/ft x 1.0 x 0.97 = 2.2 W/ft @ T_M 40°F (7.3 W/m @ T_M 4°C)
Supply voltage	208 V (from Step 1)
Pipe material	Metal (from Step 1)
Select heating cable	$Q_{CORRECTED}$ = 2.2 W/ft @ T_M 40°F (from Step 1) 5XL2 = 5.6 W/ft @ 40°F (from Fig. 11)
Supply voltage correction factor	1.00 (from Table 4)
Pipe material correction factor	Metal = 1.00
Corrected heating cable power	5.6 x 1.00 x 1.00 = 5.6 W/ft
Selected heating cable	**5XL2**

SELECT OUTER JACKET

Select the appropriate heating cable outer jacket for the application. Jacket options are:

-CR	Compatible with most XL-Trace applications
-CT	Required for buried piping; may be used in other XL-Trace applications for improved mechanical strength and chemical resistance.

Example: Fire Standpipe

Location: Aboveground, outdoors

Selection: 12XL2-CR

Example: Branch Line with Sprinkler

Location: Aboveground, indoors

Selection: 5XL2-CR

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Step 3 Determine the heating cable length

In Step 2 you selected the appropriate heating cable and the number of runs of heating cable required for the pipe. Multiply the length of the pipe by the number of heating cable runs for the heating cable length.

Heating cable length = Pipe length x No. heating cable runs

Additional heating cable will be required for heat sinks and connection kits. Use Table 5 and Table 6 to determine the additional footage required for heat sinks (valves, flanges, and pipe supports). You will determine the additional heating cable for connection kits in Step 5. Round up fractional lengths to ensure heating cable lengths are sufficient.

Total heating cable length required = (Pipe length x No. heating cable runs) + Additional heating cable for heat sinks (valves, pipe supports, and flanges)

TABLE 5 ADDITIONAL HEATING CABLE FOR VALVES

Pipe diameter (IPS) inches	Heating cable feet (meters)	
1/2	0.8	(0.24)
3/4	1.3	(0.4)
1	2.0	(0.6)
1-1/4	3.3	(1.1)
1-1/2	4.3	(1.3)
2	4.3	(1.3)
3	4.3	(1.3)
4	4.3	(1.3)
6	5.0	(1.5)
8	5.0	(1.5)
10	5.6	(1.7)
12	5.9	(1.9)
14	7.3	(2.2)
18	9.4	(2.9)
20	10.5	(3.2)

TABLE 6 ADDITIONAL HEATING CABLE FOR PIPE SUPPORTS, FLANGES AND SPRINKLERS

Support	Additional cable
Pipe hangers (insulated)	No additional heating cable
Pipe hangers (noninsulated) and U-bolt supports	Add 2x pipe diameter
Welded support shoes	Add 3x the length of the shoe
Flanges	Add 2x pipe diameter
Sprinklers	
Sprinkler without sprig	Add 4x pipe diameter
Sprinkler with sprig	Add 3x sprig length
Dry sprinkler for freezer application	Add 2x sprinkler length

Note: For applications where more than one heating cable is required per foot of pipe, this correction factor applies for each cable run.

Example: Fire Standpipe

Pipe length	50 ft (60 m) (from Step 1)
Pipe diameter	10-inch metal (from Step 1)
Number of heating cable runs	1 (from Step 2)
Valves	1 control valve
	5.6 ft x 1 valve = 5.6 ft (1.7 m)
Pipe supports	5 pipe hangers with U-bolts
	10-inch pipe diameter = 10/12 = 0.83
	(0.83 ft pipe diameter x 2) x 5 pipe supports
	= 8.3 ft (2.5 m)
Flanges	3
	10-inch pipe diameter – 10/12 = 0.83 ft
	(0.83 ft pipe diameter x 2) x 3 pipe supports
	= 5.0 ft (1.5 m)
Total heating cable for heat sinks	5.6 ft (1.7 m) + 8.3 ft (2.5 m) + 5.0 ft (1.5 m)
	= 18.9 ft (4.2 m) Rounded up to 19 ft (65 m)
Total heating cable length required	50 ft (15 m) x 1 run + 19 ft = **69 ft (21 m) of 12XL2-CR**

Example: Branch Line with Sprinkler

Pipe length	200 ft (61 m) (from Step 1)
Pipe diameter	1-inch metal (from Step 1)
Number of heating cable runs	1 (from Step 2)
Valves	2 gate valves (2.0 ft x 2 gate valves) x 1 run = 4.0 ft (1.2 m)
Pipe supports	10 noninsulated hangers 1-inch pipe diameter = 1 /12 = 0.1 ft (0.1 ft pipe diameter x 2) x 10 pipe supports) x 1 run = 2.0 ft (0.6 m)
Sprinklers	20 with 1 foot sprigs (3 x 1 ft sprig) x 20 = 60 ft (18.3 m)
Total heating cable for heat sinks	4.0 ft (1.2 m) + 2.0 ft (0.6 m) + 60 ft (18.3 m) = 66 ft (20.1 m)
Total heating cable length required	200 ft x 1 run + 66 ft = **266 ft (81 m) of 5XL2-CR**

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Step 4 Determine the electrical parameters

To determine the electrical requirements for your application, you must determine the number of circuits and calculate the transformer load.

DETERMINE NUMBER OF CIRCUITS

To determine the number of circuits, you need to know:

- Total heating cable length
- Supply voltage
- Minimum start-up temperature

Use Table 7 to determine the maximum circuit length allowed. If the total heating cable length exceeds the maximum circuit length for the expected start-up temperature, more than one circuit will be required.

$$\text{Number of circuits} = \frac{\text{Heating cable length required}}{\text{Maximum heating cable circuit length}}$$

Important: Select the smallest appropriate ground-fault circuit breaker size.

⚠ **WARNING:** To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

TABLE 7 MAXIMUM CIRCUIT LENGTH IN FEET

		40°F Maintain										
Start-up temperature (°F)	CB size (A)	5XL1	8XL1	5XL2			8XL2			12XL2		
		120 V	120 V	208 V	240 V	277 V	208 V	240 V	277 V	208 V	240 V	277 V
–20°F	15	101	76	174	178	183	131	138	146	111	114	117
	20	134	101	232	237	245	175	184	194	148	151	156
	30	201	151	349	356	367	262	276	291	223	227	234
	40	270	201	465	474	478	349	368	388	297	303	312
0°F	15	115	86	199	203	209	149	157	166	120	122	126
	20	153	115	265	271	279	199	209	221	160	163	168
	30	230	172	398	406	419	298	314	331	239	244	252
	40	270	210	470	490	530	370	390	420	319	326	336
20°F	15	134	100	232	237	244	173	182	192	126	129	133
	20	178	133	309	315	325	231	243	257	169	172	177
	30	270	200	464	473	488	346	365	385	253	258	266
	40	270	210	470	490	530	370	390	420	340	344	355
40°F	15	160	119	278	283	292	206	217	229	142	145	150
	20	214	159	370	378	390	275	290	306	190	194	200
	30	270	210	470	490	530	370	390	420	285	291	300
	40	270	210	470	490	530	370	390	420	340	360	380

TABLE 8 MAXIMUM CIRCUIT LENGTH IN METERS

Start-up temperature (°C)	CB size (A)	4°C Maintain										
		5XL1	8XL1	5XL2			8XL2			12XL2		
		120 V	120 V	208 V	240 V	277 V	208 V	240 V	277 V	208 V	240 V	277 V
–29°C	15	31	23	53	54	56	40	42	44	34	35	36
	20	41	31	71	72	75	53	56	59	45	46	48
	30	61	46	106	108	112	80	84	89	68	69	71
	40	82	61	142	145	149	106	112	118	90	92	95
–18°C	15	35	26	61	62	64	45	48	51	36	37	38
	20	47	35	81	83	85	61	64	67	49	50	51
	30	70	52	121	124	128	91	96	101	73	74	77
	40	82	64	143	149	162	113	119	128	97	99	102
–7°C	15	41	31	71	72	74	53	56	59	39	39	41
	20	54	41	94	96	99	70	74	78	51	52	54
	30	82	61	141	144	149	106	111	117	77	79	81
	40	82	64	143	149	162	113	119	128	104	105	108
4°C	15	49	36	85	86	89	63	66	70	43	44	46
	20	65	48	113	115	119	84	88	93	58	59	61
	30	82	64	143	149	162	113	119	128	87	89	91
	40	82	64	143	149	162	113	119	128	104	110	116

Example: Fire Standpipe

Total heating cable length	69 ft (21 m) of 12XL2-CR (from Step 3)
Supply voltage	208 V (from Step 1)
Minimum start-up temperature	–20°F (–29°C) (from Step 1)
Number of circuits	69 ft / (111 ft max 15 A CB at –20°F) = 0.6 circuits
	Round up to 1 circuit

Example: Branch Line with Sprinkler

Total heating cable length	266 ft (81 m) of 5XL2-CT (from Step 3)
Supply voltage	208 V (from Step 1)
Minimum start-up temperature	0°F (–18°C) (from Step 1)
Number of circuits	266 ft / (398 ft max 30 A CB at 0°F) = 0.67 circuits
	Round up to 1 circuit

DETERMINE TRANSFORMER LOAD

Transformers must be sized to handle the load of the heating cable. Use the following tables to calculate the total transformer load.

TABLE 9 TRANSFORMER SIZING (AMPERES/FOOT)

Minimum start-up temperature (°F)	5XL1	8XL1	5XL2			8XL2			12XL2		
	120	120	208	240	277	208	240	277	208	240	277
–20	0.119	0.159	0.069	0.067	0.065	0.092	0.087	0.082	0.108	0.106	0.102
0	0.105	0.139	0.060	0.059	0.057	0.080	0.076	0.072	0.100	0.098	0.095
20	0.090	0.120	0.052	0.051	0.049	0.069	0.066	0.062	0.095	0.093	0.090
40	0.075	0.101	0.043	0.042	0.041	0.058	0.055	0.052	0.084	0.083	0.080

TABLE 10 TRANSFORMER SIZING (AMPERES/METER)

Minimum start-up temperature (°C)	5XL1	8XL1	5XL2			8XL2			12XL2		
	120	120	208	240	277	208	240	277	208	240	277
–20	0.391	0.521	0.226	0.221	0.215	0.301	0.286	0.270	0.354	0.347	0.336
–18	0.343	0.457	0.198	0.194	0.188	0.264	0.251	0.238	0.329	0.322	0.312
–7	0.294	0.394	0.170	0.166	0.161	0.227	0.216	0.205	0.311	0.305	0.296
4	0.246	0.331	0.142	0.139	0.135	0.191	0.181	0.172	0.276	0.271	0.263

Use Table 9 or Table 10 to determine the applied voltage and the maximum A/ft (A/m) at the minimum start-up temperature to calculate the transformer load as follows:

$$\frac{\text{Max A/ft at minimum start-up temperature x Heating cable length (ft) x Supply voltage}}{1000} = \text{Transformer load (kW)}$$

Example: Fire Standpipe

Total heating cable length	69 ft (21 m) of 12XL2-CR (from Step 3)
Supply voltage	208 V
Minimum start-up temperature	–20°F (–29°C) (from Step 1)

$$\frac{\text{Max A/ft at –20°F x Total feet x Supply voltage}}{1000} = \text{(0.108 A/ft x 69 ft x 208 V) / 1000}$$

Transformer load (kW) = 1.68 kW

Example: Branch Line with Sprinkler

Total heating cable length	266 ft (81 m) of 5XL2-CT (from Step 3)
Supply voltage	208 V
Minimum start-up temperature	0°F (–18°C) (from Step 1)

$$\frac{\text{Max A/ft at 0°F x Total feet x Supply voltage}}{1000} = \text{(0.060 A/ft x 266 ft x 208 V) / 1000}$$

Transformer load (kW) = 3.3 kW

Pipe Freeze Protection and Flow Maintenance
1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Step 5 Select the connection kits and accessories

All XL-Trace systems require a power connection and end seal kit. Splice and tee kits are used as required. Use Table 11 on page 71 (for aboveground applications) and Table 13 on page 73 (for buried applications) to select the appropriate connection kits.

Note: Add extra cable on your Bill of Materials for power connections, tees, and end seals. See Table 11 on page 71, Table 13 on page 73, and Table 14 on page 74 for more information.

⚠ **WARNING:** Approvals and performance are based on the use of Thermal Management-specified parts only. Do not substitute parts or use vinyl electrical tape.

ABOVEGROUND PIPING

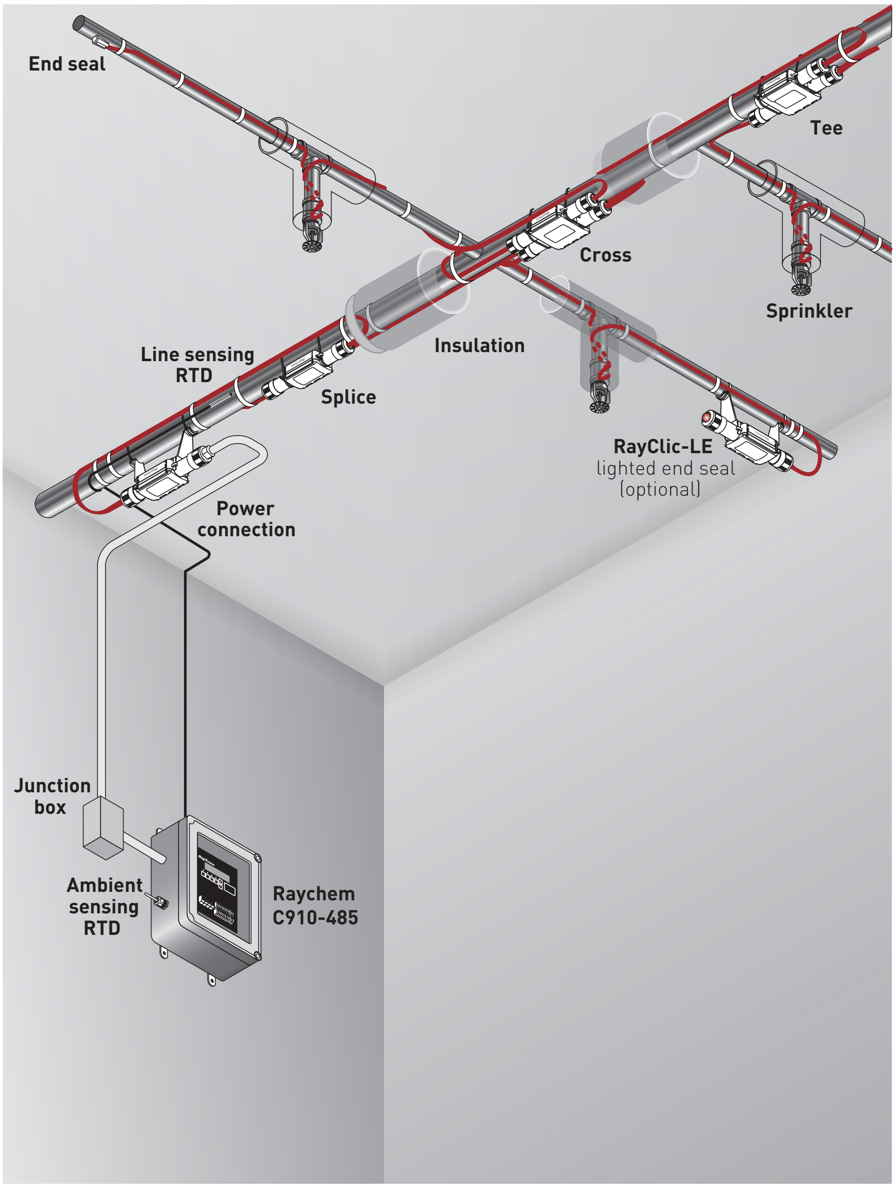


Fig. 12 RayClic connection system

Use the following table for general piping, standpipe and sprinkler. Develop a Bill of Materials from the connection kits listed in the following table.

TABLE 11 CONNECTION KITS AND ACCESSORIES FOR ABOVEGROUND PIPING

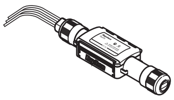
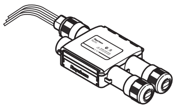
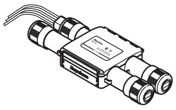
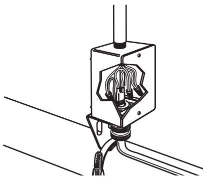
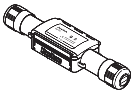
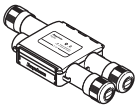
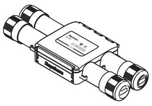
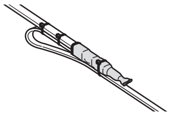
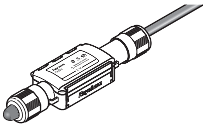
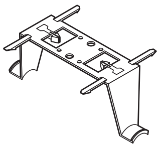
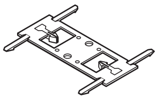
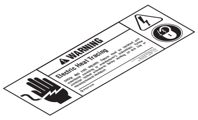
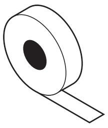
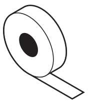
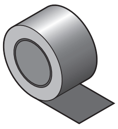
	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Connection kits					
	RayClic-PC	Power connection and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	2 ft (0.6 m)
	RayClic-PS	Powered splice and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	4 ft (1.2 m)
	RayClic-PT	Powered tee and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	6 ft (1.8 m)
	FTC-P[2]	Power connection and end seal kit **Note:** FTC-P is required for circuits requiring 40 A circuit breakers.	1	1 per circuit	3 ft (0.9 m)
	RayClic-S	Splice used to join two sections of heating cable	1	As required	2 ft (0.6 m)
	RayClic-T	Tee kit with end seal; use as needed for pipe branches	1	As required	3 ft (0.9 m)
	RayClic-X	Cross connection to connect four heating cables	1	As required	8 ft (2.4 m)
	FTC-HST[3]	Low-profile splice/tee; use as needed for pipe branches	2	As required	3 ft (0.9 m)
	RayClic-LE	Lighted end seal (RayClic-SB-04 pipe mounting bracket included)	1	Alternate end seal	2 ft (0.6 m)
	RayClic-E	Replacement end seal	1	Additional end seal	0.3 ft (0.1 m)

TABLE 11 CONNECTION KITS AND ACCESSORIES FOR ABOVEGROUND PIPING

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Accessories					
	RayClic-SB-04	Pipe mounting bracket. Required for mounting the kits off the pipe for exposure temperatures greater than 150°F (65°C) and for grease and fuel line splices and tees.	1	As required	–
	RayClic-SB-02	Wall mounting bracket	1	As required	–
	ETL	"Electric Traced" label (use 1 label per 10 feet of pipe)	1	1 label per 10 feet (3 m) of pipe	–
	GT-66	Glass cloth adhesive tape for attaching heating cable to pipe at 40°F (4°C) or above.	66 ft (20 m)	See Table 12	–
	GS-54	Glass cloth adhesive tape for attaching heating cable to pipe above –40°F (–40°C).	54 ft (20 m)	See Table 12	–
	AT-180	Aluminum tape. Required for attaching heating cable to plastic pipe (use 1 foot of tape per foot of heating cable)	180 ft (55 m)	1 ft/ft (0.3 m/m) of heating cable	–

[1] Allow extra heating cable for ease of component installation.

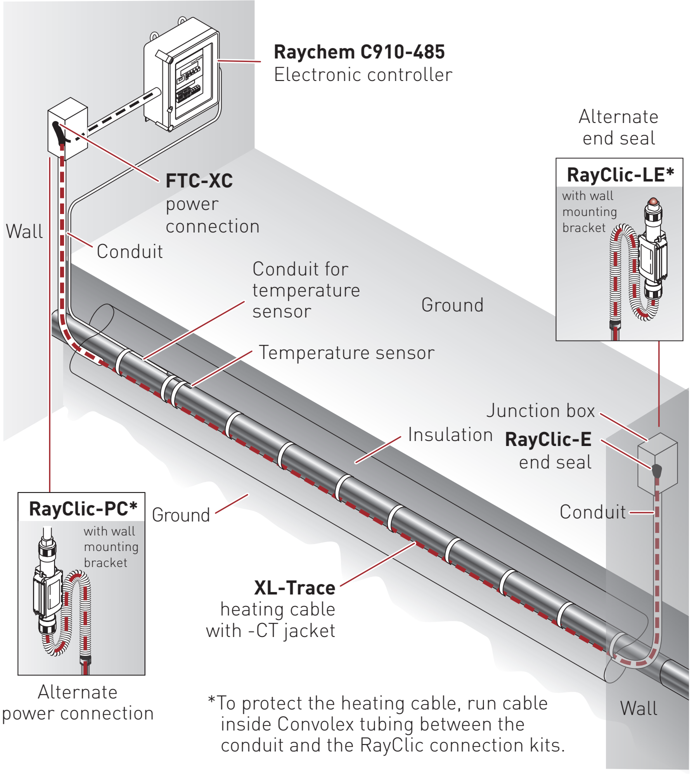
[2] Junction box not included.

[3] One RayClic-E end seal is required for each FTC-HST used as a tee kit.

TABLE 12 QUANTITY OF GLASS CLOTH ADHESIVE TAPE REQUIRED (ATTACH AT 1-FOOT INTERVALS)

Pipe size (in)	<2	3	4	6	8	10
Feet of pipe per GT-66 roll	60 (18 m)	50 (15 m)	40 (12 m)	25 (8 m)	20 (6 m)	15 (5 m)
Feet of pipe per GS-54 roll	49 (15 m)	41 (13 m)	33 (10 m)	20 (6 m)	16 (5 m)	12 (4 m)

BURIED PIPING



*To protect the heating cable, run cable inside Convolex tubing between the conduit and the RayClic connection kits.

Fig. 13 Typical buried supply piping system

Use the following for buried water supply piping. Note that all connections must be aboveground and that no splices/tees are allowed. Develop a Bill of Materials from the connection kits in this table.

TABLE 13 CONNECTION KITS AND ACCESSORIES FOR BURIED PIPING

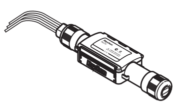
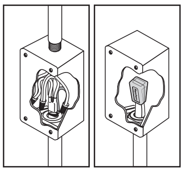
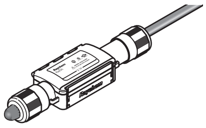
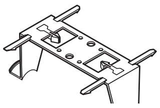
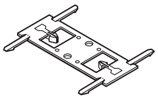
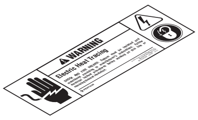
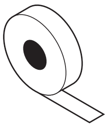
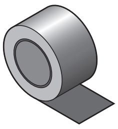
	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
	RayClic-PC	Power connection and end seal kit (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	2 ft (0.6 m)
	FTC-XC[2]	The FTC-XC power connection and end seal kit is for use with XL-Trace heating cable that is run through conduit to a junction box. Materials for one power connection and end seal is included in the kit. **Note:** FTC-XC is required for circuits requiring 40 A circuit breakers.	1	1 per circuit	2 ft (0.6 m)
	RayClic-LE	Lighted end seal (RayClic-SB-04 pipe mounting bracket included)	1	Alternate end seal	2 ft (0.6 m)
	RayClic-E	Replacement end seal	1	Additional end seal	0.3 ft (0.1 m)

TABLE 13 CONNECTION KITS AND ACCESSORIES FOR BURIED PIPING

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance[1]
Accessories					
	RayClic-SB-04	Pipe mounting bracket	1	As required	–
	RayClic-SB-02	Wall mounting bracket	1	As required	–
	ETL	"Electric Traced" label (use 1 label per 10 feet of pipe)	1	1 label per 10 feet (3 m) of pipe	–
	GT-66	Glass cloth adhesive tape for attaching heating cable to pipe at 40°F (4°C) or above	66 ft (20 m)	See Table 14	–
	GS-54	Glass cloth adhesive tape for attaching heating cable to pipe above –40°F (–40°C)	54 ft (20 m)	See Table 14	–
	AT-180	Aluminum tape. Required for attaching heating cable to plastic pipe (use 1 foot of tape per foot of heating cable)	180 ft (55 m)	1 ft/ft (0.3 m/m) of heating cable	–

[1] Allow extra heating cable for ease of component installation.

[2] Junction box not included.

TABLE 14 QUANTITY OF GLASS CLOTH ADHESIVE TAPE REQUIRED (ATTACH AT 1-FOOT INTERVALS)

Pipe size (in)	<2	3	4	6	8	10
Feet of pipe per GT-66 roll	60 (18 m)	50 (15 m)	40 (12 m)	25 (8 m)	20 (6 m)	15 (5 m)
Feet of pipe per GS-54 roll	49 (15 m)	41 (13 m)	33 (10 m)	20 (6 m)	16 (5 m)	12 (4 m)

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Step ❻ Select the control system

Temperature control with heating cable circuit supervision is required by approval agencies, codes and Thermal Management. To satisfy this requirement Thermal Management offers a wide variety of monitoring and control options for fire suppression system.

Raychem C910-485 and ACS-30 are the only controllers approved for this application:

- Temperature controls save energy by ensuring that the system is energized only when necessary.
- Superior accuracy and reliability with RTD temperature sensors.
- Integrated 30 mA ground-fault protection for cost savings and circuit protection.
- Self-test features to ensure the heating cable circuit integrity even when the system is not in demand.
- Modbus® protocol communication over RS-485 system is supported using Raychem ProtoNode multi-protocol gateways.
- Dry contact alarm relay outputs for loss of power, low temperature, RTD failure, relay failure and ground-fault trip.

Note: NFPA 13 requires that heat tracing for fire suppression systems are supervised by controllers with alarm relays connected to the fire control panel.

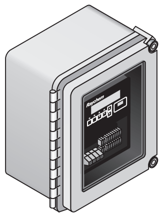
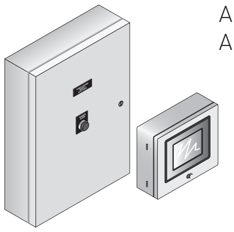
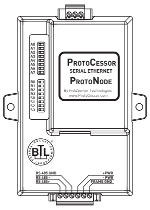
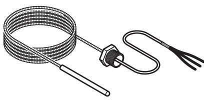
Use the following table to identify the control system suitable for your application. Contact your Thermal Management representative or call (800) 545-6258 for more information and other control options.

TABLE 15 TEMPERATURE CONTROL OPTIONS

Application	Raychem C910-485	Raychem ACS-30
Ambient sensing	x	x
Line sensing	x	x
Buried pipe	x	x
Proportional ambient control	x	x
Fire sprinklers	x	x
Sensor	RTD	RTD
Sensor length	See data sheet	See data sheet
Setpoint range	30°F to 200°F (–1°C to 92°C)	"
Enclosure	NEMA 4X	"
Differential	3°F (1.6°C)	"
Setpoint repeatability	3°F (1.6°C)	"
Enclosure limits	–40°F to 140°F (–40°C to 60°C)	"
Switch rating	30 A	30 A
Switch type	DPST	DPST
Electrical rating	100–277 V	100–277 V
Approvals	c-CSA-us	c-CSA-us
Ground-fault protection	20 mA to 100 mA	20 mA to 100 mA
BMS interface	Standard	Modbus[1]
Alarm outputs	x	x
AC relay dry contact relay	x	x

[1] ProtoNode multi-protocol gateways are available from Thermal Management.

TABLE 16 CONTROL SYSTEMS

	Catalog number	Description
Electronic Controllers and Sensors		
	C910-485	The Raychem C910-485 is a compact, full-featured microprocessor-based single-point heat-trace controller. The C910-485 provides control and monitoring of electrical heat-tracing circuits for both freeze protection and temperature maintenance, and can be set to monitor and alarm for high and low temperature, and ground-fault level. The C910-485 controller is available with an electromechanical relay (EMR). Communications modules are available for remote control and configuration. The Raychem C910-485 includes RS-485 communications module for interfacing with Building Management Systems (BMS) and fire control panels.
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in commercial freeze protection and flow maintenance applications. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers. The ProtoNode-RER is for BACnet® or Metasys® N2 systems.
	RTD-200 RTD3CS RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD3CS: temperature sensor with a 3-ft (0.9 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

Pipe Freeze Protection and Flow Maintenance

1. Determine design conditions and pipe heat loss
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits and accessories
6. Select the control system
7. Complete the Bill of Materials

Step 7 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details necessary complete your Bill of Materials.

INSTALLATION AND MAINTENANCE

Follow the installation and maintenance procedures in the XL-Trace System Installation and Operation Manual (H58033) when installing XL-Trace on fire suppression systems with the following additional instructions.

When installing XL-Trace on sprinklers follow the methods shown below:

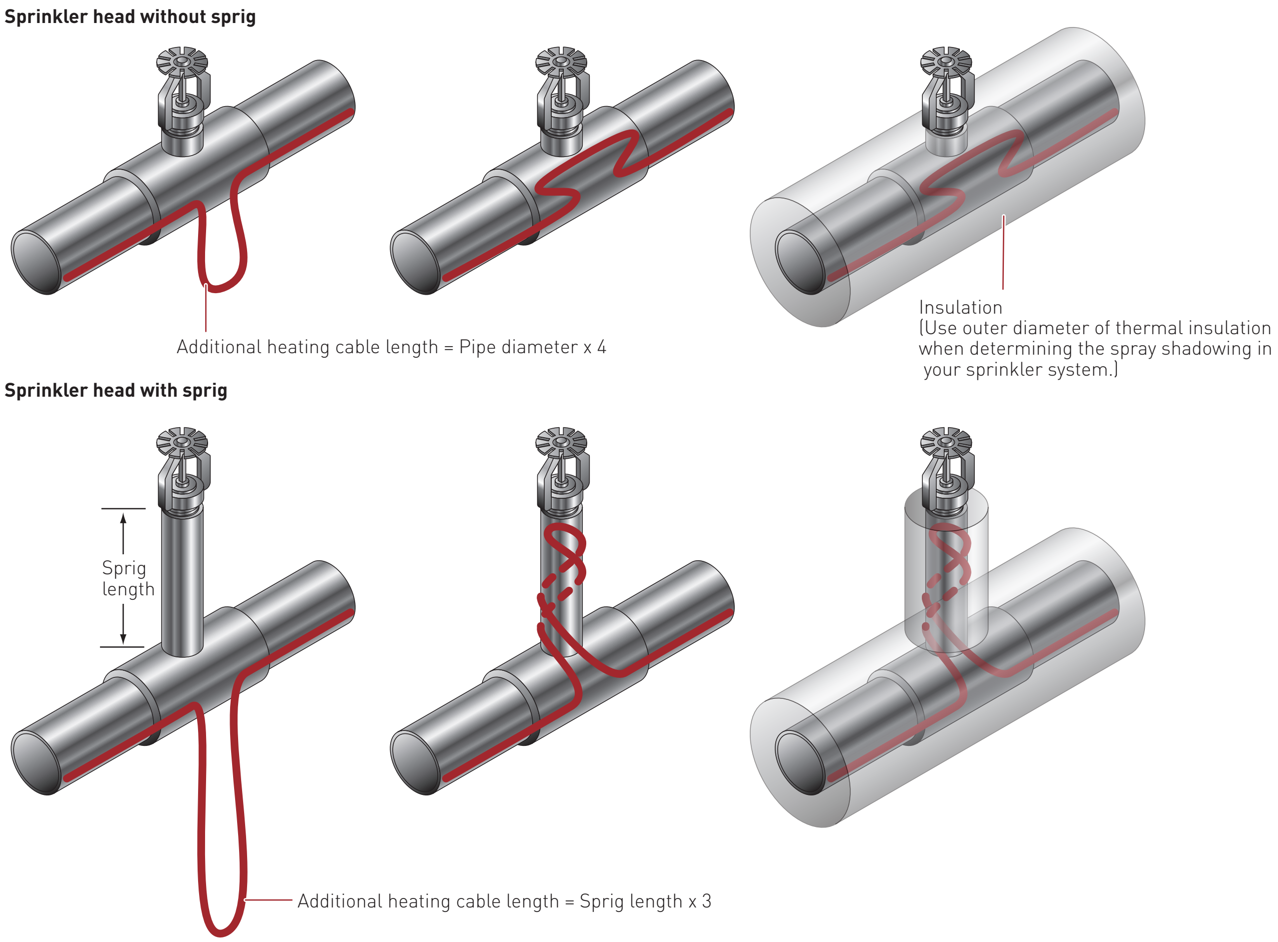


Fig. 14 XL-Trace on sprinklers

Note: The orientation and type of sprinkler head shown above is only for reference. The illustrations only depict the amount of heat tracing required and how to install it.

When installing XL-Trace on dry pendant sprinklers used in freezer applications follow the methods shown below:

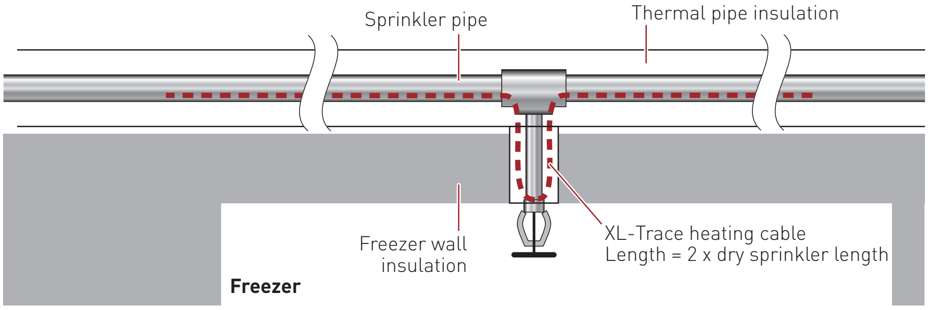


Fig. 15 XL-Trace on extended pendant sprinklers

XL-TRACE SYSTEM FIRE SPRINKLER SYSTEM FREEZE PROTECTION DESIGN WORKSHEET

TraceCalc Pro

TraceCalc Pro for Buildings is an online design tool available to help you create simple or complex heat-tracing designs for pipe freeze protection or flow maintenance applications. It is available at http://www.pentairthermal.com.

Step 1 Determine design conditions and pipe heat loss

Design conditions

Fire sprinkler system	Location		Maintain temp. (T_M)	Min. ambient temp. (T_A)	Pipe diameter and material		Pipe length	Thermal insulation type and thickness	
☐ Supply piping ☐ Standpipe	☐ Indoors ☐ Outdoors	☐ Aboveground ☐ Buried	______	______	____ in	☐ Metal ☐ Plastic	_____ ft (m)	☐ Fiberglass ☐ ________	____ in
☐ Sprinkler piping	☐ Indoors ☐ Outdoors	☐ Aboveground ☐ Buried	______	______	____ in	☐ Metal ☐ Plastic	_____ ft (m)	☐ Fiberglass ☐ ________	____ in
☐ Branchpipe	☐ Indoors ☐ Outdoors	☐ Aboveground	______	______	____ in	☐ Metal ☐ Plastic	_____ ft (m)	☐ Fiberglass ☐ ________	____ in
☐ Branchpipe with sprinkler	☐ Indoors ☐ Outdoors	☐ Aboveground	______	______	____ in	☐ Metal ☐ Plastic	_____ ft (m)	☐ Fiberglass ☐ ________	____ in
Example: **✓ Branch line with sprinkler**	**✓ Indoor**		**40°F**	**50°F**	**1 in**	**✓ Metal**	**200 ft**	**✓ Foam elastomer**	**1/2 in**

Pipe heat loss

Calculate temperature differential ΔT

Pipe maintain temperature (T_M) ______________ °F (°C)

Ambient temperature (T_A) ______________ °F (°C)

$$\underset{T_M}{\underline{\qquad\qquad}} - \underset{T_A}{\underline{\qquad\qquad}} \longrightarrow = \underset{\Delta T}{\underline{\qquad\qquad}}$$

Example: Pipe Freeze Protection – Branch line with sprinkler

Pipe maintain temperature (T_M) 40 °F °F (from Step 1)

Ambient temperature (T_A) 0 °F °F (from Step 1)

$$\underset{T_M}{\underline{40\ °F}} - \underset{T_A}{\underline{0\ °F}} \longrightarrow = \underset{\Delta T}{\underline{40\ °F}}$$

Determine the pipe heat loss: See Table 1 for the base heat loss of the pipe (Q_B). If the ΔT for your system is not listed, interpolate between the two closest values.

$Q_{B\text{-}T1}$ ΔT1 ____________ W/ft (W/m)

$Q_{B\text{-}T2}$ ΔT2 ____________ W/ft (W/m)

Q_B ____________ W/ft (W/m)

Pipe diameter ____________ in

Insulation thickness ____________ in

ΔT ____________ °F (°C)

$Q_{B\text{-}T1}$ ____________ W/ft (W/m)

$Q_{B\text{-}T2}$ ____________ W/ft (W/m)

Example: Pipe Freeze Protection – Branch line with sprinkler

Pipe diameter 1 in

Insulation thickness 1/2 in

ΔT 40°F

$Q_{B\text{-}T1}$ 1.4 W/ft

$Q_{B\text{-}T2}$ 3.5 W/ft

ΔT interpolation ΔT 40°F is 67% of the distance between ΔT 20°F and ΔT 50°F

$Q_{B\text{-}40}$ $Q_{B\text{-}50} + [0.67 \times (Q_{B\text{-}50} - Q_{B\text{-}20})] = 1.4 + [0.67 \times (3.5 - 1.4)] = 2.8$ W/ft

Pipe heat loss (Q_B) **2.8 W/ft @ T_M 40°F (9.2 W/m @ T_M 4°C)**

Compensate for insulation type and pipe location

See Table 1 for the pipe heat loss (Q_B). If the ΔT for your system is not listed, interpolate between the two closest values.
See Table 3 for insulation multiple
See Table 2 for indoor multiple

Location ____________

Insulation thickness and type ____________

Q_B ____________ W/ft (W/m)

Insulation multiple ____________

Indoor multiple (if applicable) ____________

____________ x ____________ x ____________ = ____________

Q_B x Insulation multiple x Indoor multiple (if applicable) = $Q_{CORRECTED}$

Example: Pipe Freeze Protection – Branch line with sprinklers

Location	Indoors
Insulation thickness and type	1-1/2 in foamed elastomer
Q_B	2.8 W/ft @ T_M 40°F (9.2 W/m @ T_M 4°C)
Insulation multiple	1.00
Indoor multiple	0.79
$Q_{CORRECTED}$	2.8 W/ft x 1.0 x 0.79 = 2.2 W/ft @ T_M40°F (7.3/m @ T_M4°C)

Step ❷ Select the heating cable

Power output data: See Fig. 11
Power output correction factors: See Table 4

Pipe maintain temperature (T_M) ______________ (from Step 1)

Corrected heat loss ($Q_{CORRECTED}$) ______________ (from Step 1)

Supply voltage ______________ (from Step 1)

Pipe material (metal or plastic) ______________ (from Step 1)

XL-Trace sprinkler application (from Step 1)
    Indoor/outdoor ______________
    Aboveground/buried ______________

Location ______________ (from Step 1)

Heating cable selected ______________ (from Step 1)

Power at T_M (120/208 V) ______________

Power output correction factor ______________ (from Step 1)

Plastic pipe correction factor ______________

______________ x ______________ = ______________
Power at rated V factor   Plastic pipe correction factor   Corrected power

Is the heating cable power output ($P_{CORRECTED}$) ≥ the corrected heat loss? ☐ Yes ☐ No
If No, then design with additional runs of heating cable or thicker thermal insulation.

Example: Pipe Freeze Protection – Branch line with sprinklers

Maintain temperature (T_M) 40°F

Corrected heat loss ($Q_{CORRECTED}$) 2.2 W/ft @ T_M 40°F

Supply voltage 208 V

Pipe material (metal or plastic) metal
(*AT-180 aluminum tape required for installing heating cable on plastic pipes)

Q_B = 2.2 W/ft @ T_M 40°F
Select curve C: 5XL2 = **5.6 W/ft @ 40°F**
Power output correction factor: 208 V = 1.00
Pipe material correction factor: Metal = 1.00
Corrected heating cable power: 5.6 @/ft x 1.00 x 1.00 = **5.6 W/ft**
Select: **5XL2**

Select outer jacket
☐ -CR
☐ -CT (Required for buried applications)

Example: Pipe Freeze Protection – Branch line with sprinklers

Location Aboveground, indoors

Selection: 5XL2-CR

Step 3 Determine the heating cable length

For additional heating cable allowance for valves: See Table 5

For additional heating cable allowance for pipe supports, flanges and sprinklers: See Table 6.

Additional heating cable for heat sinks

Type of valves	→	How many	x	Additional heating cable	=	**Total heating cable for valves**
Type of pipe supports	→	How many	x	Additional heating cable	=	**Total heating cable for pipe supports**
Type of flanges	→	How many	x	Additional heating cable	=	**Total heating cable for flanges**
Type of sprinklers	→	How many	x	Additional heating cable	=	**Total heating cable for sprinklers**

Total heating cable for heat sinks: ____________

Total heating cable length

(	Pipe length	x	Number of heating cable runs	)	+	Additional cable for valves, pipe supports, flanges, and sprinklers	=	**Total heating cable length required**

Example:

Additional heating cable for heat sinks

Gate valves	→	2	x	2 ft	=	**4 ft**
Type of valves		How many		Additional heating cable		**Total**
Noninsulated hangers	→	10	x	(0.1 ft* x 2) x 10 = 2 ft	=	**1.7 ft**
Type of pipe supports		How many		Additional heating cable (*1-in pipe = 1-in/12-in = 0.1 ft)		**Total**
1 foot springs	→	20	x	3	=	**60 ft**
Type of sprinklers		How many		Additional heating cable		**Total**

Total: **66 ft**

Total heating cable length

(	200 ft	x	1	)	+	66 ft	=	**266 ft**
	Pipe length		Number of heating cable runs			Additional cable for valves, pipe supports, flanges, and sprinklers		**Total heating cable length required**

Step 4 Determine the electrical parameters

Determine maximum circuit length and number of circuits

See Table 7 and Table 8.

Total heating cable length required ____________

Supply voltage: ☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V

Circuit breaker size: ☐ 15 A ☐ 20 A ☐ 30 A ☐ 40 A

Minimum start-up temperature ____________

Maximum circuit length ____________

____________ / ____________ = ____________

Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Example:

Total heating cable length required 266 ft of 5XL2-CT

Supply voltage: ☐ 120 V ☑ 208 V ☐ 240 V ☐ 277 V

Circuit breaker size: ☐ 15 A ☐ 20 A ☑ 30 A ☐ 40 A

Minimum start-up temperature 0°F

Number of circuits 0.67 ft

266 ft / 398 ft = **0.67 circuits, round up to 1**

Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Determine transformer load

See Table 9 and Table 10.

____________ x ____________ x ____________ / 1000 = ____________

Max A/ft* at minimum start-up temperature x Heating cable length x Supply voltage / 1000 = **Transformer load (kW)**

Example:

0.06 A/ft x 266 ft x 208 V / 1000 = **3.3 kW**

Max A/ft* at minimum start-up temperature x Heating cable length x Supply voltage / 1000 = **Transformer load (kW)**

Step 5 Select the connection kits and accessories

See Table 11.

Connection kits – Aboveground	Description	Quantity	Heating cable allowance
☐ RayClic-PC	Power connection and end seal	________	____________
☐ RayClic-PS	Power splice and end seal	________	____________
☐ RayClic-PT	Powered tee and end seal	________	____________
☐ FTC-P	Power connection and end seal	________	____________
☐ RayClic-S	Splice	________	____________
☐ RayClic-T	Tee kit with end seal	________	____________
☐ RayClic-X	Cross connection	________	____________
☐ FTC-HST	Low-profile splice/tee	________	____________
☐ RayClic-LE	Lighted end seal	________	____________
☐ RayClic-E	Extra end seal	________	____________

Connection kits – Buried	Description	Quantity	Heating cable allowance
☐ RayClic-PC	Power connection and end seal	________	____________
☐ FTC-XC	Power splice and end seal	________	____________
☐ RayClic-LE	Lighted end seal	________	____________
☐ RayClic-E	Extra end seal	________	____________

Accessories – Aboveground and buried	Description	Quantity
☐ RayClic-SB-04	Pipe mounting bracket	________
☐ RayClic-SB-02	Wall mounting bracket	________
☐ ETL	"Electric-Traced" label	________
☐ GT-66	Glass cloth adhesive tape	________
☐ GS-54	Glass cloth adhesive tape	________
☐ AT-180	Aluminum tape (for plastic pipes)	________

____

Total heating cable allowance for connection kits

____________ + ____________ = ____________

Total heating cable length + Total heating cable allowance for connection kits = **Total heating cable length required**

Step 6 Select the control system

See Table 16.

Thermostats, controllers and accessories	Description	Quantity
☐ C910-485	Microprocessor-based single-point heat-tracing controller with RS-485 communication	____________
☐ ACS-UIT2	ACS-30 user interface terminal	____________
☐ ACS-PCM2-5	ACS-30 power control panel	____________
☐ ProtoNode-RER	Multi-protocol gateway	____________
☐ RTD3CS	Resistance temperature device	____________
☐ RTD10CS	Resistance temperature device	____________
☐ RTD-200	Resistance temperature device	____________
☐ RTD50CS	Resistance temperature device	____________

Step 7 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

ROOF ICE MELT — RIM SYSTEM

This design guide provides the information necessary to help our design engineers design your Raychem Roof Ice Melt (RIM) system. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

Raychem Roof Ice Melt (RIM) system maintains a continuous path for roof snow melt to drain from the roof through the gutter and downspout and is ideal for the following applications:

- Roofs made from standard roofing materials, including shake, shingle, rubber, tar, wood, metal, and plastic.
- Gutters made from standard materials, including metal, plastic, and wood.
- Downspouts made from standard materials, including metal and plastic.

How to Use this Guide

Our Thermal Management design professionals work with Customers—architects, contractors, or building owners—to understand the design requirements for a project.

This design guide presents the key design and performance data that we need to collect in order to design your system.

For questions, please contact your Thermal Management representative, or call 888.313.5666, or email: RIMCustomerCare@pentair.com.

Warranty

Thermal Management' standard limited warranty applies to Raychem Roof and Gutter De-icing Systems.

20 YEAR Product warranty

An extension of the limited warranty period to twenty (20) years from the date of installation is available, except for the control and distribution systems, if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

The Raychem RIM System is our premier engineered, aesthetically elegant, concealed roof & gutter de-icing solution to prevent ice dams, icicles, and frozen gutter problems. The RIM system mechanically protects the self-regulating cable, provides high power output along the entire roof edge, and is ideal for new construction or renovation of buildings for all snow load areas, for residential or commercial buildings.

RIM System panels secure the heating cables in a fixed heat transfer position. They are specifically designed for eaves, valleys, channels, rakes and flat roof sections and come in a variety of aesthetically pleasing colors and finishes as standard or custom options to meet any project need.

Typically the performance requirements of a system vary based on the severity of the annual snow load and snow accumulation in a given area as well as other design factors, including the weather patterns and temperature cycles, ambient temperatures, wind speeds, lake effects, elevation, northern/southern roof exposures, type of roof and roof material, overhang distance and roof features such as dormers, towers and valleys.

Snow load is the amount of snow on a roof for a large portion of winter, whereas snow accumulation is the actual depth of snow on the ground from a single or series of snow storms. Both conditions play a role in the severity of roof and gutter challenges you may face.

	Annual Snow Load in (cm)	Annual Snow Accumulation in (cm)
Light	under 20 (51)	<6 (15)
Moderate	20 - 100 (51 - 254)	6 - 15 (15 - 38)
Heavy	over 100 (254)	>15 (38)

Typical RIM System

RIM System embeds multiple runs of high wattage IceStop self-regulating heating cable offering the highest performing heating system with the most efficient heat transfer and cable protection. It is designed for heavy snow load areas with roof snow accumulation over 15 inches, and annual snowfall of over 100 inches.

A typical RIM system includes the following:

- RIM panels and connection kits
- Control system
- Power distribution

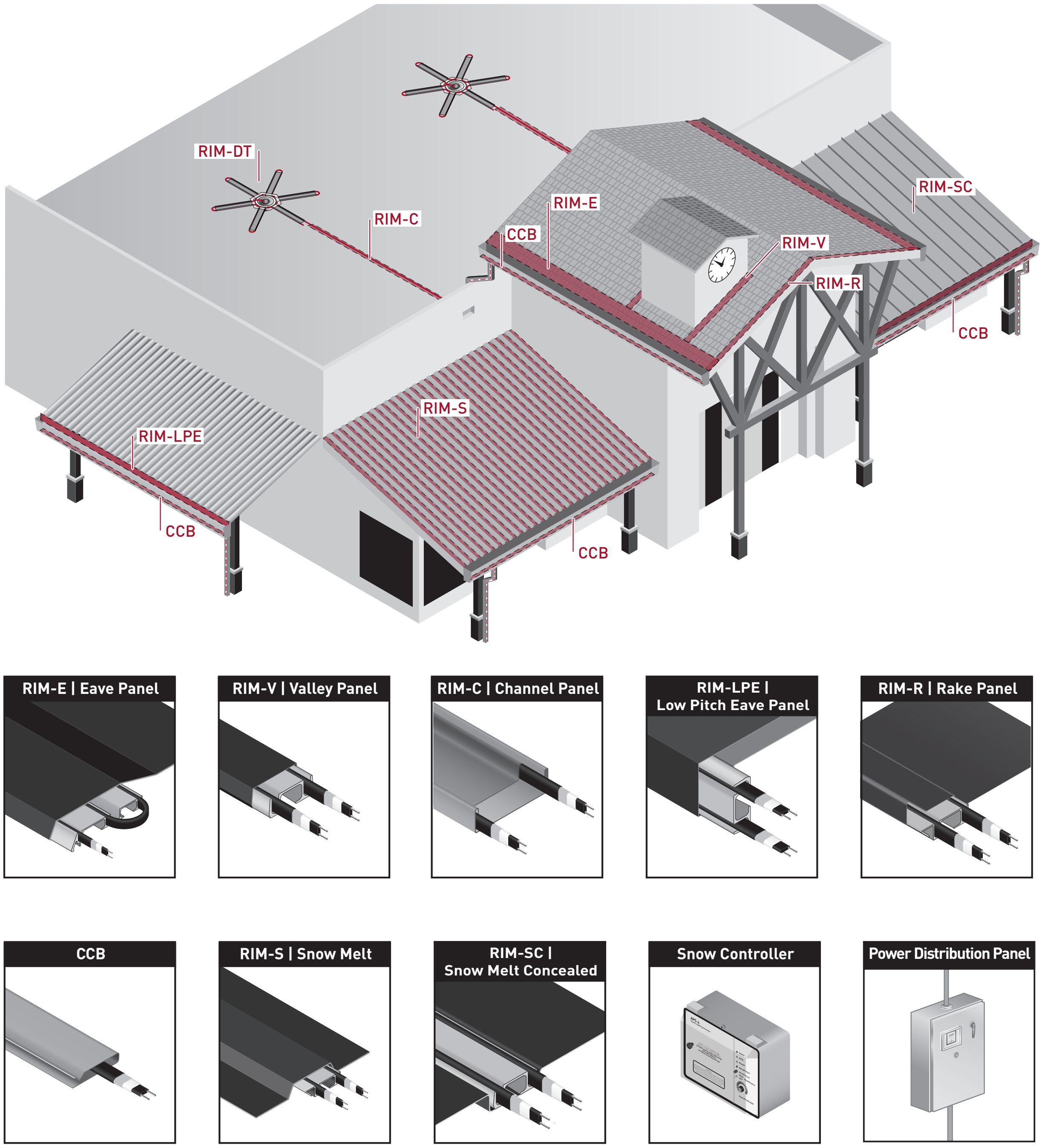

Fig. 1 Typical RIM Roof Ice Melt system

Typical RIM2 System

RIM2 System embeds 2 runs of energy-efficient WFP self-regulating heating cable and is designed for light to moderate snow load areas with roof snow accumulation under 15 inches, and annual snowfall of under 100 inches.

A typical RIM2 system includes the following:

- RIM2 panels and connection kits
- Control system
- Power distribution

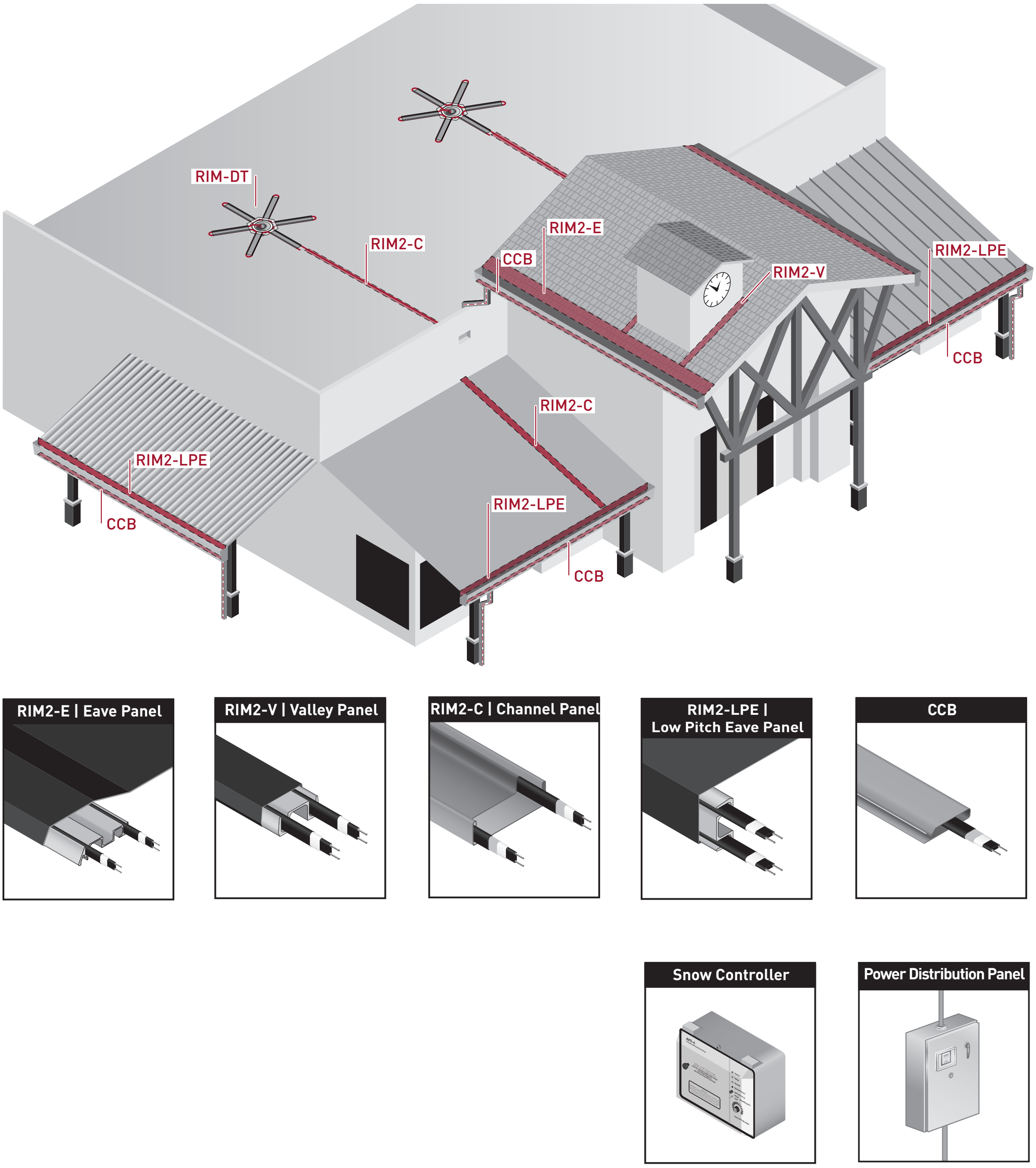

Fig. 2 Typical RIM2 Roof Ice Melt system

ROOF ICE MELT (RIM) DESIGN

Design Step by Step

These simple steps depict how Customers work with Thermal Management design professionals to incorporate Raychem RIM system into a project.

Step 1 Customer Provides Preliminary Design Inputs

For new construction, provide the following to our Thermal Management design professionals:

- Site plan locating walkways, decks and driveways
- Roof plan, power distribution
- Building elevations and recommendations

For retrofits, provide the following to our Thermal Management design professionals

- Complete the Estimate Form that will determine the basis for the design
- For color options with Aluminum cover panel please refer to RIM color guide H59379

Step 2 Thermal Management Prepares a Budgetary System Proposal

- Prepare the design with recommended scope, Raychem RIM materials layout and power requirements.

Step 3 Customer Reviews RIM System Budgetary Proposal

- Review the proposal and either confirm the scope or specify changes to the proposal as needed for the RIM system installation you desire.
- Specify wiring for future RIM System additions, as needed
  (Note: A retrofit RIM system installation can cost 25 – 40%
  more than the cost of installing a RIM system initially)

Step 4 Thermal Management Finalizes the RIM System Proposal

- Implement the requested changes and make any final recommendations that are appropriate, like a control and monitoring solution or any relevant Field Support / Engineering Services that are best suited for the project.

Step 5 Customer Approves Final System Design

Approve the final system design and Field Support / Engineering Services, as applicable.

Step 6 Thermal Management Provides the Materials for the Project

- Supply the RIM materials to the customer, including:
  - Metal base panel for attachment to the roof
  - Safe, self-regulating heating cable
  - Copper or painted aluminum cover panel
  - Accessory components as required (end caps, splice covers, etc.)
  - Appropriate control system, as applicable.
- Provide the following details to the project's Engineer and/or Contractor:
  - Engineering designs and installation instructions
  - Junction box locations (per design recommendations)
  - Control panel loads and location, circuit breaker sizing
  - Material layout plans with circuit design loads and circuit breaker sizing
  - Control panel layout and system testing procedures

Step 7 Field Support Services Provide Project Support, as applicable

- Perform the electrical evaluation/ testing procedure
- Train the installer to install the RIM system
- Commissioning, supervision and troubleshooting

Step 8 Installer Installs and Tests the RIM System

- Install the RIM system per the installation instructions as per design layouts
- Conduct control panel layout and system testing procedures
- Perform commissioning tests and complete warranty documentation

Raychem

Email completed form to your Thermal Management Sales Rep for a complete Bill of Materials and quote!

ROOF & GUTTER SYSTEM ESTIMATE FORM

Need Quote For: ☐ HEATING CABLE SYSTEM ☐ RIM CONCEALED SYSTEM ☐ BOTH

CHECK OUT OUR ONLINE ROOF AND GUTTER DE-ICING DESIGN TOOL at **www.pentairthermal.com**
by selecting the Commercial or Residential segment -> Resources and click on the **Roof & Gutter De-Icing Calculator** design tool.

1. Building Type & Conditions: (check all that apply)	☐ House	☐ Small shop / strip mall	☐ High-rise residential /multi-use bldg.	☐ Commercial building
		☐ New Construction	☐ Retrofit	
		Annual Snow Fall ☐ less than 100 inches	☐ more than 100 inches	
2. Area Name:				
3. Type of Roof:	☐ Sloped Roof Shingle Metal Roof–Seams ☐18" ☐24" ☐ __" ☐ Don't Trace Roof	☐ Sloped Roof Shingle Metal Roof–Seams ☐18" ☐24" ☐ __" ☐ Don't Trace Roof	☐ Sloped Roof Shingle Metal Roof–Seams ☐18" ☐24" ☐ __" ☐ Don't Trace Roof	☐ Sloped Roof Shingle Metal Roof–Seams ☐18" ☐24" ☐ __" ☐ Don't Trace Roof
4. Roof Pitch:	☐Less than 3/12 ☐Equal to or more than 3/12	☐Less than 3/12 ☐Equal to or more than 3/12	☐Less than 3/12 ☐Equal to or more than 3/12	☐Less than 3/12 ☐Equal to or more than 3/12
5. Length of Roof Edge:	________ feet	________ feet	________ feet	________ feet
6. Eave Overhang Distance:	☐ 0" ☐ 12" ☐ 24" ☐ 36" (other) ______ inches	☐ 0" ☐ 12" ☐ 24" ☐ 36" (other) ______ inches	☐ 0" ☐ 12" ☐ 24" ☐ 36" (other) ______ inches	☐ 0" ☐ 12" ☐ 24" ☐ 36" (other) ______ inches
7. Gutters:	Total Length: ________ feet	Total Length: ________ feet	Total Length: ________ feet	Total Length: ________ feet
	Depth: ________ inches	Depth: ________ inches	Depth: ________ inches	Depth: ________ inches
	Width: ________ Inches	Width: ________ Inches	Width: ________ Inches	Width: ________ Inches
	☐ No Gutters	☐ No Gutters	☐ No Gutters	☐ No Gutters
8. Downspouts:	Number of Downspouts: ____	Number of Downspouts: ____	Number of Downspouts: ____	Number of Downspouts: ____
	Average Downspout Length: _____ ft	Average Downspout Length: _____ ft	Average Downspout Length: _____ ft	Average Downspout Length: _____ ft
	☐ Single Run in Downspout ☐ Loop Run in Downspout ☐ No Preference	☐ Single Run in Downspout ☐ Loop Run in Downspout ☐ No Preference	☐ Single Run in Downspout ☐ Loop Run in Downspout ☐ No Preference	☐ Single Run in Downspout ☐ Loop Run in Downspout ☐ No Preference
9. Valleys:	Number of Valleys: ____	Number of Valleys: ____	Number of Valleys: ____	Number of Valleys: ____
	Average Valley Length: _____ ft	Average Valley Length: _____ ft	Average Valley Length: _____ ft	Average Valley Length: _____ ft
10. Voltage:	☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V	☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V	☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V	☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V
11. Circuit Breaker Size:	☐ 15 A ☐ 20 A ☐ 30 A	☐ 15 A ☐ 20 A ☐ 30 A	☐ 15 A ☐ 20 A ☐ 30 A	☐ 15 A ☐ 20 A ☐ 30 A
12. RIM Cover Panel:	☐ Kynar® Painted Aluminum ☐ Copper	☐ Kynar® Painted Aluminum ☐ Copper	☐ Kynar® Painted Aluminum ☐ Copper	☐ Kynar® Painted Aluminum ☐ Copper
13. Controllers:	☐ Ambient Temperature Only ☐ Ambient & RIM Panel Temperature (HECS) ☐ Gutter Moisture & Temperature Sensor	☐ Ambient Temperature Only ☐ Ambient & RIM Panel Temperature (HECS) ☐ Gutter Moisture & Temperature Sensor	☐ Ambient Temperature Only ☐ Ambient & RIM Panel Temperature (HECS) ☐ Gutter Moisture & Temperature Sensor	☐ Ambient Temperature Only ☐ Ambient & RIM Panel Temperature (HECS) ☐ Gutter Moisture & Temperature Sensor
14. Notes:				
15. Customer name:				
Company:				
Phone:				
Email:				
Project name:				
Project location:			**BUSINESS CARD**	

Raychem

ROOF AND GUTTER DE-ICING — ICESTOP SYSTEM

This step-by-step design guide provides the tools necessary to design a Raychem IceStop roof and gutter de-icing system. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

Raychem IceStop is a roof and gutter de-icing system that provides drain paths for the following applications:

- Roofs made from standard roofing materials, including shake, shingle, rubber, tar, wood, metal, and plastic.
- Gutters made from standard materials, including metal, plastic, and wood.
- Downspouts made from standard materials, including metal and plastic.

The guide does **not** cover applications in which any of the following conditions exist:

- Preventing snow movement on roofs — IceStop will not keep snow or ice from falling off the roof. IceStop is designed to remove melt water, not accumulated snow. Snow fences or snow guards should be used to eliminate snow movement.
- Melting snow on a roof and/or reduction of snow load — IceStop is designed to remove melt water, not accumulated snow.

If your application conditions are different, or if you have any questions, contact your Thermal Management representative, or call (800) 545-6258.

How to Use this Guide

This design guide presents Thermal Management's recommendations for designing an IceStop roof and gutter de-icing system. It provides design and performance data, electrical sizing information, and heating-cable layout suggestions. Following these recommendations will result in a reliable, energy-efficient system.

OTHER REQUIRED DOCUMENTS

This guide is not intended to provide comprehensive installation instructions. For complete IceStop roof and gutter de-icing system installation instructions, please refer to the following additional required documents:

- IceStop System Installation and Operation Manual (H58067)
- Additional installation instructions that are included with the connection kits, thermostats, controllers, and accessories

If you do not have these documents, you can obtain them from the Thermal Management web site at www.pentairthermal.com.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system components could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

✎ This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

Thermal Management' standard limited warranty applies to Raychem Roof and Gutter De-icing Systems.

An extension of the limited warranty period to ten (10) years from the date of installation is available, except for the control and distribution systems, if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

The Raychem IceStop system can prevent ice dams and icicles by maintaining a continuous path for melt water to drain from the roof. The IceStop system uses a self-regulating heating cable which reduces heat output automatically as the cable warms to above freezing, resulting in lower energy use, and eliminating the possibility of overheating. A typical roof and gutter de-icing system includes the IceStop self-regulating heating cables, connection kits, control system and power distribution.

Typical System

A typical system includes the following:

- IceStop self-regulating heating cable
- Connection kits and accessories
- Control system
- Power distribution

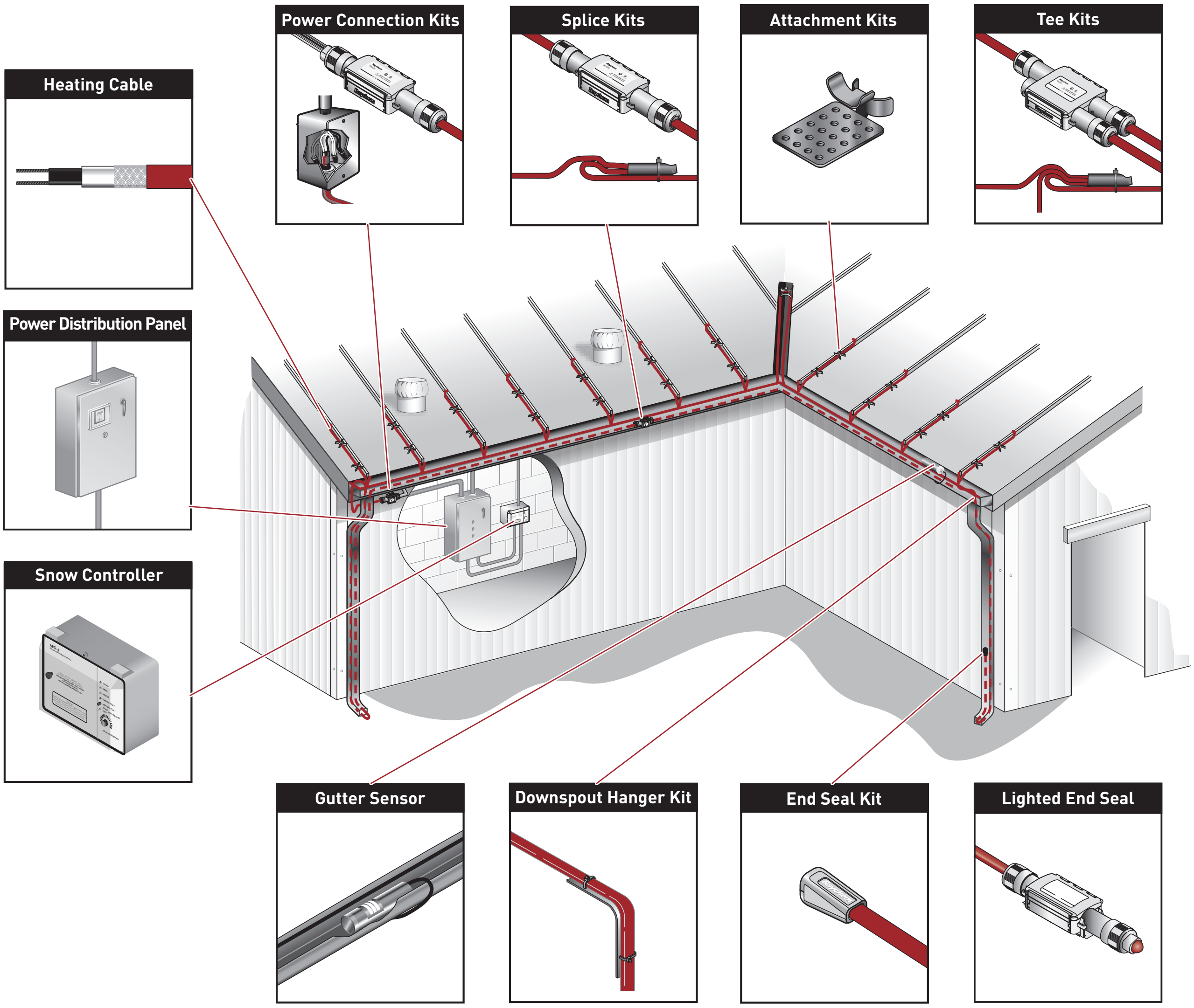


Fig. 1 Typical IceStop roof and gutter de-icing system

Self-Regulating Heating Cable Construction

Raychem IceStop self-regulating heating cables are comprised of two parallel nickel-coated bus wires in a cross-linked polymer core, a tinned copper braid and a fluoropolymer or polyolefin outer jacket. These cables are cut to length simplifying the application design and installation.

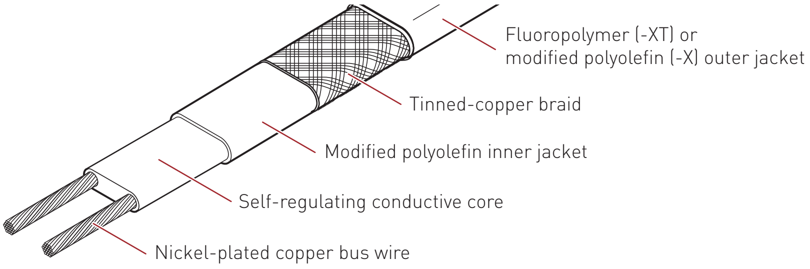


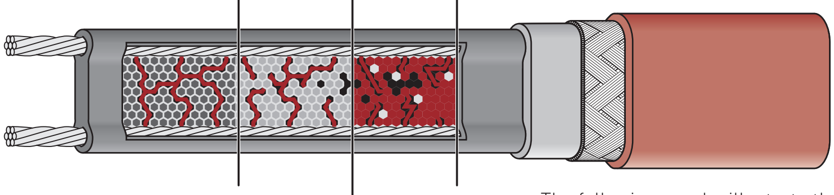
Fig. 2 IceStop heating cable construction

With self-regulating technology, the number of electrical paths between bus wires changes in response to temperature fluctuations. As the temperature surrounding the heater decreases, the conductive core contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core.

As the temperature rises, the core expands microscopically. This expansion increases electrical resistance and the number of electrical paths decreases. The heating cable automatically begins to reduce its output.

At low temperature, there are many conducting paths, resulting in high output and rapid heat-up. Heat is generated only when it is needed and precisely where it is needed.

At high temperature, there are few conducting paths and output is correspondingly lower, conserving energy during operation.



At moderate temperature, there are fewer conducting paths because the heating cable efficiently adjusts by decreasing output, eliminating any possibility of overheating.

The following graphs illustrate the response of self-regulating heating cables to changes in temperature. As the temperature rises, electrical resistance increases, and our heaters reduce their power output.

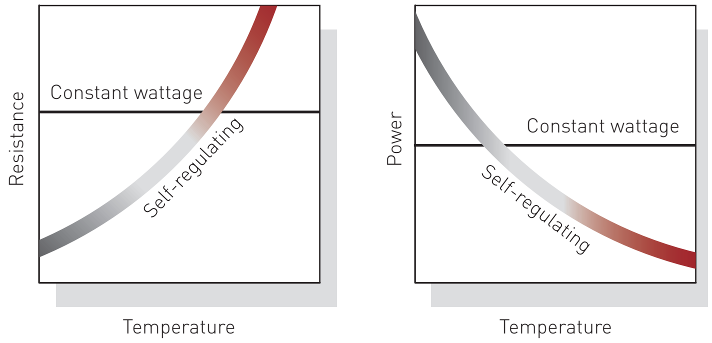


Fig. 3 Self-regulating heating cable technology

Approvals

The IceStop roof and gutter de-icing system is UL Listed, CSA Certified, and FM Approved for use in nonhazardous locations. GM-1XT and GM-2XT are FM Approved for use in Class I, Division 2 hazardous locations.

-WS

ROOF AND GUTTER DE-ICING DESIGN

This section details the design steps necessary to design your application. The example provided in each step is intended to incrementally illustrate the project parameter output for a sample design from start to finish. As you go through each step, use the "IceStop System Roof and Gutter De-Icing Design Worksheet" on page 128, to document your project parameters, so that by the end of this section, you will have the information you need for your Bill of Materials.

Roof & Gutter De-Icing Calculator is an online design tool available to help you create roof & gutter designs and layouts. It is available at http://www.pentairthermal.com.

Design Step by Step

1. Determine design conditions
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits
6. Select attachment accessories and method
7. Select the control system and power distribution
8. Complete the Bill of Materials

Roof and Gutter De-Icing

1. Determine design conditions
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits
6. Select attachment accessories and method
7. Select the control system and power distribution
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Step 1 Determine design conditions

Collect the following information to determine your design conditions:

- Type of roof
- Layout
  - Roof edge
  - Eave overhang
  - Gutters
    - Length
    - Depth
    - Width
  - Roof valley
  - Roof/wall intersections
  - Downspouts
- Supply voltage
- Minimum start-up temperature
- Control method

PREPARE SCALE DRAWING

Draw to scale the roof of the building noting roof valleys, different roof levels and gutter and downspout locations. Note rating and location of voltage supply. Measurements for each distinct section of the roof system, the gutters and the downspouts, will allow for an accurate systems design, including control configuration.

Example: Roof and Gutter De-Icing System

Type of roof	Sloped roof – standard with wood shingles and gutters
Layout	
Roof edge	50 ft (15.2 m) x 2 roof edges = 100 ft (30.5 m)
Eave overhang	24 inch (60 cm)
Gutters	2 gutters
Length	50 ft (15.2 m) x 2 roof edges = 100 ft (30.5 m)
Depth	6 in (15 cm)
Width	4 in (11 cm)
Roof valley	20 ft (6.1 m)
Downspouts	12 ft (3.7 m) x 2 downspouts = 24 ft (7.4 m)
Supply voltage	208 V
Minimum start-up temperature	20°F (–7°C)
Control method	Automatic controller

Roof and Gutter De-Icing

1. Determine design conditions
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits
6. Select attachment accessories and method
7. Select the control system and power distribution
8. Complete the Bill of Materials

Step 2 Select the heating cable

To select the appropriate IceStop heating cable for your application, use the supply voltage from Step 1, and select the appropriate outer jacket material. Once you select these, you will be able to determine the catalog number for your cable.

HEATING CABLE CATALOG NUMBER

Before beginning, take a moment to understand the structure underlying the heating cable catalog numbers. You will refer to this numbering convention throughout the product selection process. Select the appropriate heating cable catalog number based on the voltage and outer jacket, as indicated below.

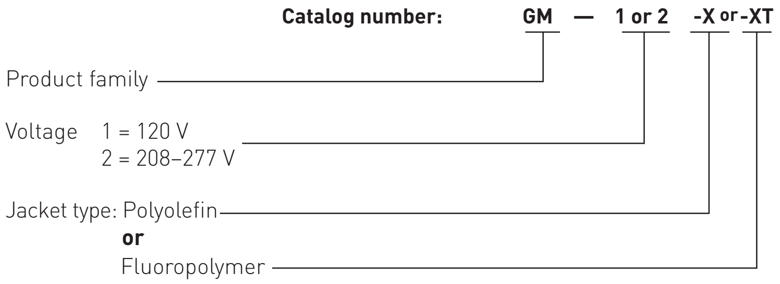


Fig. 4 Heating cable catalog number

SELECT HEATING CABLE SUPPLY VOLTAGE

Select the heating cable supply voltage. Note that a higher supply voltage will allow for longer circuit lengths. Supply voltage options include:

1 = 120 V
2 = 208–277 V

EVALUATE HEATING CABLE SPECIFICATIONS

Use the following table to evaluate heating cable specifications that describe some important aspects of the heating cable.

TABLE 1 ICESTOP SELF-REGULATING HEATING CABLE SPECIFICATIONS

Power output (nominal)	12 W/ft (39 W/m) in ice or snow
Minimum installation temperature	0°F (–18°C)
Minimum bend radius	5/8 in (16 mm)

SELECT OUTER JACKET

Select the appropriate heating cable outer jacket for the application. Jacket options include:

-X	A polyolefin outer jacket (-X) is more economical for less demanding applications.
-XT	A fluoropolymer outer jacket (-XT) provides maximum abrasion, chemical, and mechanical resistance.

Example: Roof and Gutter De-Icing System

Supply voltage	208 V (from Step 1)
Catalog number	**GM-2XT**

Roof and Gutter De-Icing
1. Determine design conditions
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits
6. Select attachment accessories and method
7. Select the control system and power distribution
8. Complete the Bill of Materials

Step 3 Determine the heating cable length

To determine the required heating cable length for your application, you will need to determine the heating cable layout for each roof and gutter section that requires ice protection. Detailed sketches of the building from Step 1 can ensure each area and level is accounted for. The following guide will help determine length of cable required for a variety of roof types and sections. For applications not covered in this section, please contact Thermal Management for assistance.

Heating cable layout depends primarily on the roof type and its related roof features. The following sections show typical layouts on standard roof types

TABLE 2 ROOF TYPES AND AREAS

Roof type	Page
Sloped roof – standard	page 103
Sloped roof – standing seam	page 104
Flat roof	page 105
Sloped roof without gutters	page 106
Roof features	
Roof valley	page 107
Roof/wall intersections	page 107
Gutters	page 108
Downspouts	page 109

Important: For optimum performance, the heating cable should be in contact with snow or ice. Installing the heating cable under the roofing or the roofing materials will reduce the efficiency of the heating system. Please contact Thermal Management for assistance.

Fig. 5 and Fig. 6 below illustrate several important terms:

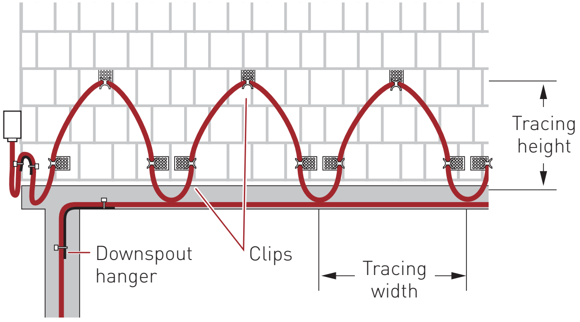


Fig. 5 Front view of roof with IceStop system

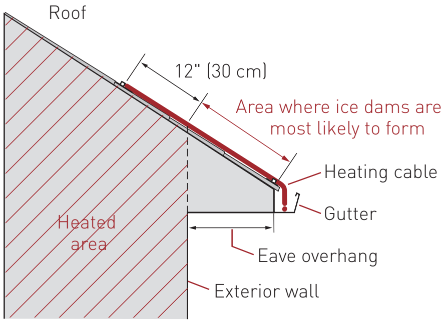


Fig. 6 Side view of roof with IceStop system

SLOPED ROOF — STANDARD

For sloped roofs, ice dams may form at the roof edge. To maintain a continuous path for melt water runoff, route the heating cable in a zig-zag pattern as shown in Fig. 7 and follow the appropriate attachment recommendations in “Step 6 Select attachment accessories and method”. Additional heating cable may be needed for other gutters, downspouts, and valleys.

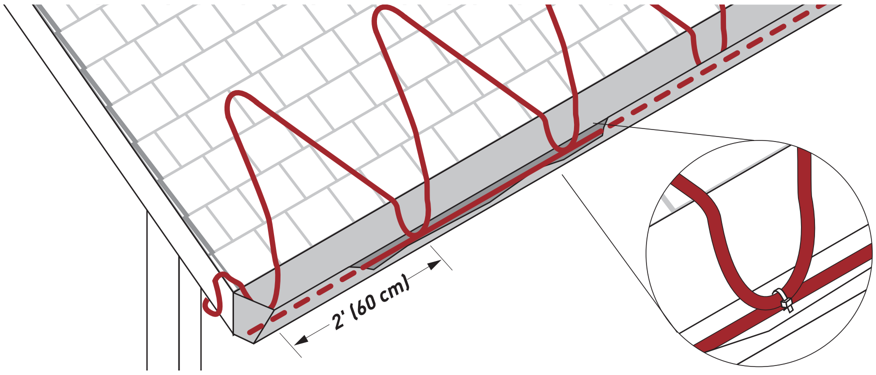


Fig. 7 Layout in a zig-zag pattern

- Install the heating cable on the roof in a zig-zag pattern as shown in Fig. 7.
- Run heating cable up the roof until it is 12 inches (30 cm) past the exterior wall into the heated area (see Fig. 6 on page 102).
- Use Table 3 to determine how much heating cable to use per foot of roof edge. This will determine how much heating cable you need to trace on the roof. Additional heating cable will be needed for gutters, downspouts, and component connections.

TABLE 3 ICESTOP HEATING CABLE LENGTH FOR SLOPED ROOF – STANDARD

Eave overhang distance	Tracing width	Tracing height	Feet of heating cable per foot of roof edge	Meters of heating cable per meter of roof edge
0	2 ft (60 cm)	12 in (30 cm)	2.5 ft	2.5 m
12 in (30 cm)	2 ft (60 cm)	24 in (60 cm)	3.1 ft	3.1 m
24 in (60 cm)	2 ft (60 cm)	36 in (90 cm)	4.2 ft	4.2 m
36 in (90 cm)	2 ft (60 cm)	48 in (120 cm)	5.2 ft	5.2 m

For roofs without gutters, add 6 inches of heating cable per foot of roof edge (0.5 meters of heating cable per meter of roof edge) to allow for a 2–3 inch (5–8 cm) drip loop to hang off the roof edge as shown in Fig. 10 on page 106.

For roofs with gutters, heating cable must be run to the bottom of the gutter. You can determine the amount of extra heating cable required by adding twice the gutter depth per foot of roof edge to the amount determined in Table 3.

For example, for a 6 inch deep gutter, add 1 foot of heating cable per foot of roof edge to the amount determined using Table 3.

Additional heating cable must be run along the bottom of the gutter. See “Gutters” on page 108.

Note: Attachment methods are not shown in Fig. 7. For attachment methods, proceed to “Step 6 Select attachment accessories and method”.

SLOPED ROOF — STANDING SEAM

For sloped standing-seam metal roofs, ice dams may form at the roof edge. To maintain a continuous path for melt water to run off, route the heating cable along the seams as shown in Fig. 8 and follow the attachment recommendations in "Step 6 Select attachment accessories and method" on page 115. Additional heating cable may be needed for gutters, downspouts, and valleys.

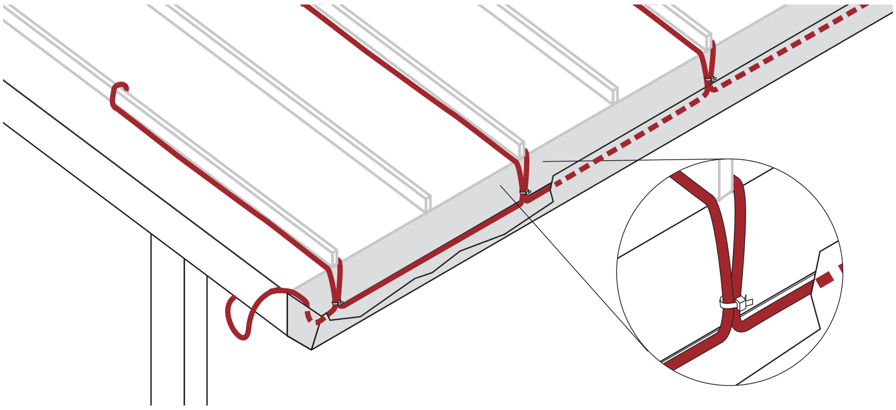


Fig. 8 Layout on a standing seam roof

- Run the heating cable up one side of the seam, loop it over to the other side, and return it to the bottom of the gutter. Continue along the bottom of the gutter to the third seam and repeat the process (Fig. 8 on page 104). If the seams are more than 24 inches (60 cm) apart, trace every seam.
- Run the heating cable up the seam until it is 12 inches (30 cm) past the exterior wall and into a heated area, Fig. 6 on page 102.
- If the roofing materials continue down the fascia, contact your local Thermal Management representative or Thermal Management directly for design assistance.
- If there are no gutters, refer to "Heated Drip Edges" on page 120, for information on how to install heating cable for this application.

TABLE 4 ICESTOP HEATING CABLE LENGTH FOR SLOPED ROOF – STANDING SEAM

Eave overhang distance	Standing seam spacing	Tracing height	Feet of heating cable per foot of roof edge	Meters of heating cable per meter of roof edge
12 in (30 cm)	18 in (45 cm)	24 in (60 cm)	2.8 ft	2.8 m
24 in (60 cm)	18 in (45 cm)	36 in (90 cm)	3.6 ft	3.6 m
36 in (90 cm)	18 in (45 cm)	48 in (120 cm)	4.3 ft	4.3 m
12 in (30 cm)	24 in (60 cm)	24 in (60 cm)	2.4 ft	2.4 m
24 in (60 cm)	24 in (60 cm)	36 in (90 cm)	2.9 ft	2.9 m
36 in (90 cm)	24 in (60 cm)	48 in (120 cm)	3.6 ft	3.6 m

For standing seam roofs without gutters, add 6 inches (0.1 meter) of heating cable for each seam traced to allow for a 2–3 inch (5–8 cm) drip loop to hang off the roof edge as shown in Fig. 10.

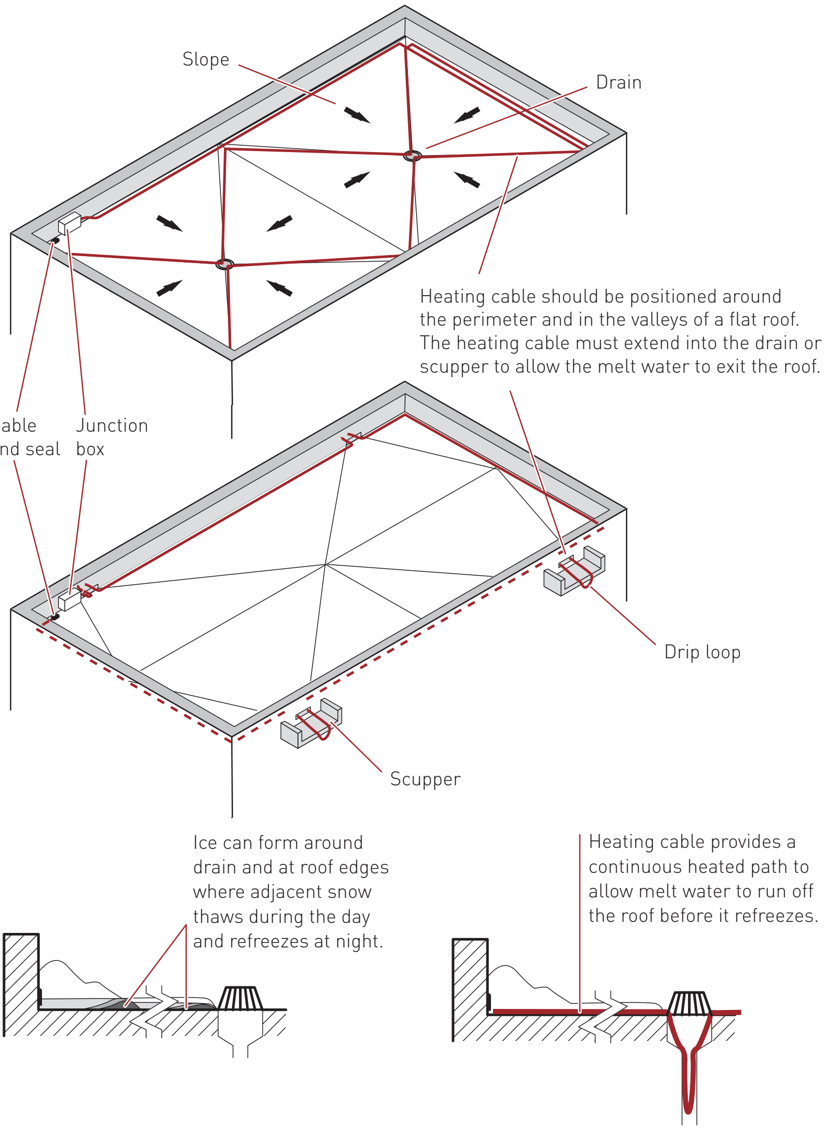
For standing seam roofs with gutters, heating cable must be run to the bottom of the gutter. You can determine the amount of extra heating cable required by adding twice the gutter depth per seam traced to the amount determined in Table 4.

Additional heating cable will be needed for component connections and downspouts.

Note: Attachment methods are not shown in Fig. 8. For attachment methods, proceed to "Step 6 Select attachment accessories and method" on page 115.

FLAT ROOF

Ice dams may occur on flat roofs at the edge flashing and at drains. Flat roofs are typically pitched toward drains and these paths often become obstructed by snow and ice. To maintain a continuous path for melt water to run off, route the heating cable as shown in Fig. 9 and follow the appropriate attachment recommendations in “Step 6 Select attachment accessories and method” on page 115. Additional heating cable may be needed for downspouts.



Heating cable should be positioned around the perimeter and in the valleys of a flat roof. The heating cable must extend into the drain or scupper to allow the melt water to exit the roof.

Ice can form around drain and at roof edges where adjacent snow thaws during the day and refreezes at night.

Heating cable provides a continuous heated path to allow melt water to run off the roof before it refreezes.

Fig. 9 Layout on a flat roof

- Place heating cable around perimeter.
- Trace valleys from perimeter to drain.
- Extend heating cable into internal downspouts at least 12 inches (30 cm) into heated space.
- External downspouts and scuppers must be treated carefully. A path must be provided for the valley/perimeter heating cable to the point of discharge (see Fig. 17 on page 109).
- To avoid damage, do not walk on the heating cable.

SLOPED ROOF WITHOUT GUTTERS

When gutters are not used on a building, ice dams may form at the roof edge. To maintain a continuous path for melt water to run off, a drip loop or heated drip edge may be used. Drip loops and drip edges allow water to drip free of the roof edge.

Route the heating cable as shown in Fig. 10 or Fig. 11 below and follow the appropriate attachment recommendations in "Step 4 Determine the electrical parameters" on page 110. Additional heating cable may be needed for valleys.

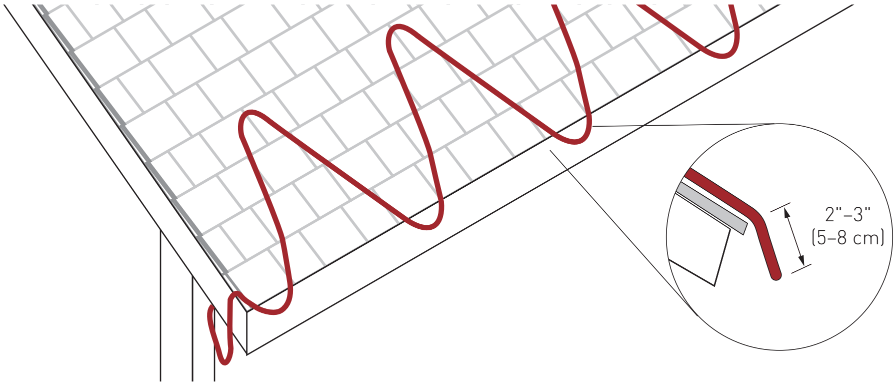


Fig. 10 Layout for heated drip loops

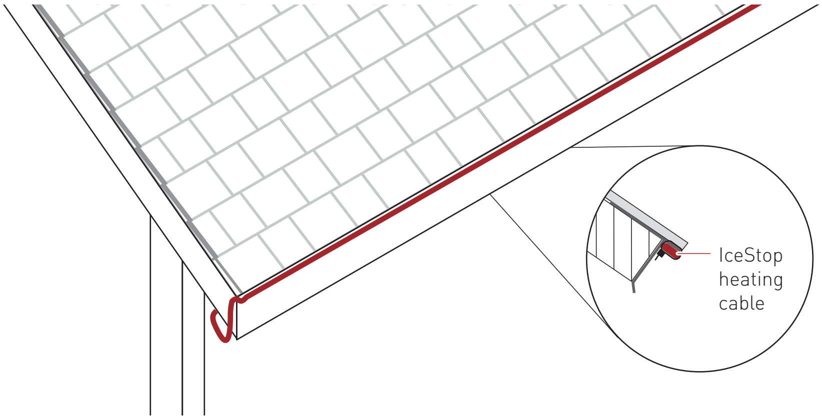


Fig. 11 Layout for heated drip edge

Note: Attachment methods are not shown in the above illustrations. For attachment methods, proceed to "Step 6 Select attachment accessories and method" on page 115.

OTHER CONSIDERATIONS

- Ice will build up on the surfaces below the drip loop or drip edge if gutters are not used.
- Ice may also build up on the vertical surfaces if there isn't a sufficient overhang or if there is a strong wind. Using a gutter system will prevent this ice buildup.

ROOF VALLEYS

Ice dams may form at the valley on a roof where two different slopes meet. To maintain a continuous path for melt water, run the heating cable up and down the valley as shown in Fig. 12 and follow the appropriate attachment recommendations in "Step 6 Select attachment accessories and method" on page 115. Additional heating cable may be needed for the roof surface, gutters, and downspouts.

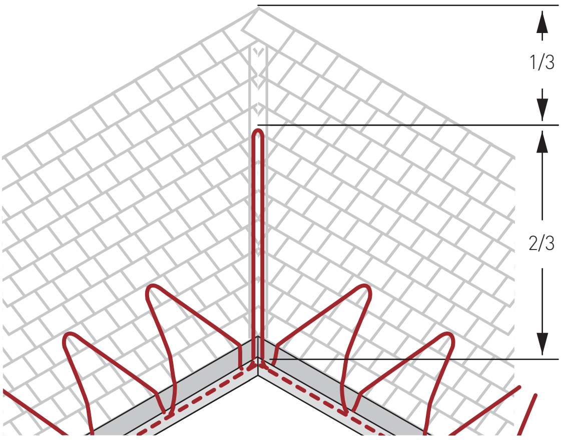


Fig. 12 Layout for a roof valley

- Trace two-thirds of the way up each valley with a double run of heating cable (loop up and back once).
- The heating cable must extend into the gutter. If you don't have gutters, the heating cable should extend over the edge 2 to 3 inches (5 to 8 cm) to form a drip loop.
- For attachment methods, proceed to "Step 6 Select attachment accessories and method" on page 115.

ROOF/WALL INTERSECTIONS

Roof/wall intersections can be treated in the same manner as valleys. Snow has a tendency to collect at this interface. Providing a loop of heating cable two-thirds of the way up the slope will provide a path for the extra melt water in this area to escape.

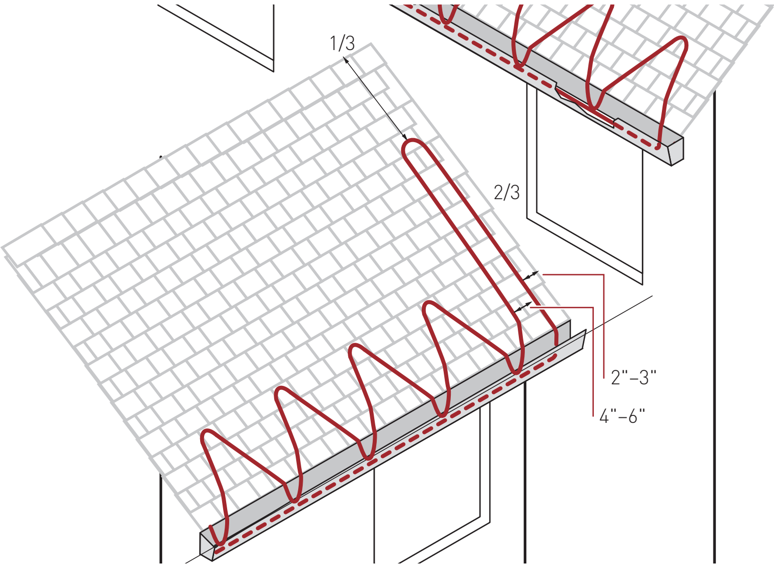


Fig. 13 Layout for a roof/wall intersection.

- Extend a loop of heating cable two-thirds of the way up the slope adjacent to the wall.
- Position the closest heating cable approximately 2 to 3 inches (5 to 8 cm) from the wall. Position the second heating cable 4 to 6 inches (10 to 16 cm) from the first.

GUTTERS

Ice may accumulate in gutters and at the roof edge. To maintain a continuous path for melt water to run off, route the heating cable as shown in Fig. 14 below. Additional heating cable may be needed for the roof surface, downspouts, and valleys.

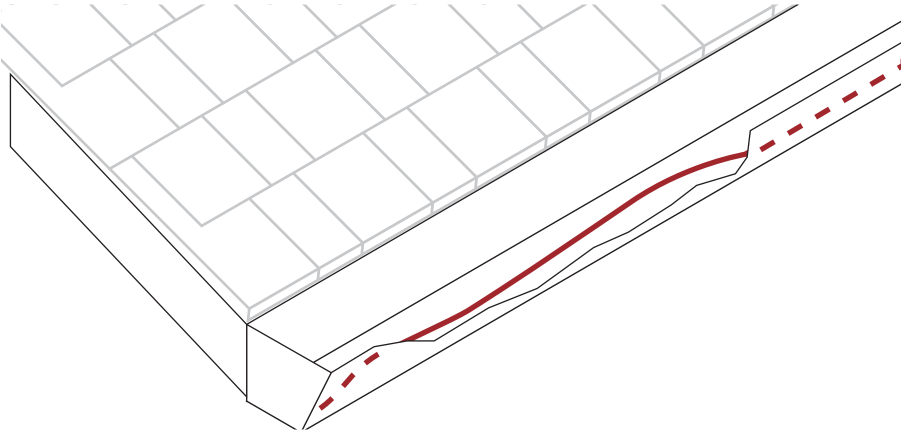


Fig. 14 Layout in standard gutters — up to 6" (16 cm) wide

- Use one run of heating cable in the gutter.
- No attachment to gutter is normally required. If attachment is desired, use a roof clip such as a Raychem GMK-RC clip.
- Continue heating cable down the inside of the downspout. See "Downspouts," page 109, for more information.

In wide gutters, snow and ice can bridge over the tunnel created by a single heating cable and prevent melt water from getting into the gutter and downspouts. To maintain a continuous path for melt water to run off, run the heating cable in the gutter as shown in Fig. 15 below and follow the appropriate attachment recommendations in "Step 6 Select attachment accessories and method" on page 115. Additional heating cable may be needed for the roof surface, downspouts, and valleys.

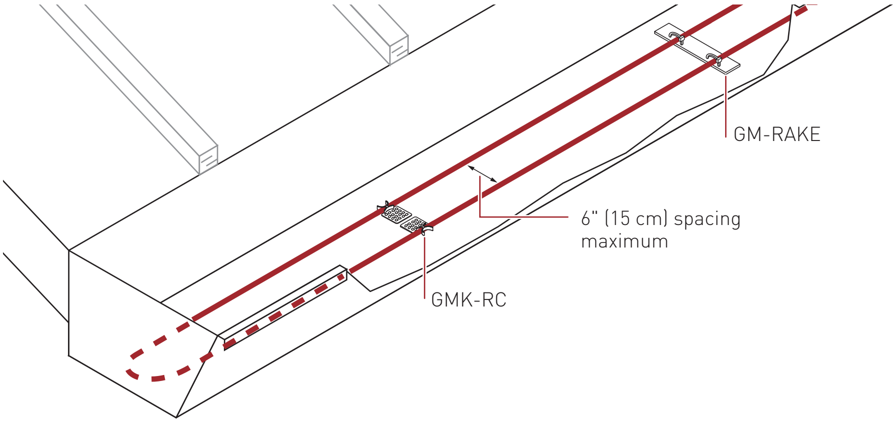


Fig. 15 Layout in wide gutters — 6" to 12" (16 to 31 cm) wide

- Use two parallel runs of heating cable. Separate the two runs of heating cable with a pair of GMK-RC clips or a single GM-RAKE downspout hanger bracket.
- No attachment to the gutter is normally required. If attachment is desired, use a GMK-RC with appropriate adhesive.
- Continue heating cable down the inside of the downspout. See "Downspouts," page 109 for more information.

DOWNSPOUTS

Ice may form in downspouts and prevent melt water from escaping from the roof. To maintain a continuous path for melt water to run off, run the heating cable inside the downspout to the end as shown in Fig. 16 and Fig. 17 below. Follow the appropriate attachment recommendations in "Step 6 Select attachment accessories and method" on page 115. Additional heating cable may be needed for the roof surface, gutters, and valleys.

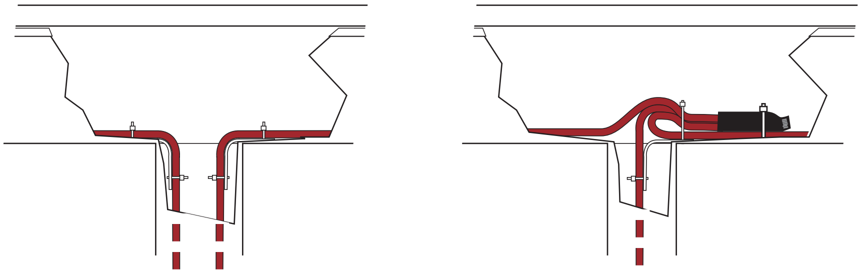
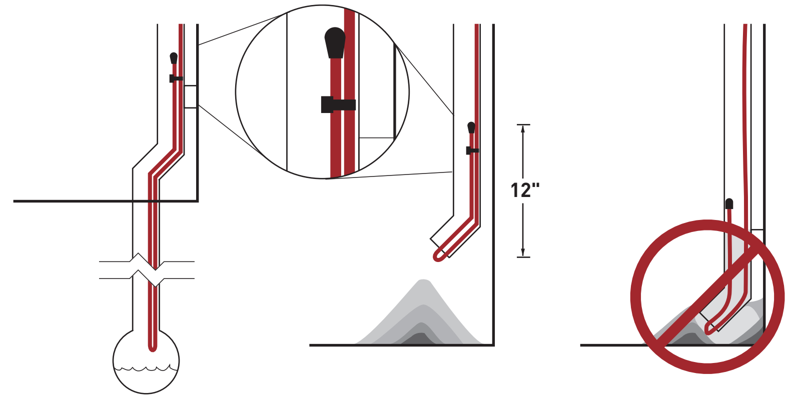


Fig. 16 Heating cable at top of downspout



Drain removes melt water below the frost line.

Accumulated ice can be removed.

Accumulated ice may block drains.

Fig. 17 Heating cable at bottom of downspout

- If the downspout ends underground, the heating cable should extend into a heated area or below the frost line.
- For low water-flow situations, teeing the heating cable so that a single run goes down the downspout is usually sufficient. For high water-flow situations, where ambient temperatures often fall below –10°F (–23°C), or where it isn't convenient to tee the heating cable, use two runs by running the heating cable down to the bottom and then back to the top.
- Leave drip loops below the downspout at bottom.
- If a single run of heating cable is used, the end seal should be looped back up at least 12 inches (30 cm) inside the downspout.
- If the downspout ends near the ground, water will refreeze on the ground and build up around the downspout, eventually blocking the opening.

⚠ **WARNING:** To prevent mechanical damage, do not leave the end seal exposed at the end of the downspout.

Example: Roof and Gutter De-Icing System

Type of roof	Sloped roof – standard with wood shingles and gutters (from 1)
Layout	
Roof edge	100 ft (30.5 m) (from Step 1)
Eave overhang	24 inch (60 cm) (from Step 1) Requires 4.2 ft of heating cable per foot of roof edge (4.2 m per meter of roof edge). See Table 2.
Gutters	
Length	100 ft (30.5 m) (from Step 1) = **100 ft (30.5 m)** heating cable
Depth	6 in (11 cm) x 2 (from Step 1) = 1 foot of additional heating cable 4.2 ft + 1 ft = 5.2 ft x 100 ft = **520 ft (158.5 m)** heating cable
Width	4 in (from Step 1) therefore single run of heating cable at indicated gutter length
Roof valley	20 ft (6.1 m) (from Step 1) x 1.33 = 26.6 = rounded to **27 ft (8.3 m)** heating cable
Downspouts	Two 12 ft (3.7 m) (from Step 1) = **26 ft (8.0 m)** heating cable (Single runs in each downspout with 1 ft (0.3 m) loop back from bottom)
Total heating cable length	**673 ft (205.2 m)**

Additional heating cable will be required for connection kits. After determining kit requirements, heating cable allowances for each will be added to total heating cable length for Bill of Materials.

Roof and Gutter De-Icing

1. Determine design conditions
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits
6. Select attachment accessories and method
7. Select the control system and power distribution
8. Complete the Bill of Materials

Step 4 Determine the electrical parameters

This section will help you determine the electrical parameters for an IceStop system including circuit breaker sizing and maximum circuit length. Total required heating cable length divided by maximum heating cable circuit length will determine the number of circuits required for your snow melting solution.

DETERMINE MAXIMUM CIRCUIT LENGTH

To determine maximum circuit length, it is important to establish a minimum startup temperature for the system. Table 5 provides maximum circuit lengths based on minimum startup temperature, circuit breaker rating and supply voltage. Colder temperature startup requires shorter maximum circuit lengths. The use of an automatic system, which energizes the system above 20°F (–7°C), ensures that you can use maximum circuit lengths. Manual control systems may require you to use shorter circuit lengths to compensate for startup below 20°F (–7°C).

Select the smallest appropriate circuit breaker size. A 30-mA ground-fault protection device (GFPD) must be used to provide protection from arcing or fire, and to comply with warranty requirements, agency certifications, and national electrical codes. If the heating cable is improperly installed, or physically damaged, sustained arcing or fire could result. If arcing does occur, the fault current may be too low to trip conventional circuit breakers.

TABLE 5 MAXIMUM CIRCUIT LENGTH IN FEET (METERS)

Heating cable	Start-up temperature		Circuit breaker size 15 A		20 A		30 A		40 A [1]		Max. A/ft	(A/m)
GM-1X and -1XT at 120 V	32°F	(0°C)	100	(30)	135	(41)	200	(61)	–		0.120	(0.394)
	20°F	(–7°C)	95	(29)	125	(38)	185	(56)	200	(61)	0.126	(0.414)
	0°F	(–18°C)	80	(24)	100	(30)	155	(47)	200	(61)	0.150	(0.492)
GM-2X and -2XT at 208 V	32°F	(0°C)	190	(58)	250	(76)	380	(116)	–		0.063	(0.207)
	20°F	(–7°C)	180	(55)	235	(72)	355	(108)	380	(116)	0.067	(0.220)
	0°F	(–18°C)	145	(44)	195	(59)	290	(88)	380	(116)	0.083	(0.272)
GM-2X and -2XT at 240 V	32°F	(0°C)	200	(61)	265	(81)	400	(122)	–		0.060	(0.197)
	20°F	(–7°C)	190	(58)	250	(76)	370	(113)	400	(122)	0.063	(0.207)
	0°F	(–18°C)	155	(47)	205	(62)	305	(93)	400	(122)	0.077	(0.253)
GM-2X and -2XT at 277 V	32°F	(0°C)	215	(66)	290	(88)	415	(126)	–		0.056	(0.184)
	20°F	(–7°C)	200	(61)	265	(81)	400	(122)	415	(126)	0.060	(0.197)
	0°F	(–18°C)	165	(50)	225	(69)	330	(101)	415	(126)	0.073	(0.240)

[1] Only FTC-P power connection, FTC-HST splice/tee, and RayClic-E end kits may be used with 40-A circuits.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Example: Roof and Gutter De-Icing System

Startup temperature	20°F (–7°C) (from Step 1)
Circuit breakers	30 A
Supply voltage	208 V (from Step 1)
Maximum circuit length	**355 ft (108 m)** (from Table 5)

DETERMINE NUMBER OF CIRCUITS

Use the following formula to determine number of circuits for the system:

$$\text{Number of circuits} = \frac{\text{Heating cable length required}}{\text{Maximum heating cable circuit length}}$$

Example: Roof and Gutter De-Icing System

Total heating cable length	673 ft (205.2 m) (from Step 3)
Maximum circuit length	355 ft (108 m) (from above)
Number of circuits	673 ft / 355 ft = 1.9 rounded to **2 circuits**

DETERMINE TRANSFORMER LOAD

The total transformer load is the sum of load on all the circuit breakers in the system.

Calculate the Circuit Breaker Load (CBL) as:

$$\text{CBL (kW)} = \frac{\text{Circuit breaker rating (A)} \times 0.8 \times \text{Supply voltage}}{1000}$$

If the CBL is equal on all circuit breakers, calculate the Total Transformer Load as follows:

Total Transformer Load (kW) = CBL x Number of circuits

If the CBL is **not** equal on all circuit breakers, calculate the Total Transformer Load as follows:

Total Transformer Load (kW) = $\text{CBL}_1 + \text{CBL}_2 + \text{CBL}_3 ... + \text{CBL}_N$

Example: Roof and Gutter De-Icing System

Circuit breaker load (CBL)	= (30 A x 0.8 x 208 V) / 1000 = 5 kW
Total transformer load	= 5 kW x 2 circuits = 10 kW

Roof and Gutter De-Icing

1. Determine design conditions
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits
6. Select attachment accessories and method
7. Select the control system and power distribution
8. Complete the Bill of Materials

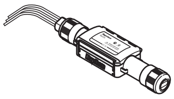
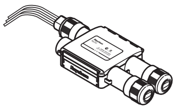
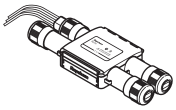
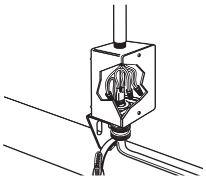
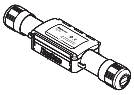
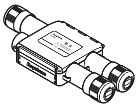
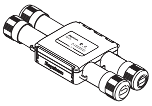
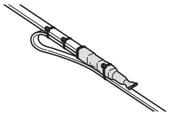
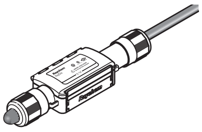
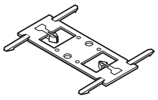
Step 5 Select the connection kits

A typical IceStop system may have several connection kits to seal and power the heating cable. The connection kits work together with the IceStop heating cable to provide a safe and reliable de-icing system that is easy to install and maintain. The available accessories are listed in Table 6. A complete IceStop system also consists of attachment accessories and adhesives which we discuss later in "Step 6 Select attachment accessories and method" on page 115.

The self-regulating IceStop heating cable is cut to length at the job site. In order to seal the heating cable from the environment and provide power, Thermal Management approved connection kits must be used. A power connection kit is required to attach power to one end of the heating cable. An end seal is required, and is provided with each power connection to seal the other end. Splice and tee kits are also available to connect two or three heating cables together.

RayClic and FTC connection kits are available for the IceStop system. The RayClic connection kits are insulation-displacement quick connect systems. The FTC connection kits use heat-shrinkable tubing and crimp barrels. All of these connection kits are outlined in Table 6 below. Additional heating cable will be required to allow for connection kit assembly and drip loops.

TABLE 6 CONNECTION KITS

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance [1]
Connection kits					
	RayClic-PC	Power connection and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	2 ft (0.6 m)
	RayClic-PS	Powered splice and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	4 ft (1.2 m)
	RayClic-PT	Powered tee and end seal (RayClic-SB-04 pipe mounting bracket included)	1	1 per circuit	6 ft (1.8 m)
	FTC-P[2]	Power connection and end seal **Note:** FTC-P is required for circuits requiring 40 A circuit breakers.	1	1 per circuit	2 ft (0.6 m)
	RayClic-S	Splice	1	As required	2 ft (0.6 m)
	RayClic-T	Tee kit with end seal	1	As required	3 ft (0.9 m)
	RayClic-X	Cross connection to connect four heating cables	1	As required	8 ft (2.4 m)
	FTC-HST[3]	Low-profile splice/tee	2	As required	2 ft (0.6 m)
	RayClic-LE	Lighted end seal (RayClic-SB-04 pipe mounting bracket included)	1	Alternate end seal	2 ft (0.6 m)
	RayClic-E	Extra end seal	1	Additional end seal	0.3 ft (0.1 m)
Accessories					
	RayClic-SB-02	Wall mounting bracket	1	Required for every RayClic connection kit	–

[1] Additional heating cable required for connection kit assembly and drip loops.

[2] Junction box not included.

[3] One RayClic-E end seal is required for each FTC-HST used as a tee kit.

Example: Roof and Gutter De-Icing System

Connection kit	Quantity	Heating cable allowance
RayClic-PC	2	4 ft (1.2 m)
RayClic-PS	2	8 ft (2.4 m)
RayClic-SB-02	4	NA

Determine how much additional heating cable you need for the connection kits.

Example: Roof and Gutter De-Icing System

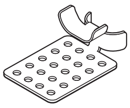
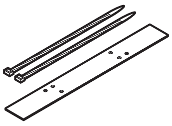
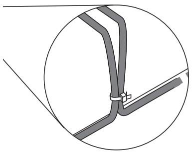
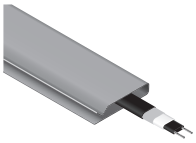
Sloped roof – standard	520 ft (158.5 m)
Gutters	100 ft (30.5 m)
Roof valley	27 ft (8.3 m)
Downspouts	26 ft (8.0 m)
Total heating cable allowance for connection kits	12 ft (4.0 m)
Total heating cable length required	**685 ft (208.8 m)**

Step 6 Select attachment accessories and method

A typical IceStop system also consists of various attachment accessories and adhesives for attaching the heating cable to the roof. The available accessories are listed in Table 7 and the adhesives in Table 9. The type of attachment accessories you need will depend on the type of roof you have. See Table 8 for details.

Always check with the roofing manufacturer for recommendations on how to attaching heating cables to their roofing material.

TABLE 7 ATTACHMENT ACCESSORIES

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance
	GMK-RC	Roof clips	50/box	1 box per 35' of roof edge when zig-zag layout is used. See Table 8 for other layout options.	–
	GMK-RAKE	Hanger bracket	1	1 hanger per cable in downspout or as required for mechanical protection. See Table 8 for other layout options.	–
	CT-CABLE-TIE	UV-resistant cable tie	100/box	As required.	–
	CCB-CU CCB-AL	Cable cover bracket, copper or aluminum	1	As required.	–

Heating cable attachment depends primarily upon the roof type. The following table shows the recommended attachment methods for typical roof materials and roof areas.

TABLE 8 ATTACHMENT METHODS FOR TYPICAL ROOFS

Roof material	Recommended attachment method	Alternate attachment method
Shake/shingle	"Mechanical Attachment," page 117	
Rubber/membrane	"Belt Loop Approach," page 118	"Adhesive Attachment," page 117
Metal	"Mechanical Attachment," page 117	"Adhesive Attachment," page 117 "Belt Loop Approach," page 118
Wood	"Mechanical Attachment," page 117	
Other	"Attachment Methods for Other Areas," page 119	
Area	**Attachment method**	
Gutters	Recommend using hanger clips glued to gutter for security if possible (see page 119)	
Downspouts	Downspout hangers (page 119)	
Drip edges	Attached to a flat sheet or standard drip edge, or installed informed sheet metal (see page 120)	
Component locations	Drip loops	
Roof edges with no gutter	Drip loops	

Note: Do not use adhesives on slate or tile roofs. Please contact roofing manufacturer for a recommended attachment method or contact your Thermal Management representative.

Adhesive is not supplied by Thermal Management. Follow manufacturer's instructions for surface preparation and installation.

TABLE 9 ADHESIVES

Adhesive	Description	Color	Approximate tooling time	Cure time	Dispensing equipment
Momentive Performance Materials, Inc. RTV167	Neutral-cure silicone adhesive	Gray	20 minutes	48 hours	Caulking gun
SpeedBonder® H3300	Methacrylate adhesive	Tan	15 minutes	24 hours	2 part mixing dispenser
SpeedBonder H4800	Methacrylate adhesive	Light yellow	45 minutes	24 hours	2 part mixing dispenser
Plexus® MA300	Methacrylate adhesive	Yellow	15 minutes	16 hours	2 part mixing dispenser
Plexus MA310	Methacrylate adhesive	Yellow	30 minutes	16 hours	2 part mixing dispenser

Note: Before using adhesives on metal roofs check with the roofing manufacturer. Trademarks are the property of their respective owners.

ROOF ATTACHMENT METHODS

Mechanical Attachment

One of the most common attachment methods is to use Raychem GMK-RC roof clips. It can be used on all surfaces where nails or screws are acceptable.

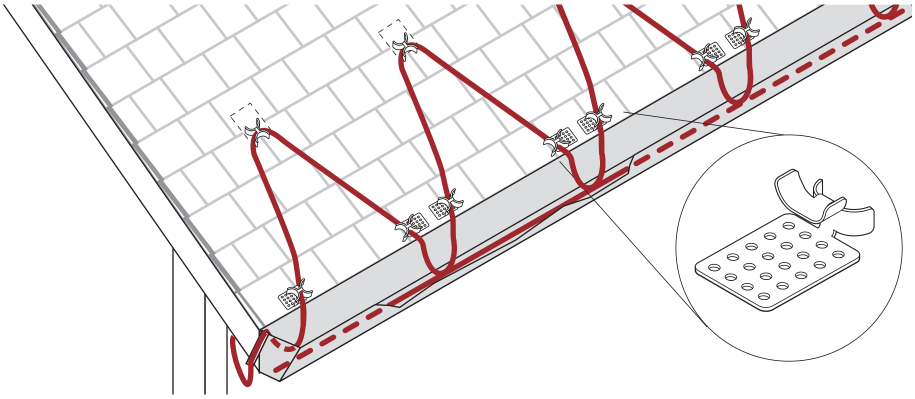


Fig. 18 GMK-RC clip attachment

- The GMK-RC roof clips are used to secure IceStop heating cable. This multipurpose bracket attaches with a screw, nail, or adhesive to many types of roofs and gutters.
- One box of 50 GMK-RC roof clips is sufficient to attach the heating cable on 35 feet (9.1 m) of roof edge using a zig-zag layout. Your layout may require additional clips.
- For layouts other than the standard zig-zag, use one clip for each 5 to 10 feet (1.5 to 3 m) of unsupported heating cable and at every change of heating cable direction.
- For standard sloped roofs, the loops of heating cable being zig-zag on the roof should be attached using a UV-resistant cable tie to the heating cable run in the gutter.
- For standing-seam roofs, the heating cable should be cable-tied together at the bottom of the seam.
- For high wind areas, it is recommended to use a UV resistant cable tie to further secure the heating cable to the attachment clip.

Adhesive Attachment

For roofs where penetrating attachments are not desired, use the GMK-RC roof clip attached by adhesive.

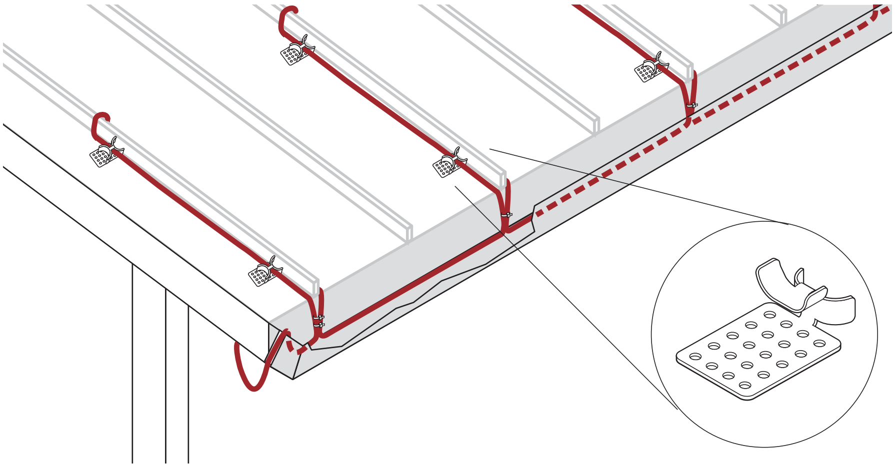


Fig. 19 GMK-RC clip on standing-seam roof

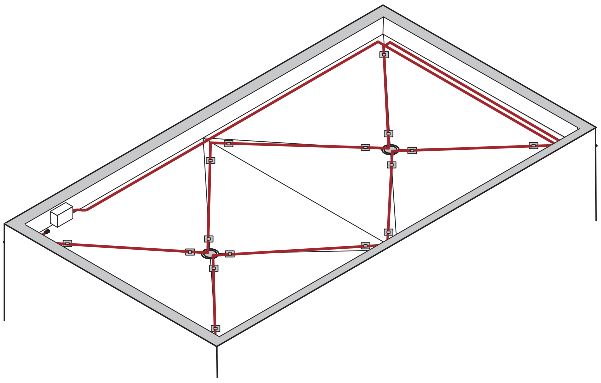


Fig. 20 GMK-RC clip on flat roof

- The GMK-RC roof clips are used to secure IceStop heating cable. The clip attaches with adhesive (not supplied by Thermal Management) to many types of roofs and gutters.
- Several different adhesives are recommended by Thermal Management. See Table 9 on page 116 or contact Thermal Management for alternatives.
- On a standing seam roof, use four clips on each seam being traced. On a flat surface, use one clip for every 5 to 10 feet (1.5 to 3 m) of unsupported heating cable and at every change of direction.
- Follow all recommendations from the adhesive manufacturer with regard to cleaning and preparing the roof surface for the adhesive.

Belt Loop Approach

With the belt loop approach, strips of roofing materials are fastened to the roof using standard means for that particular type of roof. The heating cable is attached with a UV-resistant cable tie to the loop formed by this material.

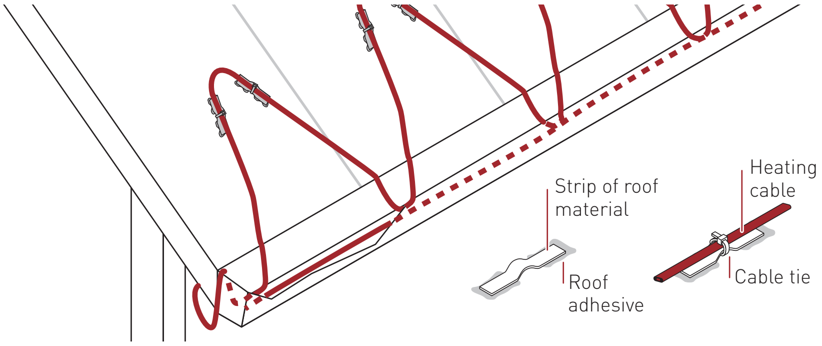


Fig. 21 Belt loop approach on a sloped roof

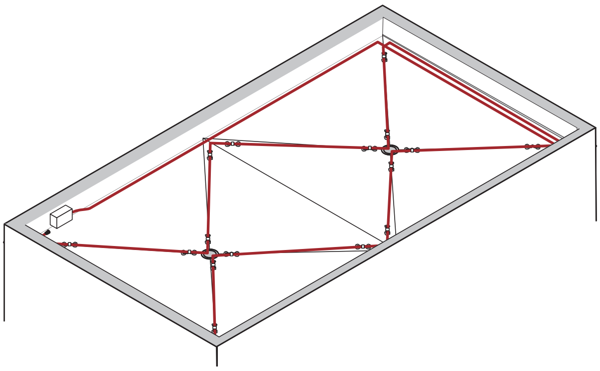


Fig. 22 Belt loop approach on a flat roof

- The belt loop method of securing the IceStop heating cable involves using a small piece of roofing material to form a "belt loop."
- Use at least one belt loop for every 5 to 10 feet (1.5 to 3 m) of unsupported heating cable and at every heating cable change of direction.

ATTACHMENT METHODS FOR OTHER AREAS

Gutters

Attachment is not generally required for standard gutters. If attachment is desired, such as in high-wind areas, use GMK-RC adhesive-mounted attachment clips. Several different adhesives are recommended by Thermal Management. See Table 9 on page 116.

For large gutters (6 to 12 inches wide [15 cm to 30 cm]), use two runs of heating cable separated by GMK-RC roof clips. It is not necessary to attach the clips to the gutter. Use one pair of GMK-RC roof clips for every 10 feet (3 m).

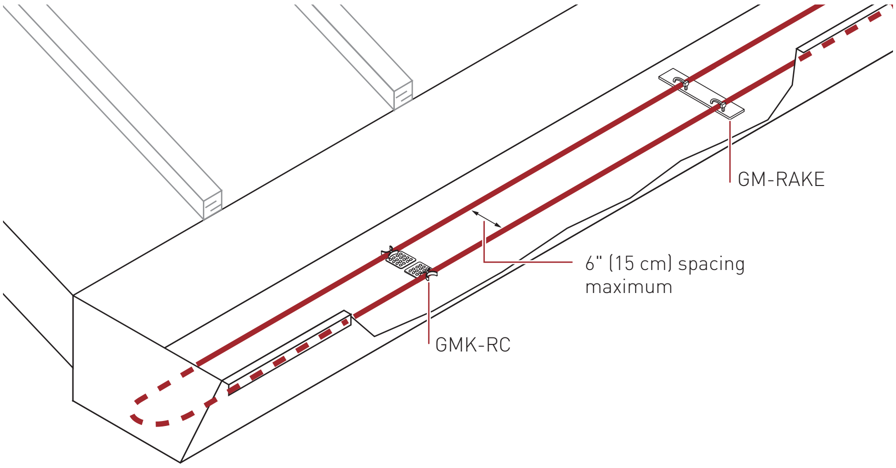


Fig. 23 GMK-RC clip in a gutter

Downspouts

The IceStop heating cable needs to be attached at the top of each downspout, using one GM-RAKE downspout hanger per heating cable. The GM-RAKE downspout hanger clamps around the heating cable and attaches to the fascia with a screw or nail.

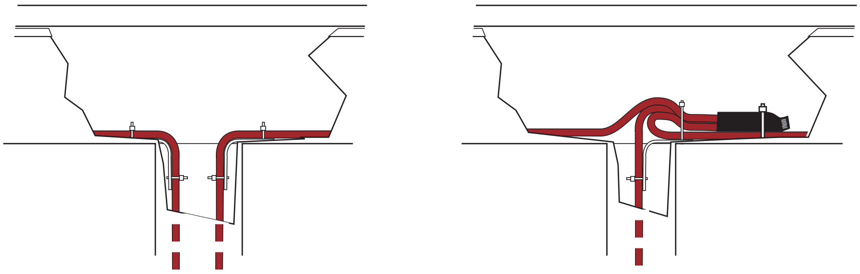


Fig. 24 GM-RAKE downspout hangers

- GM-RAKE downspout hangers protect the heating cable from damage from sharp edges and also provide support for the weight of the heating cable.
- Use two GM-RAKE downspout hangers for double-traced downspouts.
- Attach the GM-RAKE downspout hangers to the structure with a nail or other suitable method.

Heated Drip Edges

When installing a heated drip edge, you can attach the heating cable to the roof's drip edge or to a flat sheet of sheet metal with a UV-resistant cable tie, or place the heating cable in a formed (J-channel) piece of sheet metal.

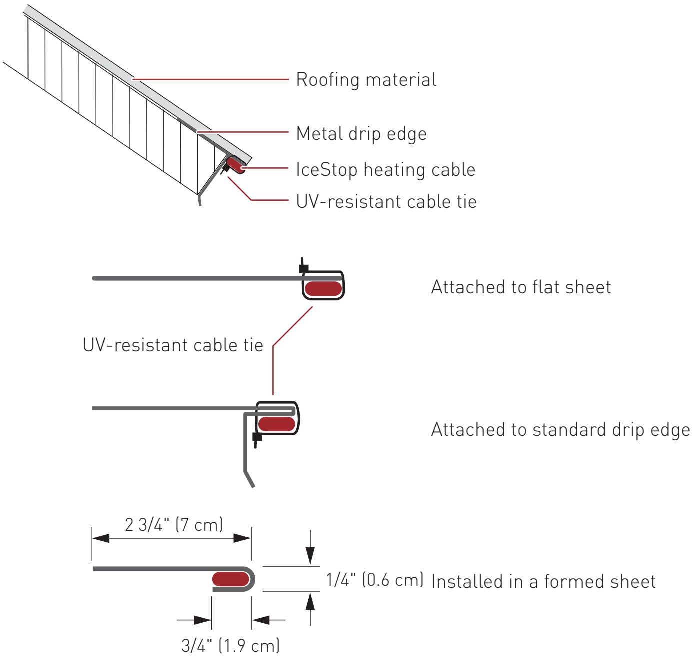


Fig. 25 Heated drip edge attachment guidelines

- The illustrations above are guidelines for heating cable attachment in a heated drip edge application. Thermal Management does not manufacture drip edge attachment clips.
- Use 20-gauge or thicker corrosion-resistant sheet metal.
- Contact your Thermal Management representative or Thermal Management directly for specific recommendations.

Example: Roof and Gutter De-Icing System

100 ft (30.5 m) roof edge and 2 gutters

GMK-RC	3 boxes of 50
GM-RAKE	2

Step 7 Select the control system and power distribution

CONTROL SYSTEMS

Three control methods are commonly used with roof de-icing systems:

- Manual on/off control
- Ambient thermostat
- Automatic moisture/temperature controller

All three methods require contactors if any significant length of heating cable is being used. The contactor must be sized to carry the load. Each method offers a trade-off of initial cost versus energy efficiency and ability to provide effective de-icing. If the system is not energized when needed, ice will form. If the system is energized when de-icing is not needed, there will be unnecessary power consumption. Choose the control method that best meets the project performance requirements. Contact your Thermal Management representative for details.

For Class I, Division 2 hazardous locations, use an agency-approved controller or thermostat suitable for the same area use.

Manual On/Off Control

A manually controlled system is operated by a switch that controls the system power contactor. This method requires constant supervision to work effectively. A manual system can be controlled by a building management system.

Ambient Thermostat

When an ambient sensing thermostat is used, the roof and gutter system will be energized when the ambient temperature is below freezing. This will ensure the heating cable is energized any time the water might freeze.

TABLE 10 ECW-GF THERMOSTAT

Number of heating cable circuits	Single
Sensor	Thermistor
Sensor length	35 ft
Set point range	32°F to 200°F (0°C to 93°C)
Enclosure	NEMA 4X
Deadband	2°F to 10°F (2°C to 6°C)
Enclosure limits	–40°F to 140°F (–40°C to 60°C)
Switch rating	30 A
Switch type	DPST
Electrical rating	100–277 V
Approvals	c-UL-us Listed
Ground-fault protection	30 mA fixed
Alarm outputs	
AC relay	2 A at 277 Vac
Dry contact relay	2 A at 48 Vdc

Automatic Moisture/Temperature Controller

The most conservative approach from an energy-consumption point of view is an automatic moisture/temperature sensor. Thermal Management supplies an automatic moisture/temperature sensor, which consists of a control panel, one or more gutter sensors, and one or more aerial snow sensors. Table 11 outlines the options for this approach.

The gutter sensor should be mounted in gutters near downspouts. It senses the actual environmental conditions, such as temperature and moisture. A gutter sensor is recommended for each critical area that needs to be monitored for icing conditions (such as when one side of a building gets sun in the morning and the other side gets sun in the afternoon, or one side gets the prevailing winds and the other side is protected). An aerial-mounted snow sensor is also recommended. Having both gutter and snow sensors allows for snow to begin melting in the gutters at the onset of any snow or ice condition.

For areas where a large number of circuits are required, the Raychem ACS-30 can be used. The Roof & Gutter De-icing control mode in the ACS-30 includes an External Device control option. This option allows a Snow/Moisture sensing controller (from Table 11) to be integrated into the ACS-30 system. Note that sensors (snow or gutter) cannot be directly connected to the ACS-30 system. Refer to the ACS-30 Programming Guide (H58692) for more information on system setup.

TABLE 11 AUTOMATIC CONTROLLERS

Application	**APS-3C**	**APS-4C**	**SC-40C**	**PD Pro**	**GF Pro**
	Snow controller	Snow controller with ground-fault protection	Satellite contactor	Snow controller	Snow controller with ground-fault protection
Number of sensors	1 to 6	1 to 6	1 to 6	1 to 2	1 to 2
Set point	38°F (3°C) and moisture	38°F (3°C) and moisture	38°F (3°C) and moisture	38°F (3°C) and moisture	38°F (3°C) and moisture
High limit temperature set point	40°F to 90°F (4°C to 32°C) adjustable	40°F to 90°F (4°C to 32°C) adjustable	40°F to 90°F (4°C to 32°C) adjustable	NA	NA
Enclosure	NEMA 3R	NEMA 3R	NEMA 3R	NEMA 4X	NEMA 4X
Temperature operating limits	–40°F to 160°F (–40°C to 71°C)	–40°F to 160°F (–40°C to 71°C)	–40°F to 160°F (–40°C to 71°C)	–31°F to 130°F (–35°C to 55°C)	–31°F to 130°F (–35°C to 55°C)
Electrical rating	24 A, 120 V 24 A, 208–240 V	50 A, 208–240 V 40 A, 277 V 50 A, 277–480 V 50 A, 600 V	50 A, 208/240 V 40 A, 277 V 50 A, 277–480 V 50 A, 600 V	30 A, 120 V	30 A, 208-277 V
Approvals	c-UL-us Listed	c-UL-us Listed	c-UL-us Listed	c-UL-us Listed	c-UL-us Listed
Ground-fault protection	Not included	30 mA	30 mA, 60 mA and 120 mA	Not included	30 mA

TABLE 12 MOISTURE/TEMPERATURE SENSORS

Application	**GIT-1**	**CIT-1**
	Gutter-mounted moisture/temperature	Aerial-mounted moisture/temperature
Set point	38°F (3°C)	38°F (3°C)

TABLE 13 CONTROL SYSTEMS

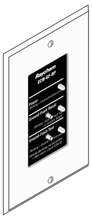
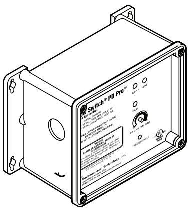
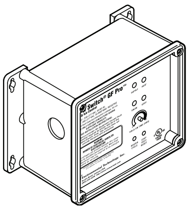
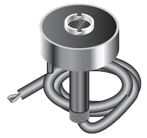
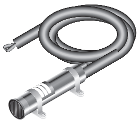
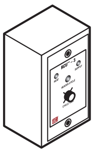
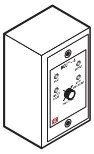
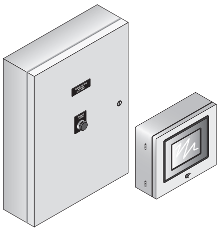
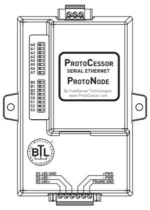
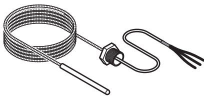
	Catalog number	Description
Electronic Thermostats and Accessories		
	ECW-GF	Electronic ambient sensing controller with 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor and is housed in a NEMA 4X rated enclosure. The controller features an AC/DC dry alarm contact relay.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
Snow Melting Controllers		
	APS-3C	Automatic snow melting controller housed in a NEMA 3R enclosure provides effective, economical automatic control of all snow melting applications. CSA Certified, c-UL-us Listed, available in 120 V and 208-240 V, 50/60 Hz models, 24-Amp DPDT output relay, adjustable hold-on timer. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6-9/16 in (292 mm x 232 mm x 167 mm)
	APS-4C	Automatic snow melting controller housed in a NEMA 3R enclosure provides effective, economical automatic control of all snow melting applications. The APS-4C can operate with any number of SC-40C satellite contactors for larger loads. Features include: 277 V single-phase or 208–240, 277/480, and 600 V three-phase models, built-in 3-pole contactor, integral 30 mA ground-fault circuit interrupter and an adjustable hold-on timer. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6-9/16 in (292 mm x 232 mm x 167 mm)
	SC-40C	Satellite contactor power control peripheral for an APS-4C snow melting controller, housed in a NEMA 3R enclosure. Features include: 277 V single-phase or 208–240, 277/480 and 600 V three-phase models, built-in 3-pole contactor and integral 30 mA ground-fault circuit interrupter. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6 in (292 mm x 232 mm x 152 mm)
Gutter De-Icing Controllers		
	PD Pro	Automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments. The PD Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The PD Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds.
	GF Pro	Automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments. The GF Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The GF Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds. Features a built-in 30 mA, self-testing Ground-Fault Equipment Protection (GFEP) capability, digitally filtered to minimize false tripping. A ground-fault alarm must be manually reset using the Test/Reset switch before heater operation can continue.

TABLE 13 CONTROL SYSTEMS

	Catalog number	Description
Snow Melting and Gutter De-Icing Sensors and Accessories		
	CIT-1	Overhead snow sensor that detects precipitation or blowing snow at ambient temperatures below 38°F (3.3°C). For use with an APS-3C or APS-4C automatic snow controller, or an SC-40C satellite contactor.
	GIT-1	Gutter sensor that detects moisture at ambient temperatures below 38°F (3.3°C). For use with an APS-3C or APS-4C automatic snow controller, or a SC-40C satellite contactor.
	RCU-3	The RCU–3 provides control and status display to the APS–3C controller from a remote location. It has a 2, 4, 6 or 8 hour CYCLE TIME adjustment, independent of APS-3C setting.
	RCU-4	The RCU–4 provides control and status display to the APS–4C controller and SC-40C Satellite Contactor from a remote location. It has a 2, 4, 6 or 8 hour CYCLE TIME adjustment, independent of the APS-4C or SC-40C setting.
Electronic Controllers		
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in various commercial applications such as pipe freeze protection, roof and gutter de-icing, surface snow melting, hot water temperature maintenance and floor heating. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electro-mechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers.
	RTD-200 RTD3CS RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD3CS: temperature sensor with a 3-ft (0.9 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

Example: Roof and Gutter De-Icing System

208 V system with 2 circuits

APS-4C	1
SC-40C	1
GIT-1	2 (one for each gutter section)
CIT-1	1

POWER DISTRIBUTION

Once the heating cable circuits and control have been defined, you must select how to provide power to them. Power to the IceStop heating cables can be provided in several ways: directly through the controller, through external contactors, or through SMPG power distribution panels.

Single circuit control

Heating cable circuits that do not exceed the current rating of the selected control device shown in Table 11 can be switched directly (see Fig. 26).

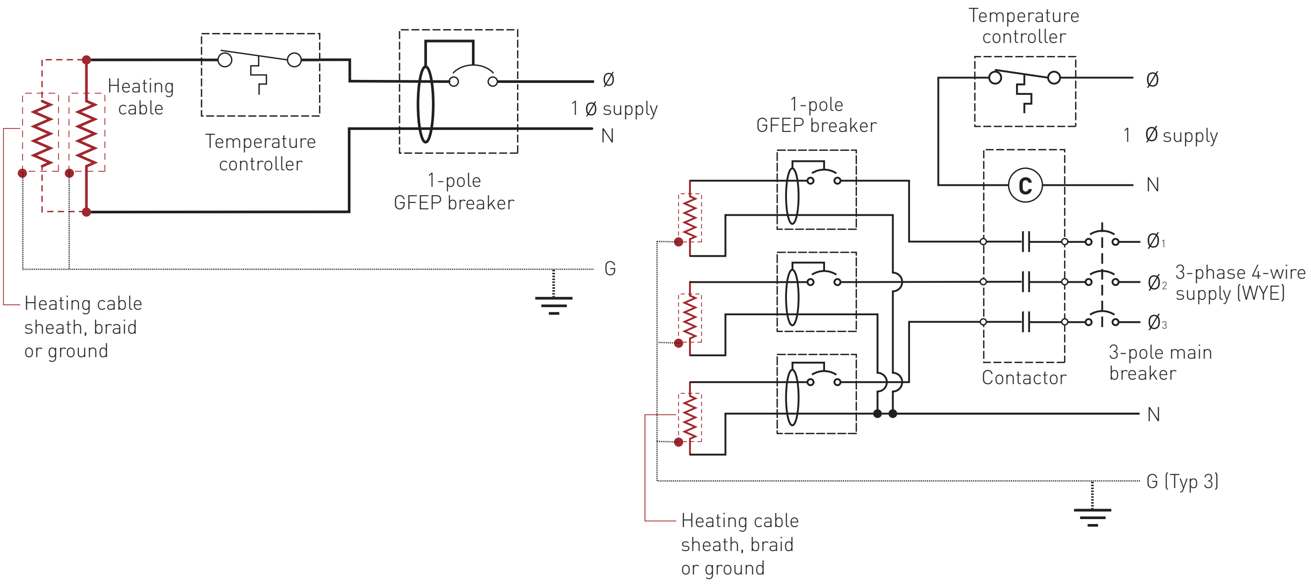
Group control

If the current draw exceeds the switch rating, or if the controller will activate more than one circuit (group control), an external contactor must be used.

Note: Large systems with many circuits should use an SMPG power distribution panel. The SMPG is a dedicated power-distribution, control, ground-fault protection, monitoring, and alarm panel for roof and gutter de-icing applications. This enclosure contains an assembled circuit-breaker panelboard. Panels are equipped with ground-fault circuit breakers with or without alarm contacts. The group control package allows the system to operate automatically in conjunction with an ambient-sensing thermostat, individual electronic, or duty cycle controller.

TABLE 14 POWER DISTRIBUTION PANELS

Application	SMPG1
	Control panel
Controller	EUR-5A included
Number of sensors	Up to 6
Enclosure	NEMA 1/12, NEMA 3R/4
Temperature operating limits	Without space heater 14°F to 122°F (–10°C to 50°C) With a space heater –40°F to 122°F (–40°C to 50°C)
Supply voltage	208 V, 277 V
Circuit breaker rating	15 A, 20 A, 30 A, 40 A, 50 A
Approvals	c-UL-us
Ground-fault protection	Yes



Single circuit control

Group control

Fig. 26 Single circuit and group control

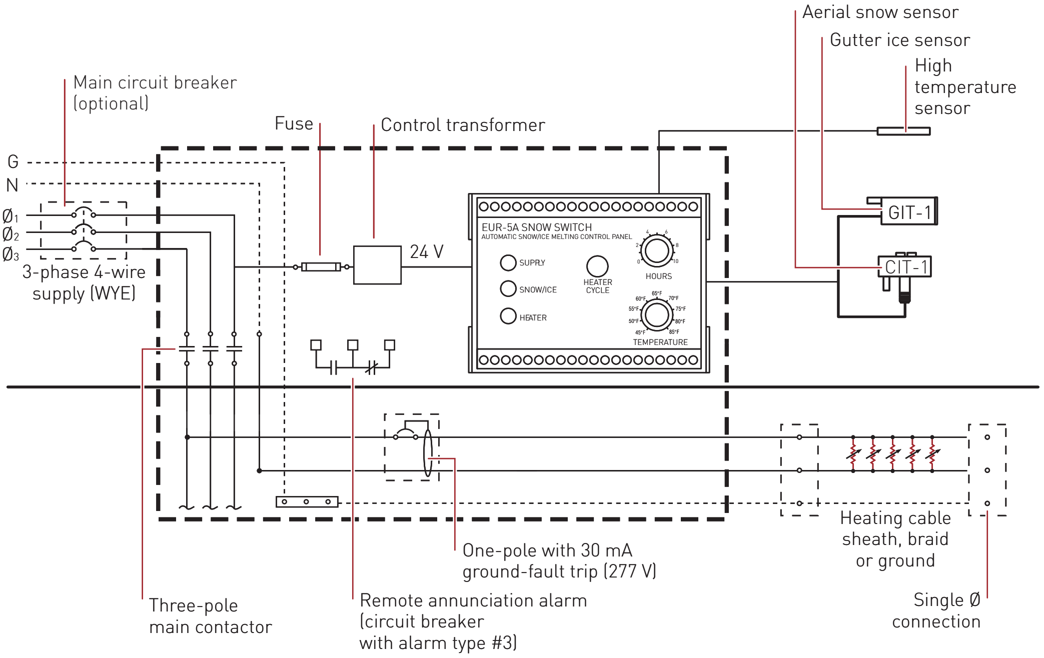
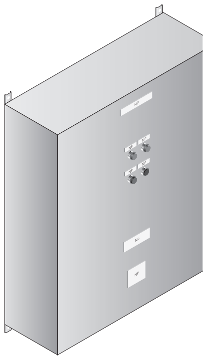


Fig. 27 Typical wiring diagram of group control with SMPG1

TABLE 15 POWER DISTRIBUTION

	Catalog number	Description
Power Distribution and Control Panels		
	SMPG1	Single-phase power distribution panel that includes ground-fault protection, monitoring, and control for snow melting systems. Single-phase voltages include 208 and 277 V.

Roof and Gutter De-Icing
1. Determine design conditions
2. Select the heating cable
3. Determine the heating cable length
4. Determine the electrical parameters
5. Select the connection kits
6. Select attachment accessories and method
7. Select the control system and power distribution
8. Complete the Bill of Materials

Step 8 Complete the Bill of Materials

If you used the Design Worksheet to document all your project parameters, you should have all the details you need to complete your Bill of Materials.

ICESTOP SYSTEM ROOF AND GUTTER DE-ICING DESIGN WORKSHEET

Step 1 Determine design conditions

Type of roof

- ☐ Sloped roof – standard
- ☐ Sloped roof – standing seam
- ☐ Flat roof

Roof material

- ☐ Shake/shingle
- ☐ Rubber membrane
- ☐ Metal
- ☐ Wood
- ☐ Other: ____________________

Layout

Roof edge
Length of roof edge (ft/m) __________
Number of edges __________

Eave overhang
Distance of overhang (in/cm) ________

Gutters
Length of gutters (ft/m) __________
Number of gutters __________
Depth of gutters (in/cm) __________
Width of gutters (in/cm) __________

Roof valley
Height of roof valley (ft/m) __________

Number of roof valleys __________

Roof/wall intersection
Height of intersection (ft/m) ________
Number of intersections __________

Downspouts
Downspout height (ft/m) __________
Number of downspouts __________

Supply voltage

- ☐ 120 V
- ☐ 208–277 V

Min. start-up temperature

______ (°F/°C)

Control method

- ☐ Manual on/off control
- ☐ Ambient thermostat
- ☐ Automatic controller

Example:

✓ **Sloped roof – standard with wood shingles and gutters**

Roof edge: **50 ft** Length of roof edge x **2** Number of edges → = **100 ft** **Total length of roof edges**

Eave overhang: **24 in**

Gutters: **50 ft** Length of gutter x **2** Number of gutters → = **100 ft** **Total length of gutters**

6 in Depth of gutter

4 in Width of gutter

Roof valley: **20 ft** Height of roof valley **1** Number of roof valleys

Downspouts: **12 ft** Downspout height x **2** Number of downspouts → = **24 ft** **Total downspout height**

Supply voltage: **208 V**

Minimum start-up temperature: **20°F**

Control method: **Automatic controller**

Step 2 Select the heating cable

See Fig. 4.

Product family	Supply voltage	Outer jacket
	☐ **1** = 120 V	☐ -**X** polyolefin
	☐ **2** = 208, 240, 277 V	☐ -**XT** fluoropolymer

Use catalog number:	**GM**		—		→	
	Product family	Supply voltage		Outer jacket		**Catalog number**

Example catalog number:	**GM**	**2**	—	**XT**	→	**GM-2XT**
	Product family	Supply voltage		Outer jacket		Catalog number

Step 3 Determine the heating cable length

Sloped roof – standard

______ Roof edge (ft/m) with ______ Eave overhang (in/cm) requires → ______ **Heating cable per foot of roof edge (ft/m)**

Sloped roof – standing seam

______ Roof edge (ft/m) with ______ Eave overhang (in/cm) requires → ______ **Heating cable per foot of roof edge (ft/m)**

Flat roof

______ Roof perimeter (ft/m) x ______ From perimeter to drains (ft/m) x ______ Into internal downspouts (ft/m) = ______ **Heating cable for flat roof (ft/m)**

Gutters

______ Gutter depth (ft/m) x 2 = ______ Additional heating cable (ft/m) + ______ Heating cable per foot of roof edge (ft/m) = ______ **Heating cable with gutter depth allowance (ft/m)**

______ Roof edge (ft/m) x ______ Heating cable with gutter depth allowance (ft/m) = ______ **Total heating cable for roof edge (ft/m)**

______ Gutter length (ft/m) x ______ Gutter width multiplier → = ______ **Heating cable for gutters (ft/m)**

No gutters – heated drip edge

______ Roof edge (ft/m) x 1 → = ______ **Heating cable for heated drip edge (ft/m)**

Roof valleys

______ Height of roof valley (ft/m) x 1.33 x ______ Number of roof valleys → = ______ **Heating cable for roof valleys (ft/m)**

Roof/wall intersection

______ Height of intersection (ft/m) x 1.33 ______ Number of intersections → = ______ **Heating cable for roof/wall intersections (ft/m)**

Downspouts

______ Height of downspouts (ft/m) x ______ Number of downspouts x ______ Runs of heating cable per downspout = ______ **Heating cable per downspout (ft/m)**

______ **Total heating cable length**

Example: Sloped roof – standard with eave overhang and gutters

100 ft Feet of roof edge (ft/m) with **24 in** Eave overhang (in/cm) requires → **4.2 ft** **Heating cable per foot of roof edge (ft/m)**

6 in Gutter depth (ft/m) x 2 = **1 ft** Additional heating cable (ft/m) + **4.2 ft** Heating cable per foot of roof edge (ft/m) = **5.2 ft** **Heating cable with gutter depth allowance (ft/m)**

100 ft Roof edge (ft/m) x **5.2 ft** Heating cable with gutter depth allowance (ft/m) → = **520 ft *** **Total heating cable for roof edge (ft/m)**

100 ft Gutter length (ft/m) x **1** Gutter width multiplier → = **100 ft *** **Heating cable for gutters (ft/m)**

20 ft Height of roof valley (ft/m) x 1.33 x **1** Number of roof valleys → = **26.6 ft rounded to 27 ft *** **Heating cable for roof valleys (ft/m)**

12 ft Height of downspouts (ft/m) x **2** Number of downspouts x **1** Runs of heating cable per downspout = **24 ft** **Heating cable per downspouts (ft/m)**

\+ **2** Drip loop allowance (1 ft with loopback) = **26 ft *** **Feet heating cable for downspouts**

= **673 ft** *** Total heating cable length**

Step 4 Determine the electrical parameters

Determine maximum circuit length and number of circuits (See Table 5)

Total heating cable length required ____________

Supply voltage: ☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V

Start-up temperature ____________

Circuit breaker size: ☐ 15 A ☐ 20 A ☐ 30 A ☐ 40 A

Maximum circuit length ____________

____________ / ____________ = ____________
Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Determine transformer load

Calculate the circuit breaker load (CBL)

(____________ x **0.8** x ____________) / **1000** → = ____________
Circuit breaker rating x 0.8 x Supply voltage → = **Circuit breaker load (kW)**

If the CBL is equal on all circuits, calculate the transformer load as:

____________ x ____________ → = ____________
Circuit breaker load (kW) x Number of breakers → = **Total transformer load (kW)**

If the CBL is NOT equal on all circuits, calculate the transformer load as:

$CBL_1 + CBL_2 + CBL_3... + CBL_N$ = ____________ **Total transformer load (kW)**

Example:

Determine the maximum circuit length and number of circuits

Total heating cable length required **673 ft of GM-2XT**

Supply voltage: ☐ 120 V ☑ 208 V ☐ 240 V ☐ 277 V

Start-up temperature **20°F**

Circuit breaker size: ☐ 15 A ☐ 20 A ☑ 30 A ☐ 40 A

Maximum circuit length **355 ft**

673 ft / **355 ft** = **1.9 circuits, round up to 2**
Total heating cable length required / Maximum heating cable circuit length = **Number of circuits**

Determine transformer load

(**30 A** x **0.8** x **208 V**) / **1000** → = **4.99 kW rounded to 5 kW**
Circuit breaker rating x 0.8 x Supply voltage → = **Circuit breaker load (kW)**

5 kW x **2** → = **10 kW**
Circuit breaker load (kW) x Number of breakers → = **Total transformer load (kW)**

Step 5 Select the connection kits (See Table 6)

Connection kits and accessories	Description	Quantity	Heating cable allowance
☐ RayClic-PC	Power connection and end seal		
☐ RayClic-PS	Power splice and end seal		
☐ RayClic-PT	Powered tee and end seal		
☐ FTC-P	Power connection and end seal		
☐ RayClic-S	Splice		
☐ RayClic-T	Tee kit with end seal		
☐ RayClic-X	Cross connection		
☐ FTC-HST	Low-profile splice/tee		
☐ RayClic-LE	Lighted end seal		
☐ RayClic-E	Extra end seal		
☐ RayClic-SB-02	Wall mounting bracket		

____

Total heating cable allowance for connection kits

______________ + ______________ = ______________

Total heating cable length + Total heating cable allowance for connection kits = **Total heating cable length required**

Example:

Connection kit catalog number	Quantity	Heating cable allowance
✓ RayClic-PC	2	**4 ft**
✓ RayClic-PS	2	**8 ft**
✓ RayClic-SB-02	4	**NA**

12 ft

Total heating cable allowance for connection kits

673 ft + **12 ft** = **685 ft**

Total heating cable length + Total heating cable allowance for connection kits = **Total heating cable length required**

Step 6 Select attachment accessories and method

See "Table 7 Attachment Accessories" "Table 8 Attachment Methods for Typical Roofs" and "Table 9 Adhesives"

Adhesive is not supplied by Thermal Management

Attachment accessories	Description	Quantity
☐ GMK-RC	Roof clips	
☐ GMK-RAKE	Hanger bracket	
☐ CT-CABLE-TIE	UV-resistant cable tie	
☐ CCB	Cable cover bracket, copper or aluminum	

Example:

100 ft roof edge and 2 gutters

✓ **GMK-RC**	**3 boxes of 50 (from Table 7)**
✓ **GM-RAKE**	**2 (from Table 7)**

Step 7 Select the control system and power distribution

Control Systems

See "Table 10 ECW-GF Thermostat" "Table 11 Automatic Controllers" "Table 12 Moisture/Temperature Sensors" "Table 13 Control Systems"

Thermostats, controllers and accessories	Description	Quantity
☐ ECW-GF	Electronic thermostat with 25-ft sensor	____________
☐ APS-3C	Automatic snow melting controller	____________
☐ APS-4C	Automatic snow melting controller	____________
☐ SC-40C	Satellite contactor	____________
☐ PD Pro	Gutter de-icing controller	____________
☐ GF Pro	Gutter de-icing controller	____________
☐ CIT-1	Overhead snow sensor	____________
☐ GIT-1	Gutter sensor	____________
☐ RCU-3	Remote control unit for APS-3C	____________
☐ RCU-4	Remote control unit for APS-4C	____________
☐ ACS-UIT2	ACS-30 user interface terminal	____________
☐ ACS-PCM2-5	ACS-30 power control panel	____________
☐ ProtoNode-RER	Multi-protocol gateway	____________
☐ RTD3CS	Resistance temperature device for Raychem ACS-30	____________
☐ RTD10CS	Resistance temperature device for Raychem ACS-30	____________
☐ RTD200	Resistance temperature device for Raychem ACS-30	____________
☐ RTD50CS	Resistance temperature device for Raychem ACS-30	____________

Example:

Supply voltage	208 V (from Step 1)	
Controller(s)	✓ **APS-4C**	**1**
	✓ **SC-40C**	**1**
Snow melting and gutter de-icing sensors and accessories	✓ **GIT-1**	**2 (one for each gutter section)**
	✓ **CIT-1**	**1**

Power distribution

See "Table 14 Power Distribution Panels" and "Table 15 Power Distribution"

Power distribution and control panels	Description	Quantity
☐ SMPG1	Single-phase power distribution panel	____________

Step 8 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

Raychem

SURFACE SNOW MELTING – MI MINERAL INSULATED HEATING CABLE SYSTEM

This step-by-step design guide provides the tools necessary to design a Raychem Mineral Insulated heating cable surface snow melting system. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

The Raychem Mineral Insulated (MI) heating cable system is designed for surface snow melting in concrete and asphalt, and under pavers.

If your application conditions are different, or if you have any questions, contact your Thermal Management representative or call (800) 545-6258.

How to Use this Guide

This design guide presents Thermal Management's recommendations for designing a Raychem Mineral Insulated (MI) heating cable surface snow melting system. It provides design and performance data, electrical sizing information, and heating cable layout suggestions. Following these recommendations will result in a reliable, energy-efficient system.

Follow the design steps in the section "Surface Snow Melting Design" on page 140 and use the "Raychem MI System Surface Snow Melting Design Worksheet" on page 171 to document the project parameters that you will need for your project's Bill of Materials.

OTHER REQUIRED DOCUMENTS

This guide is not intended to provide comprehensive installation instructions. For complete Raychem MI surface snow melting system installation instructions, please refer to the following additional required documents:

- Surface Snow Melting – MI Installation and Operation Manual (H57754)
- Additional installation instructions included with thermostats, controllers, and accessories

If you do not have these documents, you can obtain them from the Thermal Management web site at www.pentairthermal.com.

For products and applications not covered by this design guide, including installations in hazardous locations or where electromagnetic interference (EMI) may be of concern, such as traffic loop detectors, please contact your Thermal Management representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system components could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

✎ This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

Thermal Management's standard limited warranty applies to Raychem Snow Melting Systems.

An extension of the limited warranty period to ten (10) years from the date of installation is available, except for the control and distribution systems, if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

The Raychem MI heating cable surface snow melting system provides snow melting for concrete, asphalt, and pavers. The copper-sheathed, mineral insulated heating cables are coated with a high-density polyethylene (HDPE) jacket and are supplied as complete factory-assembled cables ready to connect to a junction box. The series-type technology, inherent to all mineral insulated heating cables, provides a reliable and consistent heat source that is ideal for embedded snow melting applications. The system includes heating cable, junction boxes, a control system and sensors, power distribution, and the tools necessary for a complete installation.

Typical System

A typical system includes the following:

- MI heating cable
- Junction boxes and accessories
- Snow controller and sensors
- Power distribution

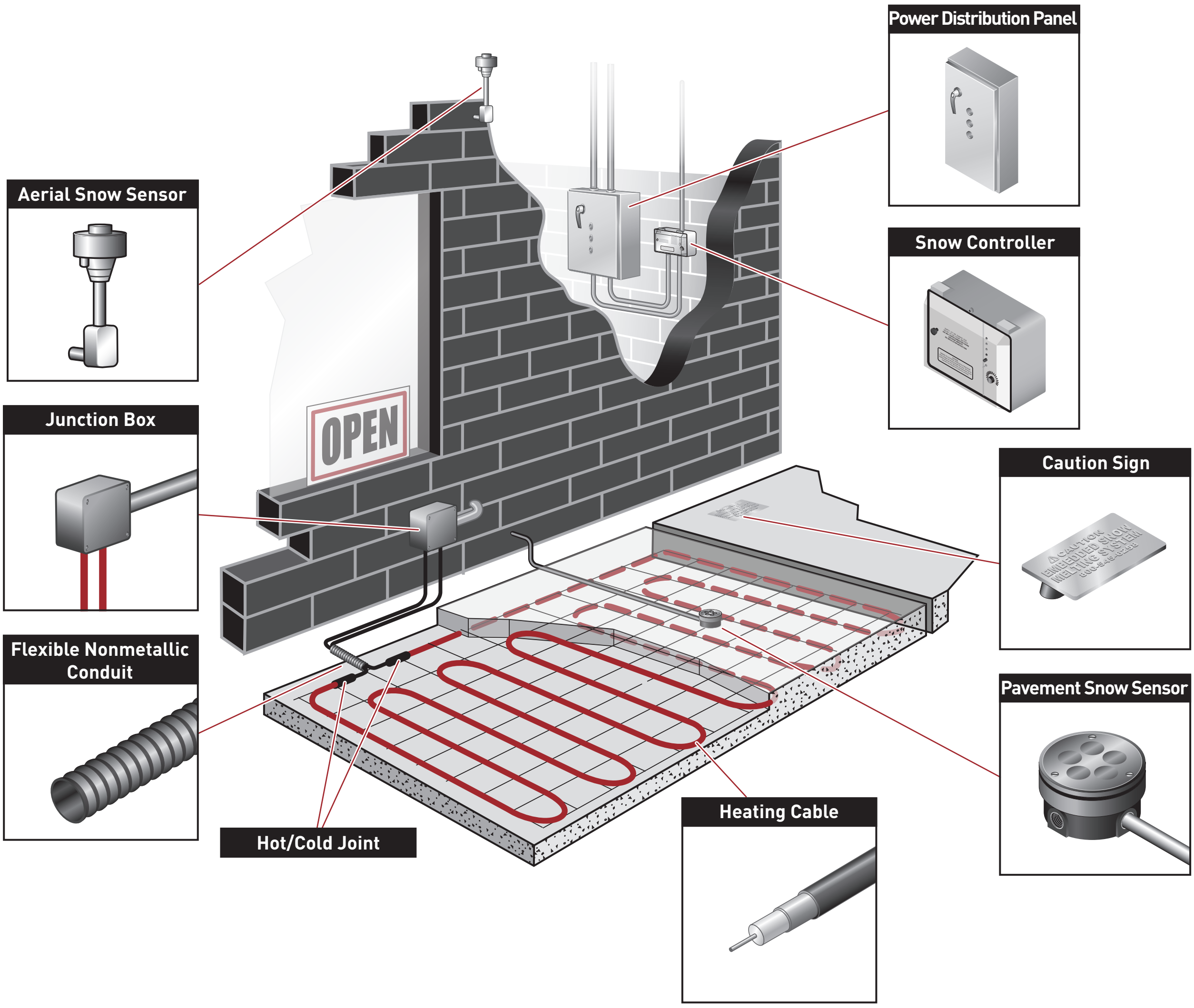


Fig. 1 Typical Raychem MI system

MI Heating Cable Construction

Standard surface snow melting MI heating cables are comprised of a single conductor surrounded by magnesium oxide insulation, a solid copper sheath, and an extruded high density polyethylene (HDPE) jacket. The HDPE jacket protects the copper sheath from corrosive elements that can exist in surface snow melting applications.

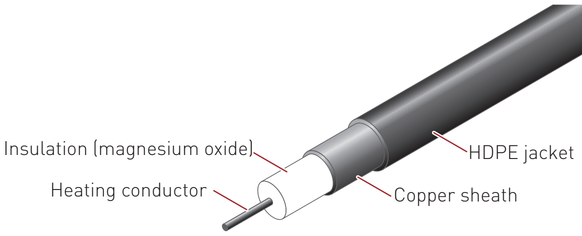


Fig. 2 MI heating cable construction

Custom engineered heating cables are also available for applications outside the scope of this design guide. For design criteria, including the maximum cable loading (watts/foot) for installations in concrete, asphalt and paver applications, refer to the MI Heating Cable for Commercial Applications data sheet (H56990) or contact Thermal Management at (800) 545-6258 for design assistance.

MI Heating Cable Configuration

MI heating cables are supplied as complete factory-fabricated assemblies consisting of an MI heating section that is joined to a section of MI nonheating cold lead and terminated with NPT-threaded connectors. Two configurations are available for standard heating cables:

1. Type SUA, consisting of a looped cable joined to a single 7 ft (2.1 m) cold lead with one 1/2-in NPT-threaded connector.
2. Type SUB, consisting of a single run of cable with a 15 ft (4.6 m) cold lead and a 1/2-in NPT-threaded connector on each end. Where custom cold lead lengths are required for the heating cables shown in Table 2, Table 3, Table 4, and Table 5, contact your Thermal Management sales representative for assistance.

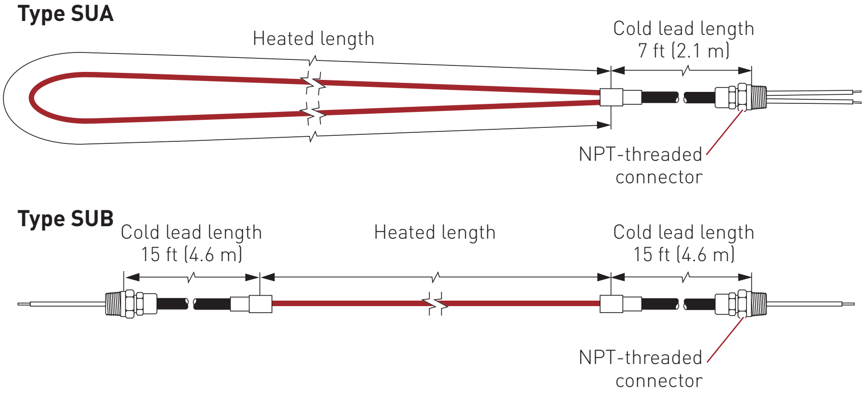


Fig. 3 MI heating cable configurations

Approvals

The Raychem MI surface snow melting system is UL Listed and CSA Certified for installation in nonhazardous locations in concrete and asphalt, and under pavers where the cables are embedded in concrete. For paver snow melting installations where the heating cables are embedded in sand or limestone screenings, special permission is required from the Authority Having Jurisdiction, e.g. the local inspection authority.

LISTED
De-Icing and Snow
Melting Equipment
421H

C US
-PS

SURFACE SNOW MELTING APPLICATIONS

SURFACE SNOW MELTING

Surface snow melting systems provide the required heat flux (W/ft^2 or W/m^2) to melt snow and ice on ramps, slabs, driveways, sidewalks, platform scales, and stairs and prevent the accumulation of snow under normal snow conditions.

APPLICATION REQUIREMENTS AND ASSUMPTIONS

The design for a standard surface snow melting application is based on the following:

Reinforced Concrete

- 4 to 6 in (10 to 15 cm) thick
- Placed on grade
- Standard density

Heating cable

- Secured to reinforcing steel, mesh or with prepunched strapping
- Located approximately 2 in (5 cm) below finished surface, but not exceeding 3 in (7.5 cm)

Asphalt

- Install on 1 in (2.5 cm) asphalt base layer if a concrete base is used in construction
- Placed on grade

- Secured with prepunched strapping
- Located 2 in (5 cm) below finished surface

Pavers

- 1 ½ to 2 ¼ in (4 to 6 cm) thick pavers
- Minimum 1 in (2.5 cm) limestone screenings or sand layer
- Placed on an approved compacted base or concrete slab

- Secured to the compacted base or concrete with mesh or prepunched strapping
- Located in a minimum 1 in (2.5 cm) layer of limestone screenings or sand

Nonstandard applications are not covered in this design guide, but are available by contacting your Thermal Management representative for design assistance. Using proprietary computer modeling based on a finite difference program for nonstandard applications, Thermal Management can design an appropriate snow melting system.

The following are examples of nonstandard applications not addressed in this design guide:

- Concrete thinner than 4 in (10 cm)
- Concrete thicker than 6 in (15 cm)
- Lightweight concrete
- Ramps, walkways, and stairs with air below
- Concrete without reinforcing bar or mesh
- Retrofitting of heating cable to existing pavement

SURFACE SNOW MELTING DESIGN

This section details the steps necessary to design your application. The examples provided in each step are intended to incrementally illustrate sample project designs from start to finish. As you go through each step, use the "Raychem MI System Surface Snow Melting Design Worksheet" on page 171 to document your project parameters, so that by that end of this section, you will have the information you need for your Bill of Materials.

SnoCalc

SnoCalc is an online design tool available to help you create surface snow melting designs and layouts. It is available at http://www.pentairthermal.com.

Design Step by Step

Your system design requires the following essential steps:

1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Surface Snow Melting

1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 1 Determine design conditions

Collect the following information to determine your design conditions:

- Environment
  - Geographical location
- Paving material
  - Concrete
  - Asphalt
  - Pavers
- Size and layout
  - Slab surface area
  - Ramp surface area
  - Stairs
    - Number of stairs
    - Stair width
    - Riser height
    - Stair depth
    - Landing surface area
  - Wheel tracks
    - Track length
  - Concrete joints
  - Surface drains
  - Location of area structures
  - Other information as appropriate
- Supply voltage
- Phase (single-phase or three-phase)
- Control method
  - Automatic snow melting controller
  - Slab sensing thermostat
  - Manual on/off control

Note: Drainage must be a primary concern in any snow melting system design. Improper drainage will result in ice formation on the surface of the heated area once the system is de-energized. Ice formation along the drainage path away from the heated area may create an ice dam and prohibit proper draining. If your design conditions may lead to drainage problems, please contact Thermal Management Technical Support for assistance.

PREPARE SCALE DRAWING

Draw to scale the area in which the snow melting cables will be installed, and note the rating and location of the voltage supply. Include stairs and paths for melting water runoff. Show concrete joints, surface drains, and location of area structures including post installations for railings, permanent benches, and flagpoles. Measurements for each distinct section of the snow melting application, including stairs, will allow for an accurate system design, including control configuration. Use these symbols to indicate the heating cable expansion and crack-control joints:

—•—•— Expansion joint

– – – – Crack-control joint

Fig. 4 Design symbols

Example: Surface Snow Melting System

Geographical location	Philadelphia, PA
Ramp surface area	45 ft x 12 ft (13.7 m x 3.66 m)
Paving material	Concrete
Supply voltage	480 V, three-phase
Control method	Automatic snow melting controller

Example: Surface Snow Melting System for Stairs

Geographical location	Philadelphia, PA
Number of stairs	5
Stair width	5 ft (1.52 m)
Riser height	8 in (20 cm)
Stair depth	11 in (28 cm)
Landing surface area	5 ft x 3 ft (1.52 m x 0.91 m)
Paving material	Concrete
Supply voltage	208 V, single-phase
Control method	Slab sensing thermostat

Example: Surface Snow Melting System for Wheel Tracks

Geographical location	Philadelphia, PA
Track length	28 ft (8.5 m)
Paving material	Asphalt
Supply voltage	240 V, single-phase
Control method	Automatic snow melting controller

Surface Snow Melting
1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 2 Determine the required watt density

For maximum performance from any snow melting system, you must first take into account the local snowfall patterns. A system design that works well in one city may be inadequate in another. The energy required to melt snow varies with air temperature, wind speed, relative humidity, snow density, and the depth of the snow on the pavement.

SURFACE SNOW MELTING

Table 1 summarizes the required watt density for most major cities in North America based on typical minimum ambient temperatures and the snowfall patterns. Select the city from the list, or closest city, where similar climatic conditions exist.

TABLE 1 REQUIRED WATT DENSITY FOR SURFACE SNOW MELTING

	Watts/ft²			Watts/m²		
City	Concrete	Asphalt or pavers	Concrete stairs	Concrete	Asphalt or pavers	Concrete stairs
USA						
Baltimore, MD	35	40	40	377	431	431
Boston, MA	35	40	45	377	431	484
Buffalo, NY	40	45	45	431	484	484
Chicago, IL	35	40	40	377	431	431
Cincinnati, OH	35	40	40	377	431	431
Cleveland, OH	35	40	40	377	431	431
Denver, CO	35	40	40	377	431	431
Detroit, MI	35	40	40	377	431	431
Great Falls, MT	50	50	55	538	538	592
Greensboro, NC	35	35	40	377	377	431
Indianapolis, IN	35	40	40	377	431	431
Minneapolis, MN	50	50	55	538	538	592
New York, NY	35	40	45	377	431	484
Omaha, NE	45	50	50	484	538	538
Philadelphia, PA	35	40	45	377	431	484
Salt Lake City, UT	35	35	40	377	377	431
Seattle, WA	35	35	40	377	377	431
St. Louis, MO	35	40	45	377	431	484
Canada						
Calgary, AB	45	45	50	484	484	538
Edmonton, AB	50	50	55	538	538	592
Fredericton, NB	40	45	45	431	484	484
Halifax, NS	35	40	40	377	431	431
Moncton, NB	40	40	45	431	431	484
Montreal, QC	45	45	50	484	484	538
Ottawa, ON	45	45	50	484	484	538
Prince George, BC	50	55	55	538	592	592
Quebec, QC	45	45	50	484	484	538
Regina, SK	50	55	55	538	592	592
Saskatoon, SK	50	50	55	538	538	592
St. John, NB	40	45	45	431	484	484
St. John's, NF	35	35	40	377	377	431
Sudbury, ON	40	45	50	431	484	538
Thunder Bay, ON	50	55	55	538	592	592
Toronto, ON	35	40	40	377	431	431
Vancouver, BC	35	40	40	377	431	431
Winnipeg, MB	50	55	55	538	592	592

Example: Surface Snow Melting System

Geographical location	Philadelphia, PA (from Step 1)
Paving material	Concrete (from Step 1)
Required watt density	**35 W/ft^2 (377 W/m^2)** (from Table 1)

Example: Surface Snow Melting System for Stairs

Geographical location	Philadelphia, PA (from Step 1)
Paving material	Concrete (from Step 1)
Required watt density	**45 W/ft^2 (484 W/m^2)** (from Table 1)

Example: Surface Snow Melting System for Wheel Tracks

Geographical location	Philadelphia, PA (from Step 1)
Paving material	Asphalt (from Step 1)
Required watt density	**40 W/ft^2 (431 W/m^2)** (from Table 1)

Surface Snow Melting
1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 3 Determine the total area to be protected

SURFACES

To select the proper heating cable you need to know the size of the surface area you will be protecting from snow accumulation. For large areas, divide the area into smaller subsections no greater than 400 ft^2 (37.2 m^2). For three-phase voltage supplies, create multiples of three equal areas not exceeding 400 ft^2 (37.2 m^2) as shown in Fig. 5. Do not exceed 20 ft (6.1 m) in any direction. If assistance is required to select heating cables for irregularly-shaped areas, please contact your Thermal Management representative.

Total surface area (ft^2/m^2) = Length (ft/m) x Width (ft/m)

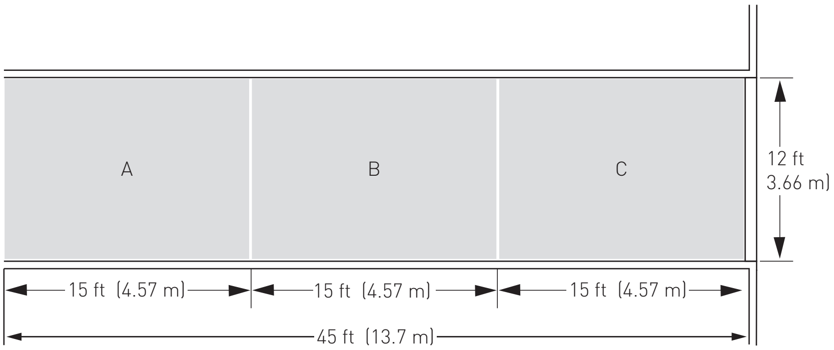


Fig. 5 Example for surface snow melting

Joints in Concrete

Many large concrete slabs are constructed with control and expansion joints. There are three types of joints that can be placed in concrete slabs. An explanation of each follows:

1. Crack-control joints (sawcuts) are intended to control where the slab will crack. Their exact location is determined by the concrete installers before the concrete is poured. Because of the reinforcement in the base slab, there is rarely a shearing action caused by differential vertical movement between the concrete on either side of the crack. As a precautionary measure, however, either of the two methods of crossing control joints shown in Fig. 7 should be used. Minimize the number of times the joint is crossed as shown in Fig. 7. When installing cables using the two-pour method, control joints must be placed in both the base slab and the surface slab.

2. Construction joints are joints that occur when the concrete pour is going to stop but will resume at a later date. Therefore their location may not be known beforehand. However, the rebar is left protruding out of the first pour so that it enters the next pour and therefore shearing action rarely occurs due to differential vertical movement between the concrete on either side of the joint. As a precautionary measure, either of the two methods of crossing control joints shown in Fig. 7 should be used.

3. Expansion joints are placed where a concrete slab abuts a structure, such as a building, a slab, or a foundation, etc. Since the reinforcement does not cross expansion joints, differential movement will occur between the slab and the adjoining structure. **Avoid crossing expansion joints with the heating cable.** If this is not possible, expansion joints can be crossed using a sand filled metal box as shown in Fig. 6.

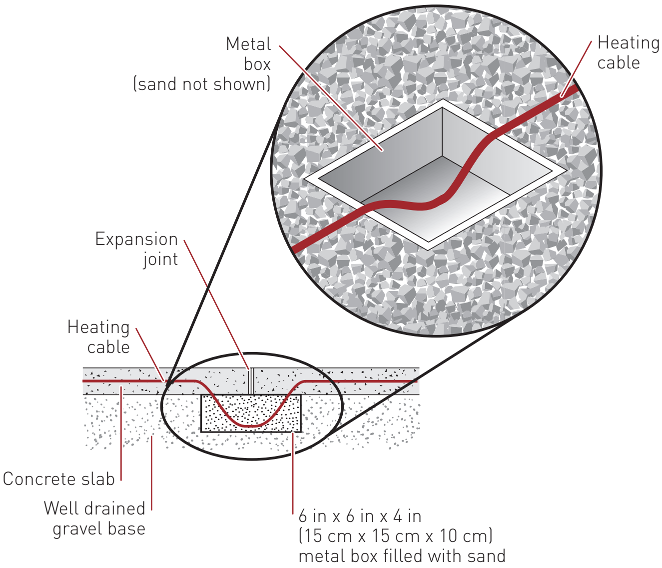


Fig. 6 Crossing expansion joints

Cold leads may cross expansion joints provided that they are fed through nonmetallic conduit to protect against shear (see Fig. 7).

Important Points to Remember

- Concrete slabs should have crack-control joints at intervals typically not exceeding 20 ft (6.1 m).
- When crossing crack-control joints, protect the cable as shown in Fig. 7 or design for a sufficient number of heating cables to avoid crossing control joints altogether.
- Avoid crossing expansion joints. If possible, design for a sufficient number of heating cables so that the cables do not cross expansion joints.

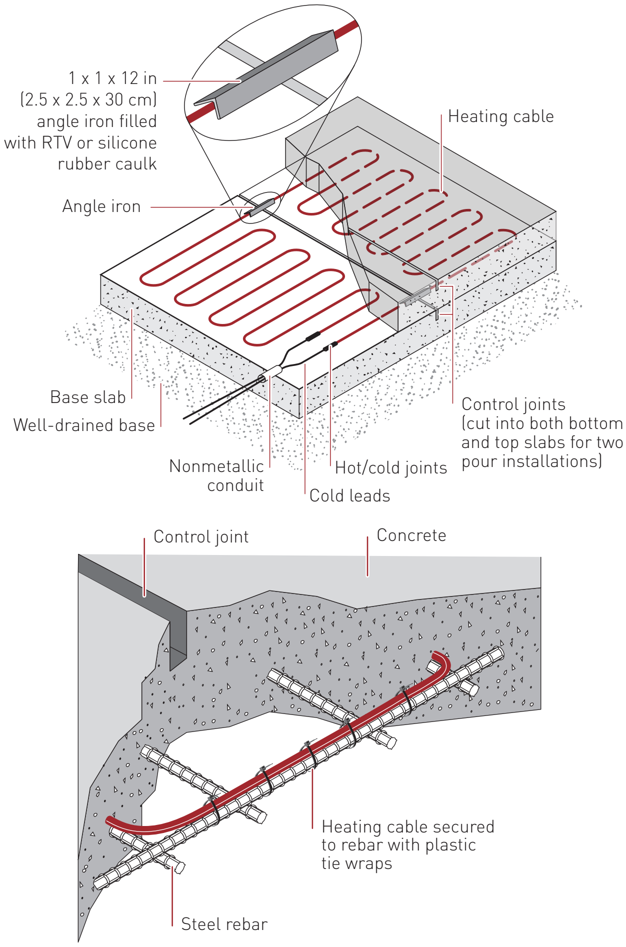


Fig. 7 Method of crossing crack-control joints with MI heating cable in concrete slabs

Example: Surface Snow Melting System

Total ramp surface area	45 ft x 12 ft = 540 ft^2 (from Step 1) (13.7 m x 3.66 m = 50.1 m^2)
For three-phase, divide the ramp into three equal subsections	15 ft x 12 ft = 180 ft^2 (see Fig. 5) (4.57 m x 3.66 m = 16.7 m^2)

Continue with "Step 4 Select the heating cable" on page 149, and use Table 2 or Table 3 to select an appropriate heating cable.

STAIRS

Snow melting applications in concrete stairs present a problem distinct from snow melting on single layer surfaces. Heat loss in stairs occurs from the two exposed surfaces: the top of each stair and its side. Melting snow and ice from stairs requires one run of heating cable be installed 2 to 3 in (5 to 7.5 cm) maximum from the front, or nose, of each stair at a depth of 2 in (5 cm) below the surface of the stair.

Note: Stairs typically require a heating cable that is a specific length. In many cases, it may not be possible to find a SUA/SUB heating cable of the exact length, and a custom engineered heating cable will be required. In these cases, or for elevated stairs or stairs that are not concrete, please contact your Thermal Management representative for assistance in designing a custom engineered heating cable.

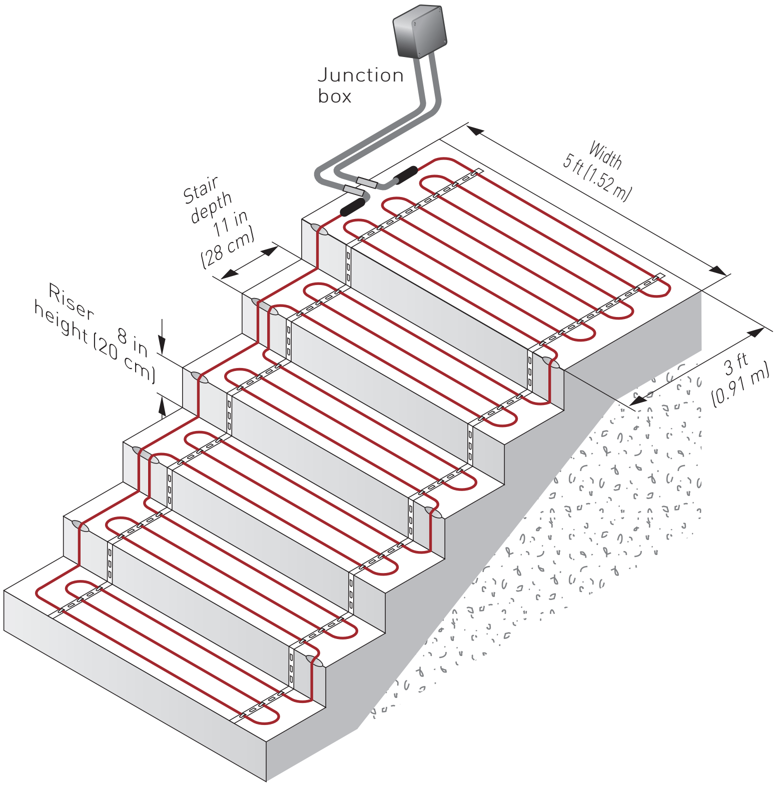


Fig. 8 **Example for concrete stair**

Typically, three runs of cable are used for stairs with a depth of 10.5 to 12 in (27–30 cm); two runs of cable may be used for stairs with a depth of less than 10.5 in (27 cm). Riser height is typically 8 in (20 cm). For stairs greater than 12 in (30 cm) in depth, contact your Thermal Management representative.

Use the formulas below to determine the length of cable required for stairs (a) and for an attached landing (b), if any, where no expansion joint exists between the stair and landing.

(a) Length of cable for stair (ft/m) = No. of stairs x [(No. of runs per stair x stair width (ft/m)) + (2 x riser height (ft/m))]

(b) $$\text{Length of cable for attached landing (ft)} = \frac{\text{Landing area (ft}^2\text{) x 12}}{4.5}$$

$$\text{Length of cable for attached landing (m)} = \frac{\text{Landing area (m}^2\text{) x 1000}}{115}$$

For applications where the landing area is very large or where an expansion joint exists between the stairs and landing, consider the stairs and landing as two separate areas. In these cases, determine the length of cable required for the stairs as shown above and select the cable for the landing as shown for surface snow melting.

Example: Surface Snow Melting System for Stairs

Number of stairs	5 stairs (from Step 1)
Stair width	5 ft (1.52 m) (from Step 1)
Riser height	8 in (20 cm) convert to 0.7 ft (0.2 m) (from Step 1)
Stair depth	11 in (28 cm) (from Step 1)
Number of cable runs per stair	3 runs (for 11 in (28 cm) stair depth)
Length of cable for stair	5 stairs x [(3 x 5 ft) + (2 x 0.7 ft)] = 82 ft 5 stairs x [(3 x 1.52 m) + (2 x 0.2 m)] = 25 m
Landing surface area	5 ft x 3 ft = 15 ft² (from Step 1) 1.52 m x 0.91 m = 1.4 m²
Length of cable for attached landing	(15 ft² x 12) / 4.5 = 40 ft (1.4 m² x 1000) / 115 = 12.2 m
Total heating cable length required	**82 ft + 40 ft = 122 ft** **25 m + 12.2 m = 37.2 m**

Continue with "Step 4 Select the heating cable" on page 149. and use Table 4 on page 154 to select an appropriate heating cable.

WHEEL TRACKS

To reduce power consumption for concrete and asphalt driveways, it may be sufficient to snow melt only the wheel tracks. However, do not snow melt only the wheel tracks in paver applications because of potential problems with pavers sinking.

It is not necessary to calculate the area of the wheel track to select the heating cable. Four runs of heating cable per wheel track spaced evenly over the track width, typically 18 in (46 cm), will provide sufficient heat for snow melting.

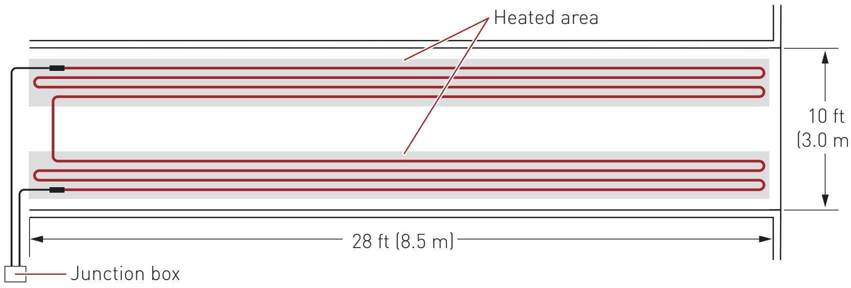


Fig. 9 Example for wheel tracks

Example: Surface Snow Melting System for Wheel Tracks

Wheel track length	28 ft (8.5 m) (from Step 1)
Typical wheel track width	18 in (46 cm)

Continue with "Step 4 Select the heating cable" on page 149 and use Table 5 on page 155 to select an appropriate heating cable.

Surface Snow Melting

1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 4 Select the heating cable

Three-phase supply voltages, including 208 V, 480/277 V, and 600/347 V, are commonly used for snow melting applications for large areas. For small areas, a single-phase supply voltage must be used. A snow melting system designed for a three-phase supply uses three identical heating cables in each circuit, resulting in the following advantages: fewer circuits, reduced distribution system costs, and a balanced heating system load.

SURFACES

Select a heating cable from Table 2 on page 150 or Table 3 on page 151. When selecting cables from Table 2, ensure that the selected cable is suitable for use when embedded in the paving material being used. The heating cables in Table 3 are suitable for surface snow melting applications where the cables will be directly embedded only in concrete. To select a cable, first calculate the required heating cable output (watts) by multiplying the watt density by the area or subsection area.

Under the appropriate voltage in Table 2 or Table 3, select a heating cable from the shaded column with a heating cable output equal to or up to 30% greater than the calculated wattage. In cases where the surface area has been divided into equal subsections, select the appropriate number of heating cables.

Required watts = Watt density x Area

Number of cables = Number of subsection areas

Example: Surface Snow Melting System

Supply voltage	480 V, three-phase (from Step 1)
Required watt density for ramp	35 W/ft² (377 W/m²) (from Step 2)
Subsection area (for 3 equal areas)	180 ft² (16.7 m²) (from Step 3)
Required watts (for each subsection)	35 W/ft² x 180 ft² = 6300 W 377 W/m² x 16.7 m² = 6300 W
Heating cable catalog number	**SUB20**
Cable wattage	6450 W
Cable voltage	480 V (for cables connected in Delta configuration)
Heating cable length	340 ft (103.6 m)
Number of cables	3 (one cable required for each subsection)

TABLE 2 SELECTION TABLE FOR CONCRETE, ASPHALT, AND PAVER AREAS

Heating cable catalog number	Concrete	Asphalt	Pavers [1]	Heating cable output	Heating cable length		Heating cable current
				(W)	(ft)	(m)	(A)
120 V							
SUA5	Yes	Yes	Yes	550	40	12.2	4.6
SUA9	Yes	Yes	Yes	1100	66	20.1	9.2
208 V							
SUA4	Yes	Yes	No	1600	68	20.7	7.7
SUA7	Yes	Yes	No	2300	95	29	11.1
SUB1	Yes	Yes	No	3100	132	40.2	14.9
SUB3	Yes	Yes	Yes	3900	280	85.3	18.8
SUB5	Yes	Yes	No	5500	260	79.2	26.4
SUB7	Yes	Yes	No	7000	310	94.5	33.7
SUB9	Yes	Yes	Yes	9000	630	192	43.3
SUB10	Yes	Yes	Yes	13000	717	218.5	62.5
240 V							
SUA3	Yes	Yes	Yes	2000	140	42.7	8.3
SUA8	Yes	Yes	Yes	3200	177	53.9	13.3
SUB2	Yes	Yes	Yes	4000	240	73.1	16.7
SUB3	Yes	Yes	Yes	5200	280	85.3	21.7
SUB4	Yes	Yes	Yes	6000	320	97.5	25
SUB5	Yes	No	No	7350	260	79.2	30.6
SUB6	Yes	Yes	Yes	7500	375	114.3	31.3
SUB8	Yes	Yes	Yes	9000	550	167.6	37.5
SUB7	Yes	No	No	9250	310	94.5	38.5
SUB9	Yes	Yes	Yes	12000	630	192	50
SUB10	Yes	Yes	No	17000	717	218.5	70.8
277 V							
SUA3	Yes	Yes	Yes	2740	140	42.7	9.9
SUA8	Yes	Yes	No	4100	177	53.9	14.8
SUB15	Yes	Yes	Yes	4250	225	68.6	15.3
SUB2	Yes	Yes	No	5300	240	73.1	19.1
SUB16	Yes	Yes	Yes	6180	310	94.5	22.3
SUB3	Yes	Yes	No	6850	280	85.3	24.7
SUB4	Yes	Yes	No	8000	320	97.5	28.9
SUB17	Yes	Yes	Yes	8700	440	134.1	31.4
SUB6	Yes	No	No	10200	375	114.3	36.8
SUB18	Yes	Yes	No	12000	560	170.7	43.3
SUB8	Yes	Yes	No	12200	550	167.6	44.0
SUB9	Yes	No	No	16400	630	192	59.2
480 V							
SUB19	Yes	Yes	Yes	4700	245	74.7	9.8
SUB20	Yes	Yes	Yes	6450	340	103.6	13.4
SUB21	Yes	Yes	Yes	8700	440	134.1	18.1
SUB22	Yes	Yes	No	11000	525	160	22.9

[1] Cables embedded in sand or limestone screenings.

Note: Type SUA cables supplied with 7 ft (2.1 m) cold lead. Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%.
To modify cold lead length, contact your Thermal Management sales representative.

TABLE 2 SELECTION TABLE FOR CONCRETE, ASPHALT, AND PAVER AREAS

Heating cable catalog number				Heating cable output	Heating cable length		Heating cable current
	Concrete	Asphalt	Pavers [1]	(W)	(ft)	(m)	(A)
600 V							
SUB11	Yes	Yes	Yes	4100	225	68.6	6.8
SUB12	Yes	Yes	Yes	5800	310	94.5	9.7
SUB13	Yes	Yes	Yes	8000	428	130.5	13.3
SUB14	Yes	Yes	Yes	11000	548	167	18.3

[1] Cables embedded in sand or limestone screenings.

Note: Type SUA cables supplied with 7 ft (2.1 m) cold lead. Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%.
To modify cold lead length, contact your Thermal Management sales representative.

The heating cables in Table 3 have been specifically designed for use only in concrete. Do not use these cables in asphalt or for paver areas because they exceed the maximum watts per foot loading for these applications (embedded in asphalt 25 watts/foot maximum; embedded in sand/limestone screenings for paver areas - 20 watts/foot maximum). To select a cable, calculate the required heating cable output (watts) as shown in the example earlier in this section.

TABLE 3 SELECTION TABLE FOR CONCRETE AREAS

Heating cable catalog number	Heating cable output	Heating cable length		Heating cable current
	(W)	(ft)	(m)	(A)
208 V				
SUB1402	1400	50	15.2	6.7
SUB1702	1700	64	19.5	8.2
SUB2002	2000	72	22.0	9.6
SUB2402	2400	90	27.4	11.5
SUB2802	2800	103	31.4	13.5
SUB3402	3400	121	36.9	16.3
SUB3902	3900	139	42.4	18.8
SUB4502	4500	160	48.8	21.6
SUB5502	5500	197	60.1	26.4
SUB6402	6400	226	68.9	30.8
SUB7802	7800	277	84.5	37.5
SUB10302	10300	368	112.2	49.5
SUB12802	12800	455	138.7	61.5
SUB16102	16100	576	175.6	77.4

Note: Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%. To modify cold lead length, contact your Thermal Management sales representative.

TABLE 3 SELECTION TABLE FOR CONCRETE AREAS

Heating cable catalog number	Heating cable output	Heating cable length		Heating cable current
	(W)	(ft)	(m)	(A)
240 V				
SUB1604	1600	59	18.0	6.7
SUB2004	2000	74	22.6	8.3
SUB2304	2300	84	25.6	9.6
SUB2804	2800	103	31.4	11.7
SUB3204	3200	120	36.6	13.3
SUB3904	3900	140	42.7	16.3
SUB4504	4500	160	48.8	18.8
SUB5204	5200	185	56.4	21.7
SUB6404	6400	225	68.6	26.7
SUB7304	7300	263	80.2	30.4
SUB9004	9000	320	97.6	37.5
SUB11904	11900	426	129.9	49.6
SUB14704	14700	528	161.0	61.3
SUB18604	18600	664	202.4	77.5
277 V				
SUB1807	1800	70	21.3	6.5
SUB2307	2300	85	25.9	8.3
SUB2707	2700	95	29.0	9.7
SUB3207	3200	119	36.3	11.6
SUB3807	3800	135	41.2	13.7
SUB4507	4500	162	49.4	16.2
SUB5207	5200	184	56.1	18.8
SUB6007	6000	213	64.9	21.7
SUB7307	7300	262	79.9	26.4
SUB8507	8500	300	91.5	30.7
SUB10307	10300	372	113.4	37.2
SUB13707	13700	491	149.7	49.5
SUB17207	17200	600	182.9	62.1
347 V				
SUB2305	2300	85	25.9	6.6
SUB2905	2900	107	32.6	8.4
SUB3405	3400	119	36.3	9.8
SUB4105	4100	148	45.1	11.8
SUB4705	4700	171	52.1	13.5
SUB5605	5600	205	62.5	16.1
SUB6505	6500	231	70.4	18.7
SUB7505	7500	267	81.4	21.6
SUB9205	9200	327	99.7	26.5
SUB10605	10600	380	115.9	30.5
SUB13005	13000	463	141.2	37.5
SUB17205	17200	614	187.2	49.6

Note: Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%. To modify cold lead length, contact your Thermal Management sales representative.

TABLE 3 SELECTION TABLE FOR CONCRETE AREAS

Heading cable catalog number	Heating cable output	Heating cable length		Heating cable current
	(W)	(ft)	(m)	(A)
480 V				
SUB3208	3200	118	36.0	6.7
SUB4008	4000	147	44.8	8.3
SUB4708	4700	163	49.7	9.8
SUB5708	5700	202	61.6	11.9
SUB6608	6600	233	71.0	13.8
SUB7908	7900	278	84.8	16.5
SUB9008	9000	320	97.6	18.8
SUB10408	10400	368	112.2	21.7
SUB12808	12800	450	137.2	26.7
SUB14808	14800	520	158.5	30.8
SUB18008	18000	640	195.1	37.5
600 V				
SUB4006	4000	147	44.8	6.7
SUB5106	5100	181	55.2	8.5
SUB5806	5800	207	63.1	9.7
SUB7106	7100	254	77.4	11.8
SUB8206	8200	293	89.3	13.7
SUB9806	9800	350	106.7	16.3
SUB11206	11200	402	122.6	18.7
SUB13006	13000	462	140.9	21.7
SUB15906	15900	566	172.6	26.5

Note: Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%. To modify cold lead length, contact your Thermal Management sales representative.

STAIRS

For stairs, select a heating cable from Table 4. Under the appropriate voltage, select a cable from the shaded column with a length equal to or up to 20 ft (6.1 m) longer than the calculated length from Step 3. Next, confirm that the watt density is equal to, or greater than, the watt density determined from Step 2. If a cable of the required length is not available, please contact your Thermal Management representative for assistance in designing a custom heating cable.

Anticipate and design for the addition of railings or other follow on construction that will require cutting or drilling into the concrete as damage to installed heating cable may occur. Allow for at least 4 in (10 cm) clearance between the heating cable and any planned cuts or holes.

Example: Surface Snow Melting System for Stairs

Supply voltage	208 V, single-phase (from Step 1)
Required watt density	45 W/ft^2 (484 W/m^2) (from Step 2)
Total heating cable length required	122 ft (37.2 m) (from Step 3)
Heating cable catalog number	**SUB1**
Cable wattage	3100 W
Cable voltage	208 V
Heating cable length	132 ft (40.2 m)
Number of cables	1
Installed watt density	55 W/ft^2 (592 W/m^2) (from Table 4)

TABLE 4 SELECTION TABLE FOR CONCRETE STAIRS

Heating cable catalog number	Heating cable length		Watt density				Heating cable output	Heating cable current
			3 runs cable [1]		2 runs cable [2]			
	(ft)	(m)	(W/ft^2)	(W/m^2)	(W/ft^2)	(W/m^2)	(W)	(A)
120 V								
SUA5	40	12.2	40	431	–	–	550	4.6
SUA9	66	20.1	50	538	40	431	1100	9.2
208 V								
SUA4	68	20.7	55	592	55	592	1600	7.7
SUA7	95	29.0	55	592	55	592	2300	11.1
SUB1	132	40.2	55	592	55	592	3100	14.9
SUB3	280	85.3	40	431	–	–	3900	18.8
SUB5	260	79.2	55	592	50	538	5500	26.4
SUB7	310	94.5	55	592	50	538	7000	33.7
SUB9	630	192.0	40	431	–	–	9000	43.3
240 V								
SUA3	140	42.7	40	431	–	–	2000	8.3
SUB2	240	73.1	50	538	40	431	4000	16.7
SUB3	280	58.3	55	592	40	431	5200	21.7
SUB4	320	97.5	55	592	45	484	6000	25.0
SUB6	375	114.3	55	592	45	484	7500	31.3
SUB8	550	167.6	50	538	40	431	9000	37.5
SUB9	630	192.0	55	592	45	484	12000	50.0
277 V								
SUA3	140	42.7	55	592	45	484	2740	9.9
SUB15	225	68.6	55	592	45	484	4250	15.3
SUB2	240	73.1	55	592	50	538	5300	19.1
SUB16	310	94.5	55	592	45	484	6180	22.3
SUB3	280	85.3	55	592	55	592	6850	24.7
SUB4	320	97.5	55	592	55	592	8000	28.9
SUB17	440	134.1	55	592	45	484	8700	31.4
SUB6	375	114.3	55	592	55	592	10200	36.8
SUB18	560	170.7	55	592	50	538	12000	43.3
480 V								
SUB19	245	74.7	55	592	45	484	4700	9.8
SUB20	340	103.6	55	592	45	484	6450	13.4
SUB21	440	134.1	55	592	45	484	8700	18.1
SUB22	525	160.0	55	592	50	538	11000	22.9
600 V								
SUB11	225	68.6	55	592	40	431	4100	6.8
SUB12	310	94.5	55	592	45	484	5800	9.7
SUB13	428	130.5	55	592	45	484	8000	13.3
SUB14	548	167.0	55	592	45	484	11000	18.3

[1] Based on stairs with a depth of 10.5–12 in (27–30 cm) and 3 runs of cable

[2] Based on stairs with a depth of less than 10.5 in (27 cm) and 2 runs of cable

Note: Type SUA cables supplied with 7 ft (2.1 m) cold lead. Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%.
To modify cold lead length, contact your Thermal Management sales representative.

WHEEL TRACKS

The heating cables shown in Table 5 will allow for four runs of cable in each wheel track. Under the appropriate voltage, select a heating cable from the shaded column for the wheel track length required. For wheel tracks outside the scope of this design guide, please contact your Thermal Management representative for assistance in designing a custom engineered heating cable.

Example: Surface Snow Melting System for Wheel Tracks

Supply voltage	240 V, single-phase (from Step 1)
Wheel track length	28 feet (8.5 m)
Heating cable catalog number	**SUB2**
Cable wattage	4000 W
Cable voltage	240 V
Heating cable length	240 ft (73.1 m)
Number of cables	1

TABLE 5 SELECTION TABLE FOR CONCRETE AND ASPHALT WHEEL TRACKS

Heating cable catalog number	Wheel track length		Spacing (inches)		Spacing (cm)		Heating cable length		Heating cable output	Heating cable current
	(ft)	(m)	Normal heat	High heat	Normal heat	High heat	(ft)	(m)	(W)	(A)
208 V										
SUA7	8 – 11	2.4 – 3.4	7	5	18	13	95	29	2300	11.1
SUB1	12 – 15	3.5 – 4.6	7	5	18	13	132	40.2	3100	14.9
SUA8	16 – 21	4.7 – 6.4	4	3	10	8	177	54	2400	11.5
SUB5	22 – 31	6.5 – 9.5	6	5	15	13	260	79.2	5500	26.4
SUB7	32 – 38	9.6 – 11.6	6	5	15	13	310	94.5	7000	33.7
SUB6	39 – 46	11.7 – 14.0	4	3	10	8	375	114.3	5700	27.4
SUB8	47 – 68	14.1 – 20.7	4	3	10	8	550	167.7	6800	32.7
SUB9	69 – 78	20.8 – 23.8	4	3	10	8	630	192	9000	43.3
SUB10	79 – 88	23.9 – 26.8	5	4	13	10	717	218.5	13000	62.5
240 V										
SUA3	8 – 16	2.4 – 4.9	4	3	10	8	140	42.7	2000	8.3
SUA8	17 – 21	5.0 – 6.4	5	4	13	10	177	53.9	3200	13.3
SUB2	22 – 29	6.5 – 8.8	5	4	13	10	240	73.1	4000	16.7
SUB3	30 – 34	8.9 – 10.4	5	4	13	10	280	85.3	5200	21.7
SUB4	35 – 39	10.5 – 11.9	5	4	13	10	320	97.5	6000	25
SUB6	40 – 46	12.0 – 14.0	6	5	15	13	375	114.3	7500	31.3
SUB8	47 – 68	14.1 – 20.7	5	4	13	10	550	167.6	9000	37.5
SUB9	69 – 78	20.8 – 23.8	6	5	15	13	630	192	12000	50
SUB10	79 – 88	23.9 – 26.8	7	5	18	13	717	218.5	17000	70.8
277 V										
SUA3	11 – 16	3.4 – 4.9	6	5	15	13	140	42.7	2740	9.9
SUB15	17 – 27	5.0 – 8.2	6	5	15	13	225	68.6	4250	15.3
SUB16	28 – 38	8.3 – 11.6	6	5	15	13	310	94.5	6180	22.3
SUB17	39 – 54	11.7 – 16.5	6	5	15	13	440	134.1	8700	31.4
SUB18	55 – 69	16.6 – 21.0	6	5	15	13	560	170.7	12000	43.3
SUB9 [1]	70 – 78	21.1 – 23.8	7	6	18	15	630	192	16400	59.2

[1] Not for asphalt applications; for use when embedded in concrete only

Note: Type SUA cables supplied with 7 ft (2.1 m) cold lead. Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%.
To modify cold lead length, contact your Thermal Management sales representative.

TABLE 5 SELECTION TABLE FOR CONCRETE AND ASPHALT WHEEL TRACKS

Heating cable catalog number	Wheel track length		Spacing (inches)		Spacing (cm)		Heating cable length		Heating cable output	Heating cable current
	(ft)	(m)	Normal heat	High heat	Normal heat	High heat	(ft)	(m)	(W)	(A)
480 V										
SUB19	20 – 29	6.1 – 8.8	6	5	15	13	245	74.7	4700	9.8
SUB20	30 – 41	8.9 – 12.5	6	5	15	13	340	103.6	6450	13.4
SUB21	42 – 54	12.6 – 16.5	6	5	15	13	440	134.1	8700	18.1
SUB22	55 – 64	16.6 – 19.5	6	5	15	13	525	160	11000	22.9
600 V										
SUB11	20 – 27	6.1 – 8.2	6	4	15	10	225	68.6	4100	6.8
SUB12	28 – 38	8.3 – 11.6	6	5	15	13	310	94.5	5800	9.7
SUB13	39 – 52	11.7 – 15.9	6	5	15	13	428	130.5	8000	13.3
SUB14	53 – 67	16.0 – 20.4	6	5	15	13	548	167	11000	18.3

[1] Not for asphalt applications; for use when embedded in concrete only

Note: Type SUA cables supplied with 7 ft (2.1 m) cold lead. Type SUB cables supplied with 15 ft (4.6 m) cold leads. Tolerance on heating cable length is –0% to +3%.
To modify cold lead length, contact your Thermal Management sales representative.

Surface Snow Melting

1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 5 Determine heating cable spacing

SURFACES

Determine the spacing between runs of heating cables using the formula below. For concrete installations, do not exceed 10 in (25 cm) spacing of cable, and for asphalt and paver installations do not exceed 6 in (15 cm) spacing. If the cable spacing for asphalt or pavers exceeds 6 in (15 cm), contact your Thermal Management representative for assistance.

To determine heating cable spacing required for surface snow melting

$$\text{Cable spacing (in)} = \frac{\text{Area (ft}^2\text{) x 12 in}}{\text{Heating cable length (ft)}}$$

$$\text{Cable spacing (cm)} = \frac{\text{Area (m}^2\text{) x 100 cm}}{\text{Heating cable length (m)}}$$

Round to the nearest 1/2 in or nearest 1 cm to obtain cable spacing.

Note: If a large area has been divided into subsections or if a three-phase voltage supply is used, the area in the above equations will be the subsection area and the heating cable length will be the length of the cable selected for the subsection area.

Example: Surface Snow Melting System

Subsection area	180 ft^2 (16.7 m^2) (from Step 3)
Heating cable catalog number	SUB20 (from Step 4)
Heating cable length	340 ft (103.6 m) (from Step 4)
Cable spacing	(180 ft^2 x 12 in) / 340 ft = 6.4 in **Rounded to 6.5 in** **(16.7 m^2** x 100 cm) / 103.6 m = 16.1 cm **Rounded to 16 cm**

STAIRS

For concrete stairs with a depth of 10.5–12 in (27–30 cm), use three runs of cable with one run 2 to 3 in (5–7.5 cm) maximum from the front edge of the stair (this is where snow and ice build-up is the most dangerous) and the remaining two runs spaced equally apart from this run of cable. For stairs with a depth of less than 10.5 in (27 cm), use two runs of cable with one run 2 to 3 in (5–7.5 cm) maximum from the front edge of the stair and the second run spaced 4 in (10 cm) from this run of cable. Up to 20 ft (6.1 m) of excess cable may be used up in an attached landing, preferably, or by adding an extra run to one or more stairs.

For attached landings, space heating cables 4.5 in (11.5 cm) apart; up to 20 ft (6.1 m) of excess cable may be used up in the landing, decreasing cable spacing as necessary to accommodate the extra cable.

Example: Surface Snow Melting System for Stairs

Heating cable catalog number	SUB1 (from Step 4)
Stair depth	11 in (28 cm) (from Step 1)
Cable spacing – stairs	3 runs per stair spaced as described above
Cable spacing – landing	4.5 in (11.5 cm)

WHEEL TRACKS

For wheel tracks, use the spacing shown in Selection Table for Concrete and Asphalt Wheel Tracks for "Normal" or "High" heat. Use the spacing for "High heat" for all asphalt applications, or where a watt density of 45 W/ft^2 (484 W/m^2) or higher is required.

Example: Surface Snow Melting System for Wheel Tracks

Paving material	Asphalt (from Step 1) – high heat required
Heating cable catalog number	SUB2 (from Step 4)
Cable spacing	4 in (10 cm) (from Table 5)

Step 6 Determine the electrical parameters

DETERMINE NUMBER OF CIRCUITS

For single phase circuits, individual heating cables are generally connected to separate circuit breakers. Multiple heating cables may be connected in parallel to reduce the number of circuits with permission from the Authority Having Jurisdiction. The single-phase heating cable current is shown in the appropriate selection table.

For three-phase circuits used in snow melting systems, the three heating cables are generally connected in the Delta configuration shown in Fig. 11 on page 164. Heating cables may also be connected using the Wye configuration shown in Fig. 12 on page 165, but this configuration is less common. For both Delta and Wye configurations, each set of three equal cables form a single circuit.

SELECT BRANCH CIRCUIT BREAKER

The safety and reliability of any snow melting system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system components could damage the snow melting system and may result in inadequate snow melting, electric shock, or fire. To minimize the risk of fire, Thermal Management and national electrical codes require a grounded metallic covering on all heating cables. Thermal Management, agency certifications, and national electrical codes require a grounded metallic covering on all heating cables. They also require that all heating cables be protected with ground-fault equipment protection.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

The power output and heating cable current draw for the snow melting cables are shown in Table 2 through Table 5.

For single-phase circuits, the load current must not exceed 80% of the circuit breaker rating.

Load current = Heating cable current **(for a single circuit)**
Circuit breaker rating = Load current x 1.25

For a Delta connected three-phase circuit, shown in Fig. 11 on page 164, the load current can be determined by multiplying the heating cable current times 1.732 and it must not exceed 80% of the 3-pole circuit breaker rating.

Load current = Heating cable current x 1.732 **(for a single Delta connected circuit)**
Circuit breaker rating = Load current x 1.25

For a Wye connected three-phase circuit, shown in Fig. 12 on page 165, the load current is the same as the heating cable current and it must not exceed 80% of the 3-pole circuit breaker rating.

Load current = Heating cable current **(for a single Wye connected circuit)**
Circuit breaker rating = Load current x 1.25

Record the number and ratings of the circuit breakers to be used. Use ground-fault protection devices (GFPDs) for all applications. For three-phase circuits, ground fault may be accomplished using a shunt trip 3-pole breaker and a ground fault sensor.

Circuit breaker rating (A) ____________ Number of circuit breakers ____________

DETERMINE TRANSFORMER LOAD

The total transformer load is the sum of the loads in the system. Calculate the Total Transformer Load as follows:

For cables of equal wattage:

$$\text{Transformer load (kW)} = \frac{\text{Cable (W) x Number of cables}}{1000}$$

When cable wattages are not equal:

$$\text{Transformer load (kW)} = \frac{\text{Cable}_1\text{ (W) + Cable}_2\text{ (W) + Cable}_3\text{ (W)... + Cable}_N\text{ (W)}}{1000}$$

Example: Surface Snow Melting System

Heating cable catalog number	SUB20 (from Step 4)
Heating cable current	13.4 A (from Table 2)
Load current	13.4 x 1.732 = 23.2 A
Circuit breaker rating	30 A breaker, 80% loading 24 A
Number of circuit breakers	1
Cable power output	6450 W (from Step 4)
Number of cables	3 (from Step 4)
Total transformer load	**(6450 W x 3) / 1000 = 19.4 kW**

Example: Surface Snow Melting System for Stairs

Heating cable catalog number	SUB1 (from Step 4)
Heating cable current	14.9 A (from Table 4)
Load current	14.9 A
Circuit breaker rating	20 A breaker, 80% loading 16 A
Number of circuit breakers	1
Cable power output	3100 W (from Step 4)
Number of cables	1 (from Step 4)
Total transformer load	**3100 W / 1000 = 3.1 kW**

Example: Surface Snow Melting System for Wheel Tracks

Heating cable catalog number	SUB2 (from Step 4)
Heating cable current	16.7 A (from Table 5)
Load current	16.7 A
Circuit breaker rating	30 A breaker, 80% loading 24 A
Number of circuit breakers	1
Cable power output	4000 W (from Step 4)
Number of cables	1 (from Step 4)
Total transformer load	**4000 W / 1000 = 4.0 kW**

Surface Snow Melting
1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 7 Select the control system and power distribution

CONTROL SYSTEM

Select a control system from the following three options keeping in mind that an automatic snow melting controller offers the highest system reliability and the lowest operating cost.

- Manual on/off control
- Slab sensing thermostat
- Automatic snow melting controller

If the current rating of the control means is exceeded, all three methods will require contactors sized to carry the load. Each method offers a tradeoff, balancing initial cost versus energy efficiency and ability to provide effective snow melting. If the system is not energized when required, snow will accumulate. If the system is energized when it is not needed, there will be unnecessary power consumption. Choose the control method that best meets the project performance requirements. For additional information, refer to "Power Distribution" on page 164 or contact your Thermal Management representative for details.

Manual On/Off Control

A manually controlled system is operated by a switch that controls the system power contactor. This method requires constant supervision to work effectively. A manual system can be controlled by a building management system.

Slab Sensing Thermostat

A slab sensing thermostat can be used to energize the system whenever the slab temperature is below freezing, but is not energy efficient when used as the sole means of control. The slab sensing thermostat is recommended for all snow melting applications, even when an automatic snow controller is used, and is required for all asphalt and paver installations (for asphalt, it prevents surface damage due to overheating). The snow melting controllers shown in Table 4 include a slab temperature sensor.

Automatic Snow Melting Controller

With an automatic snow melting controller, the snow melting system is automatically energized when both precipitation and low temperature are detected. When precipitation stops or the ambient temperature rises above freezing, the system is de-energized. In addition, a slab sensor de-energizes the system when the slab temperature reaches the slab sensor set point even if freezing precipitation is still present. Using an automatic snow controller with a slab sensor offers the most energy-efficient control solution. For additional information, refer to Fig. 10.

For areas where a large number of circuits are required, the Raychem ACS-30 can be used. The Surface Snow Melting control mode in the ACS-30 includes an External Device control option. This option allows a Snow/Moisture sensing controller (from Table 6) to be integrated into the ACS-30 system. Note that sensors (snow or gutter) cannot be directly connected to the ACS-30 system. Refer to the ACS-30 Programming Guide (H58692) for more information on system setup.

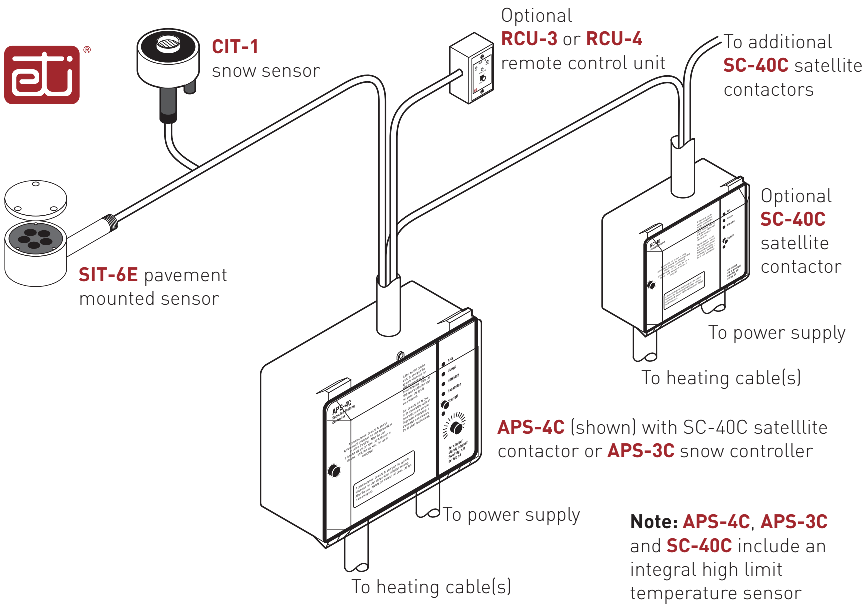


Fig. 10 Automatic snow melting control system

TABLE 6 CONTROL SYSTEMS

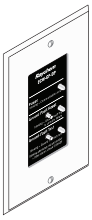
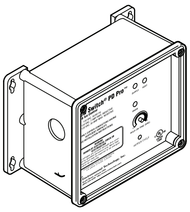
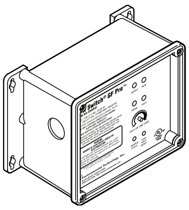
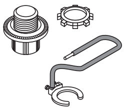
	Catalog number	Description
Slab Sensing Thermostat and Accessory		
	ECW-GF	Electronic ambient sensing controller with 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor and is housed in a Type 4X rated enclosure. The controller features an AC/DC dry alarm contact relay. An optional ground-fault display panel (ECW-GF-DP) that can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) that can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	PD Pro	Automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments. The PD Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The PD Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds.
	GF Pro	Automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments. The GF Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The GF Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds. Features a built-in 30-mA, self-testing Ground-Fault Equipment Protection (GFEP) capability, digitally filtered to minimize false tripping. A ground-fault alarm must be manually reset using the Test/Reset switch before heater operation can continue.

TABLE 6 CONTROL SYSTEMS

	Catalog number	Description
	MI-GROUND-KIT	Grounding kit for nonmetallic enclosures.

Automatic Snow Melting Controllers

	APS-3C	Automatic snow melting controller housed in a Type 3R enclosure provides effective, economical automatic control of all snow melting applications. Features include: 120 V or 208–240 V models, 24-A DPDT output relay and an adjustable hold-on timer. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6-9/16 in (292 mm x 232 mm x 167 mm)
	APS-4C	Automatic snow melting controller housed in a Type 3R enclosure provides effective, economical automatic control of all snow melting applications. The APS-4C can operates with any number of SC-40C satellite contactors for larger loads. Features include: 277 V single-phase or 208–240, 277/480, and 600 V three-phase models, built-in 3-pole contactor, integral 30 mA ground-fault circuit interrupter and an adjustable hold-on timer. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6-9/16 in (292 mm x 232 mm x 167 mm)
	SC-40C	Satellite contactor power control peripheral for an APS-4C snow melting controller, housed in a NEMA 3R enclosure. Features include: 277 V single-phase or 208–240, 277/480 and 600 V three-phase models, built-in 3-pole contactor and integral 30 mA ground-fault circuit interrupter. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6 in (292 mm x 232 mm x 152 mm)

Snow Melting Sensors and Accessories

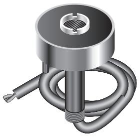
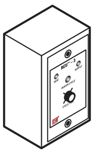
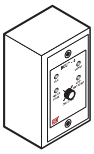
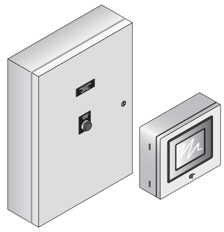
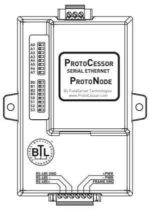
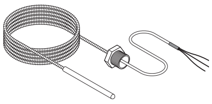
	CIT-1	Overhead snow sensor that detects precipitation or blowing snow at ambient temperatures below 38°F (3.3°C). For use with either an APS-3C or APS-4C automatic snow melting controller.
	SIT-6E	Pavement-mounted sensor signals for the heating cable to turn on when the pavement temperature falls below 38°F (3.3°C) and precipitation in any form is present. Microcontroller technology effectively eliminates ice bridging while ensuring accurate temperature measurement. For use with either an APS-3C or APS-4C automatic snow melting controller.
	RCU-3	The RCU–3 provides control and status display to the APS–3C controller from a remote location. It has a 2, 4, 6 or 8 hour CYCLE TIME adjustment, independent of APS-3C setting.
	RCU-4	The RCU–4 provides control and status display to the APS–4C controller and SC-40C Satellite Contactor from a remote location. It has a 2, 4, 6 or 8 hour CYCLE TIME adjustment, independent of the APS-4C or SC-40C setting.

TABLE 6 CONTROL SYSTEMS

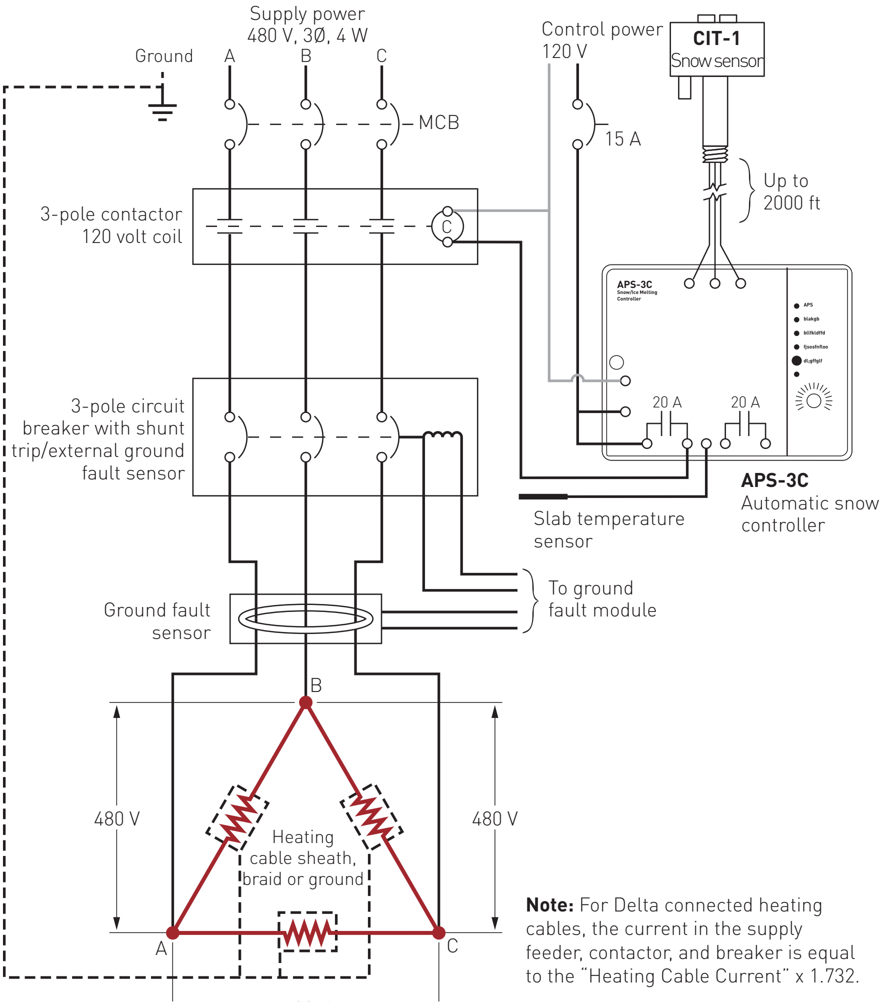
	Catalog number	Description
Electronic Controllers		
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in various commercial applications such as pipe freeze protection, roof and gutter de-icing, surface snow melting, hot water temperature maintenance and floor heating. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers. The ProtoNode-RER is for BACnet® or Metasys® N2 systems..
	RTD-200 RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

POWER DISTRIBUTION

Three-phase, 4-wire voltage supplies such as 208 V, 480 V, and 600 V are commonly used for snow melting applications, especially for large areas. Designing the snow melting system using a three-phase voltage supply results in a balanced heating system load, since three identical cables are used in each circuit. In addition, since three cables are used in each circuit, the result is a system with fewer circuits. For small areas, it may not be possible to select three cables, and one or two heating cables, single-phase connected, must be used.

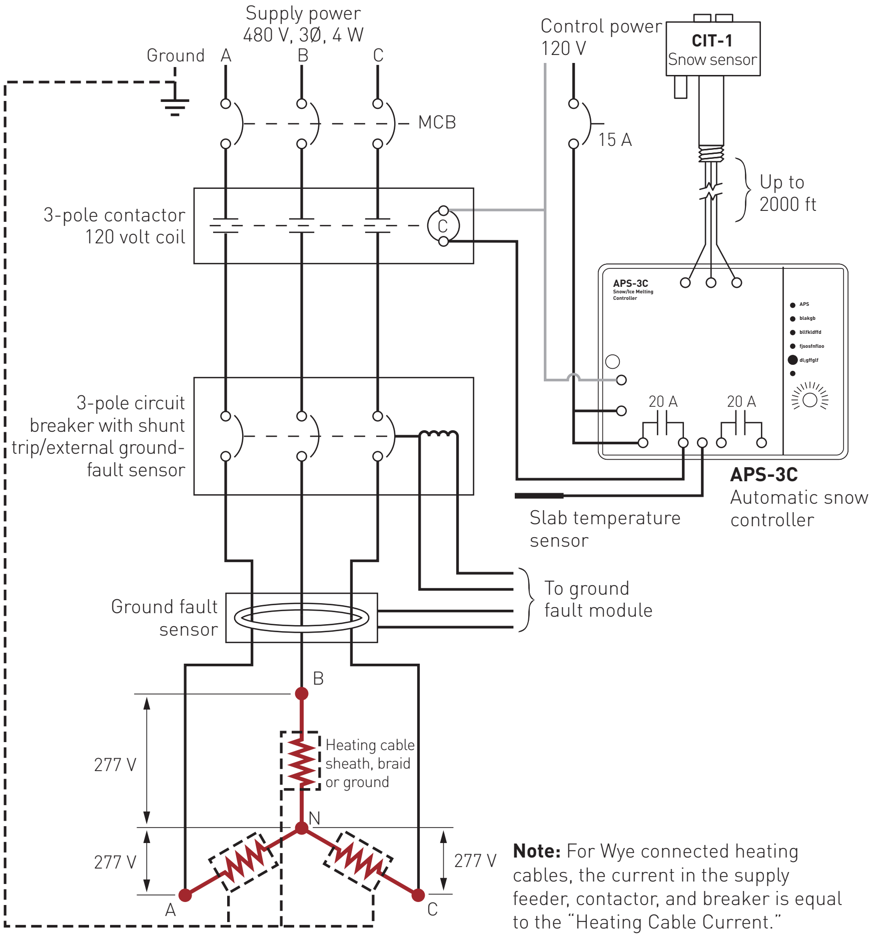
The Delta wiring configuration shown in Fig. 11 is commonly used for three-phase snow melting circuits. Each circuit comprises three heating cables of equal wattage and connected as shown.

Fig. 12 shows the less common Wye wiring configuration. In this case, the three heating cables are also of equal wattage, but most important is that the heating cable voltage must equal the phase-to-neutral supply voltage.



Note: For Delta connected heating cables, the current in the supply feeder, contactor, and breaker is equal to the "Heating Cable Current" x 1.732.

Fig. 11 Typical three-phase DELTA connected heating cables with automatic snow melting controller



Note: For Wye connected heating cables, the current in the supply feeder, contactor, and breaker is equal to the "Heating Cable Current."

Fig. 12 Typical three-phase WYE connected heating cables with automatic snow melting controller

Connecting heating cables in Delta or Wye configuration using three-phase voltage supplies reduces the number of circuits required because three heating cables are used in each circuit. For example, if you select three heating cables to operate on 480 V, single-phase (i.e. 480 V across each cable), you need three 2-conductor feeders, three 2-pole contactors, and three 2-pole breakers (i.e. three circuits) as shown in Fig. 13. If the same three heating cables are connected in Delta configuration to the 480 V, three-phase supply, you need one 3-conductor feeder, one 3-pole contactor, and one 3-pole breaker (i.e. one circuit) as shown in Fig. 11. In addition, decreasing the number of circuits will reduce the cost of the distribution system.

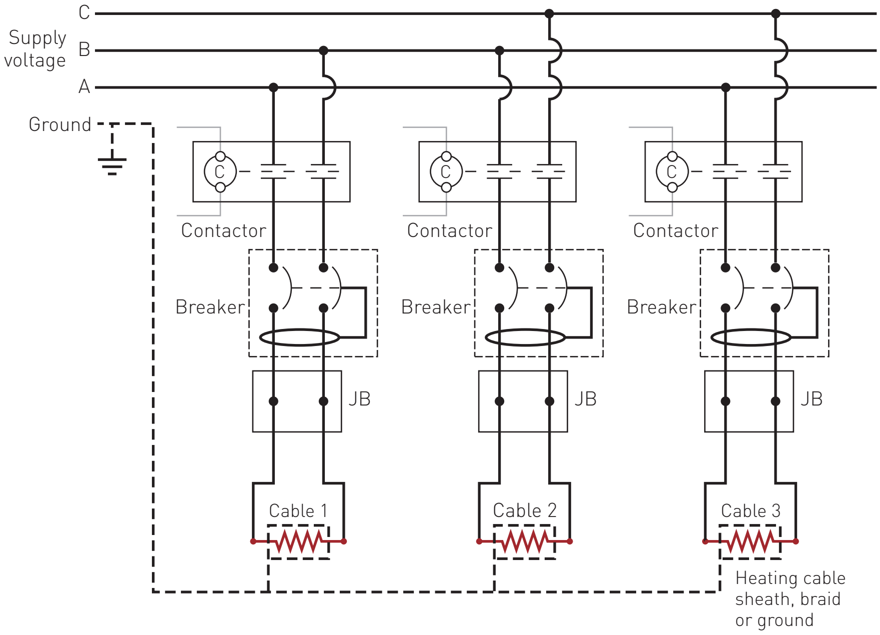


Fig. 13 Simplified single-phase connected heating cables

SINGLE CIRCUIT CONTROL

Heating cable circuits that do not exceed the current rating of the selected controller can be switched directly. Fig. 14 shows a typical single-phase circuit where the heating cable is controlled by a thermostat. When the total electrical load exceeds the rating of the controller or if a single-pole controller is used to control a three-phase circuit, an external contactor is required. In Fig. 11 and Fig. 12, the snow melting controller is used to control the three-phase connected heating cables through a contactor.

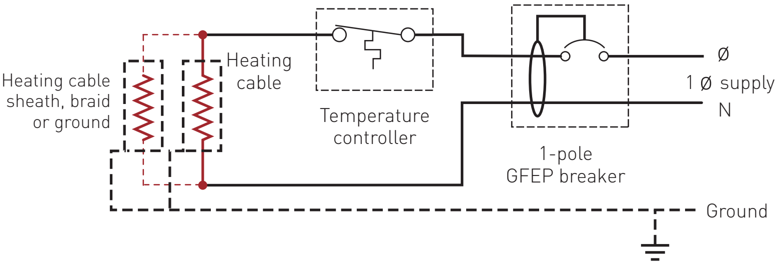


Fig. 14 Single circuit control

GROUP CONTROL

Multiple single-phase or three-phase circuits may be activated by a single snow melting controller or thermostat (group control).

The SMPG power distribution panel is designed to control snow melting circuits installed in medium sized areas. This panel is available in single-phase (SMPG1) and three-phase (SMPG3) versions and includes ground fault protection, monitoring, and control for snow melting systems. The snow melting system is energized after the integrated snow controller receives an input from any of the remote sensors.

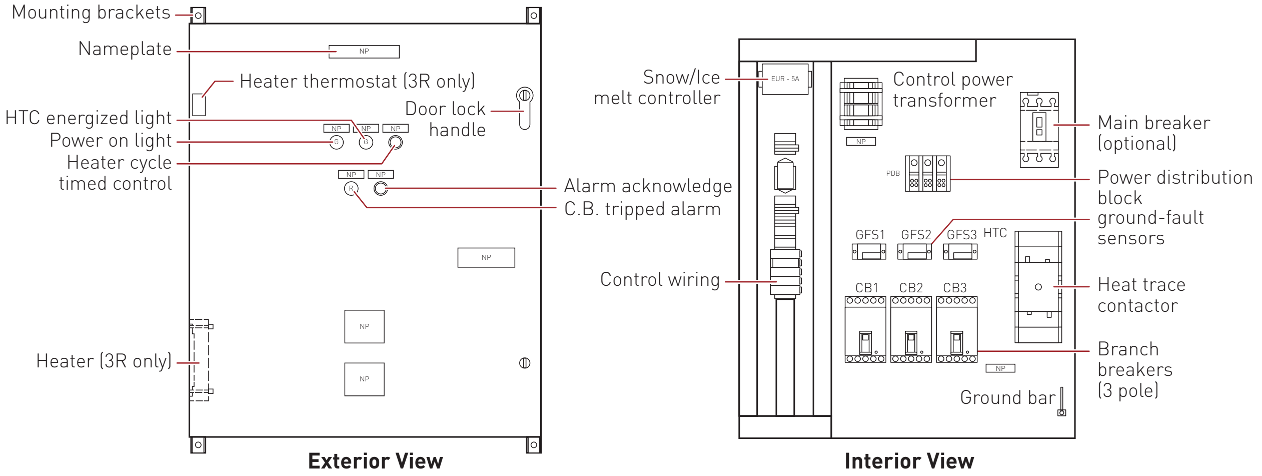


Fig. 15 SMPG3 power distribution panel

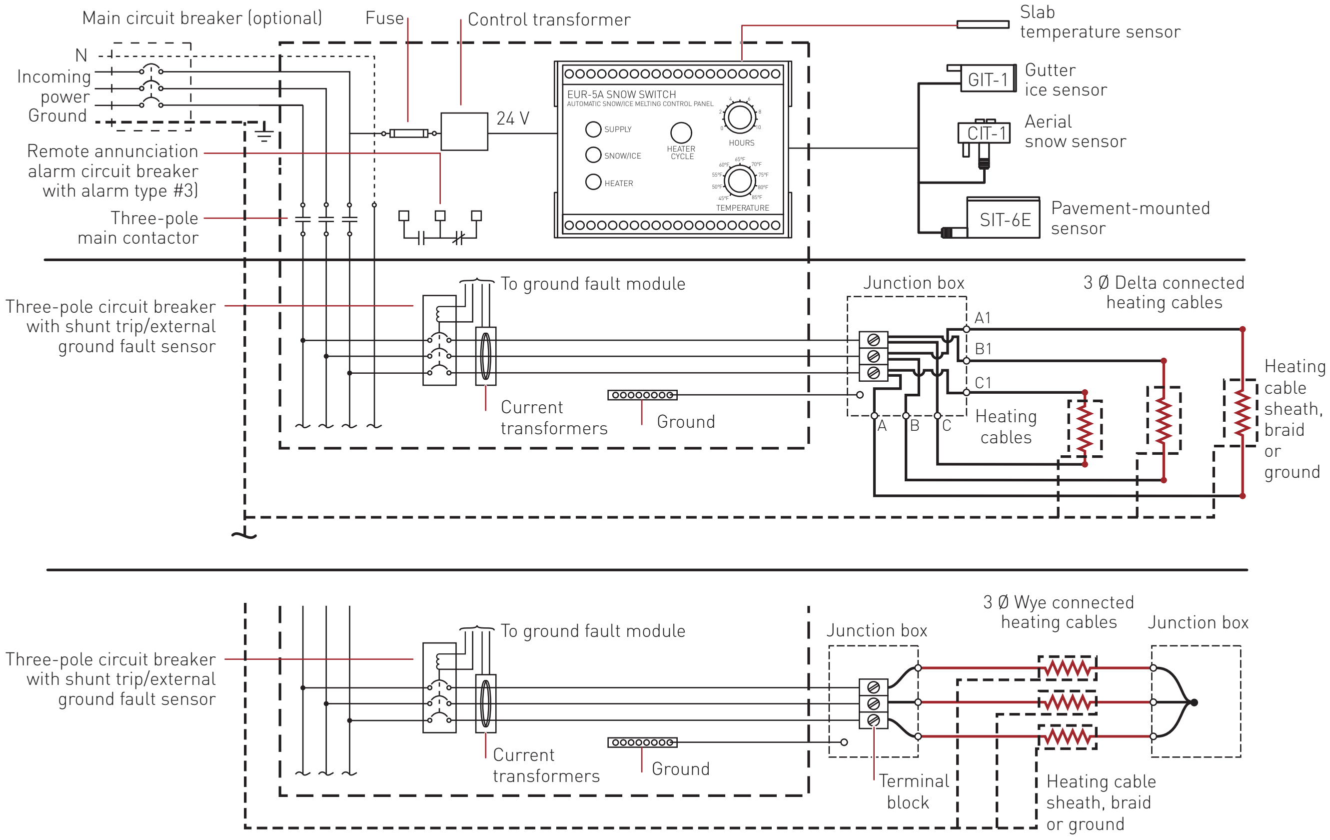
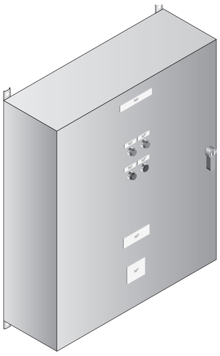
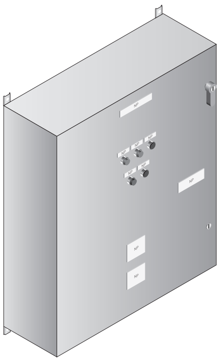


Fig. 16 Typical wiring diagram of group control with SMPG3

TABLE 7 POWER DISTRIBUTION

	Catalog number	Description
Power Distribution and Control Panels		
	SMPG1	Single-phase power distribution panel that includes ground-fault protection, monitoring, and control for snow melting systems. Single-phase voltages include 208 and 277 V. Refer to the SMPG1 data sheet (H57680) for information on selecting a control panel. If standard configurations do not meet your requirements, contact your Thermal Management representative for a quotation on a custom SMPG1 panel.
	SMPG3	Three-phase power distribution panel that includes ground-fault protection, monitoring, and control for snow melting systems. Three-phase voltages include 208, 480, and 600 V. Refer to the SMPG3 data sheet (H57814) for information on selecting a control panel. If standard configurations do not meet your requirements, contact your Thermal Management representative for a quotation on a custom SMPG3 panel.

Example: Surface Snow Melting System

Automatic snow melting controller	APS-4C
Quantity	1
Pavement-mounted sensor	SIT-6E
Quantity	1

Example: Surface Snow Melting System for Stairs

Slab sensing thermostat	ECW-GF
Quantity	1

Example: Surface Snow Melting System for Wheel Tracks

Automatic snow melting controller	APS-4C
Quantity	1
Overhead snow sensor	CIT-1
Quantity	1

Surface Snow Melting

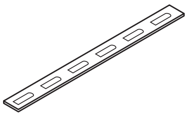
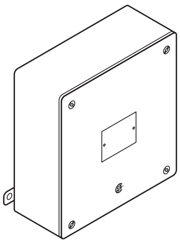
1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 8 Select the accessories

A typical Raychem snow melting system consists of several accessories. All of the accessories work together to provide a safe and reliable snow melting system that is easy to install and maintain.

We recommend using the following as appropriate.

TABLE 8 ACCESSORIES

	Catalog number	Description	Standard packaging	Usage
	HARD-SPACER-GALV-25MM-25M	Galvanized steel prepunched strapping	82 ft (25 m) rolls	No. rolls = 0.005 x area (ft^2) No. rolls = 0.05 x area (m^2)
	HARD-SPACER-SS-25MM-25M	Stainless steel prepunched strapping	82 ft (25 m) rolls	No. rolls = 0.005 x area (ft^2) No. rolls = 0.05 x area (m^2)
	SMCS	Snow melt caution sign Dimensions 6 x 4 in (150 x 100 mm)	1	1 minimum per system
	D1297TERM4	A cast aluminum junction box (Type 3) for installation in nonhazardous and CID2 locations. Three 1/2" NPT entries on bottom, provided with plugs. Includes 4-pole terminal block (CSA - 600 V, 65 A, 18 - 6 AWG; UL - 300 V, 65 A, 18 - 6 AWG). External mounting feet. CSA approved for Class I, Div. 2, Groups A, B, C, and D. Enclosure dimensions: 6 in x 6 in x 4 in (150 mm x 150 mm x 100 mm).	1	

Example: Surface Snow Melting System

Junction box	Contractor supplied
Prepunched strapping [1]	HARD-SPACER-GALV-25MM-25M
Quantity	3
Snow melt caution sign	SMCS
Quantity	2

[1] Only required for two-pour slab construction

Example: Surface Snow Melting System for Stairs

Junction box	D1297TERM4
Quantity	1
Prepunched strapping [1]	HARD-SPACER-GALV-25MM-25M
Quantity	1
Snow melt caution sign	SMCS
Quantity	1

[1] Only required for two-pour slab construction

Example: Surface Snow Melting System for Wheel Tracks

Junction box	D1297TERM4
Quantity	1
Prepunched strapping [1]	HARD-SPACER-GALV-25MM-25M
Quantity	1
Snow melt caution sign	SMCS
Quantity	1

[1] Only required for two-pour slab construction

Surface Snow Melting

1. Determine design conditions
2. Determine the required watt density
3. Determine the total area to be protected
4. Select the heating cable
5. Determine heating cable spacing
6. Determine the electrical parameters
7. Select the control system and power distribution
8. Select the accessories
9. Complete the Bill of Materials

Step 9 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details you need to complete the Bill of Materials.

RAYCHEM MI SYSTEM SURFACE SNOW MELTING DESIGN WORKSHEET

Step 1 Determine design conditions

Application and environment	Size and layout	Supply voltage	Phase	Control method
☐ Surface snow melting Geographical location: ________________ **Paving material** ☐ Concrete ☐ Asphalt ☐ Pavers	Slab surface area (ft^2 / m^2): ________ Ramp surface area (ft^2 / m^2): ________ Stairs Number of stairs: ________ Stair width (ft/m): ________ Riser height (in/cm): ________ Stair depth (in/cm): ________ Landing surface area (ft^2 / m^2): ________ Wheel tracks Track length (ft/m): ________ Concrete joints: ________ Surface drains: ________ Location of area structures: ________ Other information as appropriate: ________________ ________________ ________________	☐ 120 V ☐ 208 V ☐ 240 V ☐ 277 V ☐ 347 V ☐ 480 V ☐ 600 V	☐ Single-phase ☐ Three-phase	☐ Automatic snow melting controller ☐ Slab-sensing thermostat ☐ Manual on/off control
Example: ✓ Surface snow melting ✓ Philadelphia, PA ✓ Concrete ramp	**Ramp surface: 45 ft x 12 ft**	✓ 480 V	✓ Three-phase	✓ Automatic snow melting controller

Step 2 Determine the required watt density

Surface snow melting system for slabs, ramps, stairs, and wheel tracks: See Table 1

Geographical location: ________________

Paving material: ________________

Required watt density: ________________

Example: Surface Snow Melting System

Ramp surface

Geographical location: Philadelphia, PA (from Step 1)

Paving material: Concrete (from Step 1)

Required watt density: **35 W/ft^2** (from Table 1)

Step ❸ Determine the total area to be protected

Total ramp/slab surface area

______ x ______ = ——→ ______

Length (ft/m) Width (ft/m) **Surface area to be protected (ft²/m²)**

For large areas and areas using a three-phase voltage supply

______ / No. of subsections = ______ x ______ = ______

Length (ft/m) Length of each subsection (ft/m) Width (ft/m) **Subsection area to be protected (ft²/m²)**

Note: For three-phase voltage supplies, use multiples of three equal subsections.

Example: Surface Snow Melting System

Ramp

Calculate the surface area of the ramp for three-phase application

45 ft / 3 = **15 ft** x **12 ft** = **180 ft²**

Length (ft) Length of each subsection (ft) Width (ft) **Subsection area to be protected (ft²)**

Stairs

Calculate the heating cable needed for stairs and landing

Determine the number of cable runs needed

Stair depth: < 10.5 in (27 cm): 2 cable runs

Stair depth: 10.5–12 in (27–30 cm): 3 cable runs

Cable runs needed: ______

Calculate the heating cable length for stairs

______ x [(______ x ______) + (2 x ______)] = ______

No. of stairs No. runs per stair Stair width (f/m) Riser height (ft/m) **Length of cable for stairs (ft/m)**

Landing (attached to stairs)

Calculate the heating cable length for landing

(______ x 12) / 4.5 = ——→ ______

Landing area (ft²) **Length of cable for attached landing (ft)**

(______ x 1000) / 115 = ——→ ______

Landing area (m²) **Length of cable for attached landing (m)**

______ + ______ = ——→ ______

Length of cable for stairs (ft/m) Length of cable for landing (ft/m) **Total heating cable length required (ft/m)**

Wheel tracks

Wheel track length: ______

Step 4 Select the heating cable

Surfaces: See Table 2 and Table 3.

Supply voltage: ______________________________ (from Step 1)

Required watt density: ______________________________ (from Step 2)

Subsection area: ______________________________ (from Step 3)

________________ x ________ = ____________________

Watt density (W/ft^2) (W/m^2) Area (ft^2/m^2) **Required watts for area (W)**

Heating cable catalog number: ________________________

Cable wattage: ______________________________

Cable voltage: ______________________________

Heating cable length: ______________________________

Number of cables = Number of subsection areas

Example: Surface Snow Melting System

Supply voltage:	480 V, three-phase (from Step 1)
Required watt density for ramp:	35 W/ft^2 (from Step 2)
Subsection area (for 3 equal areas):	180 ft^2 (from Step 3)
Required watts (for each subsection):	35 W/ft^2 x 180 ft^2 = 6300 W
Heating cable catalog number:	**SUB20**
Cable wattage:	6450 W
Cable voltage:	480 V (for cables connected in Delta configuration)
Heating cable length:	340 ft
Number of cables:	3 (one cable required for each subsection)

Stairs: See Table 4

Supply voltage: ______________________________ (from Step 1)

Required watt density: ______________________________ (from Step 2)

Total heating cable length required: ______________________________ (from Step 3)

Heating cable catalog number: ______________________________

Cable wattage: ______________________________

Cable voltage: ______________________________

Heating cable length: ______________________________

Number of cables: ______________________________

Installed watt density: ______________________________ (from Table 4)

Wheel Tracks: See Table 5

Supply voltage: ______________________________ (from Step 1)

Wheel track length: ______________________________

Heating cable catalog number: ______________________________

Cable wattage: ______________________________

Cable voltage: ______________________________

Heating cable length: ______________________________

Number of cables: ______________________________

Step 5 Determine the heating cable spacing

Surfaces

Imperial $$\left(\frac{\rule{3cm}{0.4pt}}{\text{Surface area (ft}^2\text{)}} \times 12\ \text{in}\right) / \frac{\rule{6cm}{0.4pt}}{\text{Heating cable length (ft)}} = \longrightarrow \frac{\rule{4cm}{0.4pt}}{\textbf{Heating cable spacing (in)}}$$

Metric $$\left(\frac{\rule{3cm}{0.4pt}}{\text{Surface area (m}^2\text{)}} \times 100\ \text{cm}\right) / \frac{\rule{6cm}{0.4pt}}{\text{Heating cable length (m)}} = \longrightarrow \frac{\rule{4cm}{0.4pt}}{\textbf{Heating cable spacing (cm)}}$$

Round to the nearest 1/2 in or 1 cm to obtain cable spacing.

Example: Surface Snow Melting System

Subsection area:	180 ft² (from Step 3)
Heating cable catalog number:	SUB20 (from Step 4)
Heating cable length:	340 ft (from Step 4)

Cable spacing

$$\left(\frac{\textbf{180 ft}^2}{\text{Surface area (ft}^2\text{)}} \times 12\right) / \frac{\textbf{340 ft}}{\text{Heating cable length (ft)}} = \longrightarrow \frac{\textbf{6.4 in rounded to 6.5 in}}{\textbf{Heating cable spacing (in)}}$$

Stairs

Stair depth: ____________________ (from Step 1)

Cable spacing – stairs: ____________________ (refer to Step 5)

Cable spacing – landing: ____________________ (refer to Step 5)

Wheel Tracks: See Table 5

Paving material: ____________________ (from Step 1)

Heating cable catalog number: ____________________ (from Step 4)

Cable spacing: ____________________ (refer to Step 5)

Step 6 Determine the electrical parameters

Determine circuit breaker rating and number of circuits

Circuit breaker rating (A) ____________ Number of circuit breakers ____________

For single-phase circuit

Load current = Heating cable current (from selection tables) ________ → ____________

(________ x 1.25) = ____________ ________ → = ____________

Load current (A) **Minimum circuit breaker rating (A)** **Circuit breaker rating (A)**

For Delta connected three-phase circuit

Load current = Heating cable current (from selection tables) x 1.732 ________ → ____________

(________ x 1.25) = ____________ ________ → = ____________

Load current (A) **Minimum circuit breaker rating (A)** **Circuit breaker rating (A)**

For Wye connected three-phase circuit

Load current = Heating cable current (from selection tables) ________ → ____________

(________ x 1.25) = ____________ ________ → = ____________

Load current (A) **Minimum circuit breaker rating (A)** **Circuit breaker rating (A)**

Determine transformer load

For cables of equal wattage

(________ x ________) / 1000 ________ → = ____________

Cable (W) Number of cables **Transformer load (kW)**

When cable wattages are not equal

(________ + ________ + ________ + ________) / 1000 = ____________

Cable_1 (W) Cable_2 (W) Cable_3 (W)... Cable_N (W) **Transformer load (kW)**

Example: Surface Snow Melting System

For Delta connected three-phase circuit

Heating cable catalog number:	SUB20 (from Step 4)
Number of heating cables:	3 (from Step 4)
Cable power output:	6450 W (from Step 4)
Load current:	13.4 A (from Table 2) x 1.732 = 23.2 A

(**23.2 A** x 1.25) = **29.0 A** ________ → = **30 A**

Load current (A) **Minimum circuit breaker rating (A)** **Circuit breaker rating (A)**

(**6450 W** x **3**) / 1000 ________ → = **19.4 kW**

Cable (W) Number of cables **Transformer load (kW)**

Step 7 Select the control system and power distribution

Control Systems

See Table 6 Control Systems.

Thermostats, controllers and accessories	Description	Quantity
☐ ECW-GF	Electronic thermostat with 25-ft sensor	______
☐ ECW-GF-DP	Remote display panel for ECW-GF	______
☐ PD Pro	Automatic snow and ice melting controller	______
☐ GF-Pro	Automatic snow and ice melting controller	______
☐ MI-GROUND-KIT	Grounding kit for nonmetallic enclosures	______
☐ APS-3C	Automatic snow melting controller	______
☐ APS-4C	Automatic snow melting controller	______
☐ SC-40C	Satellite contactor	______
☐ CIT-1	Overhead snow sensor	______
☐ SIT-6E	Pavement-mounted sensor	______
☐ RCU-3	Remote control unit for APS-3C	______
☐ RCU-4	Remote control unit for APS-4C	______
☐ ACS-UIT2	ACS-30 user interface terminal	______
☐ ACS-PCM2-5	ACS-30 power control panel	______
☐ ProtoNode-RER	Multi-protocol gateway	______
☐ RTD3CS	Resistance temperature device for Raychem ACS-30	______
☐ RTD10CS	Resistance temperature device for Raychem ACS-30	______
☐ RTD200	Resistance temperature device for Raychem ACS-30	______
☐ RTD50CS	Resistance temperature device for Raychem ACS-30	______

Power Distribution and Control Panels

See Table 7 Power Distribution.

Power distribution and control panels	Description	Quantity
☐ SMPG1	Single-phase power distribution panel	______
☐ SMPG3	Three-phase power distribution panel	______

Example: Surface Snow Melting System

✓ APS-4C	Automatic snow melting controller	1
✓ SIT-6E	Pavement-mounted sensor	1

Step 8 Select the accessories

See Table 8 Accessories.

Accessories	Description	Quantity
☐ HARD-SPACER-GALV-25MM-25M	Galvanized steel prepunched strapping	______
☐ HARD-SPACER-SS-25MM-25M	Stainless steel prepunched strapping	______
☐ SMCS	Snow melt caution sign	______
☐ D1297TERM4	Cast aluminum junction box	______

Example: Surface Snow Melting System

✓	Junction box	(contractor supplied)
✓ **HARD-SPACER-GALV-25MM-25M**[1]	Prepunched strapping	**3**
✓ **SMCS**	Snow melt caution sign	**2**

[1] Only required for two-pour slab construction

Step 9 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

Raychem

SURFACE SNOW MELTING AND ANTI-ICING – ELECTROMELT SYSTEM

This step-by-step design guide provides the tools necessary to design a Raychem ElectroMelt heating cable surface snow melting and anti-icing system. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

Raychem ElectroMelt heating cable systems can be used as a surface snow melting system when installed in concrete pavement or under paving stones. It can also be used as an anti-icing system but only when installed in concrete pavement.

Important: ElectroMelt is not approved for use in asphalt.

If your application conditions are different, or if you have any questions, contact your Thermal Management representative or call (800) 545-6258.

How to Use this Guide

This design guide presents Thermal Management's recommendations for designing an ElectroMelt surface snow melting and anti-icing system. It provides design and performance data, electrical sizing information, and heating-cable layout suggestions. Following these recommendations will result in a reliable, energy-efficient system.

Follow the design steps in the section "Surface Snow Melting and Anti-Icing Design," page 182 and use the "ElectroMelt System Surface Snow Melting and Anti-Icing Design Worksheet," page 204 to document the project parameters that you will need for your project's Bill of Materials.

OTHER REQUIRED DOCUMENTS

This guide is not intended to provide comprehensive installation instructions. For complete ElectroMelt surface snow melting system and anti-icing installation instructions, please refer to the following additional required documents:

- ElectroMelt System Installation and Operation Manual (H58086)
- Additional installation instructions that are included with the connection kits, thermostats, controllers and accessories

If you do not have these documents, you can obtain them from the Thermal Management web site at www.pentairthermal.com.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system components could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

✎ This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

Thermal Management' standard limited warranty applies to Raychem Snow Melting Systems.

10 YEAR Product warranty

An extension of the limited warranty period to ten (10) years from the date of installation is available, except for the control and distribution systems, if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

The Raychem ElectroMelt system provides surface snow melting and anti-icing for concrete surfaces and pavement. The ElectroMelt system uses a self-regulating heating cable that reduces heat output automatically as the pavement warms, resulting in lower energy use, and eliminating the possibility of overheating. The system includes heating cable, connection kits, junction boxes, a control system and sensors, power distribution panels, and the tools necessary for a complete installation.

Typical System

A typical system includes the following:

- ElectroMelt self-regulating heating cable
- Connection kits and accessories
- Snow controller and sensors
- Power distribution

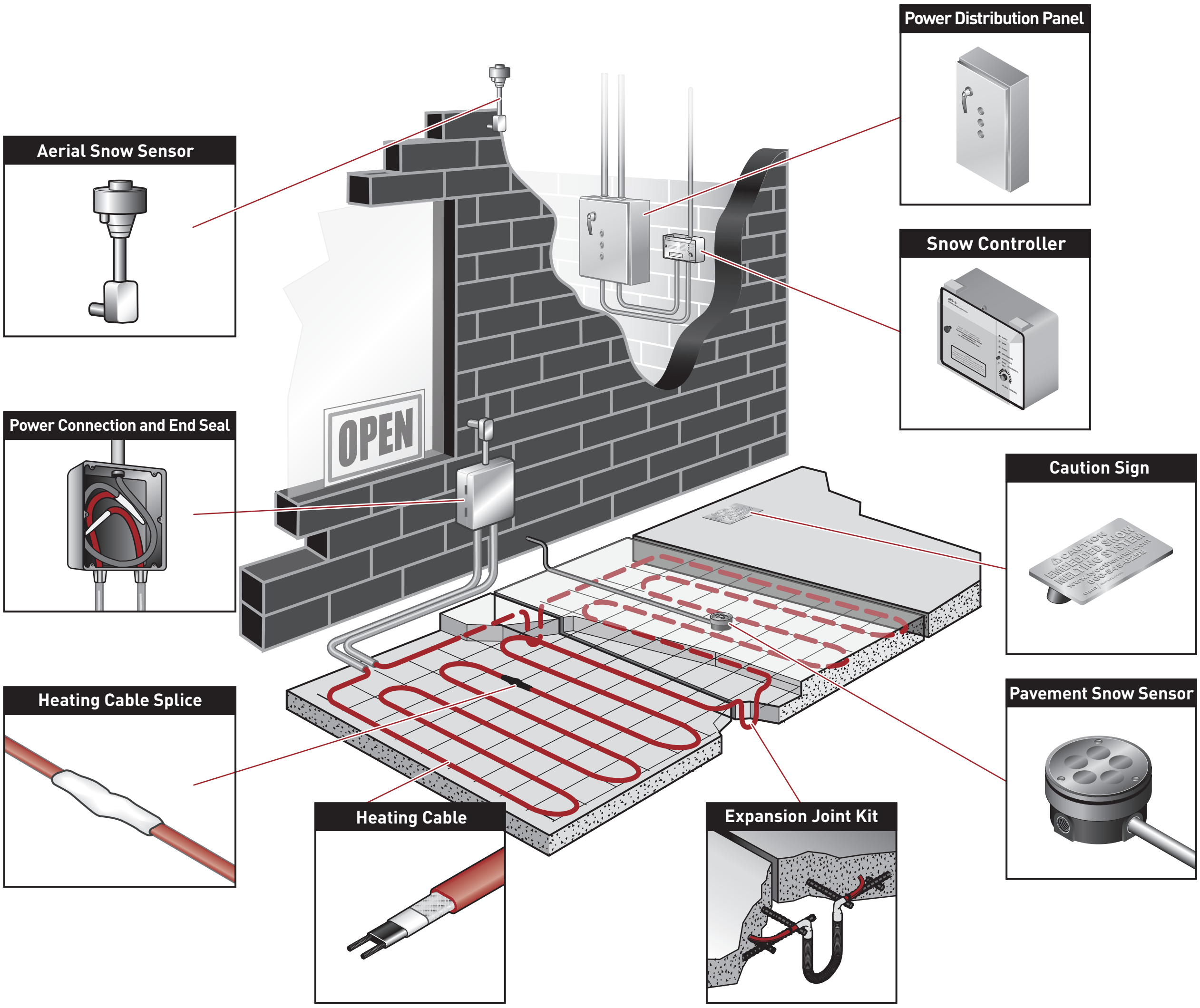


Fig. 1 Typical ElectroMelt system

Self-Regulating Heating Cable Construction

The ElectroMelt self-regulating heating cable is embedded in concrete pavement to melt snow and ice that might otherwise accumulate on the surface. The heating cable responds to the local concrete temperature, increasing heat output when concrete temperature drops and decreasing heat output when concrete temperature rises. The self-regulating heating cable cannot overheat and destroy itself, even if overlapped in the concrete, and therefore does not require the use of overlimit thermostats.

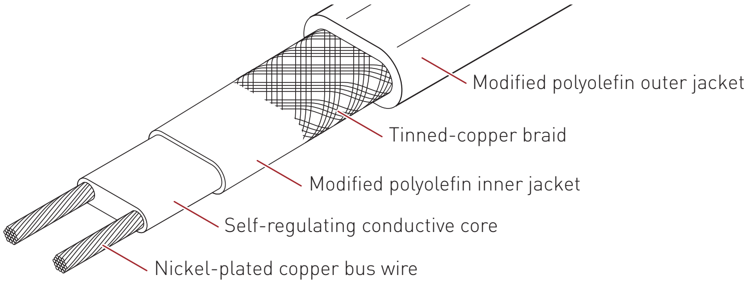
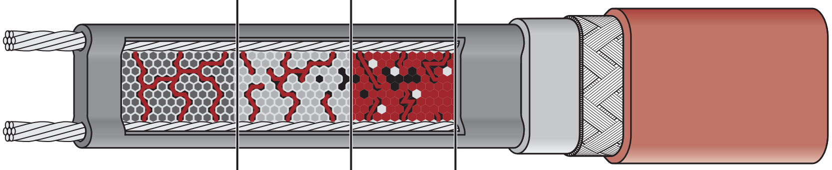


Fig. 2 ElectroMelt heating cable construction

With self-regulating technology, the number of electrical paths between bus wires changes in response to temperature fluctuations. As the temperature surrounding the heater decreases, the conductive core contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core.

As the temperature rises, the core expands microscopically. This expansion increases electrical resistance and the number of electrical paths decreases. The heating cable automatically reduces its output.



At low temperature, there are many conducting paths, resulting in high output and rapid heat-up. Heat is generated only when it is needed and precisely where it is needed.

At high temperature, there are few conducting paths and output is correspondingly lower, conserving energy during operation.

At moderate temperature, there are fewer conducting paths because the heating cable efficiently adjusts by decreasing output, eliminating any possibility of overheating.

The following graphs illustrate the response of self-regulating heating cables to changes in temperature. As the temperature rises, electrical resistance increases, and our heaters reduce their power output.

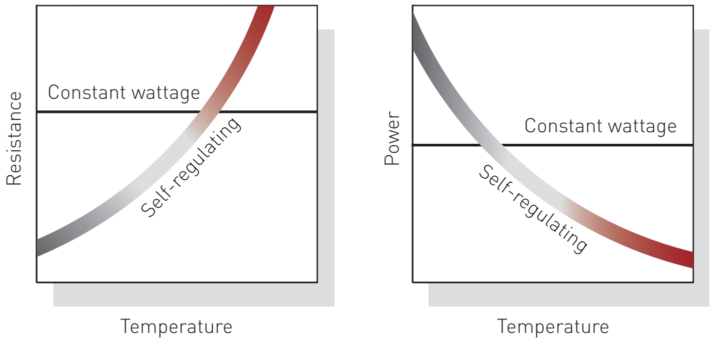


Fig. 3 Self-regulating heating cable technology

Approvals

The ElectroMelt surface snow melting and anti-icing system is UL Listed and CSA Certified for use in nonhazardous locations.

SURFACE SNOW MELTING AND ANTI-ICING APPLICATIONS

SURFACE SNOW MELTING

Surface snow melting systems prevent the accumulation of snow on ramps, slabs, driveways, sidewalks, platform scales, and stairs under most snow conditions.

ANTI-ICING

Anti-icing systems keep the surface temperature above freezing at all times to prevent ice formation. Anti-icing applications require a higher watt density and longer hours of operation than a surface snow melting system.

APPLICATION REQUIREMENTS AND ASSUMPTIONS

The design for a standard surface snow melting and anti-icing application is based on the following:

Reinforced Concrete	**Heating cable**
• 4 to 6 inches (10 to 15 cm) thick • Placed on grade • Standard density	• Secured to reinforcement steel or mesh • Located 1 1/2 to 2 inches (4 to 6 cm) below finished surface
Pavers	**Heating cable**
• Concrete pavers 1 to 1 1/2 (2.5 to 4 cm) inches thick • Placed on concrete or mortar base on grade	• Secured to mesh • Embedded in concrete or mortar base below the pavers

For products and applications not covered by this guide, contact your Thermal Management representative for design assistance. Using proprietary computer modeling, Thermal Management can design the appropriate system for these applications.

The following are examples of applications not addressed in this design guide:

- Concrete thinner than 4 inches (10 cm)
- Concrete thicker than 6 inches (15 cm)
- Lightweight concrete
- Concrete with pavers thicker than 1 1/2 inches (4 cm)
- Ramps and walkways with air below
- Concrete without reinforcement
- Retrofitting of heating cable to existing pavement
- Pavers composed of material other than concrete

SURFACE SNOW MELTING AND ANTI-ICING DESIGN

This section details the steps necessary to design your application. The examples provided in each step are intended to incrementally illustrate sample designs from start to finish. As you go through each step, use the "ElectroMelt System Surface Snow Melting and Anti-Icing Design Worksheet," page 204 to document your project parameters, so that by that end of this section you will have the information you need for your Bill of Materials.

SnoCalc is an online design tool available to help you create surface snow melting designs and layouts. It is available at http://www.pentairthermal.com.

Design Step by Step

Your system design requires the following essential steps:

1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Surface Snow Melting and Anti-Icing
1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Step 1 Determine design conditions

Collect the following information to determine your design conditions:

- Application (surface snow melting or anti-icing)
- Environment
  - For surface snow melting: Geographical location
  - For anti-icing: Minimum ambient temperature and average wind speed
- Paving material
- Size and layout
  - Slab surface area
  - Ramp surface area
  - Stairs
    - Number of stairs
    - Width of stair
    - Riser height
    - Depth of stair
    - Landing dimensions
  - Wheel tracks
    - Track length
  - Concrete joints
  - Surface drains
  - Location of area structures
  - Other information as appropriate
- Supply voltage
- Automatic or manual control method

Note: Drainage must be a primary concern in any snow melting system design. Improper drainage can result in ice formation on the surface of the heated area once the system is de-energized. Ice formation along the drainage path away from the heated area may create an ice dam and prohibit proper draining. If your design conditions may lead to drainage problems, please contact Thermal Management Technical Support for assistance.

PREPARE SCALE DRAWING

Draw to scale the snow melting area and note the rating and location of the voltage supply. Include stairs and paths for melting water runoff. Show concrete joints, surface drains, and location of area structures including post installations for railings, permanent benches, and flagpoles. Measurements for each distinct section of the snow melting application, including stairs, will allow for an accurate system design, including control configuration. Use these symbols to indicate the heating cable expansion and crack-control joints:

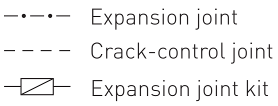


Fig. 4 Design symbols

Example: Surface Snow Melting System

Application	Surface snow melting
Geographical location	Buffalo, NY
Size and layout	80 ft x 50 ft (24.4 m x 15.2 m)
Paving material	Concrete slab
Stairs:	
Number of stairs	10
Width of stair	5 ft (1.5 m)
Riser height	6 in (15 cm)
Depth of stair	12 in (30 cm)
Supply voltage	277 V
Phase	Single-phase
Control method	Automatic snow melting controller

Example: Anti-Icing System

Application	Anti-icing
Minimum ambient temperature	10°F (–12°C)
Average wind speed	20 mph (32 kmph)
Size and layout	80 ft x 50 ft (24.4 m x 15.2 m)
Paving material	Concrete slab
Stairs:	
Number of stairs	10
Width of stair	5 ft (1.5 m)
Riser height	6 in (20 cm)
Depth of stair	12 in (30 cm)
Supply voltage	277 V
Phase	Single-phase
Control method	Slab sensing thermostat

Surface Snow Melting and Anti-Icing

1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Step 2 Select the heating cable

Thermal Management offers the option of two self-regulating heating cables with the ElectroMelt system. Cable selection is independent of application and depends only upon supply voltage. ElectroMelt heating cables must only be powered by single phase voltage. In applications where the power supply is three-phase, all circuits must be wired to provide single-phase voltage to the heating cables. Select the appropriate cable based on the supply voltage available for the application area.

TABLE 1 ELECTROMELT SELF-REGULATING HEATING CABLE

Supply voltage	Catalog number
208 V, 240 V, 277 V	EM2-XR

Example: Surface Snow Melting System

Supply voltage	277 V (from Step 1)
Heating cable	**EM2-XR**

Example: Anti-Icing System

Supply voltage	277 V (from Step 1)
Heating cable	**EM2-XR**

Step 3 Determine the required watt density

SURFACE SNOW MELTING

For maximum performance from any snow melting system, you must first take into account the local snowfall and icing patterns. A system design that works well in one city may be inadequate in another. The energy required to melt snow varies with air temperature, wind speed, relative humidity, snow density, and the depth of the snow on the pavement.

Table 2 summarizes the required watt density for most major cities in North America based on typical minimum ambient temperatures and the snowfall and icing patterns. Select the city from the list, or closest city, where similar climatic conditions exist.

TABLE 2 REQUIRED WATT DENSITY FOR SURFACE SNOW MELTING

	Watts/ft²		Watts/m²	
City	**Concrete**	**Pavers**	**Concrete**	**Pavers**
USA				
Baltimore, MD	35	40	377	431
Boston, MA	35	40	377	431
Buffalo, NY	40	45	431	484
Chicago, IL	35	40	377	431
Cincinnati, OH	35	40	377	431
Cleveland, OH	35	40	377	431
Denver, CO	35	40	377	431
Detroit, MI	35	40	377	431
Great Falls, MT	50	50	538	538
Greensboro, NC	35	35	377	377
Indianapolis, IN	35	40	377	431
Minneapolis, MN	50	50	538	538
New York, NY	35	40	377	431
Omaha, NE	45	50	484	538
Philadelphia, PA	35	40	377	431
Salt Lake City, UT	35	35	377	377
Seattle, WA	35	35	377	377
St. Louis, MO	35	40	377	431
Canada				
Calgary, AB	45	45	484	484
Edmonton, AB	50	50	538	538
Fredericton, NB	40	45	431	484
Halifax, NS	35	40	377	431
Moncton, NB	40	40	431	431
Montreal, QC	45	45	484	484
Ottawa, ON	45	45	484	484
Prince George, BC	50	55	538	592
Quebec, QC	45	45	484	484
Regina, SK	50	55	538	592
Saskatoon, SK	50	50	538	538
St. John, NB	40	45	431	484
St. John's, NF	35	35	377	377
Sudbury, ON	40	45	431	484
Thunder Bay, ON	50	55	538	592
Toronto, ON	35	40	377	431
Vancouver, BC	35	40	377	431
Winnipeg, MB	50	55	538	592

Note: To provide faster heat-up, the required watt density in Table 2 is greater than what is suggested by ASHRAE.

Example: Surface Snow Melting System

Geographical location	Buffalo, NY (from Step 1)
Required watt density	**40 W/ft^2 (431 W/m^2)** (from Table 2)

ANTI-ICING

From the minimum ambient temperature and average wind speed that you determined in Step 1 for your anti-icing application, use the tables below to determine the required watt density for that application.

TABLE 3 REQUIRED WATT DENSITY FOR ICE-FREE SURFACES W/FT^2

Minimum ambient temperature	Average wind speed during freezing periods			
°F	**5 mph**	**10 mph**	**15 mph**	**20 mph**
20°F	30	30	35	40
10°F	30	30	35	45
0°F	30	40	45	60
–10°F	30	45	60	80
–20°F	35	55	80	–
–30°F	40	65	–	–
–40°F	45	75	–	–

TABLE 4 REQUIRED WATT DENSITY FOR ICE-FREE SURFACES W/M^2

Minimum ambient temperature	Average wind speed during freezing periods			
°C	**8 kmph**	**16 kmph**	**24 kmph**	**32 kmph**
–7°C	323	323	377	431
–12°C	323	323	377	484
–18°C	323	431	484	646
–23°C	323	484	646	861
–29°C	377	592	861	–
–34°C	431	699	–	–
–40°C	484	807	–	–

Note: This procedure is derived from finite model studies of 4-inch slabs and is applicable to standard concrete pavement from 4 to 6 inches thick placed directly on grade. If your application involves other materials or construction, contact your Thermal Management representative.

Example: Anti-Icing System

Minimum ambient temperature	10°F (–12°C) (from Step 1)
Average wind speed	20 mph (32 kmph) (from Step 1)
Required watt density	**45 W/ft^2 (484 W/m^2)** (from Table 3 and Table 4)

Surface Snow Melting and Anti-Icing
1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Step 4 Determine heating cable spacing

SURFACES

To determine your heating cable spacing, you need to know your applications's power output and required watt density.

The power output from the ElectroMelt heating cable depends on the supply voltage used in the application. Table 5 lists power output per linear foot of heating cable determined by the supply voltage. Divide this figure by the required watt density that you determined in Step 3. You will get the required heating cable spacing in feet or meters as applicable. Multiply this figure by 12 inches or by 100 centimeters to determine your heating cable spacing.

TABLE 5 HEATING CABLE SPACING IN CONCRETE

Supply voltage	Catalog number	Power output W/ft (W/m)
208 V	EM2-XR	30 (98)
240 V	EM2-XR	32 (105)
277 V	EM2-XR	34 (112)

To determine cable spacing required for surface snow melting and anti-icing

$$\text{Heating cable spacing (in)} = \frac{\text{(W/ft power output of cable per Table 5) x 12 in}}{\text{W/ft}^2 \text{ requirement from Step 3}}$$

$$\text{Heating cable spacing (cm)} = \frac{\text{(W/m power output of cable per Table 5) x 100 cm}}{\text{W/m}^2 \text{ requirement from Step 3}}$$

Round answer to nearest whole number of inches or centimeters.

Example: Surface Snow Melting System

Supply voltage	277 V (from Step 1)
Heating cable	EM2-XR (from Step 2)
Power output	34 W/ft (112 W/m^2) (from Table 5)
Spacing	(34 W/ft x 12 in) /40 W/ft^2 = **10.2 in** **Rounded to 10 in** (112 W/m x 100 cm) / 431 W/m^2 = 26 cm

Example: Anti-Icing System

Supply voltage	277 V (from Step 1)
Heating cable	EM2-XR (from Step 2)
Power output	34 W/ft (from Table 5)
Spacing	(34 W/ft x 12 in) / 45 W/ft^2 = **9.1 in** **Rounded to 9 in** (112 W/m x 100 cm) / 484 w/m^2 = 23.1 cm **Rounded to 23 cm**

STAIRS

Heat loss in stairs occurs from the two exposed surfaces: the top of the stair and its side. Watt density requirements are therefore greater for snow melting and anti-icing. Rather than calculating heating cable spacing in the stair, refer to Table 6 and determine the number of runs of heating cable per stair based on the depth of the stair. Space the heating cable evenly across the depth of the stair with one run 2 in (5 cm) from the front, or nose, of the stair. This method will provide sufficient watt density for both snow melting and anti-icing.

TABLE 6 HEATING CABLE RUNS PER STAIR

Stair depth	Number of cable runs per stair
Less than 10.5 in (27 cm)	2
10.5–12 in (27–30 cm)	3

For landings in the stairway, use cable spacing as calculated for surfaces. As with stairs, a run of heating cable must be placed 2 in (5 cm) from the exposed edge of the landing leading to the stairs.

Anticipate and design for the addition of railings or other follow on construction that will require cutting or drilling into the concrete as damage to installed heating cable may occur. Allow for at least 4 inches clearance between the heating cable and any planned cuts or holes.

Example: Surface Snow Melting and Anti-Icing System

Depth of stair	12 in (30 cm) (from Step 1)
Number of cable runs per stair	3 runs
Spacing	Equally spaced across the width of the stair with one run 2 in (5 cm) from the front edge

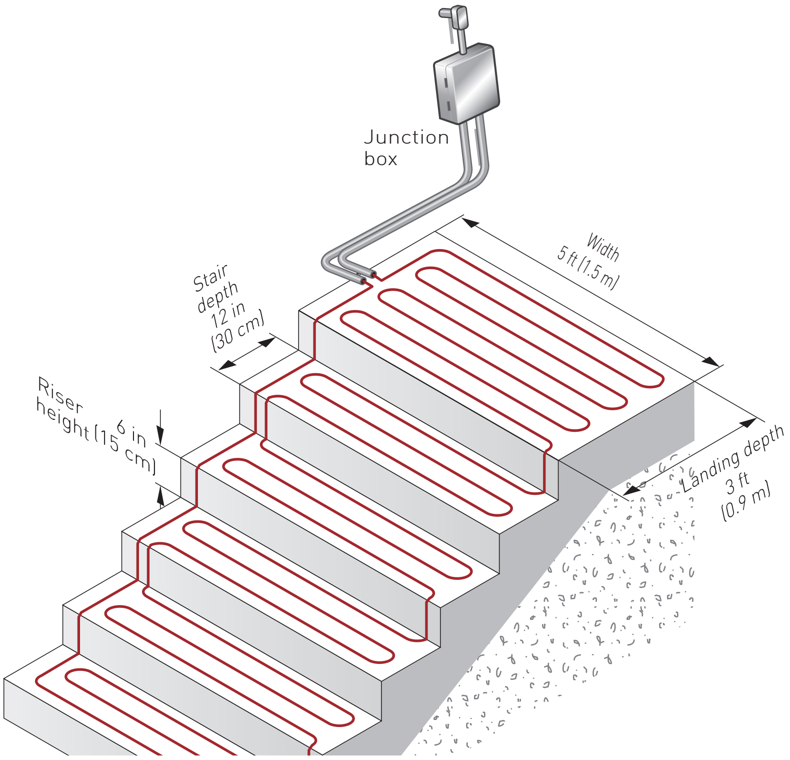


Fig. 5 **Typical heating cable layout for concrete stairs**

Surface Snow Melting and Anti-Icing
1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Step 5 Determine the total area to be protected

SURFACES

To determine the total amount of heating cable, you need to determine the surface area you will be protecting from snow and ice accumulation. If assistance is required in designing for irregular shaped areas, please contact your Thermal Management representative.

Example: Surface Snow Melting System

Total area of concrete slab	80 ft x 50 ft = 4000 ft^2 (24.4 m x 15.2 m = 370.8 rounded to = 371 m^2)

Example: Anti-Icing System

Total area of concrete slab	80 ft x 50 ft = 4000 ft^2 (24.4 m x 15.2 m = 370.8 rounded to = 371 m^2)

WHEEL TRACKS

To reduce power consumption for concrete driveways, it may be sufficient to provide snow melting for only the wheel tracks.

Design wheel track applications with the same spacing used for concrete slabs. Heating cable should run to the edge of each side of the wheel track and be laid in a serpentine pattern along the length of the wheel track.

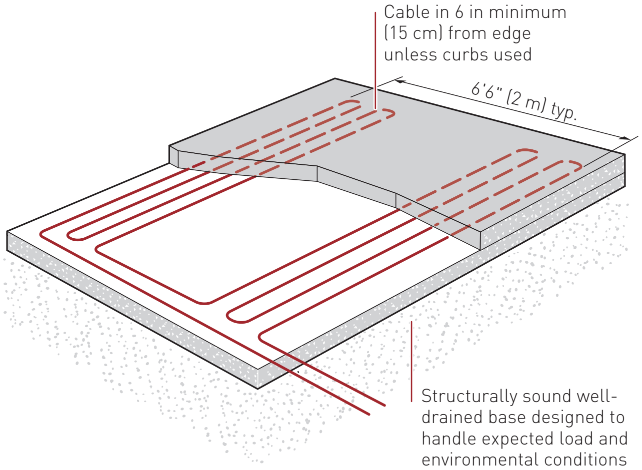


Fig. 6 Wheel track example

STAIRS

Surface area of the stairs is not required to determine heating cable required.

Surface Snow Melting and Anti-Icing
1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Step 6 Determine heating cable length

SURFACES

Calculate the heating cable length by dividing the total heated area by the heating cable spacing calculated in the previous steps. In Step 8, you will need to add additional heating cable for connection kits and end terminations which will then give you the total heating cable length.

Calculate the heating cable length for the surface as follows:

$$\text{Heating cable length} = \frac{\text{Heated area (ft}^2\text{) x 12}}{\text{Heating cable spacing (in)}} \quad \frac{\text{Heated area (m}^2\text{) x 100}}{\text{Heating cable spacing (cm)}}$$

Example: Surface Snow Melting System for Concrete Slab

Total area of concrete slab	4000 ft² (371 m²) (from Step 5)
Cable spacing	10 in (26 cm) (from Step 4)
	(4000 ft² x 12 in) / 10 in spacing = 4800 ft (371 m² x 100 cm) / 26 cm spacing = 1427 m
Heating cable length	4800 ft (1427 m)

Example: Anti-Icing System for Concrete Slab

Total area of concrete slab	4000 ft² (371 m²) (from Step 5)
Cable spacing	9 in (23 cm) (from Step 4)
	(4000 ft² x 12 in) / 9 in spacing = 5333 ft (371 m² x 100 cm) / 23 cm spacing = 1613 m
Heating cable length	5333 ft (1613 m)

STAIRS

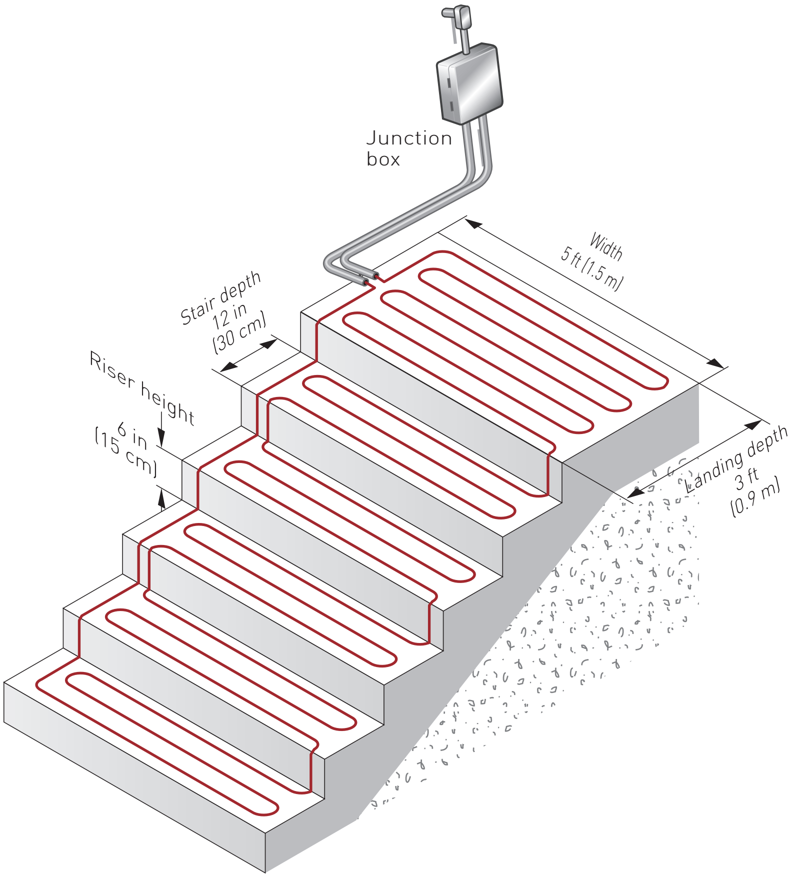


Fig. 7 Concrete stair example

Use the formula below to determine the length of cable required for stairs. Stair area is not needed for the cable length calculation. Two or three runs of heating cable will be installed per stair as determined in Step 3. For landing areas, use the equation for surfaces.

Length of cable = No. of stairs x [(No. runs per stair x width of stair) + (2 x riser height)]
for stair (ft) (m)

Example: Surface Snow Melting and Anti-Icing System for Stairs

Number of stairs	10 stairs (from Step 1)
Number of cable runs per stair	3 runs
Width of stair	5 ft (1.5 m) (from Step 1)
Riser height	6 in (15 cm) convert to 0.5 ft (0.15 m) (from Step 1)
	10 stairs x [(3 x 5 ft) + (2 x 0.5 ft)] = 160 ft 10 stairs x [(3 x 1.5 m) + (2 x 0.15 m)] = 48 m
Heating cable length	**160 ft (48 m)**

For applications where the landing area is very large or where an expansion joint exists between the stairs and landing, consider the stairs and landing as two separate areas. In these cases, determine the length of cable required for the stairs as shown earlier in this section and select the cable for the landing as shown for ramps, slabs, driveways, sidewalks, platform scales.

Surface Snow Melting and Anti-Icing
1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Step 7 Determine the electrical parameters

This section will help you determine the electrical parameters for an ElectroMelt system including circuit breaker sizing and maximum circuit length. Total required heating cable length divided by maximum circuit length will determine the number of circuits required for your snow melting solution.

DETERMINE MAXIMUM CIRCUIT LENGTH

To determine maximum circuit length, it is important to establish a minimum startup temperature for the system. The following tables provide maximum circuit lengths based on minimum startup temperature, circuit breaker rating, and supply voltage. Colder temperature startup requires shorter maximum circuit lengths. The use of an automatic system, which energizes the system above 20°F (–7°C), ensures that you can use maximum circuit lengths. Manual control systems may require you to use shorter circuit lengths to compensate for startup below 20°F (–7°C).

A 30-mA ground-fault protection device (GFPD) must be used to provide protection from arcing or fire, and to comply with warranty requirements, agency certifications, and national electrical codes. If the heating cable is improperly installed, or physically damaged, sustained arcing or fire could result. If arcing does occur, the fault current may be too low to trip conventional circuit breakers.

TABLE 7 MAXIMUM CIRCUIT LENGTH FOR STARTUP AT 20°F (–7°C) IN FEET (METERS) USING AN AUTOMATIC SNOW CONTROL SYSTEM

Circuit Breaker (A)	Heating cable supply voltage					
	208 V		240 V		277 V	
15	80	(24)	85	(26)	100	(31)
20	105	(32)	115	(35)	130	(40)
30	160	(49)	170	(52)	195	(59)
40	210	(64)	230	(70)	260	(79)
50	265	(81)	285	(87)	325	(99)

TABLE 8 MAXIMUM CIRCUIT LENGTH FOR STARTUP AT 0°F (–18°C) IN FEET (METERS) USING A MANUAL CONTROL SYSTEM

Circuit Breaker (A)	Heating cable supply voltage					
	208 V		240 V		277 V	
15	75	(23)	80	(24)	90	(27)
20	100	(31)	110	(34)	120	(37)
30	145	(44)	160	(49)	180	(55)
40	200	(61)	210	(64)	240	(73)
50	245	(75)	265	(81)	300	(91)

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Example: Surface Snow Melting and Anti-Icing System with Automatic Snow Control

Startup temperature	20°F (–7°C) (from Step 1)
Circuit breakers	50 A
Supply voltage	277 V (from Step 1)
Maximum circuit length	325 ft (99 m) (from Table 7)

DETERMINE NUMBER OF CIRCUITS

Use the following formula to determine number of circuits for the system:

$$\text{Number of circuits} = \frac{\text{Heating cable length required}}{\text{Maximum heating cable circuit length}}$$

Example: Surface Snow Melting

Surfaces

Total heating cable length	4800 ft (1427 m) (from Step 6)
Maximum circuit length	325 ft (99 m) (from above)
Number of circuits	4800 / 325 = 14.8 rounded to **15 circuits**

Stairs

Total heating cable length	160 ft (48 m) (from Step 6)
Maximum circuit length	325 ft (99 m) (from above)
Number of circuits	160 / 325 = 0.5 rounded to **1 circuit**

Example: Anti-Icing System

Surfaces

Total heating cable length	5333 ft (1613 m) (from Step 6)
Maximum circuit length	325 ft (99 m)
Number of circuits	5333 / 325 = 16.4 rounded to **17 circuits**

Stairs

Total heating cable length	160 ft (48 m) (from Step 6)
Maximum circuit length	325 ft (99 m) (from above)
Number of circuits	160 / 325 = 0.5 rounded to **1 circuit**

DETERMINE TRANSFORMER LOAD

The total transformer load is the sum of load on all the circuit breakers in the system.

Calculate the Circuit Breaker Load (CBL) as:

$$\text{CBL (kW)} = \frac{\text{Circuit breaker rating (A)} \ \text{x} \ 0.8 \ \text{x} \ \text{Supply voltage}}{1000}$$

Calculate the Total Transformer Load as follows:

If the CBL is equal on all circuit breakers, calculate the Total Transformer Load as:

$$\text{Total Transformer Load (kW)} = \text{CBL x Number of circuits}$$

If the CBL is **not** equal on all circuit breakers, calculate the Total Transformer Load as:

$$\text{Total Transformer Load (kW)} = \text{CBL}_1 + \text{CBL}_2 + \text{CBL}_3 ... + \text{CBL}_N$$

Example: Surface Snow Melting

Circuit breaker load	(50 A x 0.8 x 277 V) / 1000 = 11.1 kW
Transformer Load	11.1 kW x 16 circuits = 177.6 kW rounded to 178 kW
	178 kW

Example: Anti-Icing System

Circuit breaker load	(50 A x 0.8 x 277 V) / 1000 = 11.1 kW
Transformer load	11.1 kW x 18 circuits = 199.8 kW rounded to 200 kW
	200 kW

Surface Snow Melting and Anti-Icing

1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

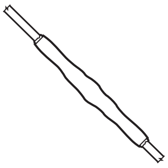
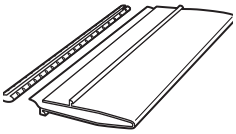
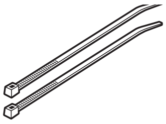
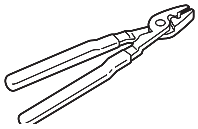
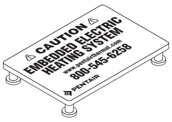
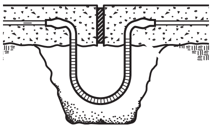
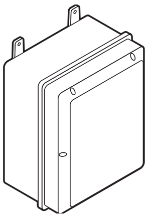
Step 8 Select the connection kits and accessories

Thermal Management provides all the connection kits and accessories necessary to satisfy code, approval agency, and warranty requirements for the ElectroMelt system. Additional heating cable will be required for connection kits and end terminations. Adding the additional heating cable allowances needed with the heating cable length required for the layout will give you the total heating cable length required.

Prepare a drawing of your system showing distinct circuits, layout of cables, connection kits, expansion joints, drains, heated pathways for meltwater, power connections, junction boxes, and sensors. Determine length of cable from slab for power connection for all circuits. If possible, avoid crossing expansion, crack control, or other pavement joints. Use the EMK-XEJ expansion joint kit to protect the heating cable if crossing is unavoidable.

Junction boxes must be mounted above grade to prevent water entry. Use an EMK-XJB or equivalent UL Listed or CSA Certified weatherproof junction box. Protect heating cable from slab to junction box inside individual 1-inch rigid metal conduits. Do not penetrate floors or walls with conduit, nor insulate the conduit.

TABLE 9 CONNECTION KITS AND ACCESSORIES

	Catalog number	Description	Standard packaging	Usage	Heating cable allowance [1]
Connection Kits					
 Power connection EMK-XP  End seal EMK-XP	EMK-XP	Power connection and end seal kit	1	1 per circuit	3 ft (1 m) for connection plus conduit length for power connection and conduit length for end seal
	EMK-XS	Splice kit	1	As required	1 ft (30 cm)
Accessories					
	EMK-XJR	Jacket repair kit	1	As required	–
	EMK-CT	Nylon cable ties	100/pack	1 per foot of cable used	–
	EMK-XT	Crimping tool	1	–	–
	SMCS	Snow melt caution sign Dimensions: 6 x 4 in (150 x 100 mm)	1	1 minimum per system	–
	EMK-XEJ	Expansion joint kit	1	1 per expansion joint crossing	1 1/2 ft (45 cm)
	EMK-XJB	Junction box Dimensions: 15 1/2 x 11 3/4 x 7 5/8 in (394 x 299 x 194 mm)	1		1–2 ft (30–60 cm) for each end in the junction box Maximum of two circuits per EMK-XJB

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[1] Allow extra heating cable for ease of component installation.

Example: Surface Snow Melting System

Number of circuits	15 for concrete slab + 1 for stairs = 16
Power connection kits	16 power connection kits
Conduit length (from slab to junction box)	
Power connection	15 ft (4.5 m)
End seal	15 ft (4.5 m)
	(15 ft + 15 ft) x 16 circuits = 480 ft (4.5 m + 4.5 m) x 16 circuits = 144 m
Heating cable allowance for each power connection	
	3 ft x 16 circuits = 48 ft 1 m x 16 circuits = 16 m
Total heating cable length required	**528 ft (160 m)**

Example: Anti-Icing System

Number of circuits	17 for concrete slab + 1 for stairs = 18
Power connection kits	18 power connection kits
Conduit length (from slab to junction box)	
Power connection	15 ft (4.5 m)
End seal	15 ft (4.5 m)
	(15 ft + 15 ft) x 18 circuits = 540 ft (4.5 m + 4.5 m) x 18 circuits = 162 m
Heating cable allowance for each power connection	
	3 ft x 18 circuits = 54 ft 1 m x 18 circuits = 18 m
Total heating cable length required	**594 ft (180 m)**

Step 9 Select the control system and power distribution

CONTROL SYSTEMS

Select a control system from the following three options, but keep in mind that an automatic snow controller offers the highest system efficiency and the lowest operating cost.

- Manual on/off control
- Slab sensing thermostat
- Automatic snow melting controller

If the current rating of the control means is exceeded, all three methods will require contactors sized to carry the load. Each method offers a tradeoff balancing initial cost versus energy efficiency and ability to provide effective snow melting. If the system is not energized when required, snow will accumulate. If the system is energized when it is not needed, there will be unnecessary power consumption. Choose the control method that best meets the project performance requirements. For additional information, refer to the "Typical Control Diagrams," Table 7, or contact your Thermal Management representative for details.

Manual On/Off Control

A manually controlled system is operated by a switch that controls the system power contactor. This method requires constant supervision to work effectively. A manual system can be controlled by a building management system.

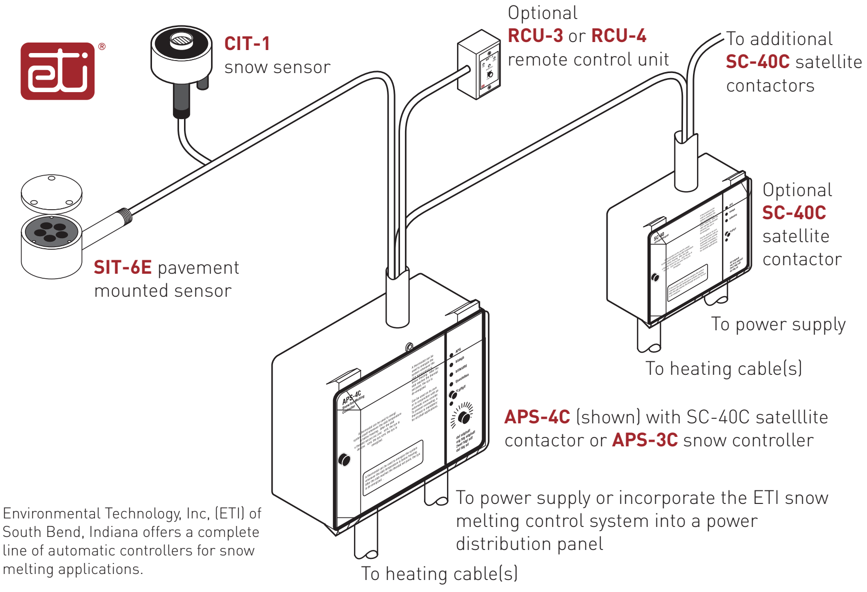
Slab Sensing Thermostat

A slab sensing thermostat can be used to energize the system whenever the slab temperature is below freezing, but is not energy efficient when used as the sole means of control. The slab sensing thermostat is recommended for all snow melting applications, even when an automatic snow controller is used, and is required for all asphalt and paver installations (for asphalt, it prevents surface damage due to overheating).

Automatic Snow Melting Controller

With an automatic snow controller, the snow melting system is automatically energized when both precipitation and low temperature are detected. When precipitation stops or the ambient temperature rises above freezing, the system is de-energized. In addition, a slab sensor de-energizes the system after the slab reaches the slab sensing set point even if freezing precipitation is still present. Using an automatic snow controller with a slab sensor offers the most energy-efficient control solution.

For areas where a large number of circuits are required, the Raychem ACS-30 can be used. The Surface Snow Melting control mode in the ACS-30 includes an External Device control option. This option allows a Snow/Moisture sensing controller (from Table 10) to be integrated into the ACS-30 system. Note that sensors (snow or gutter) cannot be directly connected to the ACS-30 system. Refer to the ACS-30 Programming Guide (H58692) for more information on system setup.



Environmental Technology, Inc, (ETI) of South Bend, Indiana offers a complete line of automatic controllers for snow melting applications.

Fig. 8 Automatic snow melting control system

TABLE 10 CONTROL SYSTEMS

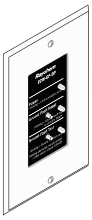
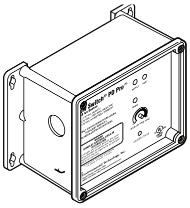
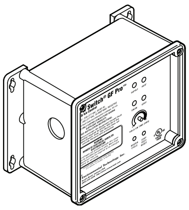
	Catalog number	Description
Slab Sensing Thermostat		
	ECW-GF	Electronic ambient sensing controller with 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor and is housed in a Type 4X rated enclosure. The controller features an AC/DC dry alarm contact relay. An optional ground-fault display panel (ECW-GF-DP) that can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	PD Pro	Automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments. The PD Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The PD Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds.
	GF Pro	Automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments. The GF Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The GF Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds. Features a built-in 30 mA, self-testing Ground-Fault Equipment Protection (GFEP) capability, digitally filtered to minimize false tripping. A ground-fault alarm must be manually reset using the Test/Reset switch before heater operation can continue.

TABLE 10 CONTROL SYSTEMS

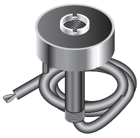
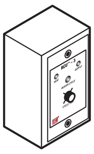
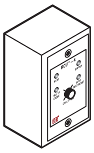
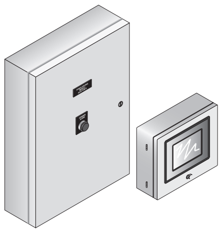
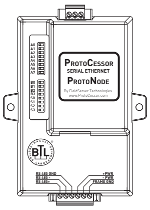
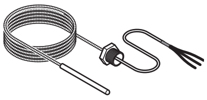
	Catalog number	Description
Automatic Snow Melting Controllers		
	APS-3C	Automatic snow melting controller housed in a Type 3R enclosure provides effective, economical automatic control of all snow melting applications. Features include: 120 V or 208–240 V models, 24-A DPDT output relay and an adjustable hold-on timer. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6-9/16 in (292 mm x 232 mm x 167 mm)
	APS-4C	Automatic snow melting controller housed in a Type 3R enclosure provides effective, economical automatic control of all snow melting applications. The APS-4C can operate with any number of SC-40C satellite contactors for larger loads. Features include: 277 V single-phase or 208–240, 277/480, and 600 V three-phase models, built-in 3-pole contactor, integral 30 mA ground-fault circuit interrupter and an adjustable hold-on timer. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6-9/16 in (292 mm x 232 mm x 167 mm)
	SC-40C	Satellite contactor power control peripheral for an APS-4C snow melting controller, housed in a Type 3R enclosure. Features include: 277 V single-phase or 208–240, 277/480 and 600 V three-phase models, built-in 3-pole contactor and integral 30 mA ground-fault circuit interrupter. Enclosure dimensions: 11-1/2 in x 9-1/8 in x 6 in (292 mm x 232 mm x 152 mm)
Snow Melting and Gutter De-Icing Sensors and Accessories		
	CIT-1	Overhead snow sensor that detects precipitation or blowing snow at ambient temperatures below 38°F (3.3°C). For use with either an APS-3C or APS-4C automatic snow melting controller.
	SIT-6E	Pavement-mounted sensor signals for the heating cable to turn on when the pavement temperature falls below 38°F (3.3°C) and precipitation in any form is present. Microcontroller technology effectively eliminates ice bridging while ensuring accurate temperature measurement. For use with either an APS-3C or APS-4C automatic snow melting controller.
	RCU-3	The RCU–3 provides control and status display to the APS–3C controller from a remote location. It has a 2, 4, 6 or 8 hour CYCLE TIME adjustment, independent of APS-3C setting.
	RCU-4	The RCU–4 provides control and status display to the APS–4C controller and SC-40C Satellite Contactor from a remote location. It has a 2, 4, 6 or 8 hour CYCLE TIME adjustment, independent of the APS-4C or SC-40C setting.

TABLE 10 CONTROL SYSTEMS

	Catalog number	Description
Electronic Controllers		
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in various commercial applications such as pipe freeze protection, roof and gutter de-icing, surface snow melting, hot water temperature maintenance and floor heating. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers. The ProtoNode-RER is for BACnet® or Metasys® N2 systems.
	RTD-200 RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

POWER DISTRIBUTION

Single Circuit Control

Heating cable circuits that do not exceed the current rating of the selected temperature control can be switched directly (see Fig. 9).

Group Control

If the current draw exceeds the switch rating, or if the controller will activate more than one circuit, or group control, an external contactor must be used (see Fig. 9).

Large systems with many circuits should use an SMPG power distribution panel. The SMPG is a dedicated power-distribution, control, ground-fault protection, monitoring, and alarm panel for surface snow melting and anti-icing applications. This enclosure contains an assembled circuit-breaker panelboard. Panels are equipped with ground-fault circuit breakers with or without alarm contacts. The group control package allows the system to operate automatically in conjunction with an ambient-sensing thermostat, individual electronic, or duty cycle controller.

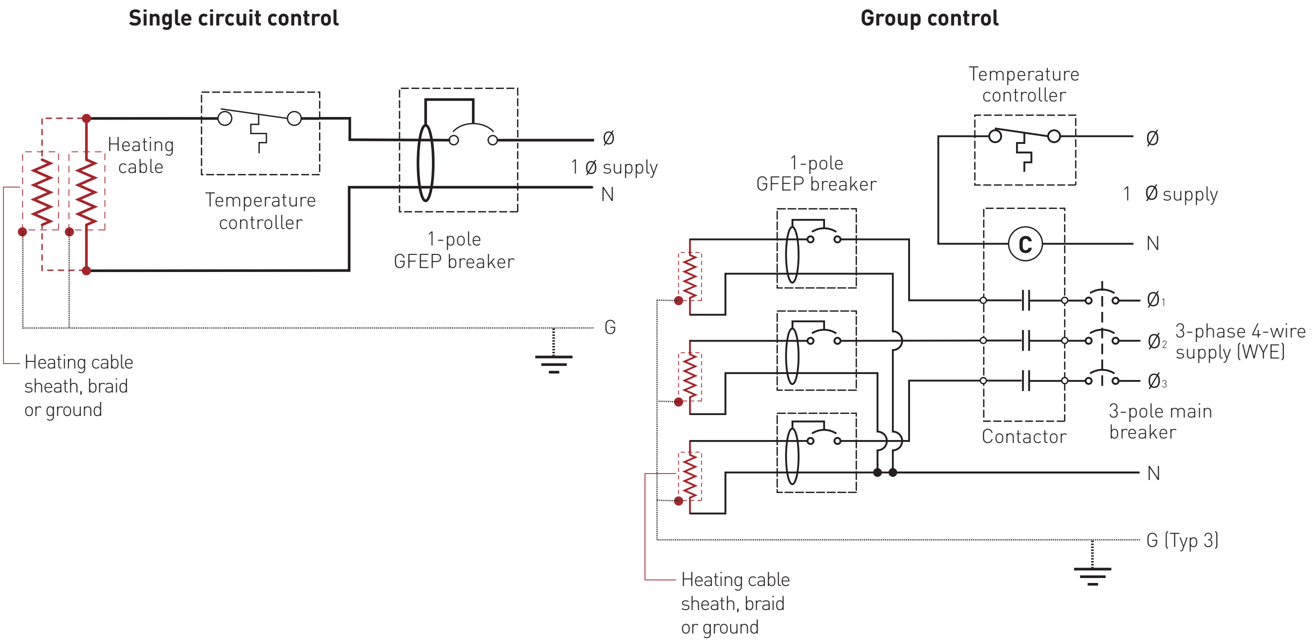


Fig. 9 Single circuit and group control

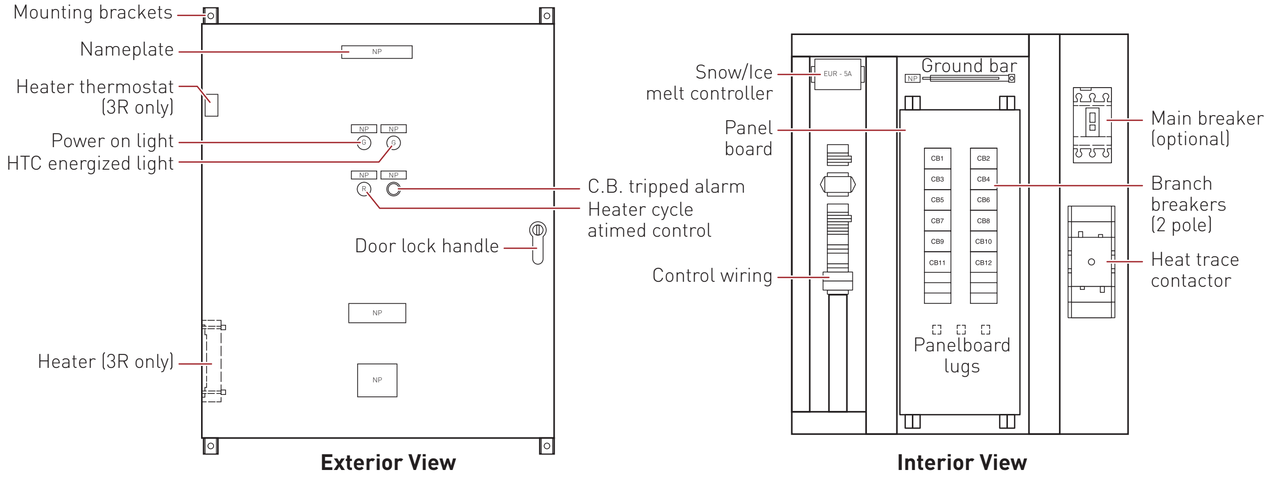


Fig. 10 SMPG1 power distribution panel

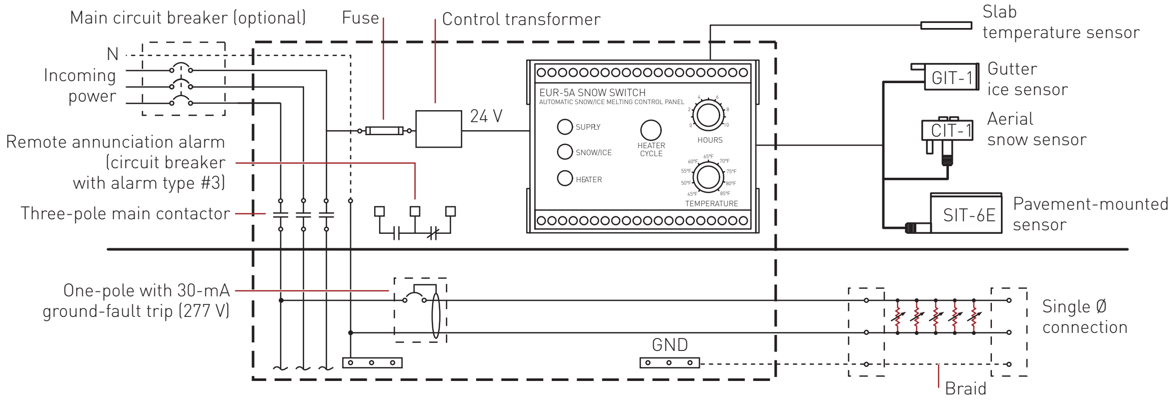
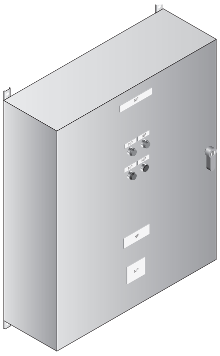


Fig. 11 Typical wiring diagram of group control with SMPG1

TABLE 11 POWER DISTRIBUTION

	Catalog number	Description
Power Distribution and Control Panels		
	SMPG1	Single-phase power distribution panel that includes ground-fault protection, monitoring, and control for snow melting systems. Single-phase voltages include 208 and 277 V. If standard configurations do not meet your needs, custom SMPG panels are available and processed under the catalog number SMPG-GENERAL, part number P000000763. Please contact your Thermal Management representative for a custom SMPG panel quotation.

Example: Surface Snow Melting System

This system has 16 circuits and will require a specially designed control panel. As many as eight SIT-6E sensors can be used in this configuration. The amount depends upon designer preference.

Example: Anti-Icing System

This system has 18 circuits and will require a specially designed control panel. As many as eight SIT-6E sensors can be used in this configuration. The amount depends upon designer preference.

Surface Snow Melting & Anti-Icing

1. Determine design conditions
2. Select the heating cable
3. Determine the required watt density
4. Determine heating cable spacing
5. Determine the total area to be protected
6. Determine heating cable length
7. Determine the electrical parameters
8. Select the connection kits and accessories
9. Select the control system and power distribution
10. Complete the Bill of Materials

Step 10 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details you need to complete the Bill of Materials.

ELECTROMELT SYSTEM SURFACE SNOW MELTING AND ANTI-ICING DESIGN WORKSHEET

Step 1 Determine design conditions

Application	Size and layout	Supply voltage	Phase	Control method
☐ Surface snow melting Geographical location: ________________ ☐ Anti-icing Minimum ambient temperature: ________________ Average wind speed during freezing periods (mph/kmph): ________________ **Paving material** ☐ Concrete pavement ☐ In concrete under paving stones	Slab surface (ft/m) ________________ Ramp surface (ft/m) ________________ Stairs Number of stairs ____________ Width of stair (ft/m) ____________ Riser height (in/cm) ____________ Depth of stair (in/cm)____________ Landing dimensions (ft/m) ____________ Wheel tracks Track length (ft/m) ____________	☐ 208 V ☐ 240 V ☐ 277 V	☐ Single-phase	☐ Manual on/off control ☐ Slab-sensing thermostat ☐ Automatic snow melting controller
Example: ✓ **Surface snow melting** ✓ **Buffalo, NY** ✓ **Concrete slab**	Slab surface: **80 ft x 50 ft** Stairs Number of stairs **10** Width of stair **5 ft** Riser height **6 in** Depth of stair **12 in**	✓ **277 V**	✓ **Single-phase**	✓ **Automatic snow melting controller**

Step 2 Select the heating cable

See Table 1
☐ EM2-XR

Example:
✓ **EM2-XR**

Step 3 Determine the required watt density

Surface snow melting See Table 2	**Anti-icing** See Table 3 and Table 4
Geographical location: ________________________ Required watt density (W/ft^2)(W/m^2): ________________________	Minimum ambient temperature (°F/°C): ______ Average wind speed during freezing periods (mph/kmph): ______ Required watt density (W/ft^2)(W/m^2): ______
Example: Geographical location: **Buffalo, NY** Required watt density: **40 W/ft^2**	

Step 4 Determine heating cable spacing

See Table 5

Surfaces

(______ Power output (W/ft) x **12 in/ft**) / ______ Watt density (W/ft²) → = ______ **Heating cable spacing (in)**

Note: Round result to the nearest whole number of inches or centimeters.

Stairs

Calculate the heating cable needed for stairs and landing

Determine the number of cable runs needed:

Depth of stair: <10.5 in (27 cm): 2 cable runs

Depth of stair: 10.5–12 in (27–30 cm): 3 cable runs

Cable runs needed: ______

Concrete stair depth (in/cm): ______ Number of cable runs: ______ Spacing: ______

Example:

Surfaces

(**34 W/ft** Power output (W/ft) x **12 in/ft**) / **40 W/ft²** Watt density (W/ft²) → = **10 in** **Heating cable spacing (in/cm)**

Note: Round result to the nearest whole number of inches or centimeters.

Stairs

Calculate the heating cable needed for stairs and landing

Determine the number of cable runs needed:

Depth of stair: <10.5 in (27 cm): 2 cable runs

Depth of stair: 10.5–12 in (27–30 cm): 3 cable runs

Cable runs needed: **3**

Concrete stair depth (in/cm): **12 in** Number of cable runs: **3** Spacing: **Equally spaced across the width of the stair with one run 2 in from the front edge**

Step 5 Determine the total area to be protected

Surfaces

______ Length (ft/m) x ______ Width (ft/m) → = ______ **Surface area to be protected (ft²/m²)**

Example:

80 ft Length x **50 ft** Width → = **4000 ft²** **Surface area to be protected (ft)**

Step 6 Determine the heating cable length

Surfaces

________ x **12 in** / ________ → = ________

Total concrete slab area (ft^2/m^2) Heating cable spacing (in/cm) **Heating cable length for surface (ft/m)**

Calculate the heating cable for stairs and landing

________ x [(________ x ________) + (**2** x ________)] = ________

No. of stairs No. of runs per stair Width of stair (ft/m) Riser height (ft/m) **Heating cable length for stairs (ft/m)**

Note: Additional heating cable for connection kits and end terminations is calculated in Step 8.

Calculate heating cable needed for wheel tracks

________ **x 2 x 4 runs** → = ________

Length (ft/m) **Wheel track to be protected (ft/m)**

____

Total heating cable length required (ft/m)

Example:

Surfaces

4000 ft^2 x **12 in** / **10 in** = → = **4800**

Total concrete slab area Heating cable spacing **Heating cable length for surface**

Calculate the heating cable for stairs and landing

10 x [(**3** x **5 ft**) + (**2** x **0.5 ft**)] = **160 ft**

No. of stairs No. of runs per stair Width of stair Riser height **Heating cable length for stairs**

Note: Additional heating cable for connection kits and end terminations is calculated in Step 8.

4960 ft

Total heating cable length required

Step 7 Determine the electrical parameters

See Table 7 and Table 8

Determine number of circuits

Heating cable length required for surface (ft/m) / Maximum heating cable circuit length (ft/m) → = **Number of circuits**

Determine total transformer load

Calculate circuit breaker load (CBL)

(Circuit breaker rating (Amps) x **0.8** x Supply voltage) / **1000** → = **Circuit breaker load (kW)**

Calculate the total transformer load as follows:

If the CBL is equal on all circuits, calculate the transformer load as:

Circuit breaker load (kW) x Number of breakers → = **Total transformer load (kW)**

If the CBL is NOT equal on all circuits, calculate the transformer load as:

CBL$_1$ + CBL$_2$ + CBL$_3$... + CBL$_N$ → = **Total transformer load (kW)**

Example:

Determine number of circuits: Surfaces

4800 ft / **325 ft** → = **14.8 rounded to 15**

Heating cable length required for surface / Maximum heating cable circuit length → = **Number of circuits**

Determine number of circuits: Stair

160 ft / **325 ft** → = **0.5 rounded to 1**

Heating cable length required for surface / Maximum heating cable circuit length → = **Number of circuits**

Determine transformer load

(**50 A** x **0.8** x **277 V**) / **1000** → = **11.1 kW**

(Circuit breaker rating x 0.8 x Supply voltage) / 1000 → = **Circuit breaker load (kW)**

11.1 kW x **16** → = **177.6 kW rounded to 178**

Circuit breaker load (kW) x Number of breakers → = **Total transformer load (kW)**

Step 8 Select the connection kit and accessories

See Table 9

Connection kits	Description	Quantity	Heating cable allowance
☐ EMK-XP	Power connection and end seal kit	____	____
☐ EMK-XS	Splice kit	____	____

Accessories	Description	Quantity	
☐ EMK-XJR	Jacket repair kit	____	
☐ EMK-CT	Nylon cable ties	____	
☐ EMK-XT	Crimping tool	____	
☐ SMCS	Snow melt caution sign	____	
☐ EMK-XEJ	Expansion joint kit	____	____
☐ EMK-XJB	Junction box	____	____

____

Total heating cable allowance for connection kits

____	+	____	+	____	=	____	=	____
Number circuits for concrete slab		Circuit(s) for stairs		Circuit(s) for expansion joints		**Total no. of circuits**		**Total no. of power connection kits**

(____	+	____)	x	____	→	=	____
Power connection conduit length (slab to junction box) (ft/m)		End seal conduit length (slab to junction box) (ft/m)		Total number of circuits			**Total conduit length (ft/m)**

____	x	____	→	=	____
Cable allowance per circuit connection (ft/m)		Total number of circuits			**Total heating cable allowance per power connection (ft/m)**

____	+	____	→	=	____
Total conduit length (ft/m)		Total allowance per power connection kit (ft/m)			**Total additional heating cable (ft/m)**

____	+	____	→	=	____
Total heating cable length (ft/m)		Total heating cable allowance (ft/m)			**Total heating cable with connection kit allowance (ft/m)**

Example:

15	+	**1**	+		=	**16**	=	**16**
Number circuits for concrete slab		Circuit(s) for stairs		Circuit(s) for expansion joints		**Total no. of circuits**		**Total no. of power connection kits**

(**15 ft**	+	**15 ft**)	x	**16**	→	=	**480 ft**
Power connection conduit length (slab to junction box)		End seal conduit length (slab to junction box)		Total number of circuits			**Total conduit length**

3 ft	x	**16**	→	=	**48 ft**
Cable allowance per circuit connection		Total number of circuits			**Total heating cable allowance per power connection**

480 ft	+	**48 ft**	→	=	**528 ft**
Total conduit length		Total allowance per power connection kit			**Total additional heating cable**

Step 9 Select the control system and power distribution

Control Systems

See Table 10.

Thermostats, controllers and accessories	Description	Quantity
☐ ECW-GF	Electronic thermostat with 25-ft sensor	____________
☐ ECW-GF-DP	Remote display panel for ECW-GF	____________
☐ PD Pro	Automatic snow and ice melting controller	____________
☐ GF-Pro	Automatic snow and ice melting controller	____________
☐ APS-3C	Automatic snow and ice melting controller	____________
☐ APS-4C	Automatic snow and ice melting controller	____________
☐ SC-40C	Satellite contactor	____________
☐ CIT-1	Overhead snow sensor	____________
☐ SIT-6E	Pavement-mounted sensor	____________
☐ RCU-3	Remote control unit for APS-3C	____________
☐ RCU-4	Remote control unit for APS-4C	____________
☐ ACS-UIT2	ACS-30 user interface terminal	____________
☐ ACS-PCM2-5	ACS-30 power control panel	____________
☐ ProtoNode-RER	Multi-protocol gateway	____________
☐ RTD3CS	Resistance temperature device for Raychem ACS-30	____________
☐ RTD10CS	Resistance temperature device for Raychem ACS-30	____________
☐ RTD-200	Resistance temperature device for Raychem ACS-30	____________
☐ RTD50CS	Resistance temperature device for Raychem ACS-30	____________

Power Distribution

See Table 11.

Power distribution and control panels	Description	Quantity
☐ SMPG1	Single-phase power distribution panel	____________

Step 10 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

Raychem

FREEZER FROST HEAVE PREVENTION – RAYSOL AND MI HEATING CABLE SYSTEM

This step-by-step design guide provides the tools necessary to design a Raychem RaySol self-regulating heating cable system or a Raychem Mineral Insulated heating cable system for freezer frost heave prevention. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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RaySol and MI Heating Cable in Conduit Freezer Frost Heave Prevention Design Worksheet 259

MI Cables Directly Embedded Freezer Frost Heave Prevention Design Worksheet 264

INTRODUCTION

Thermal Management offers two different heating cable technologies for freezer frost heave prevention: Raychem RaySol self-regulating heating cable system and Raychem MI heating cable system. Both RaySol and MI heating cables can be installed in conduit. Only MI heating cables can be embedded directly in the subfloor (concrete, sand, or compacted fill).

If your application conditions are different, or if you have any questions, contact your Thermal Management representative or call (800) 545-6258.

How to Use this Guide

This design guide presents Thermal Management's recommendations for designing freezer frost heave prevention systems. It provides design and performance data, electrical sizing information, and heating cable layout suggestions. Following these recommendations will result in a reliable, energy-efficient system.

Follow the design steps in the respective "Design" sections and use the appropriate "RaySol and MI Heating Cable in Conduit Freezer Frost Heave Prevention Design Worksheet" on page 259 and "MI Cables Directly Embedded Freezer Frost Heave Prevention Design Worksheet" on page 264 to document the project parameters that you will need for your project's Bill of Materials.

OTHER REQUIRED DOCUMENTS

This guide is not intended to provide comprehensive installation instructions. For complete freezer frost heave prevention system installation instructions, please refer to the following additional required documents:

- Raychem RaySol Floor Heating and Frost Heave Prevention Installation and Operation Manual (H58138)
- Raychem Mineral Insulated Heating Cable Floor Heating and Frost Heave Prevention Installation and Operation Manual (H58137)
- Additional installation instructions are included with the connection kits, thermostats, controllers, and accessories

If you do not have these documents, you can obtain them from the Thermal Management web site at www.pentairthermal.com.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system components could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

✎ This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

Thermal Management's standard limited warranty applies to Raychem and Raychem Freezer Frost Heave Prevention Systems.

An extension of the limited warranty period to ten (10) years from the date of installation is available, except for the control and distribution systems, if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

Subfreezing temperatures inside cold rooms, freezers, and ice arenas cause heat to be lost from the soil under the floor, even when it is well insulated. As the soil freezes, capillary action draws water into the frozen areas where the water forms a concentrated ice mass. As the ice mass grows, it heaves the freezer floor and columns, causing damage.

Thermal Management offers two different heating cable technologies for freezer frost heave prevention: Raychem RaySol self-regulating heating cable and Raychem MI heating cable system. Both RaySol and MI heating cables can be installed in conduit. Only MI heating cables can be embedded directly in the subfloor (sand, compacted fill or concrete). The electrical conduit carrying the heating cable or the directly embedded heating cable is installed in the subfloor under the freezer-floor insulation, as illustrated below. The subfloor layer may be a reinforced concrete slab, a concrete mud slab, a bed of compacted sand, or simply compacted fill.

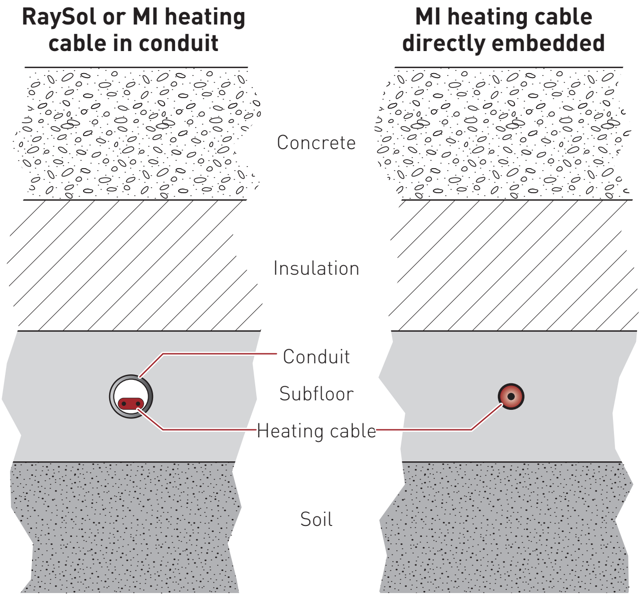


Fig. 1 Typical freezer frost heave installation

The RaySol self-regulating heating cable provides a cut-to-length solution. The backbone of the system is the self-regulating heating cable available for 120 and 208–277 V applications. As Fig. 4 on page 216 indicates, the cable's output is reduced automatically as the subfloor warms, so there is no possibility of failure due to overheating. Since there is no possibility of overheating, RaySol may be operated without thermostatic control. Elements of a RaySol system include the heating cable, termination, splice connections and accessories, controls, power distribution panels, and the tools necessary for a complete installation.

Raychem MI heating cable can be used for single-phase and three-phase applications up to 600 V and the cable can be installed in conduit or directly embedded in sand (recommended), concrete, or compacted fill. For directly embedded applications, long cable runs can be accommodated allowing frost heave prevention systems to be designed for large freezers and ice arenas using only a few circuits. Raychem MI heating cables are rugged factory-terminated cables (Fig. 6 and Fig. 7) that are engineered to suit your application, power and configuration requirements. Elements of an MI system include the heating cable, accessories, controls, power distribution panels, and the tools for a complete installation.

Typical System

A typical system includes the following:

- RaySol self-regulating heating cable or Raychem MI heating cable
- Connection kits (for RaySol only)
- Junction boxes
- Temperature control and power distribution systems

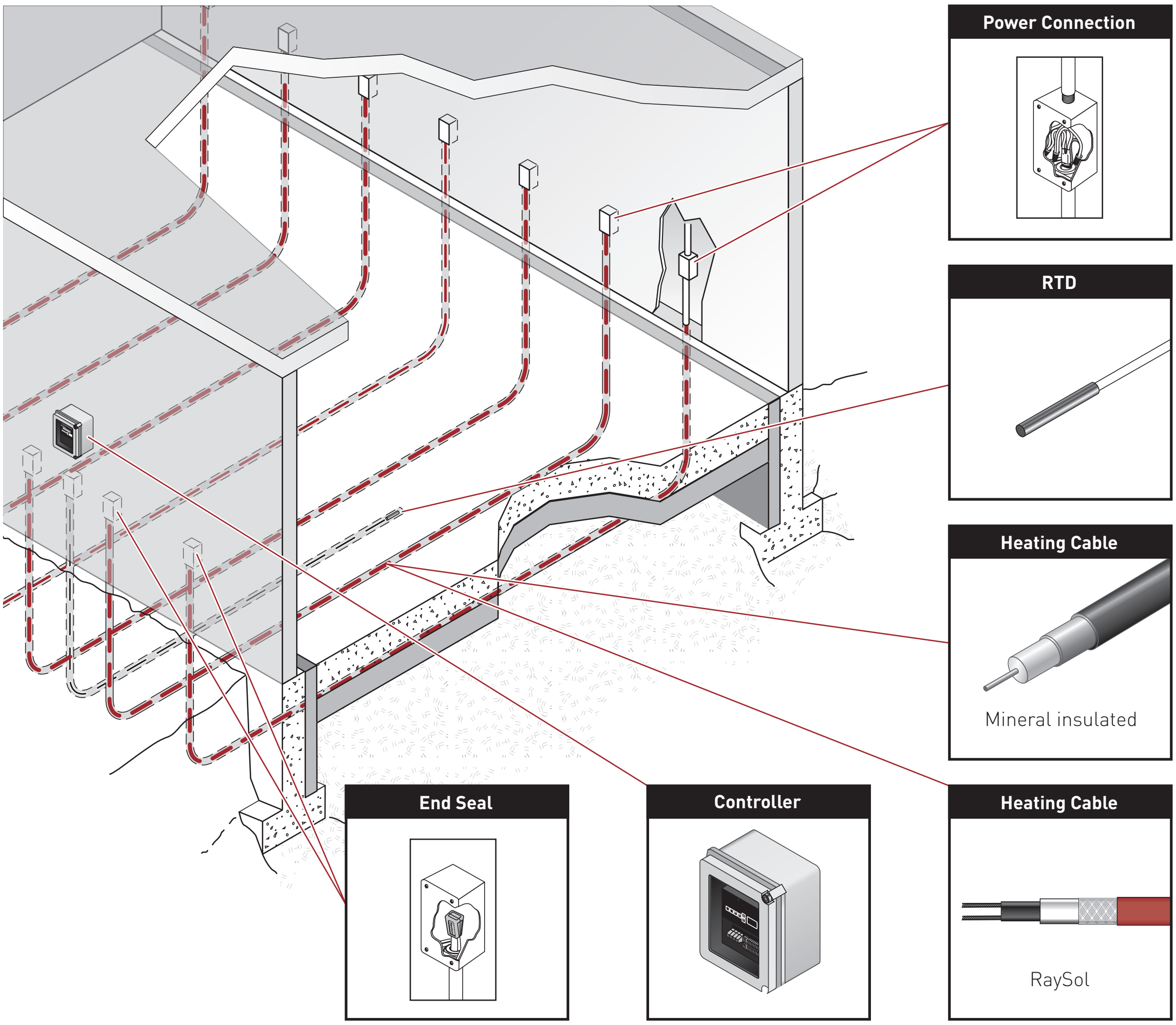


Fig. 2 Typical freezer frost heave system

The following table lists the heating cable, required connection kits, and accessories for a RaySol and MI heating cable systems.

TABLE 1 HEATING CABLES AND CONNECTION KITS

	Catalog Number	**Description**
Heating cable	RaySol-1 RaySol-2	120 V 208–277 V
	HDPE jacketed copper sheath MI heating cable	≤600 V
Connection kits for RaySol heating cables	FTC-XC	Power connection and end seal
	RayClic-E	End seal
	FTC-HST	Splice (as required – not for use inside conduit)

Self-Regulating Heating Cable Construction

Raychem RaySol self-regulating heating cables are comprised of two parallel nickel-coated bus wires in a cross-linked polymer core, a tinned copper braid, and a fluoropolymer outer jacket. These cables are cut to length simplifying the application design and installation.

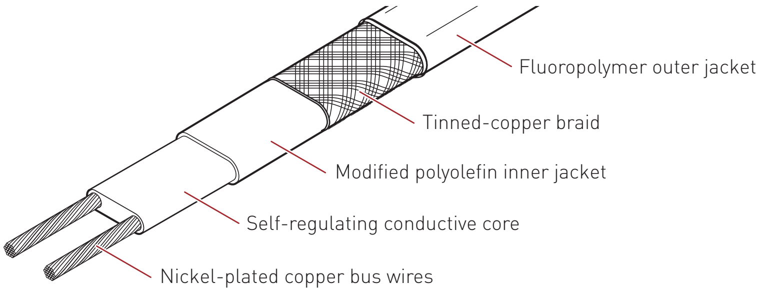
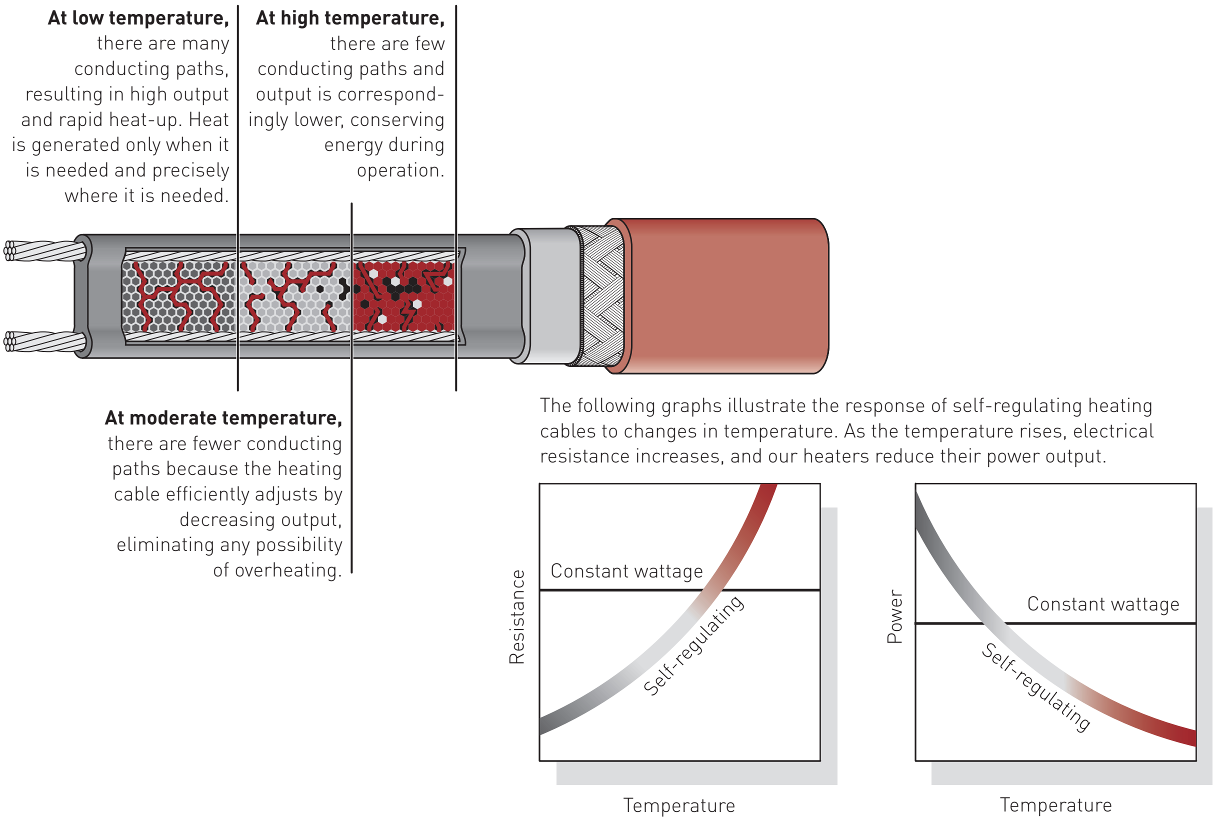


Fig. 3 Typical RaySol heating cable construction

With self-regulating technology, the number of electrical paths between bus wires changes in response to temperature fluctuations. As the temperature surrounding the heater decreases, the conductive core contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core.

As the temperature rises, the core expands microscopically. This expansion increases electrical resistance and the number of electrical paths decreases. The heating cable automatically reduces its output.



At low temperature, there are many conducting paths, resulting in high output and rapid heat-up. Heat is generated only when it is needed and precisely where it is needed.

At high temperature, there are few conducting paths and output is correspondingly lower, conserving energy during operation.

At moderate temperature, there are fewer conducting paths because the heating cable efficiently adjusts by decreasing output, eliminating any possibility of overheating.

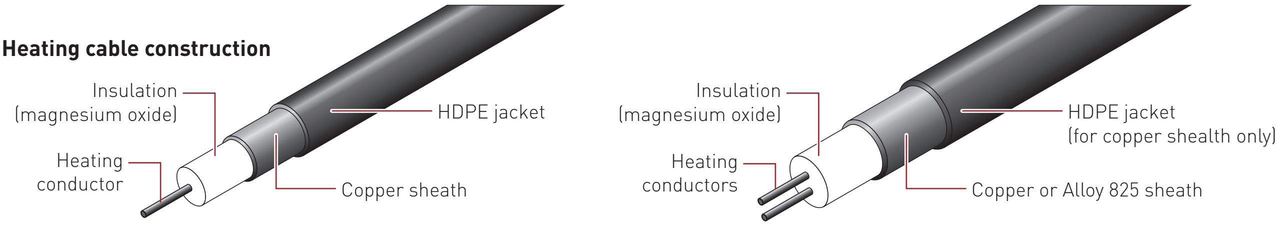
The following graphs illustrate the response of self-regulating heating cables to changes in temperature. As the temperature rises, electrical resistance increases, and our heaters reduce their power output.

Fig. 4 Self-regulating heating cable technology

MI Heating Cable Construction

Raychem MI heating cables used for frost heave prevention applications are comprised of one or two conductors surrounded by magnesium oxide insulation and a solid copper sheath with an extruded high density polyethylene (HDPE) jacket or Alloy 825 stainless steel sheath for directly embedded or in conduit applications.

Heating cable construction



Single-conductor cable (61 series)

Dual-conductor cable (32, 62 series)

Fig. 5 Typical MI heating cable construction

These heating cables are supplied as complete factory-fabricated assemblies consisting of an MI heating cable that is joined to a section of MI non-heating cold lead and terminated with NPT connectors. Three configurations are available: Type SUA consisting of a looped cable joined to a single 7 ft (2.1 m) cold lead with one 1/2-in NPT connector; Type SUB/FFHP consisting of a single run of cable with a 15 ft (4.6 m) cold lead and a 1/2-in NPT connector on each end; and Type FFHPC consisting of a single run of cable joined to a single 7 ft (2.1 m) cold lead with one 1/2-in NPT connector.

Types SUA and SUB/FFHP heating cables (Fig. 6) are used for directly embedded applications, and Type FFHPC heating cables (Fig. 7) are used for installation in conduit. Type FFHPC heating cables are supplied with a bare copper sheath cold lead and a 3/4-in NPT reversed gland connector and a pulling eye. The reversed gland connector provides a seal for the end of the conduit (see Fig. 13 on page 231).

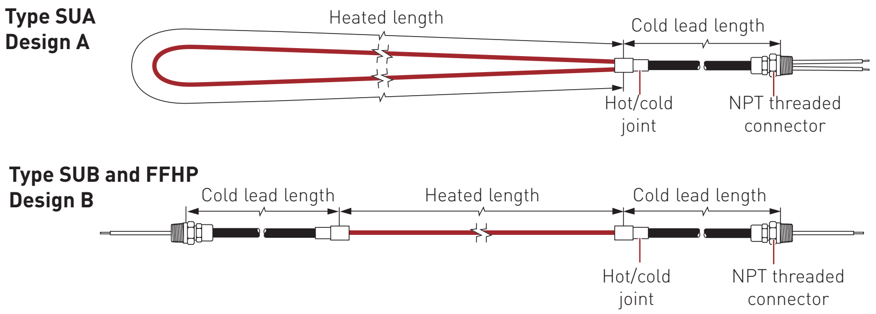


Fig. 6 Configurations for directly embedded installations

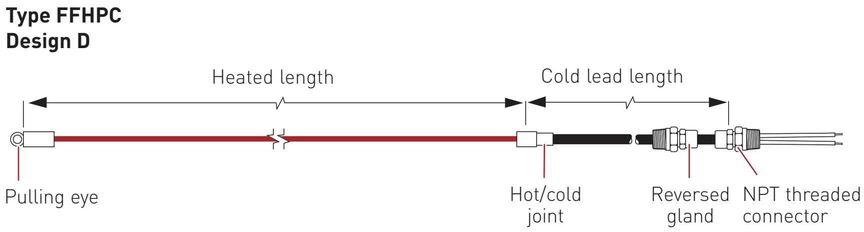


Fig. 7 Configuration for installation in conduit

Thermal Management offers all the major components necessary for system installation. Details of these components and additional accessories can be found later in this section.

Approvals

Installation of Raychem RaySol and Raychem MI heating cable systems is governed by national and local electrical codes. Thermal Management, the NEC, and the CEC all require the use of ground-fault protection of equipment to reduce the risk of fire caused by damage or improper installation.

RaySol system is UL Listed and CSA Certified for use in nonhazardous locations.

MI system is c-CSA-us Certified and FM Approved for use in nonhazardous locations. FM applies only to the bare copper and stainless steel cable for Freezer Frost Heave installation inside of conduits.

FREEZER FROST HEAVE PREVENTION DESIGN

This section details the steps necessary to design your application. The examples provided in each step are intended to incrementally illustrate the project parameter output for sample designs from start to finish. As you go through each step, use the appropriate "RaySol and MI Heating Cable in Conduit Freezer Frost Heave Prevention Design Worksheet" on page 259 and "MI Cables Directly Embedded Freezer Frost Heave Prevention Design Worksheet" on page 264 to document your project parameters, so that by that end of this section, you will have the information you need for your Bill of Materials.

This section contains two major parts:

1. Design Step by Step RaySol and MI Heating Cables in Conduit (see page 219)
2. Design Step by Step MI Heating Cable Directly Embedded (see page 240)

Design Assumptions

When using this guide to design a system you need the following information:

- Size and layout of freezer or ice arena
- Freezer operating temperature
- Insulation R-value
- Supply voltage and phase
- Control recommendations (over-limit thermostat and monitoring)

The information and recommendations in this section are based on the following design assumptions:

- The information in this guide is based on the application of the RaySol and MI heating cables in the subfloor on grade only.
- Any size freezer or cold room operating below 32°F (0°C) may experience frost heaving.
- The heating cable is located in a sub-slab underneath the insulation. (see Fig. 1)
- The heating cable is in conduit embedded in concrete, sand, or soil (or directly embedded if using MI heating cables). If you are using a different medium, contact Thermal Management for an analysis.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call (800) 545-6258.

Design Step by Step RaySol and MI Heating Cables in Conduit

This section guides you through the steps necessary to design your system using RaySol self-regulating or MI heating cables in conduit.

Your system design requires the following essential steps:

1. Determine the freezer configuration
2. Select the heating cable
   A. RaySol heating cable in conduit
   B. MI heating cable in conduit
3. Determine the heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
   A. RaySol heating cable in conduit
   B. MI heating cable in conduit
5. Determine the electrical parameters
   A. RaySol heating cable in conduit
   B. MI heating cable in conduit
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

The "RaySol and MI Heating Cable in Conduit Freezer Frost Heave Prevention Design Worksheet" on page 259 is included to help you document the project parameters that you will need for your project's Bill of Materials.

Freezer Frost Heave Prevention System Design Steps (in Conduit)
1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 1 Determine the freezer configuration

GATHERING INFORMATION

The following information is required to complete the freezer frost heave prevention system design.

- Size and layout of freezer or ice arena
- Freezer operating temperature
- Insulation R-value
- Supply voltage (single-phase)
- Control requirements

PREPARE SCALE DRAWING

Draw to scale the floor area to be heated. Carefully note the limits of the area to be heated. Show all concrete joints on the drawing and note the location and size of obstacles, such as floor drains, pipe penetrations, conduit runs (if required), columns, fixtures, and voltage supply location.

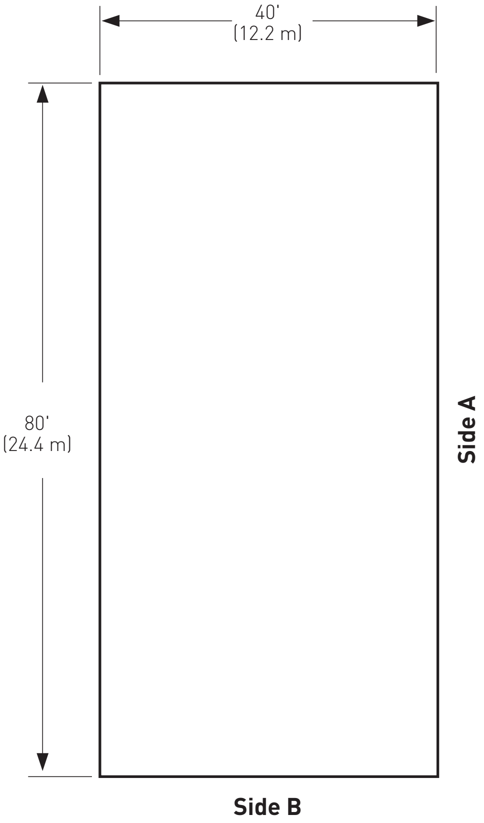


Fig. 8 Typical freezer example

DETERMINE THE FREEZER OPERATING TEMPERATURE

Determine the temperature at which your freezer operates. If it operates at more than one temperature, or if the operating temperature may be changed in the future, base the spacing selection on the lowest anticipated operating temperature.

RECORD INSULATION R-VALUE

The insulation R-value is the thermal resistance of the floor’s insulation. Normally the R-value will be printed on the insulation material. If that is not the case, you can calculate it by dividing the insulation thickness in inches by the insulation thermal conductivity.

Example: RaySol and MI heating cables in conduit

Area	80 ft x 40 ft = 3200 ft^2 (24.4 m x 12.2 m = 297 m^2)
Freezer operating temperature	–20°F (–29°C)
Insulation R-value	R-40 (40 ft^2·°F·hr/Btu)
Supply voltage	208 V, single-phase

Freezer Frost Heave Prevention System Design Steps (in Conduit)

1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 2 Select the heating cable

The heating cable you select will depend on your system:

A. RaySol heating cable in conduit

B. MI heating cable in conduit

STEP 2A: FOR RAYSOL HEATING CABLE IN CONDUIT

Select the heating cable based on the operating voltage determined in Step 1. For 120 volts, select RaySol-1; for 208/240/277 V, select RaySol-2.

TABLE 2 RAYSOL HEATING CABLE

Supply voltage	Catalog number
120 V	RaySol-1
208–277 V	RaySol-2

Example: RaySol heating cables in conduit

Supply voltage	208 V (from Step 1)
Catalog number	**RaySol-2**

STEP 2B: FOR MI HEATING CABLE IN CONDUIT

Select the heating cable from Table 3 based on the operating voltage from Step 1 and the freezer length. The freezer length must be equal to or within the minimum and maximum "Freezer length" shown in the shaded columns. For the example in Fig. 8, under 208 V, select the heating cable that corresponds to the Minimum (80 ft/24.4 m) and Maximum (84 ft/25.6 m) "Freezer length" in the shaded columns.

If your freezer is longer than 104 ft (32 m), or the supply voltage is different than those listed, or the system will be powered from a three-phase supply, please contact your Thermal Management representative or call (800) 545- 6258 for a custom design.

If it is not possible to install the conduit runs parallel to the freezer length (Side A), then select the heating cable based on the freezer width (Side B).

TABLE 3 SELECTION TABLE FOR MI HEATING CABLES IN CONDUIT

Catalog number	Freezer length				Heated length		Power output	Heating cable current
	Min (ft)	Max (ft)	Min (m)	Max (m)	(ft)	(m)	(W)	(A) [1]
120 V								
FFHPC1	15	19	4.6	5.8	15	4.6	105	0.9
FFHPC2	20	24	6.1	7.3	20	6.1	120	1.0
FFHPC3	25	29	7.6	8.8	25	7.6	145	1.2
FFHPC4	30	34	9.1	10.4	30	9.1	175	1.5
FFHPC5	35	39	10.7	11.9	35	10.7	240	2.0
FFHPC6	40	44	12.2	13.4	40	12.2	315	2.6
FFHPC7	45	49	13.7	14.9	45	13.7	280	2.3
FFHPC8	50	54	15.2	16.5	50	15.2	360	3.0
FFHPC9	55	59	16.8	18.0	55	16.8	330	2.8
FFHPC10	60	64	18.3	19.5	60	18.3	400	3.3
FFHPC11	65	69	19.8	21.0	65	19.8	370	3.1
FFHPC12	70	74	21.3	22.6	70	21.3	515	4.3
FFHPC13	75	79	22.9	24.1	75	22.9	480	4.0
FFHPC14	80	84	24.4	25.6	80	24.4	450	3.8
FFHPC15	85	89	25.9	27.1	85	25.9	565	4.7
FFHPC16	90	94	27.4	28.7	90	27.4	535	4.5
FFHPC17	95	99	29.0	30.2	95	29.0	750	6.3
FFHPC18	100	104	30.5	31.7	100	30.5	720	6.0
208 V								
FFHPC19	25	29	7.6	8.8	25	7.6	155	0.7
FFHPC20	30	34	9.1	10.4	30	9.1	190	0.9
FFHPC21	35	39	10.7	11.9	35	10.7	205	1.0
FFHPC22	40	44	12.2	13.4	40	12.2	270	1.3
FFHPC23	45	49	13.7	14.9	45	13.7	350	1.7
FFHPC24	50	54	15.2	16.5	50	15.2	315	1.5
FFHPC25	55	59	16.8	18.0	55	16.8	390	1.9
FFHPC26	60	64	18.3	19.5	60	18.3	425	2.0
FFHPC27	65	69	19.8	21.0	65	19.8	390	1.9
FFHPC28	70	74	21.3	22.6	70	21.3	540	2.6
FFHPC29	75	79	22.9	24.1	75	22.9	505	2.4
FFHPC30	80	84	24.4	25.6	80	24.4	475	2.3
FFHPC31	85	89	25.9	27.1	85	25.9	635	3.1
FFHPC32	90	94	27.4	28.7	90	27.4	600	2.9
FFHPC33	95	99	29.0	30.2	95	29.0	570	2.7
FFHPC34	100	104	30.5	31.7	100	30.5	720	3.5

[1] Single-phase current shown
Tolerance on cable length is –0% to +1%.
All heating cables supplied with 3/4-in NPT reversed gland and pulling eye.
Type FFHPC cables supplied with 7 ft (2.1 m) long cold lead.

TABLE 3 SELECTION TABLE FOR MI HEATING CABLES IN CONDUIT

Catalog number	Freezer length				Heated length		Power output	Heating cable current (A) [1]
	Min (ft)	Max (ft)	Min (m)	Max (m)	(ft)	(m)	(W)	
277 V								
FFHPC35	30	34	9.1	10.4	30	9.1	230	0.8
FFHPC36	35	39	10.7	11.9	35	10.7	240	0.9
FFHPC37	40	44	12.2	13.4	40	12.2	255	0.9
FFHPC38	45	49	13.7	14.9	45	13.7	285	1.0
FFHPC39	50	54	15.2	16.5	50	15.2	380	1.4
FFHPC40	55	59	16.8	18.0	55	16.8	350	1.3
FFHPC41	60	64	18.3	19.5	60	18.3	465	1.7
FFHPC42	65	69	19.8	21.0	65	19.8	430	1.6
FFHPC43	70	74	21.3	22.6	70	21.3	400	1.4
FFHPC44	75	79	22.9	24.1	75	22.9	500	1.8
FFHPC45	80	84	24.4	25.6	80	24.4	480	1.7
FFHPC46	85	89	25.9	27.1	85	25.9	530	1.9
FFHPC47	90	94	27.4	28.7	90	27.4	500	1.8
FFHPC48	95	99	29.0	30.2	95	29.0	700	2.5
FFHPC49	100	104	30.5	31.7	100	30.5	670	2.4

[1] Single-phase current shown
Tolerance on cable length is –0% to +1%.
All heating cables supplied with 3/4-in NPT reversed gland and pulling eye.
Type FFHPC cables supplied with 7 ft (2.1 m) long cold lead.

Example: MI heating cables in conduit

Supply voltage	208 V
Freezer (Side A) length	80 ft (24.4 m) (from Step 1)
Catalog number	**FFHPC30**
Power output	**475 W**

Freezer Frost Heave Prevention System Design Steps (in Conduit)

1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 3 Determine the heating cable conduit spacing and freezer load

FOR RAYSOL AND MI CABLE SYSTEMS

In this step you will determine the conduit spacing, and freezer loads for the RaySol or MI heating cable systems. Use the freezer operating temperature and the floor insulation R-value to select the correct spacing shown in Table 4. If your calculated R-value or freezer operating temperature does not match the values in the table, use the values that give the closer spacing.

Within each cell in Table 4, there are two numbers: conduit spacing and freezer load. Freezer load is the additional cooling load imposed on the cooling system by the freezer frost heave prevention heating cable. It is the heat transferred through the insulation into the freezer, expressed in W/ft^2 (W/m^2) of floor area.

TABLE 4 RAYSOL AND MI CONDUIT SPACING AND FREEZER LOAD

Freezer operating temperature			Floor insulation R-value (ft^2·°F·hr/Btu)			
			R-10	R-20	R-30	R-40
30°F (–1°C)	Conduit spacing	in (cm)	96 (244)	96 (244)	96 (244)	96 (244)
	Freezer load	W/ft^2 (W/m^2)	0.7 (8)	0.4 (4)	0.3 (3)	0.2 (2)
20°F (–7°C)	Conduit spacing	in (cm)	81 (206)	96 (244)	96 (244)	96 (244)
	Freezer load	W/ft^2 (W/m^2)	0.8 (9)	0.5 (5)	0.3 (3)	0.3 (3)
10°F (–12°C)	Conduit spacing	in (cm)	63 (160)	96 (244)	96 (244)	96 (244)
	Freezer load	W/ft^2 (W/m^2)	1.0 (11)	0.6 (6)	0.4 (4)	0.3 (3)
0°F (–18°C)	Conduit spacing	in (cm)	51 (130)	84 (213)	96 (244)	96 (244)
	Freezer load	W/ft^2 (W/m^2)	1.2 (13)	0.8 (9)	0.5 (5)	0.4 (4)
–10°F (–23°C)	Conduit spacing	in (cm)	42 (107)	72 (183)	96 (244)	96 (244)
	Freezer load	W/ft^2 (W/m^2)	1.5 (16)	0.8 (9)	0.6 (6)	0.5 (5)
–20°F (–29°C)	Conduit spacing	in (cm)	36 (91)	63 (160)	87 (221)	96 (244)
	Freezer load	W/ft^2 (W/m^2)	1.8 (19)	1.0 (11)	0.6 (6)	0.5 (5)
–30°F (–34°C)	Conduit spacing	in (cm)	33 (84)	57 (145)	78 (198)	93 (236)
	Freezer load	W/ft^2 (W/m^2)	2.0 (22)	1.1 (12)	0.8 (9)	0.6 (6)
–40°F (–40°C)	Conduit spacing	in (cm)	30 (76)	51 (130)	69 (175)	84 (213)
	Freezer load	W/ft^2 (W/m^2)	2.3 (25)	1.2 (13)	0.8 (9)	0.7 (8)

Example: RaySol and MI heating cables in conduit

Freezer operating temperature	–20°F (–29°C) (from Step 1)
Insulation R-value	R-40 (40 ft^2·°F·hr/Btu) (from Step 1)
Conduit spacing	**96 in (244 cm)**
Freezer load	**0.5 W/ft^2 (5 W/m^2)**

Freezer Frost Heave Prevention System Design Steps (in Conduit)

1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 4 Determine the heating cable layout and length

STEP 4A FOR RAYSOL HEATING CABLE IN CONDUIT

Estimate number of conduit runs

To calculate the number of conduit runs and heating cable length from your scaled drawing, refer to Fig. 9 and Fig. 10.

Define Side "A" as the side that is parallel to the conduit runs. Side "A" cannot be greater than the maximum circuit length for RaySol (Table 5).

Define Side "B" as the side that is perpendicular to the conduit runs. Refer to Fig. 9 and Fig. 10 for examples of Side A and Side B.

Two basic types of heating cable layouts are used:

1. The hairpin layout (Fig. 9) is used both in smaller freezers where it results in material and labor savings over the straight run layout (Fig. 10), and in other freezers where only one wall of the freezer is accessible for mounting junction boxes.
2. The straight run layout (Fig. 10) is used when the freezer dimension exceeds one-half the maximum heating cable circuit length (insufficient heating cable allowed for a run down and back).

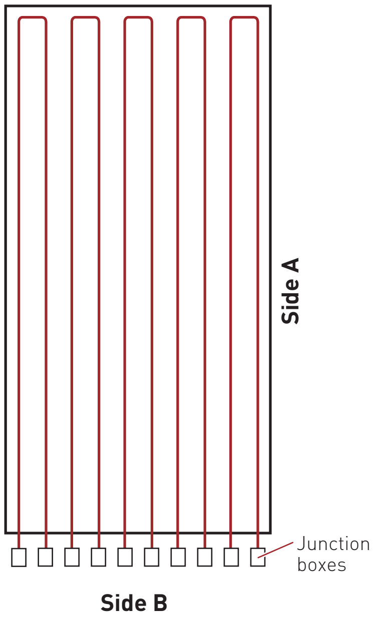


Fig. 9 Hairpin layout

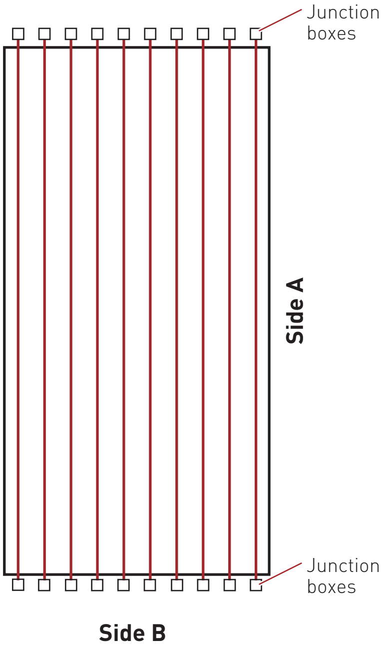


Fig. 10 Straight run layout

Calculate the number of estimated conduit runs as follows:

$$\text{Estimated number of conduit runs} = \frac{\text{Side B (ft)} \times 12}{\text{Conduit spacing (in)}}$$

$$\frac{\text{Side B (m)} \times 100}{\text{Conduit spacing (cm)}}$$

Round the estimated number of conduit runs to the next larger whole number. For example, if the result is 7.4, then 8 conduit runs are required. It may be necessary to recalculate the conduit spacing following this step.

Example: RaySol heating cables in conduit

Side B length	40 ft (12.2 m) (from Step 1)
Conduit spacing	96 in (244 cm) (from Step 3)
Number of conduit runs	
Side B x 12 / spacing (in)	40 ft x 12 / 96 in = 5
Side B x 100 / spacing (cm)	12.2 m x 100 / 244 cm = 5

Estimate the heating cable length required for conduit runs

Multiply the conduit length (Side A) by the number of conduit runs to determine the length of heating cable required for the freezer area.

Heating cable length = Conduit length (Side A) x number of conduit runs

Example: RaySol heating cables in conduit (continued)

Heating cable length required 80 ft (24.4 m) x 5 = **400 ft (122 m)**

Determine the maximum circuit length for the heating cable length and layout

For the appropriate supply voltage, use Table 5 to select the maximum circuit length which is closest to, but greater than the length calculated. Select the smallest appropriate circuit breaker size.

TABLE 5 RAYSOL MAXIMUM CIRCUIT LENGTHS IN FEET (METERS)

Supply voltage	120 V		208 V		240 V		277 V	
Circuit breaker size (A)	ft	m	ft	m	ft	m	ft	m
15	180	54.9	305	93.0	335	102.1	375	114.3
20	240	73.2	410	125.0	450	137.2	500	152.4
30	240	73.2	410	125.0	450	137.2	500	152.4
40	240	73.2	410	125.0	450	137.2	500	152.4

If the heating cable length required is greater than the maximum circuit length, multiple circuits must be used.

When Side A x 2 is less than or equal to the maximum circuit length, then the conduit run can be looped into the hairpin layout (Fig. 9). In a hairpin configuration, when you have an odd number of conduit runs, one run will be a straight run as shown in Fig. 11.

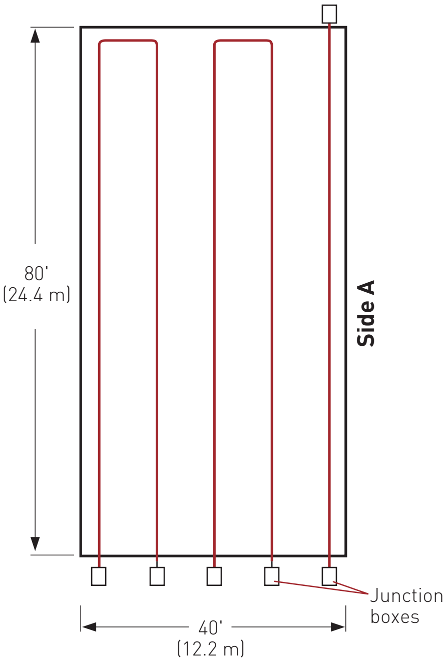


Fig. 11 Layout for example (two hairpins and one straight run)

Example: RaySol heating cables in conduit (continued)

Heating cable length required	**400 ft (122 m)**
Supply voltage	208 V (from Step 1)
Maximum circuit length	410 ft (125 m) (from Table 5)
Number of circuits	1
Power supply	One 20 A circuit breaker Run in two hairpin loops and one straight run (see Fig. 11)

Ground-Fault Protection

A 30-mA ground-fault protection device (GFPD) must be used to provide protection from arcing or fire, and to comply with warranty requirements, agency certifications, and national electrical codes. If the heating cable is improperly installed, or physically damaged, sustained arcing or fire could result. If arcing does occur, the fault current may be too low to trip conventional circuit breakers.

Determine additional heating cable allowance

Additional heating cable is required to make power connections and to route the circuits to junction boxes. This extra heating cable shall not be considered when determining the maximum heating cable length for circuit breaker sizing. In order to estimate the total heating cable length, you will need to take the heating cable length you already calculated, and then add heating cable allowances, as follows:

Estimated total heating cable length = Required heating cable + End allowances + Connection kit allowances

TABLE 6 RAYSOL ADDITIONAL HEATING CABLE ALLOWANCE

Heating cable allowance	Description	Hairpin layout	Straight run layout
End allowances	From end of conduit to junction box	8 ft per hairpin conduit	8 ft per straight run conduit
Connection kit allowances	Required to assemble the connection kit	4 ft per kit	4 ft per kit

The end allowance is the length of heating cable installed in protective conduit between the heated floor and the power connection junction box. The connection kit allowance (usually 2 ft per end) is the length of heating cable inside the power connection junction box.

Example: RaySol heating cables in conduit (continued)

Heating cable length required	**400 ft (122 m)**
End allowance	2 hairpin runs = **16 ft (4.9 m)** 1 straight run = **8 ft (2.4 m)**
Connection kit allowance	2 hairpin runs (2 FTC-XC kits) = **8 ft (2.4 m)** 1 straight run (1 FTC-XC kit) = **4 ft (1.2 m)**
Total heating cable allowance	[16 ft (4.9 m) + 8 ft (2.4 m)] + [8 ft (2.4 m) + 4 ft (1.2 m)] = **36 ft (11 m)**
Total heating cable length required	400 ft (122 m) + 36 ft (11 m) = **436 ft (133 m) of RaySol-2**

Locate the junction boxes for a RaySol heating cable system

The heating cable connects to the branch circuit wiring in a junction box using a Raychem FTC-XC power connection and end seal kit. The heating cable is routed from the subfloor to a junction box located above grade through protective conduit. In most freezer frost heave prevention applications, separate junction boxes are used for the power connection and end seal.

Lay out heating cable runs, circuits, and junction boxes

After determining the approximate total length of heating cable, the number of circuits, and the junction box location, do a trial layout. In making the trial layout, follow these recommendations:

- Start and end each circuit in a junction box.
- Do not design more than one run of heating cable per conduit.
- Arrange the conduit so it uniformly covers the area to be heated.
- Maintain the design conduit spacing within 4 in (10 cm).
- Do not extend the heating cable beyond the room or area in which it originates.
- Do not cross expansion or other subfloor joints.
- Do not route the conduit closer than 4 in (10 cm) to the edge of the subfloor, drains, anchors, or other material in the concrete.
- Do not exceed the maximum circuit length allowed on a branch circuit breaker as given in Table 5.
- The maximum length of heating cable that can be pulled through conduit is 500 feet (150 m). The maximum total degree of conduit turn is 360 degrees.
- When the combined lengths of two or more circuit runs are less than the maximum circuit length allowed, these runs can be combined in parallel on one circuit breaker.

Record circuit information

Reconfigure the trial circuit layout until the design meets all of the previous recommendations. Assign each circuit to a circuit breaker in a specific panel board and record each circuit length.

STEP 4B FOR MI HEATING CABLE IN CONDUIT

Estimate number of conduit runs

MI cables in conduit can only be installed using the straight run layout shown in Fig. 12.

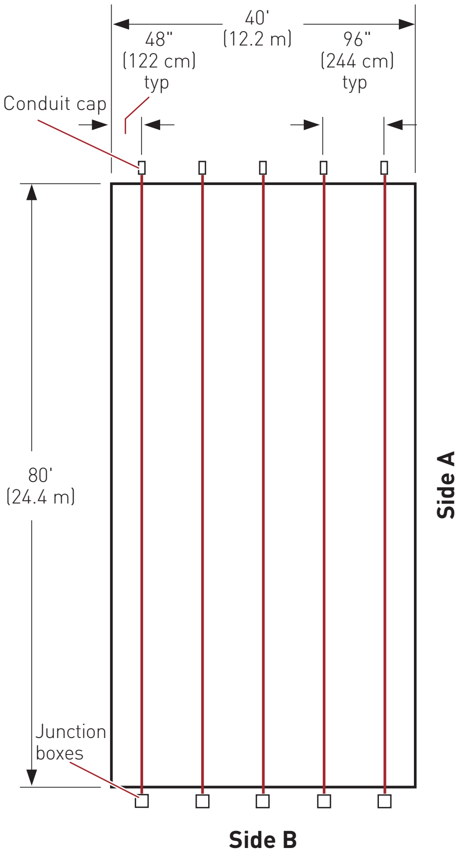


Fig. 12 Layout for straight run example

To calculate the number of conduit runs from your scaled drawing, refer to Fig. 12, and calculate as follows:

$$\text{Estimated number of conduit runs} = \frac{\text{Side B (ft) x 12}}{\text{Conduit spacing (in)}}$$

$$\frac{\text{Side B (m) x 100}}{\text{Conduit spacing (cm)}}$$

Round the estimated number of conduit runs to the next larger whole number. For example, if the result is 7.4, then 8 conduit runs are required. It may be necessary to recalculate the conduit spacing following this step.

Note: If the heating cable was selected using the freezer width (Side B) in Step 2, use Side A in the above formula.

Example: MI heating cables in conduit

Side B length	40 ft (12.2 m) (from Step 1)
Conduit spacing	96 in (244 cm) (from Step 3)
Number of conduit runs	
Side B x 12 / spacing (in)	40 ft x 12 / 96 in = 5
Side B x 100 / spacing (cm)	12.2 m x 100 / 244 cm = 5

Determine the number of MI heating cables

Number of heating cables required = Number of conduit runs

Example: MI heating cables in conduit (continued)

Heating cable	FFHPC30 (from Step 2)
Number of conduit runs	5
Number of heating cables required	5

Locate the junction boxes for an MI heating cable system

Raychem MI heating cables are factory terminated with 7 ft (2.1 m) long non-heating cold leads, making it possible to connect two or three heating cables to a single junction box. A Raychem D1297TERM4 may be used where two heating cables are connected in parallel. A junction box is only required for the power connection end.

Lay out the MI heating cable runs, circuits, and junction boxes

After determining the number of heating cables required, the number of circuits, and the junction box locations, do a trial layout. In making the trial layout, follow these recommendations:

- The conduits must be laid out in straight runs as shown in Fig. 12.
- Where cable lengths exceed 50 ft (15.2 m), the conduit must be accessible from both ends to allow long runs of cable to be pulled into the conduit.
- If it is necessary to stub-up the ends of the conduit, use a minimum 12 in (30 cm) radius as shown in Fig. 13.
- Arrange the conduits so that they uniformly cover the area to be heated.
- Maintain the design conduit spacing within 4 in (10 cm).
- Do not cross expansion or other subfloor joints.
- Do not route the conduit closer than 4 in (10 cm) to the edge of the subfloor, drains, anchors, or other material in the concrete.

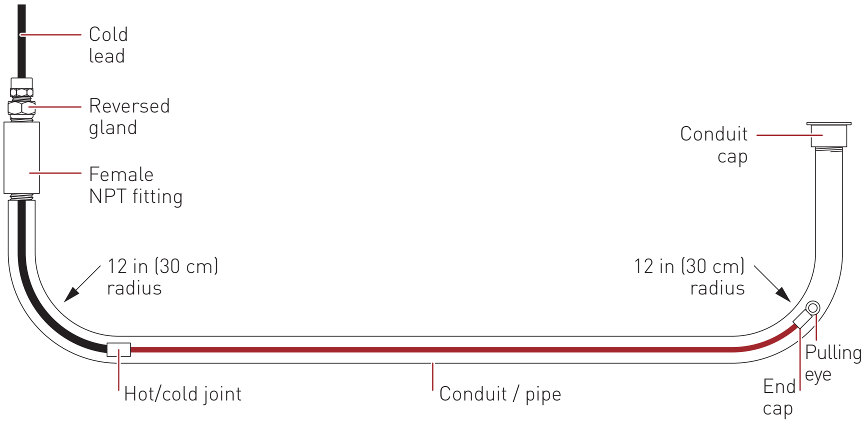


Fig. 13 Installation where conduit ends stub-up

Freezer Frost Heave Prevention System Design Steps (in Conduit)
1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 5 Determine the electrical parameters

5A FOR RAYSOL HEATING CABLE IN CONDUIT

Determine number of circuits

For RaySol, the circuit breaker sizing was determined in Step 4 using Table 5. Record the number and ratings of the circuit breakers to be used on the worksheet.

A 30-mA ground-fault protection device (GFPD) must be used to provide protection from arcing or fire, and to comply with warranty requirements, agency certifications, and national electrical codes. If the heating cable is improperly installed, or physically damaged, sustained arcing or fire could result. If arcing does occur, the fault current may be too low to trip conventional circuit breakers.

> ⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Determine transformer load

The total transformer load is the sum of the loads on all the circuit breakers in the system.

Calculate the Circuit Breaker Load (CBL) as:

$$\text{CBL (kW)} = \frac{\text{Circuit breaker rating (A)} \times 0.8 \times \text{Supply voltage}}{1000}$$

Calculate the Total Transformer Load as follows:

$$\text{Total Transformer Load (kW)} = \text{CBL}_1 + \text{CBL}_2 + \text{CBL}_3 ... + \text{CBL}_N$$

Example: RaySol heating cables in conduit

Circuit breaker size	One 20 A circuit (from Step 4)
Supply voltage	208 V (from Step 1)
Circuit breaker load	(20 A x 0.8 x 208) / 1000 = 3.3 kW
Total transformer load	**3.3 kW**

5B FOR MI HEATING CABLE IN CONDUIT

For MI heating cable, the power output and current draw is shown in Table 3. Heating cables may be individually connected to circuit breakers, but to reduce the number of circuits, cables may be connected in parallel. When connecting heating cables in parallel, total the individual heating cable currents to 80% of the circuit breaker rating.

Determine number of circuits

Refer to Table 3 to determine the Amps for the selected heating cable. Next, calculate the total Amps to determine the circuit breaker requirements, as follows:

Total Amps = Amps per cable x Number of heating cables required

From the Total Amps, determine the most appropriate circuit breaker size and number of circuit breakers.

A 30-mA ground-fault protection device (GFPD) must be used to provide protection from arcing or fire, and to comply with warranty requirements, agency certifications, and national electrical codes. If the heating cable is improperly installed, or physically damaged, sustained arcing or fire could result. If arcing does occur, the fault current may be too low to trip conventional circuit breakers.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Determine transformer load

The total transformer load is the sum of the loads in the system. Calculate the Total Transformer Load as follows:

$$\text{Transformer load (kW)} = \frac{\text{Cable}_1\text{ (W)} + \text{Cable}_2\text{ (W)} + \text{Cable}_3\text{ (W)}\ldots + \text{Cable}_N\text{ (W)}}{1000}$$

Example: MI heating cables in conduit

Amps/cable	2.3 A (from Table 3)
Total Amps	2.3 A x 5 = 11.5 A (5 cables wired in parallel on one circuit)
Circuit breaker size	15 A circuit breaker, 80% loading 12 A
Number of circuit breakers	1

Cable power output	475 W (from Step 2)
Number of cables	5 (from Step 4)
Total Transformer load	**(475 W x 5) / 1000 = 2.4 kW**

Record the number and ratings of the circuit breakers to be used and total transformer load on the worksheet.

Freezer Frost Heave Prevention System Design Steps (in Conduit)
1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 6 Select the connection kits and accessories

For RaySol systems, determine the number of junction boxes, power connections, end seals and splice kits required.

- Hairpin and straight layouts have one junction box per conduit end (see Fig. 9 and Fig. 10).

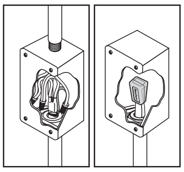
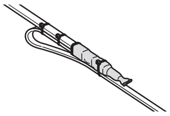
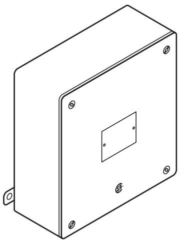
For MI systems, determine the number of junction boxes required.

- Straight run layout has one junction box per conduit run (see Fig. 12 for MI cable).

SELECT JUNCTION BOX

For RaySol and MI cable, use a UL Listed and/or CSA Certified junction box that is suitable for the location. Use a box with minimum internal volume of 16 cubic inches if the box is metallic and 19 cubic inches if the box is not metallic. Metal junction boxes, such as the Raychem D1297TERM4, are recommended for MI cable.

TABLE 7 CONNECTION KITS AND ACCESSORIES

	Catalog number	Description	Standard packaging	Usage
RaySol Connection Kits				
	FTC-XC	Power connection and end seal. (Junction box not included)	1	1 per conduit run
	FTC-HST	Low-profile splice/tee	2	As required (for use inside intermediate pull box or cable tray)
	RayClic-E	Extra end seal	1	Replacement end seal
Accessories				
	D1297TERM4	A cast aluminum junction box (NEMA 3) for installation in nonhazardous and CID2 locations. Three 1/2-in NPT entries on bottom, provided with plugs. Includes 4-pole terminal block (CSA - 600 V, 65 A, 18 - 6 AWG; UL - 300 V, 65 A, 18 - 6 AWG). External mounting feet. CSA approved for Class I, Div. 2, Groups A, B, C, and D. (for MI only) Enclosure dimensions: 6 in x 6 in x 4 in (150 mm x 150 mm x 100 mm).	1	For MI systems only

Example: RaySol heating cables in conduit

Power connection and end seal kit	FTC-XC
Quantity	3
Junction box	Contractor supplied
Quantity	6

Example: MI heating cables in conduit

Junction box	D1297TERM
Quantity	5

Freezer Frost Heave Prevention System Design Steps (in Conduit)

1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 7 Select the control system

The following control systems are suitable for both RaySol and MI heating cable frost heave protection systems. For MI cable, a temperature controller must be used to maintain the subfloor temperature at 40°F (5°C). For RaySol or MI heating cable installations where temperature control and temperature monitoring is desired, a Thermal Management Raychem C910-485 or Raychem ACS-30 controller is recommended.

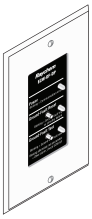
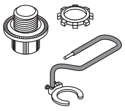
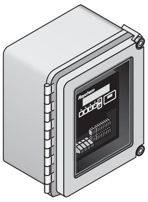
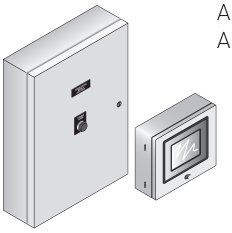
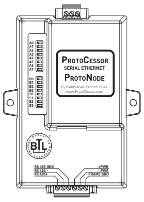
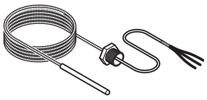
TABLE 8 TEMPERATURE CONTROL OPTIONS

Features	Raychem ECW-GF	Raychem C910-485 [2]	Raychem ACS-30
Number of heating cable circuits	Single	Single	Multiple
Sensor	Thermistor	RTD [1]	See data sheet
Sensor length	25 ft	Varies	"
Set point range	32°F to 200°F (0°C to 93°C)	–0°F to 200°F (–18°C to 93°C)	"
Enclosure	NEMA 4X	NEMA 4X	"
Deadband	2°F to 10°F (2°C to 6°C)	1°F to 10°F (1°C to 6°C)	"
Enclosure limits	–40°F to 140°F (–40°C to 60°C)	–40°F to 140°F (–40°C to 60°C)	"
Switch rating	30 A	30 A	"
Switch type	DPST	DPST	"
Electrical rating	100–277 V	100–277 V	"
Approvals	c-UL-us	c-CSA-us	"
Ground-fault protection	30 mA fixed	20 mA to 100 mA (adjustable)	"
Alarm outputs			
AC relay	2 A at 277 Vac	100–277 V, 0.75 A max.	"
Dry contact relay	2 A at 48 Vdc	48 Vac/dc, 500 mA max.	"

[1] Ordered separately

[2] The C910-485 is available to provide RS-485 communication capability. Connect to the BMS using Raychem ProtoNode multi-protocol gateways

TABLE 9 CONTROL SYSTEMS

	Catalog number	Description
Electronic thermostats and accessories		
	ECW-GF	Electronic ambient sensing controller with 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor and is housed in a Type 4X rated enclosure. The controller features an AC/DC dry alarm contact relay. An optional ground-fault display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	MI-GROUND-KIT	Grounding kit for nonmetallic enclosures (for MI only)
Electronic controllers and sensors		
	C910-485	The Raychem C910-485 is a compact, full featured, microprocessor-based, single-point commercial heating cable controller. The C910-485 provides control and monitoring of electrical heating cable circuits for commercial heating applications, with built-in ground-fault protection. The C910-485 can be set to monitor and alarm for high and low temperature, high and low current, ground-fault level, and voltage. Communications modules are available for remote control and configuration.
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in various commercial applications such as pipe freeze protection, roof and gutter de-icing, surface snow melting, hot water temperature maintenance and floor heating. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electro-mechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers. The ProtoNode-RER is for BACnet® or Metasys® N2 systems.
	RTD-200 RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

Example: RaySol and MI heating cables in conduit

Electronic thermostat	Raychem C910-485
Quantity	1

Freezer Frost Heave Prevention System Design Steps (in Conduit)

1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 8 Select the power distribution

FOR RAYSOL AND MI HEATING CABLE IN CONDUIT

Power to the heating cables can be provided in several ways:

- Directly to the power connection kits (RaySol only)
- Directly through the temperature controller
- Through external contactors or through HTPG power distribution panels

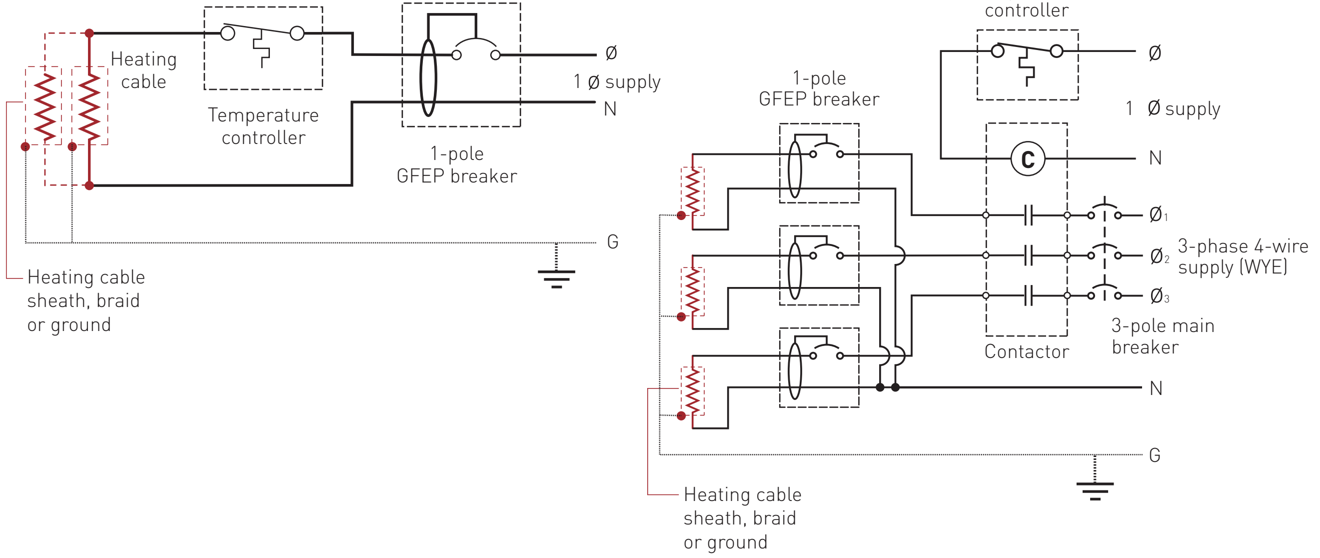
Single circuit control

Heating cable circuits that do not exceed the current rating of the selected controller can be switched directly (Fig. 14). When the total electrical load exceeds the rating of the controller, an external contactor is required.

RaySol systems without temperature control can be connected directly to the power connection kits from the ground-fault circuit breakers in subpanels.

Group control

If the controller will activate multiple circuits (group control) then an external contactor must be used (Fig. 14).



Single circuit control

Group control

Fig. 14 Single circuit and group control

Large systems with many circuits should use an HTPG power distribution panel. The HTPG is a dedicated power-distribution, control, ground-fault protection, monitoring, and alarm panel for freeze protection and broad temperature-maintenance heat-tracing applications. This enclosure contains an assembled circuit-breaker panelboard. Panels are equipped with ground-fault circuit breakers with or without alarm contacts. The group control package allows the system to operate automatically in conjunction with a temperature control system.

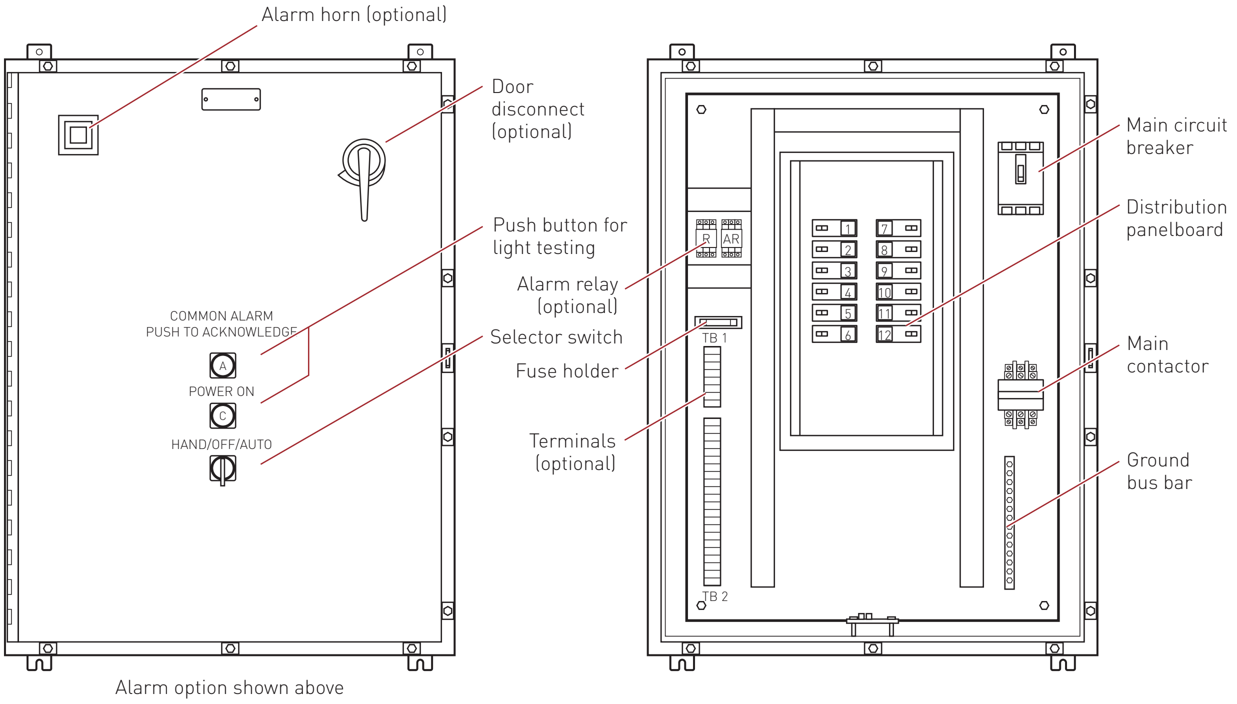


Fig. 15 HTPG power distribution panel

Three-phase, 4 wire supply (Wye)

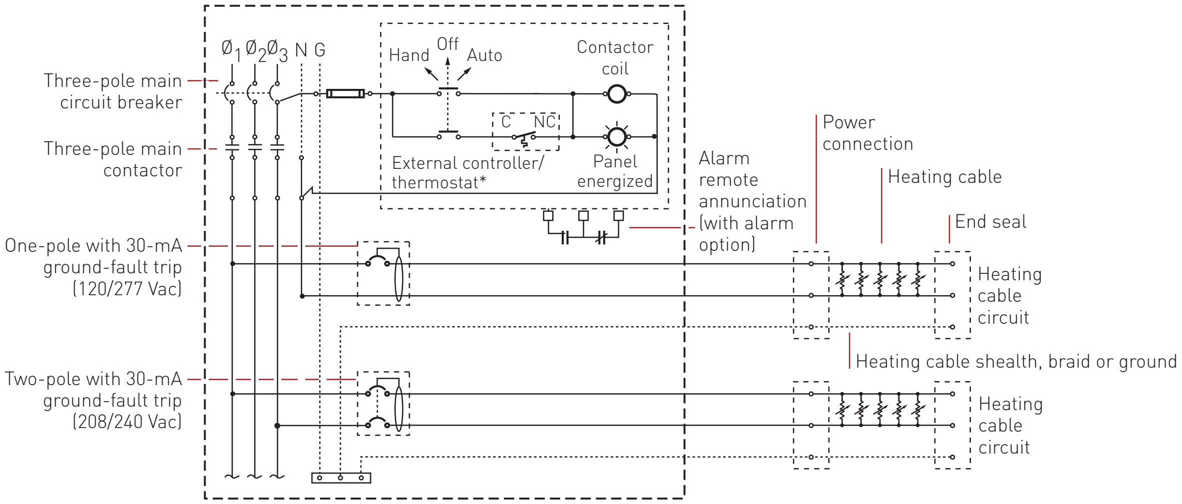
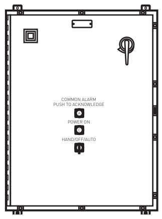


Fig. 16 HTPG power schematic

TABLE 10 POWER DISTRIBUTION

	Catalog number	Description
Power Distribution and Control Panels		
	HTPG	Heat-tracing power distribution panel with ground-fault and monitoring for group control.

Freezer Frost Heave Prevention System Design Steps (in Conduit)
1. Determine the freezer configuration
2. Select the heating cable
3. Determine heating cable conduit spacing and freezer load
4. Determine the heating cable layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 9 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details necessary complete your Bill of Materials.

Design Step by Step MI Heating Cables Directly Embedded

Embedding cables directly in sand (recommended), concrete, or compacted fill subfloors has the advantage of simpler installation and reduced costs. The number of electrical circuits can be minimized considerably compared to a similar installation using conduit. If embedded in a concrete subfloor below the insulation, the cable must not cross any joints in the subfloor.

Follow these steps to design your system:

1 Determine the freezer configuration

2 Determine heat loss and freezer load

3 Select the heating cable, layout and length

4 Determine the heating cable spacing

5 Determine the electrical parameters

6 Select the accessories

7 Select the control system

8 Select the power distribution

9 Complete the Bill of Materials

The "MI Cables Directly Embedded Freezer Frost Heave Prevention Design Worksheet" on page 264 is included to help you document the project parameters that you will need for your project's Bill of Materials.

Freezer Frost Heave Prevention System Design Steps (Embedded)

1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 1 Determine the freezer configuration

GATHERING INFORMATION

The following information is required to complete the freezer frost heave prevention system design.

- Size and layout of freezer or ice arena
- Freezer operating temperature
- Insulation R-value
- Supply voltage and phase
- Control requirements

PREPARE SCALE DRAWING

Draw to scale the floor area to be heated. Carefully note the limits of the area to be heated. Show all concrete joints on the drawing and note the location and size of obstacles, such as floor drains, pipe penetrations, columns, fixtures, and voltage supply location.

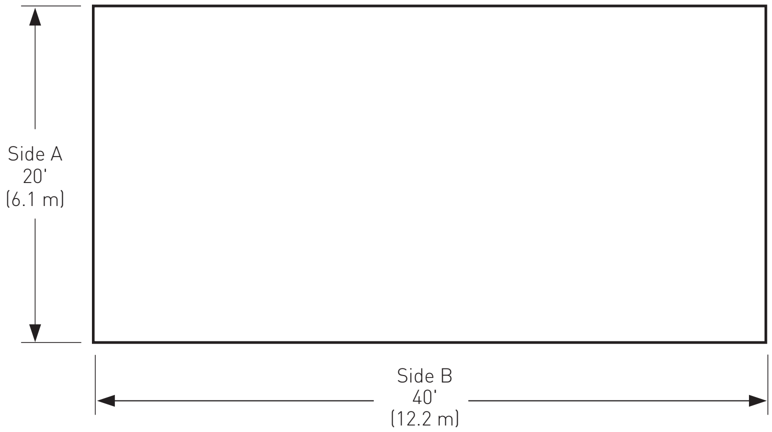


Fig. 17 Typical freezer example – single-phase

DETERMINE FREEZER OPERATING TEMPERATURE

Determine the temperature at which your freezer operates. If it operates at more than one temperature, or if the operating temperature may be changed in the future, base the design on the lowest anticipated operating temperature.

RECORD INSULATION R-VALUE

The insulation R-value is the thermal resistance of the floor's insulation. Normally the R-value will be printed on the insulation material. If that is not the case, you can calculate it by dividing the insulation thickness in inches by the insulation thermal conductivity.

Example: MI heating cables directly embedded – Single-phase

Area	40 ft x 20 ft = 800 ft^2 (12.2 m x 6.1 m = 74 m^2)
Freezer operating temperature	–30°F (–34°C)
Insulation R-value	R-20 (20 ft^2·°F·hr/Btu)
Supply voltage	208 V, single-phase

Example: MI heating cables directly embedded – Three-phase

Area	80 ft x 80 ft = 6400 ft^2 (24.4 m x 24.4 m = 595 m^2)
Freezer operating temperature	–20°F (–29°C)
Insulation R-value	R-20 (20 ft^2·°F·hr/Btu)
Supply voltage	208 V, three-phase

Freezer Frost Heave Prevention System Design Steps (Embedded)

1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 2 Determine heat loss and freezer load

In Table 11, we have calculated the heat loss for directly embedded MI heating cable systems based on the freezer temperatures and the floor insulation R-values; from this table, you will select your design power and freezer load. If your calculated R-value or freezer operating temperature does not match the values in the table, use the values that give the higher design power.

Within each cell, there are two numbers; design power and freezer load. Freezer load is the additional cooling load imposed on the cooling system by the freezer frost heave prevention heating cable. It is the heat transferred through the insulation into the freezer, expressed in W/ft^2 (W/m^2) of floor area.

TABLE 11 MI HEATING CABLE: DESIGN POWER REQUIREMENT AND FREEZER LOAD BASED ON 40°F (5°C) CONTROL

Freezer operating temperature			Floor insulation R-value (ft^2·°F·hr/Btu)			
			R-10	R-20	R-30	R-40
30°F (–1°C)	Design power	W/ft^2 (W/m^2)	0.5 (5.4)	0.2 (2.2)	0.1 (1.1)	0.1 (1.1)
	Freezer load	W/ft^2 (W/m^2)	0.7 (7.5)	0.4 (4.3)	0.3 (3.2)	0.3 (3.2)
20°F (–7°C)	Design power	W/ft^2 (W/m^2)	0.6 (6.5)	0.4 (4.3)	0.2 (2.2)	0.1 (1.1)
	Freezer load	W/ft^2 (W/m^2)	0.8 (8.6)	0.5 (5.4)	0.4 (4.3)	0.3 (3.2)
10°F (–12°C)	Design power	W/ft^2 (W/m^2)	0.9 (9.7)	0.6 (6.5)	0.3 (3.2)	0.2 (2.2)
	Freezer load	W/ft^2 (W/m^2)	1.0 (10.8)	0.6 (6.5)	0.4 (4.3)	0.3 (3.2)
0°F (–18°C)	Design power	W/ft^2 (W/m^2)	1.1 (11.8)	0.7 (7.5)	0.5 (5.4)	0.3 (3.2)
	Freezer load	W/ft^2 (W/m^2)	1.3 (14.0)	0.8 (8.6)	0.5 (5.4)	0.4 (4.3)
–10°F (–23°C)	Design power	W/ft^2 (W/m^2)	1.4 (15.1)	0.8 (8.6)	0.6 (6.5)	0.4 (4.3)
	Freezer load	W/ft^2 (W/m^2)	1.5 (16.1)	0.8 (8.6)	0.6 (6.5)	0.5 (5.4)
–20°F (–29°C)	Design power	W/ft^2 (W/m^2)	1.6 (17.2)	0.9 (9.7)	0.7 (7.5)	0.5 (5.4)
	Freezer load	W/ft^2 (W/m^2)	1.8 (19.4)	1.0 (10.8)	0.7 (7.5)	0.6 (6.5)
–30°F (–34°C)	Design power	W/ft^2 (W/m^2)	1.7 (18.3)	1.1 (11.8)	0.8 (8.6)	0.6 (6.5)
	Freezer load	W/ft^2 (W/m^2)	2.0 (21.5)	1.1 (11.8)	0.8 (8.6)	0.6 (6.5)
–40°F (–40°C)	Design power	W/ft^2 (W/m^2)	2.0 (21.5)	1.2 (12.9)	0.8 (8.6)	0.7 (7.5)
	Freezer load	W/ft^2 (W/m^2)	2.3 (24.7)	1.2 (12.9)	0.8 (8.6)	0.7 (7.5)

Example: MI heating cables directly embedded – Single-phase

Freezer operating temperature	–30°F (–34°C) (from Step 1)
Insulation R-value	R-20 (20 ft^2·°F·hr/Btu) (from Step 1)
Design power	1.1 W/ft^2 (11.8 W/m^2)
Freezer load	1.1 W/ft^2 (11.8 W/m^2)

Example: MI heating cables directly embedded – Three-phase

Freezer operating temperature	–20°F (–29°C) (from Step 1)
Insulation R-value	R-20 (20 ft^2·°F·hr/Btu) (from Step 1)
Design power	0.9 W/ft^2 (9.7 W/m^2)
Freezer load	1.0 W/ft^2 (10.8 W/m^2)

Freezer Frost Heave Prevention System Design Steps (Embedded)
1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 3 Select the heating cable, layout and length

To select the correct MI heating cable for the heated area, you must determine the wattage required for the area or subsection area.

For small freezers, one heating cable may be sufficient. For large freezers, it may be necessary to divide the freezer into two or more equal subsection areas. To balance the load in a three-phase circuit, three cables will be required, or a multiple of three cables when more than one three-phase circuit is required. If the heating cables are to be embedded in a concrete subfloor, divide the area so that the heating cables will not cross any joints in the subfloor.

The heating cables shown in Table 12 are general purpose cables and may be used for a variety of applications depending on the supply voltage; the heating cables in Table 13 have been optimized for frost heave prevention applications. If assistance is required to select heating cables for irregular shaped areas or applications outside the scope of this design guide, contact your Thermal Management representative for assistance in designing a custom heating cable.

SINGLE-PHASE SUPPLY

Small freezer areas require only one heating cable. Large freezer areas may require two or more heating cables.

- Divide large freezer areas into equal subsection areas, if possible.
- Calculate the power required for the total area (small freezers) or for each subsection area (large freezers) by multiplying the design power (from Table 11) by the total area or subsection area.

Power required = Design power x Total area (or Subsection area)

Simply select the heating cable from Table 12 or Table 13 based on the total area or subsection area. Under the appropriate voltage, make sure that the total area or subsection area falls within the minimum and maximum range of the "Area coverage" columns and verify that the "Cable wattage" shown directly across from the "Area coverage" is equal to or higher than the calculated "Power required" for the total area or subsection area (see example following).

Note: If two or more cables in the Tables meet the requirements, use the cable with the lower wattage.

In cases where the freezer area has been divided into equal subsections, select the appropriate number of heating cables. Where heating cables are directly embedded in concrete subfloors, calculate the wattage required for each area bounded by joints in the subfloor and select an appropriate cable for each area.

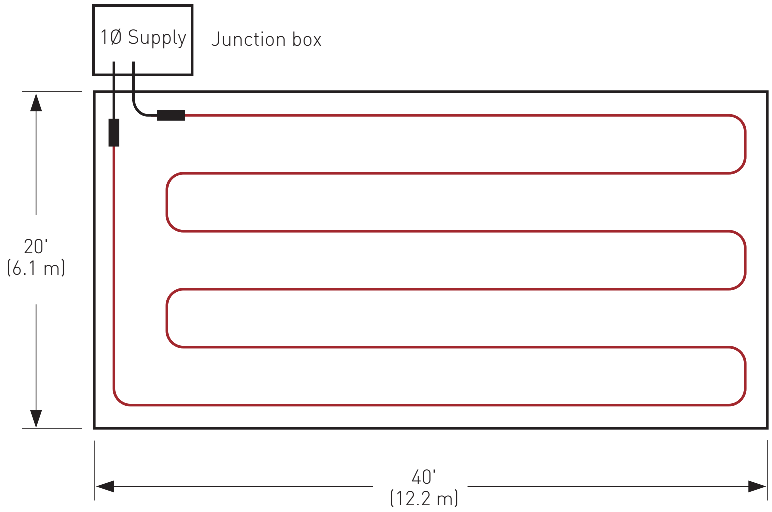


Fig. 18 Single-phase layout

Example: MI heating cables directly embedded – Single-phase

Area	800 ft² (74 m²) (See Fig. 18)
Design power	1.1 W/ft² (11.8 W/m²) (from Step 2)
Power required	Design power x Area = 1.1 W/ft² x 800 ft² = 880 W (11.8 W/m² x 74 m² = 880 W)
Supply voltage	208 V, single-phase (from Step 1)
Catalog number	**SUB19**
Cable wattage	885 W
Heated length	245 ft (74.7 m)
Quantity	1

THREE-PHASE SUPPLY

Designing the frost heave prevention system using a three-phase voltage supply has the added advantages of fewer circuits, reduced distribution costs, and a balanced heating system load and is recommended for large freezers.

Three-phase voltages include 208/120 V, 480/277 V, and 600/347 V. When selecting heating cables for three-phase voltages, cable layout will be easier if the heating cables are wye connected (Fig. 19); therefore select the cables based on the phase-to-neutral voltage (e.g., select 277 V cables for a 480 V supply).

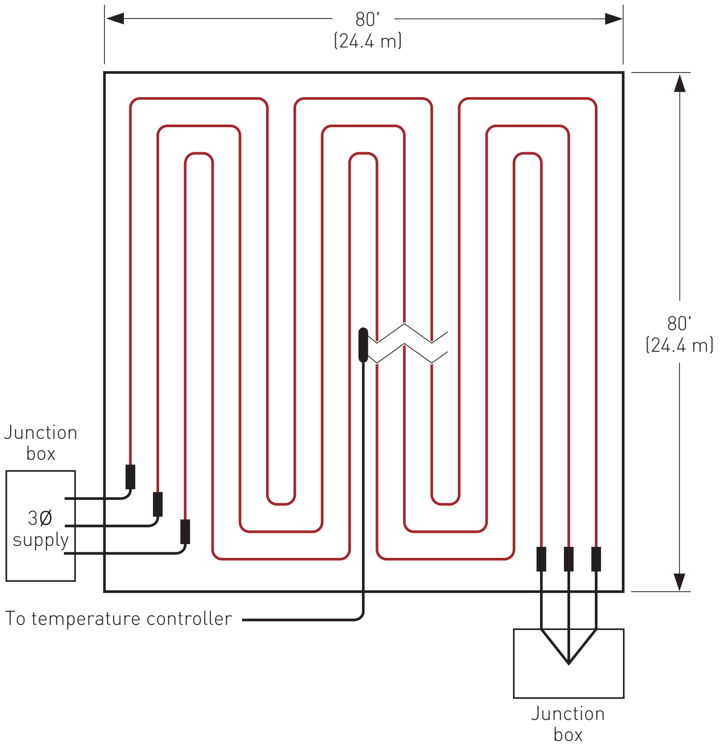


Fig. 19 Three-phase wye connected heating cable layout

Since a balanced three-phase system requires three cables, each cable will occupy 1/3 of the freezer area when installed.

- Calculate the "Power required" by multiplying the design power from Table 11 by the total freezer area.
- Divide the total freezer area by three to determine the "Area coverage for each cable."
- Calculate the "Wattage for each cable" by dividing the "Power required" by three.

Wattage for each cable = (Design power x Total freezer area) / 3

Simply select the heating cable from Table 12 on page 248 or Table 13 on page 249 based on the area coverage for each cable. Under the appropriate voltage, make sure that the area coverage for each cable falls within the minimum and maximum range of the "Area coverage" columns and verify that the "Cable wattage" shown directly across from the "Area coverage" is equal to or higher than the calculated "Wattage for each cable" (see example following). Three of the same cables are required for balanced three-phase systems.

Note: If two or more cables in the Tables meet the requirements, use the cable with the lower wattage.

Note: For very large freezers, it may be necessary to divide the freezer into subsections and use two or more three-phase circuits.

Example: MI heating cables directly embedded – Three-phase

Area	6400 ft^2 (595 m^2) (see Fig. 19)
Design power	0.9 W/ft^2 (9.7 W/m^2) (from Step 2)
Power required	(Design Power x Area) = (0.9 W/ft^2 x 6400 ft^2) = 5760 W (9.7 W/m^2 x 595 m^2) = 5760 W
Area coverage for each cable	Area/3 = 6400 ft^2/3 = 2133 ft^2 (595 m^2/3 = 198.3 m^2)
Wattage for each cable	Power required/3 = 5760/3 = 1920 W
Supply voltage	208 V, three-phase (from Step 1) (select 120 volt cable for wye connection)
Catalog number	**SUB8**
Cable wattage	2300 W
Cable voltage	120 V
Heated length	550 ft (167.6 m)
Quantity	3

TABLE 12 SELECTION TABLE FOR MI HEATING CABLES FOR DIRECTLY EMBEDDED CABLES

Catalog number	Area coverage				Cable wattage (W)	Heated length [1]		Heating cable current (A)[2]
	Min (ft^2)	Max (ft^2)	Min (m^2)	Max (m^2)		(ft)	(m)	
120 V and 208 V, three-phase wye								
SUA3	205	700	19.1	65.1	500	140	42.7	4.2
SUA4	220	340	20.4	31.6	550	68	20.7	4.6
SUA7	300	480	27.9	44.6	750	95	29.0	6.3
SUA8	310	885	28.8	82.2	800	177	53.9	6.7
SUB1	420	660	39.0	61.3	1000	132	40.2	8.3
SUB2	400	1200	37.2	111.5	1000	240	73.1	8.3
SUB3	520	1400	48.3	130.1	1300	280	85.3	10.8
SUB4	600	1600	55.8	148.7	1500	320	97.5	12.5
SUB5	750	1300	69.7	120.8	1800	260	79.2	15.0
SUB6	780	1875	72.5	174.3	1900	375	114.3	15.8
SUB7	940	1550	87.4	144.1	2300	310	94.5	19.2
SUB8	930	2750	86.4	255.6	2300	550	167.6	19.2
SUB9	1250	3150	116.2	292.8	3000	630	192.0	25.0
SUB10	1700	3585	158.0	333.2	4300	717	218.5	35.8
208 V								
SUA1	260	540	24.2	50.2	650	108	32.9	3.1
SUA6	650	1320	60.4	122.7	1560	264	80.5	7.5
SUB19	350	1225	32.5	113.8	885	245	74.7	4.3
SUB20	480	1700	44.6	158.0	1210	340	103.6	5.8
SUB21	650	2200	60.4	204.5	1640	440	134.1	7.9
SUB22	820	2625	76.2	244.0	2060	525	160.0	9.9
240 V								
SUB19	350	1225	32.5	113.8	1175	245	74.7	4.9
SUB20	480	1700	44.6	158.0	1615	340	103.6	6.7
SUB21	650	2200	60.4	204.5	2180	440	134.1	9.1
SUB22	820	2625	76.2	244.0	2745	525	160.0	11.4
277 V and 480 V, three-phase wye								
SUB19	400	1225	37.2	113.8	1565	245	74.7	5.6
SUB20	550	1700	51.1	158.0	2150	340	103.6	7.8
SUB21	720	2200	66.9	204.5	2900	440	134.1	10.5
SUB22	940	2625	87.4	244.0	3650	525	160.0	13.2
347 V and 600 V, three-phase wye								
SUB11	540	1125	50.2	104.6	1400	225	68.6	4.0
SUB12	770	1550	71.6	144.1	1950	310	94.5	5.6
SUB13	1060	2140	98.5	198.9	2700	428	130.5	7.8
SUB14	1440	2740	133.8	254.6	3700	548	167.0	10.7

[1] Tolerance on heating cable length is –0% to +3%

[2] Single-phase current shown

Note: Type SUA cables supplied with 7 ft (2.1 m) long cold lead; type SUB cables supplied with 15 ft (4.6 m) long cold leads.

TABLE 13 SELECTION TABLE FOR MI HEATING CABLES FOR DIRECTLY EMBEDDED CABLES

Catalog number	Area coverage				Cable wattage (W)	Heated length [1]		Heating cable current (A)[2]
	Min (ft²)	Max (ft²)	Min (m²)	Max (m²)		(ft)	(m)	
120 V and 208 V, three-phase Wye								
FFHP1	163	290	15.1	27.0	405	58	17.7	3.4
FFHP2	205	360	19.1	33.5	510	72	22.0	4.3
FFHP3	231	415	21.5	38.6	580	83	25.3	4.8
FFHP4	282	510	26.2	47.4	705	102	31.1	5.9
FFHP5	328	585	30.5	54.4	820	117	35.7	6.8
FFHP6	392	700	36.4	65.1	980	140	42.7	8.2
FFHP7	450	800	41.8	74.3	1125	160	48.8	9.4
FFHP8	519	925	48.2	86.0	1300	185	56.4	10.8
FFHP9	637	1130	59.2	105.0	1590	226	68.9	13.3
FFHP10	733	1310	68.1	121.7	1830	262	79.9	15.3
FFHP11	900	1600	83.6	148.7	2250	320	97.6	18.8
FFHP12	1186	2130	110.2	198.0	2965	426	129.9	24.7
FFHP13	1470	2640	136.6	245.4	3675	528	161.0	30.6
FFHP14	1862	3320	173.0	308.6	4650	664	202.4	38.8
208 V								
FFHP15	281	505	26.1	46.9	700	101	30.8	3.4
FFHP16	352	630	32.7	58.6	880	126	38.4	4.2
FFHP17	401	720	37.2	66.9	1000	144	43.9	4.8
FFHP18	492	880	45.7	81.8	1230	176	53.7	5.9
FFHP19	568	1015	52.8	94.3	1420	203	61.9	6.8
FFHP20	678	1215	63.0	112.9	1700	243	74.1	8.2
FFHP21	778	1390	72.3	129.2	1945	278	84.8	9.4
FFHP22	901	1600	83.8	148.7	2250	320	97.6	10.8
FFHP23	1098	1970	102.1	183.1	2745	394	120.1	13.2
FFHP24	1268	2275	117.8	211.4	3170	455	138.7	15.2
FFHP25	1553	2785	144.4	258.8	3885	557	169.8	18.7
240 V								
FFHP26	326	580	30.3	53.9	815	116	35.4	3.4
FFHP27	407	725	37.9	67.4	1020	145	44.2	4.3
FFHP28	463	830	43.0	77.1	1160	166	50.6	4.8
FFHP29	567	1015	52.7	94.3	1420	203	61.9	5.9
FFHP30	656	1170	61.0	108.7	1640	234	71.3	6.8
FFHP31	786	1395	73.1	129.6	1965	279	85.1	8.2
FFHP32	900	1600	83.6	148.7	2250	320	97.6	9.4
FFHP33	1038	1850	96.5	171.9	2600	370	112.8	10.8
FFHP34	1274	2260	118.4	210.0	3185	452	137.8	13.3
FFHP35	1471	2610	136.7	242.6	3680	522	159.1	15.3
FFHP36	1800	3200	167.3	297.4	4500	640	195.1	18.8

[1] Tolerance on heating cable length is –0% to +3%.

[2] Single-phase current shown

Note: Type FFHP cables supplied with 15 ft (4.6 m) long cold leads.

TABLE 13 SELECTION TABLE FOR MI HEATING CABLES FOR DIRECTLY EMBEDDED CABLES

Catalog number	Area coverage				Cable wattage (W)	Heated length[1]		Heating cable current (A)[2]
	Min (ft^2)	Max (ft^2)	Min (m^2)	Max (m^2)		(ft)	(m)	
277 V and 480 V, three-phase wye								
FFHP37	375	670	34.9	62.3	940	134	40.9	3.4
FFHP38	468	840	43.5	78.1	1170	168	51.2	4.2
FFHP39	536	955	49.8	88.8	1340	191	58.2	4.8
FFHP40	656	1170	60.9	108.7	1640	234	71.3	5.9
FFHP41	758	1350	70.4	125.5	1895	270	82.3	6.8
FFHP42	908	1610	84.4	149.6	2270	322	98.2	8.2
FFHP43	1037	1850	96.4	171.9	2590	370	112.8	9.4
FFHP44	1201	2130	111.6	198.0	3000	426	129.9	10.8
FFHP45	1462	2625	135.8	244.0	3655	525	160.1	13.2
FFHP46	1697	3015	157.7	280.2	4240	603	183.8	15.3
FFHP47	2074	3700	192.7	343.9	5185	740	225.6	18.7
347 V and 600 V, three-phase wye								
FFHP48	470	840	43.7	78.1	1175	168	51.2	3.4
FFHP49	588	1050	54.7	97.6	1470	210	64.0	4.2
FFHP50	672	1195	62.4	111.1	1680	239	72.9	4.8
FFHP51	819	1470	76.1	136.6	2050	294	89.6	5.9
FFHP52	950	1690	88.3	157.1	2375	338	103.0	6.8
FFHP53	1133	2025	105.3	188.2	2830	405	123.5	8.2
FFHP54	1295	2325	120.3	216.1	3240	465	141.8	9.3
FFHP55	1500	2675	139.4	248.6	3750	535	163.1	10.8
FFHP56	1838	3275	170.8	304.4	4600	655	199.7	13.3
FFHP57	2126	3775	197.6	350.8	5315	755	230.2	15.3

[1] Tolerance on heating cable length is –0% to +3%.

[2] Single-phase current shown

Note: Type FFHP cables supplied with 15 ft (4.6 m) long cold leads.

Freezer Frost Heave Prevention System Design Steps (Embedded)

1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 4 Determine the heating cable spacing

To determine the spacing between runs of heating cables, use the formula below:

$$\text{Cable spacing (in)} = \frac{\text{Area (ft}^2\text{) x 12 in}}{\text{Heated length (ft)}}$$

$$\text{Cable spacing (cm)} = \frac{\text{Area (m}^2\text{) x 100 cm}}{\text{Heated length (m)}}$$

Note: If a large area has been divided into subsections or if a three-phase voltage supply is used, the "Area" in the above equations will be the subsection area or area coverage for each cable and the "Heated length" will be the length of the selected cable.

Example: MI heating cables directly embedded – Single-phase

Area	800 ft^2 (74 m^2) (from Step 3)
Catalog number	SUB19 (from Step 3)
Heated length	245 ft (74.7 m) (from Step 3)
Cable spacing	800 ft^2 x 12 / 245 ft = 39.2 in **rounded to 39 in** 74 m^2 x 100 / 74.7 m = 99.1 cm **rounded to 99 cm**

Example: MI heating cables directly embedded – Three-phase

Area coverage for each cable	2133 ft^2 (198.3 m^2) (from Step 3)
Catalog number	SUB8 (from Step 3)
Heated length	550 ft (167.6 m) (from Step 3)
Cable spacing	2133 ft^2 x 12 / 550 ft = 46.5 in **rounded to 47 in** 198.3 m^2 x 100 / 167.6 m = 118.3 cm **rounded to 118 cm**

Freezer Frost Heave Prevention System Design Steps (Embedded)

1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 5 Determine the electrical parameters

DETERMINE NUMBER OF CIRCUITS

For single-phase circuits, when connecting individual heating cables to circuit breakers, the cable current draw must not exceed 80% of the circuit breaker rating. To reduce the number of circuits, multiple heating cables may be connected in parallel. When multiple cables are connected in parallel, the total of the individual heating cable currents must not exceed 80% of the circuit breaker rating. The single-phase heating cable current is shown in Table 12 and Table 13.

For three-phase circuits used in frost heave protection systems, the three heating cables are generally connected in the wye configuration shown in Fig. 21 on page 256. For a wye connected three-phase circuit, the current draw is the same as the single-phase heating cable current and must not exceed 80% of the 3-pole circuit breaker rating.

A 30-mA ground-fault protection device (GFPD) must be used to provide protection from arcing or fire, and to comply with warranty requirements, agency certifications, and national electrical codes. If the heating cable is improperly installed, or physically damaged, sustained arcing or fire could result. If arcing does occur, the fault current may be too low to trip conventional circuit breakers.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

SELECT BRANCH CIRCUIT BREAKER SIZE

Record the number and ratings of the circuit breakers to be used. Use ground-fault protection devices (GFPDs) for all applications. For three-phase circuits, ground fault may be accomplished using a shunt trip 3-pole breaker and a ground fault sensor.

DETERMINE TRANSFORMER LOAD

The total transformer load is the sum of the wattages of the selected heating cables.
Calculate the Total Transformer Load as follows:

$$\text{Transformer load (kW)} = \frac{\text{Cable}_1\text{ (W)} + \text{Cable}_2\text{ (W)} + \text{Cable}_3\text{ (W)}\ldots + \text{Cable}_N\text{ (W)}}{1000}$$

Example: MI heating cables directly embedded – Single-phase

Amps	4.3 A (from Table 12)
Circuit breaker size	15 A breaker, 80% loading 12 A
Number of circuit breakers	1
Cable power output	885 W (from Step 3)
Number of cables	1 (from Step 3)
Transformer load	**885 W / 1000 = 0.9 kW**

Example: MI heating cables directly embedded – Three-phase

Amps/cable	19.2 A (from Table 12)
Circuit breaker size	25 A, 3-pole breaker, 80% loading 20 A
Number of circuit breakers	1 (3 cables wye connected – see Fig. 21)
Cable power output	2300 W (from Step 3)
Number of cables	3 (from Step 3)
Total Transformer load	**(2300 W x 3) / 1000 = 6.9 kW**

Record the number and ratings of the circuit breakers to be used and total transformer load on the worksheet.

Freezer Frost Heave Prevention System Design Steps (Embedded)

1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 6 Select the accessories

For your embedded system, determine the number of junction boxes required.

SELECT JUNCTION BOX

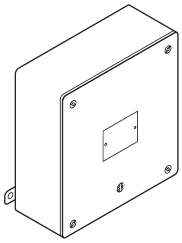
Select a UL Listed and/or CSA Certified junction box that is suitable for the location, such as the Raychem D1297TERM4. Use a box with minimum internal volume of 16 cubic inches if the box is metallic and 19 cubic inches if the box is not metallic. Metal junction boxes are recommended.

Note: The junction box must be accessible according to the national electrical codes.

After determining the number of heating cables required, the number of circuits, and the junction box locations, do a trial layout. In making the trial layout, follow these recommendations:

- Install the heating cables in a sand layer beneath the insulation.
- Maintain the design spacing within 4 in (10 cm).
- When directly embedded in the concrete floor, do not cross expansion joints in the floor.
- Do not route the cables closer than 4 in (10 cm) to the edge of the subfloor, drains, anchors, or other material.

TABLE 14 ACCESSORIES

	Catalog number	Description	Standard packaging	Usage
	D1297TERM4	A cast aluminum junction box (Type 3) for installation in nonhazardous and CID2 locations. Three 1/2-in NPT entries on bottom, provided with plugs. Includes 4-pole terminal block (CSA - 600 V, 65 A, 18 - 6 AWG; UL - 300 V, 65 A, 18 - 6 AWG). External mounting feet. CSA approved for Class I, Div. 2, Groups A, B, C, and D. (for MI only) Enclosure dimensions: 6 in x 6 in x 4 in (150 mm x 150 mm x 100 mm).	1	For MI cable only

Example: MI heating cables directly embedded – Single-phase

Junction box	D1297TERM4
Quantity required	1

Example: MI heating cables directly embedded – Three-phase

Junction box	Contractor supplied
Quantity required	2

Freezer Frost Heave Prevention System Design Steps (Embedded)
1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 7 Select the control system

For MI cable, a temperature controller must be used to maintain the subfloor temperature at 40°F (4°C). For installations where temperature control and temperature monitoring is desired, a Thermal Management Raychem C910-485 or Raychem ACS-30 controller is recommended. For additional information on temperature controller options, refer to Table 8 on page 235.

TABLE 15 CONTROL SYSTEMS

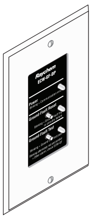
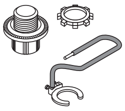
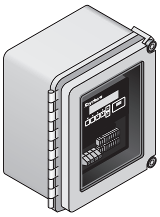
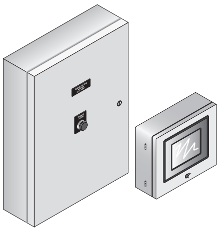
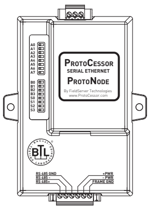
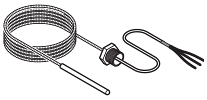
	Catalog number	Description
Electronic thermostats and accessories		
	ECW-GF	Electronic ambient sensing controller with 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor and is housed in a Type 4X rated enclosure. The controller features an AC/DC dry alarm contact relay. An optional ground-fault display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) that can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	MI-GROUND-KIT	Grounding kit for nonmetallic enclosures (for MI only)
Electronic controllers and sensors		
	C910-485	The Raychem C910-485 is a compact, full featured, microprocessor-based, single-point commercial heating cable controller. The C910-485 provides control and monitoring of electrical heating cable circuits for commercial heating applications, with built-in ground-fault protection. The C910-485 can be set to monitor and alarm for high and low temperature, high and low current, ground-fault level, and voltage. Communications modules are available for remote control and configuration.

TABLE 15 CONTROL SYSTEMS

	Catalog number	Description
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in various commercial applications such as pipe freeze protection, roof and gutter de-icing, surface snow melting, hot water temperature maintenance and floor heating. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers. The ProtoNode-RER is for BACnet® or Metasys® N2 systems.
	RTD-200 RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

Example: MI heating cables directly embedded – Single-phase

Single circuit, electronic controller	Raychem C910-485
Quantity	1

Example: MI heating cables directly embedded – Three-phase

Single circuit, monitoring requested	Raychem ACS-30*
Quantity	1

*Use ACS-30 General part number (P000001232) for custom three-phase panels. Please contact your Thermal Management representative for a custom ACS-PCM2-5 panel quotation.

Freezer Frost Heave Prevention System Design Steps (Embedded)
1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 8 Select the power distribution

Power to the heating cables can be provided in three ways:

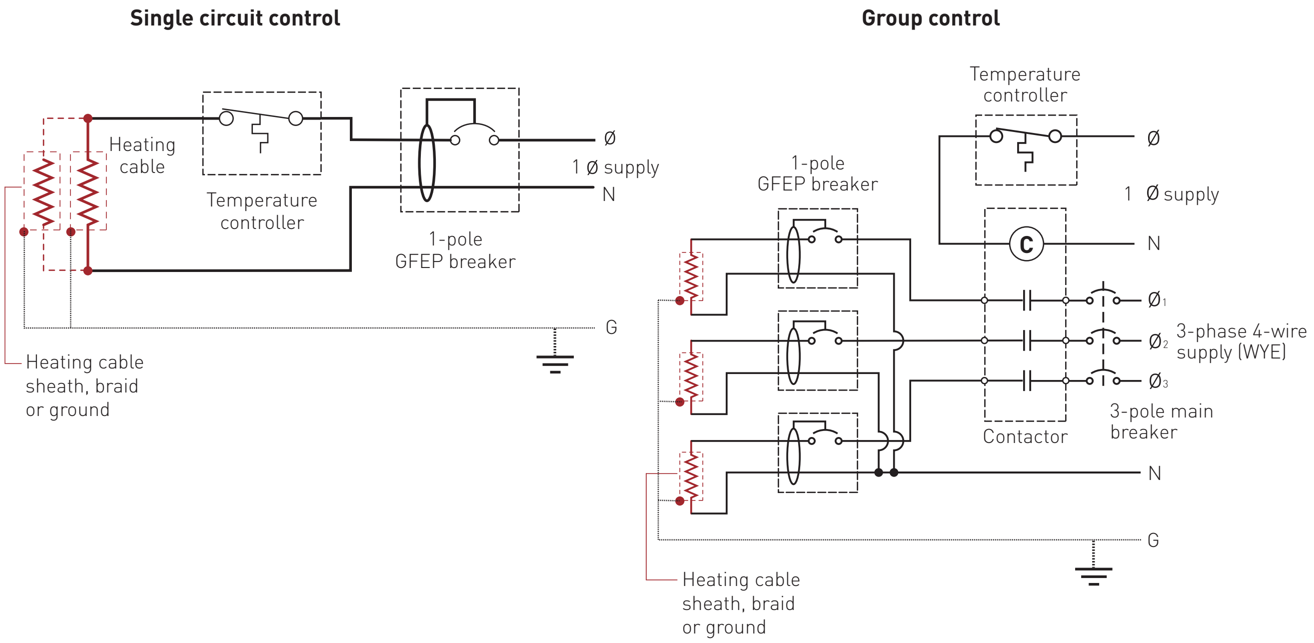
1. Directly through the temperature controller
2. Through external contactors activated by a temperature controller
3. Through an HTPG power distribution panel

SINGLE CIRCUIT CONTROL

Heating cable circuits that do not exceed the current rating of the selected controller can be switched directly (Fig. 20). When the total electrical load exceeds the rating of the controller or if a single-pole temperature controller is used to control a three-phase circuit (Fig. 21), an external contactor is required.

GROUP CONTROL

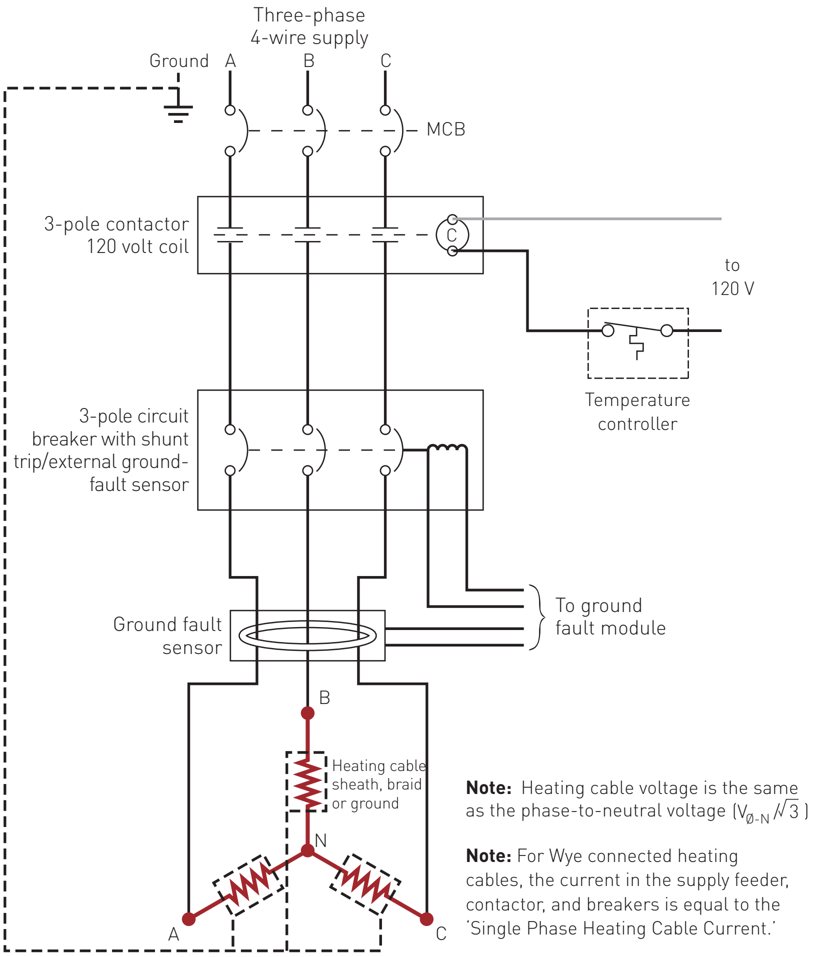
If the temperature controller will activate multiple single-phase or three-phase circuits (group control), then an external contactor must be used. In Fig. 20, three single-phase circuits are activated by a temperature controller through an external contactor.



Single circuit control

Group control

Fig. 20 Single circuit and group control



Note: Heating cable voltage is the same as the phase-to-neutral voltage ($V_{Ø\text{-}N}/\sqrt{3}$)

Note: For Wye connected heating cables, the current in the supply feeder, contactor, and breakers is equal to the 'Single Phase Heating Cable Current.'

Fig. 21 Typical three-phase wye connected cables with temperature controller and contactor

Large systems with many circuits should use an HTPG power distribution panel. The HTPG is a dedicated power-distribution, control, ground-fault protection, monitoring, and alarm panel for freeze protection and broad temperature-maintenance heat-tracing applications. This enclosure contains an assembled circuit-breaker panelboard. Panels are equipped with ground-fault circuit breakers with or without alarm contacts. The group control package allows the system to operate automatically in conjunction with a temperature control system.

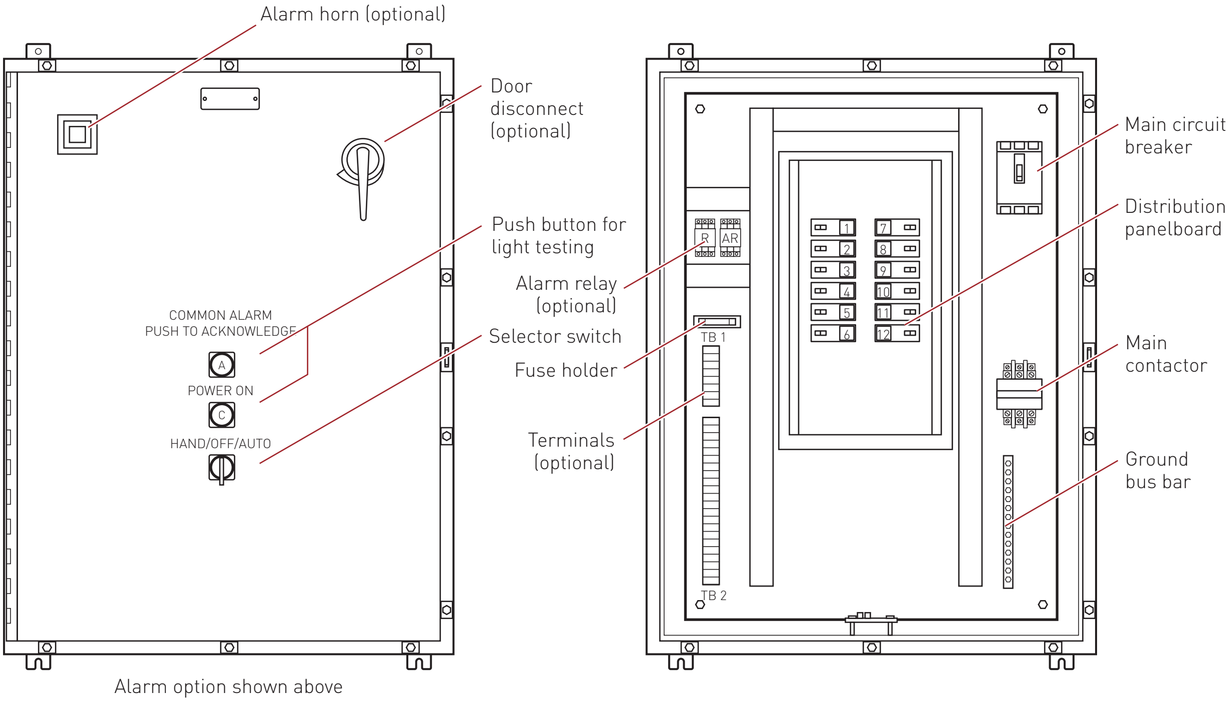


Fig. 22 HTPG power distribution panel

Three-phase, 4 wire supply (Wye)

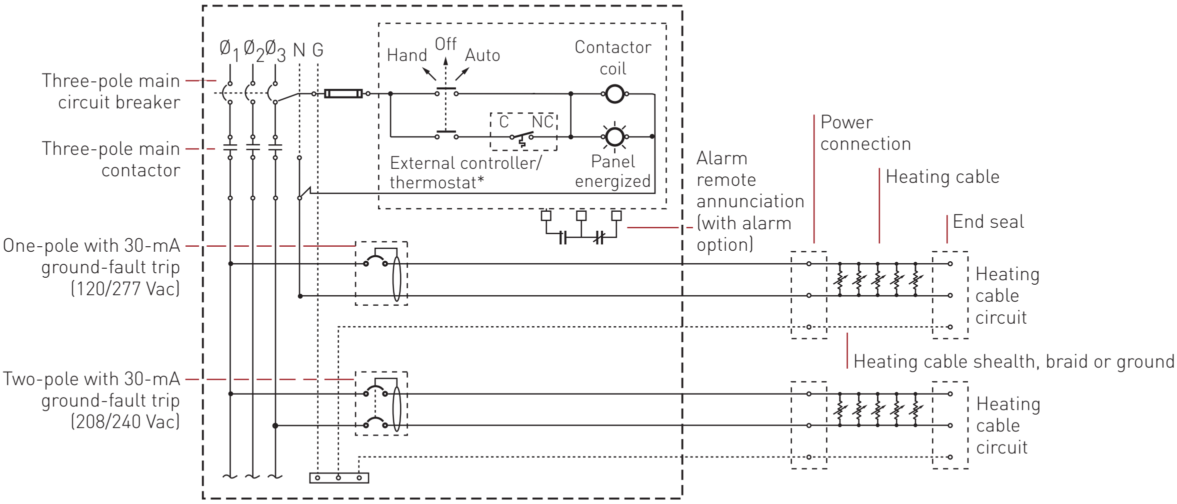
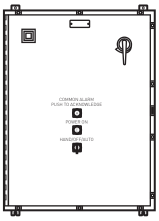


Fig. 23 Typical HTPG power schematic

TABLE 16 POWER DISTRIBUTION

	Catalog number	Description
Power distribution and control panels		
	HTPG	Heat-tracing power distribution panel with ground-fault and monitoring for group control.

Freezer Frost Heave Prevention System Design Steps (Embedded)
1. Determine the freezer configuration
2. Determine heat loss and freezer load
3. Select the heating cable, layout and length
4. Determine the heating cable spacing
5. Determine the electrical parameters
6. Select the accessories
7. Select the control system
8. Select the power distribution system
9. Complete the Bill of Materials

Step 9 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details necessary complete your Bill of Materials.

RAYSOL AND MI HEATING CABLE IN CONDUIT FREEZER FROST HEAVE PREVENTION DESIGN WORKSHEET

Step 1 Determine the freezer configuration (RaySol and MI heating cable systems)

Determine freezer area (from scale drawing)	Determine freezer operating temperature	Record insulation R-value	Supply voltage
________ x ________ = ________ Side A (length) (ft/m) x Side B (width) (ft/m) = **Freezer area (ft²/m²)**	____________°F/°C	____________ ft²·°F·hr/Btu	____________ Volts

Example: RaySol and MI heating cables

80 ft x **40 ft** = **3200 ft²** Side A (length) (ft) x Side B (width) (ft) = **Freezer area (ft²)**	**–20°F**	**R-40 (40 ft²·°F·hr/Btu)**	**208 Volts**

Step 2 Select the heating cable

RaySol heating cable

Supply voltage

- ☐ 120 V
- ☐ 208 V
- ☐ 240 V
- ☐ 277 V

Catalog number: ____________________

MI heating cable

Supply voltage

- ☐ 120 V
- ☐ 208 V
- ☐ 277 V

Freezer side A length (ft/m): ____________________

Catalog number: ____________________

Power output (W): ____________________

Example: RaySol heating cable

Supply voltage

✓ **208 V**

Catalog number: **RaySol-2**

Supply voltage

✓ **208 V**

Freezer side A length: **80 ft**

Catalog number: **FFHPC30**

Power output: **475 W**

Step 3 Determine the heating cable conduit spacing and freezer load (RaySol and MI heating cable systems)

Based on the insulation R-value and freezer operating temperature you recorded in Step 1, use Table 4 to select the following:

Conduit spacing (in/cm) ____________________

Freezer load (W/ft²) (W/m²) ____________________

Example: For RaySol and MI heating cables

Conduit spacing: **96 in**

Freezer load: **0.5 W/ft²**

Step 4 Determine the heating cable layout and length

RaySol heating cable in conduit

1. Estimate the number of conduit runs

Imperial

(________ x 12) / ________ = ________
Side B (ft) — Conduit spacing (in) — **Estimated number of conduit runs**

Metric

(________ x 100) / ________ = ________
Side B (m) — Conduit spacing (cm) — **Estimated number of conduit runs**

If necessary, round to the next whole number

Example: RaySol heating cable

(**40 ft** x 12) / **96 in** = **5**
Side B (ft) — Conduit spacing (in) — **Estimated number of conduit runs**

2. Estimate the heating cable length required for conduit runs

________ x ________ = ________
Side A (ft/m) — Number of conduit runs — **Heating cable length required (ft/m)**

Example: RaySol heating cable

80 ft x **5** = **400 ft**
Side A (ft) — Number of conduit runs — **Heating cable length required (ft)**

3. Determine the maximum circuit length (see Table 5)

________ ________ → ________
Heating cable length required (ft/m) — Supply voltage (V) — **Maximum circuit length (ft/m)**

Is the heating cable length required > the maximum circuit length?

☐ No – One circuit is sufficient
☐ Yes – Multiple circuits are required

________ ________
Number of circuits — Power supply

Example: RaySol heating cable

400 ft **208 V** → **410 ft**
Heating cable length required (ft) — Supply voltage (V) — **Maximum circuit length (ft)**

Is the heating cable length required > the maximum circuit length?

✔ No – One circuit is sufficient

1 **One 20 A circuit breaker**
Number of circuits — Power supply

4. Determine layout

Is Side A x 2 ⩽ to the maximum circuit length?

☐ Yes – Conduit can be looped in hairpin configuration
  ☐ Odd number of conduit runs – One conduit run will be straight
  ☐ Even number of conduit runs – All conduit run are looped in hairpin configuration
☐ No – Use a straight run layout

Example: RaySol heating cable

Is Side A x 2 ⩽ to the maximum circuit length?

✔ Yes – Conduit can be looped in hairpin configuration
✔ Odd number of conduit runs – One conduit run will be straight

Layout: Run in two hairpin loops and one straight run

MI heating cable in conduit

1. Estimate the number of conduit runs

Imperial

(________ x 12) / ________ = ________
Side B (ft) — Conduit spacing (in) — **Estimated number of conduit runs**

Metric

(________ x 100) / ________ = ________
Side B (m) — Conduit spacing (cm) — **Estimated number of conduit runs**

If necessary, round to the next whole number

Example: MI heating cable

(**40 ft** x 12) / **96 in** = **5**
Side B (ft) — Conduit spacing (in) — **Estimated number of conduit runs**

2. Determine the number of MI heating cables

________ = ________
Number of conduit runs — Number of heating cables required

Example: MI heating cable

5 = **5**
Number of conduit runs — Number of heating cables required

Step 4 Determine the heating cable layout and length

5. Determine end allowances and kit connection kit allowances (see Table 6) and total heating cable length required.

Determine end allowances

__________ x 8 ft = ______
Number of
hairpin conduits

__________ x 8 ft = ______
Number of straight
run conduits

Heating cable length for end allowances__________

Example: RaySol heating cable

2 x 8 ft = **16 ft**
Number of
hairpin conduits

1 x 8 ft = **8 ft**
Number of straight
run conduits

Heating cable length for end allowances **24 ft**

Determine connection kit allowances

__________ x 4 ft = ______
Number of FTC-XC
kits for hairpin conduits

__________ x 4 ft = ______
Number of FTC-XC
kits for straight run conduits

Heating cable length for connection kit allowances__________

Example: RaySol heating cable

2 x 4 ft = **8 ft**
Number of FTC-XC
kits for hairpin conduits

1 x 4 ft = **4 ft**
Number of FTC-XC
kits for straight run conduits

Heating cable length for connection kit allowances **12 ft**

Determine total heating cable length required for conduit runs and allowances

______ + ______ + ______ = ______
Heating cable length for conduit runs (ft/m) + Heating cable length for end allowances (ft/m) + Heating cable length for connection kit allowances (ft/m) = **Total heating cable length required (ft/m)**

Example: RaySol heating cable

400 ft + **24 ft** + **12 ft** = **436 ft**
Heating cable length for conduit runs (ft) + Heating cable length for end allowances (ft) + Heating cable length for connection kit allowances (ft) = **Total heating cable length required (ft)**

Step 5 Determine the electrical parameters

RaySol heating cable in conduit

Determine number of circuits

Circuit breaker rating (A): ______________ (from Step 4, Table 5)

Number of circuits: ______________ (from Step 4)

Calculate circuit breaker load

(______________ x 0.8 x ______________) / 1000 = ______________

Circuit breaker rating (A) — Supply voltage — **Circuit breaker load (kW)**

MI heating cable in conduit

Determine circuit breaker rating and number of circuits

Circuit breaker rating (A): ______________

Number of circuits: ______________

Calculate circuit breaker rating and number of circuits

(______________ x 1.25) = ______________ = ______________

Total current (A) — **Minimum circuit breaker rating (A)*** — **Circuit breaker rating (A)**

↓

= ______________

Number of circuits

*Use next largest available circuit breaker or break into smaller circuits

Example: RaySol heating cable

(20 A x 0.8 x 208 V) / 1000 = **3.3 kW**

Circuit breaker rating (A) — Supply voltage — **Circuit breaker load**

Example: MI heating cable

(11.5 A x 1.25) = **14.4 A** = **15 A**

Total current (A) — **Minimum circuit breaker rating (A)*** — **Circuit breaker rating (A)**

↓

= **1**

Number of circuits

*Use next largest available circuit breaker or break into smaller circuits

Calculate total transformer load

______ + ______ + ______ + ______ = ______________

CBL$_1$ — CBL$_2$ — CBL$_3$ ... — CBL$_N$ — **Total transformer load (kW)**

Calculate total transformer load

(______ + ______ + ______ + ______)/ 1000 = ______________

Cable$_1$ (W) — Cable$_2$ (W) — Cable$_3$ (W)... — Cable$_N$ (W) — **Total transformer load (kW)**

Example: RaySol heating cable

3.3 kW = **3.3 kW**

CBL$_1$ — **Total transformer load (kW)**

Example: MI heating cable

(**475 W** + **475 W** + **475 W** + **475 W** + **475 W**) / 1000 = **2.4 kW**

Cable$_1$ — Cable$_2$ — Cable$_3$ — Cable$_4$ — Cable$_5$ — **Total transformer load**

Step 6 Select the connection kits and accessories

Connection kits and accessories	Description	Quantity	
☐ FTC-XC	Power connection and end seal	______	
☐ FTC-HST	Low-profile splice/tee	______	
☐ RayClic-E	Extra end seal	______	
☐ D1297TERM4	Cast aluminum junction box (for MI cable only)	______	
Example:			
✔ FTC-XC	Power connection and end seal	3	(for RaySol)
✔ D1297TERM4	Cast aluminum junction box (for MI cable only)	5	(for MI)

Step 7 Select the control system

Thermostats, controllers, and accessories	Description	Quantity
☐ ECW-GF	Electronic thermostat with 25-ft sensor	________
☐ ECW-GF-DP	Remote display panel for ECW-GF	________
☐ MI-GROUND-KIT	Grounding kit for nonmetallic enclosures	________
☐ C910-485	Microprocessor-based single-point heat-trace controller	________
☐ ACS-UIT2	ACS-30 user interface terminal	________
☐ ACS-PCM2-5	ACS-30 power control panel	________
☐ ProtoNode-RER	Multi-protocol gateway	________
☐ RTD10CS	Resistance temperature device for Raychem C910-485 & ACS-30	________
☐ RTD-200	Resistance temperature device for Raychem C910-485 & ACS-30	________
☐ RTD50CS	Resistance temperature device for Raychem C910-485 & ACS-30	________
Example: ✔ Raychem C910-485	Microprocessor-based single-point heat-trace controller	1

Step 8 Select the power distribution

Power distribution	Description	Quantity
☐ HTPG	Heat-tracing power distribution panel for group control	________

Step 9 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

MI CABLES DIRECTLY EMBEDDED FREEZER FROST HEAVE PREVENTION DESIGN WORKSHEET

Step 1 Determine the freezer configuration

Determine freezer area (from scale drawing)	Determine freezer operating temperature	Record insulation R-value	Supply voltage	Phase
______ Side A (length) (ft/m) x ______ Side B (width) (ft/m) = ______ **Freezer area (ft^2/m^2)**	______ °F/°C	______ ft^2·°F·hr/Btu	______ Volts	______ Phase
Example: **40 ft** Side A (length) (ft) x **20 ft** Side B (width) (ft) = **800 ft^2** **Freezer area (ft^2)**	**–30°F**	**R-20 (20 ft^2·°F·hr/Btu)**	**208 V**	**Single phase**

Step 2 Determine the heat loss and freezer load

Based on the insulation R-value and freezer operating temperature you recorded in Step 1, use Table 11 to select the following:

Design power ______________W/ft^2 (W/m^2)

Freezer load ______________W/ft^2 (W/m^2)

Example:

Design power	Freezer load
1.1 W/ft^2	**1.1 W/ft^2**

Step 3 Select the heating cable, layout and length

Use Table 12 and Table 13 to select your heating cable and determine your cable wattage.

Heating cable voltage

☐ 120 V

☐ 208 V

☐ 240 V

☐ 277 V

☐ 347 V

______	x	______	=	______	→	______	→	______	→	______	______
Design power (W/ft^2) / (W/m^2)		Area (ft^2/m^2)		Power required (W)		Catalog number		Cable wattage (W)		Heated length (ft)	Quantity

Example:

✓ **208 V**

1.1 W/ft^2	x	**800 ft^2**	=	**880 W**	→	**SUB19**	→	**885 W**	→	**245 ft**	**1**
Design power (W/ft^2)		Area (ft^2)		Power required (W)		Catalog number		Cable wattage (W)		Heated length (ft)	Quantity

Step 4 Determine the heating cable spacing

Imperial

______ x 12 / ______ = ______

Area (ft^2) Heated length (ft) Cable spacing (in)

Metric

______ x 100 / ______ = ______

Area (m^2) Heated length (m) Cable spacing (cm)

If necessary, round to whole number.

Example:

800 ft^2 x 12 / **245 ft** = **39.2 in rounded to 39 in**

Area (ft^2) Heated length (ft) Cable spacing (in)

Step 5 Determine the electrical parameters

Determine circuit breaker rating and number of circuits

Circuit breaker rating (A): ______ Number of circuits: ______

Calculate circuit breaker rating and number of circuits

(______ x 1.25) = ______ = ______ = ______

Total current (A) **Minimum circuit breaker rating (A)*** **Circuit breaker rating (A)** **Number of circuits**

*Use next largest available circuit breaker or break into smaller circuits

Example

(**4.3 A** x 1.25) = **5.4 A** = **15 A** = **1**

Total current (A) **Minimum circuit breaker rating (A)*** **Circuit breaker rating (A)** **Number of circuits**

*Use next largest available circuit breaker or break into smaller circuits

Calculate total transformer load

(______ + ______ + ______ + ______) / 1000 = ______

$Cable_1$ (W) $Cable_2$ (W) $Cable_3$ (W)... $Cable_N$ (W) **Total transformer load (kW)**

Example

(**885 W**) / 1000 → = **0.9 kW**

$Cable_1$ **Total transformer load**

Step 6 Select the accessories

Accessory	Description	Quantity
☐ D1297TERM4	Cast aluminum junction box	______
Example: ✔ D1297TERM4	Cast aluminum junction box	1

Step 7 Select the control system

Thermostats, controllers, and accessories	Description	Quantity
☐ ECW-GF	Electronic thermostat with 25-ft sensor	______
☐ ECW-GF-DP	Remote display panel for ECW-GF	______
☐ MI-GROUND-KIT	Grounding kit for nonmetallic enclosures	______
☐ C910-485	Microprocessor-based single-point heat-trace controller	______
☐ ACS-UIT2	ACS-30 user interface terminal	______
☐ ACS-PCM2-5	ACS-30 power control panel	______
☐ ProtoNode-RER	Multi-protocol gateway	______
☐ RTD10CS	Resistance temperature device for Raychem C910-485 & ACS-30	______
☐ RTD-200	Resistance temperature device for Raychem C910-485 & ACS-30	______
☐ RTD50CS	Resistance temperature device for Raychem C910-485 & ACS-30	______
Example: ✓ Raychem C910-485	Microprocessor-based single-point heat-trace controller	1

Step 8 Select the power distribution

Power distribution	Description	Quantity
☐ HTPG	Heat-tracing power distribution panel for group control	______

Step 9 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

Raychem

HEAT LOSS REPLACEMENT – RAYSOL AND MI HEATING CABLE SYSTEM

This step-by-step design guide provides the tools necessary to design a heat loss replacement system using Raychem RaySol self-regulating heating cable system or Raychem Mineral Insulated heating cable system. For other applications or for design assistance, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

Thermal Management offers Raychem RaySol and MI heating cable systems for large floor heating areas, like garages, loading docks, arcades, lobbies, foyers, gymnasiums, etc.. RaySol heating cables and MI heating cables can be directly attached to the bottom of the concrete floor or be directly embedded in the concrete floor or in a thick mortar bed.

Thermal Management also offers a full suite of best-in-class Nuheat floor heating products for smaller floor heating areas, like kitchens, bathrooms, living spaces, shower benches, shower floors, granite counter tops, etc. For more information, refer to www.nuheat.com.

If your application conditions are different than described in this guide, or if you have any questions, contact your Thermal Management representative or call (800) 545-6258.

How to Use this Guide

This design guide presents Thermal Management's recommendations for designing large floor heating systems. It provides design and performance data, electrical sizing information, control selection and heating-cable layout suggestions. Following these recommendations will result in a reliable, energy-efficient system.

Follow the design steps and use the appropriate design worksheets to document the project parameters that you will need for your project's Bill of Materials.

OTHER REQUIRED DOCUMENTS

This guide is not intended to provide comprehensive installation instructions. For complete floor heating system installation instructions, please refer to the following additional required documents:

- Raychem RaySol Floor Heating and Freezer Frost Heave Prevention Installation and Operation Manual (H58138)
- Raychem Mineral Insulated Heating Cable Floor Heating and Freezer Frost Heave Prevention Installation and Operation Manual (H58137)
- Additional installation instructions are included with the connection kits, thermostats, controllers, and accessories

If you do not have these documents, you can obtain them from the Thermal Management web site at www.pentairthermal.com.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call (800) 545-6258.

Safety Guidelines

As with any electrical equipment, the safety and reliability of any system depends on the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system components could damage the system and may result in inadequate performance, overheating, electric shock, or fire. To minimize these risks and to ensure that the system performs reliably, read and carefully follow the information, warnings, and instructions in this guide.

✎ This symbol identifies important instructions or information.

⚠ This symbol identifies particularly important safety warnings that must be followed.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Warranty

Thermal Management' standard limited warranty applies to Raychem and Raychem Floor Heating Systems.

FOR RAYCHEM RAYSOL AND MI HEATING CABLES

10 YEAR Product warranty

An extension of the limited warranty period to ten (10) years from the date of installation is available, except for the control and distribution systems, if a properly completed online warranty form is submitted within thirty (30) days from the date of installation. You can access the complete warranty on our web site at www.pentairthermal.com.

SYSTEM OVERVIEW

There are three main floor heating applications:

- Heat loss replacement
- Comfort floor heating (includes concrete floor heating)
- Radiant space heating

Thermal Management offers RaySol and MI heating cable systems for floor heating. Each product has specific design and installation considerations and this guide will address how to design the system that best suits your needs. RaySol and MI heating cables can be installed in multiple methods; however, the most common methods will be covered.

HEAT LOSS REPLACEMENT

Raychem RaySol and MI heating cables can be used to eliminate the chill felt from the heat lost through floors over non-heated areas such as garages, loading docks or arcades. The heating cables achieve this by replacing the heat normally lost through the floor insulation over a cold space.

For heat loss replacement, both RaySol and MI heating cables can be used and are attached to the bottom of the concrete floor.

COMFORT FLOOR HEATING

Raychem RaySol and MI heating cables can heat floors in places such as lobbies, foyers and gymnasiums. The heating cables are used to raise the floor temperature to 80°F (27°C) or warmer so it is comfortable to walk on the floor in bare feet.

For comfort floor heating, both RaySol and MI heating cables can be used and can be embedded in mortar or concrete.

RADIANT SPACE HEATING

RaySol and MI heating cable systems can be designed to provide primary space heating for rooms with concrete floors. RaySol heating cable systems must be custom designed through Thermal Management. Contact your Thermal Management representative or call (800) 545-6258 for design assistance.

For radiant space heating, both RaySol and MI heating cables can be used and are directly embedded in mortar or concrete.

Typical System

The following illustration shows a typical heat loss replacement system.

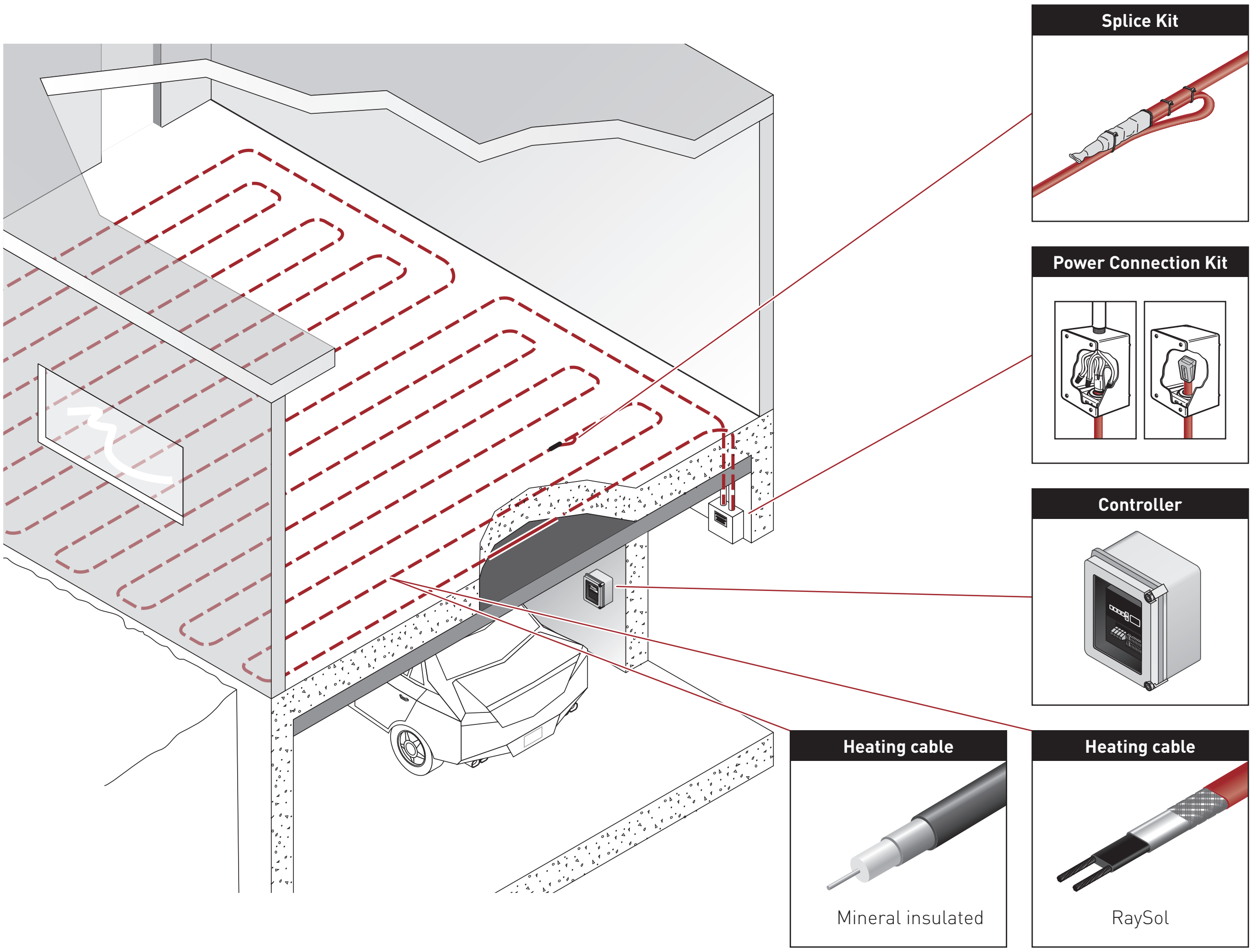


Fig. 1 Typical heat loss replacement system

The following illustration shows a typical heat loss replacement installation.

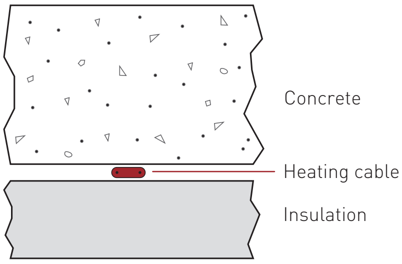


Fig. 2 Typical heat loss replacement installation

The following illustration shows a typical comfort floor heating system.

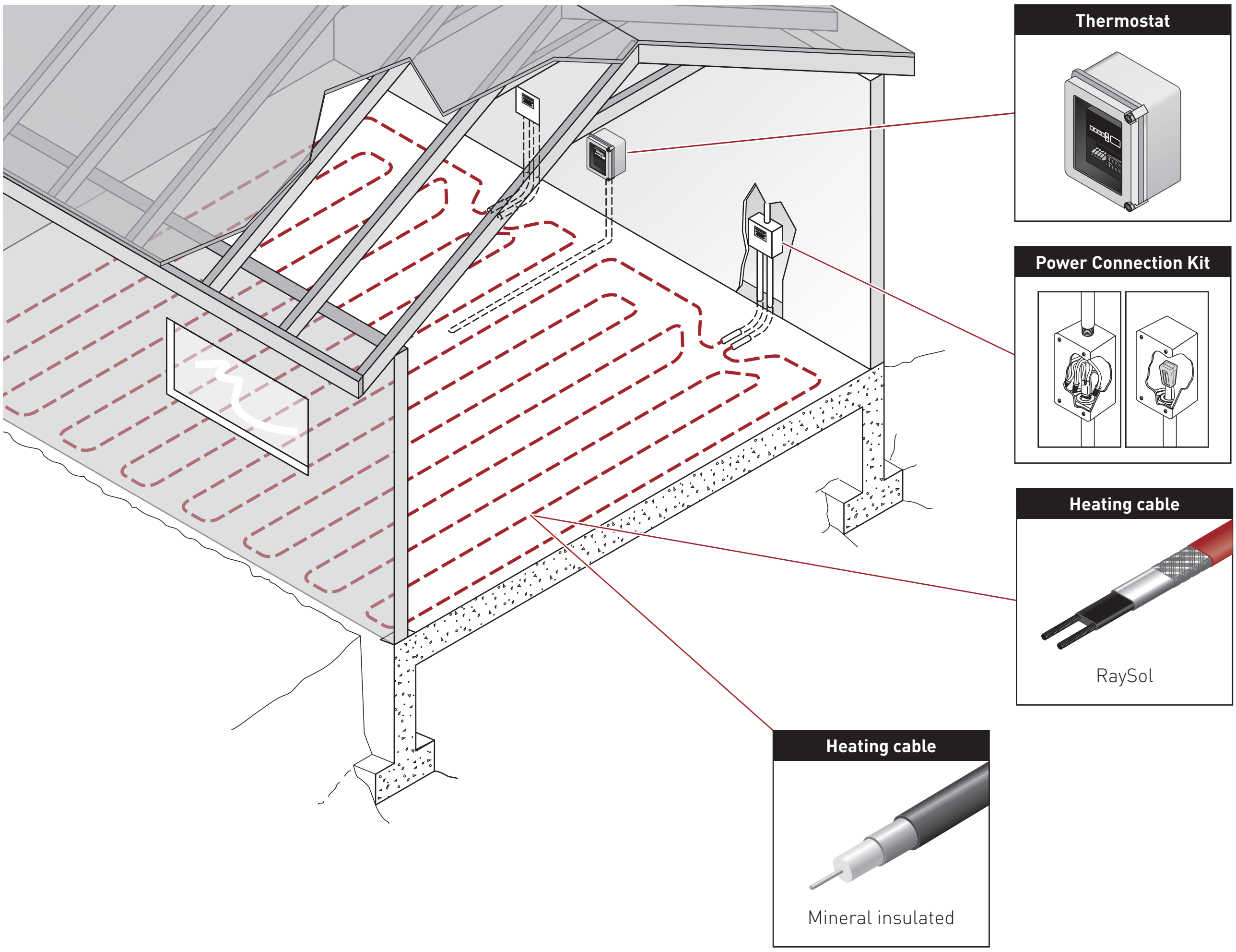


Fig. 3 Typical comfort floor heating system

The following illustration shows a typical comfort floor system installation.

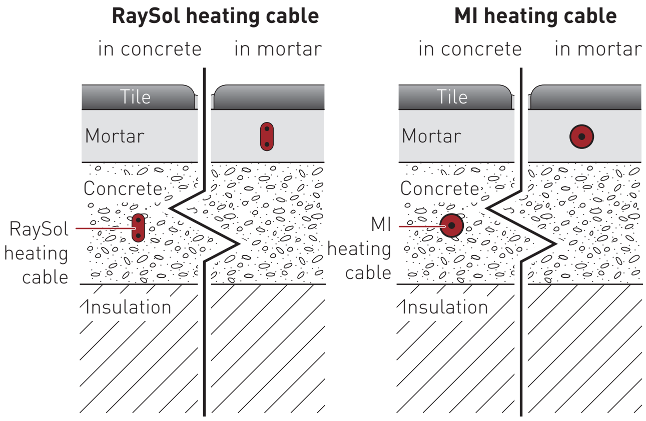


Fig. 4 Typical comfort floor heating system installation

A radiant space heating system is similar to the illustration in Fig. 3. RaySol heating cable systems must be custom designed through Thermal Management. Contact your Thermal Management representative or call (800) 545-6258 for design assistance.

Table 1 summarizes which heating cable can be used for which application.

TABLE 1 FLOOR HEATING APPLICATIONS AND RECOMMENDED HEATING CABLES

Application	RaySol	MI
Heat loss replacement	x	x
Comfort floor heating	x	x
Radiant space heating	x	x

Self-Regulating Heating Cable Construction

Raychem RaySol self-regulating heating cables are comprised of two parallel nickel-coated bus wires in a cross-linked polymer core, a tinned copper braid, and a fluoropolymer outer jacket. These cables are cut to length, simplifying the application design and installation.

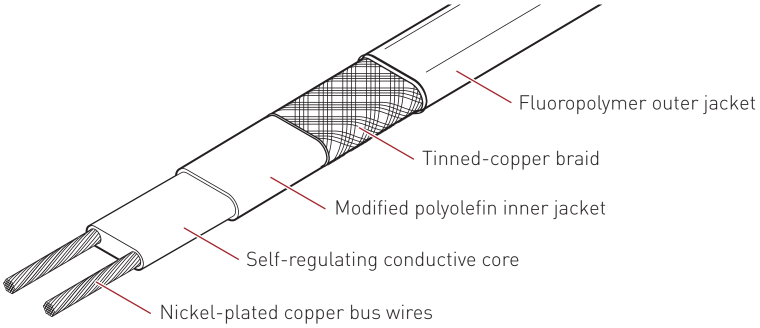
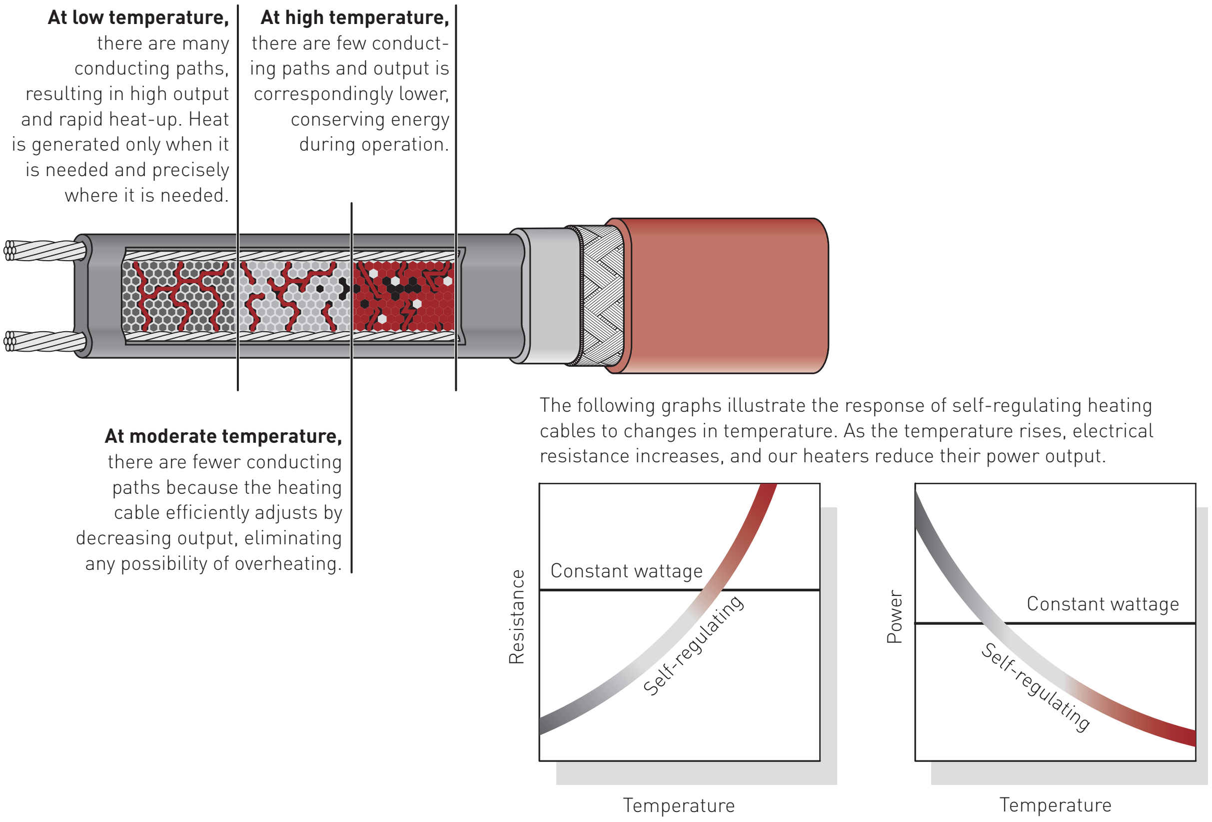


Fig. 5 Typical RaySol heating cable construction

With self-regulating technology, the number of electrical paths between bus wires changes in response to temperature fluctuations. As the temperature surrounding the heater decreases, the conductive core contracts microscopically. This contraction decreases electrical resistance and creates numerous electrical paths between the bus wires. Current flows across these paths to warm the core.

As the temperature rises, the core expands microscopically. This expansion increases electrical resistance and the number of electrical paths decreases. The heating cable automatically reduces its output.



At low temperature, there are many conducting paths, resulting in high output and rapid heat-up. Heat is generated only when it is needed and precisely where it is needed.

At high temperature, there are few conducting paths and output is correspondingly lower, conserving energy during operation.

At moderate temperature, there are fewer conducting paths because the heating cable efficiently adjusts by decreasing output, eliminating any possibility of overheating.

The following graphs illustrate the response of self-regulating heating cables to changes in temperature. As the temperature rises, electrical resistance increases, and our heaters reduce their power output.

Fig. 6 Self-regulating heating cable technology

CODES AND APPROVALS

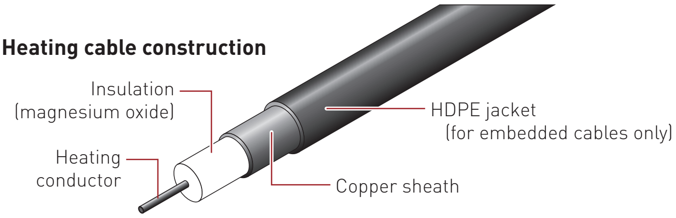
The RaySol system is UL Listed for heat loss replacement, comfort floor heating and radiant space heating applications.

The RaySol system is CSA Certified for comfort floor heating and radiant space heating applications. For heat loss replacement applications where the cable is attached to the bottom of the concrete floor, contact Thermal Management for additional information.

MI Heating Cable Construction

Raychem MI heating cables used for floor heating applications are comprised of a single conductor surrounded by magnesium oxide insulation and a solid copper sheath. For embedded applications, such as comfort floor heating and radiant space heating, the heating cable also has an extruded high density polyethylene (HDPE) jacket.

Heating cable construction

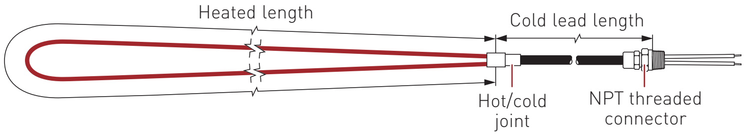


Single-conductor cable (61 series)

Fig. 7 Typical MI heating cable construction

The heating cables are supplied as complete factory-fabricated assemblies consisting of an MI heating cable that is joined to a section of MI non-heating cold lead and terminated with NPT connectors. Two configurations are available: Type SUA consisting of a looped cable joined to a single 7 ft (2.1 m) cold lead with one 1/2-in NPT connector; and Types SUB, HLR and FH consisting of a single run of cable with a 15 ft (4.6 m) cold lead and a 1/2-in NPT connector on each end.

Type SUA



Types SUB, HLR and FH

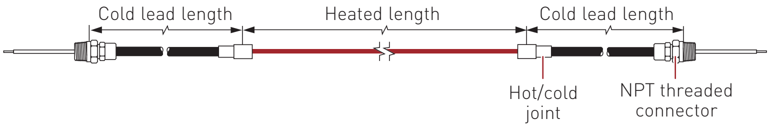


Fig. 8 Configurations for surface mount or directly embedded in concrete installations

Thermal Management offers all the components necessary for system installation. Details of these components and additional accessories can be found later in this design guide.

CODES AND APPROVALS

The MI system is c-CSA-us Certified for comfort floor heating and radiant space heating applications. For heat loss replacement applications where the cable is attached to the bottom of the concrete floor, contact Thermal Management for additional information.

FLOOR HEATING APPLICATION DESIGN

This section guides you through the steps necessary to design the correct system for your application. The examples provided in each step are intended to incrementally illustrate the project parameter output for sample designs from start to finish. As you go through each step, use the appropriate design worksheets to document your project parameters, so that by the end of this section, you will have the information you need for your Bill of Materials.

For products and applications not covered by this design guide, please contact your Thermal Management representative or call Thermal Management directly at (800) 545-6258.

Design Step by Step

Your system design requires the following essential steps:

1 Determine the application
  - Heat loss replacement
  - Comfort floor heating
  - Radiant space heating

2 Select the heating cable system and installation method
  - Heat loss replacement
  - Comfort floor heating
  - Radiant space heating

3 Determine the floor configuration

4 Determine the heating cable spacing, layout, and length
  - RaySol heating cables
  - MI heating cables

5 Determine the electrical parameters

6 Select the connection kits and accessories

7 Select the control system

8 Select the power distribution

9 Complete the Bill of Materials

Depending on the heating cable system you select, use one of the following worksheets to help you document the project parameters you will need for your project's Bill of Materials:

- Preliminary worksheet for determining your project's application and product line on page 316.
- The "RaySol Heating Cable Floor Heating Design Worksheet" on page 317.
- The "MI Heating Cable Floor Heating Design Worksheet" on page 325.

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 1 Determine the application

This step further defines the specific application and design assumptions. Once the application is verified, you will select the appropriate heating system in Step 2.

HEAT LOSS REPLACEMENT

A heat loss replacement system uses RaySol and MI heating cables for concrete floors built over garages, loading docks, arcades, or other cold spaces. The design goal is to prevent the floor over a cold space from cooling below room temperature. The heating cable system achieves this by replacing the heat normally lost through the floor insulation over a cold space.

A successful design must conform to the following requirements:

- The floor to be heated is indoors where the room temperature above the floor is approximately 70°F (21°C).
- RaySol and MI heating cables will be attached to the bottom of the concrete floor. If it is necessary to install RaySol or MI cables in conduit or to directly embed the MI cables in the concrete floor, contact your Thermal Management representative or call (800) 545-6258 for design assistance.
- The bottom of the floor is insulated.

COMFORT FLOOR HEATING

A comfort floor heating system uses RaySol or MI heating cables for lobbies, foyers, schools, or gymnasiums. The design goal is to raise the floor temperature to 80°F (27°C) or above so it is comfortable to walk on the floor with bare feet. RaySol and HDPE jacketed copper sheathed MI heating cables are directly embedded in mortar or concrete.

A successful design must conform to the following requirements:

- For RaySol, the floor to be heated is indoors, and is located on grade or is located above an area where the ambient temperature is approximately 70°F (21°C) or the bottom of the floor is insulated.
- For MI, the floor to be heated is indoors, and is located on grade or is located above an area where the ambient temperature is approximately 70°F (21°C) or the bottom of the floor is insulated with minimum R-20 insulation when exposed to the outside ambient air temperature.
- RaySol and HDPE jacketed copper sheathed MI heating cables are embedded in a standard concrete floor or embedded in a mortar layer (at least 3/4 in (2 cm) thick) under ceramic tile or natural stone.
- RaySol or MI heating cables shall not be installed in shower floors, under tubs and spas, or under other permanent fixtures.

RADIANT SPACE HEATING

RaySol and MI heating cable systems can be designed to provide primary space heating for rooms with concrete floors. RaySol heating cable systems must be custom designed by Thermal Management. Contact your Thermal Management representative or call (800) 545-6258 for design assistance.

A successful design must conform to the following requirements:

- The Btu requirement and total heated area are provided by the customer.
- The bottom of the floor is insulated or located on grade.
- RaySol and HDPE jacketed copper sheathed MI heating cables are embedded in a concrete floor or embedded in mortar (at least 3/4 in (2 cm) thick), under ceramic tile or natural stone.
- RaySol or MI heating cables shall not be installed in shower floors, under tubs and spas, or under other permanent fixtures.

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 2 Select the heating cable system and installation method

In this step you will determine the heating cable system and installation method to suit your specific needs. Table 2 indicates the various installation methods that will be discussed in this design guide for each heating cable technology as it pertains to each application.

TABLE 2 INSTALLATION METHODS BY HEATING CABLE AND APPLICATION

	Heat loss replacement		**Comfort floor heating**		**Radiant space heating**	
Installation method	**RaySol**	**MI**	**RaySol**	**MI**	**RaySol**	**MI**
Attach to bottom	x	x	–	–	–	–
Embed in concrete	–	–	x	x	x	x
Embed in mortar bed	–	–	x	x	x	x

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 3 Determine the floor configuration

All floor heating applications require determining the area to be heated. For heat loss replacement and comfort floor heating you will also need the minimum ambient design temperature and the insulation R-value. For radiant space heating you will need to provide the Btu requirement.

In this design guide, two floor layouts will be used to illustrate all floor heating applications. The first example will be for heat loss replacement and the second example will be for comfort floor heating and radiant space heating.

HEAT LOSS REPLACEMENT

GATHERING INFORMATION

When using this guide to design a system, you need the following information:

- Size and layout of exposed floor
- Minimum ambient design temperature
- Insulation R-value
- Supply voltage and phase
- Control requirements

PREPARE SCALE DRAWING

Draw to scale the floor area to be heated. Carefully note the limits of the area to be heated. Show all concrete joints on the drawing and note the voltage supply location, and location and size of obstacles, such as floor drains, pipe penetrations, conduit runs, columns and fixtures.

For heat loss replacement, the entire floor is considered the area to be heated.

Heated area = Total area

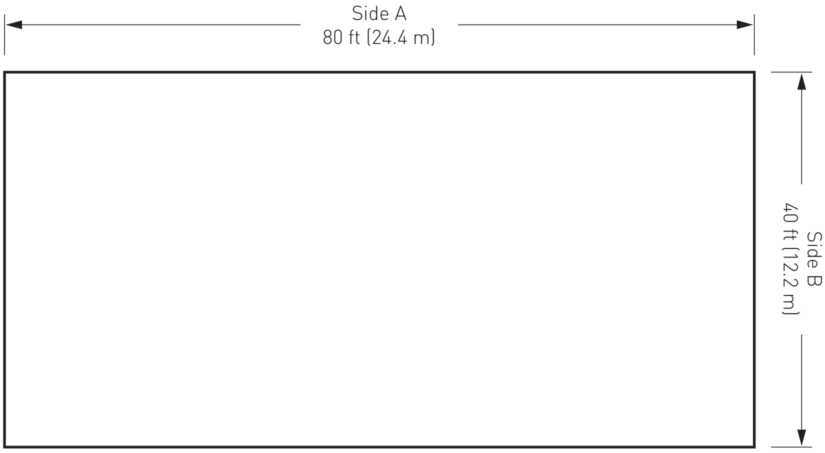


Fig. 9 Floor layout for heat loss replacement example

DETERMINE MINIMUM AMBIENT DESIGN TEMPERATURE

Determine the lowest temperature that is expected below the floor insulation.

RECORD INSULATION R-VALUE

The insulation R-value is the thermal resistance of the floor's insulation. Normally, the R-value will be printed on the insulation material. If that is not the case, you can calculate it by dividing the insulation thickness in inches by the insulation thermal conductivity.

Example: RaySol heating cables for heat loss replacement

Heated area	80 ft x 40 ft = 3200 ft^2 (see Fig. 9) (24.4 m x 12.2 m = 297.4 m^2)
Minimum ambient design temperature	–10°F (–23°C)
Insulation R-value	R-20 (20 ft^2·°F·hr/Btu)
Supply voltage and phase	208 V, single-phase
Control requirements	Electronic thermostat, monitoring requested

Example: MI heating cables for heat loss replacement

Heated area	80 ft x 40 ft = 3200 ft^2 (see Fig. 9) (24.4 m x 12.2 m = 297.4 m^2)
Minimum ambient design temperature	–10°F (–23°C)
Insulation R-value	R-20 (20 ft^2·°F·hr/Btu)
Supply voltage and phase	208 V, three-phase
Control requirements	Electronic thermostat, monitoring requested

Advance to Step 4, page 282.

COMFORT FLOOR HEATING

GATHERING INFORMATION

When using this guide to design a system you need the following information:

- Size and layout of floor
- Minimum ambient design temperature
- Insulation R-value
- Supply voltage and phase
- Control requirements

For comfort floor heating, it is also important to note the locations of shower floors, tubs, spas, toilets, and other permanent fixtures and subtract these areas from the total area.

Heated area = Total area – Permanent fixture space

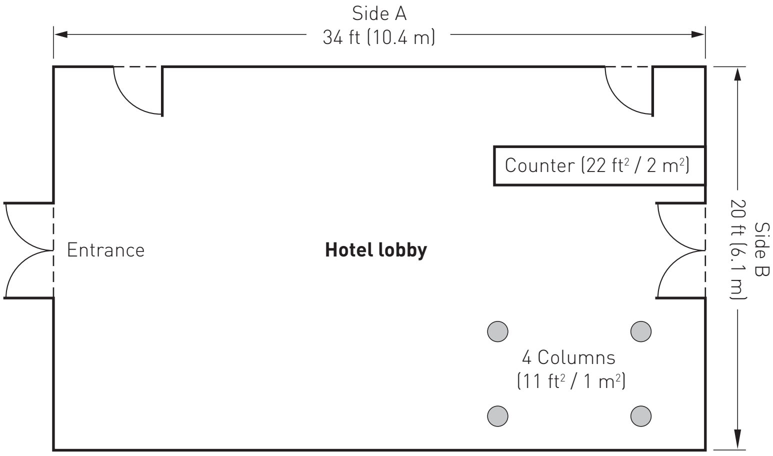


Fig. 10 **Floor layout for comfort floor heating example**

DETERMINE MINIMUM AMBIENT DESIGN TEMPERATURE

Determine the lowest temperature that is expected below the floor insulation.

RECORD INSULATION R-VALUE

The insulation R-value is the thermal resistance of the floor's insulation. Normally, the R-value will be printed on the insulation material. If that is not the case, you can calculate it by dividing the insulation thickness in inches by the insulation thermal conductivity.

Example: Comfort floor heating (RaySol and MI heating cables)

Heated area	(34 ft x 20 ft) – (22 ft^2 + 11 ft^2) = 647 ft^2 (see Fig. 10) (10.4 m x 6.1 m) – (2 m^2 + 1 m^2) = 60.4 m^2
Minimum ambient design temperature	10°F (–12°C)
Insulation R-value	R-30 (30 $ft^2 \cdot °F \cdot hr/Btu$)
Supply voltage and phase	208 V, single-phase
Control requirements	Electronic thermostat

Advance to Step 4, page 282.

RADIANT SPACE HEATING

GATHERING INFORMATION

When using this guide to design a system, you need the following information:

- Size and layout of floor
- The Btu requirement (heat loss) calculated by the engineer or architect
- Supply voltage and phase
- Control requirements

For radiant space heating, the heat loss, or Btu required, is based on the total area of the room. However, the heating cable must not be installed under the area occupied by columns, fixtures, shower floors, tubs and spas, toilets and other permanent fixtures. To determine the area in which the heating cable will be installed, subtract the area occupied by these permanent fixtures from the total area.

Heated area = Total area – Permanent fixture space

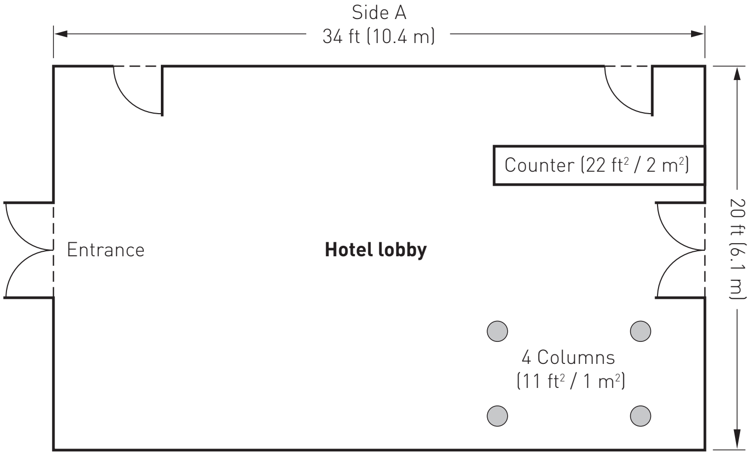


Fig. 11 Floor layout for radiant space heating example

Example: MI heating cables for radiant space heating

Floor area	(34 ft x 20 ft) – (22 ft^2 + 11 ft^2) = 647 ft^2 (see Fig. 11) (10.4 m x 6.1 m) – (2 m^2 + 1 m^2) = 60.4 m^2
Btu requirement	34,800 Btu / hr (supplied by engineer)
Supply voltage and phase	208 V, single-phase
Control requirements	Electronic thermostat

Advance to Step 4, page 282.

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 4 Determine the heating cable spacing, layout and length

In this step you will select the heating cable and determine the spacing, layout and length. This section is organized by heating cable type with specific design criteria for each application and installation method.

- For RaySol self-regulating heating cable design
  - For heat loss replacement, see below.
  - For comfort floor heating, see page 286.
- For MI heating cable design
  - For heat loss replacement, see page 291.
  - For comfort floor heating, see page 296.
  - For radiant space heating, see page 300.

RAYSOL SELF-REGULATING HEATING CABLE SYSTEM DESIGN

HEAT LOSS REPLACEMENT

Design a RaySol heating cable system for heat loss replacement as follows:

1. Select the appropriate RaySol heating cable

Select the heating cable based on the operating voltage. For 120 V, select RaySol-1; for 208–277 V, select RaySol-2.

TABLE 3 RAYSOL HEATING CABLE

Supply voltage	Catalog number
120 V	RaySol-1
208–277 V	RaySol-2

Example: RaySol heating cables for heat loss replacement

Supply voltage	208 V (from Step 3)
Catalog number	**RaySol-2**

2. Determine the RaySol heating cable spacing

Use the minimum ambient design temperature and the floor insulation R-value (from Step 3) to select the correct spacing shown in Table 4 for heat loss replacement. If the calculated R-value or minimum design temperature does not match the values in the table, use the values that give the closer spacing.

TABLE 4 RAYSOL HEATING CABLE SPACING FOR HEAT LOSS REPLACEMENT

Minimum ambient design temperature	Floor insulation R-value (ft²·°F·hr/Btu)			
	R-10	R-20	R-30	R-40
50°F (10°C)	30 in (73 cm)	36 in (91 cm)	36 in (91 cm)	36 in (91 cm)
30°F (–1°C)	24 in (61 cm)	30 in (76 cm)	36 in (91 cm)	36 in (91 cm)
10°F (–12°C)	21 in (53 cm)	30 in (76 cm)	30 in (76 cm)	36 in (91 cm)
–10°F (–23°C)	18 in (46 cm)	24 in (61 cm)	30 in (76 cm)	36 in (91 cm)
–30°F (–34°C)	15 in (38 cm)	24 in (61 cm)	30 in (76 cm)	36 in (91 cm)

If the space below the floor is maintained at 50–70°F (10–21°C), insulate the floor to R-10 minimum and select a heating cable spacing from the 50°F (10°C) row in Table 4.

Example: RaySol heating cables for heat loss replacement

Minimum ambient design temperature	–10°F (–23°C) (from Step 3)
Insulation R-value	R-20 (from Step 3)
Heating cable spacing	**24 in (61 cm)**

3. Determine the RaySol heating cable layout and length

Estimate the heating cable length The length of heating cable and the number of heating cable circuits can be estimated before a detailed layout is done if the heating cable spacing, total heated area, and the available branch circuit breaker rating are known. Fig. 12 shows typical layouts when the heating cable is directly attached to the bottom of the floor.

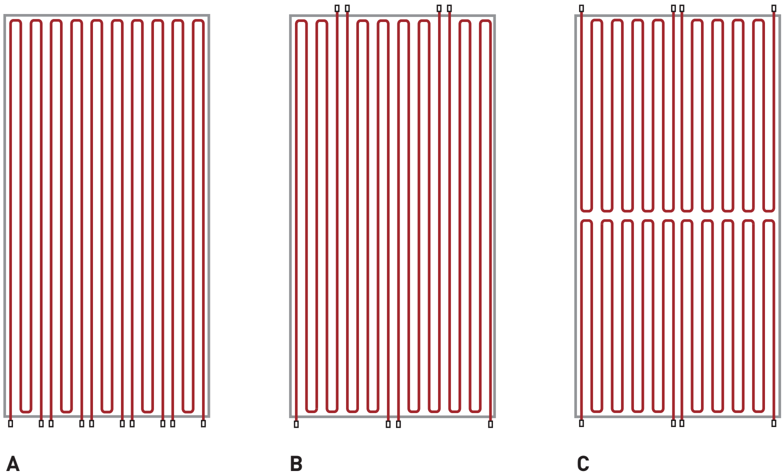


Fig. 12 Typical heating cable layouts for heat loss replacement

Estimate the heating cable length required:

$$\text{Estimated heating cable length (ft)} = \frac{\text{Heated area (ft}^2\text{) x 12}}{\text{Spacing (in)}}$$

$$\text{Estimated heating cable length (m)} = \frac{\text{Heated area (m}^2\text{) x 100}}{\text{Spacing (cm)}}$$

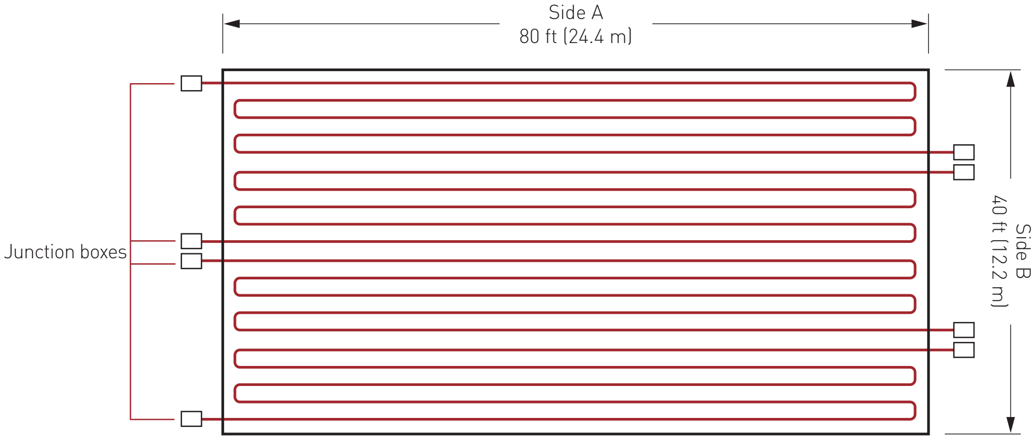


Fig. 13 RaySol heating cable layout for heat loss replacement

Example: RaySol heating cable length for heat loss replacement

Heated area	3200 ft² (297.4 m²) (from Step 3, Fig. 9)
Estimated heating cable length	3200 ft² x 12 / 24 in = **1600 ft**
	297.4 m² x 100 / 61 cm = **487.5 m**

4. Determine the maximum circuit length for the heating cable length

For the appropriate supply voltage, use Table 5 to select the maximum circuit length which is closest to, but greater than the length calculated. If the estimated heating cable length required is greater than the maximum circuit length, multiple circuits must be used.

TABLE 5 MAXIMUM RAYSOL CIRCUIT LENGTH IN FEET (METERS) WHEN ATTACHING HEATING CABLE TO THE BOTTOM OF THE FLOOR (40°F (4°C) START-UP)*

Supply voltage	**120 V**		**208 V**		**240 V**		**277 V**	
Circuit breaker size (A)	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**
15	120	36.6	205	62.5	210	64.0	215	65.5
20	160	48.8	275	83.8	285	86.9	290	88.4
30	240	73.2	410	125.0	425	129.5	430	131.1
40	240	73.2	410	125.0	425	129.5	430	131.1

*For start-up temperatures less than 40°F (4°C), contact your Thermal Management representative.

Calculate the estimated number of circuits as follows:

$$\text{Number of circuits} = \frac{\text{Estimated heating cable length (ft/m)}}{\text{Maximum circuit length (ft/m)}}$$

Round the number of circuits to the next larger whole number.

Example: RaySol heating cable length for heat loss replacement

Estimated heating cable length	1600 ft (487.5 m) (from earlier in this step)
Supply voltage	208 V (from Step 3)
Maximum circuit length	410 ft (125 m) (from Table 5)
Number of circuits	1600 ft / 410 ft = **4 circuits** (rounded)
Power supply	**Four 30 A circuit breakers** (from Table 5)

5. Determine the additional heating cable allowance

Additional heating cable is required to make power connections and to route the circuits to junction boxes. This extra heating cable need not be considered when determining the maximum heating cable length for circuit breaker sizing. In order to estimate the total heating cable length, you will need to take the estimated heating cable length you already calculated, and then add heating cable allowances, as follows:

Estimated total heating cable length = Estimated heating cable length + End allowances + Connection kit allowances

TABLE 6 RAYSOL ADDITIONAL HEATING CABLE ALLOWANCE

Heating cable allowance	Description	Length of cable
End allowances	From end of protective conduit to junction box	4 ft (1 m) per end
Connection kit allowances	Required to assemble the connection kit (one per circuit)	4 ft (1 m) per kit

Example: RaySol heating cable for heat loss replacement

Estimated heating cable length	1600 ft (487 m) (from earlier in this step)
End allowance	4 circuits x 4 ft per end x 2 ends = **32 ft (10 m)** (from Table 6)
Connection kit allowances	4 connection kits x 4 ft per kit = **16 ft (5 m)** (from Table 6)
Total heating cable allowances	32 ft (10 m) + 16 ft (5 m) = **48 ft (15 m)**
Estimated total heating cable length	1600 ft (487 m) + 48 ft (15 m) = **1648 ft (502 m)**

6. Locate the junction boxes for the RaySol heating cable system

The heating cable connects to the branch circuit wiring in a junction box with the RaySol FTC-P power connection and end seal kit.

The junction boxes may be distributed around the area to be heated, or collected at a single location. In many applications, the heating cable can be laid out so that all power connections and end seals can be grouped in a common area without using extra heating cable. If this can be done, select the common junction box location to minimize the electrical conduit and wire needed to reach the branch circuit breakers. Refer to Fig. 12 on page 283 for examples of typical layouts of cable attached to the bottom of concrete floors.

7. Lay out the heating cable runs, circuits, and junction boxes

After determining the estimated total heating cable length, the number of circuits, and the junction box location, do a trial layout. In making the trial layout, follow these recommendations:

- Start and end each circuit in a junction box. The power connection and end seal may be located in the same box or in different boxes.
- Arrange the heating cable run so it uniformly covers the area to be heated.
- Maintain the design heating cable spacing within 1 in (2.5 cm).
- Do not route the heating cable closer than 4 in (10 cm) to the edge of the subfloor, drains, anchors, or other material in the concrete.

- Do not exceed the maximum length of heating cable allowed on a branch circuit breaker as given in Table 5.
- When the combined lengths of two or more circuit runs are less than the maximum circuit length allowed, these runs can be combined in parallel on one circuit breaker.

8. Record the circuit information

Reconfigure the trial circuit layout until the design meets all of the previous recommendations. Assign each circuit to a circuit breaker in a specific panel board and record each circuit length.

Advance to Step 5, page 303.

COMFORT FLOOR HEATING

Design a RaySol heating cable system for comfort floor heating as follows:

1. Select the appropriate RaySol heating cable

Select the heating cable based on the operating voltage (see Table 3 on page 282). For 120 V, select RaySol-1; for 208–277 V, select RaySol-2.

Example: RaySol heating cables for comfort floor heating

Supply voltage	208 V (from Step 3)
Catalog number	**RaySol-2**

2. Determine the RaySol heating cable spacing

Use the minimum ambient design temperature and the floor insulation R-value (from Step 3) to select the correct spacing shown in Table 7 for comfort floor heating. If the calculated R-value or minimum design temperature does not match the values in the table, use the values that give the closer spacing.

TABLE 7 RAYSOL HEATING CABLE SPACING FOR COMFORT FLOOR HEATING

Minimum ambient design temperature		Floor insulation R-value (ft²·°F·hr/Btu)			
		R-10	R-20	R-30	R-40
50°F	(10°C)	8 in (20 cm)	9 in (23 cm)	9 in (23 cm)	9 in (23 cm)
30°F	(–1°C)	7 in (18 cm)	8 in (20 cm)	8 in (20 cm)	8 in (20 cm)
10°F	(–12°C)	7 in (18 cm)	7 in (18 cm)	8 in (20 cm)	8 in (20 cm)
–10°F	(–23°C)	6 in (15 cm)	7 in (18 cm)	7 in (18 cm)	8 in (20 cm)
–30°F	(–34°C)	6 in (15 cm)	7 in (18 cm)	7 in (18 cm)	7 in (18 cm)

For on-grade installations use heating cable on 9 in (23 cm) centers.

If the space below the floor is maintained at more than 50°F (10°C), insulate the floor to R-10 minimum and select heating cable spacing from the 50°F (10°C) row in Table 7.

Example: RaySol heating cables for comfort floor heating

Minimum ambient design temperature	10°F (–23°C) (from Step 3)
Insulation R-value	R-30 (from Step 3)
Heating cable spacing	**8 in (20 cm)**

3. Determine the RaySol heating cable layout and length

Estimate the heating cable length The length of heating cable and the number of heating cable circuits can be estimated before a detailed layout is done if the heating cable spacing, total heated area, and the available branch circuit breaker rating are known.

Estimate the heating cable length required:

$$\text{Estimated heating cable length (ft)} = \frac{\text{Heated area (ft}^2\text{) x 12}}{\text{Spacing (in)}}$$

$$\text{Estimated heating cable length (m)} = \frac{\text{Heated area (m}^2\text{) x 100}}{\text{Spacing (cm)}}$$

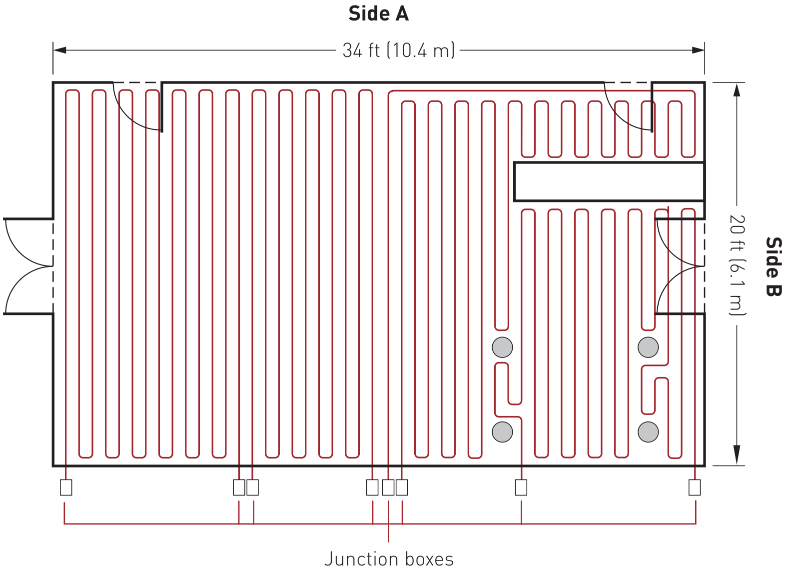


Fig. 14 RaySol heating cable layout for comfort floor heating

Example: RaySol heating cable length for comfort floor heating

Heated area	647 ft^2 (60.4 m^2) (from Step 3)
Estimated heating cable length	647 ft^2 x 12 / 8 in = **971 ft**
	60.4 m^2 x 100 / 20 cm = **302 m**

4. Determine the maximum circuit length for the heating cable length and layout

For the appropriate supply voltage, use Table 8 to select the maximum circuit length which is closest to, but greater than the length calculated. If the estimated heating cable length required is greater than the maximum circuit length, multiple circuits must be used.

TABLE 8 MAXIMUM RAYSOL CIRCUIT LENGTH IN FEET (METERS) WHEN EMBEDDED IN CONCRETE OR MORTAR (40°F (4°C) START-UP)*

Supply voltage	**120 V**		**208 V**		**240 V**		**277 V**	
Circuit breaker size (A)	**ft**	**m**	**ft**	**m**	**ft**	**m**	**ft**	**m**
15	80	24.4	135	41.1	140	42.7	145	44.2
20	105	32.0	185	56.4	185	56.4	195	59.4
30	160	48.8	275	83.8	280	85.3	290	88.4
40	170	51.8	280	85.3	320	97.5	360	109.7

* For start-up temperatures less than 40°F, contact your Thermal Management representative.

Note: If RaySol is installed in a bathroom, a 5 mA GFCI breaker must be used. In this case, the circuit breaker size cannot exceed 30 A.

Calculate the estimated number of circuits as follows:

$$\text{Number of circuits} = \frac{\text{Estimated heating cable length (ft/m)}}{\text{Maximum circuit length (ft/m)}}$$

Round the number of circuits to the next larger whole number.

Example: RaySol heating cable length for comfort floor heating

Estimated heating cable length	971 ft (302 m) (from earlier in this step)
Supply voltage	208 V (Step 3)
Maximum circuit length	275 ft (83.8 m) (from Table 8)
Number of circuits	971 ft / 275 ft (302 m / 83.8 m) = **4 circuits** (rounded)
Power supply	**Four 30 A circuit breakers** (from Table 8)

5. Determine the additional heating cable allowances

Additional heating cable is required to make power connections and to route the circuits to junction boxes. This extra heating cable shall not be considered when determining the maximum heating cable length for circuit breaker sizing. In order to estimate the total heating cable length, you will need to take the estimated heating cable length you already calculated, and then add heating cable allowances, as follows:

Estimated total heating cable length = Estimated heating cable length + End allowances + Connection kit allowances

Refer to Table 6 on page 285 to calculate the additional RaySol heating cable allowances.

Example: RaySol heating cable for comfort floor heating

Estimated heating cable length	971 ft (302 m) (from earlier in this step)
End allowance	4 circuits x 4 ft per end x 2 ends = **32 ft (10 m)** (from Table 6)
Connection kit allowances	4 connection kits x 4 ft per end = **16 ft (5 m)** (from Table 6)
Total heating cable allowances	32 ft (10 m) + 16 ft (5 m) = **48 ft (15 m)**
Estimated total heating cable length	971 ft (302 m) + 48 ft (15 m) = **1019 ft (317 m)**

6. Locate the junction boxes for RaySol heating cable system

The heating cable connects to the branch circuit wiring in a junction box with the RaySol FTC-XC power connection and end seal kit.

The junction boxes may be distributed around the area to be heated, or collected at a single location. In many applications the heating cable can be laid out so that all power connections and end seals can be grouped in a common area without using extra heating cable. If this can be done, select the common junction box location to minimize the electrical conduit and wire needed to reach the branch circuit breakers. Typical heating cable layout for comfort floor heating is similar to the examples shown in Fig. 13 on page 284 for heat loss replacement.

Fig. 15 illustrates the proper method to route the RaySol heating cable from the mortar bed up to the junction box using protective conduit.

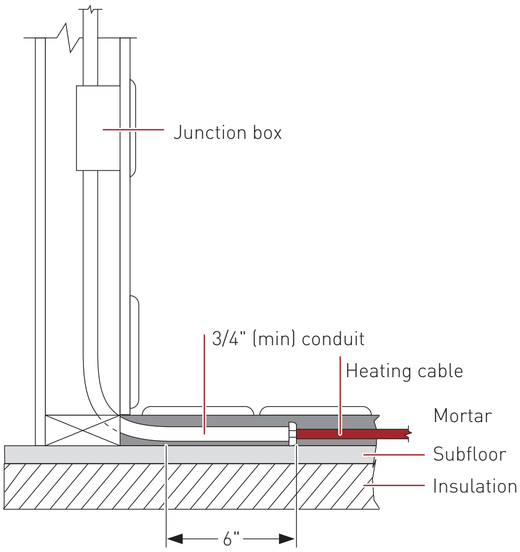


Fig. 15 Typical RaySol comfort floor heating installation

7. Lay out heating cable runs, circuits, and junction boxes

After determining the approximate total length of heating cable, the number of circuits, and the junction box location, do a trial layout. In making the trial layout, follow these recommendations:

- Start and end each circuit in a junction box. The power connection and end seal may be located in the same box or in different boxes.
- Arrange the heating cable run so it uniformly covers the area to be heated.
- Maintain the design heating cable spacing within 1 in (2.5 cm).
- Do not extend the heating cable beyond the room or area in which it originates.
- Do not install cables under shower floors, tubs and spas, toilets and other permanent fixtures.
- Do not cross expansion, crack control, or other subfloor joints.
- Do not route the heating cable closer than 4 in (10 cm) to the edge of the subfloor, drains, anchors, or other material in the concrete.
- Do not exceed the maximum length of heating cable allowed on a branch circuit breaker as given in Table 8.
- When the combined lengths of two or more circuit runs are less than the maximum circuit length allowed, these runs can be combined in parallel on one circuit breaker.

8. Record the circuit information

Reconfigure the trial circuit layout until the design meets all of the previous recommendations. Assign each circuit to a circuit breaker in a specific panel board and record each circuit length.

Advance to Step 5, page 303.

MI HEATING CABLE SYSTEM DESIGN

A single heating cable may be sufficient for small floor areas. For large floor areas, it may be necessary to divide the area into two or more equal subsections (Fig. 17 on page 296). For a three-phase voltage supply, divide the total area into three equal subsections (Fig. 16 on page 293) or a multiple of three equal subsections when more than one circuit is necessary. If expansion joints will be used in the floor, divide the area so that the heating cables will not cross any expansion joints.

Designing the floor heating system using a three-phase voltage supply has the added advantages of fewer circuits, reduced distribution costs, and a balanced heating system load and is recommended for large areas.

Three-phase voltage supplies include 208/120 V, 480/277 V, and 600/347 V. The heating cables may be connected in delta or wye configuration as shown in Fig. 20 on page 312 and Fig. 21 on page 313. If the heating cables are connected in the delta configuration, select the cables based on the phase-to-phase voltage (example: select 208 V cables for a 208 V supply). If the heating cables are connected in the wye configuration, select the cables based on the phase-to-neutral voltage (example: select 120 V cables for a 208 V supply).

HEAT LOSS REPLACEMENT

SELECT THE HEATING CABLE

Table 9 lists the heat loss for minimum design temperature and insulation R-value determined in Step 3. Select your design power from this table. If your calculated R-value or minimum design temperature does not match the values in the table, use the values that give the higher design power.

TABLE 9 DESIGN POWER BASED ON 70°F (21°C) CONTROL

Minimum design temperature		Floor insulation R-value (ft^2·°F·hr/Btu)							
		R-10		R-20		R-30		R-40	
		Design power - W/ft^2 (W/m^2)							
30°F	(–1°C)	2.2	(23.7)	1.6	(17.2)	1.4	(15.1)	1.3	(14.0)
20°F	(–7°C)	2.5	(26.9)	1.8	(19.4)	1.5	(16.1)	1.4	(15.1)
10°F	(–12°C)	2.8	(30.1)	1.9	(20.4)	1.6	(17.2)	1.5	(16.1)
0°F	(–18°C)	3.0	(32.3)	2.0	(21.5)	1.7	(18.3)	1.5	(16.1)
–10°F	(–23°C)	3.3	(35.5)	2.2	(23.7)	1.8	(19.4)	1.6	(17.2)
–20°F	(–29°C)	3.6	(38.7)	2.3	(24.7)	1.9	(20.4)	1.7	(18.3)
–30°F	(–34°C)	3.9	(42.0)	2.5	(26.9)	2.0	(21.5)	1.7	(18.3)
–40°F	(–40°C)	4.1	(44.1)	2.6	(28.0)	2.1	(22.6)	1.8	(19.4)

The heating cables shown in Table 10 have been optimized for heat loss replacement applications. They are manufactured with a bare copper sheath and are designed to be attached to the bottom of the concrete floor. Do not use these heating cables for embedded applications. If assistance is required to select heating cables for embedded heat loss replacement applications, irregular shaped areas, or applications outside the scope of this design guide, contact your Thermal Management representative or call (800) 545-6258 for design assistance.

Single-phase supply

Small floor areas require only one heating cable. Large floor areas may require two or more heating cables.

- Divide large floor areas into equal subsection areas, if possible (see Fig. 17 on page 296).
- Calculate the power required for the total area (small floor areas) or for each subsection area (large floor areas) by multiplying the design power (from Table 9) by the total area or subsection area.

Power required = Design power x Total area (or Subsection area)

Simply select the heating cable from Table 10 on page 294 based on the total area or subsection area. Under the appropriate voltage, make sure that the total area or subsection area falls within the minimum and maximum range of the "Area coverage" columns and verify that the "Cable wattage" shown directly across from the "Area coverage" is equal to or higher than the calculated "Power required" for the total area or subsection area.

In cases where the floor area has been divided into equal subsections, select the appropriate number of heating cables.

Note: Several heating cables in Table 10 may satisfy the requirements. Selecting one cable over another will simply result in a higher or lower watt density or different cable spacing. It may be desirable to select the lowest wattage cable that satisfies the area coverage to reduce the breaker size, or a longer cable to reduce cable spacing. Reduced cable spacing will provide a more uniform floor temperature.

Three-phase supply

Since a balanced three-phase system requires three cables, each cable will occupy 1/3 of the floor area when installed.

- Divide the total heated floor area into three equal subsections (Fig. 16) or a multiple of three equal subsections when more than one circuit is necessary.
- Calculate the power required for each subsection by multiplying the design power (from Table 9) by the subsection area.

Power required = Design power x Subsection area

Simply select the heating cable from Table 10 on page 294 based on the subsection area. Under the appropriate voltage, make sure that the subsection area falls within the minimum and maximum range of the "Area coverage" column and verify that the "Cable wattage" shown directly across from the "Area coverage" is equal to or higher than the calculated "Power required" for the subsection area.

Select the appropriate number of heating cables equal to the number of subsection areas (multiples of three cables required).

Note: Several heating cables in Table 10 may satisfy the requirements. Selecting one cable over another will simply result in a higher or lower watt density or different cable spacing. It may be desirable to select the lowest wattage cable that satisfies the area coverage to reduce the breaker size, or a longer cable to reduce cable spacing. Reduced cable spacing will provide a more uniform floor temperature.

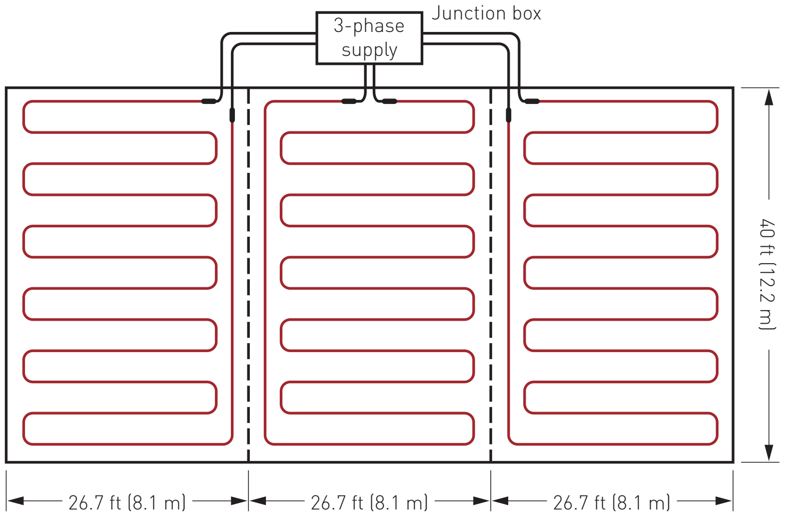


Fig. 16 Typical three-phase heating cable layout for heat loss replacement

Example: MI heating cables for heat loss replacement

Heated area	3200 ft^2 (297.4 m^2) (from Step 3)
Supply voltage and phase	208 V, three-phase (from Step 3)
Minimum ambient design temperature	–10°F (–23°C) (from Step 3)
Insulation R-value	R-20 (20 $ft^2 \cdot °F \cdot hr/Btu$) (from Step 3)
Design power	2.2 W/ft^2 (23.7 W/m^2) (from Table 9)
Subsection area	3200 ft^2 / 3 = 1067 ft^2 (see Fig. 16) 297.4 m^2 / 3 = 99.1 m^2
Power required (for each subsection)	(Design power x Subsection area) = 2.2 W/ft^2 x 1067 ft^2 = 2347 W 23.7 W/m^2 x 99.1 m^2 = 2347 W
Heating cable catalog number	**HLR24** (from Table 10)
Cable wattage	**5150 W** (from Table 10)
Cable voltage	208 V (for cables connected in Delta configuration)
Heating cable length	420 ft (128.0 m) (from Table 10)
Number of cables	**3 (one cable required for each subsection)**

TABLE 10 SELECTION TABLE FOR HEAT LOSS REPLACEMENT

Catalog number	Area coverage				Cable wattage (W)	Heated length		Heating cable current (A)
	Min (ft^2)	Max (ft^2)	Min (m^2)	Max (m^2)		(ft)	(m)	
120 V and 208 V, three-phase Wye								
HLR1	56	88	5	8	330	70	21.3	2.8
HLR2	89	132	8	12	540	44	13.4	4.5
HLR3	112	165	10	15	670	55	16.8	5.6
HLR4	127	189	12	18	760	63	19.2	6.3
HLR5	156	231	14	21	935	77	23.5	7.8
HLR6	180	267	17	25	1080	89	27.1	9.0
HLR7	216	318	20	30	1295	106	32.3	10.8
HLR8	246	366	23	34	1475	122	37.2	12.3
HLR9	286	420	27	39	1715	140	42.7	14.3
HLR10	349	516	32	48	2100	172	52.4	17.5
HLR11	404	594	38	55	2425	198	60.4	20.2
HLR12	492	732	46	68	2950	244	74.4	24.6
HLR13	654	966	61	90	3925	322	98.2	32.7
208 V								
HLR14	156	228	14	21	935	76	23.2	4.5
HLR15	195	285	18	26	1170	95	29.0	5.6
HLR16	221	327	20	30	1325	109	33.2	6.4
HLR17	271	399	25	37	1625	133	40.5	7.8
HLR18	312	462	29	43	1875	154	47.0	9.0
HLR19	373	552	35	51	2240	184	56.1	10.8
HLR20	427	633	40	59	2565	211	64.3	12.3
HLR21	495	729	46	68	2970	243	74.1	14.3
HLR22	609	888	57	83	3655	296	90.2	17.6
HLR23	697	1035	65	96	4180	345	105.2	20.1
HLR24	858	1260	80	117	5150	420	128.0	24.8
HLR25	1129	1680	105	156	6780	560	170.7	32.6
240 V								
HLR26	179	264	17	25	1075	88	26.8	4.5
HLR27	224	330	21	31	1345	110	33.5	5.6
HLR28	256	375	24	35	1535	125	38.1	6.4
HLR29	314	459	29	43	1880	153	46.6	7.8
HLR30	362	531	34	49	2170	177	54.0	9.0
HLR31	431	636	40	59	2590	212	64.6	10.8
HLR32	494	729	46	68	2965	243	74.1	12.4
HLR33	571	840	53	78	3430	280	85.4	14.3
HLR34	696	1035	65	96	4175	345	105.2	17.4
HLR35	810	1185	75	110	4860	395	120.4	20.3
HLR36	990	1455	92	135	5940	485	147.9	24.8
HLR37	1316	1920	122	178	7900	640	195.1	32.9
277 V and 480 V, three-phase wye								
HLR38	206	306	19	28	1235	102	31.1	4.5
HLR39	258	381	24	35	1550	127	38.7	5.6
HLR40	294	435	27	40	1765	145	44.2	6.4
HLR41	361	531	34	49	2170	177	54.0	7.8
HLR42	416	615	39	57	2495	205	62.5	9.0
HLR43	497	735	46	68	2985	245	74.7	10.8
HLR44	571	840	53	78	3425	280	85.4	12.4
HLR45	656	975	61	91	3935	325	99.1	14.2
HLR46	807	1188	75	110	4845	396	120.7	17.5

Note: Type HLR cables supplied with 15 ft (4.6 m) long cold lead
Heating cable length tolerance is –0% to +3%.

TABLE 10 SELECTION TABLE FOR HEAT LOSS REPLACEMENT

Catalog number	Area coverage				Cable wattage (W)	Heated length		Heating cable current (A)
	Min (ft^2)	Max (ft^2)	Min (m^2)	Max (m^2)		(ft)	(m)	
HLR47	927	1380	86	128	5560	460	140.2	20.1
HLR48	1142	1680	106	156	6850	560	170.7	24.7
HLR49	1516	2220	141	206	9100	740	225.6	32.9
347 V and 600 V, three-phase wye								
HLR50	259	381	24	35	1560	127	38.7	4.5
HLR51	322	480	30	45	1930	160	48.8	5.6
HLR52	368	546	34	51	2205	182	55.5	6.4
HLR53	452	666	42	62	2715	222	67.7	7.8
HLR54	519	774	48	72	3110	258	78.7	9.0
HLR55	625	918	58	85	3750	306	93.3	10.8
HLR56	717	1050	67	98	4300	350	106.7	12.4
HLR57	826	1215	77	113	4955	405	123.5	14.3
HLR58	1014	1485	94	138	6080	495	150.9	17.5
HLR59	1163	1725	108	160	6980	575	175.3	20.1
HLR60	1433	2100	133	195	8600	700	213.4	24.8
480 V								
HLR61	360	525	33	49	2160	175	53.4	4.5
HLR62	448	660	42	61	2685	220	67.1	5.6
HLR63	512	750	48	70	3070	250	76.2	6.4
HLR64	627	918	58	85	3770	306	93.3	7.9
HLR65	721	1065	67	99	4330	355	108.2	9.0
HLR66	863	1272	80	118	5175	424	129.3	10.8
HLR67	990	1455	92	135	5940	485	147.9	12.4
HLR68	1143	1680	106	156	6860	560	170.7	14.3
HLR69	1391	2070	129	192	8350	690	210.4	17.4
600 V								
HLR70	447	660	42	61	2685	220	67.1	4.5
HLR71	559	825	52	77	3360	275	83.8	5.6
HLR72	639	939	59	87	3835	313	95.4	6.4
HLR73	781	1152	73	107	4690	384	117.1	7.8
HLR74	903	1329	84	124	5420	443	135.1	9.0
HLR75	1078	1590	100	148	6470	530	161.6	10.8
HLR76	1240	1815	115	169	7440	605	184.5	12.4
HLR77	1429	2100	133	195	8570	700	213.4	14.3

Note: Type HLR cables supplied with 15 ft (4.6 m) long cold lead
Heating cable length tolerance is –0% to +3%.

Advance to "Determine the heating cable spacing" on page 301.

COMFORT FLOOR HEATING

The heating cables shown in Table 12 have been optimized for comfort floor heating applications. If assistance is required to select heating cables for irregular shaped areas, or applications outside the scope of this design guide, contact your Thermal Management representative or call (800) 545-6258 for design assistance.

Single-phase supply

Small floor areas require only one heating cable. Large floor areas may require two or more heating cables.

- Divide large floor areas into equal subsection areas, if possible (Fig. 17).

Simply select the heating cable from Table 11 or Table 12 based on the total area or subsection area. Under the appropriate voltage, make sure that the total area or subsection area falls within the minimum and maximum range of the "Area coverage" column.

In cases where the heated floor area has been divided into equal subsections, select the appropriate number of heating cables.

Note: Several heating cables in Table 11 may satisfy the requirements. Selecting one cable over another will simply result in a higher or lower watt density or different cable spacing. It may be desirable to select the lowest wattage cable that satisfies the area coverage to reduce the breaker size, or a longer cable to reduce cable spacing. Reduced cable spacing will provide a more uniform floor temperature.

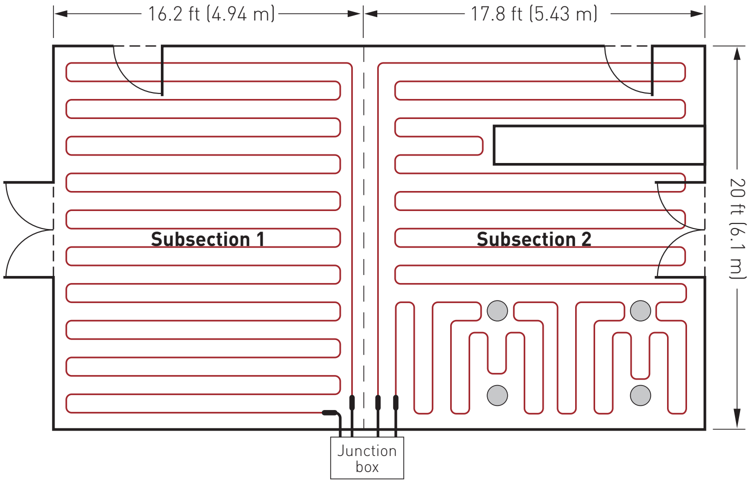


Fig. 17 Typical heating cable layout for comfort floor heating

Note: In Fig. 17, the subsections are equal heated areas.

Example: MI heating cables for comfort floor heating

Heated area	647 ft^2 (60.4 m^2) (from Step 3)
Supply voltage and phase	208 V, single-phase (from Step 3)
Subsection area	647 ft^2 / 2 = 324 ft^2 (see Fig. 17) 60.4 m^2 / 2 = 30.2 m^2
Heating cable catalog number	**FH21** (from Table 12)
Cable wattage	**3390 W** (from Table 12)
Cable voltage	208 V (from Table 12)
Heating cable length	425 ft (129.6 m) (from Table 12)
Number of cables	**2 (one cable required for each subsection)**

Three-phase supply

Since a balanced three-phase system requires three cables, each cable will occupy

1/3 of the heated floor area when installed.

- Divide the total heated floor area into three equal subsections or a multiple of three equal subsections when more than one circuit is necessary.

Simply select the heating cable from Table 11 or Table 12 based on the subsection area. Under the appropriate voltage, make sure that the subsection area falls within the minimum and maximum range of the "Area coverage" column.

Select the appropriate number of heating cables equal to the number of subsection areas (multiples of three cables required).

Note: Several heating cables in Table 11 may satisfy the requirements. Selecting one cable over another will simply result in a higher or lower watt density or different cable spacing. It may be desirable to select the lowest wattage cable that satisfies the area coverage to reduce the breaker size, or a longer cable to reduce cable spacing. Reduced cable spacing will provide a more uniform floor temperature.

TABLE 11 SELECTION TABLE FOR COMFORT FLOOR HEATING

	Area coverage					Heated length		
Catalog number	**Min (ft^2)**	**Max (ft^2)**	**Min (m^2)**	**Max (m^2)**	**Cable wattage (W)**	**(ft)**	**(m)**	**Heating cable current (A)**
120 V and 208 V, three-phase wye								
SUA2	30	42	2.8	3.9	425	55	16.8	3.5
SUA3	43	64	4.0	5.9	500	140	42.7	4.2
SUA4	45	51	4.2	4.7	550	68	20.7	4.6
SUA7	63	71	5.9	6.6	750	95	29.0	6.3
SUA8	65	97	6.0	9.0	800	177	54.0	6.7
SUB1	87	100	8.0	9.3	1000	132	40.2	8.3
SUB2	83	125	7.7	11.6	1000	240	73.2	8.3
SUB3	107	160	10.0	14.9	1300	280	85.4	10.8
SUB4	125	187	11.6	17.4	1500	320	97.6	12.5
SUB5	154	195	14.3	18.1	1800	260	79.3	15.0
SUB6	160	240	14.9	22.3	1900	375	114.3	15.8
SUB7	194	235	18.0	21.8	2300	310	94.5	19.2
SUB8	191	287	17.8	26.7	2300	550	167.7	19.2
SUB9	257	385	23.9	35.8	3000	630	192.1	25.0
SUB10	359	538	33.4	50.0	4300	717	218.6	35.8
208 V								
SUA1	50	81	4.6	7.5	650	108	32.9	3.1
SUA6	130	198	12.1	18.4	1560	264	80.5	7.5
SUB19	74	110	6.9	10.2	885	245	74.7	4.3
SUB20	101	152	9.4	14.1	1210	340	103.7	5.8
SUB21	137	205	12.7	19.1	1640	440	134.1	7.9
SUB22	160	256	14.9	23.8	2060	525	160.1	9.9
240 V								
SUA1	70	81	6.5	7.5	900	108	32.9	3.8
SUA6	175	198	16.3	18.4	2100	264	80.5	8.8
SUB19	98	146	9.1	13.6	1175	245	74.7	4.9
SUB20	135	202	12.5	18.8	1615	340	103.7	6.7
SUB21	182	274	16.9	25.5	2180	440	134.1	9.1
SUB22	229	345	21.3	32.1	2745	525	160.1	11.4

Note: Type SUA cables supplied with 7 ft (2.1 m) foot long cold lead: type SUB cables supplied with 15.1 (4.8 m) long cold lead.
Heating cable length tolerance is –0% to +3%.

TABLE 11 SELECTION TABLE FOR COMFORT FLOOR HEATING

Catalog number	Area coverage Min (ft²)	Max (ft²)	Min (m²)	Max (m²)	Cable wattage (W)	Heated length (ft)	(m)	Heating cable current (A)
277 V (and 480 V, three-phase wye)								
SUB19	130	184	12.1	17.1	1565	245	74.7	5.6
SUB20	179	255	16.6	23.7	2150	340	103.7	7.8
SUB21	242	330	22.5	30.7	2900	440	134.1	10.5
SUB22	304	394	28.3	36.6	3650	525	160.1	13.2
347 V and 600 V, three-phase wye								
SUB11	114	169	10.6	15.7	1400	225	68.6	4.0
SUB12	162	233	15	21.6	1950	310	94.5	5.6
SUB13	223	321	20.8	29.8	2700	428	130.5	7.8
SUB14	305	411	28.3	38.2	3700	548	167.1	10.7

Note: Type SUA cables supplied with 7 ft (2.1 m) foot long cold lead: type SUB cables supplied with 15.1 (4.8 m) long cold lead.
Heating cable length tolerance is –0% to +3%.

TABLE 12 SELECTION TABLE FOR COMFORT FLOOR HEATING

Catalog number	Area coverage Min (ft²)	Max (ft²)	Min (m²)	Max (m²)	Cable wattage (W)	Heated length (ft)	(m)	Heating cable current (A)
120 V and 208 V, three-phase wye								
FH1	36	41	3.4	3.8	440	54	16.5	3.7
FH2	42	51	3.9	4.7	545	68	20.7	4.5
FH3	52	58	4.8	5.4	625	77	23.5	5.2
FH4	59	71	5.5	6.6	760	95	29.0	6.3
FH5	72	82	6.7	7.6	880	109	33.2	7.3
FH6	83	98	7.7	9.1	1055	130	39.6	8.8
FH7	99	113	9.2	10.5	1200	150	45.7	10.0
FH8	114	130	10.6	12.1	1390	173	52.7	11.6
FH9	131	158	12.2	14.6	1715	210	64.0	14.3
FH10	159	185	14.8	17.2	1960	245	74.7	16.3
FH11	186	230	17.3	21.4	2400	300	91.5	20.0
208 V								
FH12	60	72	5.6	6.7	755	94	28.7	3.6
FH13	73	89	6.8	8.2	940	118	36.0	4.5
FH14	90	101	8.3	9.3	1075	134	40.9	5.2
FH15	102	123	9.5	11.4	1320	164	50.0	6.3
FH16	124	143	11.5	13.2	1520	190	57.9	7.3
FH17	144	169	13.4	15.7	1830	225	68.6	8.8
FH18	170	195	15.8	18.1	2080	260	79.3	10.0
FH19	196	230	18.2	21.4	2400	300	91.5	11.5
FH20	231	274	21.5	25.4	2960	365	111.3	14.2
FH21	275	325	25.6	30.2	3390	425	129.6	16.3
FH22	326	390	30.3	36.2	4160	520	158.5	20.0

Note: Type FH cables supplied with 15 ft (4.6 m) long cold lead.
Tolerance on heating cable length is –0% to +3%.

TABLE 12 SELECTION TABLE FOR COMFORT FLOOR HEATING

Catalog number	Area coverage				Cable wattage (W)	Heated length		Heating cable current (A)
	Min (ft^2)	Max (ft^2)	Min (m^2)	Max (m^2)		(ft)	(m)	
240 V								
FH23	70	84	6.5	7.8	875	108	32.9	3.6
FH24	85	101	7.9	9.4	1095	135	41.2	4.6
FH25	102	119	9.5	11.1	1240	155	47.3	5.2
FH26	120	145	11.2	13.5	1515	190	57.9	6.3
FH27	146	164	13.6	15.2	1785	215	65.5	7.4
FH28	165	195	15.3	18.1	2110	260	79.3	8.8
FH29	196	225	18.2	20.9	2400	300	91.5	10.0
FH30	226	265	21.0	24.6	2780	345	105.2	11.6
FH31	266	320	24.7	29.7	3430	420	128.0	14.3
FH32	321	375	29.8	34.9	3920	490	149.4	16.3
FH33	376	450	34.9	41.8	4800	600	182.9	20.0
277 V and 480 V, three-phase wye								
FH34	80	97	7.4	9.0	1005	125	38.1	3.6
FH35	98	119	9.1	11.0	1270	155	47.3	4.6
FH36	120	135	11.1	12.5	1440	178	54.3	5.2
FH37	136	165	12.6	15.3	1760	218	66.5	6.4
FH38	166	195	15.4	18.1	2020	253	77.1	7.3
FH39	196	225	18.2	20.9	2435	300	91.5	8.8
FH40	226	260	21.0	24.2	2780	345	105.2	10.0
FH41	261	310	24.3	28.8	3200	400	122.0	11.6
FH42	311	370	28.9	34.4	3915	490	149.4	14.1
FH43	371	435	34.5	40.4	4535	564	172.0	16.4
FH44	436	518	40.5	48.1	5560	690	210.4	20.1
347 V and 600 V, three-phase wye								
FH45	100	120	9.3	11.2	1275	155	47.3	3.7
FH46	121	150	11.2	13.9	1585	195	59.5	4.6
FH47	151	170	14.0	15.8	1825	220	67.1	5.3
FH48	171	205	15.9	19.1	2230	270	82.3	6.4
FH49	206	240	19.1	22.3	2550	315	96.0	7.3
FH50	241	285	22.4	26.5	3050	376	114.6	8.8
FH51	286	330	26.6	30.7	3500	430	131.1	10.1
FH52	331	380	30.8	35.3	4040	497	151.5	11.6
FH53	381	465	35.4	43.2	4935	610	186.0	14.2
FH54	466	533	43.3	49.5	5650	710	216.5	16.3
480 V								
FH55	140	167	13.0	15.5	1760	215	65.5	3.7
FH56	168	205	15.6	19.1	2190	270	82.3	4.6
FH57	206	235	19.2	21.8	2480	310	94.5	5.2
FH58	236	285	21.9	26.5	3030	380	115.9	6.3
FH59	286	335	26.6	31.1	3530	435	132.6	7.4
FH60	336	395	31.2	36.7	4220	520	158.5	8.8
FH61	396	455	36.8	42.3	4800	600	182.9	10.0
FH62	456	518	42.4	48.1	5565	690	210.4	11.6

Note: Type FH cables supplied with 15 ft (4.6 m) long cold lead.
Tolerance on heating cable length is –0% to +3%.

TABLE 12 SELECTION TABLE FOR COMFORT FLOOR HEATING

	Area coverage					Heated length		
Catalog number	**Min (ft²)**	**Max (ft²)**	**Min (m²)**	**Max (m²)**	**Cable wattage (W)**	**(ft)**	**(m)**	**Heating cable current (A)**
600 V								
FH63	170	210	15.8	19.5	2185	270	82.3	3.6
FH64	211	255	19.6	23.7	2715	340	103.7	4.5
FH65	256	295	23.8	27.4	3120	385	117.4	5.2
FH66	296	360	27.5	33.5	3830	470	143.3	6.4
FH67	361	420	33.6	39.0	4400	545	166.2	7.3
FH68	421	488	39.1	45.3	5275	650	198.2	8.8

Note: Type FH cables supplied with 15 ft (4.6 m) long cold lead.
Tolerance on heating cable length is –0% to +3%.

Advance to "Determine the heating cable spacing" on page 301.

RADIANT SPACE HEATING

For radiant space heating, the total heat loss in Btu/hr or wattage is supplied by the customer. Heating cables can be selected for single phase or three-phase voltage supplies as shown for comfort floor heating, but based on the heat loss in watts required for each area. Use Table 11 or Table 12 to select a heating cable from the "Cable wattage" column that is equal to or the next highest wattage than the wattage specified.

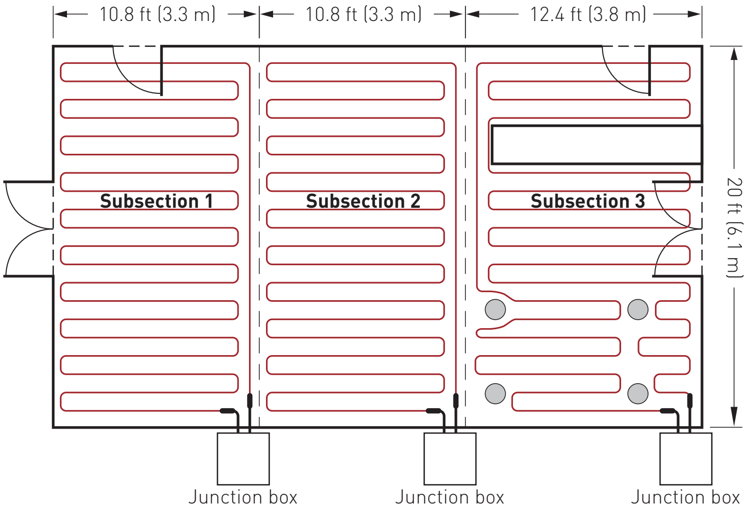


Fig. 18 Typical heating cable layout for radiant space heating

Note: In Fig. 18, the subsections are equal heated areas.

Example: MI heating cables for radiant space heating

Heated area	647 ft^2 (60.4 m^2) (from Step 3)
Supply voltage and phase	208 V, single phase (from Step 3)
Subsection area	647 ft^2 / 3 = 216 ft^2 60.4 m^2 / 3 = 20.1 m^2
Btu requirement	34,800 Btu/hr (from Step 3)
Power required	34,800 Btu/hr / 3.412 = 10200 W
Power per subsection	10200 W / 3 = 3400 W
Heating cable catalog number	**FH21** (from Table 12)
Cable wattage	**3390 W**
Cable voltage	208 V (from Table 12)
Heating cable length	425 ft (129.6 m) (from Table 12)
Number of cables	**3 (one heating cable per subsection)**

Note: Divide Btu/hr by 3.412 to convert to watts.

Advance to "Determine the heating cable spacing" following.

DETERMINE THE HEATING CABLE SPACING

In this section you will determine the heating cable spacing for heat loss replacement, comfort floor heating and radiant space heating.

For heat loss replacement, the heated area in the equation following is the total floor area. For comfort floor heating and radiant space heating, the heated area does not include the space occupied by tubs and spas, toilets, cabinets, and other permanent fixtures. This heated floor area was determined in Step 3.

$$\text{Cable spacing (in)} = \frac{\text{Heated area (ft}^2\text{) x 12 in}}{\text{Heating cable length (ft)}}$$

$$\text{Cable spacing (cm)} = \frac{\text{Heated area (m}^2\text{) x 100 cm}}{\text{Heating cable length (m)}}$$

Round to the nearest 1/2 in or nearest 1 cm to obtain cable spacing.

Note: If a large area has been divided into subsections or if a three-phase voltage supply is used, the heated area in the above equations will be the subsection area and the heating cable length will be the length of the cable selected for the subsection.

Example: MI heating cables for heat loss replacement

Subsection area	1067 ft^2 (99.1 m^2)
Heating cable catalog number	HLR24 (from Table 10)
Heating cable length	420 ft (128.0 m) (from Table 10)
Cable spacing	(1067 ft^2 x 12 in) / 420 ft = 30.5 in **Rounded to 31 in** (99.1 m^2 x 100 cm) / 128.0 m = 77.4 cm **Rounded to 77 cm**

Example: MI heating cables for comfort floor heating

Subsection area	324 ft^2 (30.2 m^2)
Heating cable catalog number	FH21 (from Table 12)
Heating cable length	425 ft (129.6 m) (from Table 12)
Cable spacing	(324 ft^2 x 12 in) / 425 ft = 9.1 in **Rounded to 9 in** (30.2 m^2 x 100 cm) / 129.6 m = 23.3 cm **Rounded to 23 cm**

Example: MI heating cables for radiant space heating

Subsection area	216 ft^2 (20.1 m^2)
Heating cable catalog number	FH21 (from Table 12)
Heating cable length	425 ft (129.6 m) (from Table 12)
Cable spacing	(216 ft^2 x 12 in) / 425 ft = 6.1 in **Rounded to 6 in** (20.1 m^2 x 100 cm) / 129.6 m = 15.5 cm **Rounded to 15 cm**

Advance to Step 5, page 303.

Floor Heating System Design Steps

1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 5 Determine the electrical parameters

In this step you will determine the electrical parameters. This section is organized by heating cable type.

For RaySol self-regulating heating cables, see below.

For MI heating cables, see page 304.

RAYSOL SELF-REGULATING HEATING CABLE

DETERMINE NUMBER OF CIRCUITS

Record the number of circuits (from Step 4) to be used on the worksheet.

SELECT BRANCH CIRCUIT BREAKING RATING

For RaySol, the circuit breaker rating was determined in Step 4 using Table 5 or Table 8.

Use ground-fault protection devices (GFPDs) for all RaySol heating cable applications.

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

DETERMINE TRANSFORMER LOAD

The total transformer load is the sum of the loads on all the circuit breakers in the system.

Calculate the Circuit Breaker Load (CBL) as:

$$\text{CBL (kW)} = \frac{\text{Circuit breaker rating (A)} \times 0.8 \times \text{Supply voltage}}{1000}$$

Calculate the Total Transformer Load as follows:

$$\text{Total Transformer Load (kW)} = \text{CBL}_1 + \text{CBL}_2 + \text{CBL}_3 ... + \text{CBL}_N$$

Example: RaySol heating cables for heat loss replacement

Heating cable catalog number	RaySol-2 (from Step 4)
Number of circuits	4 (from Step 4)
Circuit breaker rating	30 A breaker (from Step 4)
Circuit breaker load	(30 A x 0.8 x 208 V) / 1000 = 5kW
Total transformer load	**5 kW x 4 = 20 kW**

Example: RaySol heating cables for comfort floor heating

Heating cable catalog number	RaySol-2 (from Step 4)
Number of circuits	4 (from Step 4)
Circuit breaker rating	30 A breaker (from Step 4)
Circuit breaker load	(30 A x 0.8 x 208 V) / 1000 = 5kW
Total transformer load	**5 kW x 4 = 20 kW**

Advance to Step 6, page 306.

MI HEATING CABLE

DETERMINE NUMBER OF CIRCUITS

For single-phase circuits, individual heating cables are normally connected to separate circuit breakers. Multiple heating cables may be connected in parallel to reduce the number of circuits with permission from the Authority Having Jurisdiction. The single-phase heating cable current is shown in Table 10, Table 11, and Table 12.

For three-phase circuits used in floor heating systems, the three heating cables are generally connected in the delta configuration shown in Fig. 20 on page 312. Heating cables may also be connected using the wye configuration shown in Fig. 21 on page 313, but this configuration is less common. For both delta and wye configurations, each set of three equal cables form a single circuit.

SELECT BRANCH CIRCUIT BREAKING RATING

The power output and heating cable current draw for the floor heating cables are shown in Table 10, Table 11, and Table 12.

For single-phase circuits, the load current must not exceed 80% of the circuit breaker rating.

Load current = Heating cable current (for a single circuit)

Circuit breaker rating = Load current / 0.8

For a Delta connected three-phase circuit, shown in Fig. 20 on page 312, the load current can be determined by multiplying the heating cable current times 1.732 and it must not exceed 80% of the 3-pole circuit breaker rating.

Load current = Heating cable current x 1.732 (for a single Delta connected circuit)

Circuit breaker rating = Load current / 0.8

For a Wye connected three-phase circuit, shown in Fig. 21 on page 313, the load current is the same as the heating cable current and it must not exceed 80% of the 3-pole circuit breaker rating.

Load current = Heating cable current (for a single Wye connected circuit)

Circuit breaker rating = Load current / 0.8

Record the number and ratings of the circuit breakers to be used. Use ground-fault protection devices (GFPDs) for all applications. For three-phase circuits, ground fault may be accomplished using a shunt trip three-pole breaker and ground fault sensor.

Circuit breaker rating (amps) ________ Number of circuit breakers ________

⚠ **WARNING**: To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

DETERMINE TRANSFORMER LOAD

The total transformer load is the sum of the loads in the system. Calculate the Total Transformer Load as follows:

For cables of equal wattage:

$$\text{Transformer load (kW)} = \frac{\text{Cable (W)} \times \text{Number of cables}}{1000}$$

When cable wattages are not equal:

$$\text{Transformer load (kW)} = \frac{\text{Cable}_1\text{ (W)} + \text{Cable}_2\text{ (W)} + \text{Cable}_3\text{ (W)}... + \text{Cable}_N\text{ (W)}}{1000}$$

Example: MI heating cables for heat loss replacement

Heating cable catalog number	HLR24 (from Step 4)
Heating cable current	24.8 A (from Table 10)
Load current	24.8 x 1.732 = 43 A
Circuit breaker rating	**60 A breaker, 80% loading 48 A**
Number of circuit breakers	**1 (3-pole breaker)**
Cable wattage	5150 W (from Step 4)
Number of cables	3 (from Step 4)
Total transformer load	**(5150 W x 3) / 1000 = 15.5 kW**

Example: MI heating cables for comfort floor heating

Heating cable catalog number	FH21 (from Step 4)
Heating cable current	16.3 A (from Table 12)
Load current	16.3 A
Circuit breaker rating	**25 A breaker, 80% loading 20 A**
Number of circuit breakers	**2**
Cable wattage	3390 W (from Step 4)
Number of cables	2 (from Step 4)
Total transformer load	**(3390 W x 2) / 1000 = 6.8 kW**

Example: MI heating cables for radiant space heating

Heating cable catalog number	FH21 (from Step 4)
Heating cable current	16.3 A (from Table 12)
Load current	16.3 A
Circuit breaker rating	**25 A breaker, 80% loading 20 A**
Number of circuit breakers	**3**
Cable wattage	3390 W (from Step 4)
Number of cables	3 (from Step 4)
Total transformer load	**(3390 W x 3) / 1000 = 10.2 kW**

Advance to Step 6, page 306.

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 6 Select the connection kits and accessories

In this step you will determine the number of junction boxes, power connections, end seals and splice kits required. This section is separated by heating cable type.

For RaySol self-regulating heating cables, see below.

For MI heating cables, see page 307.

RAYSOL SELF-REGULATING HEATING CABLE

SELECT NUMBER OF POWER CONNECTION KITS

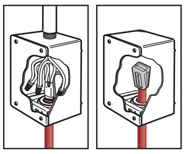
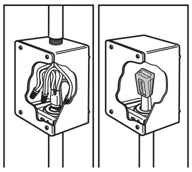
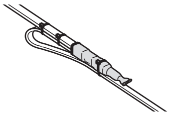
For heat loss replacement, one FTC-P power connection kit and two junction boxes are required per circuit. For comfort floor heating, one FTC-XC power connection kit and two junction boxes are required per circuit

SELECT JUNCTION BOX

Select a contractor-supplied UL Listed and/or CSA Certified junction box that is suitable for the location. Use a box with minimum internal volume of 16 cubic inches if the box is metallic and 19 cubic inches if the box is not metallic.

Note: The junction box must be accessible according to national electrical codes.

TABLE 13 CONNECTION KITS AND ACCESSORIES

	Catalog number	Description	Standard packaging	Usage
RaySol Connection Kits				
	FTC-P	Power connection and end seal. (Junction box not included)	1	1 per cable run (for heat loss replacement)
	FTC-XC	Power connection and end seal. (Junction box not included)	1	1 per cable run (for comfort floor heating and radiant space heating)
	FTC-HST	Low-profile splice/tee	2	As required (for embedded applications, splice must be accessible)
	RayClic-E	Extra end seal	1	Replacement end seal

Example: RaySol heating cables for heat loss replacement

Junction box	Contractor supplied
Quantity	8
Connection kit	FTC-P
Quantity	4

Example: RaySol heating cables for comfort floor heating

Junction box	Contractor supplied
Quantity	8
Connection kit	FTC-XC
Quantity	4

Advance to Step 7, page 308.

MI HEATING CABLES

A typical Raychem floor heating system consists of several accessories. All of the accessories work together to provide a safe and reliable floor heating system that is easy to install and maintain.

SELECT JUNCTION BOX

Select a UL Listed and/or CSA Certified junction box that is suitable for the location, such as the Raychem D1297TERM4. Use a box with minimum internal volume of 16 cubic inches if the box is metallic and 19 cubic inches if the box is not metallic. Metal junction boxes are recommended.

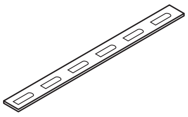
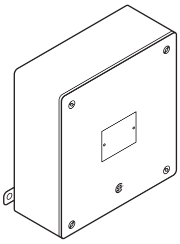
Note: The junction box must be accessible according to the national electrical codes.

SELECT PREPUNCHED STRAPPING

For heat loss replacement applications, use stainless steel prepunched strapping attached to the bottom of the concrete floor to secure the heating cables at the proper spacing. For floor heating applications where the heating cable is embedded in concrete or mortar floors, use galvanized steel prepunched strapping to maintain the heating cables at the proper spacing.

Number of rolls required = Total area (ft^2) x 0.005 (Total area (m^2) x 0.05)

TABLE 14 ACCESSORIES

	Catalog number	Description	Standard packaging	Usage
	HARD-SPACER-GALV-25MM-25M	Galvanized steel prepunched strapping. **Note:** Use when cable is embedded in concrete or mortar.	82 ft (25 m) rolls	No. rolls = 0.005 x area (ft^2) No. rolls = 0.05 x area (m^2)
	HARD-SPACER-SS-25MM-25M	Stainless steel prepunched strapping **Note:** Use with all heat loss replacement applications.	82 ft (25 m) rolls	No. rolls = 0.005 x area (ft^2) No. rolls = 0.05 x area (m^2)
	D1297TERM4	A cast aluminum junction box (NEMA 3) for installation in nonhazardous and CID2 locations. Three 1/2" NPT entries on bottom, provided with plugs. Includes 4-pole terminal block (CSA - 600 V, 65 A, 18 - 6 AWG; UL - 300 V, 65 A, 18 - 6 AWG). External mounting feet. CSA approved for Class I, Div. 2, Groups A, B, C, and D. Enclosure dimensions: 6 in x 6 in x 4 in (150 mm x 150 mm x 100 mm).	1	

Example: MI heating cables for heat loss replacement

Junction box	Contractor supplied
Quantity	1 (7 entries)
Prepunched strapping	HARD-SPACER-SS-25MM-25M
Quantity	16

Example: MI heating cables for comfort floor heating

Junction box	D1297TERM4
Quantity	2
Prepunched strapping[1]	HARD-SPACER-GALV-25MM-25M
Quantity	4

Example: MI heating cables for radiant space heating

Junction box	D1297TERM4
Quantity	3
Prepunched strapping[1]	HARD-SPACER-GALV-25MM-25M
Quantity	4

[1] For comfort floor heating and radiant space heating applications in slab floors, prepunched strapping may not be required if it is possible to attach the heating cable to the reinforcement.

Advance to Step 7, page 308.

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 7 Select the control system

There are two types of controls that may be used with floor heating systems: floor temperature sensing control and ambient temperature control with overlimit sensor.

Floor temperature sensing control must be used for heat loss replacement and comfort floor heating applications, while an ambient temperature control with an overlimit sensor must be used for radiant space heating applications.

For RaySol and MI heating cables, the recommended control for heat loss replacement and comfort floor heating is Raychem ECW-GF. For RaySol or MI heating cable installations where temperature control and temperature monitoring is desired, a Thermal Management Raychem C910-485 or Raychem ACS-30 controller is recommended.

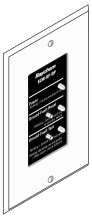
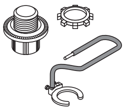
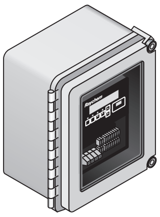
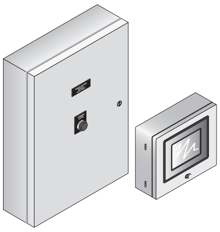
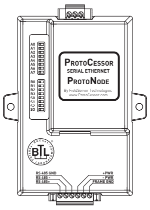
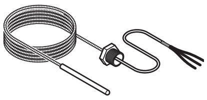
TABLE 15 TEMPERATURE CONTROL OPTIONS

Features	**Raychem ECW-GF**	**Raychem C910-485** [2]	**Raychem ACS-30**
Number of heating cable circuits	Single	Single	Multiple
Sensor	Thermistor	RTD [1]	See data sheet
Sensor length	25 ft	Varies	"
Set point range	32°F to 200°F (0°C to 93°C)	–0°F to 200°F (–18°C to 93°C)	"
Enclosure	NEMA 4X	NEMA 4X	"
Deadband	2°F to 10°F (2°C to 6°C)	1°F to 10°F (1°C to 6°C)	"
Enclosure limits	–40°F to 140°F (–40°C to 60°C)	–40°F to 140°F (–40°C to 60°C)	"
Switch rating	30 A	30 A	"
Switch type	DPST	DPST	"
Electrical rating	100–277 V	100–277 V	"
Approvals	c-UL-us	c-CSA-us	"
Ground-fault protection	30 mA fixed	20 mA to 100 mA (adjustable)	"
Alarm outputs			
AC relay	2 A at 277 Vac	100–277 V, 0.75 A max.	"
Dry contact relay	2 A at 48 Vdc	48 Vac/dc, 500 mA max.	"

[1] Ordered separately

[2] The C910-485 is available to provide RS-485 communication capability. Connect to the BMS using Raychem ProtoNode multi-protocol gateways

TABLE 16 CONTROL SYSTEMS

	Catalog number	Description
Electronic thermostats and accessories		
	ECW-GF	Electronic ambient sensing controller with 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor and is housed in a Type 4X rated enclosure. The controller features an AC/DC dry alarm contact relay. An optional ground-fault display panel (ECW-GF-DP) can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	ECW-GF-DP	An optional remote display panel (ECW-GF-DP) that can be added to provide ground-fault or alarm indication in applications where the controller is mounted in inaccessible locations.
	MI-GROUND-KIT	Grounding kit for nonmetallic enclosures (for MI only)
Electronic controllers and sensors		
	C910-485	The C910-485 is a compact, full-featured microprocessor-based single-point heat-trace controller. The C910-485 provides control and monitoring of electrical heat-tracing circuits for both freeze protection and temperature maintenance, and can be set to monitor and alarm for high and low temperature, high and low current, ground-fault level, and voltage. The Raychem C910-485 controller is available with an electromechanical relay (EMR) for use in ordinary areas. The C910-485 comes with an RS-485 communication module.
	ACS-UIT2 ACS-PCM2-5	The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in various commercial applications such as pipe freeze protection, roof and gutter de-icing, surface snow melting, hot water temperature maintenance and floor heating. The Raychem ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, with a single ACS-UIT2 user interface terminal. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V.
	ProtoNode-RER	The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the Raychem ACS-30 or C910-485 controllers. ProtoNode-RER is for BACnet® or Metasys® N2 systems.
	RTD-200 RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with Raychem C910-485 and ACS-30 controllers. RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing RTD50CS: temperature sensor with a 50-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing

Example: RaySol heating cables for heat loss replacement

Multiple circuits, monitoring requested	ACS-30
Quantity	1

Example: MI heating cables for heat loss replacement

Single circuit, monitoring requested	ACS-30*
Quantity	1

* Use ACS-30 General part number (P000001232) for custom three-phase panels. Please contact your Thermal Management representative for a custom ACS-PCM2-5 panel quotation.

Example: RaySol and MI heating cables for comfort floor heating

Multiple circuits, electronic thermostat requested	ECW-GF
Quantity	1

Example: MI heating cables for radiant space heating

Multiple circuits, electronic thermostat requested[1]	ECW-GF
Quantity	1

[1] Ambient control to be supplied by the contractor

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 8 Select the power distribution

Power to the heating cables can be provided in several ways:

- Directly through the temperature controller
- Through external contactors activated by a temperature controller
- Through an HTPG power distribution panel

SINGLE CIRCUIT CONTROL

RaySol and MI heating cable circuits that do not exceed the current rating of the selected control can be switched directly (Fig. 20). When the total electrical load exceeds the rating of the controller, an external contactor is required.

The three-phase Delta and Wye configurations shown in Fig. 20 and Fig. 21 are common wiring configurations for MI heating cables used to heat large areas. DO NOT use these wiring configurations for RaySol heating systems. A single pole temperature controller may be used to control a three-phase circuit through a contactor.

GROUP CONTROL

For group control, a single temperature controller may be used to control two or more single-phase or three-phase circuits. Multiple single-phase RaySol or MI heating cable circuits may be controlled by a single temperature controller, through a contactor, as shown in Fig. 19. Multiple three-phase MI heating cable circuits may be controlled in the same manner.

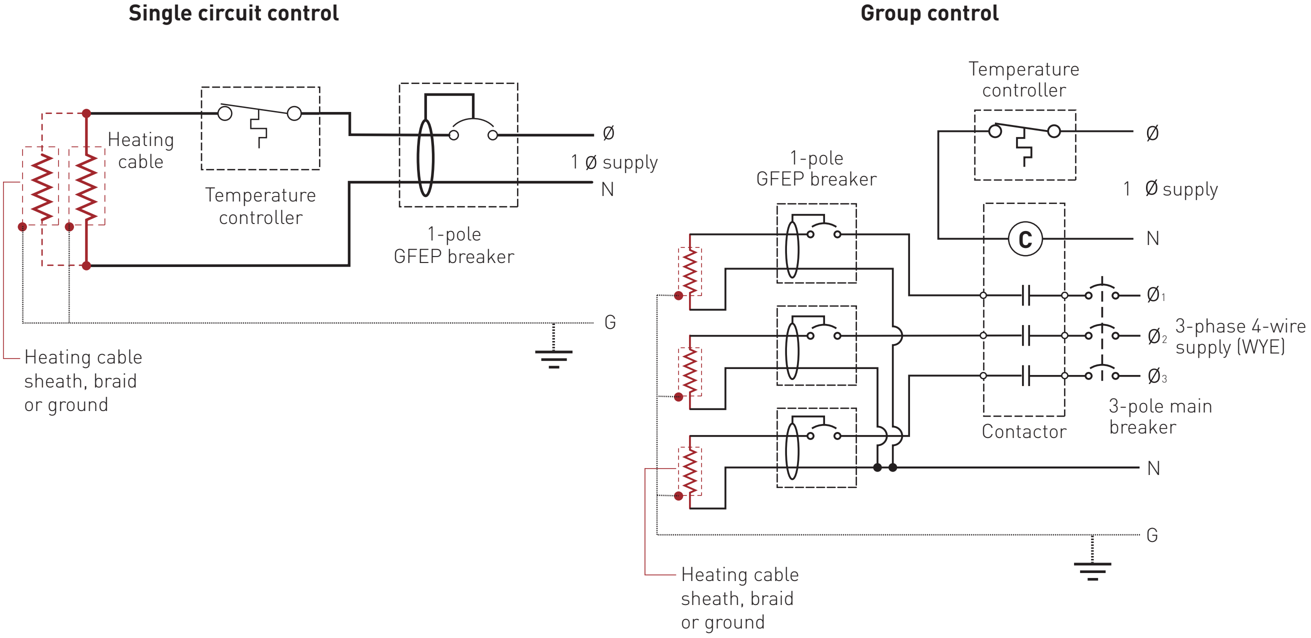
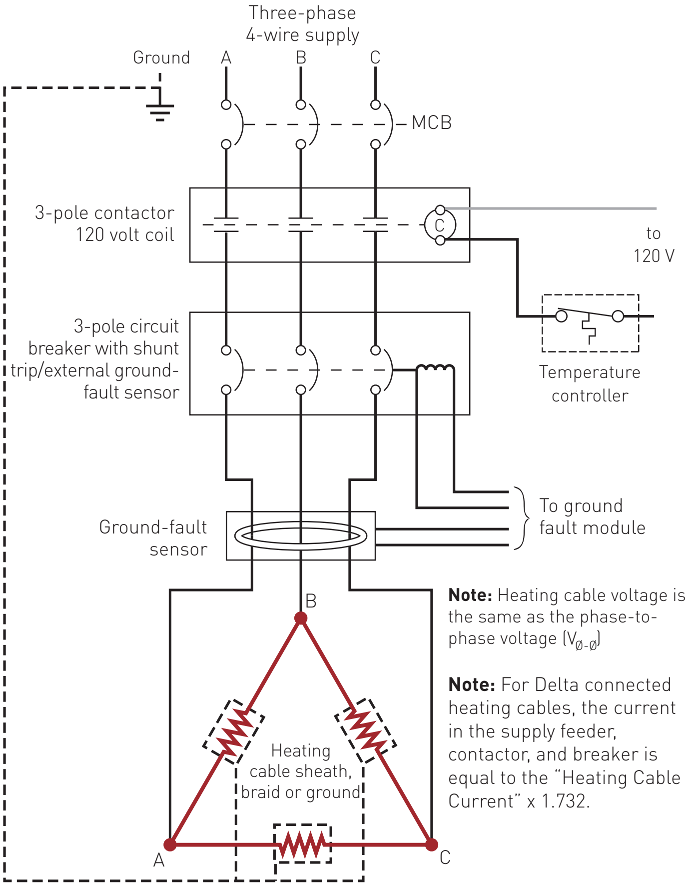


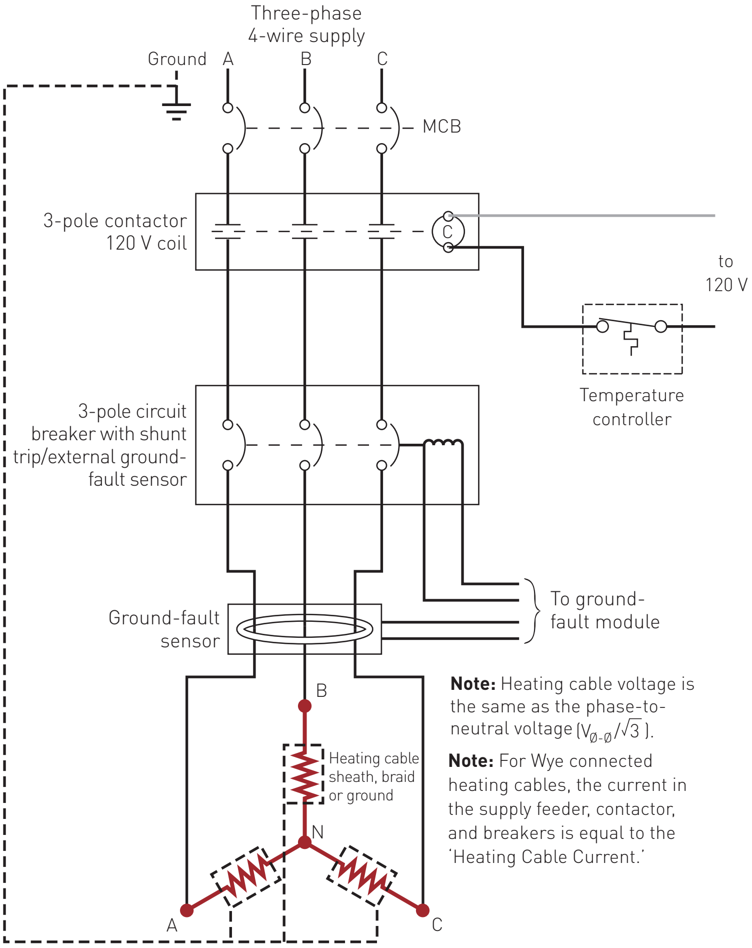
Fig. 19 Single circuit and group control



Note: Heating cable voltage is the same as the phase-to-phase voltage ($V_{Ø-Ø}$)

Note: For Delta connected heating cables, the current in the supply feeder, contactor, and breaker is equal to the "Heating Cable Current" x 1.732.

Fig. 20 Typical single circuit control for three-phase delta connected cables

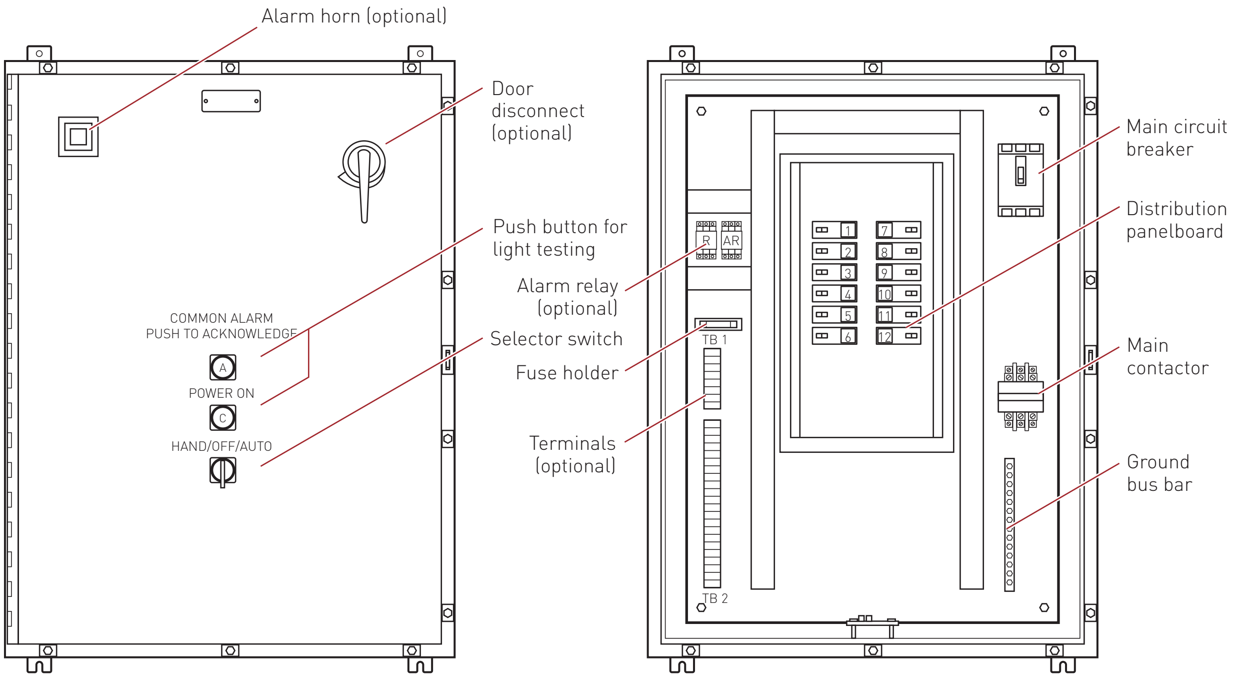


Note: Heating cable voltage is the same as the phase-to-neutral voltage $(V_{\text{Ø-Ø}}/\sqrt{3})$.

Note: For Wye connected heating cables, the current in the supply feeder, contactor, and breakers is equal to the 'Heating Cable Current.'

Fig. 21 Typical single circuit control for three-phase wye connected cables

Large systems with many circuits should use an HTPG power distribution panel. The HTPG is a dedicated power-distribution, control, ground-fault protection, monitoring, and alarm panel for broad temperature-maintenance heat-tracing applications. This enclosure contains an assembled circuit-breaker panelboard. Panels are equipped with ground-fault circuit breakers with or without alarm contacts. The group control package allows the system to operate automatically in conjunction with a temperature control system.



Alarm option shown above

Fig. 22 HTPG power distribution panel

Three-phase, 4 wire supply (Wye)

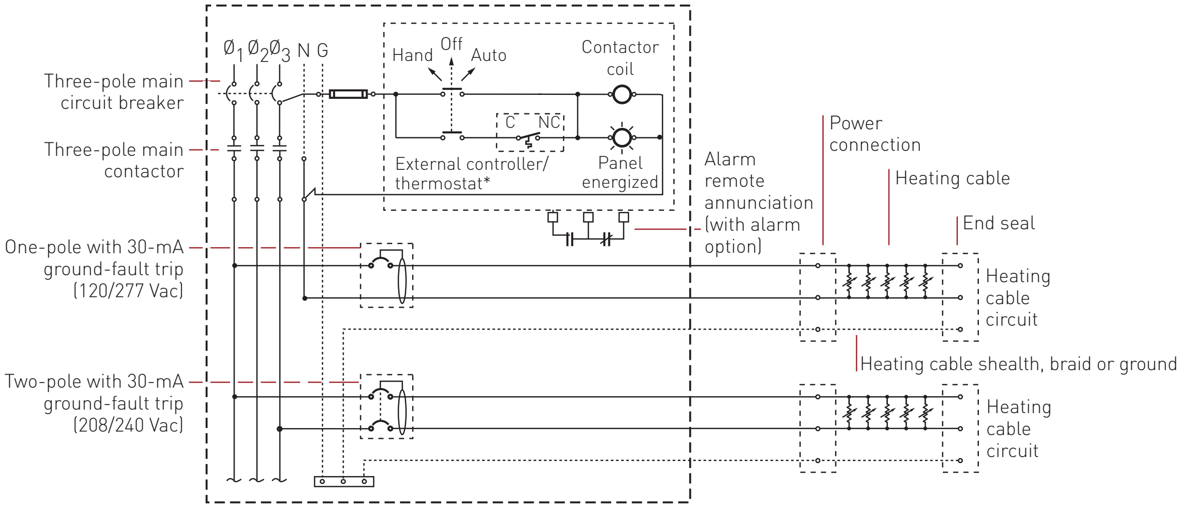
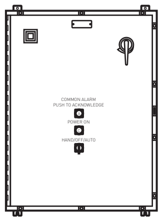


Fig. 23 HTPG power schematic

TABLE 17 POWER DISTRIBUTION

	Catalog number	Description
Power Distribution and Control Panels		
	HTPG	Heat-tracing power distribution panel with ground-fault and monitoring for group control.

Floor Heating System Design Steps
1. Determine the application
2. Select the heating cable system and installation method
3. Determine the floor configuration
4. Determine the heating cable spacing, layout and length
5. Determine the electrical parameters
6. Select the connection kits and accessories
7. Select the control system
8. Select the power distribution
9. Complete the Bill of Materials

Step 9 Complete the Bill of Materials

If you used the Design Worksheet to document all your design parameters, you should have all the details necessary complete your Bill of Materials.

FLOOR HEATING PRE-DESIGN WORKSHEET

Step 1 Determine the application (see page 277)

Select the application that best describes your needs

☐ Heat loss replacement
☐ Comfort floor heating
☐ Radiant space heating

If you have selected the radiant space heating application, use the MI Heating Cable Floor Heating Design Worksheet on page 325.

Step 2 Determine the installation method

Select the installation you plan to use.

Heat loss replacement

☐ Attach to the bottom of the floor
    ☐ RaySol
    ☐ MI

Comfort floor heating

☐ Embed in concrete
    ☐ RaySol
    ☐ MI
☐ Embed in mortar bed
    ☐ RaySol
    ☐ MI

Radiant space heating

☐ Embed in concrete
    ☐ RaySol*
    ☐ MI
☐ Embed in mortar bed
    ☐ RaySol*
    ☐ MI

* Please contact Thermal Management for design assistance.

RAYSOL HEATING CABLE FLOOR HEATING DESIGN WORKSHEET

Heat Loss Replacement

Step 3 Determine the floor configuration (Steps 1 and 2 were completed in the pre-design worksheet)

Heat loss replacement (see Fig. 9 on page 279)	**Minimum ambient design temperature**	**Insulation R-value**	**Supply voltage and phase**	**Control requirements**
______ X ______ = ______ Side A (length) (ft/m) X Side B (width) (ft/m) = **Heated area (ft^2/m^2)**	______°F/°C	______ ft^2·°F·hr/Btu	______Volts ______ Phase	______ ______

Example: RaySol heating cables for heat loss replacement

80 ft X **40 ft** = **3200 ft^2** Side A (length) (ft/m) X Side B (width) (ft/m) = **Heated area (ft^2/m^2)**	**–10°F**	**R-20** **(20 ft^2·°F·hr/Btu)**	**208 V** **Single phase**	**Electronic thermostat, monitoring requested**

Step 4 Determine the heating cable spacing, layout and length

4.1 Select the appropriate RaySol heating cable (see Table 3 on page 282)

Supply voltage: ______________ (from Step 3)
Catalog number: ______________ (from Table 3)

Example: RaySol heating cables for heat loss replacement

Supply voltage: 208 V (from Step 3)
Catalog number: **RaySol-2** (from Table 3)

4.2 Determine the RaySol heating cable spacing (see Table 4 on page 283)

Minimum ambient temperature: __________°F/°C (from Step 3)
Insulation R-value: __________ (from Step 3)
Heating cable spacing: __________in/cm (from Table 4)

Example: RaySol heating cables for heat loss replacement

Minimum ambient temperature: –10°F (from Step 3)
Insulation R-value: R-20 (from Step 3)
Heating cable spacing: **24 in** (from Table 4)

4.3 Determine the RaySol heating cable layout and length

Imperial

(__________ x 12) / __________ = __________
Heated area (ft^2) (from Step 3) / Heating cable spacing (in) (from Step 4.2) = **Estimated heating cable length**

Metric

(__________ x 100) / __________ = __________
Heated area (m^2) (from Step 3) / Heating cable spacing (cm) (from Step 4.2) = **Estimated heating cable length**

Example: RaySol heating cables for heat loss replacement

Estimate the heating cable length

(3200 ft^2 x 12) / 24 in = **1600 ft**
Heated area (ft^2) (from Step 3) / Heating cable spacing (from Step 4.2) = **Estimated heating cable length**

Step 4 Determine the heating cable spacing, layout and length

4.4 Determine the maximum circuit length for the heating cable length (see Table 5 on page 284)

______________	/	______________	=	______________
Estimated heating cable length (ft/m) (from Step 4.3)		Maximum circuit length (ft/m) (from Table 5)		**Number of circuits**

Round the number of circuits to the next larger whole number

Example: RaySol heating cables for heat loss replacement

1600 ft	/	410 ft	=	**4 (rounded)**
Estimated heating cable length (from Step 4.3)		Maximum circuit length (from Table 5)		**Number of circuits**

Power supply: **Four 30 A circuit breakers**

Step 4 Determine the heating cable spacing, layout and length

4.5 Determine the additional heating cable allowance (see Table 6 on page 285)

End allowance

______	x	______	x	______	=	______
Number of circuits (from Step 4.4)		ft/m per end (from Table 6)		Number of ends		**End allowance (ft/m)**

Connection kit allowance

______	x	______	=	______
Number of kits		ft/m per connection kit (from Table 6)		**Connection kit allowance (ft/m)**

Total heating cable allowance

______	+	______	=	______
End allowance (ft/m)		Connection kit allowance (ft/m)		**Total heating cable allowance (ft/m)**

Estimated total heating cable length

______	+	______	=	______
Estimated heating cable length (ft/m) (from Step 4.3)		Total heating cable allowance (ft/m)		**Estimated total heating cable length (ft/m)**

Example: RaySol heating cables for heat loss replacement

End allowance

4	x	**4**	x	**2**	=	**32 ft**
Number of circuits (from Step 4.4)		ft/m per end (from Table 6)		Number of ends		**End allowance**

Connection kit allowance

4	x	**4**	=	**16 ft**
Number of kits		ft/m per connection kit (from Table 6)		**Connection kit allowance**

Total heating cable allowance

32 ft	+	**16 ft**	=	**48 ft**
End allowance		Connection kit allowance		**Total heating cable allowances (ft/m)**

Estimated total heating cable length

1600 ft	+	**48 ft**	=	**1648 ft**
Estimated heating cable length (from Step 4.3)		Total heating cable allowances (ft/m)		**Estimated total heating cable length (ft/m)**

4.6 Locate the junction boxes for the RaySol heating cable (see Fig. 12 on page 283 for examples of a typical system)

4.7 Lay out the heating cable runs, circuits, and junction boxes

4.8 Record the circuit information

Advance Step 5 on page 323.

Comfort Floor Heating

Step 3 Determine the floor configuration (Steps 1 and 2 were completed in the pre-design worksheet)

Comfort floor heating (see Fig. 10 on page 280)			**Minimum ambient design temperature**	**Insulation R-value**	**Supply voltage and phase**	**Control requirements**
____________	– ____________	= ____________	________°F/°C	____________	________Volts	____________
Total area (ft^2/m^2)	Permanent fixture (ft^2/m^2)	**Heated area (ft^2/m^2)**		ft^2·°F·hr/Btu	________ Phase	____________

Step 4 Determine the heating cable spacing, layout and length

4.1 Select the appropriate RaySol heating cable (see Table 3 on page 282)

Supply voltage: ________________ (from Step 3)

Catalog number: ________________ (from Table 3)

Example: RaySol heating cables for comfort floor heating

Supply voltage: 208 V (from Step 3)

Catalog number: **RaySol-2** (from Table 3)

4.2 Determine the RaySol heating cable spacing (see Table 7 on page 286)

Minimum ambient design temperature: ___________°F/°C (from Step 3)

Insulation R-value: ___________ (from Step 3)

Heating cable spacing: ___________in/cm (from Table 7)

Example: RaySol heating cables for comfort floor heating

Minimum ambient design temperature: 10°F (from Step 3)

Insulation R-value: R-30 (from Step 3)

Heating cable spacing: **8 in** (from RaySol Heating Cable Spacing for Comfort Floor Heating)

Step 4 Determine the heating cable spacing, layout and length

4.3 Determine the RaySol heating cable layout and length (see Fig. 14 on page 287)

Imperial

(________ x 12) / ________ = ________

Heated area (ft^2) (from Step 3) / Heating cable spacing (in) (from Step 4.2) = **Estimated heating cable length**

Metric

(________ x 100) / ________ = ________

Heated area (m^2) (from Step 3) / Heating cable spacing (cm) (from Step 4.2) = **Estimated heating cable length**

Example: RaySol heating cables for comfort floor heating

Estimate the heating cable length

(647 ft^2 x 12) / 8 in = **971 ft**

Heated area (ft) (from Step 3) / Heating cable spacing (from Step 4.2) = **Estimated heating cable length**

4.4 Determine the maximum circuit length for the heating cable length and layout (see Table 8 on page 287)

________ / ________ = ________

Estimated heating cable length (ft/m) (from Step 4.3) / Maximum circuit length (ft/m) (from Table 8) = **Number of circuits**

Round the number of circuits to the next larger whole number

Example: RaySol heating cables for comfort floor heating

971 ft / 275 ft = **4 (rounded)**

Estimated heating cable length required (from Step 4.3) / Maximum heating cable circuit length (from Table 8) = **Number of circuits**

Power supply: **Four 30 A circuit breakers** (from Table 8)

Step 4 Determine the heating cable spacing, layout and length

4.5 Determine the additional heating cable allowance (see Table 6 on page 285)

End allowance

	x		x		=	
Number of circuits (from Step 4.4)		ft/m per end (from Table 6)		Number of ends		**End allowance (ft/m)**

Connection kit allowance

	x		=	
Number of kits		ft/m per connection kit (from Table 6)		**Connection kit allowance (ft/m)**

Total heating cable allowance

	+		=	
End allowance (ft/m)		Connection kit allowance (ft/m)		**Total heating cable allowance (ft/m)**

Estimated total heating cable length

	+		=	
Estimated heating cable length (ft/m) (from Step 4.3)		Total heating cable allowance (ft/m)		**Estimated total heating cable length (ft/m)**

Example: RaySol heating cables for comfort floor heating

End allowance

4	x	**4**	x	**2**	=	**32 ft**
Number of circuits (from Step 4.4)		ft/m per end (from Table 6)		Number of ends		**End allowance**

Connection kit allowance

4	x	**4**	=	**16 ft**
Number of kits		ft/m per connection kit (from Table 6)		**Connection kit allowance**

Total heating cable allowance

32 ft	+	**16 ft**	=	**48 ft**
End allowance		Connection kit allowance		**Total heating cable allowance (ft/m)**

Estimated total heating cable length

971 ft	+	**48 ft**	=	**1019 ft**
Estimated heating cable length (from Step 4.3)		Total heating cable allowance (ft/m)		**Estimated total heating cable length (ft/m)**

4.6 Locate the junction boxes for the RaySol heating cable (see Fig. 12 on page 283 for examples of a typical system)

4.7 Lay out the heating cable runs, circuits, and junction boxes

4.8 Record the circuit information

Step 5 Determine the electrical parameters

Determine transformer load

Calculate the circuit breaker load (CBL)

(______ x **0.8** x ______) / **1000** → = ______
Circuit breaker rating — Supply voltage — **Circuit breaker load (kW)**

If the CBL is equal on all circuits, calculate the transformer load as:

______ x ______ → = ______
Circuit breaker load (kW) — Number of breakers — **Total transformer load (kW)**

If the CBL is NOT equal on all circuits, calculate the transformer load as:

$\_\_\_$ + $\_\_\_$ + $\_\_\_$ + $\_\_\_$ → = ______
CBL_1 + CBL_2 + CBL_3… + CBL_N — **Total transformer load (kW)**

Example: RaySol cables for heat loss replacement and comfort floor heating

Determine transformer load:

(**30 A** x **0.8** x **208 V**) / **1000** → = **Rounded to 5 kW**
Circuit breaker rating — Supply voltage — **Circuit breaker load (kW)**

5 kW x **4** → = **20 kW**
Circuit breaker load (kW) — Number of breakers — **Total transformer load (kW)**

Step 6 Select the connection kits and accessories

RaySol connection kits	Quantity
☐ FTC-P	______
☐ FTC-XC	______
☐ FTC-HST	______
☐ RayClic-E	______

Example: RaySol heating cables for heat loss replacement

✓ FTC-P (1 per cable run)	**4**

Example: RaySol heating cables for comfort floor heating

✓ FTC-XC (1 per cable run)	**4**

Step 7 Select the control system (see Table 16 on page 309)

Control system	Quantity
☐ ECW-GF	______
☐ ECW-GF-DP	______
☐ MI-GROUND-KIT	______
☐ C910-485	______
☐ ACS-UIT2	______
☐ ACS-PCM2-5	______
☐ ProtoNode-RER	______
☐ RTD10CS	______
☐ RTD-200	______
☐ RTD50	______

Example: RaySol heating cables for heat loss replacement

✓ Raychem ACS-30	**1**

Example: RaySol heating cables for comfort floor heating

✓ **ECW-GF**	**1**

Step 8 Select the power distribution (see Table 17 on page 315)

Power Distribution and Control Panels	**Quantity**
☐ HTPG	____________

Step 9 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

MI HEATING CABLE FLOOR HEATING DESIGN WORKSHEET

Heat Loss Replacement

Step 3 Determine the floor configuration (Steps 1 and 2 were completed in the pre-design worksheet)

Heat loss replacement (see Fig. 9 on page 279)	**Minimum ambient design temperature**	**Insulation R-value**	**Supply voltage and phase**	**Control requirements**
________ x ________ = ________ Side A (length) (ft/m) x Side B (width) (ft/m) = **Heated area (ft^2/m^2)**	______°F/°C	____________ ft^2·°F·hr/Btu	_______Volts _______ Phase	____________ ____________

Example: MI heating cables for heat loss replacement

80 ft X **40 ft** = **3200 ft^2** Side A (length) (ft/m) X Side B (width) (ft/m) = **Heated area (ft^2/m^2)**	**–10°F**	**R-20** **(20 ft^2·°F·hr/Btu)**	**208 V** **Three-phase**	**Electronic thermostat, monitoring requested**

Step 4 Determine the heating cable spacing, layout and length

4.1 Select heating cable (For design power, see Table 9 on page 291; for heating cable selection, see Table 10 on page 294.)

Determine the design power

Heated area: ________________ (from Step 3)
Supply voltage and phase: ________________ (from Step 3)
Minimum ambient design temperature: ________________ (from Step 3)
Insulation R-value: ________________ (from Step 3)
Design power: ________________ (from Table 9 on page 291)

Determine the power requirement:

Single-phase supply

____________ x ________________ = ________________
Design power (W/ft^2) (W/m^2) x Total area or subsection area (ft^2/m^2) = **Power required (W)**

Three-phase supply

____________ x ________________ = ________________
Design power (W/ft^2) (W/m^2) x Subsection area (ft^2/m^2) = **Power required (for each subsection) (W)**

Select the heating cable

Heating cable catalog number: ________________ (from Table 10 on page 294)
Cable wattage: ________________ (from Table 10 on page 294)
Cable voltage: ________________ (from Table 10 on page 294)
Heating cable length: ________________ (from Table 10 on page 294)
Number of cables: ________________

Step 4 Determine the heating cable spacing, layout and length

Example: MI heating cables for heat loss replacement

Determine the design power

Heated area:	3200 ft² (from Step 3)
Supply voltage and phase:	208 V, three-phase (from Step 3)
Minimum ambient design temperature:	–10°F (from Step 3)
Insulation R-value:	R-20 (from Step 3)
Design power:	2.2 W/ft² (from Table 9 on page 291)

Determine the power requirement:

Three-phase supply (see Fig.18)

$$\frac{2.2\ \text{W/ft}^2}{\text{Design power}} \times \left(\frac{3200\ \text{ft}^2}{\text{Heated area}} \;/\; \frac{3}{\text{Number of subsections}} \right) = \frac{\mathbf{2347\ W}}{\textbf{Power required}}$$

Heating cable catalog number:	HLR24 (from Table 10 on page 294)
Cable wattage:	5150 W (from Table 10 on page 294)
Cable voltage:	208 V (from Table 10 on page 294)
Heating cable length:	420 ft (from Table 10 on page 294)
Number of cables:	3 (one cable required for each subsection)

4.2 Determine the heating cable spacing

Imperial

$$\left(\frac{\qquad}{\text{Area (ft}^2\text{)}} \times 12\ \text{in} \right) \;/\; \frac{\qquad}{\text{Heating cable length (ft)}} = \frac{\qquad}{\textbf{Cable spacing (in)}}$$

Metric

$$\left(\frac{\qquad}{\text{Area (m}^2\text{)}} \times 100\ \text{cm} \right) \;/\; \frac{\qquad}{\text{Heating cable length (m)}} = \frac{\qquad}{\textbf{Cable spacing (cm)}}$$

Example: MI heating cables for heat loss replacement

Subsection area:	1067 ft² (from Step 4.1)
Heating cable catalog number:	HLR24 (from Step 4.1)
Heating cable length:	420 ft (from Step 4.1)

$$\left(\frac{1067\ \text{ft}^2}{\text{Subsection area}} \times 12\ \text{in} \right) \;/\; \frac{420\ \text{ft}}{\text{Heating cable length}} = \frac{\textbf{31 in (rounded)}}{\textbf{Cable spacing (in)}}$$

Advance Step 5 on on page 330.

Step 3 Determine the floor configuration (Steps 1 and 2 were completed in the pre-design worksheet)

Comfort floor heating (see Fig. 10 on page 280)	**Minimum ambient design temperature**	**Insulation R-value**	**Supply voltage and phase**	**Control requirements**
______ – ______ = ______ Total area (ft^2/m^2) – Permanent fixture space (ft^2/m^2) = **Heated area (ft^2/m^2)**	______°F/°C	______ ft^2·°F·hr/Btu	______ Volts ______ Phase	______ ______

Example: MI heating cables for comfort floor heating

34 ft (Side A, see Figure 12) x 20 ft (Side B, see Figure 12) = **680 ft^2** (**Total area**)

680 ft^2 (Total area) – (22 ft^2 counter + 11 ft^2 columns) (Permanent fixture space, see Figure 12) = **647 ft^2** (**Heated area**)

Minimum ambient design temperature:	**10°F**
Insulation R-value:	**R-30**
Supply voltage and phase:	**208 V, single phase**
Control requirements:	**Electronic thermostat**

Step 4 Determine the heating cable spacing, layout, and length

4.1 Select the heating cable (see Table 11 on page 297 and Table 12 on page 298)

Heated area: ______ (from Step 3)

Supply voltage and phase: ______ (from Step 3)

Subsection area:

______ / ______ = ______

Heated area (ft^2/m^2) / Number of subsections = **Subsection area (ft^2/m^2)**

Heating cable catalog number: ______ (from Table 11 on page 297 or Table 12 on page 298)

Cable wattage: ______ (from Table 11 on page 297 or Table 12 on page 298)

Cable voltage: ______ (from Table 11 on page 297 or Table 12 on page 298)

Heating cable length: ______ (from Table 11 on page 297 or Table 12 on page 298)

Number of cables: ______

Example: MI heating cables for comfort floor heating

Note: In this example, the subsections are equal heated areas.

Supply voltage and phase:	208 V, single phase (from Step 3)
Subsection area:	(see Fig. 17 on page 296)

647 ft^2 (Heated area (ft^2/m^2)) / 2 (Number of subsections) = **324 ft^2** (**Subsection area (ft^2/m^2)**)

Heating cable catalog number:	FH21 (from Table 12 on page 298)
Cable wattage:	3390 W (from Table 12 on page 298)
Cable voltage:	208 V (from Table 12 on page 298)
Heating cable length:	425 ft (from Table 12 on page 298)
Number of cables:	2 (one cable required for each subsection)

Step 4 Determine the heating cable spacing, layout, and length

4.2 Determine the heating cable spacing

Imperial

(________ Area (ft²) x 12 in) / ________ Heating cable length (ft) = ________ **Cable spacing (in)**

Metric

(________ Area (m²) x 100 cm) / ________ Heating cable length (m) = ________ **Cable spacing (cm)**

Round to the nearest 1/2 in or 1cm.

Example: MI heating cables for comfort floor heating

Subsection area:	324 ft² (from Step 4.1)
Heating cable catalog number:	FH21 (from Step 4.1)
Heating cable length:	425 ft (from Step 4.1)

(324 ft² / Area x 12 in) / 425 ft / Heating cable length = **9 in (rounded)** / **Cable spacing (in)**

Advance Step 5 on page 330.

Radiant Space Heating

Step 3 Determine the floor configuration (Steps 1 and 2 were completed in the pre-design worksheet)

Radiant space heating (see Fig. 11 on page 281)	**Btu requirement** (supplied by engineer)	**Supply voltage and phase**	**Control requirements**
________ Total area (ft²/m²) – ________ Permanent fixture space (ft²/m²) = ________ **Heated area (ft²/m²)**	________ Btu/hr	________Volts ________ Phase	________ ________

Example: MI heating cables for radiant space heating

34 ft / Side A (see Figure 13) x 20 ft / Side B (see Figure 13) = **680 ft²** / **Total area**

680 ft² / Total area – (22 ft² counter + 11 ft² columns) / Permanent fixture space (see Figure 13) = **647 ft²** / **Heated area**

Btu requirement:	**34,800 Btu/hr** (supplied by engineer)
Supply voltage and phase:	**208 V, single phase**
Control requirements:	**Electronic thermostat**

Step 4 Determine the heating cable spacing, layout, and length

4.1 Select the heating cable

Heated area: ________________ (from Step 3)

Supply voltage and phase: ________________ (from Step 3)

Subsection area:

$$\frac{\_\_\_\_\_\_\_\_}{\text{Heated area (ft}^2/\text{m}^2)} \; / \; \frac{\_\_\_\_\_\_\_\_}{\text{Number of subsections}} = \frac{\_\_\_\_\_\_\_\_}{\textbf{Subsection area (ft}^2/\textbf{m}^2)}$$

Btu requirement: ________________ (from Step 3)

Power required:

$$\frac{\_\_\_\_\_\_\_\_}{\text{Btu/hr}} \; / \; 3.412 = \frac{\_\_\_\_\_\_\_\_}{\textbf{Power requirement (W)}}$$

Power per subsection: ________________

Heating cable catalog number: ________________ (from Table 11 on page 297 or Table 12 on page 298)

Cable wattage: ________________ (from Table 11 on page 297 or Table 12 on page 298)

Cable voltage: ________________ (from Table 11 on page 297 or Table 12 on page 298)

Heating cable length: ________________ (from Table 11 on page 297 or Table 12 on page 298)

Number of cables: ________________

Example: MI heating cables for radiant space heating

Note: In this example, the subsections are equal heated areas.

Heated area:	647 ft²
Supply voltage and phase:	208 V, single-phase (from Step 3)
Subsection area:	(see Fig. 18 on page 300)

$$\frac{647\text{ ft}^2}{\text{Heated area (ft}^2/\text{m}^2)} \; / \; \frac{3}{\text{Number of subsections}} = \frac{\textbf{216 ft}^2}{\textbf{Subsection area (ft}^2/\textbf{m}^2)}$$

Btu requirement:	34,800 Btu/hr (from Step 3)
Power required:	34,800 Btu/hr / 3.412 = 10200 W
Power per subsection:	10200 W / 3 = 3400 W
Heating cable catalog number:	FH21 (from Table 12 on page 298)
Cable wattage:	3390 W (from Table 12 on page 298)
Cable voltage:	208 V (from Table 12 on page 298)
Heating cable length:	425 ft (from Table 12 on page 298)
Number of cables:	3 (one cable required for each subsection)

Step 4 Determine the heating cable spacing, layout, and length

4.2 Determine the heating cable spacing

Imperial

(________ x 12 in) / ________ = ________

Area (ft²) Heating cable length (ft) **Cable spacing (in)**

Metric

(________ x 100 cm) / ________ = ________

Area (m²) Heating cable length (m) **Cable spacing (cm)**

Example: MI heating cables for radiant space heating

Subsection area:	216 ft²
Catalog number:	FH21
Heating cable length:	425 ft

(216 ft² / Subsection area x 12 in) / 425 ft / Heating cable length = **6 in (rounded)** / **Cable spacing (in)**

Step 5 Determine the electrical parameters

5.1 Determine the number of circuits

Single-phase circuits (see Fig. 19 on page 312) ________

Three-phase circuits (see Fig. 20 on page 312 and Fig. 21 on page 313) ________

5.2 Select the branch circuit breaker rating

Single-phase circuit

________ = ________ (for a single heating cable)

Heating cable current (A) **Load Current (A)**

________ / 0.8 = ________

Load current (A) **Circuit breaker rating**

Delta-connected three-phase circuit

________ x 1.732 = ________ (for 3 cables in Delta configuration)

Heating cable current (A) **Load current (A)**

________ / 0.8 = ________

Load current (A) **Circuit breaker rating**

Wye-connected three-phase circuit

________ = ________ (for 3 cables in Wye configuration)

Heating cable current **Load current (A)**

________ x 0.8 = ________

Load current (A) **Circuit breaker rating**

Step 5 Determine the electrical parameters

5.3 Determine the transformer load

For cables of equal wattage

$$\left(\underset{\text{Cable (W)}}{\underline{\qquad\qquad}} \text{ x } \underset{\text{Number of cables}}{\underline{\qquad\qquad}}\right) \text{ / } 1000 \longrightarrow = \underset{\textbf{Transformer load (kW)}}{\underline{\qquad\qquad}}$$

When cable wattages are not equal

$$\left(\underset{\text{Cable}_1\text{ (W)}}{\underline{\qquad}} + \underset{\text{Cable}_2\text{ (W)}}{\underline{\qquad}} + \underset{\text{Cable}_3\text{ (W)...}}{\underline{\qquad}} + \underset{\text{Cable}_N\text{ (W)}}{\underline{\qquad}}\right) \text{ / } 1000 \longrightarrow = \underset{\textbf{Total transformer load (kW)}}{\underline{\qquad\qquad}}$$

Example: MI heating cables for heat loss replacement

Heating cable catalog number: HLR24 (from Step 4.1)

Heating cable current: 24.8 A (from Table 10 on page 294)

Load current:

Delta-connected three-phase circuit

$$\underset{\text{Heating cable current}}{\underline{24.8\text{ A}}} \text{ x } 1.732 = \underset{\textbf{Load current}}{\underline{\textbf{43 A (rounded)}}}$$

Circuit breaker size: 60 A breaker, 80% loading 48 A

Number of circuit breakers: 1 (3-pole breaker)

Cable power output: 5150 W (from Step 4.1)

Number of cables: 3 (from Step 4.1)

Transformer load:

$$\left(\underset{\text{Cable power output}}{\underline{5150\text{ W}}} \text{ x } \underset{\text{Number of cables}}{\underline{3}}\right) \text{ / } 1000 = \underset{\textbf{Transformer load}}{\underline{\textbf{15.5 kW (rounded)}}}$$

Example: MI heating cables for comfort floor heating

Heating cable catalog number: FH21 (from Step 4.1)

Heating cable current: 16.3 A (from Table 12 on page 298)

Load current: 16.3 A

Circuit breaker size: 25 A breaker, 80% loading 20 A

Number of circuit breakers: 2

Cable power output: 3390 W (from Step 4.1)

Number of cables: 2 (from Step 4.1)

Transformer load:

$$\left(\underset{\text{Cable power output}}{\underline{3390\text{ W}}} \text{ x } \underset{\text{Number of cables}}{\underline{2}}\right) \text{ / } 1000 = \underset{\textbf{Transformer load}}{\underline{\textbf{6.8 kW (rounded)}}}$$

Example: MI heating cables for radiant space heating

Heating cable catalog number: FH21 (from Step 4.1)

Heating cable current: 16.3 A (from Table 12 on page 298)

Load current: 16.3 A

Circuit breaker size 25 A breaker, 80% loading 20 A

Number of circuit breakers: 3

Cable power output: 3390 W (from Step 4.1)

Number of cables: 3 (from Step 4.1)

Transformer load:

$$\left(\underset{\text{Cable power output}}{\underline{3390\text{ W}}} \text{ x } \underset{\text{Number of cables}}{\underline{3}}\right) \text{ / } 1000 = \underset{\textbf{Transformer load}}{\underline{\textbf{10.2 kW (rounded)}}}$$

Step 6 Select the connection kits and accessories

MI accessories		**Quantity**
☐ D1297TERM4	Cast aluminum junction box	
☐ HARD-SPACER-GALV-25MM-25M	Galvanized steel prepunched strapping	
☐ HARD-SPACER-SS-25MM-25M	Stainless steel prepunched strapping (use for Heat Loss Replacement applications)	

Example: MI heating cables for heat loss replacement

✓ Junction Box	**(supplied by contractor)**
✓ HARD-SPACER-SS-25MM-25M	**16**

Example: MI heating cables for comfort floor heating

✓ D1297TERM4	**2**
✓ HARD-SPACER-GALV-25MM-25M	**4**

Example: MI heating cables for radiant space heating

✓ D1297TERM4	**3**
✓ HARD-SPACER-GALV-25MM-25M	**4**

Step 7 Select the control system (see Table 16 on page 309)

Control system	**Quantity**
☐ ECW-GF	
☐ ECW-GF-DP	
☐ C910-485	
☐ ACS-UIT2	
☐ ACS-PCM2-5	
☐ ProtoNode-RER	
☐ RTD10CS	
☐ RTD-200	
☐ RTD50	

Example: MI heating cables for heat loss replacement

✓ Raychem ACS-30	**1**

Example: MI heating cables for comfort floor heating

✓ ECW-GF	**1**

Example: MI heating cables for radiant space heating

✓ ECW-GF	**1**

Step 8 Select the power distribution (see Table 17 on page 315)

Power Distribution and Control Panels	**Quantity**
☐ HTPG	

Step 9 Complete the Bill of Materials

Use the information recorded in this worksheet to complete the Bill of Materials.

Raychem

HOT WATER TEMPERATURE MAINTENANCE – HWAT SYSTEM

This step-by-step design guide provides the tools necessary to design a Raychem HWAT Hot Water Temperature Maintenance System. For additional information, contact your Thermal Management representative or call (800) 545-6258. Also, visit our web site at www.pentairthermal.com.

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INTRODUCTION

The Raychem HWAT System is a hot water temperature maintenance system that utilizes an electronic controller, self-regulating electric heating cables, and an easy-to-install set of connection kits to provide commercial buildings with immediate hot water at the tap without the use of a water recirculation system.

Recirculation systems require the water heater temperature to be at least five degrees above the maintain temperature to compensate for the heat that is lost in the recirculation loop. With HWAT systems, the water in the supply pipe is maintained at a constant temperature along the entire length of the supply pipe so heating the water above the maintain temperature is not required. Recirculation systems also require return lines, pumps, and balancing valves, all of which are all unnecessary with HWAT.

A key component of the HWAT system is the HWAT controller. In addition to providing flexible temperature control, the controllers provide energy savings; a heat-up cycle that increases the water temperature in stagnant pipes; Building Management System (BMS) interface; alarm relay to signal power, temperature, or communication problems; a water heater sensor function; and nine predefined programs that can be customized by the user.

Typical Applications

The HWAT system is designed to be installed and operated in commercial buildings. Table 1 shows typical HWAT applications, desired maintain when HWAT-R2 heating cable is used in conjunction with the HWAT-ECO or ACS-30 controllers.

TABLE 1 TYPICAL HWAT APPLICATIONS

Application	Desired maintain temperature
Hospitals, nursing homes	105°F (40°C)
Schools, prisons, some hospitals	115°F (45°C)
Offices, hotels, apartments	125°F (50°C)
Kitchens, laundries	140°F (60°C)

This design guide covers standard HWAT applications which must meet the following conditions:

- Installed on copper or rigid plastic pipes
- Insulated in accordance with the insulation schedule shown in Table 6
- Powered at 208 V or 240 V. Can also be powered at 277 V when using the Raychem ACS-30 controller
- Operated indoors where the ambient temperature is relatively constant and between 60°F (15°C) and 80°F (26°C)

If your application does not meet the above conditions, contact your Thermal Management representative for custom design assistance.

Approvals and Code Compliance

The HWAT system with the HWAT-ECO or ACS-30 controller, is UL Listed, CSA Certified, and FM Approved in nonhazardous locations.

LISTED
718K
Pipe Heating Cable

FM
APPROVED

HWAT is also in compliance with the following international and national codes:

- International Plumbing Code
- International Building Code
- International Energy Conservation Code
- National Standard Plumbing Code
- National Electrical Code
- Canadian Electrical Code

Additionally, HWAT has numerous state and local code approvals. Contact your Thermal Management representative for further information.

Safety Guidelines

The safety and reliability of any heat-tracing system depends on the quality of the products selected and on proper design, installation, and maintenance. Incorrect design, handling, installation, or maintenance of any of the system components can cause underheating or overheating of the pipe or damage to the heating cable system and may result in system failure, electric shock, or fire. The guidelines and instructions contained in this guide are important. Follow them carefully to minimize these risks and to ensure that the HWAT system performs reliably.

Pay special attention to safety warnings identified as ⚠ **WARNING**.

Ground-Fault Protection

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with Thermal Management requirements, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit breakers.

Design Requirements

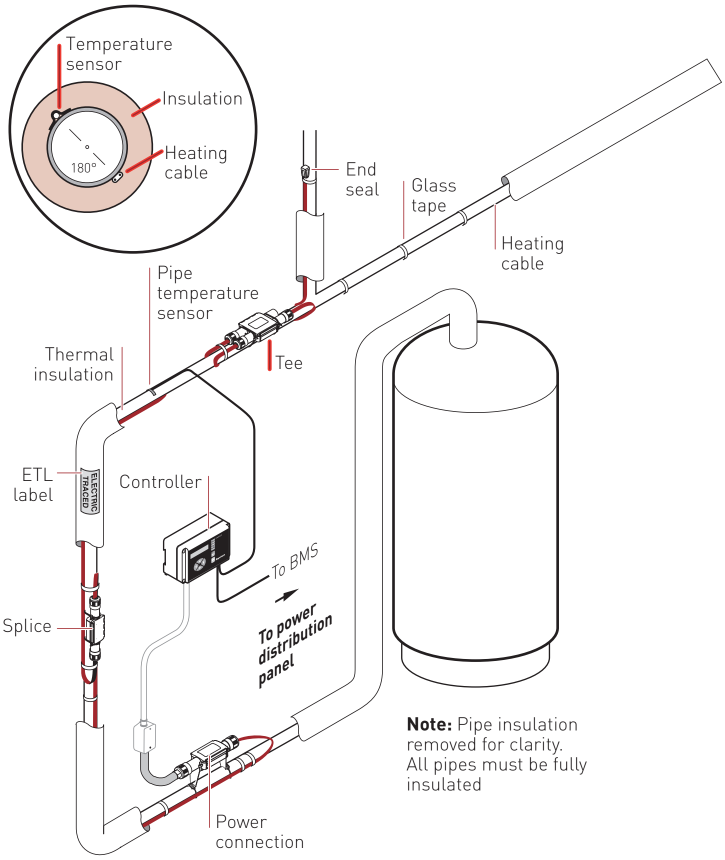
To comply with warranty requirements, the design and installation of the HWAT system must be in accordance with this guide and the additional documents listed below:

- HWAT-ECO Installation and Operations Manual (H57340)
- HWAT System Installation and Operations Manual (H57548)
- RayClic Connection Kit Installation Instructions (H55388 and H55092)

Installation documents are shipped with the respective products and are also available via the Thermal Management web site at www.pentairthermal.com.

SYSTEM OVERVIEW

A complete HWAT system includes one or more HWAT-ECO or ACS-30 electronic controllers, HWAT-R2 heating cable, and RayClic connection kits. Fig. 1 illustrates a typical HWAT system. The key components of the system will be described in this section.



Note: Pipe insulation removed for clarity. All pipes must be fully insulated

Fig. 1 Typical HWAT heating cable system

HWAT Electronic Controllers

The Raychem HWAT-ECO is an electronic controller designed for use with a single circuit of HWAT-R2 self-regulating heating cable. For large hot water systems the ACS-30 distributed controller is available, refer to the ACS-30 data sheet (H58261) for more information. The HWAT-ECO provides a variety of features and control options, listed below, for your hot water temperature maintenance system.

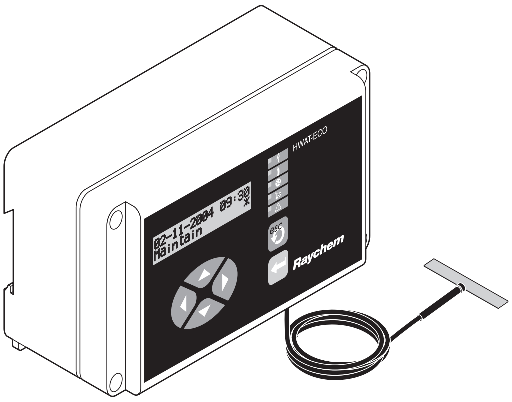


Fig. 2 HWAT-ECO controller

- **Flexible temperature control** – Selectable temperature control set points across the temperature range of the heating cable
- **Energy savings** – Lowers the maintain temperature during low water usage hours and turns off the heating cable during peak water usage hours
- **Heat-up cycle** – Increases the water temperature of a hot water system that is not in use
- **Building Management System (BMS) interface** – Receives a DC voltage to determine the desired maintain temperature
- **Alarm** – Signals power, temperature, or communication problems
- **Water heater sensor** – Monitors the supply pipe temperature, alarms on high temperature and turns off the system to prevent the possibility of scalding
- **Master/slave function** – Allows one HWAT-ECO to control up to eight additional HWAT-ECO controllers
- **Programmable settings** – Nine predefined programs that can be customized by the user

HWAT Heating Cables

HWAT-R2 self-regulating heating cables is installed on hot water supply pipes underneath standard pipe insulation. The heating cable adjusts its power output to reduce the effect of ambient temperature swings. The HWAT system provides continuous hot water temperature maintenance while eliminating the need for a recirculation system.

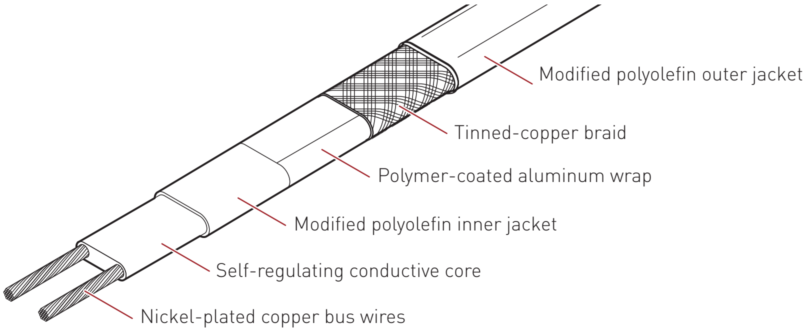


Fig. 3 HWAT-R2 heating cable

HWAT heating cables provide the following features:

- Adjust power output to reduce the variations in water temperature
- Can be cut to length, spliced, teed, and terminated in the field
- Designed for use with the HWAT-ECO or ACS-30 controller

RayClic Connection Kits

The RayClic connection system is a simple, fast, and reliable set of connection kits developed for use with HWAT self-regulating heating cables. RayClic connection kits reduce installation time, lowering the total installed cost of the HWAT system.

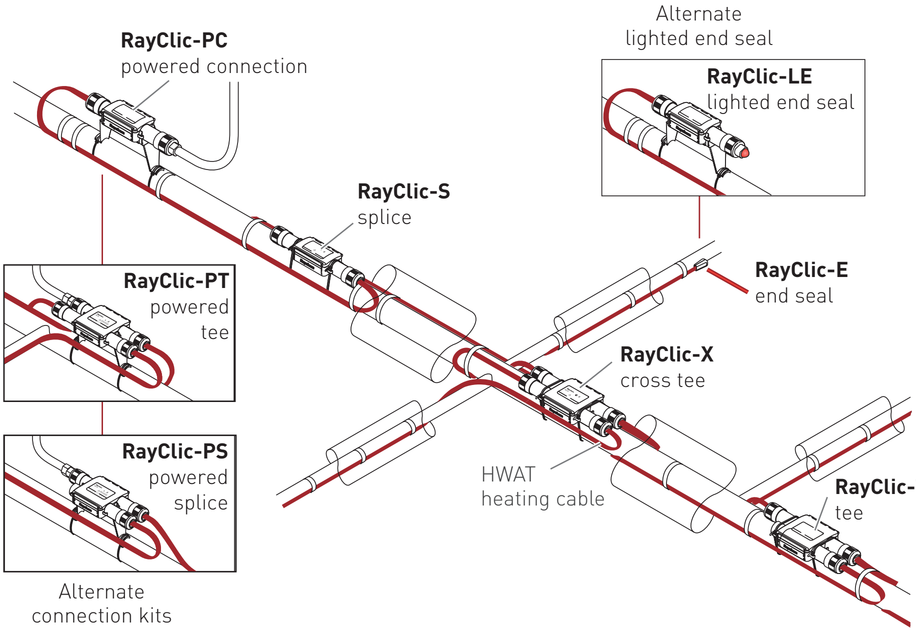


Fig. 4 RayClic connection kits

DESIGN GUIDELINES

This section describes the seven steps necessary to design an HWAT system:

1. Select the heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configurations
6. Select thermal insulation
7. Complete Bill of Materials

To assist you with the design, we will carry two design examples through this process. The example details are listed below each step in red.

Example 1

An elementary school where 115°F (46°C) is the desired maintain temperature and no heat-up cycle is required. Piping layout shows approximately 300 ft of pipe with two branches at the same location.

Example 2

A medium security prison where 115°F (46°C) is the desired maintain temperature and a 140°F (60°C) heat-up cycle is required. Piping layout shows approximately 700 ft of pipe with two branches at different locations.

Before You Begin

Before you begin designing your HWAT system, gather this necessary information:

- Desired maintain temperature
- Indoor ambient temperature
- Supply voltage
- Piping layout
- Total pipe length
- Pipe diameters

HWAT System Design

1. Select heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configuration
6. Select insulation
7. Complete Bill of Materials

Step 1 Select heating cable

Use Table 2 to select the appropriate system temperature setting. For more information on heat-up cycles, refer to "Expanded HWAT-ECO Electronic Controller Capabilities," H58449; or ACS-30 Programming Guide (H58692). HWAT-R2 heating cable will be used regardless of the controller you choose.

Record the following information:

- Desired maintain temperature (°F/°C) ______________
- Indoor ambient temperature (°F/°C) ______________
- Supply voltage (V) ______________
- Heat-up cycle (Yes/No) ______________
- Temperature (°F/°C) ______________

Example: Heating Cable Selection	Example 1	Example 2
Desired maintain temperature	115°F (46°C)	115°F (46°C)
Ambient temperature	70°F (21°C)	70°F (21°C)
Supply voltage	208 V	208 V
Heat-up cycle required	No	Yes
Heat-up cycle temperature	n/a	140°F (60°C)

TABLE 2 HWAT SYSTEM TEMPERATURE RANGE

HWAT-R2	HWAT-ECO	ACS-30
Minimum maintain temperature	105°F (40°C)	100°F (38°C)
Maximum maintain temperature	140°F (60°C)	150°F (66°C)
Heat-up cycle*	>140°F (60°C)	>150°F (66°C)

* For additional information on heat-up cycles, refer to "Expanded HWAT-ECO Electronic Controller Capabilities."

⚠ WARNING Burn Hazard

Water temperatures above 120°F (50°C) can cause skin damage and pain. Be sure the correct insulation schedule is used and the HWAT-ECO or ACS-30 is programmed properly. Avoid exposure to water during heat-up cycles or from water systems with high maintain temperatures during normal operation.

Heating Cable Selection	Example
Heating cable selected	HWAT-R2

HWAT System Design
1. Select heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configuration
6. Select insulation
7. Complete Bill of Materials

Step 2 Lay out the heating cable

The piping layout of your building may require more than one HWAT circuit. To determine the number of circuits, group your piping by maintain temperature and location for convenience, a step that may require you to consult the plumbing and/or electrical engineer. Calculate the total length of pipe in each group, allowing one foot of heating cable for each foot of pipe. The length of heating cable in each group must not exceed the circuit lengths listed in Table 3.

In Step 4, you will calculate the additional cable required to install the connection kits. This will increase the total length of heating cable and may require the need for additional circuits.

TABLE 3 MAXIMUM CIRCUIT LENGTHS

	Circuit Lengths
Circuit breaker size (Amps)	**HWAT-R2 ft (m)**
15	250 (75)
20	330 (100)
30	500 (150)

Note: Assumes a minimum water temperature of 50°F (10°C) at startup

⚠ **WARNING** To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with Thermal Management requirements, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional breakers.

Example: Lay out circuits	**Example**
HWAT heating cable selected	HWAT-R2
Length of pipe	700 ft
Number of circuits	2
Circuit breaker size	30 Amp

HWAT System Design

1. Select heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configuration
6. Select insulation
7. Complete Bill of Materials

Step 3 Select connection kits and accessories

HWAT systems are approved and warranted only as a complete system. The appropriate RayClic connection kits must be used. Use Table 4 to select the connection kits and accessories necessary for your HWAT system. Refer to the RayClic Connection System data sheet (H57545) in the Technical Data section for more information on the products.

The appropriate numbers of end seals are included with each connection kit.

TABLE 4 RAYCLIC CONNECTION KITS AND ACCESSORIES

Catalog number	Description	Quantity required	No. of end seals included
RayClic-PC	Power connection kit	One -PC, -PS, -PT required per circuit	1
RayClic-PS	Powered splice kit	One -PC, -PS, -PT required per circuit	2
RayClic-PT	Powered tee kit	One -PC, -PS, -PT required per circuit	3
RayClic-S	Splice kit	As required*	0
RayClic-X	Cross kit	As required	2
RayClic-T	Tee kit	As required	1
RayClic-E	End seal kit	As required for spares	1
GT-66	Glass tape	1 roll per 50 ft of pipe	n/a
ETL	Electric traced tape	1 label per 10 ft of pipe	n/a

* To minimize cable waste, Thermal Management recommends that one RayClic-S be ordered for every 500 feet of cable.

Example: Select connection kits and accessories

Piping layout determined that the following connection kits and accessories are required.

Example

2 RayClic-PC
2 RayClic-T
14 GT-66
70 ETL

HWAT System Design

1. Select heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configuration
6. Select insulation
7. Complete Bill of Materials

Step 4 Finalize circuit length

Additional cable is required for future access at each connection kit. Add the additional cable, as detailed in Table 5, to the estimated circuit lengths from Step 2. Confirm that the maximum lengths shown in Table 3 have not been exceeded. If your circuit lengths are greater than those shown, reconfigure your heating cable layout to allow for additional circuits.

TABLE 5 ADDITIONAL CABLE REQUIRED FOR EACH CONNECTION KIT

Connection kit name	No. of cable connections/kit	Cable length/ connection ft (m)	Total cable length (service loop) ft (m)
RayClic-PC	1	2.0 (0.6)	2.0 (0.6)
RayClic-S	2	1.0 (0.3)	2.0 (0.6)
RayClic-T	3	1.0 (0.3)	3.0 (0.9)
RayClic-X	4	1.0 (0.3)	4.0 (1.2)
RayClic-PS	2	1.5 (0.5)	3.0 (0.9)
RayClic-PT	3	1.3 (0.4)	4.0 (1.2)
RayClic-E	1	n/a	n/a

Example: Finalize circuit length	**Example Circuit 1***	**Example Circuit 2***
Length of heating cable per circuit	**350 ft**	**350 ft**
Additional cable required		
RayClic-PC	**2 ft**	**2 ft**
RayClic-T	**3 ft**	**3 ft**
RayClic-X	**n/a**	**n/a**
Total length of heating cable required	**355 ft**	**355 ft**

*** In this example, the circuits were evenly divided. Equal circuit lengths are not required.**

HWAT System Design
1. Select heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configuration
6. Select insulation
7. Complete Bill of Materials

Step 5 Select control configuration

For single circuit applications, choose the HWAT-ECO controller. For multi-circuit applications, choose the ACS-30 controller.

Example: Select control method	**Example 1**	**Example 2**
Type	Individual circuit	Multi-circuit
Number of circuits	1	up to 260
Controller	HWAT-ECO	ACS-30

HWAT System Design
1. Select heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configuration
6. Select insulation
7. Complete Bill of Materials

Step 6 Select Insulation

Select the size of thermal insulation from Table 6. You will need to know the length and diameter of each pipe used in your application.

For pipes 1 1/4 inches and smaller, use insulation that is oversized by 1/4 inch to allow room for insulating over the heating cables. Table 6 specifies IPS (Iron Pipe Size) insulation, which has a greater inner diameter than CTS (Copper Tube Size) insulation.

For pipes 3 inches and larger, the thickness of insulation can either be equal to the pipe diameter with a single heating cable or 1/3 the pipe diameter with two heating cables. For example, a 6 inch pipe with 6 inches of insulation and one run of heating cable is equivalent to a 6 inch pipe with 2 inches of insulation and two runs of heating cable.

TABLE 6 FIBERGLASS INSULATION SELECTION

Copper pipe size (in)	IPS insulation size (in)	Insulation thickness (in)
1/2	3/4	1/2
3/4	1	1
1	1 1/4	1
1 1/4	1 1/2	1 1/2
1 1/2	1 1/2	1 1/2
2	2	2
2 1/2	2 1/2	2 1/2
3	3	3

Note: For pipes 3 inches and larger, the thickness of insulation can be equal to the pipe diameter with one run of heating cable or 1/3 the pipe diameter with two runs of heating cable.

Example: Select Insulation

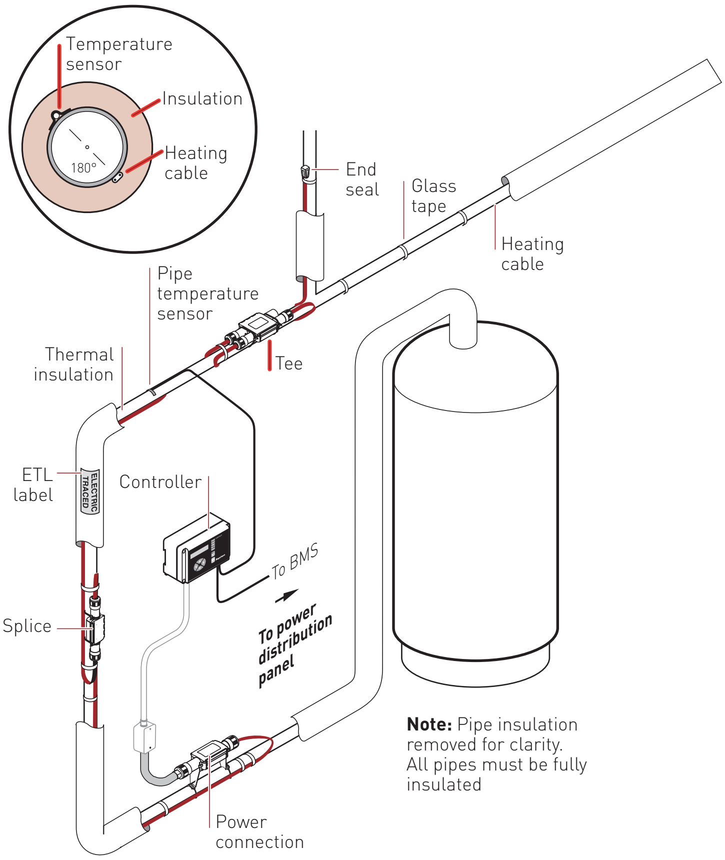
	Copper pipe size (in)	IPS insulation size (in)	Insulation thickness (in)
Example 1	3/4	1	1
	1	1 1/4	1
	1 1/2	1 1/2	1 1/2
Example 2	1	1 1/4	1
	2	2	2
	2 1/2	2 1/2	2 1/2

HWAT System Design

1. Select heating cable
2. Lay out the heating cable
3. Select connection kits and accessories
4. Finalize circuit length
5. Select control configuration
6. Select insulation
7. Complete Bill of Materials

Step 7 Complete Bill of Materials

You are now ready to compile a Bill of Materials. Using the design results, detail each item as shown in Table 7 below. Fig. 5 illustrates a complete typical HWAT system.



Note: Pipe insulation removed for clarity. All pipes must be fully insulated

Fig. 5 Typical HWAT heating cable system

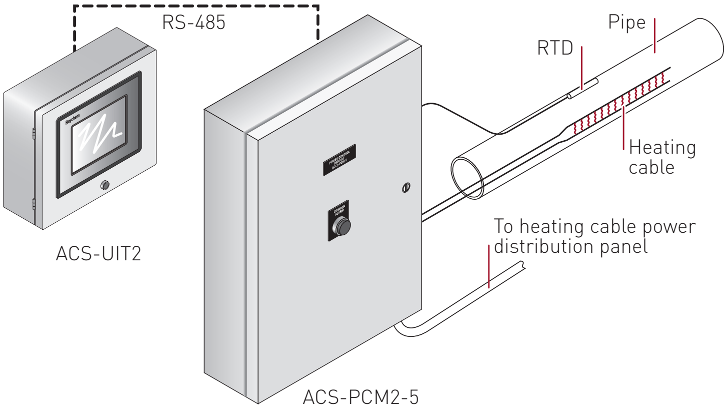


Fig. 6 Typical configuration for the Raychem ACS-30 system

TABLE 7 BILL OF MATERIALS (EXAMPLE)

Description	Catalog number	Quantity
HWAT heating cable	HWAT-R2	706 ft
Power connection kit	RayClic-PC	2
Tee connection kit	RayClic-T	2
Controller	HWAT-ECO	2
Attachment tape	GT-66	12 rolls
Labels	ETL	70

TECHNICAL DATA SHEETS

This section provides individual technical data sheets for all of the Thermal Management products. Each data sheet is also available in .pdf format on our web site at www.pentairthermal.com

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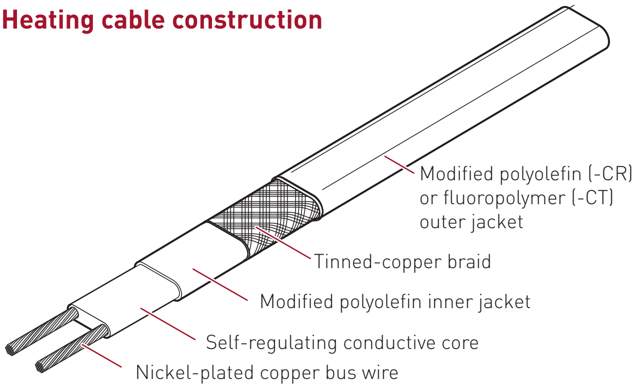
Raychem

XL-TRACE

SELF-REGULATING HEATING CABLE

For pipe freeze protection and flow maintenance

Heating cable construction



PRODUCT OVERVIEW

Raychem XL-Trace is designed for pipe freeze protection and flow maintenance in the following applications:

- Freeze protection of general water piping (aboveground and buried)
- Freeze protection of fire sprinkler system piping, including sprinklers
- Flow maintenance of greasy waste lines (aboveground and buried)
- Flow maintenance of fuel lines (aboveground)

The heating element in the XL-Trace heating cable consists of a continuous core of conductive polymer extruded between two copper bus wires. The XL-Trace heating cable regulates its power output in response to pipe temperature changes. This self-regulating technology allows XL-Trace heating cable to be overlapped or installed on plastic pipes without overheating.

Low total installed cost
The XL-Trace heating cable's parallel circuitry allows it to be cut to the exact length required, with no wasted cable. Its flexibility allows it to be wrapped around complex fittings and valves. All of these characteristics simplify and streamline the design of a heat-tracing system. Installation is quick and simple.

Low total operating cost
Building operators are assured of optimal energy efficiency and low maintenance costs when an XL-Trace system is specified.

The same features that make an XL-Trace system easy to install the first time also simplify additions or changes to the system during building renovations.

For additional information, contact your Thermal Management representative or call (800) 545-6258.

CATALOG NUMBER	5XL1-CR/CT	5XL2-CR/CT	8XL1-CR/CT	8XL2-CR/CT	12XL2-CR/CT
VOLTAGE	120 V	208–277 V	120 V	208–277 V	208–277 V
MAXIMUM OPERATING TEMPERATURE	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)
MAXIMUM EXPOSURE TEMPERATURE	150°F (65°C)	150°F (65°C)	150°F (65°C)	150°F (65°C)	185°F[1] (85°C)[1]
MINIMUM INSTALLATION TEMPERATURE	0°F (–18°C)	0°F (–18°C)	0°F (–18°C)	0°F (–18°C)	0°F (–18°C)
MINIMUM BEND RADIUS	1/2 in (12 mm)	1/2 in (12 mm)	1/2 in (12 mm)	1/2 in (12 mm)	1/2 in (12 mm)

[1] When the design requires 185°F (85°C) exposure temperature, all connections must be installed off the pipe.

MAXIMUM CIRCUIT LENGTH IN FEET

40°F / 110°F Maintain*

Start-up temperature (°F)	CB size (A)	5XL1	8XL1	5XL2			8XL2			12XL2		
		120 V	120 V	208 V	240 V	277 V	208 V	240 V	277 V	208 V	240 V	277 V
–20°F	15	101	76	174	178	183	131	138	146	111	114	117
	20	134	101	232	237	245	175	184	194	148	151	156
	30	201	151	349	356	367	262	276	291	223	227	234
	40	270	201	465	474	478	349	368	388	297	303	312
0°F	15	115	86	199	203	209	149	157	166	120	122	126
	20	153	115	265	271	279	199	209	221	160	163	168
	30	230	172	398	406	419	298	314	331	239	244	252
	40	270	210	470	490	530	370/399	390/420	420/443	319	326	336
20°F	15	134	100	232	237	244	173	182	192	126	129	133
	20	178	133	309	315	325	231	243	257	169	172	177
	30	270	200	464	473	488	346	365	385	253	258	266
	40	270	210	470	490	530	370/462	390/486	420/513	340/349	344	355
40°F	15	160	119	278	283	292	206	217	229	142	145	150
	20	214	159	370	378	390	275	290	306	190	194	200
	30	270	210	470	490	530	370/416	390/438	420/462	285	291	300
	40	270	210	470	490	530	370/554	390/584	420/616	340/398	360/406	380/419
50°F (buried)	15	–	–	–	–	–	228	240	254	152	155	160
	20	–	–	–	–	–	304	320	338	203	207	213
	30	–	–	–	–	–	457	481	507	304	310	320
	40	–	–	–	–	–	609	641	676	405	414	427
65°F (indoors grease)	15	–	–	–	–	–	272	286	302	169	172	178
	20	–	–	–	–	–	362	381	402	225	230	237
	30	–	–	–	–	–	543	572	603	338	345	356
	40	–	–	–	–	–	610	660	720	430	460	490

* When maximum circuit length is listed in:
- black type, the value is for applications with a 40°F maintain
- red type, the value is for applications with a 110°F maintain

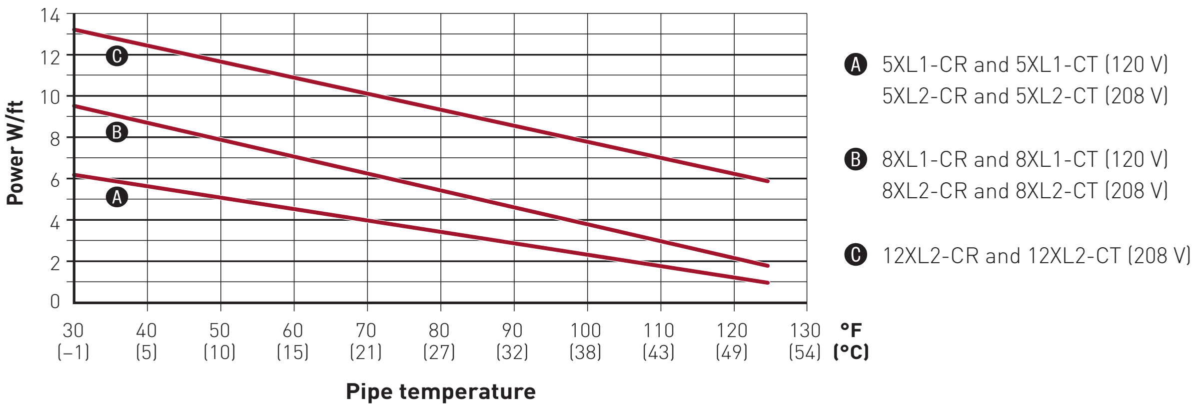
MAXIMUM CIRCUIT LENGTH IN METERS

4°C / 43°C Maintain*

Start-up temperature (°C)	CB size (A)	5XL1	8XL1	5XL2			8XL2			12XL2		
		120 V	**120 V**	**208 V**	**240 V**	**277 V**	**208 V**	**240 V**	**277 V**	**208 V**	**240 V**	**277 V**
–29°C	15	31	23	53	54	56	40	42	44	34	35	36
	20	41	31	71	72	75	53	56	59	45	46	48
	30	61	46	106	108	112	80	84	89	68	69	71
	40	82	61	142	145	149	106	112	118	90	92	95
–18°C	15	35	26	61	62	64	45	48	51	36	37	38
	20	47	35	81	83	85	61	64	67	49	50	51
	30	70	52	121	124	128	91	96	101	73	74	77
	40	82	64	143	149	162	113/122	119/128	128/135	97	99	102
–7°C	15	41	31	71	72	74	53	56	59	39	39	41
	20	54	41	94	96	99	70	74	78	51	52	54
	30	82	61	141	144	149	106	111	117	77	79	81
	40	82	64	143	149	162	113/141	119/148	128/156	104/106	105	108
4°C	15	49	36	85	86	89	63	66	70	43	44	46
	20	65	48	113	115	119	84	88	93	58	59	61
	30	82	64	143	149	162	113/127	119/134	128/141	87	89	91
	40	82	64	143	149	162	113/169	119/178	128/188	104/121	110/124	116/128
10°C (buried grease)	15	–	–	–	–	–	70	73	77	46	47	49
	20	–	–	–	–	–	93	98	103	62	63	65
	30	–	–	–	–	–	139	147	155	93	95	98
	40	–	–	–	–	–	186	195	206	124	126	130
18°C (indoors grease)	15	–	–	–	–	–	83	87	92	52	53	54
	20	–	–	–	–	–	110	116	123	69	70	72
	30	–	–	–	–	–	166	174	184	103	105	108
	40	–	–	–	–	–	186	201	220	131	140	149

* When maximum circuit length is listed in:
- black type, the value is for applications with a 40°F maintain
- red type, the value is for applications with a 110°F maintain

NOMINAL POWER OUTPUT ON METAL PIPES AT 120 V/208 V



BUS WIRES

16 AWG nickel-plated copper

BRAID/OUTER JACKET

Tinned-copper braid with modified polyolefin jacket (-CR) or fluoropolymer jacket (-CT).

DIMENSIONS	5XL AND 8XL	12XL
Maximum width	0.56 in (14 mm)	0.62 in (16 mm)
Maximum thickness	0.24 in (6 mm)	0.24 in (6 mm)

NOMINAL WEIGHT

	5XL AND 8XL	12XL
	92 lb/1000 ft	104 lb/1000 ft

CONNECTION KITS

Raychem RayClic or FTC connection kits must be used with XL-Trace heating cables. Refer to the Pipe Freeze Protection and Flow Maintenance Design Guide (H55838) for proper connection kit selection.

APPROVALS

718K Pipe Heating Cable

Refer to the Pipe Freeze Protection and Flow Maintenance Design Guide (H55838) and the Fire Sprinkler Freeze Protections Design Guide (H58489) for specific product approval details.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

ROOF ICE MELT (RIM) SYSTEM

FOR CONCEALED ROOF & GUTTER DE-ICING

20 YEAR Product warranty

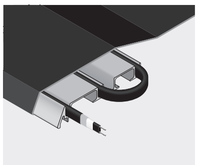
PRODUCT OVERVIEW

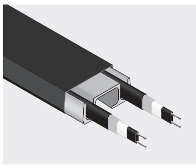
The Raychem RIM System is our premier engineered, aesthetically elegant, concealed roof & gutter de-icing solution to prevent ice dams, icicles, and frozen gutter problems. The RIM system mechanically protects the self-regulating cable, provides high power output along the entire roof edge, and is ideal for new construction or renovation of buildings for all snow load areas, for residential or commercial buildings.

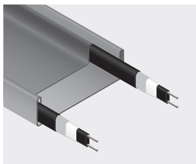
RIM System panels secure the heating cables in a fixed heat transfer position. They are specifically designed for eaves, valleys, channels, rakes and flat roof sections and come in a variety of aesthetically pleasing colors and finishes as standard or custom options to meet any project need.

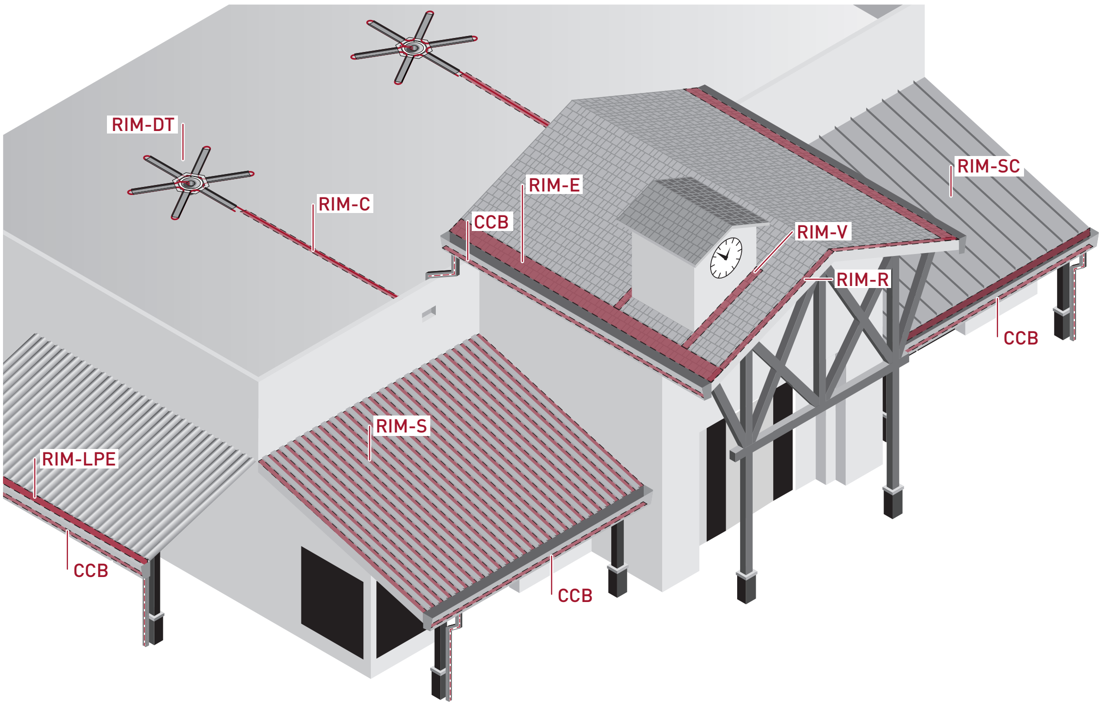
This maintenance-free RIM system embeds multiple runs of high wattage IceStop self-regulating heating cable offering the highest performing heating system with the most efficient heat transfer and cable protection. It is designed for heavy snow load areas with roof snow accumulation over 15 inches, and annual snowfall of over 100 inches. This data sheet will detail this system.

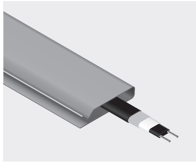
For color options with Aluminum cover panel please refer to RIM color guide H59379.

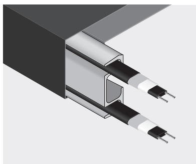

RIM-E | EAVE PANEL

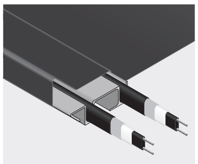

RIM-V | VALLEY PANEL

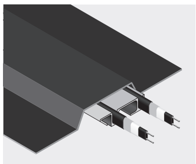

RIM-C | CHANNEL PANEL

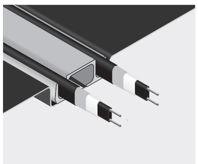



CCB | SHOWN WITH SELF-REG CABLE


RIM-LPE | LOW PITCH EAVE PANEL

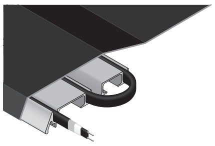
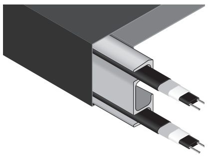
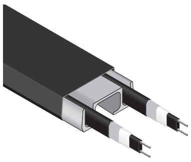
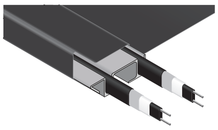
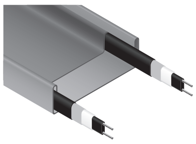
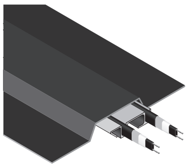
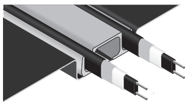

RIM-R | RAKE PANEL


RIM-S | SNOW MELT


RIM-SC | SNOW MELT CONCEALED

ROOF ICE MELT (RIM) SYSTEM

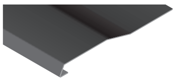
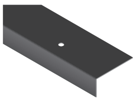
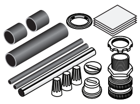
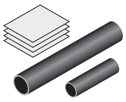
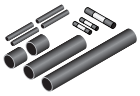
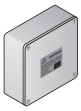
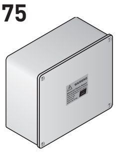
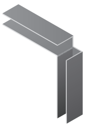
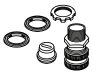
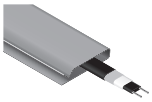
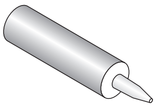
PANEL SYSTEMS

Catalog number	Part number	Description
RIM-E 	F6231-**-**-*	RIM Eave System is designed to mount on the roof eave, to minimize the formation of ice dams and icicles. RIM-Eave panels embed 3 runs of self-regulating heating cable for high power output requirements. Available in Aluminum and Copper cover panels Weight: 2,834.75 lb/1000 ft
RIM-LPE 	F6248-**-**-*	RIM Eave System, Low Pitch is specifically designed for integration with metal roof systems and for applications involving roof pitch less than 3:12. RIM-LPE panels embed 2 runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 2,190,75 lb/1000 ft
RIM-V 	F6281-**-**-*	RIM Valley System is designed to mount in the roof valleys to minimize the formation of ice dams and icicles in roof valleys. RIM-V panels embed 2 runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 819.50 lb/1000 ft
RIM-R 	F6261-**-**-*	RIM Rake System is designed to mount on the roof rake and direct the snow melt towards the eave. RIM-R panels embed 2 runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 1,264.75 lb/1000 ft
RIM-C 	F6221-**-**-*	RIM Channel System is designed to mount on the roof and provide a heated channel for snow melt to flow from one section of the roof to the other, usually a drain or eave. RIM2-C panels embed 2 runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 750.75 lb/1000 ft
RIM-S 	F6271-**-**-*	RIM Snowmelt System is designed to mount on the roof and is used to create wider snow melt paths. This panel system can be used to melt snow on roof sections between standing seams, or provide melt paths to access sections of roof. RIM-S panels embed 2 runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 1,509.75 lb/1000 ft
RIM-SC 	F6275-**-**-*	RIM Snowmelt System, Concealed is designed to mount under a metal roof surface so that the entire RIM panel is concealed. RIM-SC panels embed 2 runs of self-regulating heating cable. Weight: 1,155.75 lb/1000 ft

HEATING CABLES

Catalog number	Part number	Description
GM-1X 	832100-000	IceStop Self-regulating heating cable, 120 V
GM-2X 	446105-000	IceStop Self-regulating heating cable, 208-277 V

CONNECTION KITS & ACCESSORIES

Catalog number	Part number	Description
RIM-EPSC 	R6211-**-**	RIM Eave Panel Splice Cover is designed to cover the joints between RIM-E panels on the roof. Available in Aluminum and Copper cover panels
RIM-EPEB 	R6015-23	RIM Eave Panel End Bracket, Black is designed to cover the ends of RIM-E panels on the roof.
WPCK-R 	F1012	WPCK-R is a CSA Certified and UL Listed power connection kit for RIM system. Materials for one power connection kit and end seal are provided.
WHES 	F1009	WHES is a CSA Certified and UL Listed end seal kit for RIM system. Materials for end seal are provided.
WSTK 	P000000229	WSTK is a CSA Certified and UL Listed splice/tee/end seal kit for RIM system. Materials for one splice or tee and end seal are provided.
JB-55 	F0300	JB-55 is a CSA Certified and UL Listed junction box that can be used for a power connection kit for RIM system in conjunction with WPCK-R. Junction box dimensions 5"x5"
JB-75 	F0303	JB-75 is a CSA Certified and UL Listed junction box that can be used for a power connection kit for RIM system in conjunction with WPCK-R. JB-75 allows powering up to 3 cables (powered tee). Junction box dimensions 7"x5"
DSH 	B0402	Downspout hanger (DSH) is used to protect the heating cable from sharp edges at the corner of gutter and downspout.
HFF 	F0110	Heater Feedthrough Fitting (HFF) is used as a gland kit when the heating cable penetrates the gutter or downspout.
CCB 	R6201-**-**	Cable Cover Bracket is designed to mount on roofs or gutters and embeds one or two runs of self-regulating heating cable. It enhances the heat transfer from the heating cable to the snow, creating larger drain paths. Available in Aluminum and Copper cover panels Weight: 17 lb/1000 ft
RIM Adhesive/ Sealant 	B1626	RIM Adhesive/Sealant is a silicone sealant used to attach selected RIM systems to the underlying surface. Please refer to appropriate installation instructions included with the system. 10.3 oz. Tube

APPROVALS

The IceStop heating cables are UL Listed and CSA Certified only when used with the appropriate agency-approved Thermal Management connection kits and accessories. For approvals information, refer to the IceStop heating cable data sheet H56428.

DESIGN AND INSTALLATION

For proper design and installation of a Roof Ice Melt (RIM) system, use the appropriate product design guide (H59561) and the installation instructions included with the system.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

ROOF ICE MELT (RIM2) SYSTEM

FOR CONCEALED ROOF & GUTTER DE-ICING

20 YEAR Product warranty

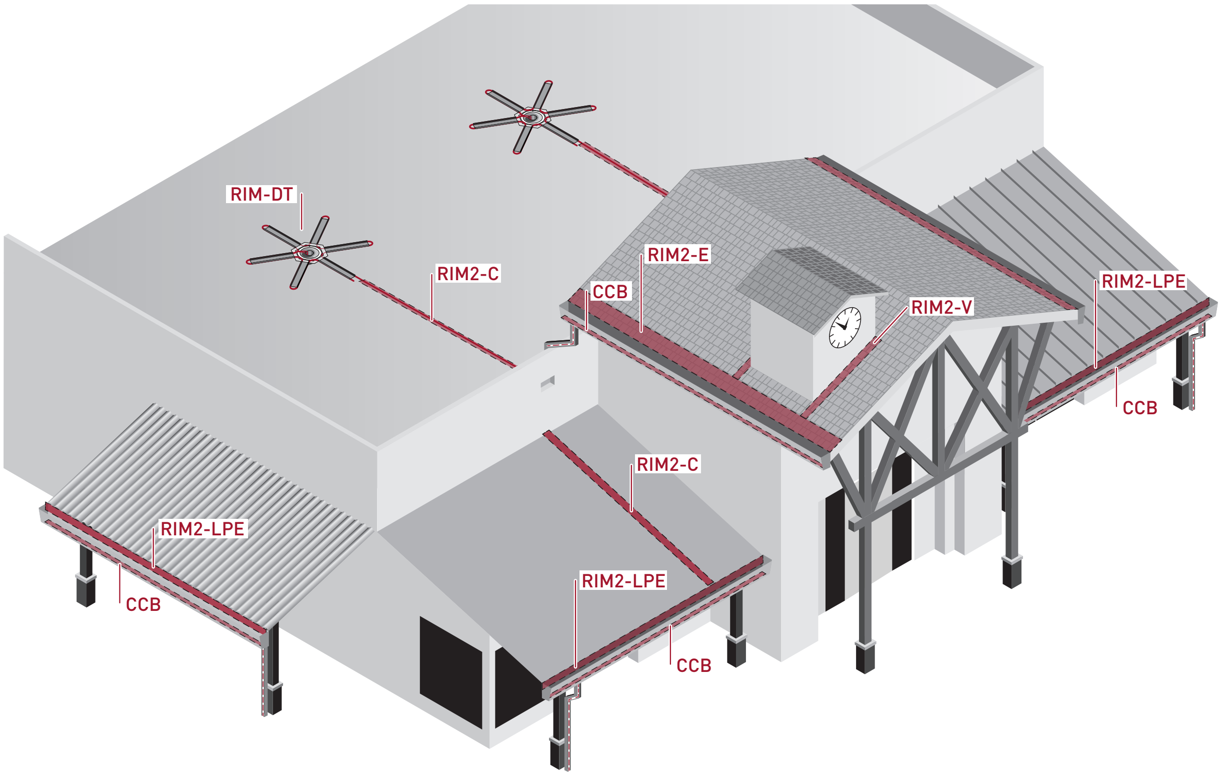
PRODUCT OVERVIEW

The Raychem RIM System is our premier engineered, aesthetically elegant, concealed roof & gutter de-icing solution to prevent ice dams, icicles, and frozen gutter problems. The RIM system mechanically protects the self-regulating cable, provides high power output along the entire roof edge, and is ideal for new construction or renovation of buildings for all snow load areas, for residential or commercial buildings.

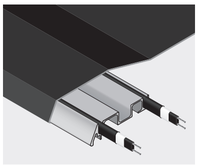
RIM2 System panels secure the heating cables in a fixed heat transfer position. They are specifically designed for eaves, valleys, channels, rakes and flat roof sections and come in a variety of aesthetically pleasing colors and finishes as standard or custom options to meet any project need.

This maintenance-free RIM2 panel system embeds 2 runs of energy-efficient WFP self-regulating heating cable and is designed for light to moderate snow load areas with roof snow accumulation under 15 inches, and annual snowfall of under 100 inches. This data sheet will detail this system.

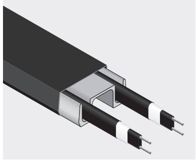
For color options with Aluminum cover panel please refer to RIM color guide H59379.



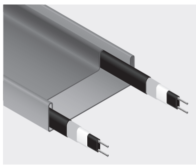
RIM2-E | EAVE PANEL



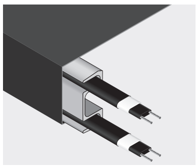
RIM2-V | VALLEY PANEL



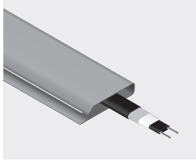
RIM2-C | CHANNEL PANEL



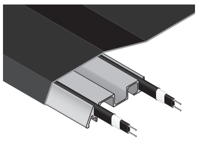
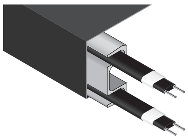
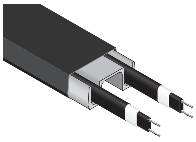
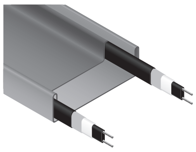
RIM2-LPE |
LOW PITCH EAVE PANEL



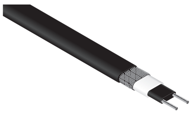
CCB | SHOWN
WITH SELF-REG CABLE



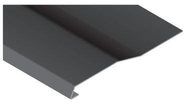
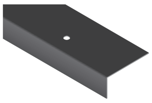
PANEL SYSTEMS

Catalog number	Part number	Description
RIM2-E 	F6237-**-**-*	RIM2 Eave System is designed to mount on the roof eave, to minimize the formation of ice dams and icicles. RIM2-Eave panels embed 2 runs of self-regulating heating cable for a more energy efficient solution. Available in Aluminum and Copper cover panels Weight: 2,035.75 lb/1000 ft
RIM2-LPE 	F6258-**-**-*	RIM2 Eave System, Low Pitch is specifically designed for integration with metal roof systems and for applications involving roof pitch of less than 3:12. RIM2-LPE uses two runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 1,696.75 lb/1000 ft
RIM2-V 	F6287-**-**-*	RIM2 Valley System is designed to mount in the roof valleys to minimize the formation of ice dams and icicles in roof valleys. RIM2-V panels embed 2 runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 677.50 lb/1000 ft
RIM2-C 	F6222-**-**-*	RIM2 Channel System is designed to mount on the roof and provide a heated channel for the snow melt to flow from one section of the roof to the other, usually a drain or eave. RIM2-C panels embed 2 runs of self-regulating heating cable. Available in Aluminum and Copper cover panels Weight: 728.75 lb/1000 ft

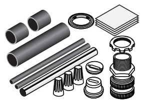
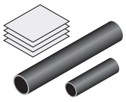
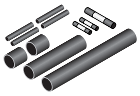
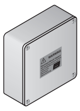
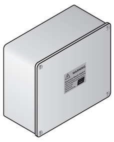
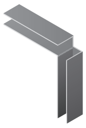
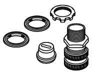
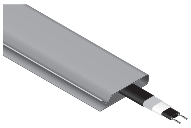
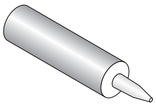
HEATING CABLES

Catalog number	Part number	Description
WFP-612 	P000000222	WFP self-regulating heating cable, 120 V
WFP-622 	P000000223	WFP self-regulating heating cable, 240 V

CONNECTION KITS & ACCESSORIES

Catalog number	Part number	Description
RIM2-EPSC 	R6209-**-**v	RIM2 Eave Panel Splice Cover is designed to cover the joints between RIM2-E panels on the roof. Available in Aluminum and Copper cover panels
RIM2-EPEB 	R6016-23	RIM2 Eave Panel End Bracket, Black is designed to cover the ends of RIM2-E panels on the roof.

CONNECTION KITS & ACCESSORIES

Catalog number	Part number	Description
WPCK-R 	F1012	WPCK-R is a CSA Certified and UL Listed power connection kit for RIM system. Materials for one power connection kit and end seal are provided.
WHES 	F1009	WHES is a CSA Certified and UL Listed end seal kit for RIM system. Materials for end seal are provided.
WSTK 	P000000229	WSTK is a CSA Certified and UL Listed splice/tee/end seal kit for RIM system. Materials for one splice or tee and end seal are provided.
JB-55 	F0300	JB-55 is a CSA Certified and UL Listed junction box that can be used for a power connection kit for RIM system in conjunction with WPCK-R. Junction box dimensions 5"x5"
JB-75 	F0303	JB-75 is a CSA Certified and UL Listed junction box that can be used for a power connection kit for RIM system in conjunction with WPCK-R. JB-75 allows powering up to 3 cables (powered tee). Junction box dimensions 7"x5"
DSH 	B0402	Downspout hanger (DSH) is used to protect the heating cable from sharp edges at the corner of gutter and downspout.
HFF DSH 	F0110	Heater Feedthrough Fitting (HFF) is used as a gland kit when the heating cable penetrates the gutter or downspout.
CCB 	R6201-**-**	Cable Cover Bracket is designed to mount on roofs or gutters and embeds one or two runs of self-regulating heating cable. It enhances the heat transfer from the heating cable to the snow, creating larger drain paths. Available in Aluminum and Copper cover panels Weight: 17 lb/1000 ft
RIM Adhesive/ Sealant 	B1626	RIM Adhesive/Sealant is a silicone sealant used to attach selected RIM systems to the underlying surface. Please refer to appropriate installation instructions included with the system. 10.3 oz. Tube

APPROVALS

The IceStop heating cables are UL Listed and CSA Certified only when used with the appropriate agency-approved Thermal Management connection kits and accessories. For approvals information, refer to the IceStop heating cable data sheet H56428.

DESIGN AND INSTALLATION

For proper design and installation of a Roof Ice Melt (RIM) system, use the appropriate product design guide (H59561) and the installation instructions included with the system.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

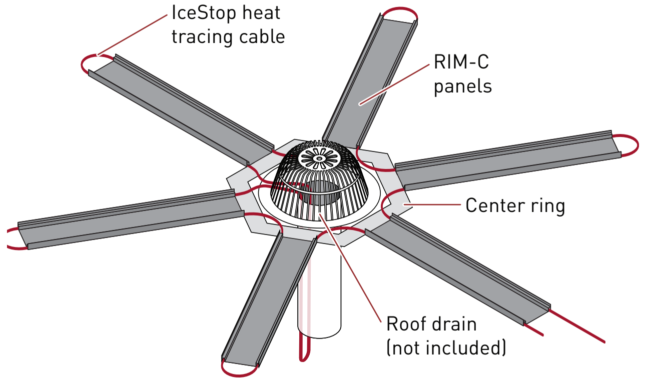
Raychem

RIM-DT

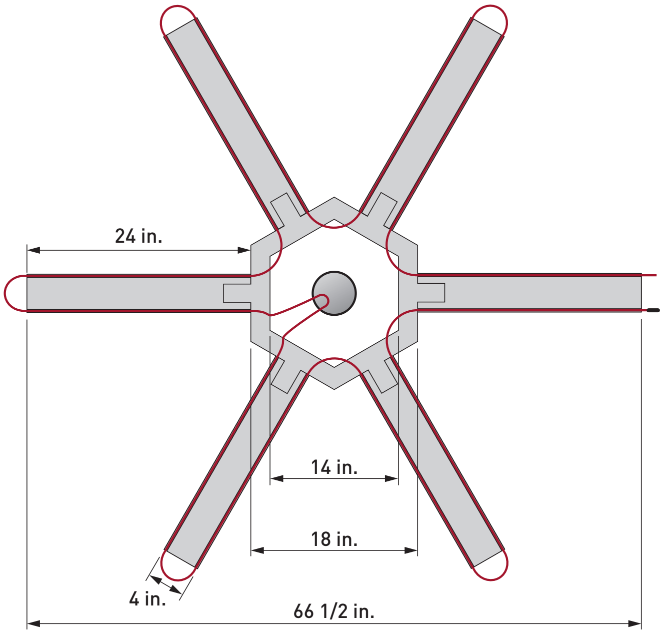
RIM-DRAINTRACE

10 YEAR Product warranty

RIM DrainTrace (RIM-DT)



Dimensions (nominal)



GENERAL INFORMATION

Raychem RIM-DRAINTRACE (RIM-DT) system is a turnkey roof ice melt unit for roof drains. It consists of a central aluminum ring which could go around up to14 inch diameter roof drain. The ring consists of six tabs that can be inserted into the RIM-C channel panels, each 2 feet long. Fifty feet of Raychem IceStop heating cable is provided for routing to and from the channel panels and the drain and to connect to a power connection kit within 10 feet of the drain. A WPCK-R connection kit is included with the system for power and end terminations.

Reliable System:

RIM-DT efficiently transfers the heat to the snow and keeps the area around the roof drains snow free. The RIM-C channel panels mechanically protect the heat tracing cable and create melt channels for the snow melt to flow into the drain.

Lower Total Installed Cost:

RIM-DT parts snap into each another eliminating the need for any field riveting, roof penetrations, or complex cable layouts—thus, reducing the field installation time. The IceStop heating cable's parallel circuitry allows it to be cut to the exact length required in the field thereby eliminating pre-engineering. The flexibility of heating cable makes the installation quick and simple

SPECIFICATION

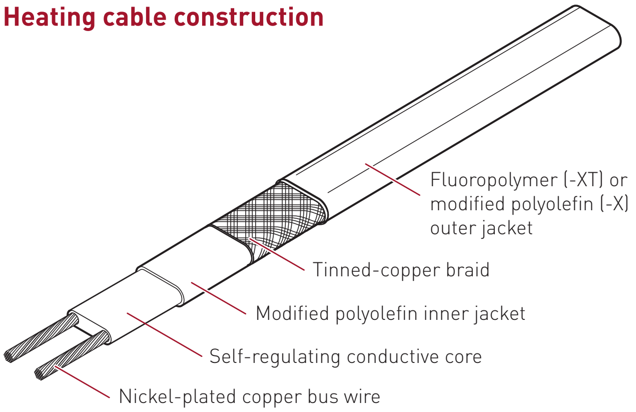
System	Fully snap-fit system with no need for rivets/ screws/ nails/ adhesive in the field and with minimal number of assembly steps required in the field
Material Selection	Kynar® painted aluminum
Color Selection	Matte Black
Contents	Aluminum center ring with tabs, RIM-C channel panels, IceStop heat tracing cable, WPCK-R
Heat Trace Cable Supplied:	GM-1X for 120 V applications GM-2X for 208-277 V applications
Dimensions	Inner size of center ring: 14 inches Channel panel length: 24 inches

Raychem

ICESTOP

SELF-REGULATING ROOF AND GUTTER DE-ICING HEATING CABLE

Heating cable construction



PRODUCT OVERVIEW

Raychem IceStop is a roof and gutter de-icing system that provides drain paths for the following applications:

- Roofs made from standard roofing materials, including shake, shingle, rubber, tar, wood, metal, and plastic.
- Gutters made from standard materials, including metal, plastic, and wood.
- Downspouts made from standard materials, including metal and plastic.

The heating element in the IceStop heating cable consists of a continuous core of conductive polymer extruded between two copper bus wires. As current flows through the core, the IceStop heating cable regulates its own heat output in response to ambient conditions.

This self-regulating feature eliminates hot spots and results in better temperature control to protect roof and gutter materials.

The IceStop heating cable is available with a fluoropolymer outer jacket (-XT) that provides maximum abrasion, chemical, and mechanical resistance; or a polyolefin outer jacket (-X) that is more economical for less demanding applications.

Low installed cost

The IceStop heating cable's parallel circuitry allows it to be cut to the exact length required, with no wasted cable.

All of these characteristics simplify and streamline the design of a roof and gutter de-icing system. Installation is quick and simple. The same features that make an IceStop system easy to install the first time also simplify additions or changes to the system during building renovations.

CATALOG NUMBER		
	GM-1XT and GM-1X	GM-2XT and GM-2X
POWER OUTPUT (NOMINAL)		
	12 W/ft (39 W/m) in ice or snow	12 W/ft (39 W/m) in ice or snow
VOLTAGE		
	120 Vac	208–277 Vac
MINIMUM INSTALLATION TEMPERATURE		
	0°F (–18°C)	0°F (–18°C)

MINIMUM BEND RADIUS

5/8 in (16 mm)	5/8 in (16 mm)

MAXIMUM CIRCUIT LENGTH IN FEET (METERS)

	Start-up temperature	Circuit breaker size			
		15 A	**20 A**	**30 A**	**40 A***
GM-1XT and GM-1X at 120 volts	32°F (0°C)	100 (30)	135 (41)	200 (61)	—
	20°F (–7°C)	95 (29)	125 (38)	185 (56)	200 (61)*
	0°F (–18°C)	80 (24)	100 (30)	155 (47)	200 (61)*
GM-2XT and GM-2X at 208 volts	32°F (0°C)	190 (58)	250 (76)	380 (116)	—
	20°F (–7°C)	180 (55)	235 (72)	355 (108)	380 (116)*
	0°F (–18°C)	145 (44)	195 (59)	290 (88)	380 (116)*
GM-2XT and GM-2X at 240 volts	32°F (0°C)	200 (61)	265 (81)	400 (122)	—
	20°F (–7°C)	190 (58)	250 (76)	370 (113)	400 (122)*
	0°F (–18°C)	155 (47)	205 (62)	305 (93)	400 (122)*
GM-2XT and GM-2X at 277 volts	32°F (0°C)	215 (66)	290 (88)	415 (126)	—
	20°F (–7°C)	200 (61)	265 (81)	400 (122)	415 (126)*
	0°F (–18°C)	165 (50)	225 (69)	330 (101)	415 (126)*

* Only FTC-P power connection kits may be used with 40-A circuits.

BUS WIRES

16 AWG nickel-plated copper

BRAID / OUTER JACKET

Tinned-copper braid with fluoropolymer (-XT) or modified polyolefin (-X) outer jacket

DIMENSIONS

Maximum width	0.54 in (14 mm)
Maximum thickness	0.24 in (6 mm)

NOMINAL WEIGHT

92 lb/1000 ft (137 kg/1000 m)

CONNECTION KITS

Raychem RayClic or FTC connection kits must be used with IceStop heating cables. Refer to the Roof and Gutter De-Icing Design Guide (H56070) for proper connection kit selection.

APPROVALS

LISTED 877Z De-icing and Snow-Melting Equipment

-WS

APPROVED

Nonhazardous and Hazardous Locations
Class 1, Div. 2, Groups A, B, C, D*
* For GM-1XT and GM-2XT

The IceStop heating cables are UL Listed, CSA Certified, and FM Approved only when used with the appropriate agency-approved Thermal Management connection kits and accessories.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

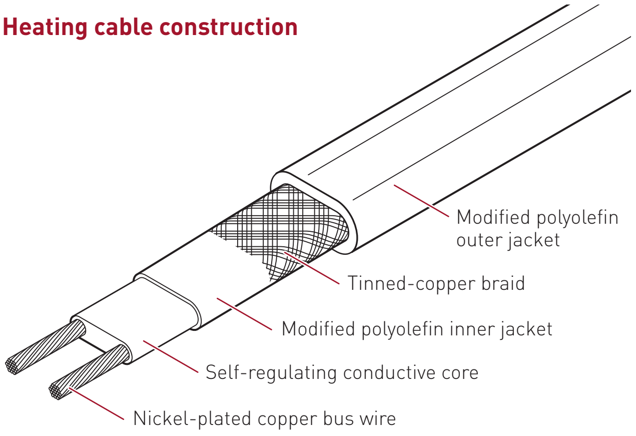
Raychem

10 YEAR Product warranty

ELECTROMELT

SELF-REGULATING SURFACE SNOW-MELTING AND ANTI-ICING HEATING CABLE

Heating cable construction



PRODUCT OVERVIEW

Raychem ElectroMelt provides surface snow melting and anti-icing in concrete pavement.

Self-regulating

The polymer core of an ElectroMelt heating cable automatically adjusts power output at every point along its length in response to concrete pavement temperature. This response characteristic eliminates burnouts caused by overlapping cable and provides improved energy efficiency without the need for special controls.

Parallel circuitry

The crosslinked, conductive polymer core of the ElectroMelt heating cable is extruded between two 14 AWG copper bus wires, forming a parallel circuit. This allows ElectroMelt heating cables to be cut to length and to be spliced and repaired, if necessary, in the field.

Rugged

Specifically designed for direct burial in concrete, ElectroMelt heating cables are protected by a tinned-copper braid encased in a 70-mil modified polyolefin outer jacket. With no exposed metal parts to corrode, no cold leads to fail, and no burnout due to overlaps or hot spots, rugged ElectroMelt heating cable offers an ideal solution for all types of concrete pavement snow melting and anti-icing.

CATALOG NUMBER		EM2-XR
POWER OUTPUT W/FT (W/M)	Voltage	Power Output W/ft (W/m)
	208	30 (98)
	240	32 (105)
	277	34 (112)

DIMENSIONS

Maximum width	0.75 in (19 mm)
Maximum thickness	0.38 in (10 mm)

MINIMUM INSTALLATION TEMPERATURE

0°F (–18°C)

MINIMUM BEND RADIUS

2 in (50 mm)

MAXIMUM CIRCUIT LENGTH FOR STARTUP AT 20°F (–7°C) IN FEET (METERS)

	Heating cable supply voltage					
Circuit breaker (A)	**208 V**		**240 V**		**277 V**	
15	80	(24)	85	(26)	100	(31)
20	105	(32)	115	(35)	130	(40)
30	160	(49)	170	(52)	195	(59)
40	210	(64)	230	(70)	260	(79)
50	265	(81)	285	(87)	325	(99)

MAXIMUM CIRCUIT LENGTH FOR STARTUP AT 0°F (–18°C) IN FEET (METERS)

	Heating cable supply voltage					
Circuit breaker (A)	**208 V**		**240 V**		**277 V**	
15	75	(23)	80	(24)	90	(27)
20	100	(31)	110	(34)	120	(37)
30	145	(44)	160	(49)	180	(55)
40	200	(61)	210	(64)	240	(73)
50	245	(75)	265	(81)	300	(91)

† Not permitted

BUS WIRES

14 AWG nickel-plated copper

BRAID / OUTER JACKET

Heavy tinned-copper braid encased in a 70-mil modified polyolefin outer jacket

NOMINAL WEIGHT

180 lb/1000 ft (268 kg/1000 m)

CONNECTION KITS

Raychem ElectroMelt connection kits must be used to terminate ElectroMelt heating cables. Refer to the Surface Snow Melting and Anti-Icing Design Guide – ElectroMelt (H53393) for proper connection kit selection.

APPROVALS

UL LISTED 877Z De-icing and Snow-melting Equipment

-W

The EM2-XR heating cable is UL Listed and CSA Certified only when used with the appropriate agency-approved Thermal Management connection kits and accessories.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

MI HEATING CABLE

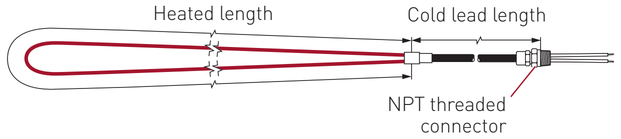
10 YEAR Product warranty

HDPE JACKETED, COPPER SHEATHED MI CABLE

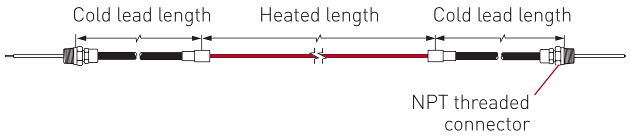
For surface snow melting in concrete, asphalt, and pavers

MI Heating Cable Configuration

Type SUA



Type SUB



PRODUCT OVERVIEW

The copper-sheathed, mineral insulated heating cables are covered with an extruded high-density polyethylene (HDPE) jacket and are supplied as complete factory-assembled cables ready to connect to a junction box. The series-type technology, inherent to all mineral insulated heating cables, provides a reliable and consistent heat source that is ideal for embedded snow melting applications.

The copper sheath provides an ideal ground path and allows for a rugged yet flexible heating cable that is easy to install.

For additional information, contact your Thermal Management representative or call (800) 545-6258.

CABLE CONSTRUCTION

Heating cable	
Jacket	HDPE
Sheath	Seamless copper
Insulation	Magnesium oxide
Conductor type	Alloy or copper
Number of conductors	1
Insulation voltage rating	600 V
Cable diameter (with jacket)	0.200 to 0.303 in (5.1 to 7.7 mm)
Cold lead	
Jacket	HDPE
Sheath	Seamless copper
Insulation	Magnesium oxide
Conductor type	Copper
Number of conductors	1 or 2
Insulation voltage rating	600 V
Cable diameter (with jacket)	0.310 to 0.420 in (7.9 to 10.7 mm)
Gland size (NPT)	1/2 in
Tail length	12 in (30 cm)

MINIMUM INSTALLATION TEMPERATURE

–4°F (–20°C) for UL, –22°F (–30°C) for CSA

MINIMUM BENDING RADIUS

6 times cable diameter

SUA/SUB HEATING CABLE SPECIFICATIONS

Catalog number	Configuration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length[1]		Cold lead code	Joint type	Nominal cable diameter		Resistance[2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
120 Volts														
SUA5	A	61HD3610	40	12.2	550	120	7	2.1	H22A	Y	0.200	5.1	26.2	14
SUA9	A	61HD3200	66	20.1	1100	120	7	2.1	H22A	Y	0.248	6.3	13.1	14
208 Volts														
SUA4	A	61HD3390	68	20.7	1600	208	7	2.1	H22A	Y	0.212	5.4	27.0	14
SUA7	A	61HD3200	95	29.0	2300	208	7	2.1	H22A	Y	0.248	6.3	18.8	14
SUB1	B	61HE3105	132	40.2	3100	208	15	4.6	H25A	Y	0.254	6.5	14.0	14
SUB3	B	61HE4400	280	85.3	3900	208	15	4.6	H30A	Y	0.265	6.7	11.2	12
SUB5	B	61HE4300	260	79.2	5500	208	15	4.6	H40A	Y	0.272	6.9	7.9	10
SUB7	B	61HE4200	310	94.5	7000	208	15	4.6	H40A	Y	0.285	7.2	6.2	10
SUB9	B	61HC5651	630	192.0	9000	208	15	4.6	H60A	Y	0.274	7.0	4.7	8
SUB10	B	61HC5409	717	218.5	13000	208	15	4.6	H80A	Y	0.303	7.7	3.4	6
SUB1402	B	61HD3610	50	15.2	1400	208	15	4.6	H25A	Y	0.232	5.9	30.9	14
SUB1702	B	61HD3390	64	19.5	1700	208	15	4.6	H25A	Y	0.242	6.1	25.4	14
SUB2002	B	61HD3300	72	22.0	2000	208	15	4.6	H25A	Y	0.240	6.1	21.6	14
SUB2402	B	61HD3200	90	27.4	2400	208	15	4.6	H25A	Y	0.248	6.3	18.0	14
SUB2802	B	61HE3150	103	31.4	2800	208	15	4.6	H25A	Y	0.250	6.4	15.5	14
SUB3402	B	61HE3105	121	36.9	3400	208	15	4.6	H25A	Y	0.254	6.5	12.7	14
SUB3902	B	61HE4800	139	42.4	3900	208	15	4.6	H25A	Y	0.262	6.7	11.1	14
SUB4502	B	61HE4600	160	48.8	4500	208	15	4.6	H25A	Y	0.274	7.0	9.6	14
SUB5502	B	61HE4400	197	60.1	5500	208	15	4.6	H30A	Y	0.265	6.7	7.9	12
SUB6402	B	61HE4300	226	68.9	6400	208	15	4.6	H40A	Y	0.272	6.9	6.8	10
SUB7802	B	61HE4200	277	84.5	7800	208	15	4.6	H40A	Y	0.285	7.2	5.5	10
SUB10302	B	61HC4100	368	112.2	10300	208	15	4.6	H60A	Y	0.278	7.1	4.2	8
SUB12802	B	61HC5651	455	138.7	12800	208	15	4.6	H80A	Y	0.274	7.0	3.4	6
SUB16102	B	61HC5409	576	175.6	16100	208	15	4.6	H80A	Y	0.303	7.7	2.7	6
240 Volts														
SUA3	A	61HD3200	140	42.7	2000	240	7	2.1	H22A	Y	0.248	6.3	28.0	14
SUA8	A	61HE3105	177	53.9	3200	240	7	2.1	H22A	Y	0.254	6.5	18.0	14
SUB2	B	61HE4600	240	73.1	4000	240	15	4.6	H25A	Y	0.274	7.0	14.5	14
SUB3	B	61HE4400	280	85.3	5200	240	15	4.6	H30A	Y	0.265	6.7	11.2	12
SUB4	B	61HE4300	320	97.5	6000	240	15	4.6	H30A	Y	0.272	6.9	9.6	12
SUB5	B	61HE4300	260	79.2	7350	240	15	4.6	H40A	Y	0.272	6.9	7.9	10
SUB6	B	61HE4200	375	114.3	7500	240	15	4.6	H40A	Y	0.285	7.2	7.5	10
SUB7	B	61HE4200	310	94.5	9250	240	15	4.6	H40A	Y	0.285	7.2	6.2	10
SUB8	B	61HC4100	550	167.6	9000	240	15	4.6	H60A	Y	0.278	7.1	6.4	8
SUB9	B	61HC5651	630	192.0	12000	240	15	4.6	H60A	Y	0.274	7.0	4.7	8
SUB10	B	61HC5409	717	218.5	17000	240	15	4.6	H80A	Y	0.303	7.7	3.4	6
SUB1604	B	61HD3610	59	18.0	1600	240	15	4.6	H25A	Y	0.200	5.1	36.0	14
SUB2004	B	61HD3390	74	22.6	2000	240	15	4.6	H25A	Y	0.212	5.4	28.8	14
SUB2304	B	61HD3300	84	25.6	2300	240	15	4.6	H25A	Y	0.240	6.1	25.0	14
SUB2804	B	61HD3200	103	31.4	2800	240	15	4.6	H25A	Y	0.248	6.3	20.6	14
SUB3204	B	61HE3150	120	36.6	3200	240	15	4.6	H25A	Y	0.228	5.8	18.0	14

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

SUA/SUB HEATING CABLE SPECIFICATIONS

Catalog number	Configuration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length[1]		Cold lead code	Joint type	Nominal cable diameter		Resistance[2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
240 Volts, cont.														
SUB3904	B	61HE3105	140	42.7	3900	240	15	4.6	H25A	Y	0.254	6.5	14.8	14
SUB4504	B	61HE4800	160	48.8	4500	240	15	4.6	H25A	Y	0.262	6.7	12.8	14
SUB5204	B	61HE4600	185	56.4	5200	240	15	4.6	H25A	Y	0.274	7.0	11.1	14
SUB6404	B	61HE4400	225	68.6	6400	240	15	4.6	H30A	Y	0.265	6.7	9.0	12
SUB7304	B	61HE4300	263	80.2	7300	240	15	4.6	H40A	Y	0.272	6.9	7.9	10
SUB9004	B	61HE4200	320	97.6	9000	240	15	4.6	H40A	Y	0.285	7.2	6.4	10
SUB11904	B	61HC4100	426	129.9	11900	240	15	4.6	H60A	Y	0.278	7.1	4.8	8
SUB14704	B	61HC5651	528	161.0	14700	240	15	4.6	H80A	Y	0.274	7.0	3.9	6
SUB18604	B	61HC5409	664	202.4	18600	240	15	4.6	H80A	Y	0.303	7.7	3.1	6
277 Volts and 480 Volts, 3-phase Wye														
SUA3	A	61HD3200	140	42.7	2740	277	7	2.1	H22A	Y	0.248	6.3	28.0	14
SUA8	A	61HE3105	177	53.9	4100	277	7	2.1	H22A	Y	0.254	6.5	18.7	14
SUB2	B	61HE4600	240	73.1	5300	277	15	4.6	H25A	Y	0.274	7.0	14.5	14
SUB3	B	61HE4400	280	85.3	6850	277	15	4.6	H30A	Y	0.265	6.7	11.2	12
SUB4	B	61HE4300	320	97.5	8000	277	15	4.6	H30A	Y	0.272	6.9	9.6	12
SUB6	B	61HE4200	375	114.3	10200	277	15	4.6	H40A	Y	0.285	7.2	7.5	10
SUB8	B	61HC4100	550	167.6	12200	277	15	4.6	H60A	Y	0.278	7.1	6.4	8
SUB9	B	61HC5651	630	192.0	16400	277	15	4.6	H60A	Y	0.274	7.0	4.7	8
SUB15	B	61HE4800	225	68.6	4250	277	15	4.6	H25A	Y	0.262	6.7	18.1	14
SUB16	B	61HE4400	310	94.5	6180	277	15	4.6	H25A	Y	0.265	6.7	12.4	14
SUB17	B	61HE4200	440	134.1	8700	277	15	4.6	H40A	Y	0.285	7.2	8.8	10
SUB18	B	61HC4100	560	170.7	12000	277	15	4.6	H60A	Y	0.278	7.1	6.4	8
SUB1807	B	61HD3610	70	21.3	1800	277	15	4.6	H25A	Y	0.200	5.1	42.6	14
SUB2307	B	61HD3390	85	25.9	2300	277	15	4.6	H25A	Y	0.212	5.4	33.4	14
SUB2707	B	61HD3300	95	29.0	2700	277	15	4.6	H25A	Y	0.240	6.1	28.4	14
SUB3207	B	61HD3200	119	36.3	3200	277	15	4.6	H25A	Y	0.248	6.3	24.0	14
SUB3807	B	61HE3150	135	41.2	3800	277	15	4.6	H25A	Y	0.228	5.8	20.2	14
SUB4507	B	61HE3105	162	49.4	4500	277	15	4.6	H25A	Y	0.254	6.5	17.1	14
SUB5207	B	61HE4800	184	56.1	5200	277	15	4.6	H25A	Y	0.262	6.7	14.8	14
SUB6007	B	61HE4600	213	64.9	6000	277	15	4.6	H25A	Y	0.274	7.0	12.8	14
SUB7307	B	61HE4400	262	79.9	7300	277	15	4.6	H30A	Y	0.265	6.7	10.5	12
SUB8507	B	61HE4300	300	91.5	8500	277	15	4.6	H40A	Y	0.272	6.9	9.0	10
SUB10307	B	61HE4200	372	113.4	10300	277	15	4.6	H40A	Y	0.285	7.2	7.4	10
SUB13707	B	61HC4100	491	149.7	13700	277	15	4.6	H60A	Y	0.278	7.1	5.6	8
SUB17207	B	61HC5651	600	182.9	17200	277	15	4.6	H80A	Y	0.274	7.0	4.5	6

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

SUA/SUB HEATING CABLE SPECIFICATIONS

Catalog number	Configuration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length[1]		Cold lead code	Joint type	Nominal cable diameter		Resistance[2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
347 Volts and 600 Volts, 3-phase Wye														
SUB2305	B	61HD3610	85	25.9	2300	347	15	4.6	H25A	Y	0.200	5.1	52.4	14
SUB2905	B	61HD3390	107	32.6	2900	347	15	4.6	H25A	Y	0.212	5.4	41.5	14
SUB3405	B	61HD3300	119	36.3	3400	347	15	4.6	H25A	Y	0.240	6.1	35.4	14
SUB4105	B	61HD3200	148	45.1	4100	347	15	4.6	H25A	Y	0.248	6.3	29.4	14
SUB4705	B	61HE3150	171	52.1	4700	347	15	4.6	H25A	Y	0.228	5.8	25.6	14
SUB5605	B	61HE3105	205	62.5	5600	347	15	4.6	H25A	Y	0.254	6.5	21.5	14
SUB6505	B	61HE4800	231	70.4	6500	347	15	4.6	H25A	Y	0.262	6.7	18.5	14
SUB7505	B	61HE4600	267	81.4	7500	347	15	4.6	H25A	Y	0.274	7.0	16.1	14
SUB9205	B	61HE4400	327	99.7	9200	347	15	4.6	H30A	Y	0.265	6.7	13.1	12
SUB10605	B	61HE4300	380	115.9	10600	347	15	4.6	H40A	Y	0.272	6.9	11.4	10
SUB13005	B	61HE4200	463	141.2	13000	347	15	4.6	H40A	Y	0.285	7.2	9.3	10
SUB17205	B	61HC4100	614	187.2	17200	347	15	4.6	H60A	Y	0.278	7.1	7.0	8
480 Volts														
SUB19	B	61HD3200	245	74.7	4700	480	15	4.6	H25A	Y	0.248	6.3	49.0	14
SUB20	B	61HE3105	340	103.6	6450	480	15	4.6	H25A	Y	0.254	6.5	35.7	14
SUB21	B	61HE4600	440	134.1	8700	480	15	4.6	H25A	Y	0.274	7.0	26.5	14
SUB22	B	61HE4400	525	160.0	11000	480	15	4.6	H25A	Y	0.265	6.7	20.9	14
SUB3208	B	61HD3610	118	36.0	3200	480	15	4.6	H25A	Y	0.200	5.1	72.0	14
SUB4008	B	61HD3390	147	44.8	4000	480	15	4.6	H25A	Y	0.212	5.4	57.6	14
SUB4708	B	61HD3300	163	49.7	4700	480	15	4.6	H25A	Y	0.240	6.1	49.0	14
SUB5708	B	61HD3200	202	61.6	5700	480	15	4.6	H25A	Y	0.248	6.3	40.4	14
SUB6608	B	61HE3150	233	71.0	6600	480	15	4.6	H25A	Y	0.228	5.8	34.9	14
SUB7908	B	61HE3105	278	84.8	7900	480	15	4.6	H25A	Y	0.254	6.5	29.2	14
SUB9008	B	61HE4800	320	97.6	9000	480	15	4.6	H25A	Y	0.262	6.7	25.6	14
SUB10408	B	61HE4600	368	112.2	10400	480	15	4.6	H25A	Y	0.274	7.0	22.2	14
SUB12808	B	61HE4400	450	137.2	12800	480	15	4.6	H30A	Y	0.265	6.7	18.0	12
SUB14808	B	61HE4300	520	158.5	14800	480	15	4.6	H40A	Y	0.272	6.9	15.6	10
SUB18008	B	61HE4200	640	195.1	18000	480	15	4.6	H40A	Y	0.285	7.2	12.8	10
600 Volts														
SUB11	B	61HD3390	225	68.6	4100	600	15	4.6	H25A	Y	0.212	5.4	87.8	14
SUB12	B	61HD3200	310	94.5	5800	600	15	4.6	H25A	Y	0.248	6.3	62.1	14
SUB13	B	61HE3105	428	130.5	8000	600	15	4.6	H25A	Y	0.254	6.5	45.0	14
SUB14	B	61HE4600	548	167.0	11000	600	15	4.6	H25A	Y	0.274	7.0	32.7	14
SUB4006	B	61HD3610	147	44.8	4000	600	15	4.6	H25A	Y	0.200	5.1	90.0	14
SUB5106	B	61HD3390	181	55.2	5100	600	15	4.6	H25A	Y	0.212	5.4	70.6	14
SUB5806	B	61HD3300	207	63.1	5800	600	15	4.6	H25A	Y	0.240	6.1	62.1	14
SUB7106	B	61HD3200	254	77.4	7100	600	15	4.6	H25A	Y	0.248	6.3	50.7	14
SUB8206	B	61HE3150	293	89.3	8200	600	15	4.6	H25A	Y	0.228	5.8	43.9	14
SUB9806	B	61HE3105	350	106.7	9800	600	15	4.6	H25A	Y	0.254	6.5	36.7	14
SUB11206	B	61HE4800	402	122.6	11200	600	15	4.6	H25A	Y	0.262	6.7	32.1	14
SUB13006	B	61HE4600	462	140.9	13000	600	15	4.6	H25A	Y	0.274	7.0	27.7	14
SUB15906	B	61HE4400	566	172.6	15900	600	15	4.6	H30A	Y	0.265	6.7	22.6	12

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

APPROVALS

C US

LISTED
421H

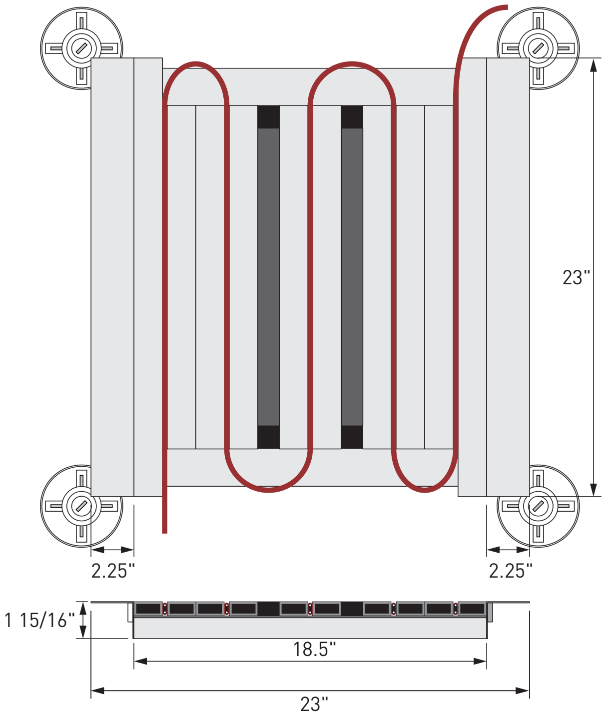
Nonhazardous Locations

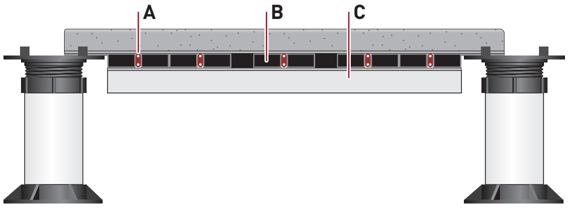
GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

PMPH

PEDESTAL MOUNTED PAVER HEATING SYSTEM FOR MELTING SNOW ON PAVERS INSTALLED ON PEDESTALS





PRODUCT OVERVIEW

Raychem brand Pedestal Mounted Paver Heating (PMPH) systems are designed to melt snow on pavers installed on pedestals. The PMPH systems are mounted on pedestals under the pavers to provide efficient, uniformed heat transfer to the pavers.

The PMPH system consists of high wattage Raychem QTVR electric heating cable [A], aluminum tray and conduits [B] designed to fit the cable, and 1 inch of closed cell foam insulation [C]. The PMPH system is designed for efficient and uniformed heat transfer across the top surface. The insulation at the bottom minimizes the heat loss from the bottom surface. The PMPH system uses 5 linear runs of 20QTVR-CT cable with power output necessary for heavy snow load areas.

PMPH systems provide:

- Long term snow melting solution by mechanically protecting the heating cable
- Efficient and uniformed heat transfer across the heated surface
- High performance and reliable solution for heavy snow load areas

CATALOG NUMBER

PMPH, Pedestal Mounted Paver Heating System

CONTENTS

PMPH	Al-Conduits and Tray
	20QTVR-CT (5 runs per PMPH system)
	1 inch closed cell foam insulation

MATERIALS OF CONSTRUCTION

Top Section	Aluminum Tray and Conduits
Bottom Section	Polyisocyanurate closed cell insulation

ADDITIONAL MATERIALS (AS REQUIRED)

Power Connection Gland (C75-100-A)	NEMA 4X rated gland kit with flexible conduit to protect and connect heating cable to a junction box
Splice Connection Kit (PMKG-LS)	Low profile splice connection kit
End Connection Kit (PMK-HSE2)	Heat shrink end seal kit
	Note: The junction boxes, pavers and pedestals are provided by others. Appropriate control and monitoring systems should be used with PMPH systems. Only approved connection kits and accessories must be used with PMPH Systems.

PRODUCT SPECIFICATIONS (NOMINAL)

Power Output	20 W/ft (65.6 W/m) of QTVR heating cable at 10°C (50°F)
Minimum Installation Temperature	0°F (-18°C)
Overall PMPH Dimensions	Width: 23 in (584 mm) Length: 23 in (584 mm) Thickness: 1 ¾ in (44 mm)
Conduit Thickness	0.0625 in (1.6 mm)
Insulation	Thickness: 1 in (25 mm)
Overall PMPH Weight	2.05 lb/Sq. ft. (10 kg/sq. m.)
Heating Cable Specifications	Please refer to QTVR datasheet H54041

GROUND-FAULT PROTECTION

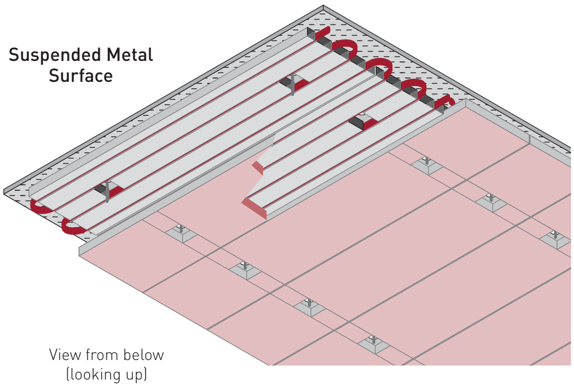
To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

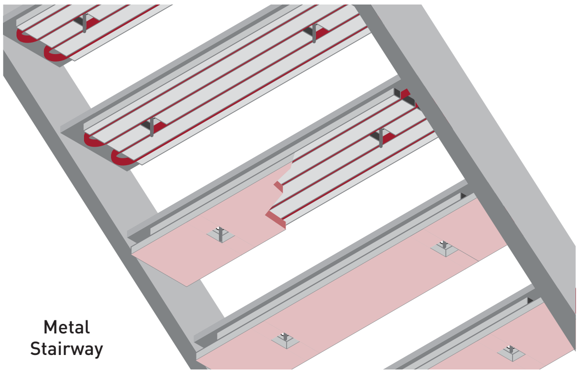
Raychem

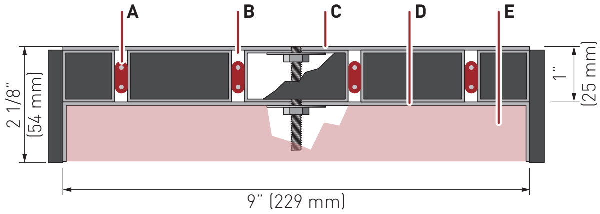
SMH

10 YEAR Product warranty

SUSPENSION MOUNTED HEATING SYSTEM FOR MELTING SNOW ON SUSPENDED SURFACES







PRODUCT OVERVIEW

Raychem brand Suspension Mounted Heating (SMH) systems are designed to melt snow on suspended surfaces such as metal stairs, catwalks, walkways etc. The SMH systems are mounted against the underside of these surfaces to ensure maximum thermal contact between the SMH system and the heated surface.

The SMH system consists of a top section which includes high wattage Raychem QTVR electric heating cable [A], aluminum channels positioned to provide a path [B] for the cable, top aluminum plate (C) in contact with the heated surface and the bottom section which includes aluminum tray (D) with insulation. The bottom tray consists of 1 inch of closed cell foam insulation [E] that minimizes the heat loss from the bottom surface of the SMH system. Once installed, the complete SMH system provides efficient and uniform heat transfer across the heated surface. The SMH system uses 4 linear runs of 20QTVR-CT cable.

SMH systems provide:

- Long term snow melting solution by mechanically protecting the heating cable
- Aesthetically pleasing solution by concealing the heating cable
- Efficient and uniformed heat transfer across the heated surface
- High performance and reliable solution for heavy snow load areas

CATALOG NUMBER

	SMH, Suspension Mounted Heating System

CONTENTS

SMH	Top section with aluminum channels and plate
	20QTVR-CT (4 runs per SMH system)
	Bottom section with aluminum tray and 1 inch closed cell foam insulation

MATERIALS OF CONSTRUCTION

Top Section	Aluminum
Bottom Section	Aluminum Closed cell foam insulation

ADDITIONAL MATERIALS (AS REQUIRED)

Power Connection Gland (C75-100-A)	NEMA 4X rated gland kit with flexible conduit to protect and connect heating cable to a junction box
Splice Connection kit (PMKG-LS)	Low profile splice connection kit
End Connection kit (PMK-HSE2)	Heat shrink end seal

Note: The junction boxes, conduits and studs for attachment are typically provided by others. Appropriate control and monitoring systems should be used with SMH systems. Only approved connection kits and accessories must be used with SMH systems.

PRODUCT SPECIFICATIONS (NOMINAL)

Power Output	20 W/ft (65.6 W/m) of QTVR heating cable at 10°C (50°F)
Minimum Installation Temperature	0°F (–18°C)
Overall SMH Dimensions*	Width: 9 in (229 mm) Length: Max. 56 in (1422 mm) Thickness: 2 3/8 in (60 mm)
Top Plate Dimensions*	Width: 9 in (229 mm) Length: Max. 50 in (1270 mm) Thickness: 0.090 in (2.3 mm)
Channel Thickness	0.0625 in (1.6 mm)
Insulation	Thickness: 1 in (25 mm)
Overall SMH Weight	5.26 lb/Sq. ft. (25.68 kg/sq. m.)
Heating Cable Specifications	Please refer to QTVR datasheet H54041

* For custom dimensions, please contact Thermal Management

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

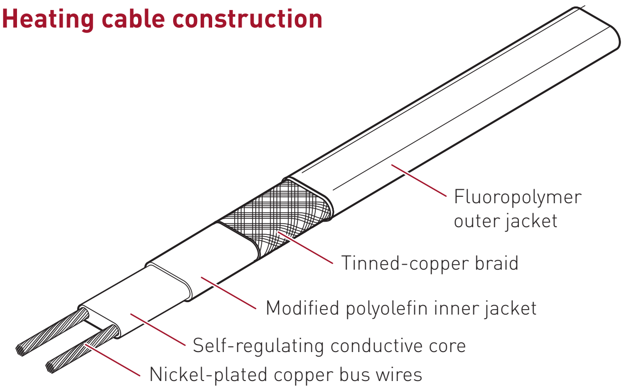
RAYSOL

SELF-REGULATING HEATING CABLE

For heat loss replacement, floor heating, radiant space heating, and frost heave prevention applications

10 YEAR Product warranty

Heating cable construction



PRODUCT OVERVIEW

The Raychem RaySol system is designed for the following floor heating applications.

Heat-loss replacement — replaces heat in concrete floors built over garages, loading docks, arcades, and other cold spaces. The cable is typically attached to the bottom of concrete floors.

Comfort floor heating — warms concrete, tile, stone and marble floors in lobbies, foyers, bathrooms, kitchens and gymnasiums. The cable is typically embedded in a thick mortar bed or concrete.

Radiant space heating – provides primary space heating for rooms with concrete floors. The cable is typically embedded in concrete or a thick mortar bed.

Freezer frost heave prevention — prevents heaving in soils under freezers, refrigerated warehouses, and cold rooms. The cable is placed in conduit buried in soil or in the subflooring under the freezer floor.

Efficient and economical to operate

Because it's self-regulating, a RaySol system will supply the right heat only where and when it is needed. The radiant heat provided by the RaySol heating cable allows you to feel comfortable at lower air temperatures, resulting in lower heating costs.

Thermal Management representatives can provide design assistance and help you install the product that meets your goals for an efficient, cost-effective floor heating system.

CATALOG NUMBER	RAYSOL-1	RAYSOL-2
VOLTAGE		
	120 V	208–277 V
MINIMUM BEND RADIUS		
	5/8 in (16 mm)	5/8 in (16 mm)

MAXIMUM CIRCUIT LENGTH IN FEET (METERS)

	Circuit breaker rating (A)	**Cable operating voltage**			
		120 V	**208 V**	**240 V**	**277 V**
Installed in conduit (at 40°F start-up temperature)	15	180 (54.9)	305 (93.0)	335 (102.1)	375 (114.3)
	20	240 (73.2)	410 (125.0)	450 (137.2)	500 (152.4)
	30	240 (73.2)	410 (125.0)	450 (137.2)	500 (152.4)
	40	240 (73.2)	410 (125.0)	450 (137.2)	500 (152.4)
Surface mounted (at 40°F start-up temperature)	15	120 (36.6)	205 (62.5)	210 (64.0)	215 (65.5)
	20	160 (48.8)	275 (83.8)	285 (86.9)	290 (88.4)
	30	240 (73.2)	410 (125.0)	425 (129.5)	430 (131.1)
	40	240 (73.2)	410 (125.0)	425 (129.5)	430 (131.1)
Embedded in concrete or mortar (at 40°F start-up temperature)	15	80 (24.4)	135 (41.1)	140 (42.7)	145 (44.2)
	20	105 (32.0)	185 (56.4)	185 (56.4)	195 (59.4)
	30	160 (48.8)	275 (83.8)	280 (85.3)	290 (88.4)
	40	170 (51.8)	280 (85.3)	320 (97.5)	360 (109.7)

BUS WIRES

16 AWG nickel-plated copper

BRAID / OUTER JACKET

Tinned-copper braid with fluoropolymer outer jacket

DIMENSIONS

Maximum width	0.56 in (14 mm)
Maximum thickness	0.24 in (6 mm)

NOMINAL WEIGHT

92 lb/1000 ft (137 kg/1000 m)

CONNECTION KITS

Raychem RayClic-E, FTC-P, FTC-XC, and FTC-HST connection kits must be used to connect and to terminate RaySol heating cables. Refer to the Freezer Frost Heave Prevention Design Guide (H58139) and the Heat Loss Replacement Design Guide (H58157) for proper connection kit selection.

APPROVALS

LISTED
9J86 Radiant
Heating Cable

-W

The RaySol system is UL Listed for heat loss replacement, comfort floor heating and radiant space heating applications.

The RaySol system is CSA Certified for comfort floor heating and radiant space heating applications. For heat loss replacement applications where the cable is attached to the bottom of the concrete floor, contact Thermal Management for additional information.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

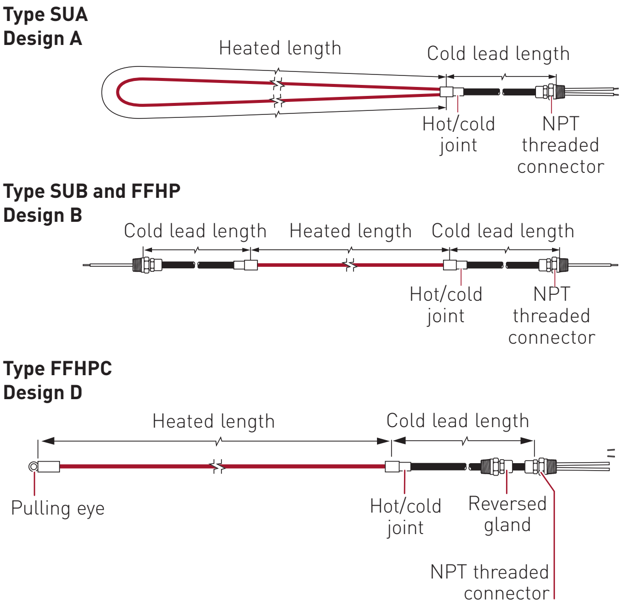
MI HEATING CABLE

10 YEAR Product warranty

HDPE JACKETED, COPPER AND ALLOY 825 SHEATHED MI CABLE

For freezer frost heave prevention applications

MI Heating Cable Configuration



PRODUCT OVERVIEW

Types SUA, SUB, and FFHP heating cables have a copper sheath that is extruded with high-density polyethylene (HDPE) jacket and are suitable for applications where the cable is directly embedded in the subfloor.

Type FFHPC heating cables are suitable for applications where the cable is installed in conduit. These heating cables are supplied with a copper sheathed cold lead and a heated length made with either Alloy 825 or a copper sheath with an extruded HDPE jacket.

MI heating cables for frost heave prevention applications are supplied as complete factory fabricated assemblies ready to fasten into a junction box. The copper or Alloy 825 sheath allows for a rugged yet flexible heating cable which is easy to install.

For additional information, contact your Thermal Management representative or call (800) 545-6258.

CABLE CONSTRUCTION

Type SUA, SUB and FFHP heating cable	
Sheath	Seamless copper
Jacket	HDPE
Insulation	Magnesium oxide
Conductor type	Alloy or copper
Number of conductors	1
Insulation voltage rating	600 V
Cable diameter (with jacket)	0.20 to 0.303 in (5.1 to 7.7 mm)
Type FFHPC heating cable	
Sheath	Alloy 825 or seamless copper
Jacket (for copper sheath cables)	HDPE
Insulation	Magnesium oxide
Conductor type	Alloy
Number of conductors	2
Insulation voltage rating	300 V
Cable diameter	
Alloy 825 sheath	0.130 to 0.174 in (3.3 to 4.4 mm)
Copper sheath (with jacket)	0.245 to 0.270 in (6.2 to 6.9 mm)

CABLE CONSTRUCTION

Cold lead

Sheath	Seamless copper
Jacket (Type SUA/SUB/FFHP cables)	HDPE
Insulation	Magnesium oxide
Conductor type	Copper
Number of conductors	1 or 2
Insulation voltage rating	600 V
Cable diameter	
With jacket	0.310 to 0.420 in (7.9 to 10.7 mm)
Without jacket (Type FFHPC)	0.371 in (9.4 mm)
Gland size (NPT)	1/2 in
Tail length	12 in (30 cm)
Reversed gland size (Type FFHPC)	3/4 in NPT

MINIMUM INSTALLATION TEMPERATURE

–22°F (–30°C)

MINIMUM BENDING RADIUS

6 times cable diameter

SUA/SUB HEATING CABLE SPECIFICATIONS

Catalog number	Design	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal heating cable diameter		Resistance [2]
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)
120 Volts and 208 Volts, 3-phase Wye													
SUA3	A	61HD3200	140	42.7	500	120	7	2.1	H22A	Y	0.248	6.3	28.0
SUA4	A	61HD3390	68	20.7	550	120	7	2.1	H22A	Y	0.212	5.4	27.0
SUA7	A	61HD3200	95	29.0	750	120	7	2.1	H22A	Y	0.248	6.3	18.8
SUA8	A	61HE3105	177	53.9	800	120	7	2.1	H22A	Y	0.254	6.5	18.0
SUB1	B	61HE3105	132	40.2	1000	120	15	4.6	H25A	Y	0.254	6.5	14.0
SUB2	B	61HE4600	240	73.1	1000	120	15	4.6	H25A	Y	0.274	7.0	14.5
SUB3	B	61HE4400	280	85.3	1300	120	15	4.6	H30A	Y	0.265	6.7	11.2
SUB4	B	61HE4300	320	97.5	1500	120	15	4.6	H30A	Y	0.272	6.9	9.6
SUB5	B	61HE4300	260	79.2	1800	120	15	4.6	H40A	Y	0.272	6.9	7.9
SUB6	B	61HE4200	375	114.3	1900	120	15	4.6	H40A	Y	0.285	7.2	7.5
SUB7	B	61HE4200	310	94.5	2300	120	15	4.6	H40A	Y	0.285	7.2	6.2
SUB8	B	61HC4100	550	167.6	2300	120	15	4.6	H60A	Y	0.278	7.1	6.4
SUB9	B	61HC5651	630	192.0	3000	120	15	4.6	H60A	Y	0.274	7.0	4.7
SUB10	B	61HC5409	717	218.5	4300	120	15	4.6	H80A	Y	0.303	7.7	3.4
208 Volts													
SUA1	A	61HD3610	108	32.9	650	208	7	2.1	H22A	Y	0.200	5.1	65.9
SUA6	A	61HE3105	264	80.5	1560	208	7	2.1	H22A	Y	0.254	6.5	27.7
SUB19	B	61HD3200	245	74.7	885	208	15	4.6	H25A	Y	0.248	6.3	49.0
SUB20	B	61HE3105	340	103.6	1210	208	15	4.6	H25A	Y	0.254	6.5	35.7
SUB21	B	61HE4600	440	134.1	1640	208	15	4.6	H25A	Y	0.274	7.0	26.5
SUB22	B	61HE4400	525	160.0	2060	208	15	4.6	H25A	Y	0.265	6.7	20.9

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: -0% to +3%

SUA/SUB HEATING CABLE SPECIFICATIONS

Catalog number	Design	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal heating cable diameter		Resistance [2]
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)
240 Volts													
SUB19	B	61HD3200	245	74.7	1175	240	15	4.6	H25A	Y	0.248	6.3	49.0
SUB20	B	61HE3105	340	103.6	1615	240	15	4.6	H25A	Y	0.254	6.5	35.7
SUB21	B	61HE4600	440	134.1	2180	240	15	4.6	H25A	Y	0.274	7.0	26.5
SUB22	B	61HE4400	525	160.0	2745	240	15	4.6	H25A	Y	0.265	6.7	20.9
277 Volts and 480 Volts, 3-phase Wye													
SUB19	B	61HD3200	245	74.7	1565	277	15	4.6	H25A	Y	0.248	6.3	49.0
SUB20	B	61HE3105	340	103.6	2150	277	15	4.6	H25A	Y	0.254	6.5	35.7
SUB21	B	61HE4600	440	134.1	2900	277	15	4.6	H25A	Y	0.274	7.0	26.5
SUB22	B	61HE4400	525	160.0	3650	277	15	4.6	H25A	Y	0.265	6.7	20.9
347 Volts and 600 Volts, 3-phase Wye													
SUB11	B	61HD3390	225	68.6	1400	347	15	4.6	H25A	Y	0.212	5.4	87.8
SUB12	B	61HD3200	310	94.5	1950	347	15	4.6	H25A	Y	0.248	6.3	62.1
SUB13	B	61HE3105	428	130.5	2700	347	15	4.6	H25A	Y	0.254	6.5	45.0
SUB14	B	61HE4600	548	167.0	3700	347	15	4.6	H25A	Y	0.274	7.0	32.7

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: -0% to +3%

FFHP HEATING CABLE SPECIFICATIONS

Catalog number	Design	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length[1]		Cold lead code	Joint type	Nominal heating cable diameter		Resistance[2]
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)
120 Volts and 208 Volts, 3-phase Wye													
FFHP1	B	61HD3610	58	17.7	405	120	15	4.6	H25A	Y	0.200	5.1	35.6
FFHP2	B	61HD3390	72	22.0	510	120	15	4.6	H25A	Y	0.212	5.4	28.2
FFHP3	B	61HD3300	83	25.3	580	120	15	4.6	H25A	Y	0.240	6.1	24.8
FFHP4	B	61HD3200	102	31.1	705	120	15	4.6	H25A	Y	0.248	6.3	20.4
FFHP5	B	61HE3150	117	35.7	820	120	15	4.6	H25A	Y	0.228	5.8	17.6
FFHP6	B	61HE3105	140	42.7	980	120	15	4.6	H25A	Y	0.254	6.5	14.7
FFHP7	B	61HE4800	160	48.8	1125	120	15	4.6	H25A	Y	0.262	6.7	12.8
FFHP8	B	61HE4600	185	56.4	1300	120	15	4.6	H25A	Y	0.274	7.0	11.1
FFHP9	B	61HE4400	226	68.9	1590	120	15	4.6	H25A	Y	0.265	6.7	9.1
FFHP10	B	61HE4300	262	79.9	1830	120	15	4.6	H25A	Y	0.272	6.9	7.9
FFHP11	B	61HE4200	320	97.6	2250	120	15	4.6	H25A	Y	0.285	7.2	6.4
FFHP12	B	61HC4100	426	129.9	2965	120	15	4.6	H30A	Y	0.278	7.1	4.9
FFHP13	B	61HC5651	528	161.0	3675	120	15	4.6	H40A	Y	0.274	7.0	3.9
FFHP14	B	61HC5409	664	202.4	4650	120	15	4.6	H40A	Y	0.303	7.7	3.1

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: -0% to +3%

FFHP HEATING CABLE SPECIFICATIONS

Catalog number	Design	Heating cable reference	Heated length		Nominal power (watts)	Cable voltage (volts)	Cold lead length[1]		Cold lead code	Joint type	Nominal heating cable diameter		Resist-ance[2] (ohms)
			(ft)	(m)			(ft)	(m)			(in)	(mm)	
208 Volts													
FFHP15	B	61HD3610	101	30.8	700	208	15	4.6	H25A	Y	0.200	5.1	61.8
FFHP16	B	61HD3390	126	38.4	880	208	15	4.6	H25A	Y	0.212	5.4	49.2
FFHP17	B	61HD3300	144	43.9	1000	208	15	4.6	H25A	Y	0.240	6.1	43.3
FFHP18	B	61HD3200	176	53.7	1230	208	15	4.6	H25A	Y	0.248	6.3	35.2
FFHP19	B	61HE3150	203	61.9	1420	208	15	4.6	H25A	Y	0.228	5.8	30.5
FFHP20	B	61HE3105	243	74.1	1700	208	15	4.6	H25A	Y	0.254	6.5	25.4
FFHP21	B	61HE4800	278	84.8	1945	208	15	4.6	H25A	Y	0.262	6.7	22.2
FFHP22	B	61HE4600	320	97.6	2250	208	15	4.6	H25A	Y	0.274	7.0	19.2
FFHP23	B	61HE4400	394	120.1	2745	208	15	4.6	H25A	Y	0.265	6.7	15.8
FFHP24	B	61HE4300	455	138.7	3170	208	15	4.6	H25A	Y	0.272	6.9	13.7
FFHP25	B	61HE4200	557	169.8	3885	208	15	4.6	H25A	Y	0.285	7.2	11.1
240 Volts													
FFHP26	B	61HD3610	116	35.4	815	240	15	4.6	H25A	Y	0.200	5.1	70.7
FFHP27	B	61HD3390	145	44.2	1020	240	15	4.6	H25A	Y	0.212	5.4	56.5
FFHP28	B	61HD3300	166	50.6	1160	240	15	4.6	H25A	Y	0.240	6.1	49.7
FFHP29	B	61HD3200	203	61.9	1420	240	15	4.6	H25A	Y	0.248	6.3	40.6
FFHP30	B	61HE3150	234	71.3	1640	240	15	4.6	H25A	Y	0.228	5.8	35.1
FFHP31	B	61HE3105	279	85.1	1965	240	15	4.6	H25A	Y	0.254	6.5	29.3
FFHP32	B	61HE4800	320	97.6	2250	240	15	4.6	H25A	Y	0.262	6.7	25.6
FFHP33	B	61HE4600	370	112.8	2600	240	15	4.6	H25A	Y	0.274	7.0	22.2
FFHP34	B	61HE4400	452	137.8	3185	240	15	4.6	H25A	Y	0.265	6.7	18.1
FFHP35	B	61HE4300	522	159.1	3680	240	15	4.6	H25A	Y	0.272	6.9	15.7
FFHP36	B	61HE4200	640	195.1	4500	240	15	4.6	H25A	Y	0.285	7.2	12.8
277 Volts and 480 Volts, 3-phase Wye													
FFHP37	B	61HD3610	134	40.9	940	277	15	4.6	H25A	Y	0.200	5.1	81.6
FFHP38	B	61HD3390	168	51.2	1170	277	15	4.6	H25A	Y	0.212	5.4	65.6
FFHP39	B	61HD3300	191	58.2	1340	277	15	4.6	H25A	Y	0.240	6.1	57.3
FFHP40	B	61HD3200	234	71.3	1640	277	15	4.6	H25A	Y	0.248	6.3	46.8
FFHP41	B	61HE3150	270	82.3	1895	277	15	4.6	H25A	Y	0.228	5.8	40.5
FFHP42	B	61HE3105	322	98.2	2270	277	15	4.6	H25A	Y	0.254	6.5	33.8
FFHP43	B	61HE4800	370	112.8	2590	277	15	4.6	H25A	Y	0.262	6.7	29.6
FFHP44	B	61HE4600	426	129.9	3000	277	15	4.6	H25A	Y	0.274	7.0	25.6
FFHP45	B	61HE4400	525	160.1	3655	277	15	4.6	H25A	Y	0.265	6.7	21.0
FFHP46	B	61HE4300	603	183.8	4240	277	15	4.6	H25A	Y	0.272	6.9	18.1
FFHP47	B	61HE4200	740	225.6	5185	277	15	4.6	H25A	Y	0.285	7.2	14.8

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%
Tolerance on heating cable length: -0% to +3%

FFHP HEATING CABLE SPECIFICATIONS

Catalog number	Design	Heating cable reference	Heated length		Nominal power (watts)	Cable voltage (volts)	Cold lead length[1]		Cold lead code	Joint type	Nominal heating cable diameter		Resistance[2] (ohms)
			(ft)	(m)			(ft)	(m)			(in)	(mm)	
347 Volts and 600 Volts, 3-phase Wye													
FFHP48	B	61HD3610	168	51.2	1175	347	15	4.6	H25A	Y	0.200	5.1	102.5
FFHP49	B	61HD3390	210	64.0	1470	347	15	4.6	H25A	Y	0.212	5.4	81.9
FFHP50	B	61HD3300	239	72.9	1680	347	15	4.6	H25A	Y	0.240	6.1	71.7
FFHP51	B	61HD3200	294	89.6	2050	347	15	4.6	H25A	Y	0.248	6.3	58.7
FFHP52	B	61HE3150	338	103.0	2375	347	15	4.6	H25A	Y	0.228	5.8	50.7
FFHP53	B	61HE3105	405	123.5	2830	347	15	4.6	H25A	Y	0.254	6.5	42.5
FFHP54	B	61HE4800	465	141.8	3240	347	15	4.6	H25A	Y	0.262	6.7	37.2
FFHP55	B	61HE4600	535	163.1	3750	347	15	4.6	H25A	Y	0.274	7.0	32.1
FFHP56	B	61HE4400	655	199.7	4600	347	15	4.6	H25A	Y	0.265	6.7	26.2
FFHP57	B	61HE4300	755	230.2	5315	347	15	4.6	H25A	Y	0.272	6.9	22.7

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%
Tolerance on heating cable length: -0% to +3%

FFHPC HEATING CABLE SPECIFICATIONS

Catalog number	Design	Heating cable reference	Heating length		Nominal power (watts)	Cable voltage (volts)	Cold lead length [1]		Cold lead code	Joint type	Nominal heating cable diameter		Resistance [2] (ohms)
			(ft)	(m)			(ft)	(m)			(in)	(mm)	
120 Volts													
FFHPC1	D	32SF2900	15	4.6	105	120	7	2.1	C22A	X	0.140	3.6	137.1
FFHPC2	D	32SA2600	20	6.1	120	120	7	2.1	C22A	X	0.135	3.4	120.0
FFHPC3	D	32SA2400	25	7.6	145	120	7	2.1	C22A	X	0.146	3.7	99.3
FFHPC4	D	32SA2275	30	9.1	175	120	7	2.1	C22A	X	0.153	3.9	82.3
FFHPC5	D	32SA2170	35	10.7	240	120	7	2.1	C22A	X	0.167	4.2	60.0
FFHPC6	D	32SB2114	40	12.2	315	120	7	2.1	C22A	X	0.174	4.4	45.7
FFHPC7	D	32SB2114	45	13.7	280	120	7	2.1	C22A	X	0.174	4.4	51.4
FFHPC8	D	32HD3800	50	15.2	360	120	7	2.1	C22A	Y	0.245	6.2	40.0
FFHPC9	D	32HD3800	55	16.8	330	120	7	2.1	C22A	Y	0.245	6.2	43.6
FFHPC10	D	32HD3600	60	18.3	400	120	7	2.1	C22A	Y	0.255	6.5	36.0
FFHPC11	D	32HD3600	65	19.8	370	120	7	2.1	C22A	Y	0.255	6.5	38.9
FFHPC12	D	32HD3400	70	21.3	515	120	7	2.1	C22A	Y	0.263	6.7	28.0
FFHPC13	D	32HD3400	75	22.9	480	120	7	2.1	C22A	Y	0.263	6.7	30.0
FFHPC14	D	32HD3400	80	24.4	450	120	7	2.1	C22A	Y	0.263	6.7	32.0
FFHPC15	D	32HD3300	85	25.9	565	120	7	2.1	C22A	Y	0.270	6.9	25.5
FFHPC16	D	32HD3300	90	27.4	535	120	7	2.1	C22A	Y	0.270	6.9	26.9
FFHPC17	D	32HE3200	95	29.0	750	120	7	2.1	C22A	Y	0.270	6.9	19.2
FFHPC18	D	32HE3200	100	30.5	720	120	7	2.1	C22A	Y	0.265	6.7	20.0

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%
Tolerance on heating cable length: –0% to +3%
Type FFHPC cables supplied with a 3/4 in NPT reversed gland connector and pulling eye.

FFHPC HEATING CABLE SPECIFICATIONS

Catalog number	Design	Heating cable reference	Heating length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal heating cable diameter		Resistance [2]
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)
208 Volts													
FFHPC19	D	32SF1110	25	7.6	155	208	7	2.1	C22A	X	0.130	3.3	279.1
FFHPC20	D	32SF2750	30	9.1	190	208	7	2.1	C22A	X	0.157	4.0	227.7
FFHPC21	D	32SA2600	35	10.7	205	208	7	2.1	C22A	X	0.135	3.4	211.0
FFHPC22	D	32SA2400	40	12.2	270	208	7	2.1	C22A	X	0.146	3.7	160.2
FFHPC23	D	32SA2275	45	13.7	350	208	7	2.1	C22A	X	0.153	3.9	123.8
FFHPC24	D	32SA2275	50	15.2	315	208	7	2.1	C22A	X	0.153	3.9	137.5
FFHPC25	D	32SA2200	55	16.8	390	208	7	2.1	C22A	X	0.169	4.3	110.9
FFHPC26	D	32SA2170	60	18.3	425	208	7	2.1	C22A	X	0.167	4.2	101.8
FFHPC27	D	32SA2170	65	19.8	390	208	7	2.1	C22A	X	0.167	4.2	110.9
FFHPC28	D	32SB2114	70	21.3	540	208	7	2.1	C22A	X	0.174	4.4	80.1
FFHPC29	D	32SB2114	75	22.9	505	208	7	2.1	C22A	X	0.174	4.4	85.7
FFHPC30	D	32SB2114	80	24.4	475	208	7	2.1	C22A	X	0.174	4.4	91.1
FFHPC31	D	32HD3800	85	25.9	635	208	7	2.1	C22A	Y	0.245	6.2	68.1
FFHPC32	D	32HD3800	90	27.4	600	208	7	2.1	C22A	Y	0.245	6.2	72.1
FFHPC33	D	32HD3800	95	29.0	570	208	7	2.1	C22A	Y	0.245	6.2	75.9
FFHPC34	D	32HD3600	100	30.5	720	208	7	2.1	C22A	Y	0.255	6.5	60.1
277 Volts													
FFHPC35	D	32SF1110	30	9.1	230	277	7	2.1	C22A	X	0.130	3.3	333.6
FFHPC36	D	32SF2900	35	10.7	240	277	7	2.1	C22A	X	0.140	3.6	319.7
FFHPC37	D	32SF2750	40	12.2	255	277	7	2.1	C22A	X	0.157	4.0	300.9
FFHPC38	D	32SA2600	45	13.7	285	277	7	2.1	C22A	X	0.135	3.4	269.2
FFHPC39	D	32SA2400	50	15.2	380	277	7	2.1	C22A	X	0.146	3.7	201.9
FFHPC40	D	32SA2400	55	16.8	350	277	7	2.1	C22A	X	0.146	3.7	219.2
FFHPC41	D	32SA2275	60	18.3	465	277	7	2.1	C22A	X	0.153	3.9	165.0
FFHPC42	D	32SA2275	65	19.8	430	277	7	2.1	C22A	X	0.153	3.9	178.4
FFHPC43	D	32SA2275	70	21.3	400	277	7	2.1	C22A	X	0.153	3.9	191.8
FFHPC44	D	32SA2200	75	22.9	500	277	7	2.1	C22A	X	0.169	4.3	153.5
FFHPC45	D	32SA2200	80	24.4	480	277	7	2.1	C22A	X	0.169	4.3	159.9
FFHPC46	D	32SA2170	85	25.9	530	277	7	2.1	C22A	X	0.167	4.2	144.8
FFHPC47	D	32SA2170	90	27.4	500	277	7	2.1	C22A	X	0.167	4.2	153.5
FFHPC48	D	32SB2114	95	29.0	700	277	7	2.1	C22A	X	0.174	4.4	109.6
FFHPC49	D	32SB2114	100	30.5	670	277	7	2.1	C22A	X	0.174	4.4	114.5

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%
Tolerance on heating cable length: –0% to +3%
Type FFHPC cables supplied with a 3/4 in NPT reversed gland connector and pulling eye.

APPROVALS

FM applies only to the bare copper and stainless steel cable for Freezer Frost Heave installation inside of conduits

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

10 YEAR Product warranty

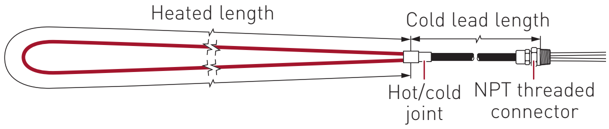
MI HEATING CABLE

COPPER AND HDPE JACKETED COPPER SHEATHED MI CABLE

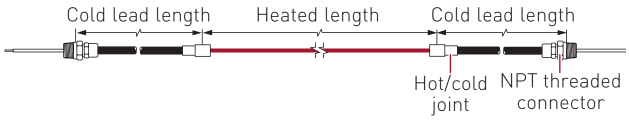
For heat loss replacement, floor heating and radiant space heating

MI Heating Cable Configuration

Type SUA
Design A



Type SUB, HLR and FH
Design B



PRODUCT OVERVIEW

Heat-loss replacement – replaces heat in concrete floors built over garages, loading docks, arcades, and other cold spaces. The cable is typically attached to the bottom of concrete floors.

Comfort floor heating – warms concrete, tile, stone and marble floors in lobbies, foyers, bathrooms, kitchens and gymnasiums. The cable is typically embedded in concrete or a thick mortar bed.

Radiant space heating – provides primary space heating for rooms with concrete floors. The cable is typically embedded in concrete or a thick mortar bed.

Type HLR heating cables are supplied with a copper sheath and are ideally suited for heat loss replacement applications. Types SUA, SUB and FH heating cables have a copper sheath that is covered with an extruded high-density polyethylene (HDPE) jacket and are suitable for applications where the cable is directly embedded in concrete or mortar floors.

The heating cables are factory assembled with an HDPE jacketed copper sheath cold lead, pre-terminated and ready to connect to a junction box. The copper sheath provides an ideal ground path and allows for a rugged yet flexible heating cable that is easy to install.

The radiant heat provided by the Raychem heating cable allows you to feel comfortable at lower air temperatures, resulting in lower heating costs.

Thermal Management representatives can provide design assistance and help you install the product that meets your goals for an efficient, cost-effective floor heating system.

CABLE CONSTRUCTION

Type HLR heating cable

Sheath	Seamless copper
Insulation	Magnesium oxide
Conductor type	Alloy or copper
Number of conductors	1
Insulation voltage rating	600 V
Cable diameter (without jacket)	0.120 to 0.205 in (3.0 to 5.2 mm)

CABLE CONSTRUCTION

Types SUA, SUB and FH heating cable	
Jacket	HDPE
Sheath	Seamless copper
Insulation	Magnesium oxide
Conductor type	Alloy or copper
Number of conductors	1
Insulation voltage rating	600 V
Cable diameter (with jacket)	0.200 to 0.303 in (5.1 to 7.7 mm)

Cold lead (Type SUA/SUB/HLR/FH cables)	
Jacket	HDPE
Sheath	Seamless copper
Insulation	Magnesium oxide
Conductor type	Copper
Number of conductors	1 or 2
Insulation voltage rating	600 V
Cable diameter (with jacket)	0.310 to 0.420 in (7.9 to 10.7 mm)
Gland size (NPT)	1/2 in
Tail length	12 in (30 mm)

MINIMUM INSTALLATION TEMPERATURE

–22°F (–30°C)

MINIMUM BENDING RADIUS

6 times cable diameter

TYPE HLR - HEAT LOSS REPLACEMENT CABLE SPECIFICATIONS

Catalog number	Config- uration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length[1]		Cold lead code	Joint type	Nominal cable diameter		Resis- tance[2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
120 Volts and 208 Volts, 3-phase Wye														
HLR1	B	61CD3610	70	21.3	330	120	15	4.6	H25A	Y	0.120	3.0	43.6	14
HLR2	B	61CD3610	44	13.4	540	120	15	4.6	H25A	Y	0.120	3.0	26.7	14
HLR3	B	61CD3390	55	16.8	670	120	15	4.6	H25A	Y	0.132	3.4	21.5	14
HLR4	B	61CD3300	63	19.2	760	120	15	4.6	H25A	Y	0.160	4.1	18.9	14
HLR5	B	61CD3200	77	23.5	935	120	15	4.6	H25A	Y	0.168	4.3	15.4	14
HLR6	B	61CE3150	89	27.1	1080	120	15	4.6	H25A	Y	0.148	3.8	13.3	14
HLR7	B	61CE3105	106	32.3	1295	120	15	4.6	H25A	Y	0.174	4.4	11.1	14
HLR8	B	61CE4800	122	37.2	1475	120	15	4.6	H25A	Y	0.182	4.6	9.8	14
HLR9	B	61CE4600	140	42.7	1715	120	15	4.6	H25A	Y	0.194	4.9	8.4	14
HLR10	B	61CE4400	172	52.4	2100	120	15	4.6	H25A	Y	0.185	4.7	6.9	14
HLR11	B	61CE4300	198	60.4	2425	120	15	4.6	H25A	Y	0.192	4.9	5.9	14
HLR12	B	61CE4200	244	74.4	2950	120	15	4.6	H30A	Y	0.205	5.2	4.9	12
HLR13	B	61CC4100	322	98.2	3925	120	15	4.6	H40A	Y	0.198	5.0	3.7	10

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

TYPE HLR - HEAT LOSS REPLACEMENT CABLE SPECIFICATIONS

Catalog number	Config-uration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal cable diameter		Resis-tance [2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
208 Volts														
HLR14	B	61CD3610	76	23.2	935	208	15	4.6	H25A	Y	0.120	3.0	46.3	14
HLR15	B	61CD3390	95	29.0	1170	208	15	4.6	H25A	Y	0.132	3.4	37.0	14
HLR16	B	61CD3300	109	33.2	1325	208	15	4.6	H25A	Y	0.160	4.1	32.7	14
HLR17	B	61CD3200	133	40.5	1625	208	15	4.6	H25A	Y	0.168	4.3	26.6	14
HLR18	B	61CE3150	154	47.0	1875	208	15	4.6	H25A	Y	0.148	3.8	23.1	14
HLR19	B	61CE3105	184	56.1	2240	208	15	4.6	H25A	Y	0.174	4.4	19.3	14
HLR20	B	61CE4800	211	64.3	2565	208	15	4.6	H25A	Y	0.182	4.6	16.9	14
HLR21	B	61CE4600	243	74.1	2970	208	15	4.6	H25A	Y	0.194	4.9	14.6	14
HLR22	B	61CE4400	296	90.2	3655	208	15	4.6	H25A	Y	0.185	4.7	11.8	14
HLR23	B	61CE4300	345	105.2	4180	208	15	4.6	H25A	Y	0.192	4.9	10.4	14
HLR24	B	61CE4200	420	128.0	5150	208	15	4.6	H30A	Y	0.205	5.2	8.4	12
HLR25	B	61CC4100	560	170.7	6780	208	15	4.6	H40A	Y	0.198	5.0	6.4	10
240 Volts														
HLR26	B	61CD3610	88	26.8	1075	240	15	4.6	H25A	Y	0.120	3.0	53.6	14
HLR27	B	61CD3390	110	33.5	1345	240	15	4.6	H25A	Y	0.132	3.4	42.8	14
HLR28	B	61CD3300	125	38.1	1535	240	15	4.6	H25A	Y	0.160	4.1	37.5	14
HLR29	B	61CD3200	153	46.6	1880	240	15	4.6	H25A	Y	0.168	4.3	30.6	14
HLR30	B	61CE3150	177	54.0	2170	240	15	4.6	H25A	Y	0.148	3.8	26.5	14
HLR31	B	61CE3105	212	64.6	2590	240	15	4.6	H25A	Y	0.174	4.4	22.2	14
HLR32	B	61CE4800	243	74.1	2965	240	15	4.6	H25A	Y	0.182	4.6	19.4	14
HLR33	B	61CE4600	280	85.4	3430	240	15	4.6	H25A	Y	0.194	4.9	16.8	14
HLR34	B	61CE4400	345	105.2	4175	240	15	4.6	H25A	Y	0.185	4.7	13.8	14
HLR35	B	61CE4300	395	120.4	4860	240	15	4.6	H25A	Y	0.192	4.9	11.9	14
HLR36	B	61CE4200	485	147.9	5940	240	15	4.6	H30A	Y	0.205	5.2	9.7	12
HLR37	B	61CC4100	640	195.1	7900	240	15	4.6	H40A	Y	0.198	5.0	7.3	10
277 Volts and 480 Volts, 3-phase Wye														
HLR38	B	61CD3610	102	31.1	1235	277	15	4.6	H25A	Y	0.120	3.0	62.1	14
HLR39	B	61CD3390	127	38.7	1550	277	15	4.6	H25A	Y	0.132	3.4	49.5	14
HLR40	B	61CD3300	145	44.2	1765	277	15	4.6	H25A	Y	0.160	4.1	43.5	14
HLR41	B	61CD3200	177	54.0	2170	277	15	4.6	H25A	Y	0.168	4.3	35.4	14
HLR42	B	61CE3150	205	62.5	2495	277	15	4.6	H25A	Y	0.148	3.8	30.8	14
HLR43	B	61CE3105	245	74.7	2985	277	15	4.6	H25A	Y	0.174	4.4	25.7	14
HLR44	B	61CE4800	280	85.4	3425	277	15	4.6	H25A	Y	0.182	4.6	22.4	14
HLR45	B	61CE4600	325	99.1	3935	277	15	4.6	H25A	Y	0.194	4.9	19.5	14
HLR46	B	61CE4400	396	120.7	4845	277	15	4.6	H25A	Y	0.185	4.7	15.8	14
HLR47	B	61CE4300	460	140.2	5560	277	15	4.6	H25A	Y	0.192	4.9	13.8	14
HLR48	B	61CE4200	560	170.7	6850	277	15	4.6	H30A	Y	0.205	5.2	11.2	12
HLR49	B	61CC4100	740	225.6	9100	277	15	4.6	H40A	Y	0.198	5.0	8.4	10

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

TYPE HLR - HEAT LOSS REPLACEMENT CABLE SPECIFICATIONS

Catalog number	Configuration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal cable diameter		Resistance [2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
347 Volts and 600 Volts, 3-phase Wye														
HLR50	B	61CD3610	127	38.7	1560	347	15	4.6	H25A	Y	0.120	3.0	77.2	14
HLR51	B	61CD3390	160	48.8	1930	347	15	4.6	H25A	Y	0.132	3.4	62.4	14
HLR52	B	61CD3300	182	55.5	2205	347	15	4.6	H25A	Y	0.160	4.1	54.6	14
HLR53	B	61CD3200	222	67.7	2715	347	15	4.6	H25A	Y	0.168	4.3	44.3	14
HLR54	B	61CE3150	258	78.7	3110	347	15	4.6	H25A	Y	0.148	3.8	38.7	14
HLR55	B	61CE3105	306	93.3	3750	347	15	4.6	H25A	Y	0.174	4.4	32.1	14
HLR56	B	61CE4800	350	106.7	4300	347	15	4.6	H25A	Y	0.182	4.6	28.0	14
HLR57	B	61CE4600	405	123.5	4955	347	15	4.6	H25A	Y	0.194	4.9	24.3	14
HLR58	B	61CE4400	495	150.9	6080	347	15	4.6	H25A	Y	0.185	4.7	19.8	14
HLR59	B	61CE4300	575	175.3	6980	347	15	4.6	H25A	Y	0.192	4.9	17.3	14
HLR60	B	61CE4200	700	213.4	8600	347	15	4.6	H30A	Y	0.205	5.2	14.0	12
480 Volts														
HLR61	B	61CD3610	175	53.4	2160	480	15	4.6	H25A	Y	0.120	3.0	106.7	14
HLR62	B	61CD3390	220	67.1	2685	480	15	4.6	H25A	Y	0.132	3.4	85.8	14
HLR63	B	61CD3300	250	76.2	3070	480	15	4.6	H25A	Y	0.160	4.1	75.0	14
HLR64	B	61CD3200	306	93.3	3770	480	15	4.6	H25A	Y	0.168	4.3	61.1	14
HLR65	B	61CE3150	355	108.2	4330	480	15	4.6	H25A	Y	0.148	3.8	53.2	14
HLR66	B	61CE3105	424	129.3	5175	480	15	4.6	H25A	Y	0.174	4.4	44.5	14
HLR67	B	61CE4800	485	147.9	5940	480	15	4.6	H25A	Y	0.182	4.6	38.8	14
HLR68	B	61CE4600	560	170.7	6860	480	15	4.6	H25A	Y	0.194	4.9	33.6	14
HLR69	B	61CE4400	690	210.4	8350	480	15	4.6	H25A	Y	0.185	4.7	27.6	14
600 Volts														
HLR70	B	61CD3610	220	67.1	2685	600	15	4.6	H25A	Y	0.120	3.0	134.1	14
HLR71	B	61CD3390	275	83.8	3360	600	15	4.6	H25A	Y	0.132	3.4	107.1	14
HLR72	B	61CD3300	313	95.4	3835	600	15	4.6	H25A	Y	0.160	4.1	93.9	14
HLR73	B	61CD3200	384	117.1	4690	600	15	4.6	H25A	Y	0.168	4.3	76.8	14
HLR74	B	61CE3150	443	135.1	5420	600	15	4.6	H25A	Y	0.148	3.8	66.4	14
HLR75	B	61CE3105	530	161.6	6470	600	15	4.6	H25A	Y	0.174	4.4	55.6	14
HLR76	B	61CE4800	605	184.5	7440	600	15	4.6	H25A	Y	0.182	4.6	48.4	14
HLR77	B	61CE4600	700	213.4	8570	600	15	4.6	H25A	Y	0.194	4.9	42.0	14

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

TYPE SUA/SUB - FLOOR HEATING AND RADIANT SPACE HEATING CABLE SPECIFICATIONS

Catalog number	Config-uration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal cable diameter		Resis-tance [2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
120 Volts and 208 Volts, 3-phase Wye														
SUA2	A	61HD3610	55	16.8	425	120	7	2.1	H22A	Y	0.200	5.1	33.6	14
SUA3	A	61HD3200	140	42.7	500	120	7	2.1	H22A	Y	0.248	6.3	28.0	14
SUA4	A	61HD3390	68	20.7	550	120	7	2.1	H22A	Y	0.212	5.4	26.5	14
SUA7	A	61HD3200	95	29.0	750	120	7	2.1	H22A	Y	0.248	6.3	19.0	14
SUA8	A	61HE3105	177	54.0	800	120	7	2.1	H22A	Y	0.254	6.5	18.6	14
SUB1	B	61HE3105	132	40.2	1000	120	15	4.6	H25A	Y	0.254	6.5	13.9	14
SUB2	B	61HE4600	240	73.2	1000	120	15	4.6	H25A	Y	0.274	7.0	14.4	14
SUB3	B	61HE4400	280	85.4	1300	120	15	4.6	H30A	Y	0.265	6.7	11.2	12
SUB4	B	61HE4300	320	97.6	1500	120	15	4.6	H30A	Y	0.272	6.9	9.6	12
SUB5	B	61HE4300	260	79.3	1800	120	15	4.6	H40A	Y	0.272	6.9	7.8	10
SUB6	B	61HE4200	375	114.3	1900	120	15	4.6	H40A	Y	0.285	7.2	7.5	10
SUB7	B	61HE4200	310	94.5	2300	120	15	4.6	H40A	Y	0.285	7.2	6.2	10
SUB8	B	61HC4100	550	167.7	2300	120	15	4.6	H60A	Y	0.278	7.1	6.3	8
SUB9	B	61HC5651	630	192.1	3000	120	15	4.6	H60A	Y	0.274	7.0	4.7	8
SUB10	B	61HC5409	717	218.6	4300	120	15	4.6	H80A	Y	0.303	7.7	3.3	6
208 Volts														
SUA1	A	61HD3610	108	32.9	650	208	7	2.1	H22A	Y	0.200	5.1	65.9	14
SUA6	A	61HE3105	264	80.5	1650	208	7	2.1	H22A	Y	0.254	6.5	27.7	14
SUB19	B	61HD3200	245	74.7	885	208	15	4.6	H25A	Y	0.248	6.3	49.0	14
SUB20	B	61HE3105	340	103.7	1210	208	15	4.6	H25A	Y	0.254	6.5	35.7	14
SUB21	B	61HE4600	440	134.1	1640	208	15	4.6	H25A	Y	0.274	7.0	26.4	14
SUB22	B	61HE4400	525	160.1	2060	208	15	4.6	H25A	Y	0.265	6.7	21.0	14
240 Volts														
SUA1	A	61HD3610	108	32.9	900	240	7	2.1	H22A	Y	0.200	5.1	65.9	14
SUA6	A	61HE3105	264	80.5	2100	240	7	2.1	H22A	Y	0.254	6.5	27.7	14
SUB19	B	61HD3200	245	74.7	1175	240	15	4.6	H25A	Y	0.248	6.3	49.0	14
SUB20	B	61HE3105	340	103.7	1615	240	15	4.6	H25A	Y	0.254	6.5	35.7	14
SUB21	B	61HE4600	440	134.1	2180	240	15	4.6	H25A	Y	0.274	7.0	26.4	14
SUB22	B	61HE4400	525	160.1	2745	240	15	4.6	H25A	Y	0.265	6.7	21.0	14
277 Volts and 480 Volts, 3-phase Wye														
SUB19	B	61HD3200	245	74.7	1565	277	15	4.6	H25A	Y	0.248	6.3	49.0	14
SUB20	B	61HE3105	340	103.7	2150	277	15	4.6	H25A	Y	0.254	6.5	35.7	14
SUB21	B	61HE4600	440	134.1	2900	277	15	4.6	H25A	Y	0.274	7.0	26.4	14
SUB22	B	61HE4400	525	160.1	3650	277	15	4.6	H25A	Y	0.265	6.7	21.0	14
347 Volts and 600 Volts, 3-phase Wye														
SUB11	B	61HD3390	225	68.6	1400	347	15	4.6	H25A	Y	0.212	5.4	87.8	14
SUB12	B	61HD3200	310	94.5	1950	347	15	4.6	H25A	Y	0.248	6.3	62.0	14
SUB13	B	61HE3105	428	130.5	2700	347	15	4.6	H25A	Y	0.254	6.5	44.9	14
SUB14	B	61HE4600	548	167.1	3700	347	15	4.6	H25A	Y	0.274	7.0	32.9	14

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

TYPE FH - FLOOR HEATING AND RADIANT SPACE HEATING CABLE SPECIFICATIONS

Catalog number	Configuration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal cable diameter		Resistance [2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
120 Volts and 208 Volts, 3-phase Wye														
FH1	B	61HD3610	54	16.5	440	120	15	4.6	H25A	Y	0.200	5.1	32.9	14
FH2	B	61HD3390	68	20.7	545	120	15	4.6	H25A	Y	0.212	5.4	26.5	14
FH3	B	61HD3300	77	23.5	625	120	15	4.6	H25A	Y	0.240	6.1	23.1	14
FH4	B	61HD3200	95	29.0	760	120	15	4.6	H25A	Y	0.248	6.3	19.0	14
FH5	B	61HE3150	109	33.2	880	120	15	4.6	H25A	Y	0.228	5.8	16.4	14
FH6	B	61HE3105	130	39.6	1055	120	15	4.6	H25A	Y	0.254	6.5	13.7	14
FH7	B	61HE4800	150	45.7	1200	120	15	4.6	H25A	Y	0.262	6.7	12.0	14
FH8	B	61HE4600	173	52.7	1390	120	15	4.6	H25A	Y	0.274	7.0	10.4	14
FH9	B	61HE4400	210	64.0	1715	120	15	4.6	H25A	Y	0.265	6.7	8.4	14
FH10	B	61HE4300	245	74.7	1960	120	15	4.6	H25A	Y	0.272	6.9	7.4	14
FH11	B	61HE4200	300	91.5	2400	120	15	4.6	H25A	Y	0.285	7.2	6.0	14
208 Volts														
FH12	B	61HD3610	94	28.7	755	208	15	4.6	H25A	Y	0.200	5.1	57.3	14
FH13	B	61HD3390	118	36.0	940	208	15	4.6	H25A	Y	0.212	5.4	46.0	14
FH14	B	61HD3300	134	40.9	1075	208	15	4.6	H25A	Y	0.240	6.1	40.2	14
FH15	B	61HD3200	164	50.0	1320	208	15	4.6	H25A	Y	0.248	6.3	32.8	14
FH16	B	61HE3150	190	57.9	1520	208	15	4.6	H25A	Y	0.228	5.8	28.5	14
FH17	B	61HE3105	225	68.6	1830	208	15	4.6	H25A	Y	0.254	6.5	23.6	14
FH18	B	61HE4800	260	79.3	2080	208	15	4.6	H25A	Y	0.262	6.7	20.8	14
FH19	B	61HE4600	300	91.5	2400	208	15	4.6	H25A	Y	0.274	7.0	18.0	14
FH20	B	61HE4400	365	111.3	2960	208	15	4.6	H25A	Y	0.265	6.7	14.6	14
FH21	B	61HE4300	425	129.6	3390	208	15	4.6	H25A	Y	0.272	6.9	12.8	14
FH22	B	61HE4200	520	158.5	4160	208	15	4.6	H25A	Y	0.285	7.2	10.4	14
240 Volts														
FH23	B	61HD3610	108	32.9	875	240	15	4.6	H25A	Y	0.200	5.1	65.9	14
FH24	B	61HD3390	135	41.2	1095	240	15	4.6	H25A	Y	0.212	5.4	52.7	14
FH25	B	61HD3300	155	47.3	1240	240	15	4.6	H25A	Y	0.240	6.1	46.5	14
FH26	B	61HD3200	190	57.9	1515	240	15	4.6	H25A	Y	0.248	6.3	38.0	14
FH27	B	61HE3150	215	65.5	1785	240	15	4.6	H25A	Y	0.228	5.8	32.3	14
FH28	B	61HE3105	260	79.3	2110	240	15	4.6	H25A	Y	0.254	6.5	27.3	14
FH29	B	61HE4800	300	91.5	2400	240	15	4.6	H25A	Y	0.262	6.7	24.0	14
FH30	B	61HE4600	345	105.2	2780	240	15	4.6	H25A	Y	0.274	7.0	20.7	14
FH31	B	61HE4400	420	128.0	3430	240	15	4.6	H25A	Y	0.265	6.7	16.8	14
FH32	B	61HE4300	490	149.4	3920	240	15	4.6	H25A	Y	0.272	6.9	14.7	14
FH33	B	61HE4200	600	182.9	4800	240	15	4.6	H25A	Y	0.285	7.2	12.0	14

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

TYPE FH - FLOOR HEATING AND RADIANT SPACE HEATING CABLE SPECIFICATIONS

Catalog number	Config-uration	Heating cable reference	Heated length		Nominal power	Cable voltage	Cold lead length [1]		Cold lead code	Joint type	Nominal cable diameter		Resis-tance [2]	Tail size
			(ft)	(m)	(watts)	(volts)	(ft)	(m)			(in)	(mm)	(ohms)	(AWG)
277 Volts and 480 Volts, 3-phase Wye														
FH34	B	61HD3610	125	38.1	1005	277	15	4.6	H25A	Y	0.200	5.1	76.3	14
FH35	B	61HD3390	155	47.3	1270	277	15	4.6	H25A	Y	0.212	5.4	60.5	14
FH36	B	61HD3300	178	54.3	1440	277	15	4.6	H25A	Y	0.240	6.1	53.4	14
FH37	B	61HD3200	218	66.5	1760	277	15	4.6	H25A	Y	0.248	6.3	43.6	14
FH38	B	61HE3150	253	77.1	2020	277	15	4.6	H25A	Y	0.228	5.8	38.0	14
FH39	B	61HE3105	300	91.5	2435	277	15	4.6	H25A	Y	0.254	6.5	31.5	14
FH40	B	61HE4800	345	105.2	2780	277	15	4.6	H25A	Y	0.262	6.7	27.6	14
FH41	B	61HE4600	400	122.0	3200	277	15	4.6	H25A	Y	0.274	7.0	24.0	14
FH42	B	61HE4400	490	149.4	3915	277	15	4.6	H25A	Y	0.265	6.7	19.6	14
FH43	B	61HE4300	564	172.0	4535	277	15	4.6	H25A	Y	0.272	6.9	16.9	14
FH44	B	61HE4200	690	210.4	5560	277	15	4.6	H25A	Y	0.285	7.2	13.8	14
347 Volts and 600 Volts, 3-phase Wye														
FH45	B	61HD3610	155	47.3	1275	347	15	4.6	H25A	Y	0.200	5.1	94.6	14
FH46	B	61HD3390	195	59.5	1585	347	15	4.6	H25A	Y	0.212	5.4	76.1	14
FH47	B	61HD3300	220	67.1	1825	347	15	4.6	H25A	Y	0.240	6.1	66.0	14
FH48	B	61HD3200	270	82.3	2230	347	15	4.6	H25A	Y	0.248	6.3	54.0	14
FH49	B	61HE3150	315	96.0	2550	347	15	4.6	H25A	Y	0.228	5.8	47.3	14
FH50	B	61HE3105	376	114.6	3050	347	15	4.6	H25A	Y	0.254	6.5	39.5	14
FH51	B	61HE4800	430	131.1	3500	347	15	4.6	H25A	Y	0.262	6.7	34.4	14
FH52	B	61HE4600	497	151.5	4040	347	15	4.6	H25A	Y	0.274	7.0	29.8	14
FH53	B	61HE4400	610	186.0	4935	347	15	4.6	H25A	Y	0.265	6.7	24.4	14
FH54	B	61HE4300	710	216.5	5650	347	15	4.6	H25A	Y	0.272	6.9	21.3	14
480 Volts														
FH55	B	61HD3610	215	65.5	1760	480	15	4.6	H25A	Y	0.200	5.1	131.2	14
FH56	B	61HD3390	270	82.3	2190	480	15	4.6	H25A	Y	0.212	5.4	105.3	14
FH57	B	61HD3300	310	94.5	2480	480	15	4.6	H25A	Y	0.240	6.1	93.0	14
FH58	B	61HD3200	380	115.9	3030	480	15	4.6	H25A	Y	0.248	6.3	76.0	14
FH59	B	61HE3150	435	132.6	3530	480	15	4.6	H25A	Y	0.228	5.8	65.3	14
FH60	B	61HE3105	520	158.5	4220	480	15	4.6	H25A	Y	0.254	6.5	54.6	14
FH61	B	61HE4800	600	182.9	4800	480	15	4.6	H25A	Y	0.262	6.7	48.0	14
FH62	B	61HE4600	690	210.4	5565	480	15	4.6	H25A	Y	0.274	7.0	41.4	14
600 Volts														
FH63	B	61HD3610	270	82.3	2185	600	15	4.6	H25A	Y	0.200	5.1	164.7	14
FH64	B	61HD3390	340	103.7	2715	600	15	4.6	H25A	Y	0.212	5.4	132.6	14
FH65	B	61HD3300	385	117.4	3120	600	15	4.6	H25A	Y	0.240	6.1	115.5	14
FH66	B	61HD3200	470	143.3	3830	600	15	4.6	H25A	Y	0.248	6.3	94.0	14
FH67	B	61HE3150	545	166.2	4400	600	15	4.6	H25A	Y	0.228	5.8	81.8	14
FH68	B	61HE3105	650	198.2	5275	600	15	4.6	H25A	Y	0.254	6.5	68.3	14

[1] To modify cold lead length, contact your Thermal Management sales representative.

[2] Resistance tolerance: +/– 10%

Tolerance on heating cable length: –0% to +3%

APPROVALS

C US

Note: For heat loss replacement applications where the cable is attached to the bottom of the concrete floor, contact Thermal Management for additional information.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

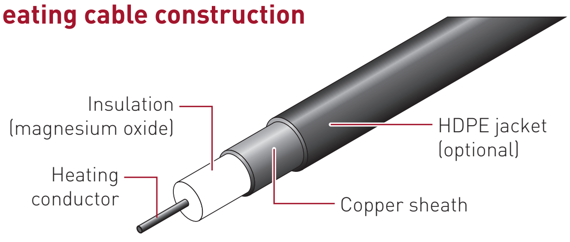
MI HEATING CABLE

10 YEAR Product warranty

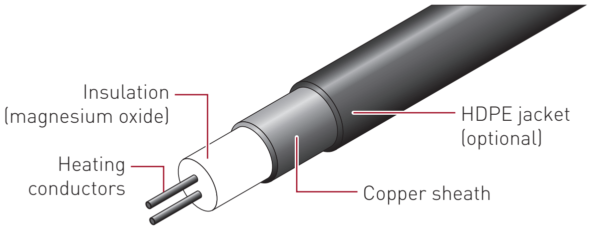
COPPER AND HDPE JACKETED COPPER SHEATHED MI CABLE

For commercial and industrial applications

Heating cable construction



Single-conductor cable (61 series)



Dual-conductor cable (32, 62 series)

PRODUCT OVERVIEW

The copper sheath provides an ideal ground path and allows for a rugged yet flexible heating cable that is easy to install. Each heating cable includes a heated section that is joined to a preterminated nonheating cold lead which is ready to connect into a junction box. For corrosive or embedded applications, such as concrete or asphalt snow melting, a cable with a high-density polyethylene (HDPE) jacket is required. Refer to the tables below for the complete list of approved applications.

For additional information or applications requiring stainless steel sheathed heating cables, contact your Thermal Management representative or call (800) 545-6258.

APPROVED APPLICATIONS AND POWER OUTPUT FOR NONHAZARDOUS AREAS

Bare copper-sheathed heating cable	c-CSA-us	FM	UL	Max. power output W/ft (W/m)
Snow melting on metal roofs	Yes	No	No	15 (49)
De-icing of metal gutters and downspouts	Yes	No	No	15 (49)
De-icing of nonmetallic gutters and downspouts	Yes	No	No	5 (16)
Freeze protection of metal pipes and vessels[2]	Yes	Yes	No	18 (59)
Process temperature maintenance (pipes and vessels)[2]	Yes	Yes	No	18 (59)
HDPE jacketed copper-sheathed heating cable				
Snow melting in concrete and mastic asphalt slab	Yes	No	Yes	30 (99)
Snow melting in road-grade asphalt slab	Yes	No	Yes	25 (82)
Snow melting in sand/limestone screenings (pavers)	No[1]	No	No	20 (66)
Snow melting on nonmetal roof	Yes	No	No	8 (26)
Pool and Spa Decks	Yes[3]	No	No	35 (115)
De-icing of metal gutters and downspouts	Yes	No	No	8 (26)
De-icing of nonmetallic gutters and downspouts	Yes	No	No	5 (16)
Floor heating in concrete slab	Yes	No	No	10 (33)
Frost heave protection - embedded in concrete	Yes	No	No	7 (23)
Freeze protection of metal pipes and vessels – internal	Yes	No	No	8 (26)
Freeze protection of metal pipes and vessels – external	Yes	No	No	8 (26)
Freeze protection of nonmetallic pipes and vessels – internal	Yes	No	No	4 (13)
Freeze protection of nonmetallic pipes and vessels – external	Yes	No	No	4 (13)

[1] Special permission for paver snow melting is required from the Authority Having Jurisdiction.

[2] When designing heating cables for pipe and vessel tracing, the "Max. power output (W/ft)" values may have to be decreased to ensure that the sheath temperature does not exceed the maximum exposure temperature (see page 2) of the cable.

[3] Pool and spa deck approval - Canada only.

APPROVED APPLICATIONS AND POWER OUTPUT FOR HAZARDOUS AREAS

Bare copper-sheathed heating cable	**c-CSA-us**	**FM**	**UL**	**Max. power output W/ft (W/m)**
Process temperature maintenance (pipes and vessels)[3]	Yes	Yes	No	18 (59)
Freeze protection of metal pipes and vessels[3]	Yes	Yes	No	18 (59)
De-icing of metal gutters and downspouts[3]	Yes	No	No	15 (49)
De-icing of nonmetallic gutters and downspouts	Yes	No	No	5 (16)
HDPE jacketed copper-sheathed heating cable				
Snow melting in concrete and mastic asphalt slab	Yes	No	No	30 (99)
Snow melting in road-grade asphalt slab	Yes	No	No	25 (82)
HDPE jacketed copper-sheathed heating cable				
De-icing of metal gutters and downspouts[3]	Yes	No	No	8 (26)
De-icing of nonmetallic gutters and downspouts	Yes	No	No	5 (16)
Freeze protection of metal pipes and vessels – external[3]	Yes	No	No	8 (26)
Freeze protection of nonmetallic pipes and vessels – external	Yes	No	No	4 (13)

[3] When designing heating cables for pipe and vessel tracing, and de-icing of metal gutters and downspouts, the "Max. power output (W/ft)" values may have to be decreased to ensure that the sheath temperature does not exceed the maximum exposure temperature of the cable (see below) or the autoignition temperature of gases and vapors present in the hazardous area. For assistance designing heating cables for hazardous areas, contact Thermal Management Technical Support at (800) 545-6258.

TEMPERATURE RATINGS

Maximum exposure temperature

392°F (200°C) Bare copper-sheathed heating cable
194°F (90°C) HDPE-jacketed heating cable*
* HDPE-sheathed cables may be exposed to higher temperatures during installation in asphalt.

Minimum installation temperature

-76°F (-60°C) Bare copper-sheathed heating cable
-4°F (-20°C) for UL, -22°F (-30°C) for CSA HDPE-jacketed heating cable

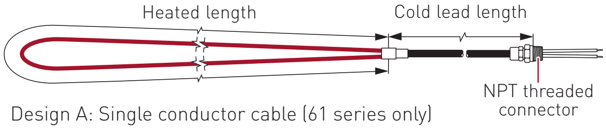
TEMPERATURE ID NUMBER (T-RATING)

To be established by calculating the maximum sheath temperature. Contact Thermal Management for assistance.

BASIC HEATING CABLE DESIGN CONFIGURATIONS

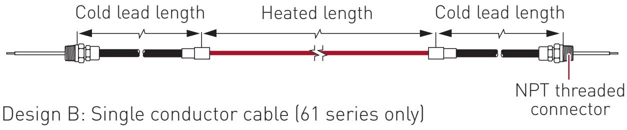
Heating cables are supplied as complete factory-fabricated assemblies consisting of the heated section joined to a length of nonheating cold lead section, preterminated with an NPT-threaded connector and ready to connect into a junction box.

Design A



Design A: Single conductor cable (61 series only)

Design B

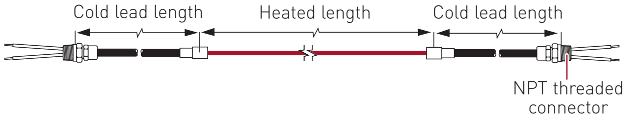


Design B: Single conductor cable (61 series only)

Design D

Design D: Dual conductor cable (32, 62 series only)

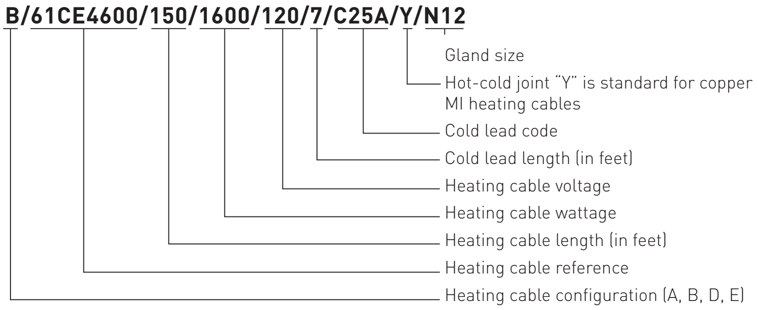
Design E



Design E: Dual conductor cable (32, 62 series only)

HEATING CABLE CATALOG NUMBER

To order an MI heating cable, it is important to understand the format of our catalog number.



In the above heating cable catalog number, the length of the heated section and the cold lead are in feet. For metric lengths, the heating cable catalog number would include a suffix "M" after the length, as shown below. A HDPE jacket on the heated section and a HDPE jacket on the cold lead have also been included in the following:
B/61HE4600/45.7M/1600/120/2.1M/H25A/Y/N12

Options

Add suffix "/PE" at the end of the catalog number for pulling eye (Design D cables only).
Add suffix "/RG1" at the end of the catalog number for 1" reverse gland (used to make a watertight seal) for Designs A and D cables. Design D cables also available with 1/2" or 3/4" reverse gland ("/RG34" for 3/4" or "/RG12" for 1/2").

Examples

Snow melting for area 1200 sq ft (spacing 7")
6 cables **B/61HE3150/343/7000/600/15/H25A/Y/N12**

- Heating cable configuration is Design B
- 600 V rated single conductor HDPE jacketed cable, resistance at 20°C is 0.150 Ω/ft (0.492 Ω/m)
- Each heating cable length is 343 ft (104.5 m)
- Each heating cable wattage is 7000 W at 600 V
- Cold lead is 15 ft (4.5 m) with HDPE jacket
- Cold lead code is H25A
- 1/2-in NPT gland connector

Pipe tracing for 2 in x 50 ft pipe
1 cable **D/32CD3800/52/340/120/3/C22A/Y/N12**

- Heating cable configuration is Design D
- 300 V rated two conductor cable, resistance at 20°C is 0.80 Ω/ft (2.625 Ω/m)
- Heating cable length is 52 ft (15.9 m)
- Heating cable wattage is 340 W at 120 V
- Cold lead is 3 ft (0.9 m)
- Cold lead code is C22A
- 1/2-in NPT gland connector

HEATING CABLE REFERENCE DECODING

6 1 C D 3 6 1 0
Digit 1 2 3 4 5 6 7 8

Digit number	Description	
1	Maximum voltage rating	3 = 300 V, 6 = 600 V
2	Number of conductors	1 or 2
3	Sheath material	C = Copper, H = HDPE jacketed copper
4	Conductor material	C, D, or E
5	Move decimal point to left indicated number of places	1, 2, 3, 4, 5, or 6 places
6 to 8	Cable resistance (Ω/ft) to 3 whole numbers (use with digit 5)	3610 = 0.610 Ω/cable foot at 20°C

COLD LEADS FOR COPPER-SHEATHED HEATING CABLES

Cold leads for copper MI heating cables are available in bare copper or for superior mechanical and corrosion resistance HDPE jacketed copper. Use HDPE jacketed copper for all embedded heating cable applications, such as snow melting and floor heating.

Bare copper cold lead code	HDPE jacketed cold lead code	Maximum voltage (V)	Maximum current (A)	Gland size (NPT)	Gland size reference for catalog number	Tail size (AWG)
Design A, D, E						
C22A	H22A	600	22	1/2"	N12	14
C29A	H29A	600	29	1/2"	N12	12
C38A	H38A	600	38	3/4"	N34	10
C50A	H50A	600	50	3/4"	N34	8
C67A	H67A	600	67	3/4"	N34	6
C90A	H90A	600	90	1"	N1	4
Design B						
C25A	H25A	600	25	1/2"	N12	14
C30A	H30A	600	30	1/2"	N12	12
C40A	H40A	600	40	1/2"	N12	10
C60A	H60A	600	60	1/2"	N12	8
C80A	H80A	600	80	1/2"	N12	6
C105A	H105A	600	105	1/2"	N12	4

SERIES 61 MI HEATING CABLE SPECIFICATIONS (600 V, SINGLE CONDUCTOR)

Heating cable reference	Nom. cable resistance at 20°C		Nominal cable diameter		Max. unjointed cable length		Nominal weight	
	Ω/ft	Ω/m	in	mm	ft	m	lb/1000 ft	kg/1000 m
61CD3610	0.610	2.00	0.120	3.0	11712	3571	35	52.1
61CD3390	0.390	1.28	0.132	3.4	9689	2954	45	67.0
61CD3300	0.300	0.984	0.160	4.1	6595	2011	45	67.0
61CD3200	0.200	0.656	0.168	4.3	5987	1825	56	83.3
61CE3150	0.150	0.492	0.148	3.8	7718	2353	49	72.9
61CE3105	0.105	0.344	0.174	4.4	5230	1594	52	77.4
61CE4800	0.0800	0.262	0.182	4.6	4948	1508	54	80.4
61CE4600	0.0600	0.197	0.194	4.9	4269	1301	56	83.3
61CE4400	0.0400	0.131	0.185	4.7	4686	1429	58	86.2
61CE4300	0.0300	0.0980	0.192	4.9	4340	1323	65	96.6
61CE4200	0.0200	0.0660	0.205	5.2	3564	1086	74	110.2
61CC4100	0.0100	0.0328	0.198	5.0	4624	1409	58	86.3
61CC5651	0.00651	0.0214	0.194	4.9	4187	1277	67	99.7
61CC5409	0.00409	0.0134	0.223	5.7	3394	1034	84	125.2
61CC5258	0.00258	0.00846	0.230	5.8	3076	938	98	146.1
61CC5162	0.00162	0.00531	0.246	6.2	2693	821	117	174.2
61CC5102	0.00102	0.00335	0.277	7.0	2056	627	154	229.1
61CC6641	0.000641	0.00210	0.298	7.6	1688	515	179	266.3
61CC6403	0.000403	0.00132	0.340	8.6	1331	406	236	351.1

Notes: 1) To specify an HDPE jacket on the heating cable, replace the C (first letter in reference) with H.
Example: 61CD3610 becomes 61HD3610 for jacketed version.
2) Tolerance on cable resistance is ± 10%.

SERIES 32 MI HEATING CABLE SPECIFICATIONS (300 V, DUAL CONDUCTOR)

Heating cable reference	Nom. cable resistance at 20°C		Nominal cable diameter		Max. unjointed cable length		Nominal weight	
	Ω/ft	Ω/m	in	mm	ft	m	lb/1000 ft	kg/1000 m
32CD3800	0.800	2.62	0.165	4.2	5800	1768	46	68.5
32CD3600	0.600	1.97	0.175	4.4	5676	1730	59	87.8
32CD3400	0.400	1.31	0.183	4.6	4686	1428	60	89.4
32CD3300	0.300	0.984	0.190	4.8	4158	1267	62	92.1
32CE3200	0.200	0.656	0.185	4.7	4686	1428	60	89.4
32CE3125	0.125	0.410	0.195	5.0	4026	1227	65	96.6
32CE3100	0.100	0.328	0.208	5.3	3564	1086	65	96.6
32CE4700	0.0700	0.230	0.230	5.8	3300	1006	110	163.7
32CE4440	0.0440	0.144	0.260	6.6	2244	684	140	208.2
32CE4280	0.0280	0.092	0.300	7.6	1782	543	182	270.8

Notes: 1) To specify a HDPE jacket on the heating cable, replace the C (first letter in reference) with H.
Example: 32CD3800 becomes 32HD3800 for jacketed version.
2) Tolerance on cable resistance is ± 10%.

SERIES 62 MI HEATING CABLE SPECIFICATIONS (600 V, DUAL CONDUCTOR)

Heating cable reference	Nom. cable resistance at 20°C		Nominal cable diameter		Max. unjointed cable length		Nominal weight	
	Ω/ft	Ω/m	in	mm	ft	m	lb/1000 ft	kg/1000 m
62CE4950	0.0950	0.312	0.283	7.2	1890	576	129	192
62CE4700	0.0700	0.230	0.309	7.9	1400	427	150	223.2
62CE4440	0.0440	0.144	0.340	8.6	1170	357	181	269.4
62CE4280	0.0280	0.0920	0.371	9.4	965	294	224	333.8
62CC4200	0.0200	0.0656	0.290	7.4	2046	624	140	208.3
62CC4130	0.0130	0.0427	0.309	7.9	1647	502	150	223.2
62CC5818	0.00818	0.0268	0.340	8.6	1217	371	189	281.2
62CC5516	0.00516	0.0169	0.371	9.4	1062	324	236	351.1
62CC5324	0.00324	0.0106	0.402	10.2	876	267	275	409.1
62CC5204	0.00204	0.00669	0.449	11.4	706	215	353	525.3

Notes: 1) To specify a HDPE jacket on the heating cable, replace the C (first letter in reference) with H.
Example: 62CE4950 becomes 62HE4950 for jacketed version.
2) Tolerance on cable resistance is ± 10%.

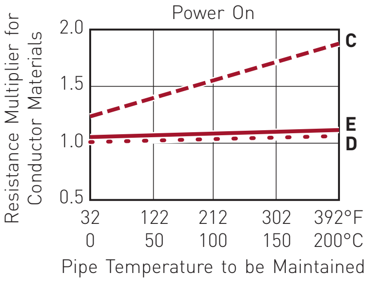
RESISTANCE CORRECTION FACTOR

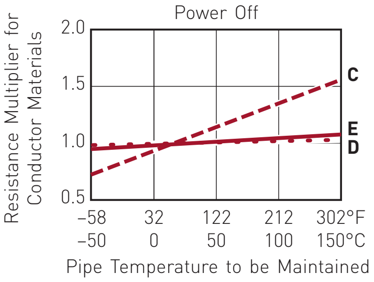
Various conductor materials behave differently. Based on the application, use the table or graphs below for approximate adjustment of power and resistance as a function of temperature. For detailed design, contact Thermal Management for further assistance.

Applications: Snow melting, floor warming, roof and gutter de-icing, frost-heave prevention

Conductor material	Correction factor
C	1.15
D	1.0
E	1.0

Applications: Freeze protection for pipes and vessels, process temperature maintenance for pipes and vessels





APPROVALS

Also refer to application tables on previous pages

Nonhazardous Locations

***Hazardous Locations**

Class I, Div 1 & 2, Groups A, B, C, D
Class II, Div 1 & 2, Groups E, F, G
Class III

* Polymer jacketed MI Heating Cables are not FM approved.

Nonhazardous Locations

***Hazardous Locations**

Class I, Div 1* & 2, Groups A, B, C,
Class II, Div 1 & 2, Groups E, F, G
Class III

* Polymer jacketed MI Heating Cabl are not approved for CID1 locatior

Nonhazardous Locations

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

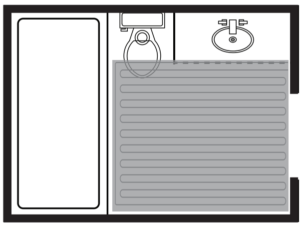
Nuheat

MAT

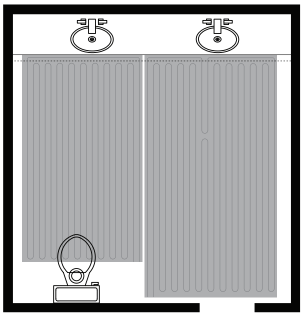
PRE-BUILT ELECTRIC FLOOR HEATING SYSTEM

25 YEAR Product warranty

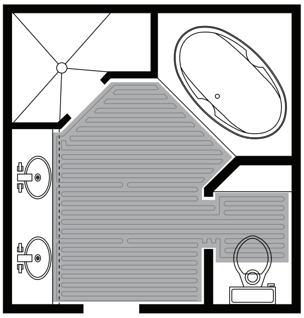
25 Total care warranty



Single Standard Mat



Multiple Standard Mats



Custom Mat

PRODUCT OVERVIEW

Pre-built like an electric blanket, Nuheat Mat is an electric floor heating system that brings soothing heat to the following surfaces:

- Ceramic or porcelain tile
- Granite
- Marble
- Natural Stone
- Laminate/Engineered wood floors

Nuheat Mat is a pre-built floor heating system meaning it does not require any on-site manipulation during installation. Thinset is applied to the subfloor, the pre-built Nuheat Mat is pressed onto the thinset, and flooring can be installed immediately. Nuheat Mat is compatible with all standard subfloor material and is only 1/8" thick and making it ideal for installations where minimal floor buildup is desired. The pre-built aspect of Nuheat Mat guarantees even heat distribution as the heating wires are evenly spaced during production.

Nuheat Mat is available in over 70 standard mat sizes (squares and rectangles of various dimensions) and are available off-the-shelf. A single standard mat can provide adequate floor heat coverage for most standard bathroom and living areas. Installers can also combine multiple standard mats to heat the desired area.

When full coverage cannot be achieved with Nuheat standard mats (example: areas with curves, angles, or obstructions), Nuheat custom mats are available to provide optimal coverage. Once area dimensions are submitted/confirmed, Nuheat custom mats are manufactured in only three days and will fit the exact shape of the area indicated in the submitted drawings. Just like Nuheat standard mats, Nuheat custom mats are pre-built thereby guaranteeing even heat distribution without cold spots.

Nuheat standard and custom mats are available in 120 V and 240 V and produces 12 watts per sqft (up to 15 watts per sqft when required/specified).

KIT CONTENTS

1 Nuheat Mat floor heating system
1 Installation instruction manual

NUHEAT STANDARD MAT SELECTION TABLE

120 VOLT STANDARD MATS

	Dimensions (inches)	Ohms	Amps	Watts	Model Number
3.5 ft series	40x27	160	0.8	90	F1006
	40x32	135	0.9	107	F1008
	40x40	108	1.1	133	F1010
	40x48	90	1.3	160	F1012
4 ft series	48x24	150	0.8	96	F1206
	48x30	120	1.0	120	F1208
	48x36	100	1.2	144	F1209
	48x48	75	1.6	192	F1212
5 ft series	60x24	120	1.0	120	F1506
	60x30	96	1.3	150	F1508
	60x36	80	1.5	180	F1509
	60x42	69	1.8	210	F1510
	60x48	60	2.0	240	F1512
	60x60	48	2.5	300	F1515
6 ft series	72x24	100	1.2	144	F1806
	72x30	80	1.5	180	F1808
	72x36	67	1.8	216	F1809
	72x42	57	2.1	252	F1810
	72x48	50	2.4	288	F1812
	72x60	40	3.0	360	F1815
	72x72	33	3.6	432	F1818
7 ft series	84x24	86	1.4	168	F2106
	84x30	69	1.8	210	F2108
	84x36	57	2.1	252	F2109
	84x42	49	2.5	294	F2110
	84x48	43	2.8	336	F2112
	84x60	34	3.5	420	F2115
	84x72	29	4.2	504	F2118
	84x84	25	4.9	588	F2121

	Dimensions (inches)	Ohms	Amps	Watts	Model Number
8 ft series	96x24	75	1.6	192	F2506
	96x30	60	2.0	240	F2508
	96x36	50	2.4	288	F2509
	96x42	43	2.8	336	F2510
	96x48	38	3.2	384	F2512
	96x60	30	4.0	480	F2515
	96x72	25	4.8	576	F2518
	96x84	21	5.6	672	F2521
	96x96	19	6.4	768	F2525
9 ft series	108x24	67	1.8	216	F2706
	108x30	53	2.3	270	F2708
	108x36	44	2.7	324	F2709
	108x42	38	3.2	378	F2710
	108x48	33	3.6	432	F2712
	108x60	27	4.5	540	F2715
	108x72	22	5.4	648	F2718
	108x84	19	6.3	756	F2721
	108x96	17	7.2	864	F2725
	108x108	15	8.1	972	F2727
10 ft series	118x24	61	2.0	236	F3006
	118x30	49	2.5	295	F3008
	118x36	41	3.0	354	F3009
	118x42	35	3.4	413	F3010
	118x48	31	3.9	472	F3012
	118x60	24	4.9	590	F3015
	118x72	20	5.9	708	F3018
	118x84	17	6.9	826	F3021
	118x96	15	7.9	944	F3025
	118x108	14	8.9	1062	F3027
	118x116	13	9.5	1141	F3030

240 VOLT STANDARD MATS

	Dimensions (inches)	Ohms	Amps	Watts	Model Number
5 ft series	60 x 36	320	0.8	180	G1509
	60 x 42	274	0.9	210	G1510
	60 x 48	240	1.0	240	G1512
	60 x 60	192	1.3	300	G1515
6 ft series	72 x 30	320	0.8	180	G1808
	72 x 36	267	0.9	216	G1809
	72 x 42	229	1.1	252	G1810
	72 x 48	200	1.2	288	G1812
	72 x 60	160	1.5	360	G1815
	72 x 72	133	1.8	432	G1818
7 ft series	84 x 24	343	0.7	168	G2106
	84 x 30	274	0.9	210	G2108
	84 x 36	229	1.1	252	G2109
	84 x 42	196	1.2	294	G2110
	84 x 48	171	1.4	336	G2112
	84 x 60	137	1.8	420	G2115
	84 x 72	114	2.1	504	G2118
	84 x 84	98	2.5	588	G2121
8 ft series	96 x 24	300	0.8	192	G2506
	96 x 30	240	1.0	240	G2508
	96 x 36	200	1.2	288	G2509
	96 x 42	171	1.4	336	G2510
	96 x 48	150	1.6	384	G2512
	96 x 60	120	2.0	480	G2515
	96 x 72	100	2.4	576	G2518
	96 x 84	86	2.8	672	G2521
	96 x 96	75	3.2	768	G2525
9 ft series	108 x 24	267	0.9	216	G2706
	108 x 30	213	1.1	270	G2708
	108 x 36	178	1.4	324	G2709
	108 x 42	152	1.6	378	G2710
	108 x 48	133	1.8	432	G2712
	108 x 60	107	2.3	540	G2715
	108 x 72	89	2.7	648	G2718
	108 x 84	76	3.2	756	G2721
	108 x 96	67	3.6	864	G2725
	108 x 108	59	4.1	972	G2727
10 ft series	118 x 24	244	1.0	236	G3006
	118 x 30	195	1.2	295	G3008
	118 x 36	163	1.5	354	G3009
	118 x 42	140	1.7	413	G3010
	118 x 48	122	2.0	472	G3012
	118 x 60	98	2.5	590	G3015
	118 x 72	81	3.0	708	G3018
	118 x 84	70	3.4	826	G3021
	118 x 96	61	3.9	944	G3025
	118 x 108	54	4.4	1062	G3027
	118 x 116	51	4.8	1141	G3030
12 ft series	144 x 36	133	1.8	432	G144036
	144 x 60	80	3.0	720	G144060
	144 x 72	67	3.6	864	G144072
	144 x 96	50	4.8	1152	G144096
	144 x 108	44	5.4	1296	G144108
	144 x 120	40	6.0	1440	G144120
	144 x 140	34	7.0	1679	G144140
14 ft series	168 x 96	43	5.6	1344	G168096
	168 x 108	38	6.3	1512	G168108
	168 x 120	34	7.0	1680	G168120
	168 x 140	29	8.2	1960	G168140
20 ft series	240 x 120	24	10.0	2400	G240120

NUHEAT CUSTOM MAT – ORDERING DETAILS

If desired coverage cannot be obtained using one or a combination of standard mats, Nuheat Custom Mats can provide the desired coverage for any area regardless of shape or size.

1. Provide an accurate drawing of the area including the full on-site perimeter dimensions, voltage, and desired thermostat location with all obstructions identified (vanities, toilets, vents, etc.). Please ensure that the installer or contractor contact information is provided in the event that we need to verify or confirm the dimensions.
2. Submit the drawing to Nuheat Customer Care Team at **res.customercare@pentair.com**. Nuheat Customer Care will provide a quote and AutoCAD drawing to confirm the submitted dimensions within 24 hours.
3. Once dimensions are accepted by the customer and payment is confirmed, the Nuheat Custom Mat will be manufactured within three days and shipped to desired location.

APPROVALS

c UL us

"-W" wet rating for Canada as per Table 1 of C22.2 NO.130-16 and CEC section 62-104.

NUHEAT MAT SPECIFICATIONS

Operating voltage	120 V, 208 V, and 240 V
Power output	12 watts per square foot (15 watts per square foot when required/specified)
Maximum continuous exposure temperature	194°F (90°C)
Minimum installation temperature	50°F (10°C)
Heating cable	Single wire with ground braid outer layer
Cold lead	2-wire, 18 AWG plus ground braid layer; 10 ft (3m) length

ACCESSORIES

	Catalog number	Description
SIGNATURE thermostat	AC0055	WiFi-enabled floor heating thermostat. This programmable thermostat can be controlled using a mobile smart phone app (iOS and Android) or web browser.
HOME thermostat	AC0056	Color touchscreen programmable floor heating thermostat with intuitive user interface and energy usage information.
Element thermostat	AC0057	Non-programmable thermostat for simple control of any electric floor heating system.

Nuheat

CABLE

ELECTRIC FLOOR HEATING SYSTEM

25 YEAR Product warranty

25 Total care warranty

PRODUCT OVERVIEW

Nuheat Cable is a free-form floor heating cable system that brings soothing heat to the following surfaces:

- Ceramic or porcelain tile
- Granite
- Marble
- Natural Stone
- Laminate/Engineered wood floors

Nuheat Cable is a floor heating product for kitchens, bathrooms and other spaces where on-site adjustments are necessary to provide the desired heating coverage. Patented plastic cable guides allow the heating cable to be installed on site based on the site dimensions. Nuheat Cable can be spaced on site to provide 12-15 watts per square foot based on the desired wattage output requirements of the installation.

Nuheat Cable is available in 33 different sizes to accommodate areas as small as 8 square feet to 240 square feet. Multiple cable kits can be combined to provide heat coverage for the desired area. Nuheat Cable is available in 120 V and 240 V.

KIT CONTENTS

1 Nuheat Cable floor heating system

1 Installation instruction manual

NUHEAT CABLE SELECTION TABLE

Square Foot Coverage					
Standard Spacing*	**Alternate Spacing****	**Model No.**	**Cable Length (ft)**	**Amps**	**Watts**
120 VOLT CABLE KITS					
8	6	N1C008	29	0.7	80
12	9	N1C012	47	1.2	138
15	12	N1C015	57	1.4	170
25	20	N1C025	98	2.5	299
30	25	N1C030	120	2.9	343
40	30	N1C040	148	3.7	442
50	40	N1C050	188	4.7	562
60	50	N1C060	234	6.0	719
70	55	N1C070	265	6.8	810
80	65	N1C080	318	7.9	947
85	70	N1C085	334	8.5	1021
95	80	N1C095	377	9.7	1161
110	90	N1C110	423	10.8	1299
120	100	N1C120	474	12.2	1461
240 VOLT CABLE KITS					
15	12	N2C015	56	0.7	165
20	15	N2C020	80	0.9	224
25	20	N2C025	102	1.3	302
35	30	N2C035	136	1.7	403
45	35	N2C045	178	2.2	523
55	45	N2C055	207	2.6	632
65	50	N2C065	250	3.1	742
70	60	N2C070	277	3.5	842
85	70	N2C085	334	4.3	1020
90	75	N2C090	358	4.6	1102
100	85	N2C100	393	5.0	1211
120	100	N2C120	472	5.9	1427
135	110	N2C135	529	6.8	1621
145	120	N2C145	561	7.1	1704
160	130	N2C160	630	8.0	1914
170	140	N2C170	665	8.6	2054
190	160	N2C190	757	9.6	2314
215	180	N2C215	849	10.8	2589
240	200	N2C240	953	12.1	2905

For installations where higher heat output is required, alternating 3"/2" spacing (15 watts/sq ft) may be used.

* 3" Spacing - 12 watts/sq ft ** Alternating 3"/2" spacing - 15 watts/sq ft

APPROVALS

c UL us ”-W” wet rating for Canada as per Table 1 of C22.2 NO.130-16 and CEC section 62-104.

NUHEAT CABLE SPECIFICATIONS

Operating voltage	120 V and 240 V
Power output	12-15 watts per square foot (depending on spacing option chosen)
Minimum bending radius	0.5 in (12 mm)
Maximum ambient temperature	194°F (90°C)
Minimum installation temperature	50°F (10°C)
Heating cable	2-wire, grounded, twisted pair with PVC outer jacket
Cold lead	2-wire, 16-18 AWG plus ground braid; PVC outer jacket, 10 ft (3 m) length

ACCESSORIES

	Catalog number	Description
Nuheat Membrane (Large Roll)	NUMEM161	Tile underlayment and uncoupling membrane for Nuheat Cable (161 sq ft roll). For use when uncoupling product is required.
Nuheat Membrane (Small Roll)	NUMEM054	Tile underlayment and uncoupling membrane for Nuheat Cable (54 sq ft roll). For use when uncoupling product is required.
SIGNATURE thermostat	AC0055	WiFi-enabled floor heating thermostat. This programmable thermostat can be controlled using a mobile smart phone app (iOS and Android) or web browser.
HOME thermostat	AC0056	Color touchscreen programmable floor heating thermostat with intuitive user interface and energy usage information.
Element thermostat	AC0057	Non-programmable thermostat for simple control of any electric floor heating system.

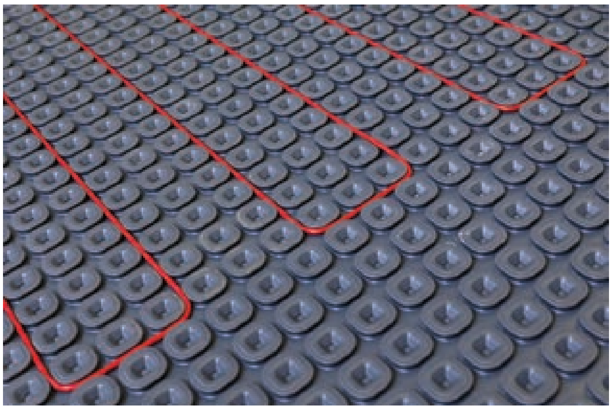
Nuheat

MEMBRANE

UNCOUPLING AND INTEGRATED FLOOR HEATING UNDERLAYMENT

25 YEAR Product warranty

25 Total care warranty



PRODUCT OVERVIEW

Nuheat Membrane is a tile underlayment that can be installed over the entire subfloor for uncoupling, crack isolation and waterproofing purposes. Nuheat Membrane replaces the need for a second layer of plywood or concrete backer board in most tile installations. Nuheat Membrane comprises of a polypropylene plastic layer that features square-shaped columns which form channels specially designed to embed and hold the Nuheat Cable Floor Heating System. The square-shaped columns provides a vapor management system which allows moisture to escape from the substrate during the curing process. The polypropylene layer is heat-welded to a non-woven polypropylene fabric which absorbs thinset and bonds the Nuheat Membrane to the subfloor.

The Nuheat Cable Floor Heating System can be installed directly into Nuheat Membrane in areas where heat is desired. Once Nuheat Cable is installed, tiling can begin immediately using thinset thereby eliminating the need to embed the heating cable in self-leveling compounds.

Additional benefits of Nuheat Membrane:

- Enables even heat distribution of the heat of the floor
- Easy adjustable on site to complexed shapes
- Eliminates need for a second layer of plywood or concrete backer boards
- Variable heat output option with 10, 12 or 15 watt spacing
- Saves installation time and material costs

Installing Nuheat Membrane with Nuheat Cable significantly decreases the time, difficulty, floor height, weight, and cost of the overall floor heating installation.

PRODUCT SELECTION

NUHEAT MEMBRANE SELECTION TABLE

Catalog number	Part Number	Description	Dimensions	Standard Package	
				Weight (lbs)	Size (in)
NUMEM161	AC0105	Nuheat Membrane - Large Roll (161 sq ft)	3'3" x 49.5 ft	30 lbs	39" x 14.5"
NUMEM054	AC0106	Nuheat Membrane - Small Roll (54 sq ft)	3'3" x 16.5 ft	10 lbs	39" x 9.5"

NUHEAT CABLE SELECTION TABLE

Model number	Square Foot Coverage			Length (ft)	Total Watts
	3 pillars*	2/3/2 pillars*	2 pillars*		
	10 watts/sq ft	12 watts/sq ft	15 watts/sq ft		
120 Volt Kit					
N1C008	9	8	6	29	80
N1C012	14	12	10	47	138
N1C015	17	15	12	57	170
N1C025	30	25	21	98	299
N1C030	36	31	25	120	343
N1C040	45	38	31	148	442
N1C050	57	48	39	188	562
N1C060	71	60	49	234	719
N1C070	81	68	55	265	810
N1C080	97	82	66	318	947
N1C085	102	86	69	334	1021
N1C095	115	97	78	377	1161
N1C110	129	109	88	423	1299
N1C120	145	122	98	474	1461
240 Volt Kit					
N2C015	17	14	12	56	165
N2C020	24	21	17	80	224
N2C025	31	26	21	102	302
N2C035	41	35	28	136	403
N2C045	54	46	37	178	523
N2C055	63	53	43	207	632
N2C065	76	64	52	250	742
N2C070	84	71	58	277	842
N2C085	102	86	69	334	1020
N2C090	109	92	74	358	1102
N2C100	120	101	82	393	1211
N2C120	145	121	98	472	1427
N2C135	162	136	110	529	1621
N2C145	172	144	116	561	1704
N2C160	193	162	131	630	1914
N2C170	204	171	138	665	2054
N2C190	233	195	157	757	2314
N2C215	261	219	176	849	2589
N2C240	293	246	198	953	2905

* pillars of the uncoupling membrane.

ROBINSON FLOOR TEST (ASTM C627) RESULTS

Report number	Substrate	Tile	Joist Spacing	Rating
TNCA-773-14	OSB/Plywood	12 x 12 Porcelain Tile	19.2" O.C	Extra Heavy
TNCA-772-14	Concrete	12 x 12 Porcelain Tile	N/A	Extra Heavy

APPROVALS

NUHEAT MEMBRANE SPECIFICATIONS

Material	Polypropylene plastic heat-welded to a non-woven polypropylene fabric
Thickness	0.22 in (5.5 mm)
Width	39 in (991 mm)
Weight	840 grams/m2
Storage Conditions	Store in a cool and dry place avoiding direct sunlight and heat sources

NUHEAT CABLE SPECIFICATIONS

Operating voltage	120 V, 208 V, and 240 V
Power output	10-15 watts per square foot (depending on wire spacing)
Minimum bending radius	0.5 in (12 mm)
Maximum continuous exposure temperature	194°F (90°C)
Minimum installation temperature	50°F (10°C)
Heating cable	2-wire, grounded, twisted pair with PVC outer jacket
Cold lead	2-wire, 16-18 AWG plus ground braid; 10 ft (3 m) length

ACCESSORIES

	Catalog number	Description
Proband Waterproofing Seam Tape	PRBPE 1505	6" (W) x 16 ft (L) waterproofing polyethylene tape used to waterproof seams and perimeter joints for waterproof applications. Comes in pack of 10.
Proband Waterproofing Seam Tape	PRBPE 1530	6" (W) x 98 ft (L) waterproofing polyethylene tape used to waterproof seams and perimeter joints for waterproof applications. Comes in pack of 6.

MESH

FLOOR HEATING SYSTEM

25 YEAR Product warranty

PRODUCT OVERVIEW

Nuheat Mesh is an electric floor heating system for installation under the following surfaces:

- Ceramic or porcelain tile
- Granite
- Marble
- Natural stone
- Laminate/Engineered wood floors

The Nuheat Mesh floor heating system provides comfort heating in bathrooms, showers, kitchens, entryways and other living areas. Nuheat Mesh's compatibility with all standard subflooring materials and its low 3/16 inch (4.76 mm) profile make it ideal for renovation projects.

The Nuheat Mesh floor heating system consists of a self-adhesive mesh which allows installers to stick the heating system onto the subfloor during the layout process. The heating cable is attached to the self-adhesive mesh layer using three mesh bands. The mesh bands help keep the heating cable spacing consistent while allowing easy removal of the heating cable during installation in hard-to-reach areas.

The PVC coated heating cable emit no measurable electromagnetic fields due to its twisted pair design and features a thin mechanical splice and a thin, flexible 10ft long cold lead which is easy to embed in the subfloor and route to the thermostat location.

The floor heating mats are available in 120 V, 208-240 V and in thirty-two (32) different sizes ranging from 12 sq ft to 240 sq ft in a single kit.

KIT CONTENTS

1 Nuheat Mesh floor heating system
1 Installation instruction manual

APPROVALS

c UL us

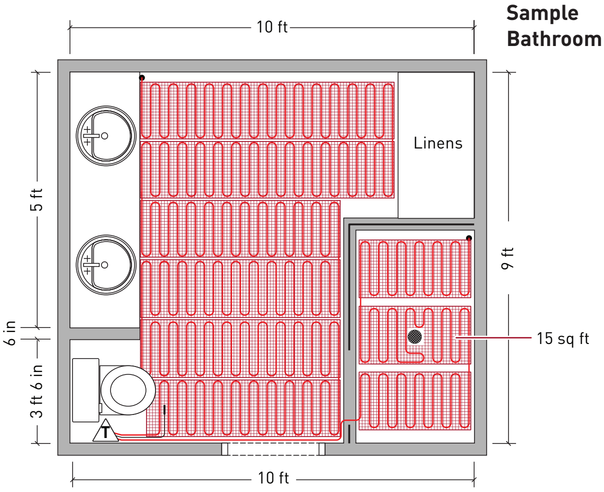
SPECIFICATIONS

Operating voltage	120 V, 208 V, and 240 V
Power output	12 watts per square foot (9 watts per square foot @ 208 V)
Minimum bending radius	0.5 in (12 mm)
Minimum cable spacing	3 in (80 mm)
Maximum ambient temperature	194°F (90°C)
Minimum installation temperature	50°F (10°C)
Heating cable	2-wire, grounded, twisted pair with PVC outer jacket
Cold lead	2-wire, 16-18 AWG plus ground braid; 10 ft (3 m) length

ORDERING DETAILS

Select the Nuheat Mesh kit that is no larger than the heated area. The heated area is the area of the floor that does not include permanent fixtures such as cabinets, toilets, sinks or tubs. The selected kit can be configured on the jobsite to fit the shape of the area to be heated.

Sample Bathroom



For example:

If your bathroom is 9 ft x 10 ft	=	90 sq ft
minus the cabinet area	-	10 sq ft
minus the toilet space	-	6 sq ft
minus the linen closet	-	8 sq ft
minus the shower area	-	15 sq ft*
Total area to be heated	=	51 sq ft

Solution:
Choose the N1M050 - 50 sq ft for 120 V or N2M045 - 45 sq ft for 240 V.

* If the shower area is to be heated, select a N1M015 - 15 sq ft for 120 V or N2M015 - 15 sq ft for 240 V.

Catalog number	Sq Ft Coverage*	Dimensions	Watts	Amps	Resistance
120 V Nuheat Mesh					
N1M012	12	20" x 8 ft	139	1.2	103
N1M015	15	20" x 9 ft	170	1.4	85
N1M025	25	20" x 15 ft	300	2.5	48
N1M030	30	20" x 19 ft	344	2.9	42
N1M040	40	20" x 23 ft	442	3.7	33
N1M050	50	20" x 29 ft	563	4.7	26
N1M060	60	20" x 36 ft	720	6.0	20
N1M070	70	20" x 41 ft	809	6.7	18
N1M080	80	20" x 49 ft	947	7.9	15
N1M085	85	20" x 52 ft	1022	8.5	14
N1M095	95	20" x 58 ft	1161	9.7	12
N1M110	110	20" x 65 ft	1299	10.8	11
N1M120	120	20" x 73 ft	1461	12.2	10
240 V Nuheat Mesh					
N2M015	15	20" x 9 ft	165	0.7	349
N2M020	20	20" x 13 ft	224	0.9	258
N2M025	25	20" x 16 ft	302	1.3	191
N2M035	35	20" x 21 ft	403	1.7	143
N2M045	45	20" x 28 ft	523	2.2	110
N2M055	55	20" x 32 ft	632	2.6	91
N2M065	65	20" x 39 ft	742	3.1	78
N2M070	70	20" x 43 ft	842	3.5	68
N2M085	85	20" x 52 ft	1020	4.3	57
N2M090	90	20" x 55 ft	1102	4.6	52
N2M100	100	20" x 61 ft	1211	5.0	48
N2M120	120	20" x 73 ft	1427	5.9	40
N2M135	135	20" x 82 ft	1621	6.8	36
N2M145	145	20" x 87 ft	1704	7.1	34
N2M160	160	20" x 97 ft	1914	8.0	30
N2M170	170	20" x 102 ft	2054	8.6	28
N2M190	190	20" x 117 ft	2314	9.6	25
N2M215	215	20" x 131 ft	2589	10.8	22
N2M240	240	20" x 147 ft	2905	12.1	20

* Square foot coverage based on square room with 2" unheated border.

ACCESSORIES

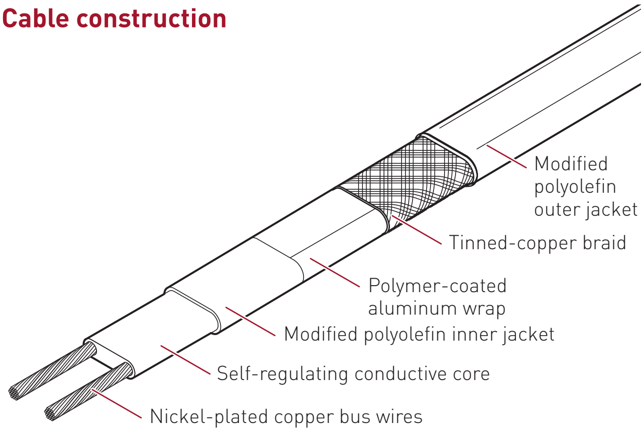
	Catalog number	Description
Electric Fault Indicator	AC0100	The Electric Fault Indicator is used to verify the continuity of the heating cable and the integrity of its outer jacket during the installation process. The device connects to the cold leads of the cable and if the heating cable is damaged, the alarm on the monitor will sound. The monitor can also be re-used for subsequent installations and to help troubleshoot any problems that may arise.
Heating Wire Repair Kit	AC0014	The Heating Wire Repair Kit is for repairing Nuheat Mesh heating cable that has been damaged during installation.

HWAT-R2

SELF-REGULATING HEATING CABLE

For hot water temperature maintenance

Cable construction



PRODUCT OVERVIEW

Raychem HWAT self-regulating heating cables are installed on hot water supply pipes underneath standard pipe insulation. The heating cable adjusts its power output to compensate for variations in water temperature and ambient temperature. The heating cable replaces supply-pipe heat losses at the point where the heat loss occurs, thereby providing continuous, energy-efficient, hot water temperature maintenance and eliminating the need for a recirculation system.

Simplified design

Single-pipe HWAT systems eliminate the need for designing complex recirculation systems, with their pumps, piping networks, and complicated flow balancing. Special cases, such as retrofits and multiple pressure zones, are simple to design.

Low installed cost

Installation of the HWAT system is simple. The heating cable can be cut to length, spliced, tee-branched, and terminated at the job site, reducing installation costs. Fewer plumbing components are needed; recirculation piping, pumps, and balancing valves are all eliminated.

Low operating cost

The HWAT system continuously maintains hot water temperature at every point along the supply pipe. Unlike conventional recirculation systems, HWAT systems do not require the overheating of supply water to allow for cooling. The HWAT system reduces the energy requirements of typical hot water systems with reduced heat loss from supply piping, no heat loss from recirculation piping, and no pump to run.

HWAT-ECO and ACS-30 controllers

The HWAT-ECO electronic controller is designed for operation with HWAT-R2 heating cable only. The HWAT-ECO provides flexible temperature control, energy savings, heat-up cycle function, BMS interface, and nine predefined programs that can be customized by the user. The Raychem ACS-30 controller also incorporates the features of the HWAT-ECO for large systems and multiple application control. The ACS-30 only supports HWAT-R2 heating cable for hot water temperature maintenance applications.

SPECIFICATIONS

Jacket	Modified polyolefin
Braid	Tinned copper
Bus wires	16 AWG nickel-plated copper
Supply voltage	208–277 V (277 V only when used with the ACS-30 Control System)
Minimum bend radius	0.5 in (12 mm)

PRODUCT CHARACTERISTICS (NOMINAL)

Catalog number	**HWAT-R2**
Jacket color	Red
Maintain temperature range*	105°F (40°C) to 140°F (60°C)
Weight	230 lbs/1000 ft (0.35 kg/m)
Dimensions	
Width	0.72 in (18 mm)
Thickness	0.38 in (10 mm)

* When designed in accordance with the HWAT System Product Selection and Design Guide

DESIGN AND INSTALLATION

For proper design and installation, use the Design section of the HWAT System Product Selection and Design Guide (H57538) and the HWAT System Installation and Operations Manual (H57548).

MAXIMUM CIRCUIT LENGTH FT (M)

	HWAT-R2
Breaker size	**@208 V**
30 A	500(150)
20 A	330(100)
15 A	250 (75)

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with Thermal Management requirements, agency certifications, and national electrical codes, 30-mA ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

APPROVALS

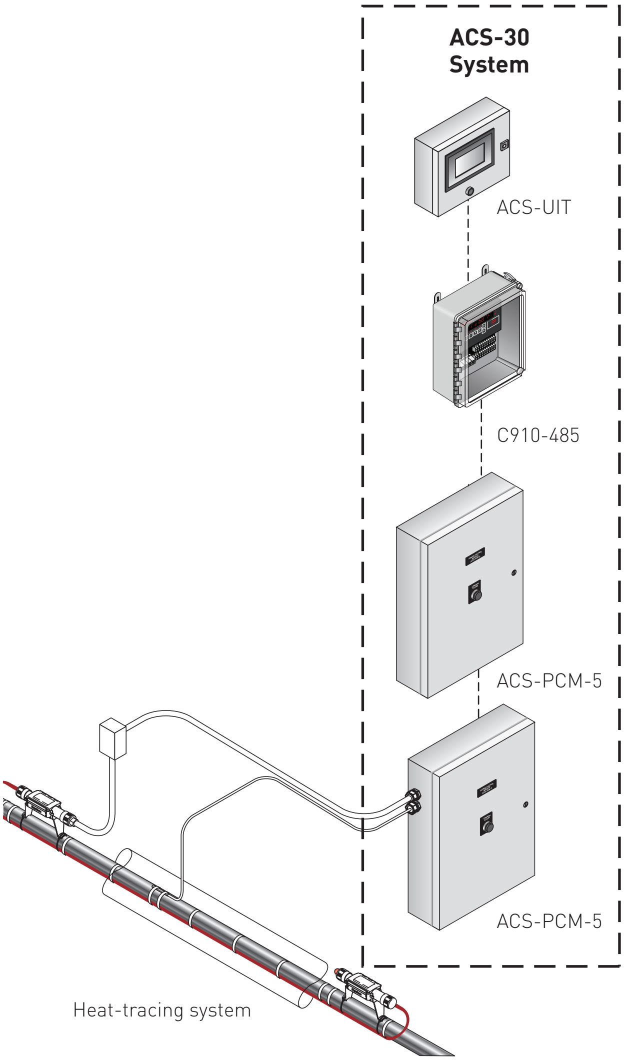
718K
Pipe Heating Cable

-G

HWAT heating cables are UL Listed, CSA Certified, and FM Approved when used with the appropriate agency-approved Raychem components and accessories

ACS-30

MULTIPOINT COMMERCIAL HEAT-TRACING SYSTEM



PRODUCT OVERVIEW

The Raychem ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing applications. These applications include commercial freeze protection, surface snow melting, roof and gutter de-icing, and flow and temperature maintenance.

The ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels, or Raychem C910-485 controllers for single circuit system extension. The ACS-PCM2-5 panel can directly control up to 5 individual heat-tracing circuits using electromechanical relays rated at 30 A up to 277 V. Four Resistance Temperature Detector (RTD) sensor inputs can be assigned for each heating cable circuit providing a variety of temperature control, monitoring, and alarm options. The ACS-30 can be fitted with 16 Raychem RMM2s, providing an additional 128 temperature inputs to a maximum of 388 inputs.

Control

The ACS-30 is pre-programmed with parameters for commercial hot water temperature maintenance, pipe freeze protection, flow maintenance, freezer frost heave prevention, surface snow melting, roof and gutter de-icing prevention and floor heating applications. The pre-programmed application settings significantly simplify setting up multiple heating cable circuits. Based on the application the ACS-30 can be configured for On/Off, Ambient Sensing, Proportional Ambient Sensing (PASC), and timed duty cycle control modes for HWAT applications.

The ACS-30 measures temperatures with 3-wire, 100-ohm platinum RTDs connected directly to the unit, or through optional Remote Monitoring Modules (RMM2). Each RMM2 accepts up to eight RTDs. Multiple RMM2s are networked over a single cable to the ACS-30, significantly reducing the cost of RTD wiring.

The built-in calendar function for hot water temperature maintenance, floor heating and greasy waste applications provides flexible timed set points providing energy savings.

Monitoring

To assist with energy management the ACS-30 monitors the power consumption of each heating cable circuit for up to five years of operation. The data may be graphically displayed daily, weekly, monthly or yearly. The ACS-30 measures 12 control parameters including ground fault, temperature, and current to ensure system integrity. Configurable alarm settings provide options for local or remote alarms. These alarms can be programmed to send notification of the alarm event by e-mail to user-selected distribution. The system can be set to periodically check for heating cable faults, alerting maintenance personnel of a pending heat tracing problem. This helps avoid costly downtime. Dry contact relays are provided for alarm annunciation back to a Building Management System (BMS).

Ground-fault protection

National electrical codes require ground-fault equipment protection on all heat-tracing circuits. The ACS-30 controller has integrated ground-fault equipment protection and therefore does not require additional ground-fault protection, simplifying installation and reducing costs.

Installation

The ACS-30 system is configured with the User Interface Terminal (ACS-UIT2) that has an LCD color display with touch-screen technology. The ACS-UIT2 provides an easy user interface for programming without keyboards or cryptic labels. The ACS-30 Program Integrator application tool is available to program, edit and download circuit parameters through the local USB port or from a remote location.
The ACS-UIT2 comes in a Type 4X enclosure suitable for nonhazardous, indoor or outdoor locations and comes complete with wiring terminals and an alarm signal light.

Communications

ACS-30 units support the Modbus® protocol and are available with RS-232, RS-485 or 10/100Base-T Ethernet communication interface. Raychem ProtoNode multi-protocol gateways are available to integrate the ACS-30 into BACnet® and Metasys® N2 BMS systems.

Complete system

The ACS-30 is supplied as a complete modular system, ready for field connections to convenient power distribution panels and temperature sensor input, reducing the cost of heating cable installation.

ACS-30 SYSTEM

Multipoint temperature control with ground-fault/current/temperature monitoring when used with the ACS-UIT2	The ACS-30 is a multipoint electronic control, monitoring, and power relay system for heat-tracing cables used in commercial heat-tracing applications. The system consists of a Raychem ACS-UIT2 and up to 52 ACS-PCM2-5 power control panels. C910-485 controllers may also be connected to the system for multiple, single circuit extensions. Raychem RMM2 heat-tracing remote monitoring modules may also be used with the ACS-30 system to expand the number of temperature measurement points. The ACS-30 provides the following alarming features per control point. • High/low temperature • Ground fault • RTD failure The ACS-30 provides ground-fault monitoring and protection for every heat-tracing circuit and fulfills the requirements of national electrical codes.

ACS-30: HEATING CABLE APPLICATION PROGRAMMING SUMMARY

Control Mode Functions

Application	Heating cable	Control Mode	Control Settings
Hot Water Temperature Maintenance	HWAT	Preset power duty cycle (HWAT Design Wizard)	• Constant temp • Variable schedule – Maintain – Economy – Off – Heat Cycle (R2 only)
Heat Loss Replacement	RaySol MI heating cable	Floor sensing	• Constant temp • Variable schedule – Maintain – Economy – Off • Circuit override through RTD or external device

ACS-30: HEATING CABLE APPLICATION PROGRAMMING SUMMARY

Control Mode Functions

Application	Heating cable	Control Mode	Control Settings
Greasy Waste Disposal and Temperature Maintenance	XL-Trace	Line sensing	• Constant temp • Variable schedule – Maintain – Economy – Off
Pipe Freeze Protection	XL-Trace	Ambient, PASC or line sensing	• Constant temp • Circuit override through external device
Fuel Oil Flow Maintenance	XL-Trace	Ambient, PASC or line sensing	• Constant temp • Circuit override through RTD or external device
Freezer Frost Heave Prevention	• RaySol • MI heating cable	Floor sensing	• Constant temp • Variable schedule – Maintain – Off
Surface Snow Melting	• ElectroMelt • MI Heating Cable	Ambient or surface temp External controller	Constant temp External snow controller
Roof and Gutter De-icing	• IceStop • MI Heating Cable	Ambient or surface temp External controller	Constant temp External snow controller

TEMPERATURE MONITOR ONLY

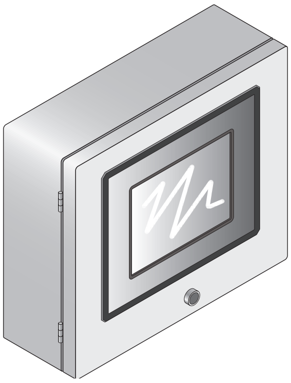
Five temperature monitor only channels
Low and high temperature alarms

VARIABLE SCHEDULE

Setpoint calendar with:

- 7 days/week calendar
- 48 - 1/2 hr time blocks/day
- Daily schedule copy function

ACS-UIT2 (USER INTERFACE TERMINAL)



The Raychem ACS-30 User Interface Terminal is a panel-mounted display for use with the ACS panel. The ACS-UIT2 has an 8.4 inch (21.7 cm) VGA color display with touch-screen technology, and provides an easy user interface for programming without keyboards or cryptic labels. It has RS-485, RS-232, or 10/100Base-T Ethernet communications ports that allow communication with external Distributed Control Systems or Building Management Systems. BACnet to Modbus protocol gateways with the Modbus registries pre-programmed are available. A USB interface is included for easy configuration and firmware upgrades.

The ACS-UIT2 is designed for use on indoor or nonhazardous location installations and is rated for NEMA 4 environments.

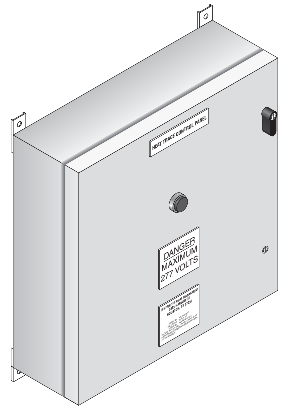
General

Approvals	**Nonhazardous Locations** C US LR67275 CE
Area of use	Nonhazardous, indoors and outdoors (IP65, Type 4)
Supply voltage	100 – 240 Vac +/–10%, 50/60 Hz
Operating temperature	–25°C to 50°C (–13°F to 122°F)
Supply terminal	26–12 AWG
Storage temperature	–25°C to 80°C (–13°F to 176°F)
Dimensions	386 mm W x 336 mm H x 180 mm D, (15.21 in. W x 13.21 in. H x 7.09 in. D)

ACS-UIT2 (USER INTERFACE TERMINAL)

Alarm outputs	
Relay outputs	Three form C relays rated at 12 A @ 250 Vac. One relay used for common alarm light. Relays may be assigned for alarm outputs.
Network connection	
Local port/remote	RS-232/RS-485 ports (RS-485, 2-wire isolated) may be used to communicate with host BMS computers using the Raychem ProtoNode-RER or ProtoNode-RER-10K.
Local RS-232	A non-isolated, 9 pin D sub male
Remote RS-485 #2	10 pin terminal block, 24–12 AWG, (0.2 mm to 2.5 mm^2) wire size
Data rate	9600 to 57600 baud
Maximum cable length	For RS-485 not to exceed 1200 m (4000 ft). Cable to be shielded twisted pair.
Field port	RS-485, 2-wire isolated. Used to communicate with external devices, such as ACS-PCM2-5, Raychem C910-485, and RMM2. Maximum cable length not to exceed 1200 m (4000 ft). Cable to be shielded twisted pair.
Field RS-485 #1	10 pin terminal block, 24–12 AWG, (0.2 mm to 2.5 mm^2) wire size
Data rate	To 9600 baud
LAN	10/100 Base-T Ethernet port with Link and Activity Status LEDs
USB port	USB 2.0 Host port Type A receptacle (X2)
LCD display	
Display	LCD is a 8.4 inch (21.7 cm) VGA, color TFT transflective device with integral CCFL backlight
Touch screen	4-wire resistive touch screen interface for user entry

ACS-PCM2-5 POWER CONTROL PANEL



The ACS-PCM2-5 enclosure is rated NEMA 4/12 and is approved for nonhazardous indoor or outdoor locations. The ACS-PCM2-5 provides ground fault and line current sensing, alarming, switching (electromechanical relays) and RTD inputs for five heat tracing circuits when used with the ACS-UIT2.

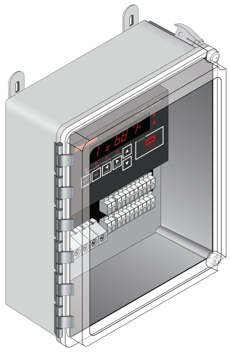
ACS-30 General (RPN P000001232) panels are available to satisfy special applications which require higher voltage, higher switching capacity, panel heaters, etc. Contact Thermal Management at 1 (800) 545-6258 for design assistance.

General	
Approvals	**Nonhazardous Locations** c UL us LISTED UL STD 508A CAN/CSA C22.2 NO. 14
Ambient operating temperature	–13°F to 122°F (–25°C to 50°C)
Dimensions	24" W x 24" H x 6.75" D (610 mm W x 610 mm H x 171 mm D)
Enclosure rating	NEMA 4/12 (indoor/outdoor locations)
Control supply voltage	90 - 280 V dropped to 12 V with switching power supply
Weight	70 lbs (31.75 kg)
Humidity	0–90% non-condensing
Fuse	Bussman MDL

ACS-PCM2-5 POWER CONTROL PANEL

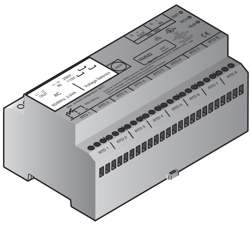
Heating cable circuit contactors	
Rating	3-pole – 30 A/pole 277 Vac
Type	Sprecher-Schuh CA7-16-10-12D
Quantity	5
Temperature sensors	
Type	100-ohm platinum RTD, 3-wire, α = 0.00385 ohm/ohm/°C Can be extended with a 3-conductor shielded cable of 20 ohm maximum per conductor
Quantity	Up to five wired directly to the ACS-CRM
Communication to ACS-UIT2, ACS-PCM2-5 panels, C910-485 and RMM2	
Type	2-wire RS-485
Cable	One shielded twisted pair
Length	4000 ft (1200 M) maximum
Quantity	Up to 52 ACS-PCM2-5 panels may be connected to one ACS-UIT2
Line current sensors	
Max current	60 A
Accuracy	± 2% of reading
Ground-fault sensors	
Range	10–200 mA
Accuracy	± 2% of reading
Connection terminals	
Power supply/line/load	#22 – 8 AWG
RS-485	#24 – 12 AWG
RTD	#24 – 12 AWG

C910-485 ELECTRONIC CONTROLLER (OPTIONAL)



The Raychem C910-485 controller Part No. 10170-026 is a compact, full-featured, microprocessor-based, single-point commercial heating cable control system with integrated equipment ground-fault protection. The C910-485 provides control and monitoring of electric heating cable circuits for commercial heating applications. The C910-485 can be set to monitor and alarm for high and low temperature, low current, and ground-fault level. The C910-485 includes an RS-485 communication module to remotely configure, control and monitor the heating cable circuits through a building management system (BMS).

REMOTE MONITORING MODULE (OPTIONAL)



A Remote Monitoring Module (RMM2, Part No: 051778-000) is used to collect additional temperatures for control and monitoring of the heat-tracing circuit by the ACS-PCM2-5 control panel, through the ACS-UIT2 user interface terminal. The RMM2 accepts up to eight RTDs that measure pipe, vessel, or ambient temperatures. Multiple RMM2s communicate with a single ACS-UIT2 to provide centralized monitoring of temperatures. A single twisted-pair RS-485 cable connects up to 16 RMM2s for a total monitoring capability of 128 temperatures. The RMM2s are placed near desired measurement locations. The RMM2 is available for DIN rail mount or pre-installed inside a polycarbonate NEMA-4X enclosure (Part No: 523420-000).

PROTOCOL GATEWAY (OPTIONAL)

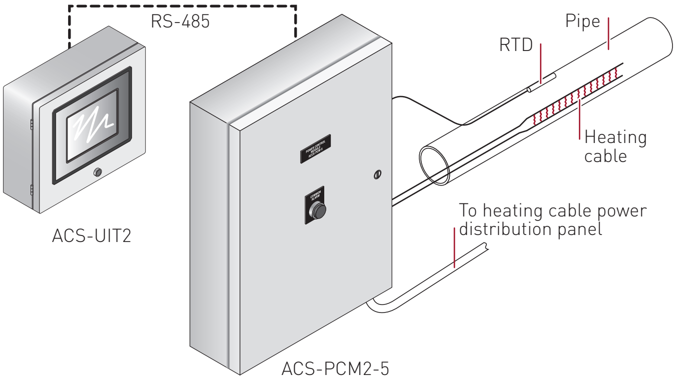
The ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between BACnet® or Metasys® N2 Building Management Systems (BMS) and the Raychem ACS-30 controller.

The ProtoNode-RER (Part No P000002008) is for ACS-30 systems with up to 5 PCM panels. The ProtoNode-RER-10K (Part No P000001983) is for ACS-30 systems with up to 34 PCM panels.

TYPICAL CONFIGURATIONS FOR THE RAYCHEM ACS-30 SYSTEM

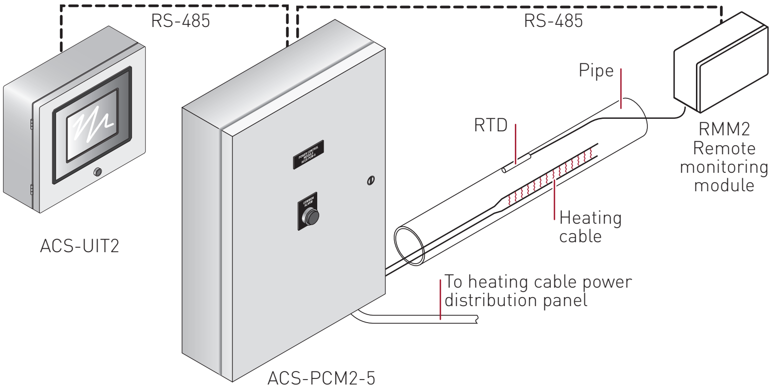
Individual controls

- Monitors ground-fault current and alarms/trip control contactor upon fault
- Monitors heater current
- Monitors pipe temperature (via RTD inputs wired back to the Raychem ACS-PCM2-5 or RMM2)



Individual controls with RMM2

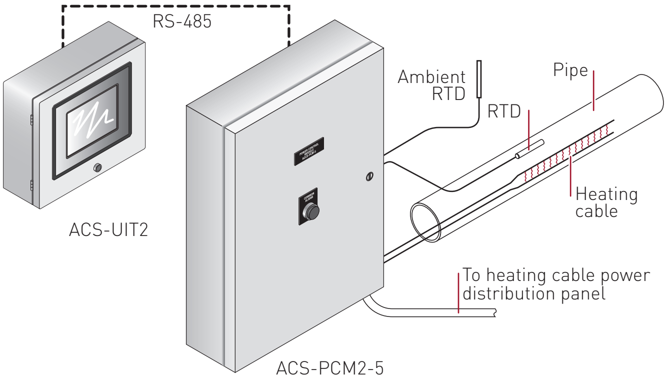
- Monitors ground-fault current and alarms/trip control contactor upon fault
- Monitors heater current
- Monitors pipe temperature (via RTD inputs wired back to the Raychem ACS-PCM2-5)
- Using optional RMM2 (remote monitoring modules) mounted in the field, up to 128 RTD inputs can be added to the ACS-30 system
- The RMMs allow the RTD cables to be terminated locally and only a single RS-485 twisted wire pair brought back to the panel. This results in a significant reduction in field wiring.



TYPICAL CONFIGURATIONS FOR THE RAYCHEM ACS-30 SYSTEM

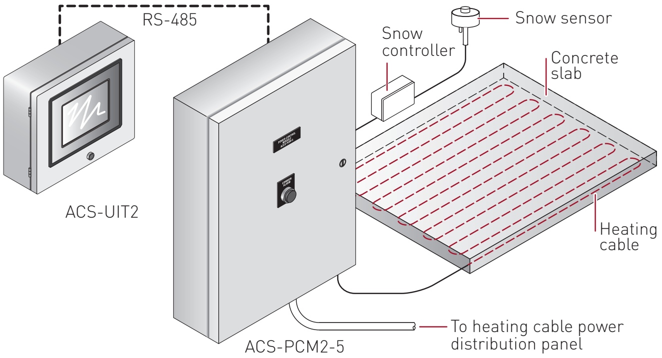
Individual ambient control

- Monitors ground-fault current and alarms/trip control contactor upon fault
- Monitors heater current
- Monitors pipe temperature (via RTD inputs wired back to the Raychem ACS-PCM2-5 or RMM2)



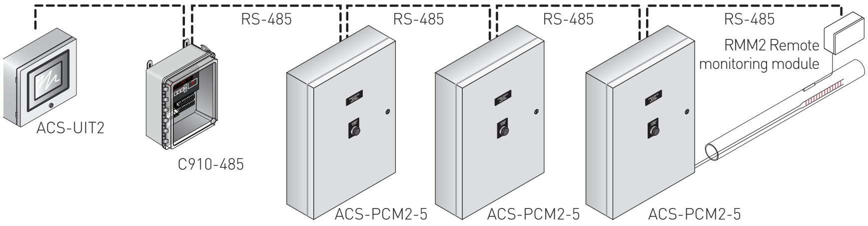
Individual external control for surface snow melting and roof & gutter application

- Monitors ground-fault current and alarms/trip control contactor upon fault
- Monitors heater current
- Monitors pipe temperature (via RTD inputs wired back to the Raychem ACS-PCM2-5 or RMM2)
- Connects to snow controllers (via RTD input) to power circuits when snow/ice melting is required



Multipanel configuration

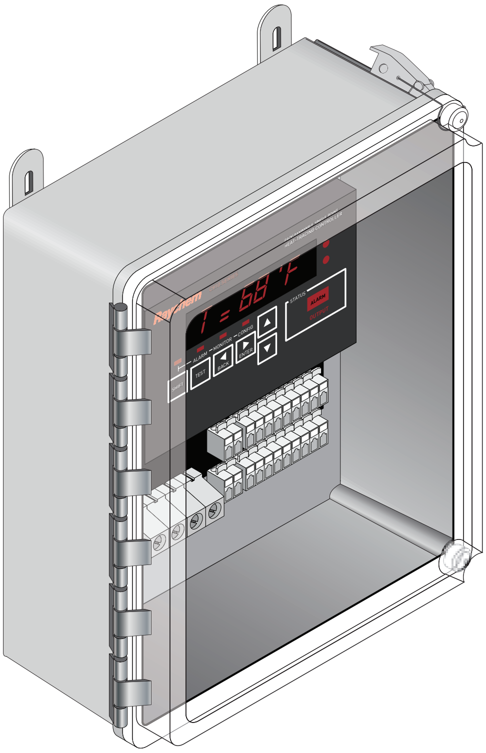
- Multiple panels can be ganged together for control using a single Raychem User Interface Terminal
- Communications is accomplished using RS-485 protocol
- Up to 260 heat trace circuits can be supported using this architecture



Raychem

C910-485

SINGLE-POINT HEAT-TRACING CONTROL SYSTEM



PRODUCT OVERVIEW

The Raychem C910-485 is a compact, full-featured, microprocessor-based, single-point commercial heating cable control system with integrated equipment ground-fault protection. The C910-485 provides control and monitoring of electric heating cable circuits for commercial heating applications. The C910-485 can be set to monitor and alarm for high and low temperature, low current, and ground-fault level. The C910-485 includes an RS-485 communication module to remotely configure, control and monitor the heating cable circuits through a building management system (BMS).

Control

The C910-485 measures temperature with one or two 3-wire 100-ohm platinum RTD(s) connected directly to the unit. The controller may be used in line-sensing, ambient-sensing and proportional ambient-sensing control (PASC) modes. The C910-485 may also be connected into the ACS-30 system for single circuit extensions. When in the ACS-30 system it is controlled by the ACS-UIT2 and has all the application functionality of the ACS-30 system.

Monitoring

A variety of parameters are measured, including ground fault, temperature, and current to ensure system integrity. The system can be set to periodically check the heating cable for faults, alerting maintenance personnel of a heat-tracing problem.

Both an isolated solid-state triac relay and a dry contact relay are provided for alarm annunciation back to a building management system (BMS).

Ground-fault protection

National electrical codes require ground-fault equipment protection on all heat-tracing circuits. The C910-485 controllers incorporate ground-fault sensing, alarm, and trip functionality internally. Heating cable circuits equipped with C910-485 controllers do not require additional ground-fault protection equipment, simplifying installation and reducing costs. The C910-485 automatically tests the integrity of the integrated ground-fault circuitry, ensuring protection in the event of a ground fault.

Installation

The C910-485 unit comes ready to install right from the box, eliminating the need for custom panel design or field assembly. The NEMA 4X-rated enclosure is approved for use in indoor and outdoor locations. Wiring is as simple as connecting the incoming and outgoing power wiring (up to 277 Vac) and an RTD.

The C910-485 operator interface includes LED displays and function keys that make it easy to use and program. No additional handheld programming devices are needed. Alarm conditions and programming settings are easy to interpret on the full-text front panel. Settings are stored in nonvolatile memory in the event of power failure.

Communications

The C910-485 supports Modbus® protocol and includes an RS-485 communications interface. Raychem ProtoNode multi-protocol gateways are available to integrate the C910-485 or ACS-30 into BACnet® and Metasys® N2 BMS systems.

GENERAL

Area of use	Nonhazardous locations
Approvals	**Nonhazardous locations**
Supply voltage	100 Vac to 277 Vac, +5 / –10%, 50/60 Hz Common supply for controller and heat-tracing circuit

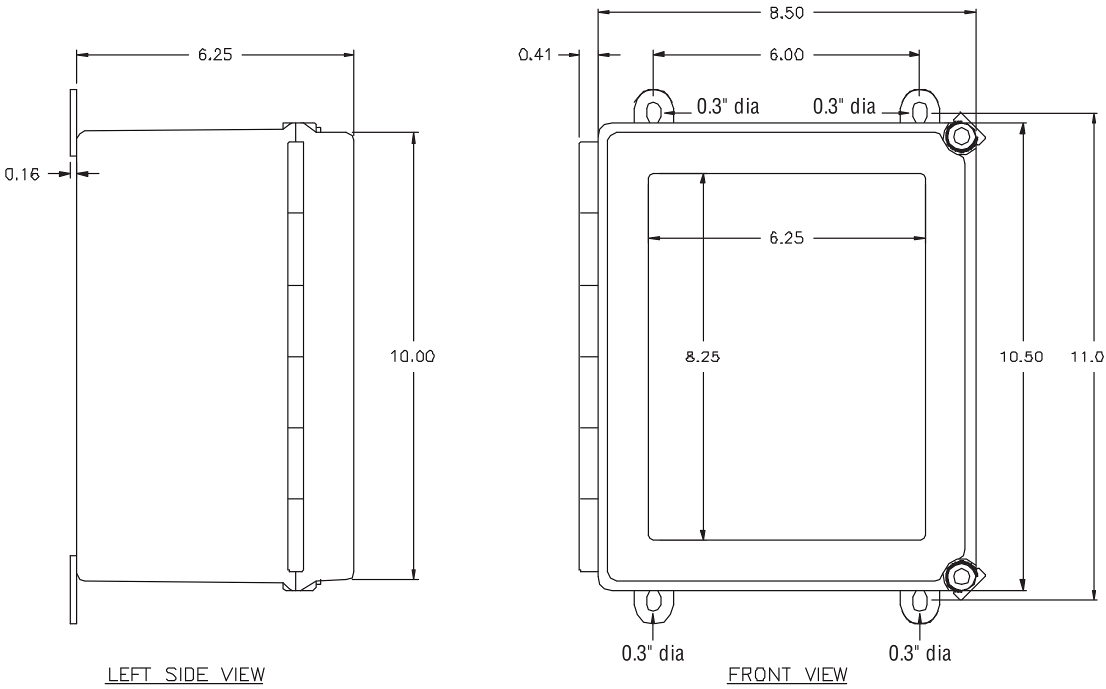
ENCLOSURE

Protection	Type 4X
Materials	FRP
Ambient operating temperature range	–40°F to 140°F (–40°C to 60°C)
Ambient storage temperature range	–40°F to 185°F (–40°C to 85°C)
Relative humidity	0% to 90%, noncondensing

CONTROL

Relay type	Double-pole, mechanical
Voltage, maximum	277 Vac nominal, 50/60 Hz
Current, maximum	30 A @ 104°F (40°C) derated to 20 A @ 140°F (60°C)
Control algorithms	EMR: On/off, proportional ambient sensing control (PASC)
Control range	0°F to 200°F (–18°C to 93°C)

TYPICAL ENCLOSURE DIMENSIONS (INCHES)



MONITORING

Temperature	Low alarm range	0°F to 180°F (–18°C to 82°C) or OFF
	High alarm range	0°F to 200°F (–18°C to 93°C) or OFF
Ground fault	Alarm range	20 mA to 100 mA
	Trip range	20 mA to 100 mA
Current	Low alarm range	0.3 A to 30 A or OFF
Autocycle	Diagnostic test interval adjustable from 1 to 240 minutes or 1 to 240 hours	

TEMPERATURE SENSOR INPUTS

Quantity	Two inputs standard
Types	100 Ω platinum RTD, 3-wire, α = 0.00385 ohms/ohm/°C Can be extended with a 3-conductor shielded cable of 20 ohms maximum per conductor

ALARM OUTPUTS

AC relay	Isolated solid-state triac, SPST, 0.75 A maximum, 100 Vac to 277 Vac nominal
Dry contact relay	Pilot duty only, 48 Vac/dc, 500 mA maximum, 10 VA maximum resistive switching

Note: Outputs are configurable as "open on alarm" or "close on alarm"

PROGRAMMING AND SETTING

Method	Programmable keypad
Units	Imperial (°F, in.) or Metric (°C, mm)
Digital display	Actual temperature, control temperature, heater current, ground fault, programming parameter values, alarm values
LEDs	Heater on, alarm condition, receive / transmit data
Memory	Nonvolatile, restored after power loss, checksum data checking

PROGRAMMING AND SETTING

Stored parameters (measured)	Minimum and maximum temperature, maximum ground-fault current, maximum heater current, contactor cycle count, time in use
Alarm conditions	Low / high temperature, low current Ground-fault alarm, trip RTD failure, loss of programmed values, or EMR failure
Other	Password protection

CONNECTION TERMINALS

Power supply input	Screw terminals, 22–8 AWG
Heating cable output	Screw terminals, 22–8 AWG
Ground	Two box lugs, 14–6 AWG
RTD/alarm/communications	28–12 AWG spring clamp terminals

MOUNTING

Enclosure	Surface mounting with four fixing holes on 7.25 in x 11.7 in (184 mm x 297 mm) centers Hole diameter: 0.31 in (8 mm)

COMMUNICATIONS WITH C910-485

Protocol	ModBus RTU / ASCI I
Topology	Multidrop, daisy chain
Cable	Single shielded twisted pair, 26 AWG or larger
Length	4000 ft (1.2km) maximum @ 9600 baud
Quantity	Up to 32 devices without repeater
Address	Programmable

ORDERING DETAILS

Raychem C910-485 Single-point Heat-Tracing Control System

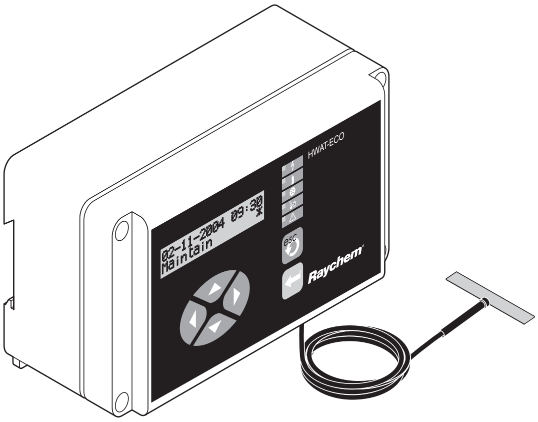
Description	Catalog number	Part number	Weight/lbs
Raychem C910-485 controller in an 8" x 10" FRP enclosure with polycarbonate cover. 2-pole 30 A EMR. Controls a single circuit with a 2-pole electromechanical relay. Includes isolated 2-wite RS-485 communication board. (Approved for nonhazardous locations only)	C910-485	10170-026	15
RTD Sensors			
100-ohm platinum RTD with 10 foot stainless steel corrugated sheath	RTD10CS	RTD10CS	1.0
RTD, ambient, cable style	RTD-200	254741	0.1
RTD, –100°F to 900°F, pipe mounted	RTD4AL	RTD4AL	1.2
Protocol Gateways			
Raychem ProtoNode-RER: BACnet MST/IP and Metasys N2 protocol gateway	ProtoNode-RER	P000002008	1.3

Raychem

HWAT-ECO-16

ELECTRONIC CONTROLLER

For hot water temperature maintenance systems



PRODUCT OVERVIEW

The Raychem HWAT-ECO-16 controller is designed for operation with the HWAT-R2 self-regulating heating cable.

The HWAT-ECO-16 controller provides the following features:

- Flexible temperature control of hot water temperature maintenance systems.
- Integrated function that lowers the maintain temperature during low use hours to save energy.
- Heat-up cycle function that increases the water temperature of a hot water system that is not in use.
- Building Management System (BMS) interface that receives a DC voltage to determine the desired maintain temperature.
- Alarm relay to signal power, temperature or communication problems.
- Pipe temperature monitoring with high temperature alarm and system shut down.
- Nine predefined programs that can be customized by the user.

GENERAL

Area of use	Nonhazardous locations
Approvals	c UL us LISTED 80BJ Type 12 **Energy Management Equipment** (for use with HWAT-R2 only.)
Maintain temperature setpoint	105°F (40°C) to 140°F (60°C)
Controller ambient exposure temperature	40°F (5°C) to 105°F (40°C)
Ambient operating range	60°F (15°C) to 80°F (27°C)
Switching capacity	16 A @ 208/240 Vac maximum SPST
Operating voltage	208/240 (±10%), 60 Hz
Internal power consumption	2.5 W
Circuit protection	Maximum 20 A with 30-mA ground-fault protection required; not provided in HWAT-ECO-16 controller
Internal temperature alarm	150°F (65°C)
BMS control voltage	0 – 10 Vdc
Alarm contacts	Maximum 24 Vdc or 24 Vac, 1 A, SPST, voltage free, NO/NC

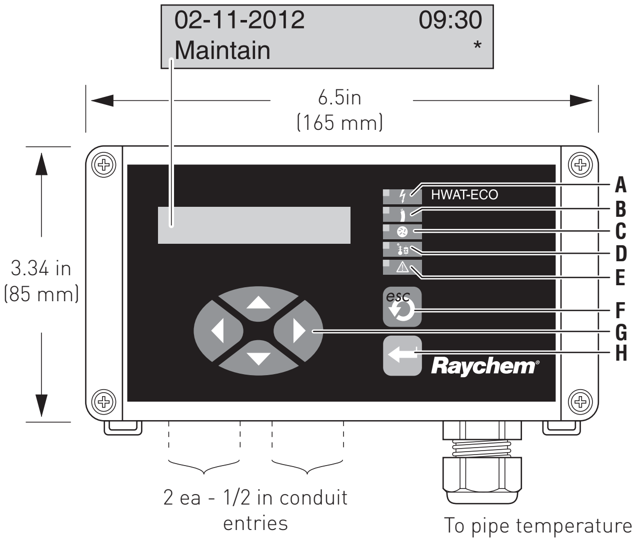
GENERAL

Alarm events	• Loss of power • Controller reinitialized • Internal controller temperature too high • Water heater temperature too high (cut-out) • Water heater temperature too low • Network error
Power correction factor	To increase or decrease your actual pipe maintain temperature or adjust for hot water systems with rigid plastic pipes
Pipe temperature sensor	Thermistor with 13 ft 3 in (4 m) lead. A PT100 RTD may optionally be used. Maximum length 328 ft. (100 m)
Electromagnetic Compatibility (EMC)	Complies to EN 5014-1 for emission and EN 50730-1 for immunity
Real time clock	Leap year correction
Clock accuracy	±10 minutes per year

ENCLOSURE

Enclosure rating	NEMA 12 (IP54) – indoor use only
Enclosure material	ABS
Mounting	Wall mount with two screws or optional DIN rail
Conduit entries	Two each – 1/2 in conduit entries
Cable gland	3-hole grommet Maximum cable size: • 2-wire: 20 AWG (0.5 mm²) • 4-wire: 24 AWG (0.2 mm²)

TYPICAL ENCLOSURE DIMENSIONS AND MODULE LAYOUT



To pipe temperature sensor
To HWAT-ECO-16 network/alarm entries

A	Power supply (green LED)
B	Power to heating cable (green LED)
C	Heat-up cycle (green LED) – increased risk of scalding
D	Pipe temperature alarm (requires installed sensor) low temp alarm and high temp cut-out.
E	Alarm (red LED)
F	Escape, backspace; NO; or display maintain temperature setpoint
G	Arrow keys: to change menu selection or position the cursor
H	Confirm selection, new value or YES

PROGRAMMING

Default programs	Nine predefined programs that can be customized by the user
Program settings	There are 48 1/2-hour time blocks of the following program settings: Off, Economy, Maintain, and Heat-up cycle

NETWORKING

Master/slave	Master is selectable in the controller, up to eight slaves can be connected
Master/slave cable	2-wire, 300 V, minimum 24 AWG twisted pair (328 ft (100 m) maximum)

MEMORY

Parameters stored in memory	All parameters are stored in nonvolatile memory, except date and time
Clock back-up time	Retain time and date for up to 30 days after power loss with rechargeable lithium battery.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of approval agencies, Thermal Management and national and local electrical codes, you must use 30-mA ground-fault equipment protection on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. The HWAT-ECO-16 does not include ground-fault protection.

ORDERING DETAILS

Catalog number	HWAT-ECO-16
Part number	P000001953
Weight	2 lb (1 kg)

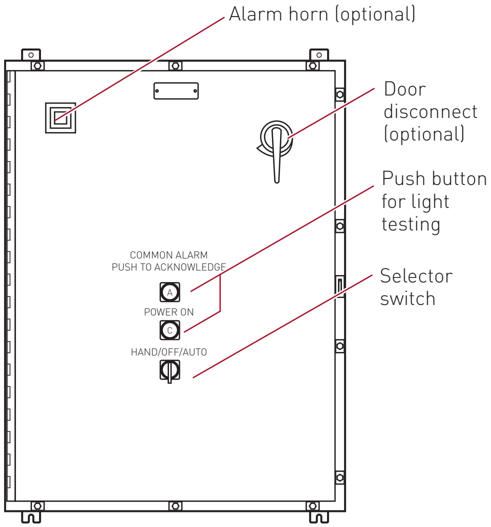
Important: The Raychem HWAT-ECO-16 controller is c-UL-us Listed for use with the Raychem HWAT-R2 heating cables only. The warranty and system listing will be invalidated if the HWAT-ECO-16 controller is used with other heating cables.

Raychem

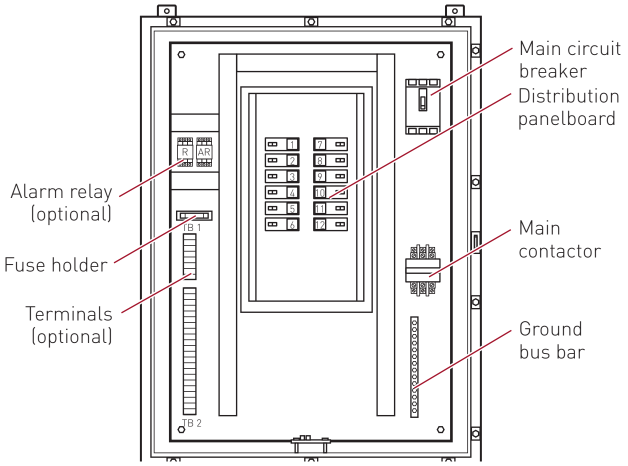
HTPG

HEAT-TRACING POWER DISTRIBUTION PANEL FOR GROUP CONTROL

Ground-fault protection, monitoring, and optional alarm panel



Alarm option shown above



PRODUCT OVERVIEW

The Raychem HTPG is a dedicated power distribution, control, ground-fault protection, monitoring, and alarm panel for freeze protection and broad temperature maintenance heat-tracing applications. This wall-mounted enclosure contains an assembled circuit-breaker panelboard.

Panels are equipped with circuit breakers with or without alarm contacts.

The group control package allows the system to operate automatically in conjunction with an external controller/thermostat.

LOAD POWER

120 / 208 / 240 / 277 Vac

AMBIENT OPERATING TEMPERATURE

32°F (0°C) to 122°F (50°C) (without space heater option)

FIELD WIRE SIZE

14–8 AWG (15–30 A), 8–4 AWG (40–50 A)

CIRCUIT BREAKER TYPES

	To comply with NEC Article 427-55(a), circuit breakers are equipped with the means for lockout in the "Off" position.
Ground-fault breaker	Square D types QOB-EPD, EDB-EPD

CIRCUIT BREAKER AMPERAGE RATING

120 Vac	20 A, 30 A, 40 A, 50 A
208 / 240 / 277 Vac	20 A, 30 A, 40 A, 50 A

MAIN CONTACTOR

3 pole

APPROVALS

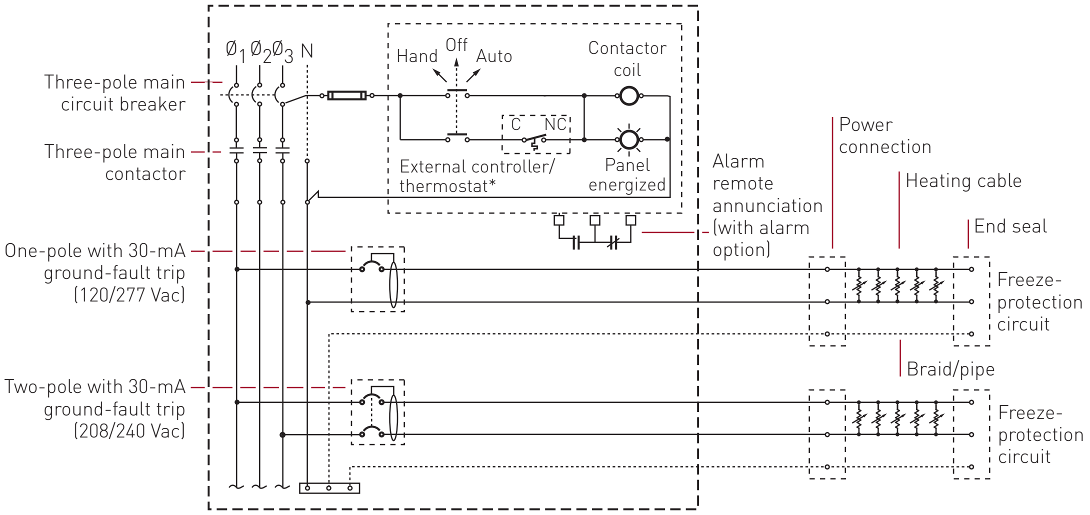
ETL LISTED
CONFORMS TO
ANSI/UL STD. 508
UL STD. 508A

CERTIFIED TO
CAN/CSA C22.2 NO. 14

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

HTPG TYPICAL FREEZE-PROTECTION APPLICATION SCHEMATIC



HTPG CATALOG NUMBER

HTPG comes in a variety of configurations. The following chart outlines the elements that constitute a configuration and the corresponding catalog number.

HTPG - Voltage - Panelboard - C.B. type - # of C.B./# of poles (rating) - Enclosure - MCB - Options

HTPG - 277/480 - 30 - 2 - 14/1P (30) - 4X - 200 - H

Voltage

120/208 120/240* 277/480

Panelboard size

18 = 18 space panelboard (277 V only)
30 = 30 space panelboard
42 = 42 space panelboard
54 = 54 space panelboard (277 V only)

Circuit breaker type

2 = GFCB (30-mA trip) without alarm
3 = GFCB (30-mA trip) with bell alarm
4 = GFCB (30-mA trip) with relay alarm (includes terminal block option). Not available for 277 V

Number of circuit breakers/number of poles (circuit breaker rating) see prior page

# of breakers (no bell alarm option)

	120 V (1P)	**208 V (2P)**	**240 V (2P)**	**277V (1P)**
18	(1–18)	(1–8)	(1–8)	(1–8)
30	(1–30)	(1–14)	(1–14)	(1–14)
42	(1–42)	(1–20)	(1–20)	(1–20)
54	–	–	–	(1–26)

# of breakers (bell alarm option)

	120 V (1P)	**208 V (2P)**	**240 V (2P)**	**277 V (1P)**
18	(1–8)	(1–6)	(1–6)	(1–8)
30	(1–14)	(1–10)	(1–10)	(1–14)
42	(1–20)	(1–14)	(1–14)	(1–20)
54	–	–	–	(1–26)

Option

0 = None
A = Alarm horn (requires C.B. type 3 or 4)
B = Alarm beacon (requires C.B. type 3 or 4)
C = Heat-trace contactor failure light
D = Door disconnect
E = Environmental purge (TYPE 4 or 4X enclosures only)
G = Panel power-on light
H = Space heater and thermostat
L = Individual circuit breaker trip indication lights (requires C.B. type 4)
P = Heat-trace energized light
T = Terminal blocks (prewired)
W = Wired for ETI controller
Z = Z-purge system (TYPE 4 or 4X enclosures only)
SP = Special requirement: Must contain complete description of variance

MCB

Main circuit breaker and contactor

Panelboard size	**120/208**	**120/240**	**277/480**
18	50, 100	50, 100	30, 50, 70, 125
30	50, 100, 150, 200, 225	50, 60, 80, 150, 175, 200, 225	50, 70, 125, 175, 225
42	50, 100, 150, 200, 225	50, 60, 80, 150, 175, 200, 225	50, 70, 125, 175, 225
54	–	–	50, 70, 125, 175, 225

Enclosure

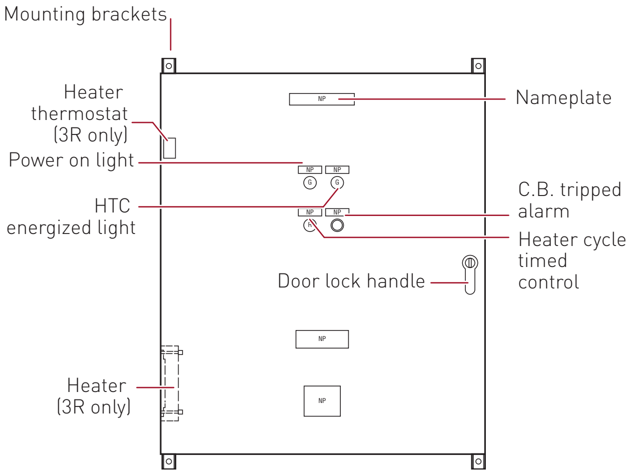
12 = TYPE 12 (indoors)
4 = TYPE 4 (outdoors)
4X = TYPE 4X (stainless steel–outdoors)

* Single phase

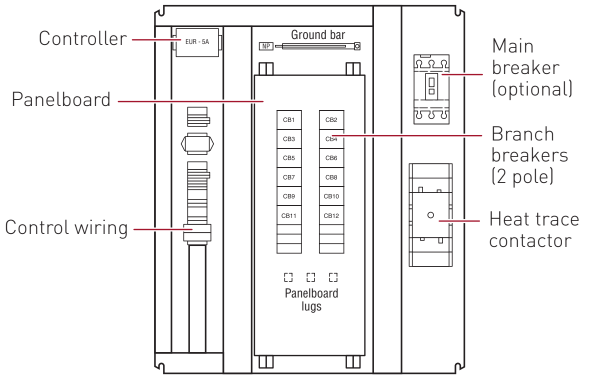
SMPG1

SNOW MELTING AND DE-ICING POWER DISTRIBUTION AND CONTROL PANEL

For single-phase heating cables



Exterior View



Interior View

PRODUCT OVERVIEW

The Raychem SMPG1 is a three-phase power distribution panel for single-phase heating cables that includes ground-fault protection, monitoring and control for snow melting or roof & gutter de-icing systems. The ETI® EUR-5A snow melting and gutter de-icing controller is included with the SMPG. When used with one or more compatible sensors, the EUR-5A automatically controls surface snow melting and roof and gutter de-icing heating cables for minimum energy costs. Applications include pavement, sidewalk, loading dock, roof, gutter, and down spout snow/ice melting in commercial and industrial environments.

The adjustable hold-on timer continues heater operation for up to 10 hours after snow stops to ensure complete melting.

The calibrated 40°F to 90°F (4°C to 32°C) high limit slab sensor prevents excessive temperatures when using constant wattage and MI heating cables. It also permits safe testing at outdoor temperatures too high for continuous heater operation. The temperature sensor is included.

The EUR-5A provides a complete interface for use in environments supervised by an energy management computer (EMC). This feature can also be used for general purpose remote control and annunciation. All sensor and communications wiring is NEC Class 2. This simplifies installation while enhancing fire and shock safety. Multiple sensors provide superior performance by better matching the controller to site performance requirements. The EUR-5A can interface up to six sensors.

For three-phase heating cable configurations, refer to the SMPG3 data sheet (H57814). For additional information on single-phase snow melting designs, contact your Thermal Management representative.

SMPG1

Ambient operating temperature	Indoor installation (NEMA 1/12): 14°F (–10°C) to 122°F (50°C) Outdoor installation (NEMA 3R/4): –40°F (–40°C) to 122°F (50°C) (Includes space heater and thermostat)
Main contactor	3-pole 100 A or 200 A
Main circuit breaker (optional)	Square D type HDL (15–150 A) 3-pole Square D type JDL (150–200 A) 3-pole
Operating heating cable voltage	208 or 277 V, single phase
Branch ground-fault breaker	Square D type QOB-EPD / EDB-EPD
Circuit breaker rating	15–50 A
Field wire size	#12–8 AWG (15–30 A C.B.), #8–2 AWG (40–50 A C.B.)

APPROVALS

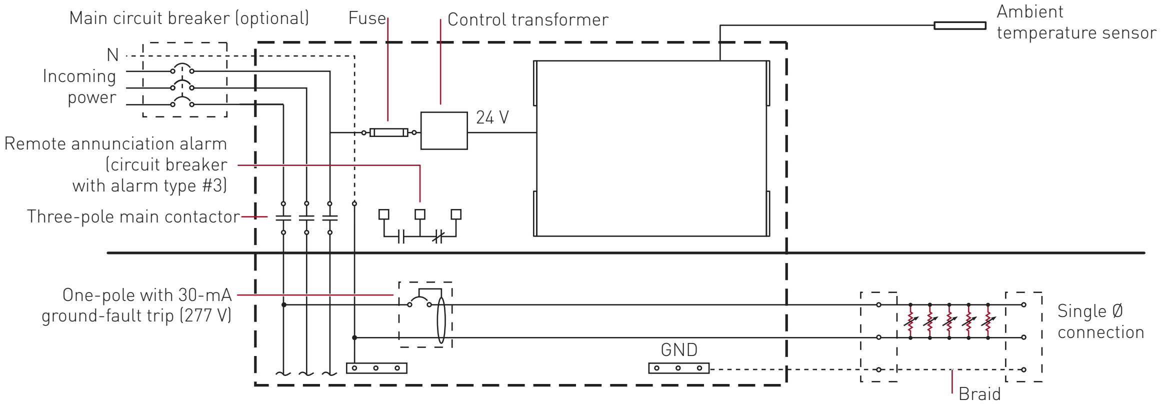
c UL US LISTED

UL STD. 508A
CAN/CSA C22.2 NO. 14

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

SMPG1 SNOW MELTING AND ROOF AND GUTTER DE-ICING CONTROL SCHEMATIC



CATALOG NUMBER

SMPG1 comes in a variety of configurations. The following chart outlines the elements that constitute a configuration and the corresponding catalog number. If standard configurations do not meet your needs, custom SMPG panels are available and processed under the catalog number SMPG-GENERAL, part number P000000763. Please contact your Thermal Management representative for a custom SMPG panel quotation. Non-standard configurations will carry ETL Certification, not a UL Listing.

SMPG1 – Voltage – Circuit breaker type – Number of circuit breakers/Number of poles (rating) – Enclosure – Contactor Size

SMPG1 – 277 – 2 – 12/1P (40) – 1 – 200 – Options: (MCB)

Voltage
208 V (Single phase)
277 V (Single phase)

Circuit breaker type
2 = Ground-fault circuit breaker (30-mA trip) without alarm
3 = Ground-fault circuit breaker (30-mA trip) with alarm

***Number of circuit breakers/ Number of poles (circuit breaker rating)**

208 V (2 pole) **# of C.B.**	**Available C.B. ratings (A)**	**277 V (1 pole)** **# of C.B.**	**Available C.B. ratings (A)**
6	15, 20, 25, 30, 40, 50	6	15, 20, 30, 40, 50
12	15, 20, 25, 30, 40, 50	12	15, 20, 30, 40, 50
		18	15, 20, 30, 40, 50

Main Circuit Breaker
MCB = Optional Main Circuit Breaker Included

Contactor Size

Contactor size (A)	**# of breakers**
100	6
200	12
200	18

Enclosure
1 = NEMA 1/12 (indoors)
3R = NEMA 3R/4 (outdoors) Includes heater

***Warning:** Confirm the total load (A) does not exceed contactor rating.

MAIN CIRCUIT BREAKERS

Installed in Control Panel

MCB rating	Voltage	Catalog number	Part number
50 A	120–600 V	HDL36050	T1010097
100 A	120–600 V	HDL36100	T1010101
110 A	120–600 V	HDL36110	T1010102
125 A	120–600 V	HDL36125	T1009792
150 A	120–600 V	HDL36150	T1010087
175 A	120–600 V	JDL36175	T1010053
200 A	120–600 V	JDL36200	T1010103
225 A	120–600 V	JDL36225	T1009945
250 A	480 or 600 V	JDL36250	T1010104

EUR-5A

Supply voltage/max current	21 to 28 Vac/2 A
Control transformer	Included
Operating temperature	–40°F (–40°C) to 140°F (60°C)
Hold on time adjustment	0 to 10 hours
High temperature limit adjustment	40°F (4°C) to 90°F (32°C)
Moisture/temperature sensors	Up to six can be used simultaneously. Members of the CIT-1/GIT-1/SIT-6E family in any combination. Locate up to 2,000 ft (609.6 m) for EUR-5A.
Ambient temperature sensor	Included
Remote interface	RCU-3 Remote Control Unit (can operate up to 500 ft (152 m) from panel)
Building/Energy management computer interface	5 Vdc @ 10 mA

POWER DISTRIBUTION

Catalog Number	Part Number	Description
SMPG1 Snow Melting and De-Icing Power Distribution and Control Panel - NEMA 1/12		
208 V 2-pole NEMA 1 enclosure		
SMPG1-208-2-6/2P(XX)-1-100	P000000456	SMPG with (6) 15–50 A ground-fault breakers, 100 A contactor
SMPG1-208-2-12/2P(XX)-1-200	P000000457	SMPG with (12) 15–50 A ground-fault breakers, 200 A contactor
SMPG1-208-3-6/2P(XX)-1-100	P000000458	SMPG with (6) 15–50 A ground-fault breakers with alarm, 100 A contactor
SMPG1-208-3-12/2P(XX)-1-200	P000000459	SMPG with (12) 15–50 A ground-fault breakers with alarm, 200 A contactor
277 V 1-pole NEMA 1 enclosure		
SMPG1-277-2-6/1P(XX)-1-100	P000000460	SMPG with (6) 15–50 A ground-fault breakers, 100 A contactor
SMPG1-277-2-12/1P(XX)-1-200	P000000461	SMPG with (12) 15–50 A ground-fault breakers, 200 A contactor
SMPG1-277-2-18/1P(XX)-1-200	P000000462	SMPG with (18) 15–50 A ground-fault breakers, 200 A contactor
SMPG1-277-3-6/1P(XX)-1-100	P000000463	SMPG with (6) 15–50 A ground-fault breakers with alarm, 100 A contactor
SMPG1-277-3-12/1P(XX)-1-200	P000000464	SMPG with (12) 15–50 A ground-fault breakers with alarm, 200 A contactor
SMPG1-277-3-18/1P(XX)-1-200	P000000465	SMPG with (18) 15–50 A ground-fault breakers with alarm, 200 A contactor
SMPG1 Snow Melting and De-Icing Power Distribution and Control Panel - NEMA 3R/4		
208 V 2-pole NEMA 3R enclosure		
SMPG1-208-2-6/2P(XX)-3R-100	P000000466	SMPG with (6) 15–50 A ground-fault breakers, 100 A contactor
SMPG1-208-2-12/2P(XX)-3R-200	P000000467	SMPG with (12) 15–50 A ground-fault breakers, 200 A contactor
SMPG1-208-3-6/2P(XX)-3R-100	P000000468	SMPG with (6) 15–50 A ground-fault breakers with alarm, 100 A contactor
SMPG1-208-3-12/2P(XX)-3R-200	P000000469	SMPG with (12) 15–50 A ground-fault breakers with alarm, 200 A contactor
277 V 1-pole NEMA 3R enclosure		
SMPG1-277-2-6/1P(XX)-3R-100	P000000470	SMPG with (6) 15–50 A ground-fault breakers, 100 A contactor
SMPG1-277-2-12/1P(XX)-3R-200	P000000471	SMPG with (12) 15–50 A ground-fault breakers, 200 A contactor
SMPG1-277-2-18/1P(XX)-3R-200	P000000472	SMPG with (18) 15–50 A ground-fault breakers, 200 A contactor
SMPG1-277-3-6/1P(XX)-3R-100	P000000473	SMPG with (6) 15–50 A ground-fault breakers with alarm, 100 A contactor
SMPG1-277-3-12/1P(XX)-3R-200	P000000474	SMPG with (12) 15–50 A ground-fault breakers with alarm, 200 A contactor
SMPG1-277-3-18/1P(XX)-3R-200	P000000475	SMPG with (18) 15–50 A ground-fault breakers with alarm, 200 A contactor

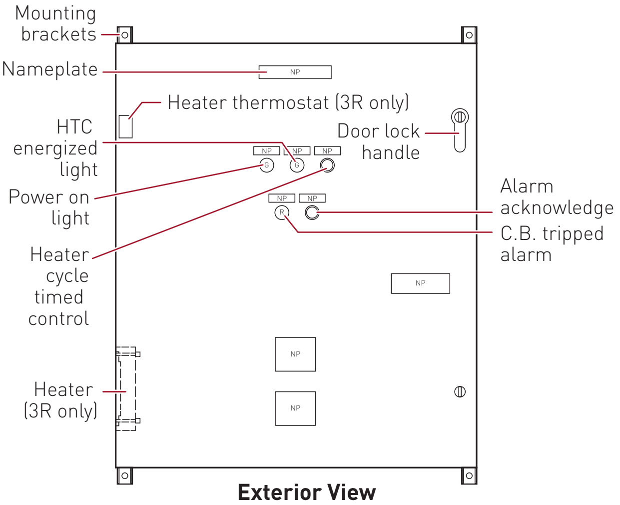
ACCESSORIES

ETI Sensors	Catalog number	Part number
Pavement-mounted sensor	SIT-6E	P000000112
Aerial snow sensor	CIT-1	512289
Gutter ice sensor	GIT-1	126795
Replacement Controller		
Snow melting and gutter de-icing controller	EUR-5A	T0001527

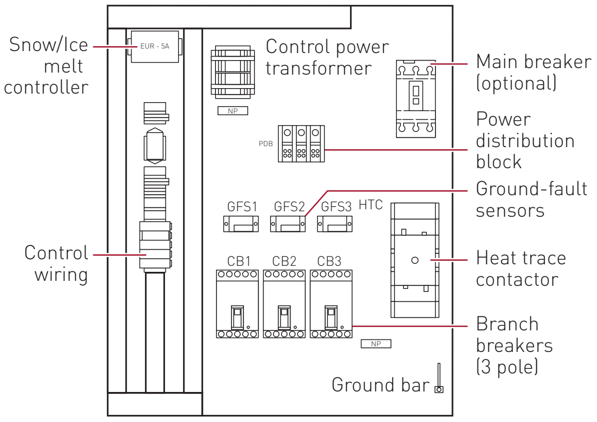
SMPG3

SNOW MELTING AND DE-ICING POWER DISTRIBUTION AND CONTROL PANEL

For three-phase heating cables



Exterior View



Interior View

PRODUCT OVERVIEW

The Raychem SMPG3 is a three-phase power distribution panel for three-phase heating cables that includes ground-fault protection, monitoring and control for snow melting or roof and gutter de-icing systems. The ETI® EUR-5A snow melting and gutter de-icing controller is included with the SMPG. When used with one or more compatible sensors, the EUR-5A automatically controls surface snow melting and roof and gutter de-icing heating cables for minimum energy costs. Applications include pavement, sidewalk, loading dock, roof, gutter, and down spout snow/ice melting in commercial and industrial environments.

The adjustable hold-on timer continues heater operation for up to 10 hours after snow stops to ensure complete melting.

The calibrated 40°F to 90°F (4°C to 32°C) high limit slab sensor prevents excessive temperatures when using constant wattage and MI heating cables. It also permits safe testing at outdoor temperatures too high for continuous heater operation. The temperature sensor is included.

The EUR-5A provides a complete interface for use in environments supervised by an energy management computer (EMC). This feature can also be used for general purpose remote control and annunciation. All sensor and communications wiring is NEC Class 2. This simplifies installation while enhancing fire and shock safety. Multiple sensors provide superior performance by better matching the controller to site performance requirements. The EUR-5A can interface up to six sensors.

For single-phase heating cable configurations, refer to the SMPG1 data sheet (H57680). For additional information on three-phase snow melting designs, contact your Thermal Management representative.

SMPG3

Ambient operating temperature	Indoor installation (NEMA 1/12): 14°F (–10°C) to 122°F (50°C) Outdoor installation (NEMA 3R/4): –40°F (–40°C) to 122°F (50°C) (Includes space heater and thermostat)
Main contactor	3-pole 100 A or 200 A
Main circuit breaker (optional) (15–150 A) 3-pole	Square D type HDL (Installed in panel when ordered/needed)
(150–200 A) 3-pole	Square D type JDL (Installed in panel when ordered/needed)
Operating heating cable voltage	208, 480, or 600 V, three phase
Branch ground-fault breaker	Square D type QOB-1021 (15A–100 A) for 208 V Square D type HDL-1021 (15A–150 A) for 600 V JDL-1021 (160–200) (All the above are Shunt trip C.B. with external ground-fault sensor)
Circuit breaker rating	15–150 A
Field wire size (Copper wires)	#12–8 AWG (15–30 A C.B.), #8–2 AWG (40–50 A C.B.), #6–1/0 AWG (60–100 A C.B.), #1/0 AWG–350 kcmil (150 A C.B.)

To comply with NEC Article 427-55(a), all circuit breakers are equipped with the means for lockout in the "Off" position.

APPROVALS

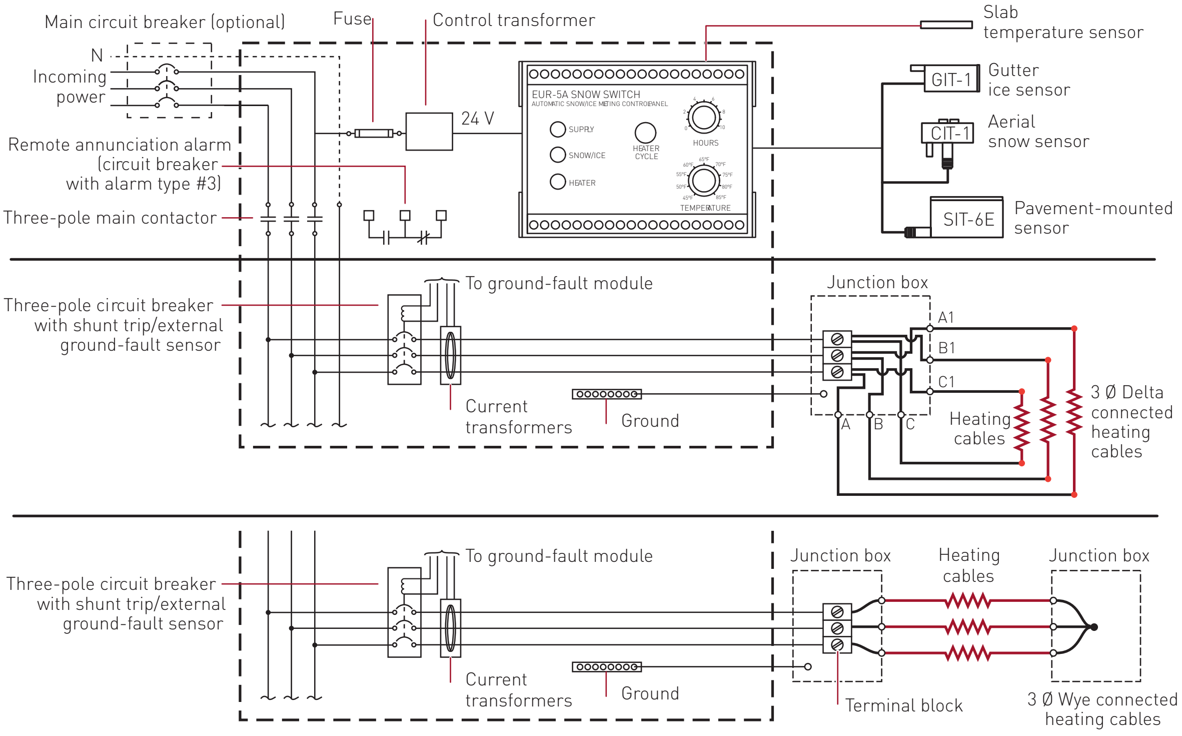
c UL US LISTED

UL STD. 508A
CAN/CSA C22.2 NO. 14

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

SMPG3 SNOW MELTING AND ROOF AND GUTTER DE-ICING CONTROL SCHEMATIC



CATALOG NUMBER

SMPG3 comes in a variety of configurations. The following chart outlines the elements that constitute a configuration and the corresponding catalog number. If standard configurations do not meet your needs, custom SMPG panels are available and processed under the catalog number SMPG-GENERAL, part number P000000763. Please contact your Thermal Management representative for a custom SMPG panel quotation. Non-standard configurations will carry ETL Certification, not a UL Listing.

SMPG3 – Voltage – Circuit breaker type – Number of circuit breakers/Number of poles (rating) – Enclosure – Contactor size

SMPG3 – 208 – 3 – 2/3P (80) – 3R – 200 – Options: (MCB)

Voltage

208 V (Three phase)
480 V (Three phase)
600 V (Three phase)

Circuit breaker type

3 = 3-pole circuit breaker w/shunt trip and external ground-fault sensor - with alarm

***Number of circuit breakers/ Number of poles (circuit breaker rating)**

208 V (3 pole) **# of C.B.**	**Available C.B. ratings (A)**	**480 V or 600 V (3 pole)** **# of C.B.**	**Available C.B. ratings (A)**
1	15–100	1	15–100
2	15–150	2	15–150
3	15–150	3	15–150

Main Circuit Breaker

MCB = Optional Main Circuit Breaker Included

Contactor Size

Contactor size (A)	**# of breakers**	**Breakers size (A)**
100	1	25, 30, 40, 50, 60, 70, 80, 100
200	1	150
100	2	25, 30, 40, 50
200	2	60, 70, 80, 100
100	3	25, 30
200	3	40, 50, 60

Enclosure

1/12 = NEMA 1/12 (indoors)
3R/4 = NEMA 3R/4 (outdoors)

***Warning:** Confirm the total load (A) does not exceed contactor rating.

EUR-5A

Supply voltage/max current	21 to 28 Vac/2 A
Control transformer	Included
Operating temperature	–40°F (–40°C) to 140°F (60°C)
Hold on time adjustment	0 to 10 hours
High temperature limit adjustment	40°F (4°C) to 90°F (32°C)
Moisture/temperature sensors	Up to six can be used simultaneously. Members of the CIT-1/GIT-1/SIT-6E family in any combination. Locate up to 2,000 ft (609.6 m) for EUR-5A.
Ambient temperature sensor	Included
Remote interface	RCU-3 Remote Control Unit (can operate up to 500 ft [152 m] from panel)
Building/energy management computer interface	5 Vdc @ 10 mA

MAIN CIRCUIT BREAKERS

Installed in Control Panel

MCB rating	Voltage	Catalog number	Part number
50 A	120–600 V	HDL36050	T1010097
100 A	120–600 V	HDL36100	T1010101
110 A	120–600 V	HDL36110	T1010102
125 A	120–600 V	HDL36125	T1009792
150 A	120–600 V	HDL36150	T1010087
175 A	120–600 V	JDL36175	T1010053
200 A	120–600 V	JDL36200	T1010103
225 A	120–600 V	JDL36225	T1009945
250 A	480 or 600 V	JDL36250	T1010104

POWER DISTRIBUTION

Catalog Number	Part Number	Description
SMPG3 Snow Melting and De-Icing Power Distribution and Control Panel - NEMA 1/12		
208 V 3-pole NEMA 1/12 Enclosure		
SMPG3-208-3-1/3P(XX)-1-100	P000000476	SMPG with (1) 15–100 A breaker, GF sensor with alarm, 100 A contactor
SMPG3-208-3-1/3P(XX)-1-200	P000000477	SMPG with (1) 15–150 A breaker, GF sensor with alarm, 200 A contactor
SMPG3-208-3-2/3P(XX)-1-100	P000000478	SMPG with (2) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-208-3-2/3P(XX)-1-200	P000000479	SMPG with (2) 15–150 A breakers, GF sensor with alarm, 200 A contactor
SMPG3-208-3-3/3P(XX)-1-100	P000001381	SMPG with (3) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-208-3-3/3P(XX)-1-200	P000000480	SMPG with (3) 15–150 A breakers, GF sensor with alarm, 200 A contactor
480 V 3-pole NEMA 1/12 Enclosure		
SMPG3-480-3-1/3P(XX)-1-100	P000000481	SMPG with (1) 15–100 A breaker, GF sensor with alarm, 100 A contactor
SMPG3-480-3-1/3P(XX)-1-200	P000001382	SMPG with (1) 15–150 A breaker, GF sensor with alarm, 200 A contactor
SMPG3-480-3-2/3P(XX)-1-100	P000000482	SMPG with (2) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-480-3-2/3P(XX)-1-200	P000000483	SMPG with (2) 15–150 A breakers, GF sensor with alarm, 200 A contactor
SMPG3-480-3-3/3P(XX)-1-100	P000001383	SMPG with (3) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-480-3-3/3P(XX)-1-200	P000000484	SMPG with (3) 15–150 A breakers, GF sensor with alarm, 200 A contactor
600 V 3-pole NEMA 1/12 Enclosure		
SMPG3-600-3-1/3P(XX)-1-100	P000000494	SMPG with (1) 15–100 A breaker, GF sensor with alarm, 100 A contactor
SMPG3-600-3-1/3P(XX)-1-200	P000001384	SMPG with (1) 15–150 A breaker, GF sensor with alarm, 200 A contactor
SMPG3-600-3-2/3P(XX)-1-100	P000000495	SMPG with (2) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-600-3-2/3P(XX)-1-200	P000000496	SMPG with (2) 15–150 A breakers, GF sensor with alarm, 200 A contactor
SMPG3-600-3-3/3P(XX)-1-100	P000000497	SMPG with (3) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-600-3-3/3P(XX)-1-200	P000000498	SMPG with (3) 15–150 A breakers, GF sensor with alarm, 200 A contactor

POWER DISTRIBUTION

Catalog Number	Part Number	Description
SMPG3 Snow Melting and De-Icing Power Distribution and Control Panel - NEMA 3R/4		
208 V 3-pole NEMA 3R/4 Enclosure		
SMPG3-208-3-1/3P(XX)-3R-100	P000000485	SMPG with (1) 15–100 A breaker, GF sensor with alarm, 100 A contactor
SMPG3-208-3-1/3P(XX)-3R-200	P000000486	SMPG with (1) 15–150 A breaker, GF sensor with alarm, 200 A contactor
SMPG3-208-3-2/3P(XX)-3R-100	P000000487	SMPG with (2) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-208-3-2/3P(XX)-3R-200	P000000488	SMPG with (2) 15–150 A breakers, GF sensor with alarm, 200 A contactor
SMPG3-208-3-3/3P(XX)-3R-100	P000001385	SMPG with (3) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-208-3-3/3P(XX)-3R-200	P000000489	SMPG with (3) 15–150 A breakers, GF sensor with alarm, 200 A contactor
480 V 3-pole NEMA 3R/4 Enclosure		
SMPG3-480-3-1/3P(XX)-3R-100	P000000490	SMPG with (1) 15–100 A breaker, GF sensor with alarm, 100 A contactor
SMPG3-480-3-1/3P(XX)-3R-200	P000001386	SMPG with (1) 15–150 A breaker, GF sensor with alarm, 200 A contactor
SMPG3-480-3-2/3P(XX)-3R-100	P000000491	SMPG with (2) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-480-3-2/3P(XX)-3R-200	P000000492	SMPG with (2) 15–150 A breakers, GF sensor with alarm, 200 A contactor
SMPG3-480-3-3/3P(XX)-3R-100	P000001387	SMPG with (3) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-480-3-3/3P(XX)-3R-200	P000000493	SMPG with (3) 15–150 A breakers, GF sensor with alarm, 200 A contactor
600 V 3-pole NEMA 3R/4 Enclosure		
SMPG3-600-3-1/3P(XX)-3R-100	P000000499	SMPG with (1) 15–100 A breaker, GF sensor with alarm, 100 A contactor
SMPG3-600-3-1/3P(XX)-3R-200	P000001388	SMPG with (1) 15–150 A breaker, GF sensor with alarm, 200 A contactor
SMPG3-600-3-2/3P(XX)-3R-100	P000000500	SMPG with (2) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-600-3-2/3P(XX)-3R-200	P000000501	SMPG with (2) 15–150 A breakers, GF sensor with alarm, 200 A contactor
SMPG3-600-3-3/3P(XX)-3R-100	P000000502	SMPG with (3) 15–100 A breakers, GF sensor with alarm, 100 A contactor
SMPG3-600-3-3/3P(XX)-3R-200	P000000503	SMPG with (3) 15–150 A breakers, GF sensor with alarm, 200 A contactor

ACCESSORIES

ETI sensors	Catalog number	Part number
Pavement-mounted sensor	SIT-6E	P000000112
Aerial snow sensor	CIT-1	512289
Gutter ice sensor	GIT-1	126795
Replacement controller		
Snow melting and gutter de-icing controller	EUR-5A	T0001527

HECS

ROOF & GUTTER DE-ICING HIGH-EFFICIENCY CONTROL PANEL SYSTEM

For Roof Ice Melt (RIM) systems

GENERAL

The High-Efficiency Control System (HECS) is designed to optimize RIM System performance while minimizing energy consumption. At the onset of snow accumulation on the roof, the owner/operator enables the heating system by turning on the main and branch circuit breakers. A temperature sensor measures the outside air temperature and only permits the RIM panel controllers to power the heating cable when the ambient temperature nears freezing (e.g., 34°F). The RIM panel controllers then maintain the RIM heater panels above freezing (e.g., 42°F) so that snowmelt will not refreeze and form icicles and ice dams at the eaves.

The RIM System uses self-regulating heating cables as the source of heat and is designed to handle over 90% of the worst-case winter storm conditions.

ENERGY EFFICIENCY

When ambient temperatures are in the 20-32°F range, only a portion of the heaters' energy is required for proper system operation, so the HECS modulates power to the heaters, keeping energy consumption to a minimum (see Figure 1). If just a simple ambient sensing, on/off controller were used, the RIM cover temperature would range anywhere from 40°F during harsh winter storm conditions (10-15°F, snowing, windy) to 70°F during milder winter conditions (25-32°F, calm, sunny). Figures 2 and 3 show the relative energy consumption for an ambient on/off controlled system versus the HECS for two winter days.

The HECS reduces energy consumption by 40-60% during mild winter days and by 10-40% during colder and stormy winter days. For the average winter, energy savings should average around 30%.

PRODUCT OVERVIEW

The HECS (High-Efficiency Control System) uses an ambient sensing RTD and temperature controller in series with Raychem roof ice melt (RIM) system panel temperature sensing RTDs, controllers and solid state relay circuitry to provide a highly energy-efficient control system.

The ambient controller powers the RIM panel controllers only when the ambient temperature is between the heater on set point and the low temp cutout set point (both field-adjustable). When this condition is met the RIM panel controllers will adjust the power level to the RIM panels to maximize efficiency and keep them at the maintain temperature set point (field-adjustable). As temperatures drop and winds pick-up, the controllers increase the heating cable output.

EXAMPLES OF STEADY STATE POWER VERSUS AMBIENT CONDITIONS:

Weather Conditions	Percent of Steady State Power
27-30°F, Light Winds	20-25%
27-30°F, Strong Winds	35-50%
20-25°F, Light Winds	40-60%
20-25°F, Strong Winds	50-70%
10-15°F, Light Winds	60-90%
10-15°F, Strong Winds	100%

Figure 1 - Energy loads for various weather conditions

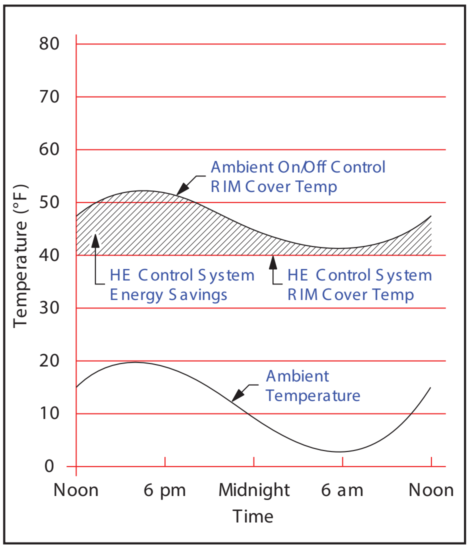


Figure 2 - Harsh winter day

LOW AMBIENT TEMPERATURE OPERATIONS

Since snowmelt at the roof/snow interface depends on the roof snow depth, ambient temperature, roof design, and building insulation, there are low ambient temperature conditions when no snowmelting occurs. For new construction in heavy snowfall areas, temperatures below a 0-10°F range will most often create "no snowmelting" conditions. The HECS includes a control panel mounted solid state controller and an eave soffit mounted RTD temperature sensor. The temperature at which the RIM System turns on can be set at the control panel and is adjustable (recommended 34-38°F). In addition, the low- temperature cutout feature can be set at the control panel (recommended 0-10°F) and can then be adjusted up or down based on the local winter conditions for the building. For example, if 10°F is the proper low temperature cutout set point and the winter had 150 hours below 10°F, up to 10% energy savings can be realized when compared to a control system Figure 4 demonstrates how the low temperature cutout option would typically operate. without the low temperature cutout option operating.

SUMMARY

When compared with standard ambient-only temperature control, the High-Efficiency Control System will provide up to 30% energy savings for a typical winter. In addition, up to 10% more energy savings can be realized when using the low temperature cutout feature.

SPECIFICATION

- NEMA 4/12 enclosure
- Up to 18 branch circuit breakers with ground fault protection
- Multiple separate control zones available
- Accommodates 1-phase or 3-phase incoming power
- Ambient controller displays sensed ambient temperature and heater-on set point
- RIM panel controllers display sensed RIM panel temperature and set point
- UL approved panel

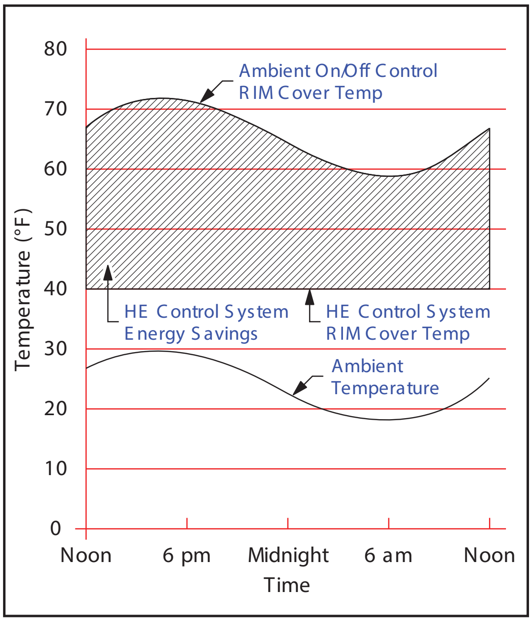


Figure 3 - Mild winter day

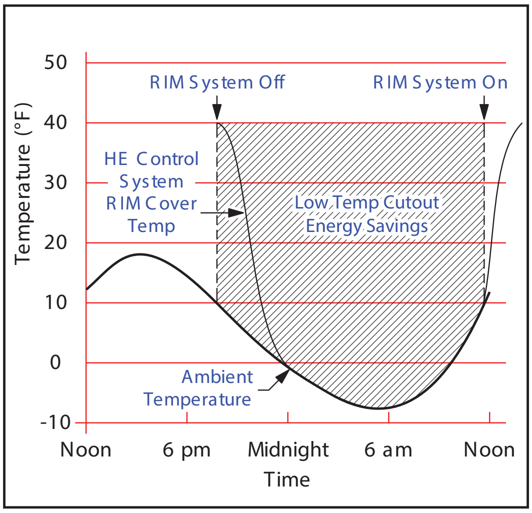
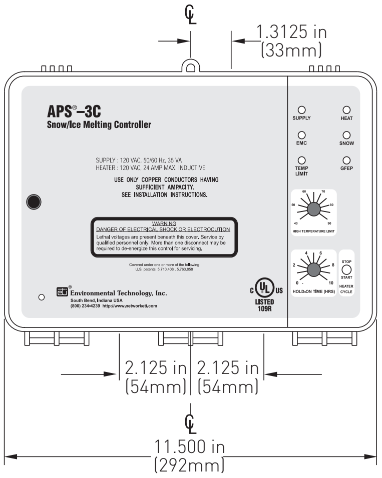
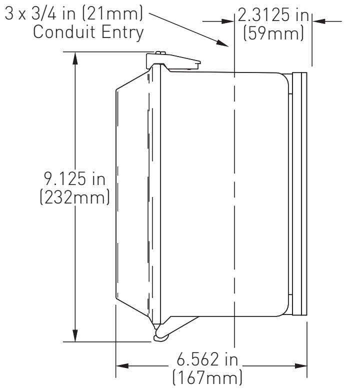


Figure 4 - Low temperature cutout operation

APS-3C

SNOW MELTING AND GUTTER DE-ICING CONTROLLER





PRODUCT OVERVIEW

The ETI® APS–3C snow melting and gutter de-icing controller when used with compatible sensors automatically controls surface snow melting and roof and gutter de-icing heating cables, ensuring minimum operating costs. Typical applications include pavement, sidewalk, loading dock, roof, gutter, and down spout snow/ice melting.

The adjustable hold-on timer continues heater operation for up to 10 hours after snow stops to ensure complete melting. The optional RCU–3 Remote Control Unit can be located where system operation can be conveniently observed. It duplicates many of the controls and indicators on the APS-3C front panel. It is used to clear tracked and drifting snow that may not land on a sensor.

The calibrated 40°F to 90°F (4°C to 32°C) high limit thermostat prevents excessive temperatures when using constant wattage and MI heating cables. It also permits safe testing at outdoor temperatures too high for continuous heater operation. The temperature sensor is included.

The APS–3C provides a relay closure interface for use with energy management computers (EMC). This feature can also be used for general purpose remote control and annunciation and other advanced applications.

All sensor and communications wiring is NEC Class 2. This simplifies installation while enhancing fire and shock safety. Multiple sensors provide superior performance by better matching the controller to site performance requirements. The APS–3C can interface up to six sensors.

The APS-3C does not provide ground-fault protection for the heating cable system. This protection is required and must be provided by other devices such as ground-fault circuit breakers or other control methods.

The APS–3C is an exceptionally capable surface snow melting and roof and gutter de-icing controller. For complete information describing its application, installation, and features, please contact your Thermal Management representative or visit our web site at www.pentairthermal.com.

GENERAL

Area of use	Nonhazardous locations
Approvals	c UL us LISTED 109R Type 873 Temperature Regulating Equipment

ENCLOSURE

Protection	NEMA 3R
Cover attachment	Hinged polycarbonate cover, lockable
Entries	Three 1-1/16" entries
Material	Polycarbonate
Mounting	Wall mounted

CONTROL

Supply voltage	APS-3C-120 V: 120 V 50/60 Hz APS-3C-208/240 V: 208/240 V 50/60 Hz
Contact type	Form C
Maximum ratings	Voltage: 240 V Current: 24 A
Heater hold-on timer	0 to 10 hours; actuated by snow stopping or toggle switch
System test	Switch toggles the heater contact on and off. If temperature exceeds high limit, heater cycles to prevent damage.

SNOW/ICE SENSORS

Sensor input	Up to 6 sensors; CIT-1, GIT-1, SIT-6E
Circuit type	NEC Class 2
Lead length	Up to 500 ft (152 m) using 18 AWG 3-wire jacketed cable Up to 2,000 ft (609 m) using 12 AWG 3-wire jacketed cable

HIGH LIMIT THERMOSTAT

Adjustment range	40°F to 90°F (4°C to 32°C)
Dead band	1°F (0.6°C)
Sensor type	Thermistor
Circuit type	NEC Class 2
Lead length	Up to 500 ft (152 m) using 18 AWG 2-wire jacketed cable Up to 1,000 ft (504 m) using 12 AWG 2-wire jacketed cable

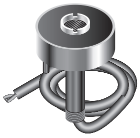
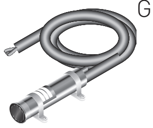
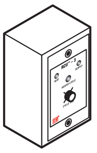
ENERGY MANAGEMENT COMPUTER (EMC) INTERFACE

Inputs	OVERRIDE ON	(10 mA dry switch contact)
	OVERRIDE OFF	(10 mA dry switch contact)
Outputs	SUPPLY	(10 mA dry switch contact)
	SNOW	(10 mA dry switch contact)
	HEAT	(10 mA dry switch contact)
	HIGH TEMP	(10 mA dry switch contact)
	REMOTE	(10 mA dry switch contact)

ENVIRONMENTAL

Operating temperature	–40°F to 160°F (–40°C to 71°C)
Storage temperature	–50°F to 180°F (–45°C to 82°C)

ORDERING DETAILS

Catalog number	Part number	Description
APS-3C-120V	P000000781	APS-3C Snow Melting and De-Icing Controller, 120 V
APS-3C-208/240V	P000000782	APS-3C Snow Melting and De-Icing Controller, 208/240 V
Snow/Ice Sensors		
 CIT-1	512289-000	CIT-1 Snow sensor
 GIT-1	126795-000	GIT-1 Gutter sensor
 SIT-6E	P000000112	SIT-6E Pavement snow sensor
 RCU-3	P000000883	RCU-3 Remote control unit

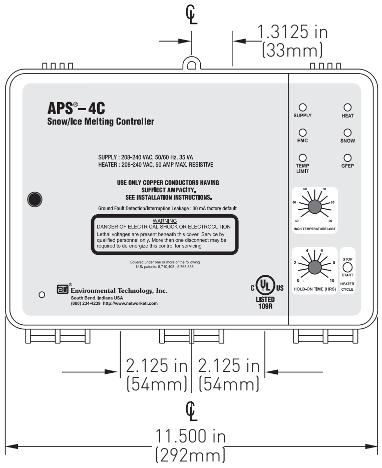
LIMITED WARRANTY

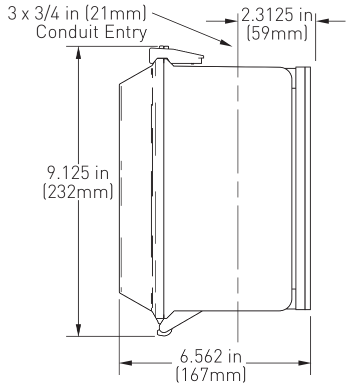
ETI's two year limited warranty covering defects in workmanship and materials applies.

APS-4C

SNOW MELTING AND GUTTER DE-ICING CONTROLLER

With ground-fault protection





PRODUCT OVERVIEW

The ETI® APS–4C snow melting and gutter de-icing controller with ground-fault protection, when used with one or more compatible sensors, automatically controls surface snow melting and roof and gutter de-icing heating cables for minimum energy costs. Applications include pavement, sidewalk, loading dock, roof, gutter, and down spout snow/ice melting in commercial and industrial environments.

The adjustable hold-on timer continues heater operation for up to 10 hours after snow stops to ensure complete melting. The optional RCU–4 Remote Control Unit can be located where system operation can be conveniently observed. It duplicates many of the APS–4C front panel functions.

The APS–4C provides advanced patented and patent pending ground-fault equipment protection (GFEP) as required by the national electrical codes. The GFEP automatically tests itself every time the contactors operate and once every 24 hours. The trip current can be set at 60 or 120 mA via a DIP an internal switch or retained at the 30 mA default value. As an aid to troubleshooting heating cable ground faults, the APS–4C provides an output that can indicate the ground current on a service person's portable DVM.

The calibrated 40°F to 90°F (4°C to 32°C) high limit thermostat prevents excessive temperatures when using constant wattage and MI heating cables. It also permits safe testing at outdoor temperatures too high for continuous heater operation. The temperature sensor is included.

The APS–4C provides a complete interface for use in environments supervised by an energy management computer (EMC). This feature can also be used for general purpose remote control and annunciation.

All sensor and communications wiring is NEC Class 2. This simplifies installation while enhancing fire and shock safety. Multiple sensors provide superior performance by better matching the controller to site performance requirements. The APS–4C can interface up to six sensors.

The APS–4C is an exceptionally capable surface snow melting and roof and gutter de-icing controller. For complete information describing its application, installation and features, please contact your Thermal Management representative or visit our web site at www.pentairthermal.com.

APS-4C

GENERAL

Area of use	Nonhazardous locations
Approvals	C UL US LISTED 109R Type 873 Temperature Regulating Equipment

ENCLOSURE

Protection	NEMA 3R
Cover attachment	Hinged polycarbonate cover, lockable
Entries	One 1-1/16" entry (top) for NEC Class 2 connections Two 1-11/16" entries (bottom) for supply and load power, except 277 V single phase Two 1-1/16" entries (bottom) for supply and load power, 277 V single phase only
Material	Polycarbonate
Mounting	Wall mounted

CONTROL

Supply voltage	APS-4C-208/240 V: 208–240 V 50/60 Hz 3-phase APS-4C-277 V: 277 V 50/60 Hz single phase APS-4C-277/480 V: 277/480 V 50/60 Hz 3-phase APS-4C-600 V: 600 V 50/60 Hz 3-phase
Contact type	3 Form A
Maximum ratings	Voltage: 600 V Current: 50 A except 277 V single phase, 40 A for 277 V single phase
Heater hold-on timer	0 to 10 hours; actuated by snow stopping or toggle switch
System test	Switch toggles the heater contact on and off. If temperature exceeds high limit, heater cycles to prevent damage.

GROUND-FAULT EQUIPMENT PROTECTION (GFEP)

Set point	30 mA (default); 60 mA and 120 mA selectable by DIP switch
Automatic self-test	Mode A: Verifies GFEP function before contactors operate Mode B: Verifies GFEP and heaters every 24 hours
Manual test/reset	Toggle switch provided for this function
Maintenance facility	DC output proportional to ground current provided for troubleshooting the heater system

SNOW/ICE SENSORS

Sensor input	Up to 6 sensors: CIT-1, GIT-1, SIT-6E
Circuit type	NEC Class 2
Lead length	Up to 500 ft (152 m) using 18 AWG 3-wire jacketed cable Up to 2,000 ft (609 m) using 12 AWG 3-wire jacketed cable

HIGH LIMIT THERMOSTAT

Adjustment range	40°F to 90°F (4°C to 32°C)
Dead band	1°F (0.6°C)
Circuit type	Thermistor
Sensor interface	NEC Class 2
Lead length	Up to 500 ft (152 m) using 18 AWG 2-wire jacketed cable Up to 1,000 ft (504 m) using 12 AWG 2-wire jacketed cable

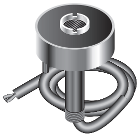
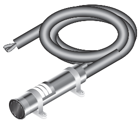
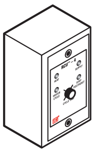
ENERGY MANAGEMENT COMPUTER (EMC) INTERFACE

Inputs	OVERRIDE ON	(10 mA dry switch contact)
	OVERRIDE OFF	(10 mA dry switch contact)
Outputs	SUPPLY	(10 mA dry switch contact)
	SNOW	(10 mA dry switch contact)
	HEAT	(10 mA dry switch contact)
	HIGH TEMP	(10 mA dry switch contact)
	REMOTE	(10 mA dry switch contact)

ENVIRONMENTAL

Operating temperature	–40°F to 160°F (–40°C to 71°C)
Storage temperature	–50°F to 180°F (–45°C to 82°C)

ORDERING DETAILS

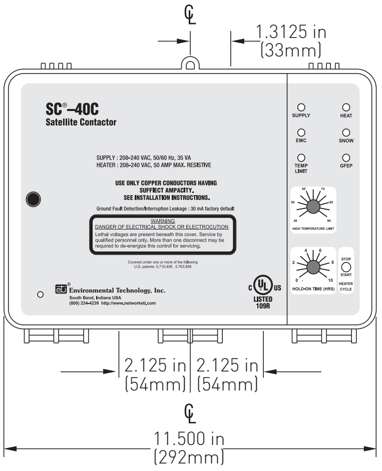
Catalog number	Part number	Description
APS-4C-208/240V	P000000783	APS-4C Snow melting and de-icing controller with ground-fault protection, 208-240 Vac 50/60 Hz three phase
APS-4C-277V	P000000784	APS-4C Snow melting and de-icing controller with ground-fault protection, 277 Vac 50/60 Hz single phase
APS-4C-277V/480V	P000000785	APS-4C Snow melting and de-icing controller with ground-fault protection, 277/480 Vac 50/60 Hz three phase
APS-4C-600V	P000000786	APS-4C Snow melting and de-icing controller with ground-fault protection, 600 Vac 50/60 Hz three phase
Snow/Ice Sensors		
 CIT-1	512289-000	CIT-1 Snow sensor
 GIT-1	126795-000	GIT-1 Gutter sensor
 SIT-6E	P000000112	SIT-6E Pavement snow sensor
 RCU-4	P000000884	RCU-4 Remote control unit

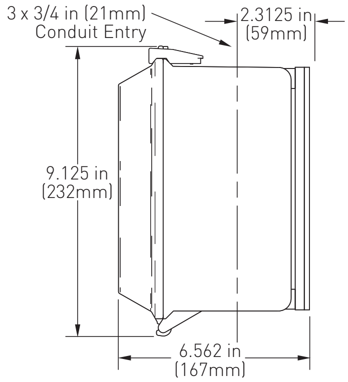
LIMITED WARRANTY

ETI's two year limited warranty covering defects in workmanship and materials applies.

SC-40C

SNOW AND ICE MELTING SATELLITE CONTACTOR





PRODUCT OVERVIEW

The ETI® SC–40C snow and ice melting satellite contactor answers the need for cost effective modular snow melting heater control. One or more SC–40Cs, when used with an APS–4C control panel acting as the master control, allow for modular snow melting system design. There is no limit to the number of SC–40Cs that can be interfaced in a single system. This approach reduces front end design, hardware, and installation costs while providing a number of useful features that would be otherwise too expensive and complex to implement.

The SC–40C provides Ground-Fault Equipment Protection (GFEP) as required by the national electrical codes. Upon sensing a ground-fault condition, the SC–40C inhibits operation of its contactor until manually reset. Circuits without a ground fault continue to operate normally, thus partitioning defective heating cables.

The adjustable hold-on timer continues heater operation on each SC–40C for up to 10 hours after snow stops to ensure complete melting and to compensate for differences between zones. The optional RCU–4 remote control unit can be located where system operation can be conveniently observed. It duplicates many of the controls and indicators on the SC–40C front panel.

Each SC–40C provides a complete energy management computer (EMC) interface. This feature provides remote access for advanced applications requiring remote or zone control along with remote annunciation.

Each SC–40C maintains communications to and from the APS–4C using a 3-wire cable. Thus, the APS–4C alarms ground faults occurring anywhere in the system. This feature inserts a short time delay between the operation of each contactor, thus improving power quality by limiting the inrush current. The RCU–4 remote control unit supplied permits overriding zone control in applications requiring the capability.

For complete information describing its application, installation and features, please contact your Thermal Management representative or visit our web site at www.pentairthermal.com.

GENERAL

Area of use	Nonhazardous locations
Approvals	c UL us LISTED 109R Type 873 Temperature Regulating Equipment

ENCLOSURE

Protection	NEMA 3R
Cover attachment	Hinged polycarbonate cover, lockable
Entries	One 1-1/16" entry (top) for NEC Class 2 connections Two 1-11/16" entries (bottom) for supply and load power, except 277 V single phase Two 1-1/16" entries (bottom) for supply and load power, 277 V single phase only
Material	Polycarbonate
Mounting	Wall mounted

COMMUNICATIONS BUS

Number of cascaded units	Unlimited
Contactor delay	5 seconds
Bus-wire type	3-wire jacketed cable
Circuit type	NEC Class 2
Lead length	Up to 500 ft (152 m) using 18 AWG 3-wire jacketed cable Up to 1,000 ft (504 m) using 12 AWG 3-wire jacketed cable

CONTROL

Supply voltage	SC-40C 208/240 V: 208–240 V 50/60 Hz 3-phase SC-40C 277 V: 277 V 50/60 Hz single phase SC-40C 277/480 V: 277/480 V 50/60 Hz 3-phase SC-40C 600 V: 600 V 50/60 Hz 3-phase
Contact type	3 Form A
Maximum ratings	Voltage: 600 V Current: 50 A except 277 V single phase, 40 A for 277 V single phase
Heater hold-on timer	0 to 10 hours; actuated by snow stopping or toggle switch
System test	Switch toggles the heater contact on and off. If temperature exceeds high limit, heater cycles to prevent damage.

GROUND-FAULT EQUIPMENT PROTECTION (GFEP)

Set point	30 mA (default); 60 mA and 120 mA selectable by DIP switch
Automatic self-test	Mode A: Verifies GFEP function before contactors operate Mode B: Verifies GFEP and heaters every 24 hours
Manual test/reset	Toggle switch provided for this function
Maintenance facility	DC output proportional to ground current provided for troubleshooting the heater system

HIGH LIMIT THERMOSTAT

Adjustment range	40°F to 90°F (4°C to 32°C)
Dead band	1°F (0.6°C)
Sensor type	Thermistor
Circuit type	NEC Class 2
Lead length	Up to 500 ft (152 m) using 18 AWG 2-wire jacketed cable Up to 1,000 ft (504 m) using 12 AWG 2-wire jacketed cable

ENERGY MANAGEMENT COMPUTER (EMC) INTERFACE

Inputs	OVERRIDE ON	(10 mA dry switch contact)
	OVERRIDE OFF	(10 mA dry switch contact)
Outputs	SUPPLY	(10 mA dry switch contact)
	SNOW	(10 mA dry switch contact)
	HEAT	(10 mA dry switch contact)
	HIGH TEMP	(10 mA dry switch contact)
	REMOTE	(10 mA dry switch contact)

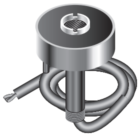
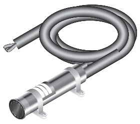
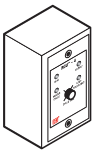
ENVIRONMENTAL

Operating temperature	–40°F to 160°F (–40°C to 71°C)
Storage temperature	–50°F to 180°F (–45°C to 82°C)

ORDERING DETAILS

Catalog number	Part number	Description
SC-40C 208/240V	P000000787	SC-40C Satellite Contactor, 208-240 Vac 50/60 Hz three phase
SC-40C 277V	P000000788	SC-40C Satellite Contactor, 277 Vac 50/60 Hz single phase
SC-40C 277/480V	P000000789	SC-40C Satellite Contactor, 277/480 Vac 50/60 Hz three phase
SC-40C 600V	P000000790	SC-40C Satellite Contactor, 600 Vac 50/60 Hz three phase

Snow/ice sensors (not included)

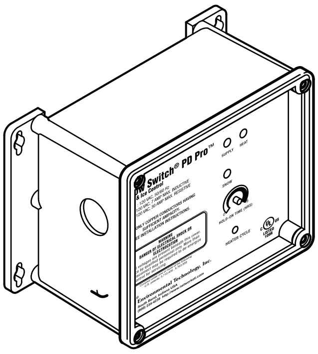
	CIT-1	512289-000	CIT-1 Snow sensor
	GIT-1	126795-000	GIT-1 Gutter sensor
	SIT-6E	P000000112	SIT-6E Pavement snow sensor
	RCU-4	P000000884	RCU-4 Remote control unit

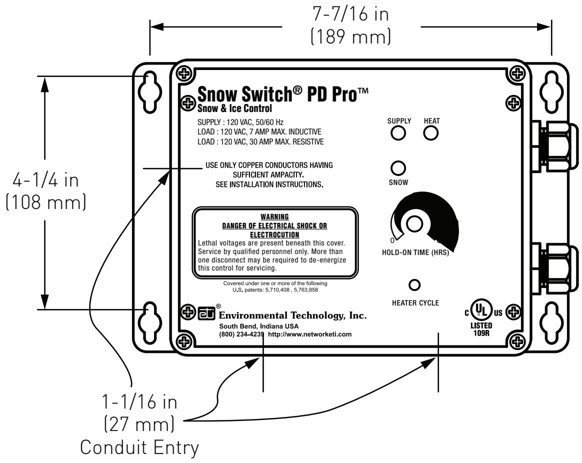
LIMITED WARRANTY

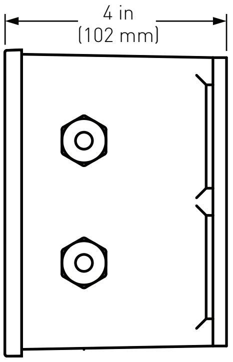
ETI's two year limited warranty covering defects in workmanship and materials applies.

PD PRO

AUTOMATIC SNOW AND ICE MELTING CONTROLLER







PRODUCT OVERVIEW

The ETI® PD Pro is an automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments.

The PD Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The controller features automatic and manual-override operator controls. The adjustable Hold-On timer continues heater operation up to 8 hours after the sensors stop detecting snow or ice to ensure the rest of the slab has completely dried. The Heater Cycle control button allows manual initiation or cancellation of a heating cycle. The optional RCU–3 remote control unit can be located for convenient monitoring and control. These flexible control options provide complete snow melting and water evaporation at a low operating cost.

The PD Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds. The PD Pro is a snow and ice controller for medium-sized applications whose features and power requirements do not require an APS or EUR Series control panel. For complete information describing application, installation, and features, please contact your Thermal Management representative or visit www.pentairthermal.com.

GENERAL

Area of use	Nonhazardous locations
Approvals	c UL us LISTED 109R Type 873 Temperature Regulating Equipment Also evaluated by Underwriters Laboratories Inc in accordance with UL 1053 Ground-Fault Sensing and Relaying Equipment

ENCLOSURE

Protection	Type 4X
Dimensions	5 1/2" (L) x 8 1/8" (W) x 4 3/8" (H) 140 mm (L) x 207 mm (W) x 112 mm (H)
Material	Polycarbonate
Cover attachment	Polycarbonate cover, machine screws
Weight	3 pounds (not including sensors)
Mounting	Wall mount
Entries	2 x 3/4" entries (right) for NEC Class 2 connections 3 x 1-1/16" entries (bottom and left) for supply and load power

CONTROL

Supply voltage	100-277 Vac; 50/60 Hz
Load	30 A maximum resistive 7 A maximum inductive
Heater Hold-On timer	0 – 8 hrs; actuated by snow stopping or toggle switch
System test	Switch toggles heater contact on and off. If temperature exceeds optional high limit thermistor (45°F), heater shuts off to reduce costs and prevent damage

FRONT PANEL INTERFACE

Status indicators	SUPPLY (green): Power on HEAT (yellow): Heating cycle in progress SNOW (yellow): Sensor(s) detect snow

ENVIRONMENTAL

Operating temperature	–31°F to 130°F (–35°C to 55°C)
Storage temperature	–67°F to 167°F (–55°C to 75°C)

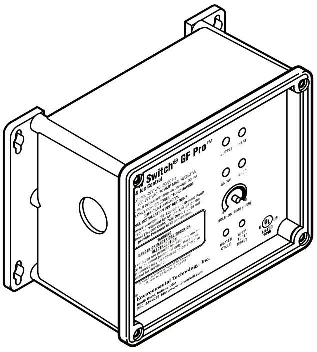
ORDERING INFORMATION

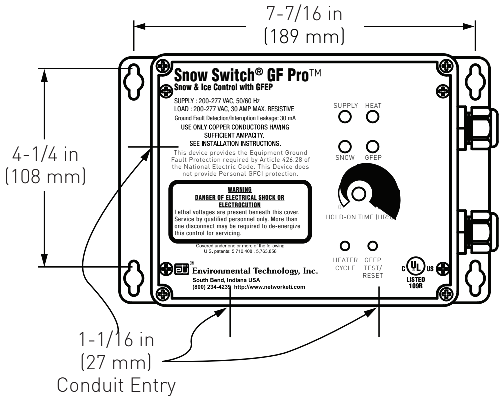
Catalog number	Part number	Description
PD Pro*	P000001508	Automatic Snow and Ice Melting Controller
CIT-1*	512289-000	Aerial Snow Sensor
GIT-1*	126795-000	Gutter Ice Sensor
SIT-6E*	P000000112	Pavement Mounted Snow and Ice Sensor

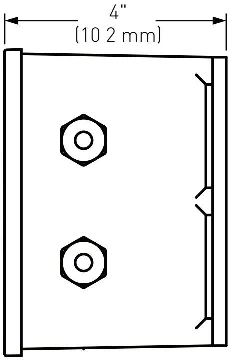
* The PD Pro does not come with any sensors. Sensors must be ordered separately.

GF PRO

AUTOMATIC SNOW AND ICE MELTING CONTROLLER







PRODUCT OVERVIEW

The ETI® GF Pro is an automatic snow and ice melting controller for pavement, sidewalks, loading docks, roofs, gutters and downspouts in commercial and residential environments.

The GF Pro interfaces with up to two sensors, (any combination of CIT-1, GIT-1 or SIT-6E) to meet site requirements. The controller features automatic and manual-override operator controls. The adjustable Hold-On timer continues heater operation up to 8 hours after the sensors stop detecting snow or ice to ensure the rest of the slab has completely dried. The Heater Cycle control button allows manual initiation or cancellation of a heating cycle. The optional RCU–4 remote control unit can be located for convenient monitoring and control. These flexible control options provide complete snow melting and water evaporation at a low operating cost.

The GF Pro also features a built-in 30 mA, self-testing Ground-Fault Equipment Protection (GFEP) capability, digitally filtered to minimize false tripping. A ground-fault alarm must be manually reset using the Test/Reset switch before heater operation can continue.

The GF Pro is housed in an environmentally-sheltered Type 4X enclosure and weighs only 3 pounds. The GF Pro is a snow and ice controller for medium-sized applications whose features and power requirements do not require an APS or EUR Series control panel. For complete information describing application, installation, and features, please contact your Thermal Management representative or visit www.pentairthermal.com.

GENERAL

Area of use	Nonhazardous locations
Approvals	c UL us LISTED 109R Type 873 Temperature Regulating Equipment Also evaluated by Underwriters Laboratories Inc in accordance with UL 1053 Ground-Fault Sensing and Relaying Equipment

ENCLOSURE

Protection	Type 4X
Dimensions	5 1/2" (L) x 8 1/8" (W) x 4 3/8" (H) 140 mm (L) x 207 mm (W) x 112 mm (H)
Material	Polycarbonate
Cover attachment	Polycarbonate cover, machine screws
Weight	3 pounds (not including sensors)
Mounting	Wall mount
Entries	2 x 3/4" entries (right) for NEC Class 2 connections 3 x 1-1/16" entries (bottom and left) for supply and load power

CONTROL

Supply voltage	100-277 Vac; 50/60 Hz
Load	30 A maximum resistive
Heater Hold-On timer	0 – 8 hrs; actuated by snow stopping or toggle switch
System test	Switch toggles heater contact on and off. If temperature exceeds optional high limit thermistor (45°F), heater shuts off to reduce costs and prevent damage

FRONT PANEL INTERFACE

Status indicators	SUPPLY (green): Power on HEAT (yellow): Heating cycle in progress SNOW (yellow): Sensor(s) detect snow GFEP (red): Ground-Fault condition GFEP (red, flashing): Failed GFEP (red, rapid flashing): GFEP test in progress

GROUND-FAULT EQUIPMENT PROTECTION (GFEP)

Set point	30 mA
Automatic self-test	GFEP verified before contactors operate; GFEP runs on start-up and every 24 hours
Manual Test/Reset	Test/Reset switch on front panel

ENVIRONMENTAL

Operating temperature	–31°F to 130°F (–35°C to 55°C)
Storage temperature	–67°F to 167°F (–55°C to 75°C)

ORDERING INFORMATION

Catalog number	**Part number**	**Description**
GF Pro*	P000001509	Automatic Snow and Ice Melting Controller
CIT-1*	512289-000	Aerial Snow Sensor
GIT-1*	126795-000	Gutter Ice Sensor
SIT-6E*	P000000112	Pavement Mounted Snow and Ice Sensor

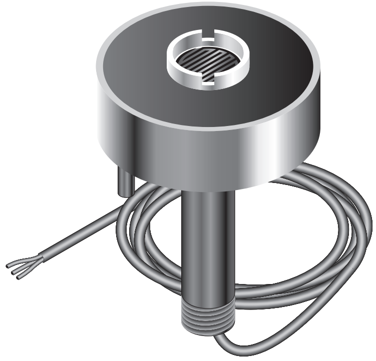
* The GF Pro does not come with any sensors. Sensors must be ordered separately.

CIT-1, GIT-1, SIT-6E

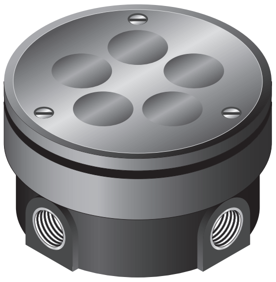
SNOW AND ICE MELTING SENSORS

CIT-1 snow sensor, GIT-1 gutter sensor, SIT-6E pavement sensor

GIT-1



CIT-1



SIT-6E

PRODUCT OVERVIEW

The ETI® CIT–1, GIT–1 and SIT–6E snow and ice melting sensors combine to reliably detect moisture and temperature for surface snow melting and roof and gutter de-icing applications. The CIT–1 sensor may be paired with either the GIT–1 sensor for gutter applications or the SIT–6E sensor for pavement applications. These sensors detect precipitation as snow at temperatures below 38°F (3.3°C). Control panels are signaled only if moisture occurs below this temperature, thus saving energy and ensuring reliable ice melting. They provide the industry's most versatile and cost effective automatic snow melting control when used with any APS or EUR series control panel.

Reliability and sensitivity are key features in the CIT–1, GIT–1 and SIT–6E sensors. The solid state design, combined with a rugged housing and epoxy potting, ensure many years of trouble free service. Precision precipitation and temperature sensing provide the sensitivity required for effective automatic control. All three are NEC Class 2 low voltage device which simplifies installation.

The CIT–1, GIT–1 and SIT–6E's unique microcontroller design frees their moisture sensors from ice bridging. Ice bridging happens if incomplete melting occurs near the heater or sensor leaving an air space. The air insulates thus preventing effective heater and sensor operation. Additional features prevent heater operation under conditions favorable to heater ice tunneling.

The CIT–1 aerial snow sensor detects falling or blowing precipitation before snow or ice begin to accumulate. This allows the control panel to begin managing the system. This sensor may be roof or mast mounted.

The GIT–1 mounts directly in gutters and down spouts sensing actual environmental conditions.

The SIT–6E accurately measures pavement temperature while reliably detecting snow and ice conditions on pavement surfaces. A built-in hold-on timer in the SIT–6E keeps heaters operating for an hour after snow stops to help ensure complete snow melting. Mounting these sensors close to the deicing heaters ensures that pavement and sensor become dry at about the same time.

An adjustable mounting system aligns the SIT–6E with the pavement surface. Six conduit locations add to installation flexibility. The sensor subassembly is field replaceable without disturbing the pavement.

Sensors are easy to install and may be mounted up to 2000 ft (609 m) from a control panel. A combination of up to six sensors may be used with a control panel to best match site performance requirements.

For complete information describing applications, installation and features, please contact your Thermal Management representative or visit our web site at www.pentairthermal.com.

GENERAL

Area of use	
CIT–1	Gutters or pavement (in conjunction with GIT–1 or SIT–6E)
GIT–1	Gutters
SIT–6E	Pavement
Heater hold-on time	
CIT–1	None
GIT–1	None
SIT–6E	1 hour
Activation temperature	38°F (3.37°C)

CONNECTIONS

Circuit type	NEC Class 2
Supply voltage	24 Vac (supplied by panel)
Output signal	Voltage drop
Bus wire type	3-wire jacketed cable
Lead length	Up to 2,000 ft (609 m) using 12 AWG 3-wire jacketed cable Up to 500 ft (152 m) using 18 AWG 3-wire jacketed cable

ENVIRONMENTAL

Operating temperature	–40°F to 160°F (–40°C to 71°C)
Storage temperature	–50°F to 180°F (–45°C to 82°C)

ORDERING DETAILS

Catalog number	Part number	Description
CIT-1	512289-000	CIT-1 Snow sensor
GIT-1	126795-000	GIT-1 Gutter sensor
SIT-6E	P000000112	SIT-6E Pavement snow sensor

LIMITED WARRANTY

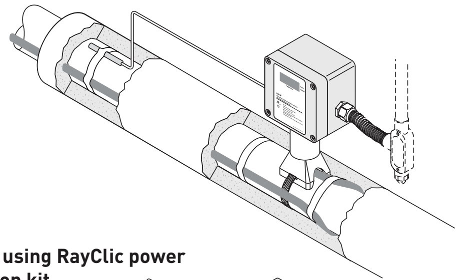
ETI's two-year limited warranty covering defects in workmanship and materials applies.

Raychem

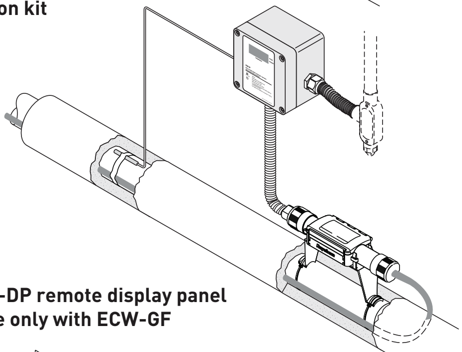
ECW-GF, ECW-GF-DP

DIGITAL ELECTRONIC CONTROLLERS AND REMOTE DISPLAY PANEL

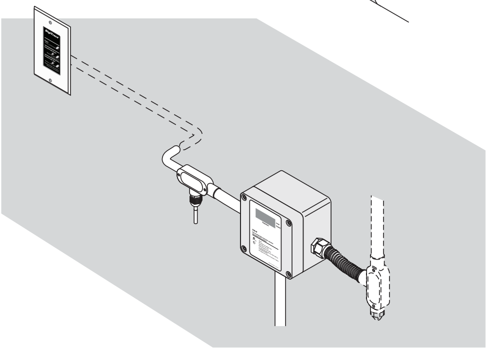
ECW-GF with FTC-PSK pipe stand and power connection kit



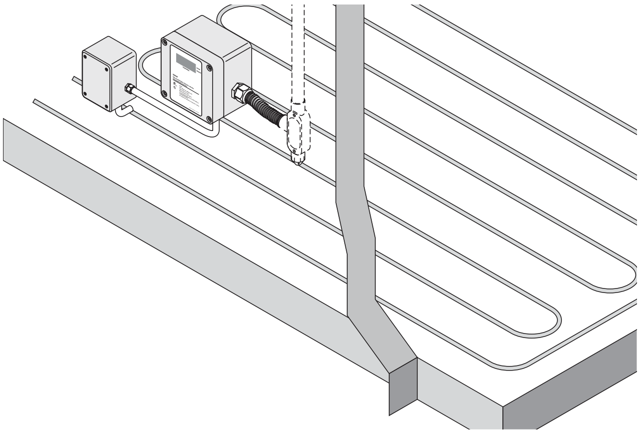
ECW-GF using RayClic power connection kit



ECW-GF-DP remote display panel available only with ECW-GF



ECW-GF using a separate junction box



PRODUCT OVERVIEW

The Raychem ECW-GF electronic controller provides accurate temperature control with integrated 30-mA ground-fault protection. The ECW-GF is ideal for pipe freeze protection, flow maintenance, freezer frost heave, floor heating and snow melting applications.

The ECW-GF is housed in a NEMA 4X enclosure designed to be wall mounted or installed on a pipe with the optional Raychem FTC-PSK pipe stand kit.

The controller includes a window and a digital display that shows the measured temperature, set point temperature and alarm conditions (temperature sensor failure, high or low temperature and ground-fault) if detected.

Alarm conditions can be indicated via a Form C dry contact connected to a building management system. Status LEDs indicate whether the digital display is showing the set point or actual temperature or if the controller is in an alarm state.

The ECW-GF can be programmed to maintain temperatures up to 200°F (93°C), at voltages from 100 to 277 V, and is capable of switching current up to 30 amperes.

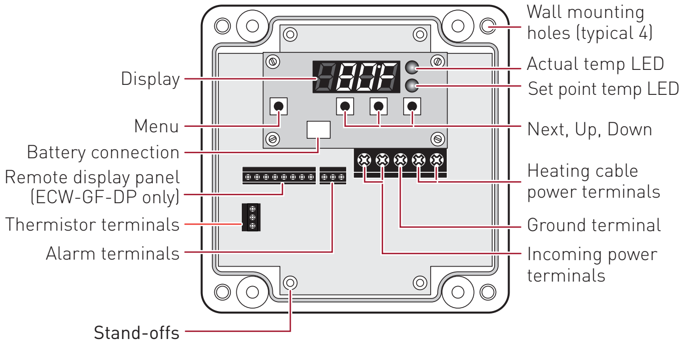
Programming the set point temperature, deadband, and the high and low alarm thresholds on the controllers is accomplished using the built-in digital display and push buttons. A 9-V battery connector is supplied to allow programming the controller before the heating cable circuit power is provided.

An optional remote display panel, the Raychem ECW-GF-DP, is available. This remote display provides remote alarm indication and ground-fault test and reset capability. The ECW-GF-DP can be installed indoors in a standard duplex box located up to 328 ft (100 m) from the controller.

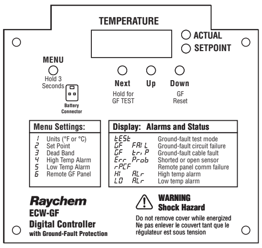
The ECW-GF is supplied with a 25-foot thermistor for line, slab or ambient sensing temperature control.

ECW-GF CONTROLLER

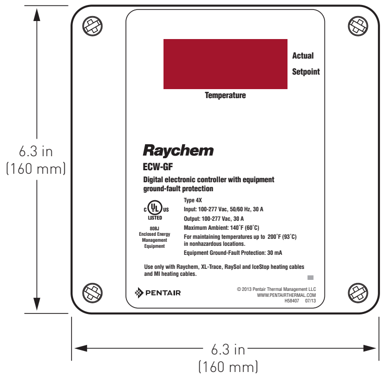
ECW-GF without wire cover



Wire cover



Lid



Note:
Next button is used for ground-fault test.
Down button is used for ground-fault reset.

GENERAL

Approvals	**Nonhazardous locations** c UL us LISTED
Supply voltage	100–277 Vac ±10% 50–60 Hz Common supply for controller and heat tracing circuit

ENCLOSURE

Protection	NEMA 4X
Material	Fiberglass reinforced polyester plastic
Entries	1 x 3/4 in (19 mm) conduit entries for power 1 x 1 in (25 mm) conduit entry for heating cable 1 x 1/2 in (13 mm) conduit entry for RTD sensor
Relative humidity	0% to 90%, noncondensing
Ambient installation and usage temperature	–40°F to 140°F (–40°C to 60°C)

CONTROL

Relay type	Double-pole, mechanical
Control range	32°F to 200°F (0°C to 93°C)
Deadband	Adjustable 2°F to 10°F (2°C to 6°C)
Accuracy	±3°F (1.7°C) of set point

INPUT POWER

Voltage	277 Vac nominal, 50/60 Hz maximum
Current	30 A maximum

MONITORING AND ALARM OUTPUT

Temperature	Low alarm range: 20°F (–6°C) to set point minus deadband, or OFF High alarm range: Set point plus (Deadband +5°F (3°C)) to 230°F, or OFF
RTD failure	Shorted or open temperature sensor
Alarm relay	Form C: 2 A at 277 Vac, 2 A at 48 Vdc

TEMPERATURE SENSOR (INCLUDED)

Input type	Thermistor 10K ohm @25C Type J

GROUND-FAULT

Ground-fault protection	30 mA fixed
Ground fault trip reset	Reset button, manual
Ground-fault test	Manual ground-fault circuitry test; automatic hourly circuitry test

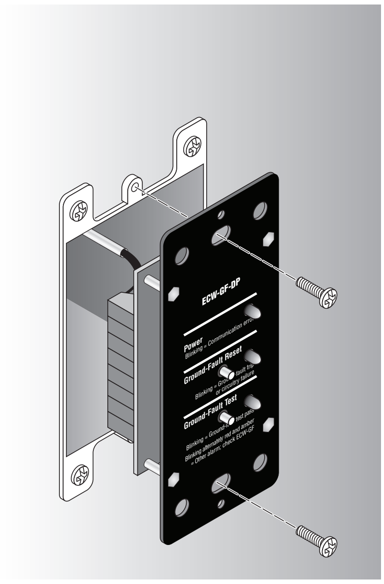
PROGRAMMING AND SETTING

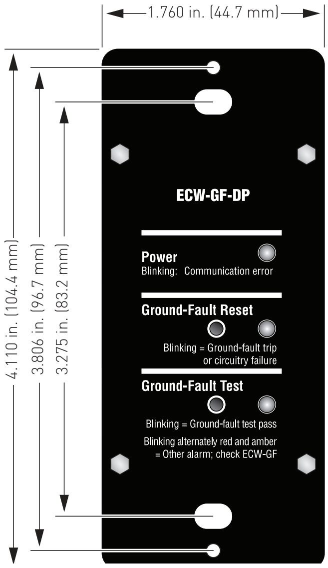
Method	Programmable at controller – Push buttons on front panel
Units	°F or °C
Digital display	Four numeric display digits for parameter and error/alarm indication
LEDs	Indicate actual and set point from display and alarm state
Memory	Nonvolatile, restored after power loss
Stored parameters	Parameters can be programmed without power supply (external battery) and parameters are stored in nonvolatile memory.
Alarm conditions	Low/high temperature and thermistor failure (open or shorted) Ground-fault trip, ground-fault circuit failure and loss of power.

CONNECTION TERMINALS

Power supply input	Screw rising cage clamp, 18–6 AWG
Heating cable output	Screw rising cage clamp, 18–6 AWG
Ground	Screw rising cage clamp, 18–6 AWG
Thermistor	Screw rising cage clamp, 22–14 AWG
Alarm	Screw rising cage clamp, 22–14 AWG
Remote display panel	Screw rising cage clamp, 22–14 AWG

ECW-GF-DP REMOTE PANEL (FOR ECW-GF CONTROLLER ONLY)





ECW-GF, ECW-GF-DP

GENERAL

Approvals	**Nonhazardous locations** c UL us LISTED
Environment	Indoors, dry area
Ambient operating temperature	32°F to 122°F (0°C to 50°C)
Humidity	90% noncondensing

FEATURES

LED	3 LEDs 1 green, 1 red, 1 amber
Buttons	2: Ground-fault reset, Ground-fault test
Power	Power provided from ECW-GF controller 12 Vdc @ 100 mA
Connection	8 position terminal block 8 conductor 22 AWG shielded cable Alpha - Cat No. 1298C or equivalent 328 ft (100 m) maximum

ORDERING DETAILS

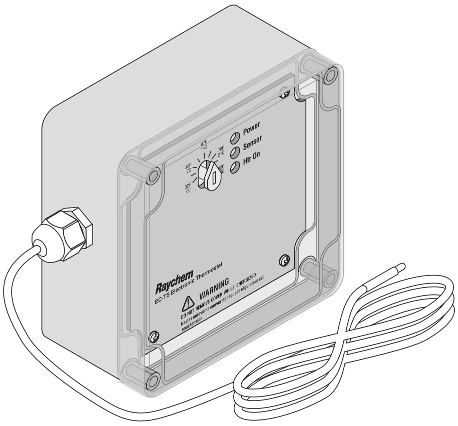
Description	Catalog number	Part number	Weight/lbs
Wall mounted digital electronic controller with ground fault	ECW-GF	P000000925	4.0
Remote display panel for ECW-GF	ECW-GF-DP	P000000926	0.3
Pipe mounting kit with power connection and end seal	FTC-PSK	P000000927	0.2

Raychem

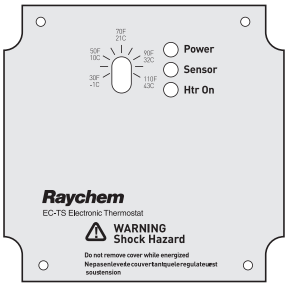
EC-TS

AMBIENT, PIPE OR SLAB SENSING ELECTRONIC THERMOSTAT

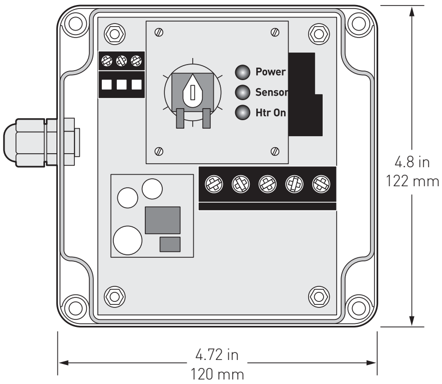
With 25 foot temperature sensing lead



Wire Cover



EC-TS without Wire Cover



PRODUCT OVERVIEW

The Raychem EC-TS electronic thermostat is an ambient, pipe or slab sensing thermostat that is ideal for pipe freeze protection, flow maintenance, freezer frost heave, floor heating and snow melting applications. The EC-TS can be used to control a single heat-tracing -circuit or as a pilot control of a contactor switching multiple heat-tracing circuits. The temperature set point can be visually checked through the clear lid, as can the LED indicators for alarm, power and heating cable status. The stainless steel temperature sensor makes it an ideal thermostat for applications that require an embedded sensor.

GENERAL

Area of use	Ordinary area, outdoor
Approvals	c UL us LISTED 80BJ Energy Management Equipment
Supply voltage	100–277 Vac ±10% 50–60 Hz. Auto ranging Common supply for controller and heat-tracing circuit

ENCLOSURE

Protection	NEMA 4X
Cover attachment	Captive stainless steel screws
Entries	2 x 1/2 in conduit entries for power 1 gland entry for the sensor
Material	Polycarbonate
Mounting	Wall mounted
Relative humidity	0% to 90%, noncondensing
Ambient installation and usage temperature	–40°F to 140°F (–40°C to 60°C)

CONTROL

Max. switching current	30 A, 277 Vac
Switch type	SPST (normally open)
Deadband	–0°F, +3°F (–0°C, +1.7°C)
Set point accuracy	±3°F (1.7°C)
Adjustable temperature range	30°F to 110°F (–1°C to 43°C)

MONITORING

Sensor failure	Shorted or open sensor
Units	°F and °C
LEDs	Green LED for power available Green LED for heating cable on Red LED for sensor failure

TEMPERATURE SENSOR

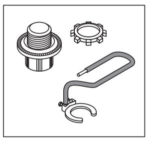
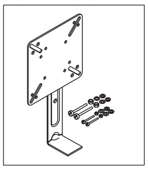
Type	Thermistor – 0.2°C, 10K ohm, Curve "A"
Construction	3 wire (twisted shielded pair plus ground)
Exposure temperature	Minimum: –40°F (–40°C) Maximum: 212°F (100°C)
Sensor sheath	304 stainless steel
Sensor diameter	0.25 in (0.63 cm)
Sensor length	2 in (5.1 cm)
Leads	20 AWG stranded, PVC overall jacket
Lead length	25 ft (7.6 m)

The sensor cable may be extended to a maximum of 100 ft (30 m) using a 3 wire (twisted shielded pair plus ground) with a wire gauge size of 20 AWG or larger.

CONNECTION TERMINALS

Power supply input	Screw Rising Cage Clamp, 18 – 6 AWG
Heating cable output	Screw Rising Cage Clamp, 18 – 6 AWG
Ground	Screw Rising Cage Clamp, 18 – 6 AWG
Thermistor (sensor)	Screw Rising Cage Clamp, 22 – 14 AWG

ORDERING DETAILS

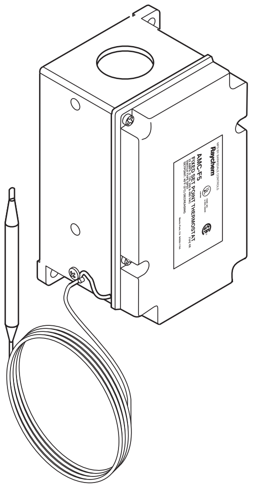
Description	**Catalog number**	**Part number**	**Weight/lbs**
Electronic thermostat with 25 ft sensing lead	EC-TS	P000001115	1.2
Spare Parts and Accessories			
MI cable grounding kit (required if installing MI heating cable) 	MI-GROUND-KIT	P000000279	0.2
Pipe support bracket 	SB-110	707366	1.0

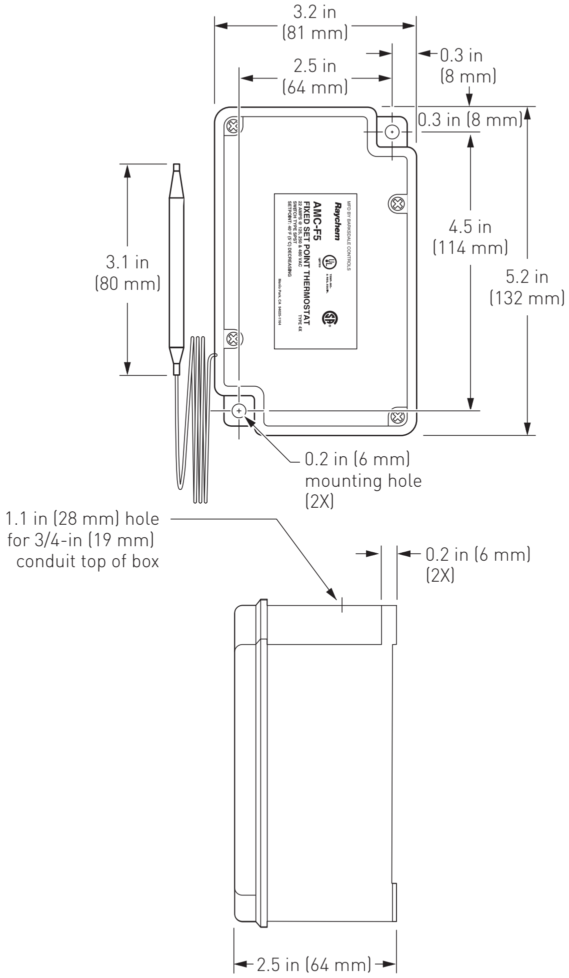
Raychem

AMC-F5

FIXED SET POINT FREEZE PROTECTION THERMOSTAT

For nonhazardous locations





PRODUCT OVERVIEW

The Raychem AMC-F5 thermostat is designed to control heat-tracing systems used for freeze protection in nonhazardous locations. The thermostat has a fixed set point of 40°F (5°C) and can be used for ambient-sensing or line-sensing. It can be used to control a single heat-tracing circuit or as a pilot control of a contactor switching multiple heat-tracing circuits.

SPECIFICATIONS

Enclosure	TYPE 4X, UV-resistant thermoplastics
Entries	One 3/4-in (19 mm) through hole
Set point	40°F (5°C) nonadjustable
Sensor exposure limits	–30°F to 140°F (–34°C to 60°C)
Housing exposure limits	–30°F to 140°F (–34°C to 60°C)
Switch	SPST
Electrical rating	22 A at 125 / 250 / 480 Vac
Accuracy	±3°F (±1.7°C)
Deadband	2°F to 12°F (1.1°C to 6.7°C) above actuation temperature
Set point repeatability	±3°F (±1.7°C)
Sensor type	Fluid-filled (silicone) bulb and 2.5 ft (0.8 m) capillary
Sensor material	Tin-plated copper
Connection	Two 14 AWG (2 mm^2) pigtails One ground screw

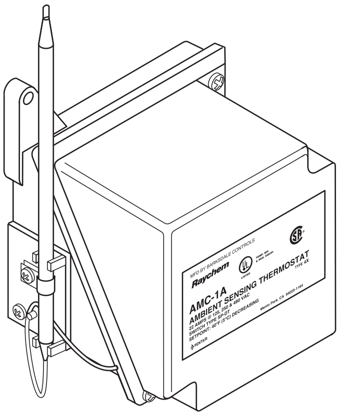
APPROVALS

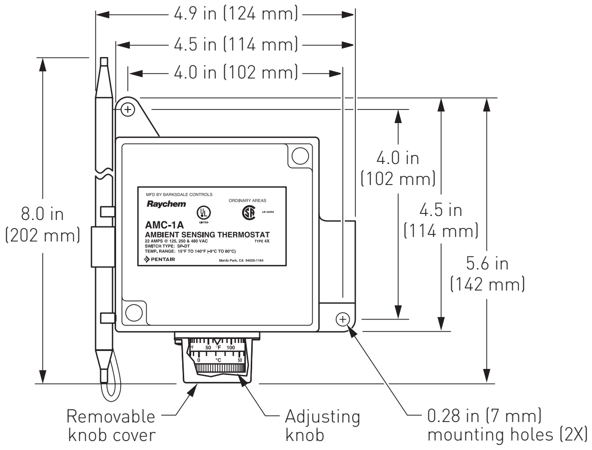
UL LISTED

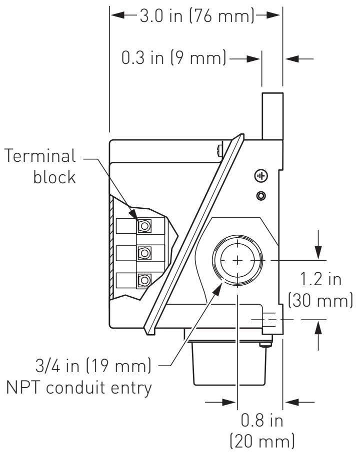
Raychem

AMC-1A

AMBIENT-SENSING THERMOSTAT FOR NONHAZARDOUS LOCATIONS







PRODUCT OVERVIEW

The Raychem AMC-1A ambient-sensing thermostat is designed to control heat-tracing systems used for freeze protection in nonhazardous locations. The thermostat responds to ambient temperature changes and has an adjustable set point. The AMC-1A can be used to control a single heat-tracing circuit or as a pilot control of a contactor switching multiple heat-tracing circuits.

SPECIFICATIONS

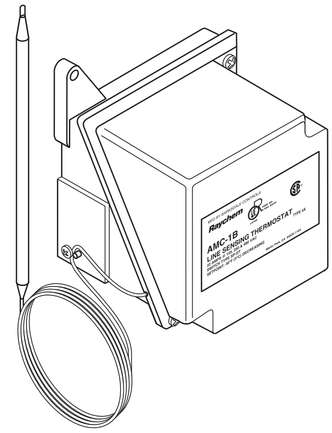
Enclosure	TYPE 4X, polyurethane-coated cast-aluminum housing, stainless-steel hardware
Entries	One 3/4-in (19 mm) NPT conduit hub
Set point range	15°F to 140°F (–9°C to 60°C)
Sensor exposure limits	–40°F to 160°F (–40°C to 71°C)
Housing exposure limits	–40°F to 160°F (–40°C to 71°C)
Switch	SPDT
Electrical rating	22 A at 125 / 250 / 480 Vac
Accuracy	±6°F (±3.3°C)
Deadband	2°F to 12°F (1.1°C to 6.7°C) above actuation temperature
Set point repeatability	±3°F (±1.7°C)
Sensor type	Fixed fluid-filled (silicone) bulb and capillary
Sensor material	300 series stainless steel
Connection terminals	Screw terminals, 10–14 AWG (2–5 mm^2)

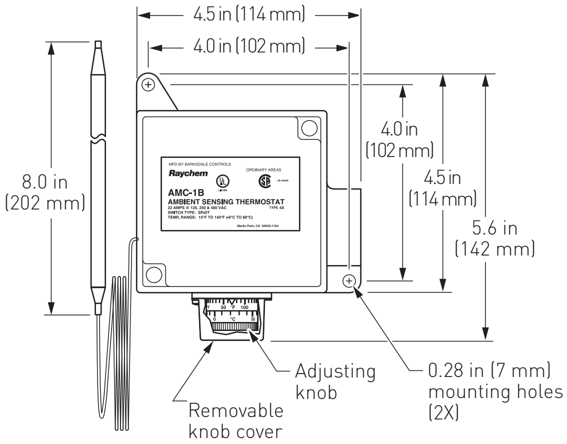
APPROVALS

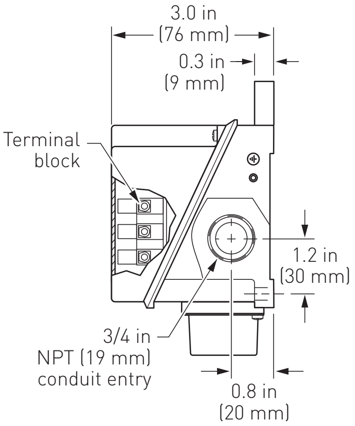
AMC-1B

LINE-SENSING THERMOSTAT

For nonhazardous locations







PRODUCT OVERVIEW

The Raychem AMC-1B line-sensing thermostat is designed to control heat-tracing systems in nonhazardous locations. The AMC-1B senses pipe or tank wall temperatures and can be used to control a single heat-tracing circuit or as a pilot control of a contactor switching multiple heat-tracing circuits. It can also be used to indicate low-temperature or high-temperature alarm conditions.

SPECIFICATIONS

Enclosure	TYPE 4X, polyurethane-coated cast-aluminum housing, stainless steel hardware
Entries	One 3/4-in NPT conduit hub
Set point range	25°F to 325°F (–4°C to 163°C)
Sensor exposure limits	–40°F to 420°F (–40°C to 215°C)
Housing exposure limits	–40°F to 160°F (–40°C to 71°C)
Switch	SPDT
Electrical rating	22 A at 125 / 250 / 480 Vac
Accuracy	±6°F (±3.3°C)
Deadband	2°F to 12°F (1.1°C to 6.7°C) above actuation temperature
Set point repeatability	±3°F (±1.7°C)
Sensor type	Fluid-filled (silicone) bulb and 9 ft (2.7 m) capillary
Sensor material	300 series stainless steel
Connection terminals	Screw terminals, 10–14 AWG (2–5 mm²)

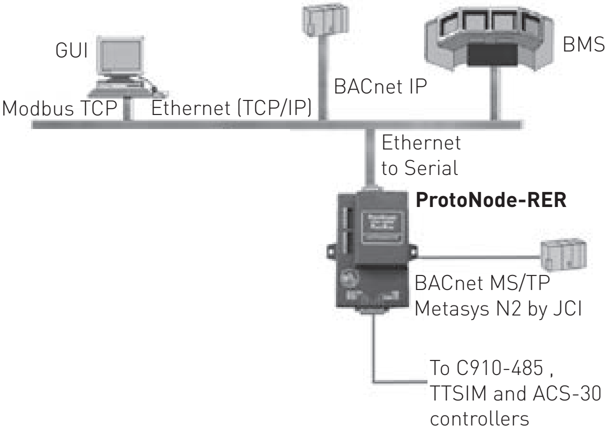
APPROVALS

Raychem

PROTONODE

MULTI-PROTOCOL DEVICE GATEWAY

ProtoNode-RER and ProtoNode-RER-10K



PRODUCT OVERVIEW

The Raychem ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) using BACnet® or Metasys® N2 and the Raychem C910-485, ACS-30 or TTSIM controllers.

The Raychem ProtoNode-RER and ProtoNode-RER-10K come pre-programmed with the C910-485, ACS-30 and TTSIM Modbus® profiles for simple integration into a BMS. One ProtoNode can connect to: one ACS-30 system or up to six C910-485 controllers or up to one hundred TTSIM modules.

ProtoNode-RER: Provides support for Modbus RTU to BACnet MS/TP, BACnet IP (BTL Certified), and Metasys N2 protocol translation for C910-485, TTSIM and smaller scale ACS-30 systems (up to 5 PCM panels). The gateway features an ARM9 processor for fast performance and includes two RS-485 and one Ethernet ports.

ProtoNode-RER-10K: Provides support for Modbus RTU to BACnet MS/TP, BACnet IP (BTL Certified), and Metasys N2 protocol translation for larger ACS-30 systems (up to 34 PCM panels). The gateway features an ARM9 processor for fast performance and includes two RS-485 and one Ethernet ports.

Features and benefits:

- The most flexible and versatile multiprotocol device server on the market
- BACnet International's BTL Certification makes the ProtoNode-RER the most reliable gateway on the market
- Multi-client and multi-server support ensures interoperability between any Industrial and or Building Automation protocols
- Flash upgradable

For additional information, contact your Thermal Management representative or call (800) 545-6258.

APPROVALS

BACnet Testing Labs (BTL) B-ASC on ProtoNode-RER

SPECIFICATIONS

	ProtoNode-RER & ProtoNode-RER-10K
Electrical connections	• One 6-pin Phoenix connector, one RS-485 +/- ground port, power +/- frame ground port • One 3-pin RS-485 Phoenix connector, one RS-485 +/- ground port • One Ethernet-10/100 Ethernet port
Power requirements	9–30 Vdc or Vac, or 5 Vdc
Current draw	150 mA @ 12 V
Supported field protocols	• BACnet IP (Ethernet) • BACnet MS/TP (RS-485) • Metasys N2 open (RS-485)
Operating temperature	–40°F to 187°F (–40°C to 85°C)
Relative humidity	5–90% RH, noncondensing
Enclosure dimensions	4.37 in L x 2.75 in W x 1.50 in H (11.10 cm L x 7.00 cm W x 3.81 cm H)

NUMBER OF PROTONODE / CONTROLLER CONNECTIONS

Description	ProtoNode-RER	ProtoNode-RER-10K
C910-485	6	N/A
TTSIM modules	100	N/A
ACS-PCM2-5 Panels	5	34

ORDERING DETAILS

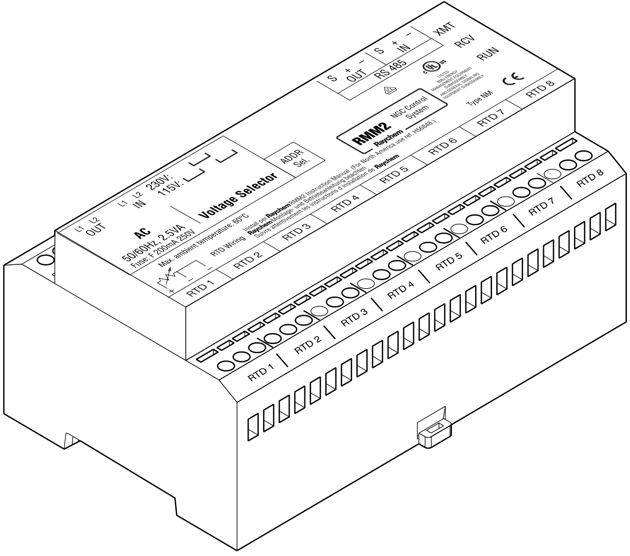
Description	Catalog number	Part number	Weight (lbs)
Raychem ProtoNode-RER: BACnet MSTP/IP and Metasys N2 protocol gateway	ProtoNode-RER	P000002008	1.3
Raychem ProtoNode-RER-10K : BACnet MSTP/IP and Metasys N2 protocol gateway	ProtoNode-RER-10K	P000001983	1.3

Raychem

RMM2

HEAT-TRACING REMOTE MONITORING MODULE

RMM2 without enclosure



PRODUCT OVERVIEW

The Raychem remote monitoring module (RMM2) provides temperature monitoring capability for the NGC heat-tracing control and monitoring systems. The RMM2 accepts up to eight RTDs that measure pipe, vessel, or ambient temperatures in a heat-tracing system. Multiple RMM2s communicate with a single NGC controller to provide centralized monitoring of temperatures. A single, twisted pair RS-485 cable connects up to 16 RMM2s for a total monitoring capacity of 128 temperatures.

Control and monitoring

The RMM2 modules are used to aggregate RTD wires in one remote location and send the information back to the control system through a single twisted pair cable. This helps reduce installation costs since only one conduit run returns to the controller, rather than eight. The RMM2s are placed near desired measurement locations in nonhazardous or hazardous locations. Multiple temperature sensor inputs are networked over a single cable, significantly reducing installation cost.

Alarms

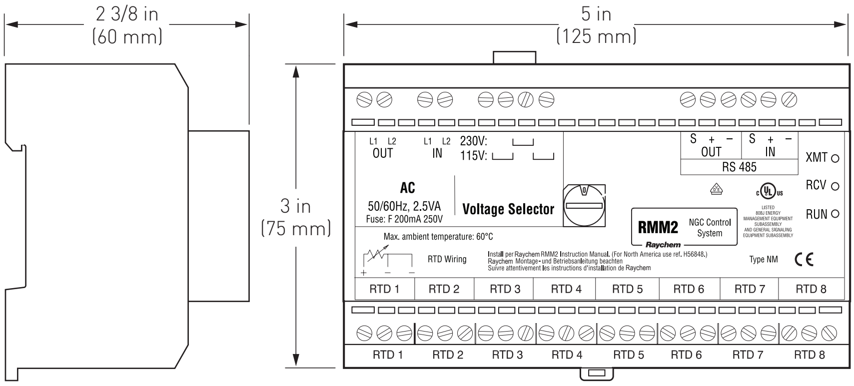
Each temperature sensor connected to a RMM2 may have individual low- and high-temperature alarms. Alarm limits are set and alarm conditions are reported at the control panel. Additional alarms are triggered for failed temperature sensors and communication errors. Alarms may be reported remotely through an alarm relay in the control system or through an RS-485 connection to a host computer supporting the Modbus® protocol.

Configurations

The RMM2 clips to a DIN 35 rail and can be mounted in a choice of enclosures, as required for the area classification and environment. For aggressive environments and Division 2 hazardous locations, Thermal Management offers a glass-reinforced polyester TYPE 4X enclosure.

DIMENSIONS

Figure 1



GENERAL

GENERAL	RMM2
Area of use (with appropriate enclosure)	Nonhazardous or hazardous locations
Approvals	Nonhazardous locations c UL us LISTED 80BJ ENERGY MANAGEMENT EQUIPMENT SUBASSEMBLY AND GENERAL SIGNALING EQUIPMENT SUBASSEMBLY Type NM
Ambient operating temperature range	–40°F to 140°F (–40°C to 60°C)
Ambient storage temperature range	–40°F to 140°F (–40°C to 60°C)
Relative humidity	5% to 95%, noncondensing
Supply voltage (nominal)	115/230 Vac, ±10%, jumper selectable. (The default voltage is 230 Vac. A jumper is supplied to convert to 115 Vac.)
Internal power consumption	< 3 W

RMM2 WITH DIVISION 2 ENCLOSURE

RMM2 WITH DIVISION 2 ENCLOSURE	RMM2-4X
Protection	TYPE 4X
Approvals	Hazardous locations c UL us LISTED 9Z63 TEMPERATURE INDICATING EQUIPMENT FOR USE IN HAZARDOUS LOCATIONS Class I, Division 2, Groups A, B, C, D Class II, Division 2, Groups F, G
Material	Glass-reinforced polyester, silicone gasket, stainless steel hardware
Entries	Six 3/4-in (19 mm) NPT conduit entrance holes, four plugged
Mounting	Surface mounting dimensions are shown in Figure 2

TEMPERATURE SENSOR INPUTS

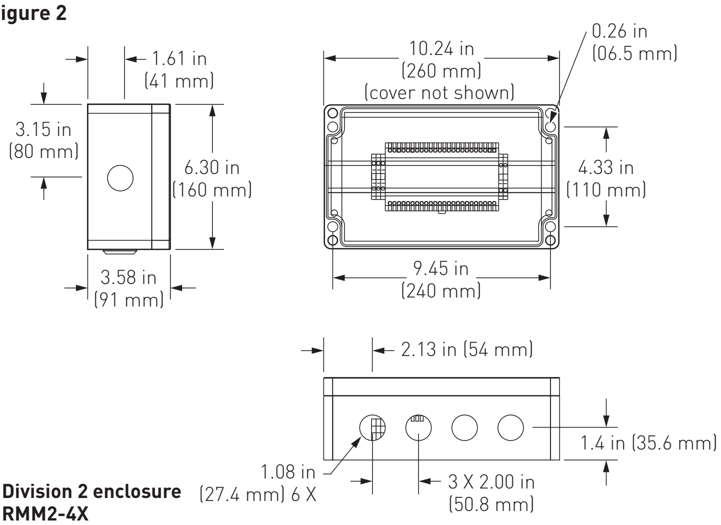
Type	100 Ω platinum RTD, 3-wire, $\alpha = 0.00385\ \Omega/\Omega/°C$
Quantity per RMM2	Up to 8 RTDs can be extended with a 3-conductor shielded cable of 20 Ω maximum per conductor

COMMUNICATION TO NGC CONTROLLER

Type	RS-485
Cable	One shielded twisted pair
Length	4000 ft (1200 m) maximum
Quantity	Up to 16 RMM2s may be connected to one NGC-30
Address	Switch-selectable on RMM2, 16 addresses, 0–9, A-F

ENCLOSURE DIMENSIONS

Figure 2



Division 2 enclosure
RMM2-4X

CONNECTION TERMINALS

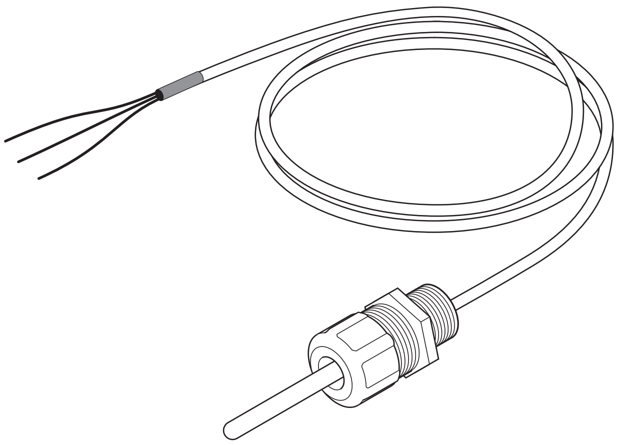
Power supply	24–12 AWG
RTD, communications	24–12 AWG

ORDERING DETAILS

	Catalog number	Part number	Weight
Remote monitoring module (RMM2)			
RMM2, eight RTD inputs, no enclosure	RMM2	051778-000	1.5 lb (0.7 kg)
RMM2 with TYPE 4X enclosure	RMM2-4X	523420-000	4 lb (1.8 kg)
Cables			
RTD extension cable, 1000-ft reel	MONI-RTD-WIRE	962661-000	20 lb (9.1 kg)
RS-485 cable, 1000-ft reel	MONI-RS485-WIRE	549097-000	17 lb (7.7 kg)

RTD-200

RTD TEMPERATURE SENSOR FOR AMBIENT SENSING



PRODUCT OVERVIEW

The Raychem RTD-200 is a three-wire platinum RTD (resistance temperature detector) typically used with electronic control systems that require accurate ambient temperature sensing. The RTD-200 comes with a 1/2" NPT fitting that installs to the appropriate conduit box.
This allows mounting of the RTD in a typical ambient location. This also allows for splicing of RTD extension wire back to the controller.

SPECIFICATIONS

Sensor	
Housing	316 stainless steel
Dimensions	3-in (7.6 mm) length, 1/4-in (6 mm) diameter
Accuracy	± 0.3°F (± 0.2°C)
Range	–100°F to 300°F (–73°C to 149°C)
Resistance	100 ohms ± 0.25 ohm at 0°C α=0.00385 ohms/ohm/°C
Extension wire	
Wire size (each of three)	22 AWG **Note:** The length of RTD extension wires is determined by the wire gauge used. To reduce the likelihood that electrical noise will affect temperature measurement, keep RTD extension wires as short as possible. Use shielded instrument cable such as Raychem MONI-RTD-WIRE (22 AWG, PVC insulation, –30°F to 140°F, –20°C to 60°C) or Belden 83553 (22 AWG, FEP insulation, –95°F to 395°F, –70°C to 200°C).
Wire dielectric strength	600 V
Length	6 ft (1.8 m)
Outer jacket	Fluoropolymer
Maximum exposure temperature	300°F (149°C)
Sensor fitting	1/2-in (12.7 mm) NPT with sealing washer and nut

APPROVALS

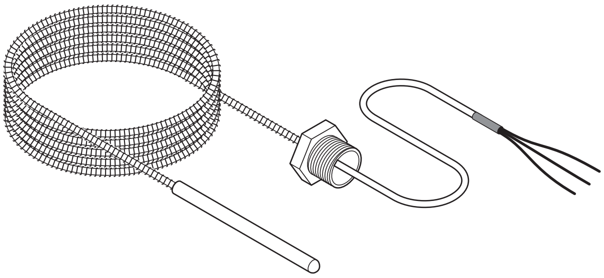
Approvals associated with control device. Not to be used in Division 1 areas.

Raychem

RTD3CS AND RTD10CS

RTD TEMPERATURE SENSORS

For temperature measurement up to 400°F (204°C)



PRODUCT OVERVIEW

The Raychem RTD3CS and RTD10CS are three-wire platinum RTD (resistance temperature detectors) typically used with monitoring and control systems such as the Raychem 910 controller when accurate temperature control is required.

The RTD3CS and RTD10CS can be installed directly to the controller using the supplied 1/2" conduit fitting or to an RTD junction box where RTD extension wire is used.

SPECIFICATIONS

Sensor	
Housing	316 stainless steel
Dimensions	3-in (76 mm) length 3/16-in (8 mm) diameter
Sensing area	1-1/2 in (38 mm)
Accuracy	±1°F (0.5°C) at 32°F (0°C)
Range	–76°F to 400°F (–60°C to 204°C)
Resistance	100 ohms at 0°C α =0.00385 ohms/ohm/°C
Extension wires	
Wire size (each of three)	20 AWG, stranded tinned copper **Note:** The length of RTD extension wires is determined by the wire gauge used. To reduce the likelihood that electrical noise will affect temperature measurement, keep RTD extension wires as short as possible. Use shielded instrument cable such as Raychem MONI-RTD-WIRE (22 AWG, PVC insulation, –30°F to 140°F, –20°C to 60°C) or Belden 83553 (22 AWG, FEP insulation, –95°F to 395°F, –70°C to 200°C).
Wire insulation rating	300 V
Length	RTD3CS: 3-ft (0.3 m) flexible armor, 18-in (457 mm) lead wire RTD10CS: 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire
Outer shield	Stainless steel flexible armor (not suitable for underground applications)
Maximum exposure temperature	400°F (204°C)
Conduit bushing	1/2-in (12.7 mm) NPT
Additional materials required	AT-180 aluminum tape

APPROVALS

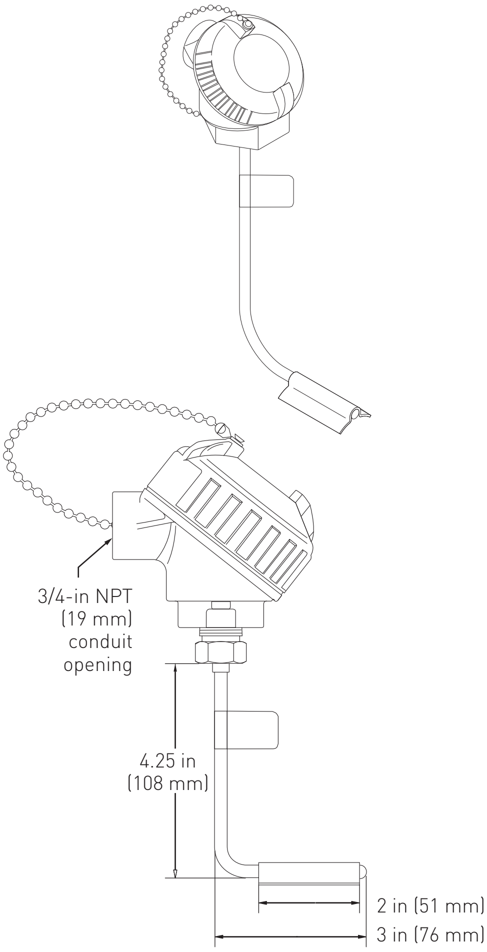
Approvals associated with control device. Not to be used in Division 1 areas.

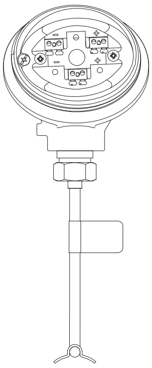
Raychem

RTD4AL

RTD TEMPERATURE SENSOR

For temperature measurement up to 900°F (482°C)





PRODUCT OVERVIEW

The Raychem RTD4AL is a three-wire platinum RTD (resistance-temperature detector) typically used with monitoring and control systems that require accurate temperature control. The RTD4AL kit can be used with a wide variety of Raychem monitoring and control systems.

SPECIFICATIONS

Sensor housing	Aluminum; TYPE 4X
Sensor sheath	316 stainless steel
Range	–100°F to 900°F (–73°C to 482°C) maximum
Accuracy	±1°F (0.5°C) at 32°F (0°C)
Resistance	100 ohms at 0°C α =0.00385 ohms/ohm/°C
Connection	3/4-in (19 mm) NPT conduit hub **Note:** The length of RTD extension wires is determined by the wire gauge used. To reduce the likelihood that electrical noise will affect temperature measurement, keep RTD extension wires as short as possible. Use shielded instrument cable such as Raychem MONI-RTD-WIRE (22 AWG, PVC insulation, –30°F to 140°F, –20°C to 60°C) or Belden 83553 (22 AWG, FEP insulation, –95°F to 395°F, –70°C to 200°C).

ADDITIONAL MATERIALS REQUIRED

Pipe strap, conduit, 16–22 AWG shielded instrument cable

KIT CONTENTS

One RTD temperature sensor

APPROVALS

The RTD4AL is CSA certified to U.S. and Canadian standards.

C US
Class I, Div. 2, Groups A, B, C, D
Class II, Div. 2, Groups F, G

Raychem

RAYCLIC
CONNECTION KITS AND ACCESSORIES

For XL-Trace, IceStop and HWAT self-regulating heating cables

PRODUCT OVERVIEW

The Raychem RayClic connection system is a simple, fast and reliable set of connection kits developed for select XL-Trace, IceStop and HWAT self-regulating heating cables. There is no wire stripping needed because the insulation displacement connector makes the electrical connection.

The easy-to-install RayClic connection system reduces installation time, lowering the total installed cost of the heating cable system.

Simple

- No need for special tools
- Three-step installation

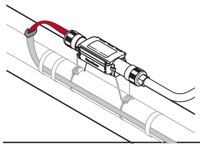
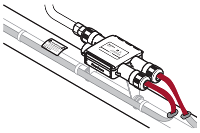
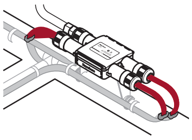
Reliable

- Intuitive installation
- Rugged, waterproof, UV-resistant enclosure

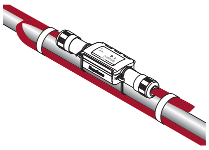
Cost-effective

- Quick installation

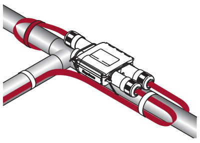
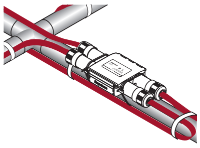
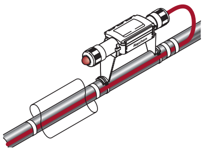
POWERED CONNECTION KITS

Catalog number	Part number	Description
RayClic-PC 	233053-000	A RayClic-PC can supply power to one heating cable. Each kit contains one RayClic-PC power connection, one RayClic-E end seal, and one SB-04 pipe mounting bracket. The kit includes 5' power lead wires and a conduit fitting; the junction box and flexible conduit required to make a complete connection are not included. Weight: 1.8 lb (0.8 kg)
RayClic-PS 	861247-000	A RayClic-PS can be used as a power connection kit for supplying power to two heating cables. Each kit contains one RayClic-PS powered splice connection, two RayClic-E end seals, and one SB-04 pipe mounting bracket. The kit includes 5' power lead wires and a conduit fitting. The junction box and flexible conduit required to make a complete connection are not included. Weight: 2.0 lb (0.9 kg)
RayClic-PT 	804231-000	A RayClic-PT can be used as a power connection kit for supplying power to three heating cables. Each kit contains one RayClic-PT powered tee connection, three RayClic-E end seals, and one SB-04 pipe mounting bracket. The kit includes 5' power lead wires and a conduit fitting. The junction box and flexible conduit required to make a complete connection are not included. Weight: 2.0 lb (0.9 kg)

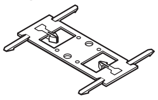
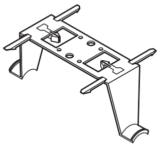
UNPOWERED CONNECTION KITS

Catalog number	Part number	Description
RayClic-S 	559871-000	Splice kits are installed as needed to connect two heating cables together at one point. Each kit contains one RayClic-S splice. Weight: 1.3 lb (0.6 kg)

UNPOWERED CONNECTION KITS

Catalog number	Part number	Description
RayClic-T 	014023-000	Tee kits are installed as needed to connect three heating cables together at one point. Each kit contains one RayClic-T tee connection and one RayClic-E end seal. Weight: 1.9 lb (0.9 kg)
RayClic-X 	546349-000	RayClic-X kits are installed as needed to connect four heating cables together at one point. Each kit contains one RayClic-X cross and two RayClic-E end seals. Weight: 2.0 lb (0.9 kg)
RayClic-LE 	P000000770	Lighted end seal kits are installed wherever an end-of-line signal light is required. Each kit contains one RayClic-LE lighted end seal and one RayClic-SB-04 pipe mounting bracket. Weight: 1.8 lb (0.8 kg)

ACCESSORIES

Catalog number	Part number	Description
RayClic-E 	805979-000	The RayClic-E is a replacement end seal kit.
RayClic-SB-02 	852001-000	The RayClic-SB-02 is a wall mounting bracket for use with any RayClic connection kit.
RayClic-SB-04 	616809-000	The RayClic-SB-04 is a pipe mounting bracket for use with any RayClic connection kit. One pipe mounting bracket is included with each powered connection kit and the RayClic-LE lighted end seal kit.

RayClic System Specifications

Rated voltage	120–277 V
Maximum circuit breaker size	30 A
Maximum exposure temperature	150°F (65°C)
Minimum installation temperature	0°F (–18°C)
Enclosure rating	NEMA 4X

Applicable Products

XL-Trace	5/8XL1-CR/CT and 5/8/12XL2-CR/CT
IceStop	GM-1XT, GM-1X, GM-2XT and GM-2X
HWAT	HWAT-R2, HWAT-P1

APPROVALS

718K Pipe Heating Cable
877Z De-Icing and Snow Melting

-W

With XL-Trace and IceStop
heating cable only
For Class I, Div. 2,
Groups A,B,C,D
hazardous locations- GM-1XT
and GM-2XT only

DESIGN AND INSTALLATION

For proper design and installation of a RayClic connection system, use the appropriate product design guide and the installation instructions included with the connection kit.

GROUND-FAULT PROTECTION

To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

FTC

HEAT SHRINKABLE CONNECTION KITS

For XL-Trace, IceStop and RaySol self-regulating heating cables

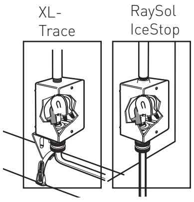
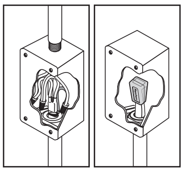
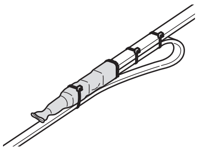
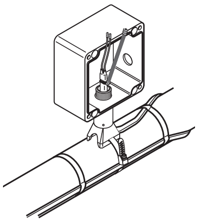
PRODUCT OVERVIEW

The Raychem FTC heat shrinkable connection kits are used with XL-Trace, IceStop and RaySol self-regulating heating cables.

The FTC connection kits are designed to provide low cost power connection and low profile splice and tee kits.

The FTC power connection kits can be used for circuit breakers rated up to 40 A.

POWERED CONNECTION KITS

Catalog number	Part number	Description
FTC-P 	111711-000	Power connection kit with end seal: The FTC-P power connection and end seal kit is for use with XL-Trace, RaySol and IceStop heating cables. Materials for one power connection and end seal is included in the kit.
FTC-XC 	368979-000	Power connection kit with end seal: The FTC-XC power connection and end seal kit is for use with XL-Trace and RaySol heating cables that are run through conduit to a junction box. Materials for one power connection and end seal is included in the kit.
FTC-HST 	354169-000	Splice or Tee kit: The FTC-HST splice or tee kit is for use with XL-Trace, RaySol and IceStop heating cables. Material for two splice or tees included in each kit.
FTC-PSK 	P000000927	Pipe stand and power connection kit: The FTC-PSK pipe stand and power connection kit is for use with XL-Trace heating cables. The stand is designed specifically for the Raychem ECW-GF electronic controllers and is compatible with other junction boxes that have 1 inch NPT entries, threaded or non-threaded. Materials for one power connection and end seal is included in the kit.

SPECIFICATIONS

Rated voltage	120–277 V
Maximum circuit breaker size	40 A
Maximum exposure temperature	150°F (65°C)
Minimum installation temperature	0°F (–18°C)
Enclosure rating	NEMA 4X

APPLICABLE PRODUCTS

XL-Trace	5/8XL1-CR/CT and 5/8/12XL2-CR/CT
IceStop	GM-1XT, GM-1X, GM-2XT and GM-2X
RaySol	RaySol-1 and RaySol-2

APPROVALS

LISTED

718K Pipe Heating Cable or
877Z De-Icing and Snow Melting
Equipment or 9J8 6 Radiant
Heating Cable

Certified with IceStop and
RaySol heating cables

FM APPROVED

With XL-Trace and IceStop heating cables

Hazardous locations:
Class I, Div 2. Groups A, B, C, D
GM-1XT and GM-2XT only

C US

For XL-Trace heating cables

DESIGN AND INSTALLATION

For proper design and installation of a FTC connection kit, use the appropriate product design guide and the installation instructions included with the connection kit.

GROUND-FAULT PROTECTION

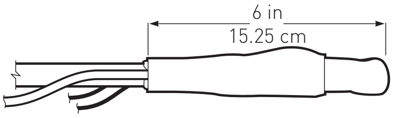
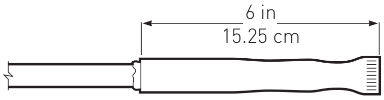
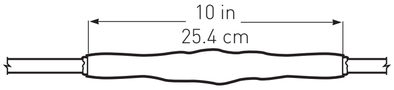
To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.

Raychem

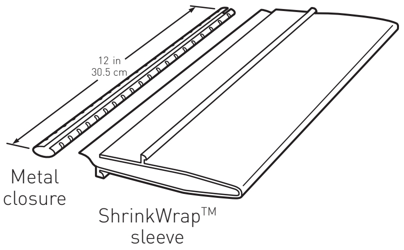
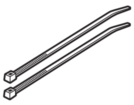
ELECTROMELT

CONNECTION KITS AND ACCESSORIES

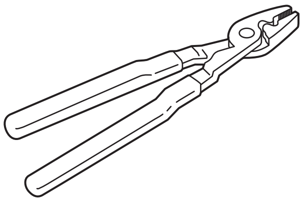
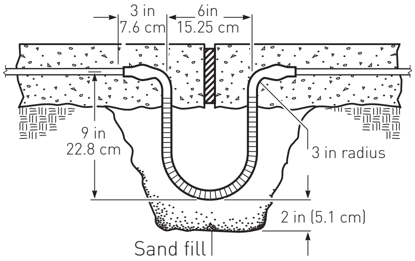
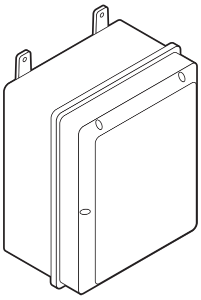
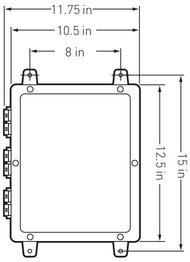
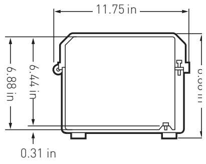
CONNECTION KITS

Catalog number	Part number	Description
EMK-XP  Power connection EMK-XP  End seal EMK-XP	579519	The power connection and end seal kit is a water-resistant electrical assembly that is sealed with a proprietary adhesive and protected by a crosslinked, modified polyolefin heat-shrinkable tube. Storage temperature: –40°F to 140°F (–40°C to 60°C) Minimum installation temperature: 0°F (–18°C) Power connection wire range: 14 to 4 AWG Voltage rating: 600 V Packaging: One power connection and one end seal per box Shipping weight: 0.4 lb (182 g)
EMK-XS 	356667	The splice kit is a water-resistant electrical assembly that is sealed with a proprietary adhesive and protected by a crosslinked, modified polyolefin heat-shrinkable tube. Storage temperature: –40°F to 140°F (–40°C to 60°C) Minimum installation temperature: 0°F (–18°C) Voltage rating: 600 V Packaging: One splice kit per box Shipping weight: 0.2 lb (91 g)

ACCESSORIES

Catalog number	Part number	Description
EMK-XJR 	693647	The jacket repair kit is a heat-shrinkable wrap-around sleeve for covering a damaged outer jacket. The repair sleeve is adhesive-lined and comes with a removable metal closure. Nominal length: 12 in (30.5 cm) Packaging: One repair sleeve per kit Shipping weight: 0.8 lb (365 g)
EMK-CT 	906441	The nylon cable ties are seven-inch nylon industrial cable ties. Manufacturer: Panduit Model number: PLT2S-C Length: 7-3/8" ± 1/2" (18.74 cm ± 1.25 cm) Width: 3/16" (0.48 cm) Packaging: 100 per pack Shipping weight: 0.5 lb (227 g)

ACCESSORIES

Catalog number	Part number	Description
EMK-XT 	980631	The crimping tool is the correct size for the crimps in the connection kit. Manufacturer: Ideal Model number: 30-425 Length: 10" (25.4 cm) Packaging: One per kit Shipping weight: 1.2 lbs (545 g)
SMCS 		Snow melt caution sign Dimensions 6 x 4 in (150 x 100 mm)
EMK-XEJ 	472207	The expansion joint kit provides physical protection for the heating cable beneath slab joints. An expansion tube is used to form an expansion loop for the heating cable. Storage temperature: –40°F to 140°F (–40°C to 60°C) Minimum installation temperature: 0°F (–18°C) Packaging: One expansion joint per kit Shipping weight: 0.3 lb (140 g)
EMK-XJB   	052577	The junction box is a large, UL Listed weatherproof enclosure suitable for terminating both ends of an ElectroMelt heating cable circuit. **This junction box is large enough for 2 circuits of ElectroMelt heating cables.** The enclosure is made of molded structural foam and provides high impact strength, excellent chemical resistance, high dielectric strength, and excellent weathering capabilities. Manufacturer: Carlon, model CJ12106 Inside dimensions: 12" x 10" x 6-7/8" (30.5 cm x 25.4 cm x 17.5 cm) Inside volume: 825 cubic inches (13528 cm^3) Outside dimensions: 15-1/2" x 11-3/4" x 7-5/8" (39.4 cm x 29.85 cm x 19.37 cm) Temperature range: –40°F to 185°F (–40°C to 85°C) UL Standard: UL508 NEMA rating: Types 1, 3, 3S, 3X, 3SX, 4, 4X, 12, 13 as indicated Packaging: One junction box per kit Shipping weight: 5.4 lbs (2.45 kg)

APPROVALS

LISTED 877Z De-icing and Snow-melting Equipment

-W

The EM2-XR heating cable is UL Listed and CSA Certified only when used with the appropriate agency-approved Thermal Management connection kits and accessories.

DESIGN AND INSTALLATION

For proper design and installation of an Electromelt connection kit, use the appropriate product design guide and the installation instructions included with the connection kit.

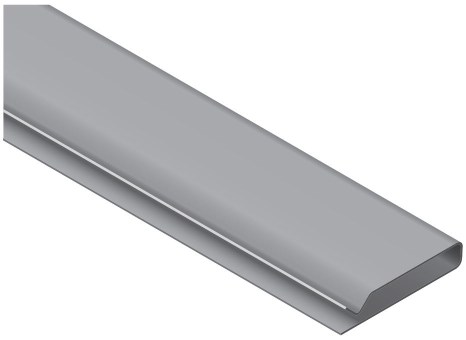
GROUND-FAULT PROTECTION

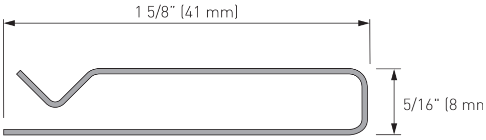
To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with the requirements of Thermal Management, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection. Many Raychem control and monitoring systems meet the ground-fault protection requirement.

Raychem

CCB

CABLE COVER BRACKET





PRODUCT OVERVIEW

Raychem Cable Cover Bracket (CCB) is designed to mount on the roof or gutters and embeds one or two runs of self-regulating heating cable. It is used to enhance the heat transfer from the heating cable to the snow and create larger drain paths.

CCB provides:

- Long term roof deicing solution by mechanically protecting the heating cable
- Aesthetically pleasing solution by concealing the heating cable
- High performance and reliable solution for snow melt in gutters or other roof sections

CATALOG NUMBER

	CCB-CU, Cable Cover Bracket, copper
	CCB-AL, Cable Cover Bracket, aluminum

MATERIALS OF CONSTRUCTION

CCB	Aluminum (available in 30 colors. Please refer to RIM color guide H59379)
	Copper
	Custom (Corten, Zinc, Lead coated copper etc.)

ADDITIONAL MATERIALS (AS REQUIRED)

RIM Adhesive/Sealant	Silicone adhesive for RIM systems

PRODUCT SPECIFICATIONS (NOMINAL)

Minimum Installation Temperature	0°F (-18°C)
Overall Dimensions	Width: 1 5/8 ± 1/16 in (41 mm) Thickness: 5/16 ± 1/32 in (8 mm)
Material Thickness	Aluminum: 0.040 in
	Copper: 20 oz/ft^2
Weight	Aluminum: 170 lb/1000 ft (252 kg/km)
	Copper: 310 lb/1000 ft (461 kg/km)

BEFORE YOU SPECIFY OR BUY, WEIGH THE FACTS

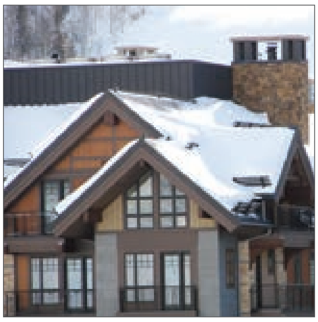
Thermal Management offers the most complete line of heating technologies and services.

As the inventors of Raychem heat-tracing products, with more than **1.75 billion feet** installed worldwide, we are the preferred brand by engineers and installers for all applications.

Whether you need **products**, **design tools**, or **project assistance from our Integrated Services experts**, rely on the proven heating solutions leader for optimized systems to enhance the safety, comfort, and performance of your building or infrastruture projects.


Pipe Freeze Protection


Flow Maintenance

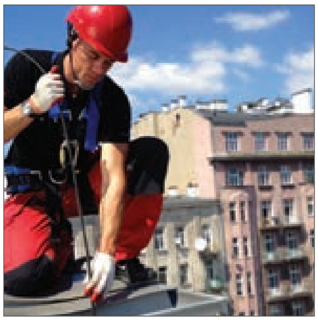

Roof & Gutter De-Icing


Surface Snow Melting


Freezer Frost Heave Prevention


Floor Heating


Hot Water Temperature Maintenance


Integrated Services

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