

Freezer Frost Heave Prevention – RaySol Heating Cable System

This step-by-step design guide provides the tools necessary to design an nVent RAYCHEM RaySol self-regulating heating cable system for freezer frost heave prevention. For other applications or for design assistance, contact your nVent representative or call (800) 545-6258. Also, visit our website at nVent.com/RAYCHEM.

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INTRODUCTION

RaySol self-regulating heating cable systems are designed for freezer frost heave prevention. The cables must be installed in conduit.

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

How to Use this Guide

This design guide presents nVent 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 Heating Cable in Conduit Freezer Frost Heave Prevention Design Worksheet” on page 25 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:

- RaySol Floor Heating and Frost Heave Prevention Installation and Operation Manual (H58138)
- 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 our website at nVent.com/RAYCHEM.

For products and applications not covered by this design guide, please contact your nVent 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 nVent, 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

nVent standard limited warranty applies to RaySol 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 website at <https://raychem.nvent.com/en-us/support/warranty-information>.

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.

RaySol heating cables are installed in conduit. The electrical conduit carrying the 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.

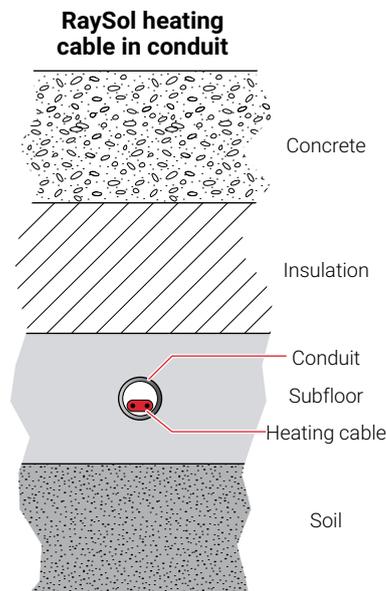


Fig. 1 Typical freezer frost heave installation

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 6 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.

Typical System

A typical system includes the following:

- RaySol self-regulating heating cable
- Connection kits
- Junction boxes
- Temperature control and power distribution systems

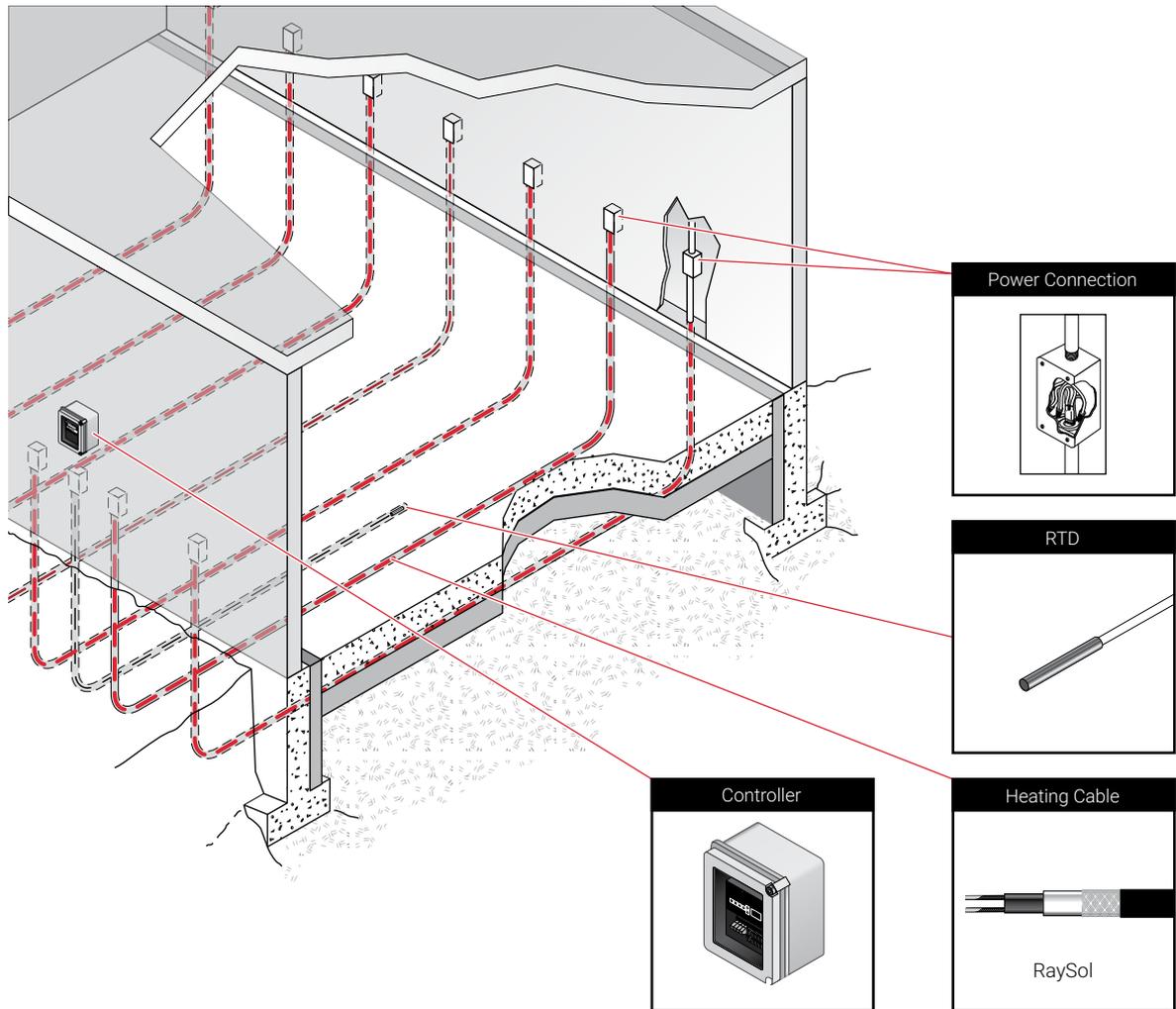


Fig. 2 Typical freezer frost heave system

The following table lists the heating cable, required connection kits, and accessories for a RaySol heating cable systems.

TABEL 1 HEATING CABLES AND CONNECTION KITS

	Catalog Number	Description
Heating cable	RaySol-1	120 V
	RaySol-2	208–277 V
Connection kits	FTC-XC	Power connection and end seal
	FTC-HST-PLUS	Splice (as required – not for use inside conduit)

Self-Regulating Heating Cable Construction

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.

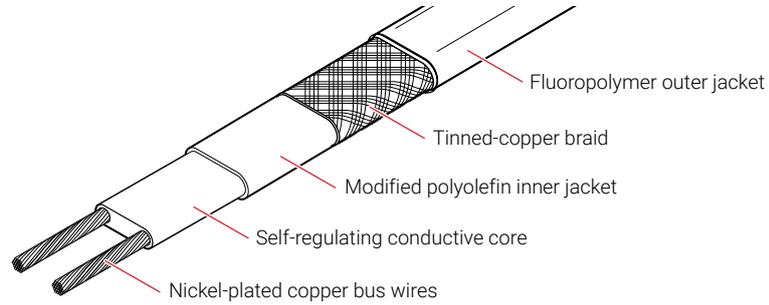


Fig. 3 Typical RaySol heating cable construction

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.

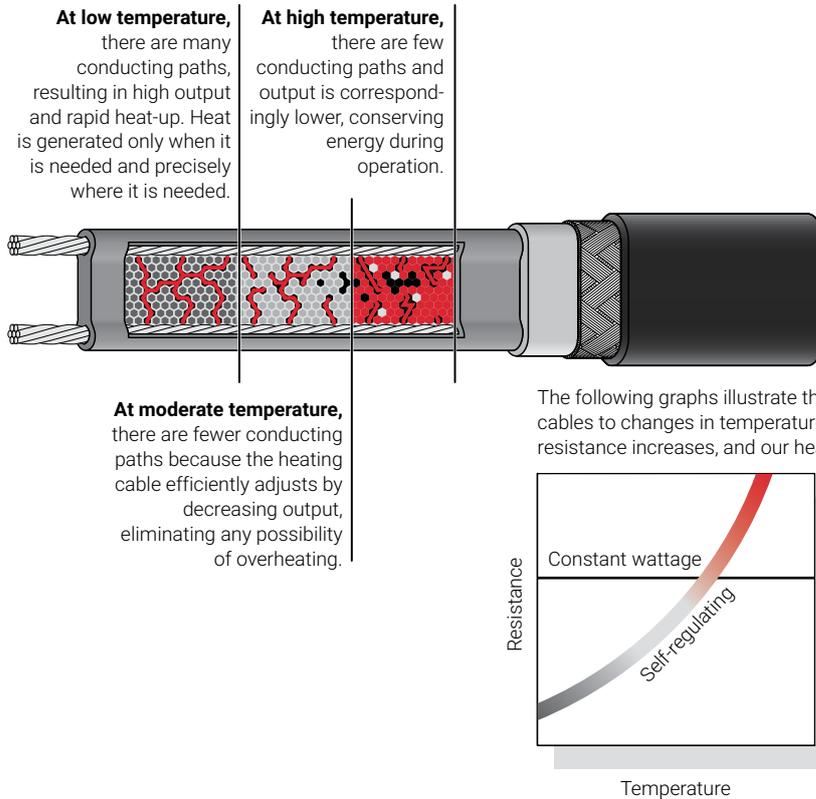


Fig. 4 Self-regulating heating cable technology

Approvals

Installation of the RaySol heating cable system is governed by national and local electrical codes. nVent, 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.

The RaySol system is UL Listed and CSA Certified for use in nonhazardous locations.



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 Heating Cable in Conduit Freezer Frost Heave Prevention Design Worksheet" on page 25 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.

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 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. If you are using a different medium, contact nVent for an analysis.

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

Design Step by Step RaySol Heating Cables in Conduit

This section guides you through the steps necessary to design your system using RaySol self-regulating heating cables in conduit.

Your system design requires the following essential steps:

- ① Determine the freezer configuration
- ② Select the heating cable
- ③ Determine the 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

The "RaySol Heating Cable in Conduit Freezer Frost Heave Prevention Design Worksheet" on page 25 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.

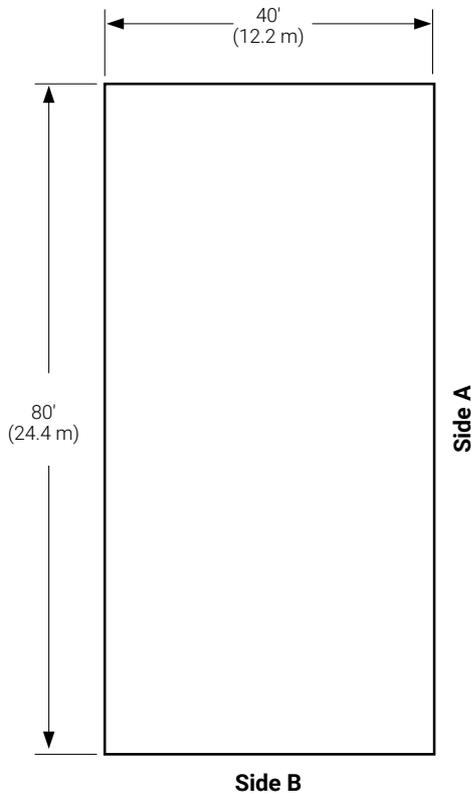


Fig. 5 Typical freezer example

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:

Area 80 ft x 40 ft = 3200 ft²
(24.4 m x 12.2 m = 297 m²)

Freezer operating temperature -20°F (-29°C)

Insulation R-value R-40 (40 ft²·°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

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 (continued):

Supply voltage 208 V (from Step 1)

Catalog number **RaySol-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 ③ Determine the heating cable conduit spacing and freezer load

In this step you will determine the conduit spacing, and freezer loads for the RaySol cable system. 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/ft² (W/m²) of floor area.

TABLE 4 RAYSOL 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 (continued):

Freezer operating temperature
 Insulation R-value
 Conduit spacing
 Freezer load

-20°F (-29°C) (from Step 1)
 R-40 (40 ft²·°F·hr/Btu) (from Step 1)
96 in (244 cm)
0.5 W/ft² (5 W/m²)

Freezer Frost Heave Prevention System Design Steps (in Conduit)
1. Determine the freezer configuration
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Step 4 Determine the heating cable layout and length

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).

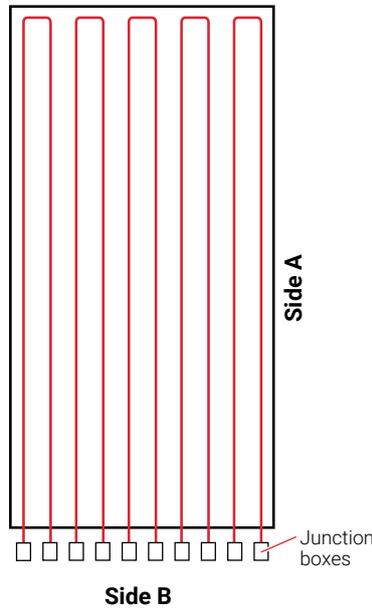


Fig. 6 Hairpin layout

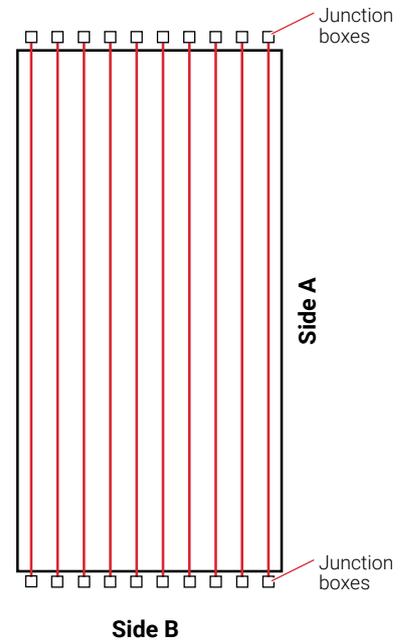


Fig. 7 Straight run layout

Calculate the number of estimated conduit runs as follows:

$$\text{Estimated number of conduit runs} = \frac{\text{Side B (ft)} \times 12}{\text{Conduit spacing (in)}}$$

$$\text{Side B (m)} \times 100$$

$$\frac{\text{Conduit spacing (cm)}}{\text{Conduit spacing (cm)}}$$

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 (continued):

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:

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	
	ft	m	ft	m	ft	m	ft	m
Circuit breaker size (A)								
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.

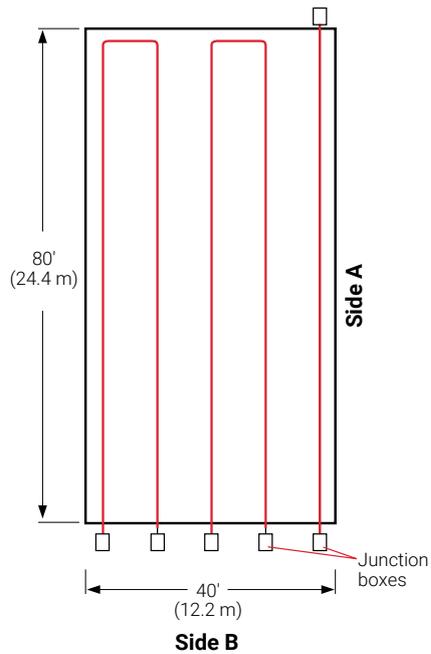


Fig. 8 Layout for example (two hairpins and one straight run)

Example (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 (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 an nVent 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.

Freezer Frost Heave Prevention System Design Steps (in Conduit)
1. Determine the freezer configuration
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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 Determine the electrical parameters

DETERMINE NUMBER OF CIRCUITS

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 nVent, 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:

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

Example (continued):

Circuit breaker size	One 20 A circuit (from Step 4)
Supply voltage	208 V (from Step 1)
Circuit breaker load	$(20 \text{ A} \times 0.8 \times 208) / 1000 = 3.3 \text{ kW}$
Total transformer load	3.3 kW

Freezer Frost Heave Prevention System Design Steps (in Conduit)
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8. Select the power distribution
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Step 6 Select the connection kits and accessories

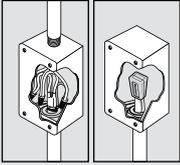
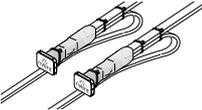
Determine the number of junction boxes, power connections, end seals and splice kits required.

- Hairpin and straight layouts have one junction box per conduit end (see Fig. 9 and Fig. 10).

SELECT JUNCTION BOX

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.

TABLE 7 CONNECTION KITS

	Catalog number	Description	Standard packaging	Usage
Connection Kits				
	FTC-XC	Power connection and end seal. (Junction box not included)	1	1 per conduit run
	FTC-HST-PLUS	Low-profile splice/tee	2	As required (for use inside intermediate pull box or cable tray)

Example: RaySol heating cables in conduit

Power connection and end seal kit	FTC-XC
Quantity	3
Junction box	Contractor supplied
Quantity	6

Freezer Frost Heave Prevention System Design Steps (In Conduit)
1. Determine the freezer configuration
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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 heating cable frost heave protection systems. For installations where temperature control and temperature monitoring is desired, an nVent RAYCHEM 460, C910-485 or ACS-30 controller is recommended.

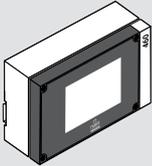
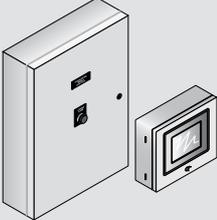
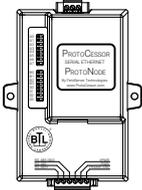
TABLE 8 TEMPERATURE CONTROL OPTIONS

Features	Electronic thermostat ECW-GF	Single-point 460	Single-point C910-485 ²	Multipoint ACS-30
Sensor	Thermistor	Thermistor	RTD ¹	See data sheet
Sensor length	25 ft	10 ft	Varies	"
Set point range	32°F to 200°F (0°C to 93°C)	32°F to 176°F (0°C to 80°C)	-0°F to 200°F (-18°C to 93°C)	"
Enclosure	NEMA 4X	Type 12 - indoor use	NEMA 4X	"
Deadband	2°F to 10°F (2°C to 6°C)	1°F to 8°F (1°C to 4°C)	1°F to 10°F (1°C to 6°C)	"
Enclosure limits	-40°F to 140°F (-40°C to 60°C)	-4°F to 122°F (-20°C to 50°C)	-40°F to 140°F (-40°C to 60°C)	"
Switch rating	30 A	24 A	30 A	"
Switch type	DPST	SPST	DPST	"
Electrical rating	100–277 V	120–277 V	100–277 V	"
Approvals	c-UL-us	c-UL-us	c-CSA-us	"
Ground-fault protection	30 mA fixed	20 mA to 200 mA	20 mA to 100 mA (adjustable)	"
Alarm outputs				
AC relay	2 A at 277 Vac	1 A at 24 Vac	100–277 V, 0.75 A max.	"
Dry contact relay	2 A at 48 Vdc	24 Vac/dc, 1A max.	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 nVent RAYCHEM ProtoNode multi-protocol gateways.

TABLE 9 CONTROL SYSTEMS

	Catalog number	Description
Electronic thermostats and accessories		
	ECW-GF	<p>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.</p> <p>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.</p>
	ECW-GF-DP	<p>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.</p>
Electronic controllers and sensors		
	460	<p>The 460 is a single-point heat tracing controller designed for pipe freeze protection and flow maintenance systems. It includes a 5" inch color touch screen display for intuitive set up and programming right out of the box. The 460 controller may be used with line-sensing or ambient-sensing and proportional ambient-sensing control (PASC) modes. It measures temperatures with two Thermistor 2 KOhm / 77°F (25°C), 2-wire connected directly to the unit. The controller can also measure ground fault current to ensure system integrity.</p>
	C910-485	<p>The 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.</p>
	ACS-UIT2 ACS-PCM2-5	<p>The 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 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.</p>
	ProtoNode-RER	<p>The ProtoNode is an external, high performance multi-protocol gateway for customers needing protocol translation between Building Management Systems (BMS) and the ACS-30 or C910-485 controllers.</p> <p>The ProtoNode-RER is for BACnet® or Metasys® N2 systems.</p>
	RTD-200 RTD10CS RTD50CS	<p>Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with C910-485 and ACS-30 controllers.</p> <p>RTD-200: 3-in (76 mm) temperature sensor with a 6-ft (1.8 m) lead wire and 1/2-in NPT bushing</p> <p>RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing</p> <p>RTD50CS: temperature sensor with a 50-ft (15.2 m) flexible armor, 18-in (457 mm) lead wire and 1/2-in NPT bushing</p>

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

Power to the heating cables can be provided in several ways:

- Directly to the power connection kits
- 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).

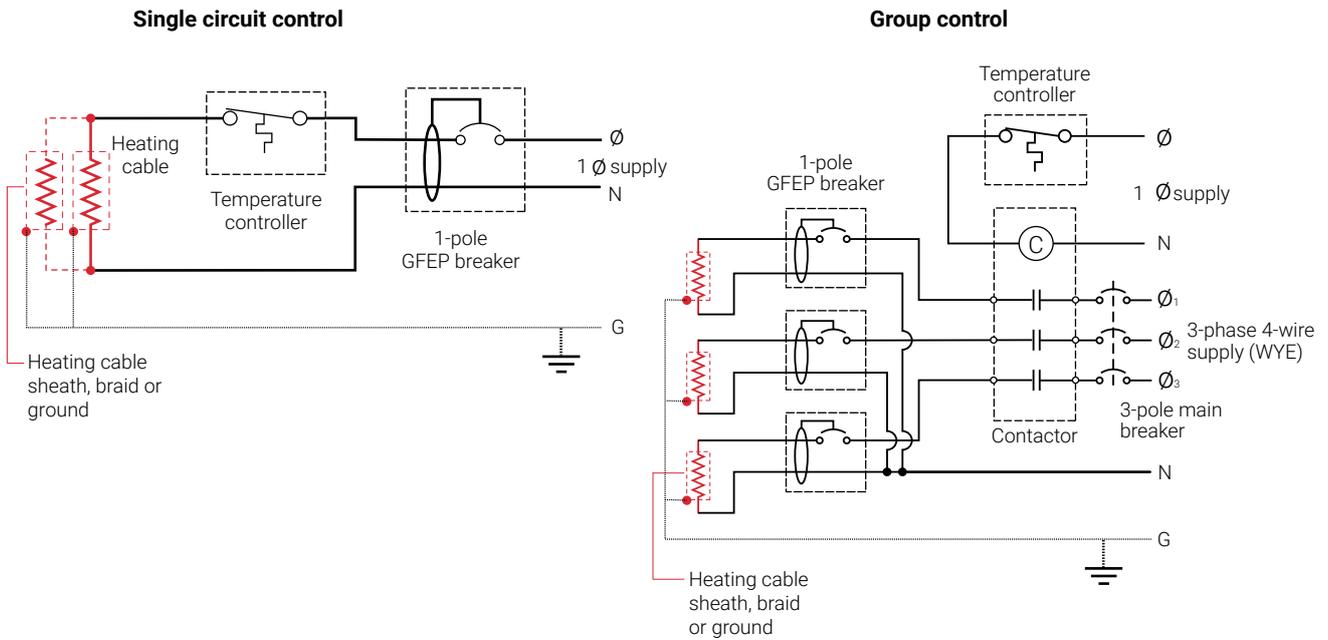


Fig. 9 Single circuit and group control

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.

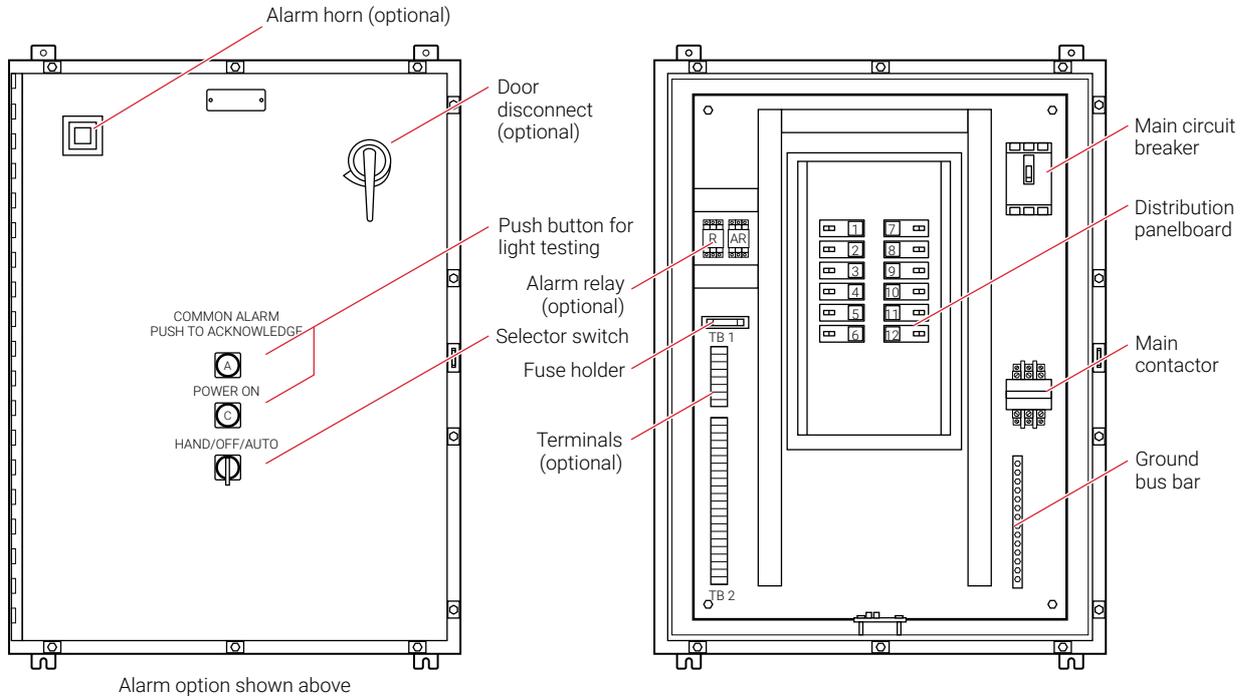


Fig. 10 HTPG power distribution panel

Three-phase, 4 wire supply (Wye)

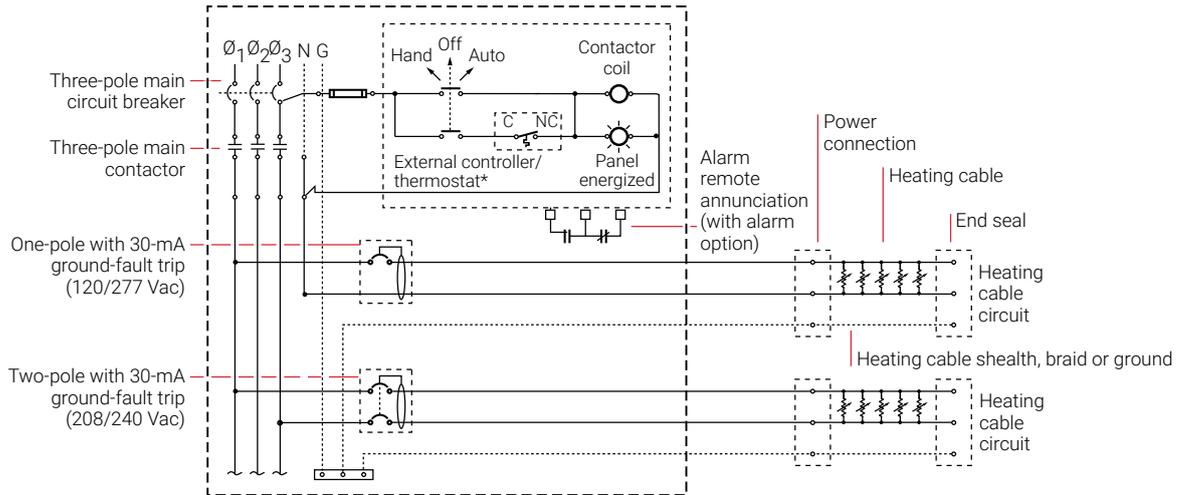


Fig. 11 HTPG power schematic

TABLE 10 POWER DISTRIBUTION

Catalog number	Description
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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.

RAYSOL HEATING CABLE IN CONDUIT 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
$\frac{\text{Side A (length)}}{\text{(ft/m)}} \times \frac{\text{Side B (width)}}{\text{(ft/m)}} = \frac{\text{Freezer area}}{\text{(ft}^2\text{/m}^2\text{)}}$	$\text{_____ } ^\circ\text{F}/^\circ\text{C}$	$\text{_____ } \text{ft}^2\cdot^\circ\text{F}\cdot\text{hr/Btu}$	$\text{_____ } \text{Volts}$

Example:

$\frac{80 \text{ ft}}{\text{Side A (length)}} \times \frac{40 \text{ ft}}{\text{Side B (width)}} = \frac{3200 \text{ ft}^2}{\text{Freezer area}}$	-20°F	$R-40 (40 \text{ ft}^2\cdot^\circ\text{F}\cdot\text{hr/Btu})$	208 Volts
---	---------------------	---	---------------------

Step 2 Select the heating cable

Supply voltage

- 120 V
- 208 V
- 240 V
- 277 V

Catalog number: _____

Example:

Supply voltage

208 V

Catalog number: **RaySol-2**

Step 3 Determine the heating cable conduit spacing and freezer load

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:

Conduit spacing: **96 in**

Freezer load: **0.5 W/ft²**

Step 4 Determine the heating cable layout and length

1. Estimate the number of conduit runs

Imperial

$$\left(\frac{\text{Side B (ft)}}{\text{Conduit spacing (in)}} \times 12 \right) / \text{Conduit spacing (in)} = \text{Estimated number of conduit runs}$$

Metric

$$\left(\frac{\text{Side B (m)}}{\text{Conduit spacing (cm)}} \times 100 \right) / \text{Conduit spacing (cm)} = \text{Estimated number of conduit runs}$$

If necessary, round to the next whole number

Example:

$$\left(\frac{40 \text{ ft}}{\text{Side B (ft)}} \times 12 \right) / \frac{96 \text{ in}}{\text{Conduit spacing (in)}} = \frac{5}{\text{Estimated number of conduit runs}}$$

2. Estimate the heating cable length required for conduit runs

$$\text{Side A (ft/m)} \times \text{Number of conduit runs} = \text{Heating cable length required (ft/m)}$$

Example:

$$\frac{80 \text{ ft}}{\text{Side A (ft)}} \times \frac{5}{\text{Number of conduit runs}} = \frac{400 \text{ ft}}{\text{Heating cable length required (ft)}}$$

3. Determine the maximum circuit length (see Table 5)

$$\frac{\text{Heating cable length required (ft/m)}}{\text{Supply voltage (V)}} \rightarrow \text{Maximum circuit length (ft/m)}$$

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:

$$\frac{400 \text{ ft}}{\text{Heating cable length required (ft)}} \frac{208 \text{ V}}{\text{Supply voltage (V)}} \rightarrow \frac{410 \text{ ft}}{\text{Maximum circuit length (ft)}}$$

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:

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

5. Determine end allowances and connection kit allowances (see Table 6) and total heating cable length required

$$\underline{\hspace{2cm}} \times 8 \text{ ft} = \underline{\hspace{2cm}}$$

Number of hairpin conduits

$$\underline{\hspace{2cm}} \times 8 \text{ ft} = \underline{\hspace{2cm}}$$

Number of straight run conduits

Heating cable length for end allowances

Example:

$$\underline{\hspace{2cm}} \times 8 \text{ ft} = \underline{\hspace{2cm}}$$

Number of hairpin conduits

$$\underline{\hspace{2cm}} \times 8 \text{ ft} = \underline{\hspace{2cm}}$$

Number of straight run conduits

Heating cable length for end allowances 24 ft

Determine connection kit allowances

$$\underline{\hspace{2cm}} \times 4 \text{ ft} = \underline{\hspace{2cm}}$$

Number of FTC-XC kits for hairpin conduits

$$\underline{\hspace{2cm}} \times 4 \text{ ft} = \underline{\hspace{2cm}}$$

Number of FTC-XC kits for straight run conduits

Heating cable length for connection kit allowances

Example:

$$\underline{\hspace{2cm}} \times 4 \text{ ft} = \underline{\hspace{2cm}}$$

Number of FTC-XC kits for hairpin conduits

$$\underline{\hspace{2cm}} \times 4 \text{ ft} = \underline{\hspace{2cm}}$$

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

<u> </u>	+	<u> </u>	+	<u> </u>	=	<u> </u>
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:

<u> 400 ft </u>	+	<u> 24 ft </u>	+	<u> 12 ft </u>	=	<u> 436 ft </u>
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

Determine number of circuits

Circuit breaker rating (A): _____ (from Step 4, Table 5)

Number of circuits: _____ (from Step 4)

Calculate circuit breaker load

$$\left(\frac{\text{Circuit breaker rating (A)}}{\text{Circuit breaker rating (A)}} \times 0.8 \times \frac{\text{Supply voltage}}{\text{Supply voltage}} \right) / 1000 = \text{Circuit breaker load (kW)}$$

Example:

$$\left(\frac{20 \text{ A}}{\text{Circuit breaker rating (A)}} \times 0.8 \times \frac{208 \text{ V}}{\text{Supply voltage}} \right) / 1000 = \text{3.3 kW}$$

Circuit breaker load (kW)

Calculate total transformer load

$$\text{CBL}_1 + \text{CBL}_2 + \text{CBL}_3 \dots + \text{CBL}_N = \text{Total transformer load (kW)}$$

Example:

$$\frac{3.3 \text{ kW}}{\text{CBL}_1} = \text{Total transformer load (kW)}$$

Step ⑥ Select the connection kits and accessories

Connection kits	Description	Quantity
<input type="checkbox"/> FTC-XC	Power connection and end seal	_____
<input type="checkbox"/> FTC-HST-PLUS	Low-profile splice/tee	_____

Example:

<input checked="" type="checkbox"/> FTC-XC	Power connection and end seal	3
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Step 7 Select the control system

Thermostats, controllers, and accessories	Description	Quantity
<input type="checkbox"/> ECW-GF	Electronic thermostat with 25-ft sensor	_____
<input type="checkbox"/> ECW-GF-DP	Remote display panel for ECW-GF	_____
<input type="checkbox"/> 460	Single-point heat tracing controller for pipe freeze protection	_____
<input type="checkbox"/> C910-485	Microprocessor-based single-point heat-trace controller	_____
<input type="checkbox"/> ACS-UIT2	ACS-30 user interface terminal	_____
<input type="checkbox"/> ACS-PCM2-5	ACS-30 power control panel	_____
<input type="checkbox"/> ProtoNode-RER	Multi-protocol gateway	_____
<input type="checkbox"/> RTD10CS	Resistance temperature device for C910-485 & ACS-30	_____
<input type="checkbox"/> RTD-200	Resistance temperature device for C910-485 & ACS-30	_____
<input type="checkbox"/> RTD50CS	Resistance temperature device for C910-485 & ACS-30	_____

Example:

C910-485 Microprocessor-based single-point heat-trace controller 1

Step 8 Select the power distribution

Power distribution	Description	Quantity
<input type="checkbox"/> 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.

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