CONNECT AND PROTECT

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 an nVent RAYCHEM RaySol self-regulating heating cable system or an nVent RAYCHEM Mineral Insulated heating cable system. 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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nVent offers 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.

nVent also offers a full suite of best-in-class nVent 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 nVent.com/NUHEAT.

If your application conditions are different than described in this guide, 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 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:

- RaySol Floor Heating and Freezer Frost Heave Prevention Installation and Operation Manual (H58138)
- 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 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 nVent RAYCHEM Floor Heating Systems.

For RaySol and MI heating cables

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://nVent.com/RAYCHEM/support/warranty-information.

There are three main floor heating applications:

- Heat loss replacement
- Comfort floor heating (includes concrete floor heating)
- Radiant space heating

nVent 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

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

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 nVent. Contact your nVent 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.

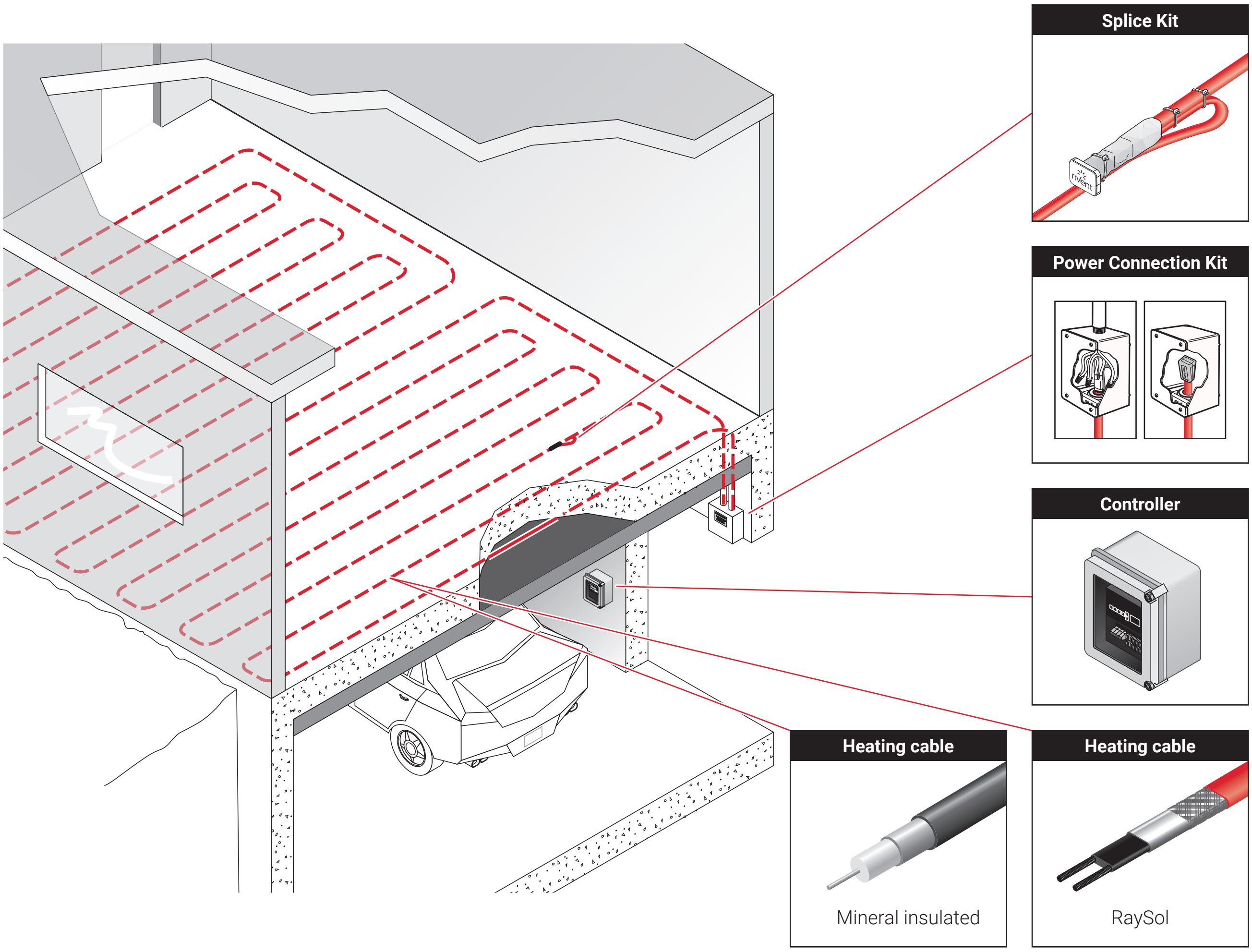


Fig. 1 Typical heat loss replacement system

The following illustration shows a typical heat loss replacement installation.

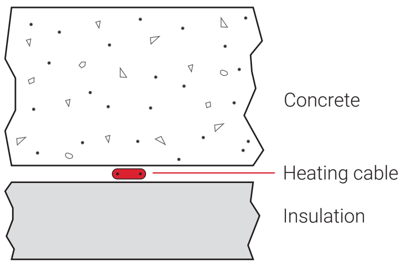


Fig. 2 Typical heat loss replacement installation

The following illustration shows a typical comfort floor heating system.

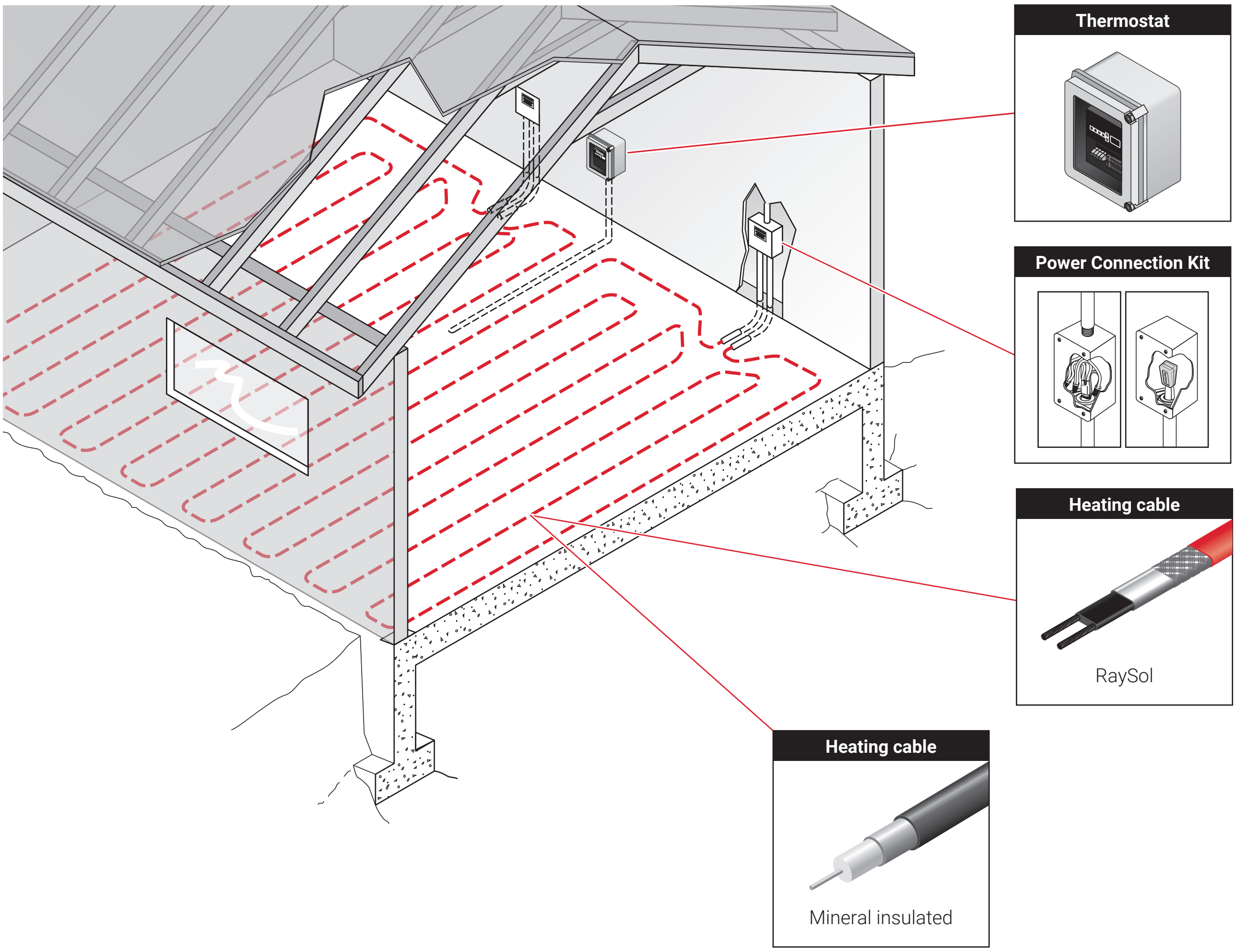


Fig. 3 Typical comfort floor heating system

The following illustration shows a typical comfort floor system installation.

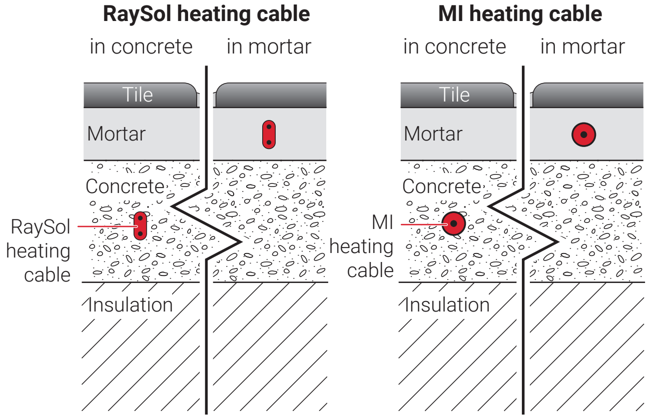


Fig. 4 Typical comfort floor heating system installation

A radiant space heating system is similar to the illustration in Fig. 3. RaySol heating cable systems must be custom designed through nVent. Contact your nVent 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

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.

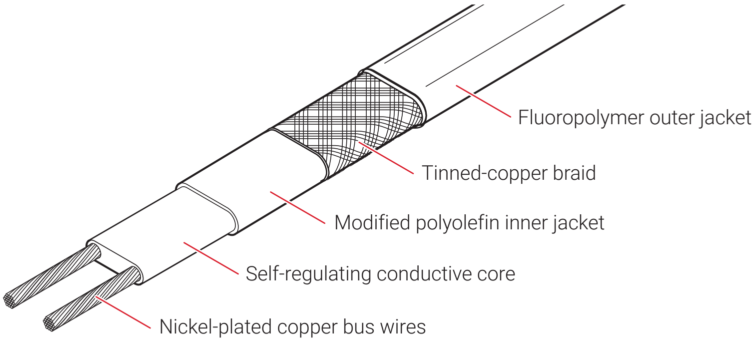
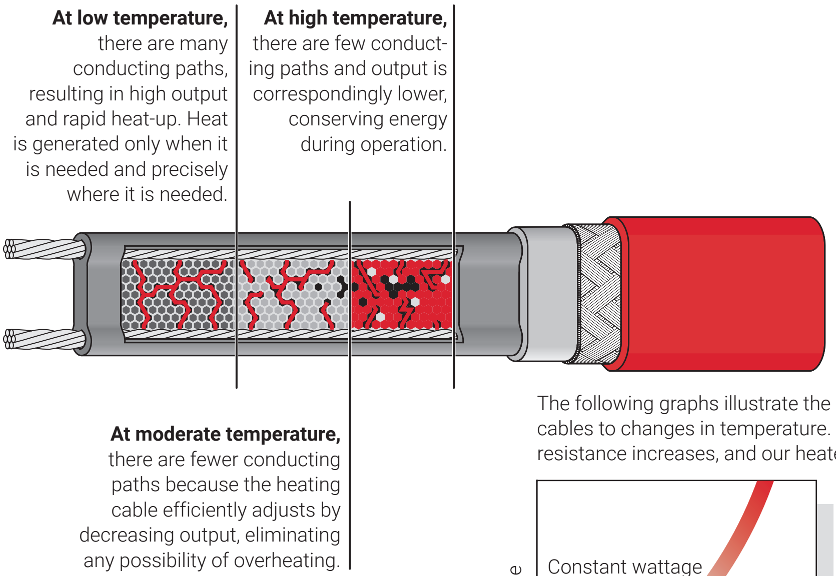


Fig. 5 Typical RaySol heating cable construction

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.



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.

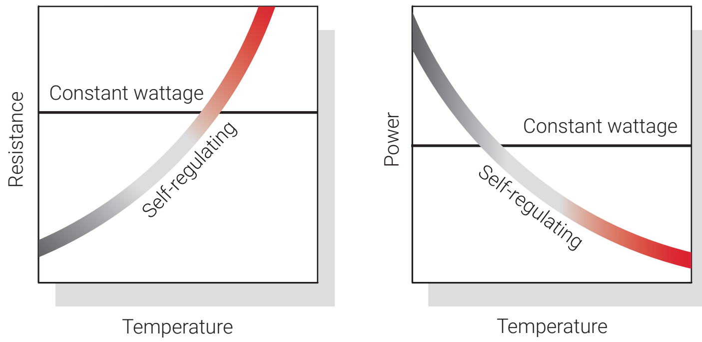


Fig. 6 Self-regulating heating cable technology

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 nVent for additional information.

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MI Heating Cable Construction

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 Low Smoke Zero Halogen (LSZH) jacket..

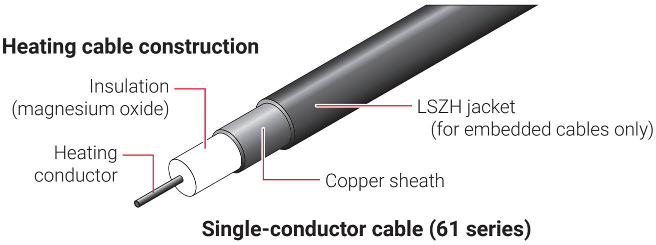

Fig. 7 Typical MI heating cable construction

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.

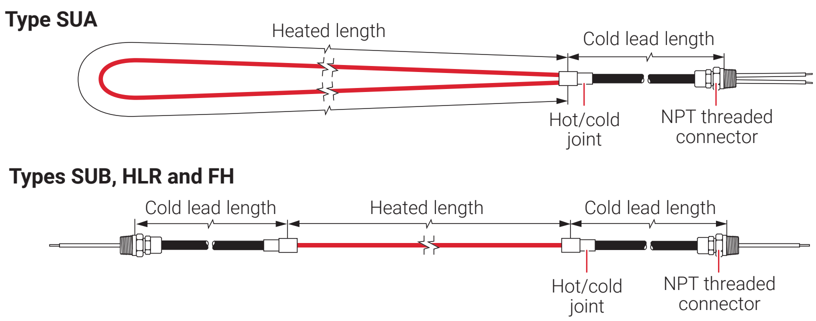

Fig. 8 Configurations for surface mount or directly embedded in concrete installations

nVent 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 nVent for additional information.

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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 nVent representative or call nVent 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 50.
- The "RaySol Heating Cable Floor Heating Design Worksheet" on page 51.
- The "MI Heating Cable Floor Heating Design Worksheet" on page 59.

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 nVent 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 LSZH 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 LSZH 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 nVent. Contact your nVent 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 LSZH 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

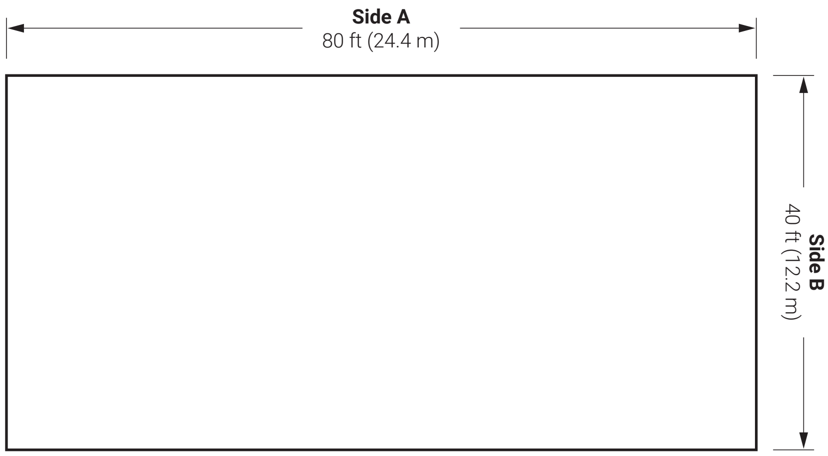


Fig. 9 Floor layout for heat loss replacement example

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 16.

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

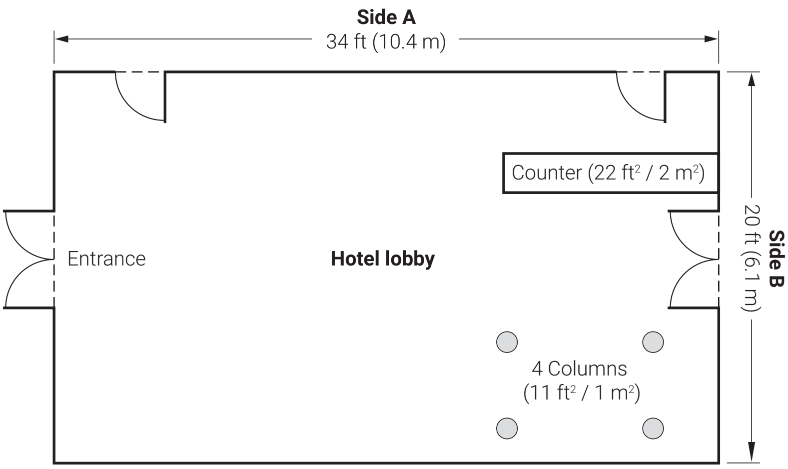


Fig. 10 Floor layout for comfort floor heating example

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·°F·hr/Btu)
Supply voltage and phase	208 V, single-phase
Control requirements	Electronic thermostat

Advance to Step 4, page 16.

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

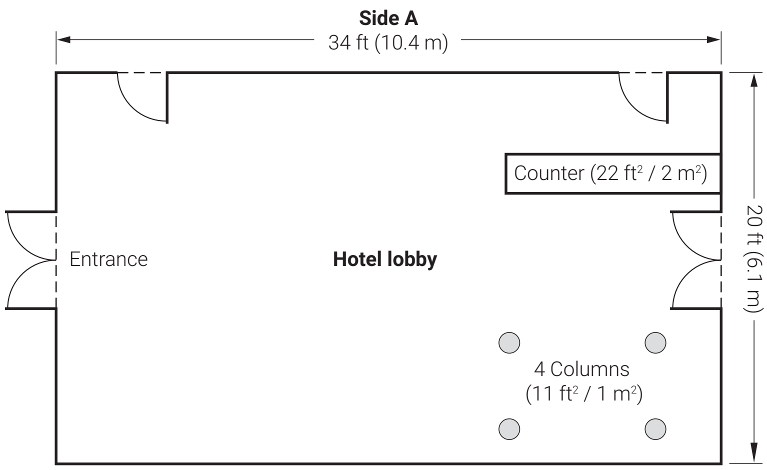


Fig. 11 Floor layout for radiant space heating example

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 16.

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 20.
- For MI heating cable design
  - For heat loss replacement, see page 25.
  - For comfort floor heating, see page 30.
  - For radiant space heating, see page 34.

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.

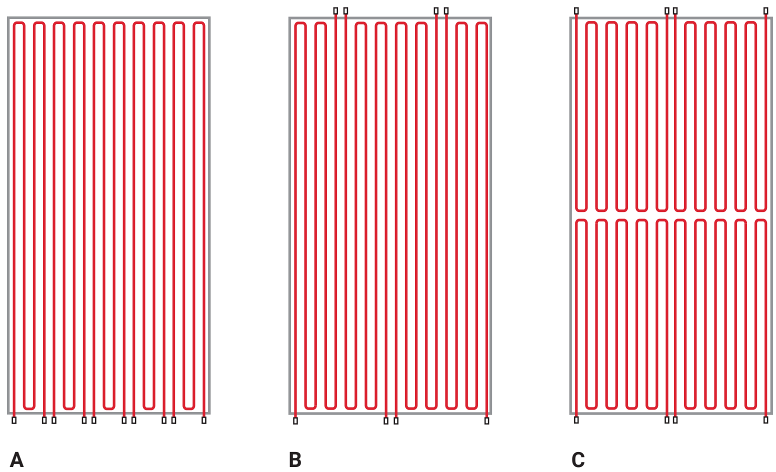


Fig. 12 Typical heating cable layouts for heat loss replacement

Estimate the heating cable length required:

$$\text{Estimated heating cable length (ft)} = \frac{\text{Heated area (ft}^2\text{) x 12}}{\text{Spacing (in)}}$$

$$\text{Estimated heating cable length (m)} = \frac{\text{Heated area (m}^2\text{) x 100}}{\text{Spacing (cm)}}$$

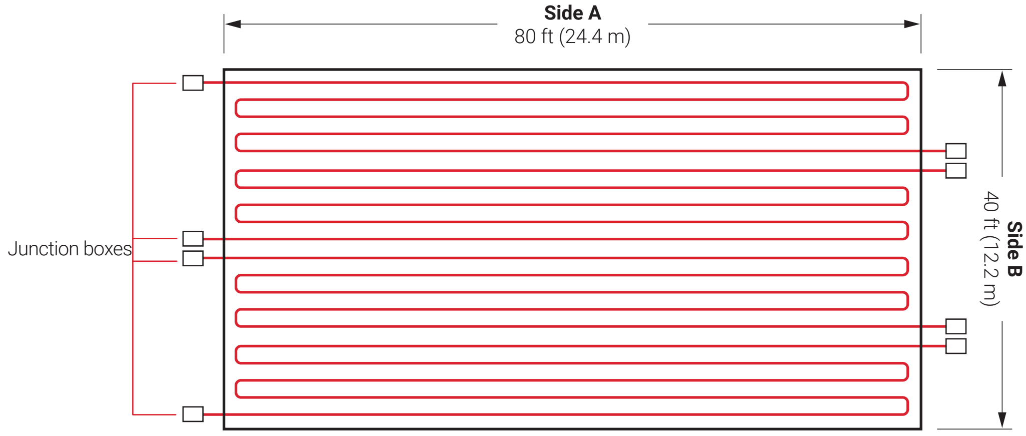


Fig. 13 RaySol heating cable layout for heat loss replacement

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 nVent 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 (1.2 m) per end
Connection kit allowances	Required to assemble the connection kit (one per circuit)	4 ft (1.2 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 nVent RAYCHEM 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 17 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 37.

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 16). 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:

$$\text{Estimated heating cable length (ft)} = \frac{\text{Heated area (ft}^2\text{) x 12}}{\text{Spacing (in)}}$$

$$\text{Estimated heating cable length (m)} = \frac{\text{Heated area (m}^2\text{) x 100}}{\text{Spacing (cm)}}$$

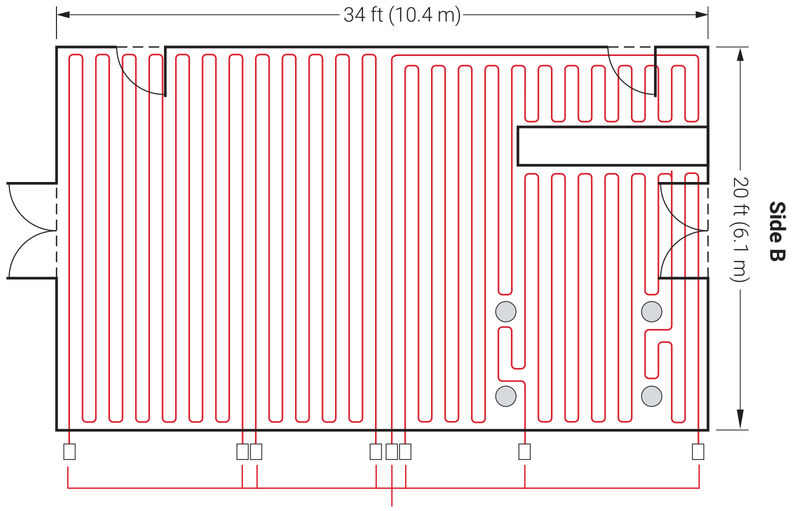


Fig. 14 RaySol heating cable layout for comfort floor heating

Example: RaySol heating cable length for comfort floor heating

Heated area	647 ft² (60.4 m²) (from Step 3)
Estimated heating cable length	647 ft² x 12 / 8 in = **971 ft**
	60.4 m² 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 nVent 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 19 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 nVent RAYCHEM 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 18 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.

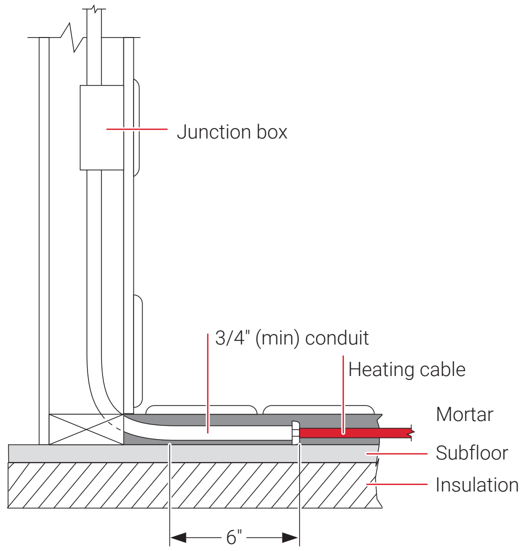


Fig. 15 Typical RaySol comfort floor heating installation

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 37.

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 30). For a three-phase voltage supply, divide the total area into three equal subsections (Fig. 16 on page 27) 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 46 and Fig. 21 on page 47. 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 (ft²·°F·hr/Btu)							
		R-10		R-20		R-30		R-40	
		Design power - W/ft² (W/m²)							
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 nVent 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 on page 30).
- 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 28 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 28 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.

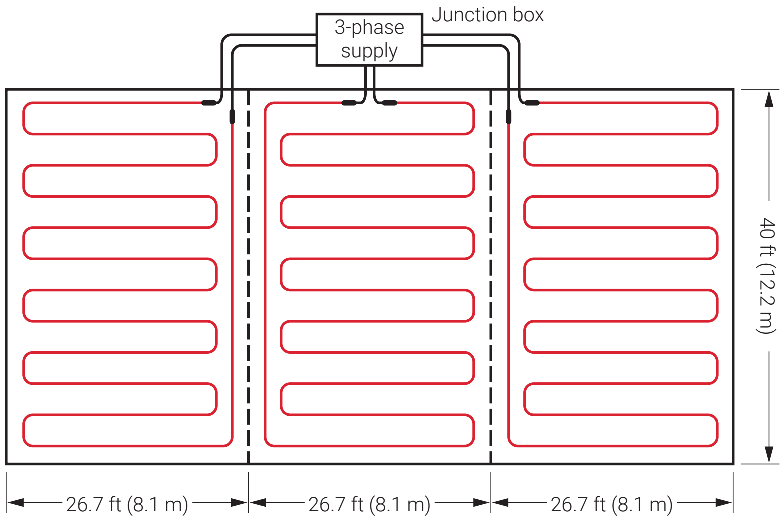


Fig. 16 Typical three-phase heating cable layout for heat loss replacement

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·°F·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 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								
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

Catalog number	Area coverage				Cable wattage (W)	Heated length		Heating cable current (A)
	Min (ft²)	Max (ft²)	Min (m²)	Max (m²)		(ft)	(m)	
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
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 35.

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 nVent 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.

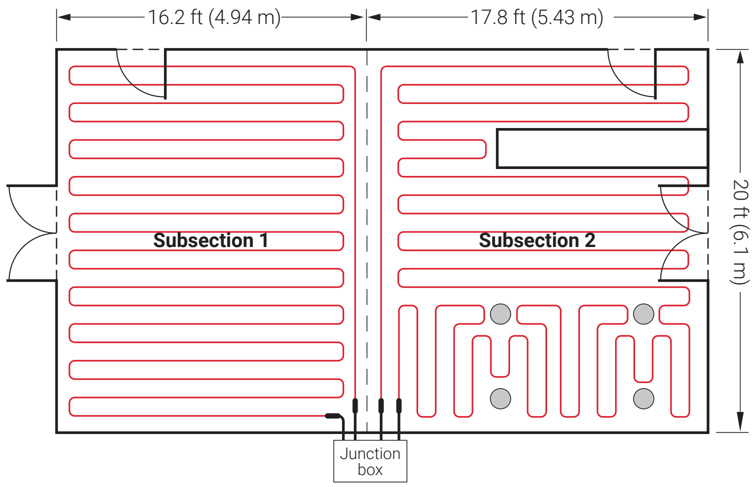


Fig. 17 Typical heating cable layout for comfort floor heating

Note: In Fig. 17, the subsections are equal heated areas.

Example: MI heating cables for comfort floor heating

Heated area	647 ft² (60.4 m²) (from Step 3)
Supply voltage and phase	208 V, single-phase (from Step 3)
Subsection area	647 ft² / 2 = 324 ft² (see Fig. 17)
	60.4 m² / 2 = 30.2 m²
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

Catalog number	Area coverage				Cable wattage (W)	Heated length		Heating cable current (A)
	Min (ft²)	Max (ft²)	Min (m²)	Max (m²)		(ft)	(m)	
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

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 ft (4.6 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

Catalog number	Area coverage				Cable wattage (W)	Heated length		Heating cable current (A)
	Min (ft²)	Max (ft²)	Min (m²)	Max (m²)		(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

Catalog number	Area coverage				Cable wattage (W)	Heated length		Heating cable current (A)
	Min (ft²)	Max (ft²)	Min (m²)	Max (m²)		(ft)	(m)	
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 35.

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.

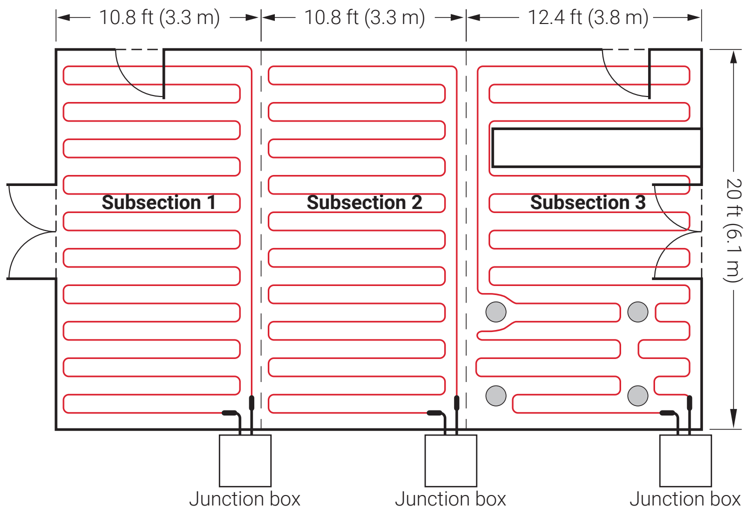


Fig. 18 Typical heating cable layout for radiant space heating

Note: In Fig. 18, the subsections are equal heated areas.

Example: MI heating cables for radiant space heating

Heated area	647 ft² (60.4 m²) (from Step 3)
Supply voltage and phase	208 V, single phase (from Step 3)
Subsection area	647 ft² / 3 = 216 ft²
	60.4 m² / 3 = 20.1 m²
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 ft² (99.1 m²)
Heating cable catalog number	HLR24 (from Table 10)
Heating cable length	420 ft (128.0 m) (from Table 10)
Cable spacing	(1067 ft² x 12 in) / 420 ft = 30.5 in
	Rounded to 31 in
	(99.1 m² 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 37.

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 38.

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 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:

Total Transformer Load (kW) = $CBL_1 + CBL_2 + CBL_3 ... + CBL_N$

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 40.

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 46. Heating cables may also be connected using the wye configuration shown in Fig. 21 on page 47, 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 46, 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 47, 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 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 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: 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 40.

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 on page 38.

RaySol Self-Regulating Heating Cable

Select Number of Power Connection Kits

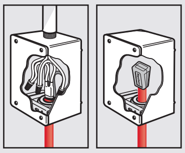
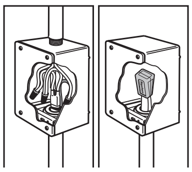
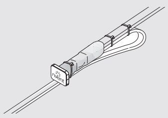
For heat loss replacement, one FTC-P power connection kit and two junction boxes are required per circuit. For comfort floor heating, one FTC-XC power connection kit and two junction boxes are required per circuit

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-PLUS	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 42.

MI Heating Cables

A typical 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 MIJB-864-A. 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.

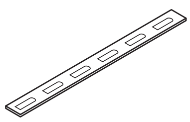
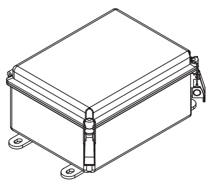
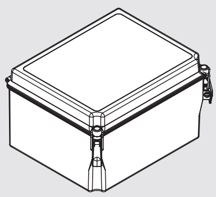
Note: The junction box must be accessible according to the national electrical codes.

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
	SPACERGALV	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)
	107826-000	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)
	MIJB-864-A	Junction box with pre-drilled earth plate for use with MI heating units. Typical uses - Power, splice and end box for three-phase systems. Hazardous locations: CID2 Groups B, C and D. Maximum operating voltage 600Vac. Maximum 35A per terminal, rated 18AWG to 6AWG, Type 4X. Entries: Up to 8 x ½" and 3 x ¾". Power cable gland and hubs not included. Two mounting brackets (MBRP-B) and two pipe straps must be ordered separately for installation. Enclosure dimensions: 8" x 6" x 4" (200 x 150 x 100 mm).	1	For MI systems only
	MIJB-1086-B	Junction box with pre-drilled earth plate for use with MI heating units. Accommodates up to 7 outgoing heating cables and one incoming power cable. It can also be used as a marshalling box – one incoming power cable and 5 outgoing power cables. Typical uses - Power or marshalling, splice and end box for three-phase systems. Hazardous locations: CID2 Groups B, C and D. Maximum operating voltage 600Vac. Maximum 35A per terminal, rated 18AWG to 6AWG, Type 4X. Entries: Up to 11 x ½" and 8 x ¾". Power cable gland and hubs not included. Two mounting brackets (MBRP-B) and two pipe straps must be ordered separately for installation. Order a separate MIJB-LPWR-KIT for #2 or #4AWG power cable to downsize to #6AWG (35A). Enclosure dimensions: 10" x 8" x 6" (250 x 200 x 150 mm).	1	For MI systems only

Example: MI heating cables for heat loss replacement

Junction box	MIJB-864-A
Quantity	1
Prepunched strapping	107826-000
Quantity	16

Example: MI heating cables for comfort floor heating

Junction box	MIJB-864-A
Quantity	1
Prepunched strapping[1]	SPACERGALV
Quantity	4

Example: MI heating cables for radiant space heating

Junction box	MIJB-864-A
Quantity	3
Prepunched strapping[1]	SPACERGALV
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 42.

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.

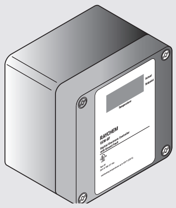
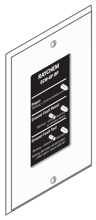
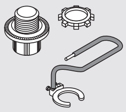
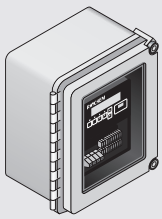
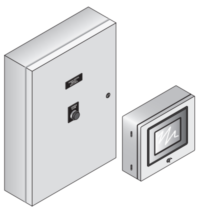
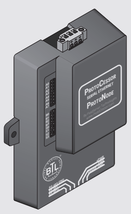
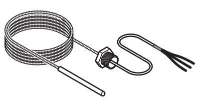
For RaySol and MI heating cables, the recommended control for heat loss replacement and comfort floor heating is nVent RAYCHEM ECW-GF. For RaySol or MI heating cable installations where temperature control and temperature monitoring is desired, an nVent RAYCHEM C910-485 or ACS-30 controller is recommended.

Table 15 Temperature Control Options

Features	ECW-GF	C910-485 [2]	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	Type 4X	Type 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 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 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-UIT3 ACS-PCM2-5	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-UIT3 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-1.5K ProtoNode-RER-10K	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 controller. ProtoNode-RER-1.5K (Part No P000002008) is for C910-485 or ACS-30 systems with up to 5 PCM panels. ProtoNode-RER-10K (Part No P000001983) is for ACS-30 systems with up to 34 PCM panels.
	RTD-200 RTD10CS RTD50CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with 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 (15.2 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 nVent 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 19). 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.

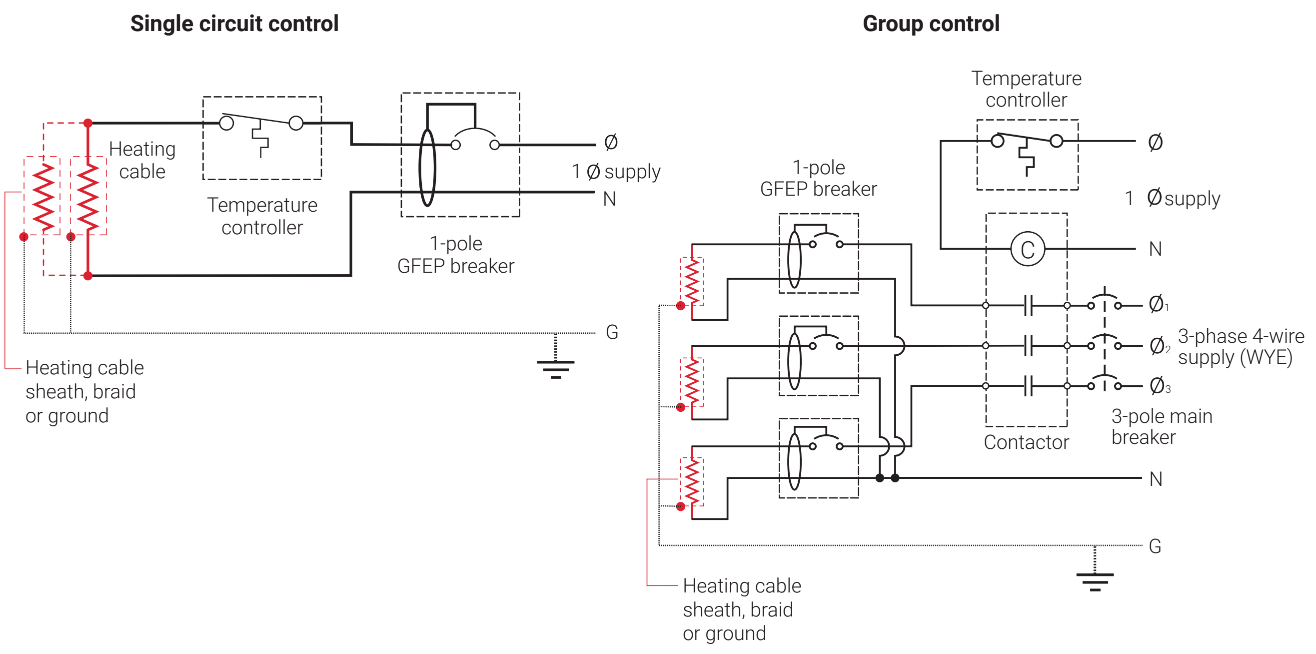


Fig. 19 Single circuit and group control

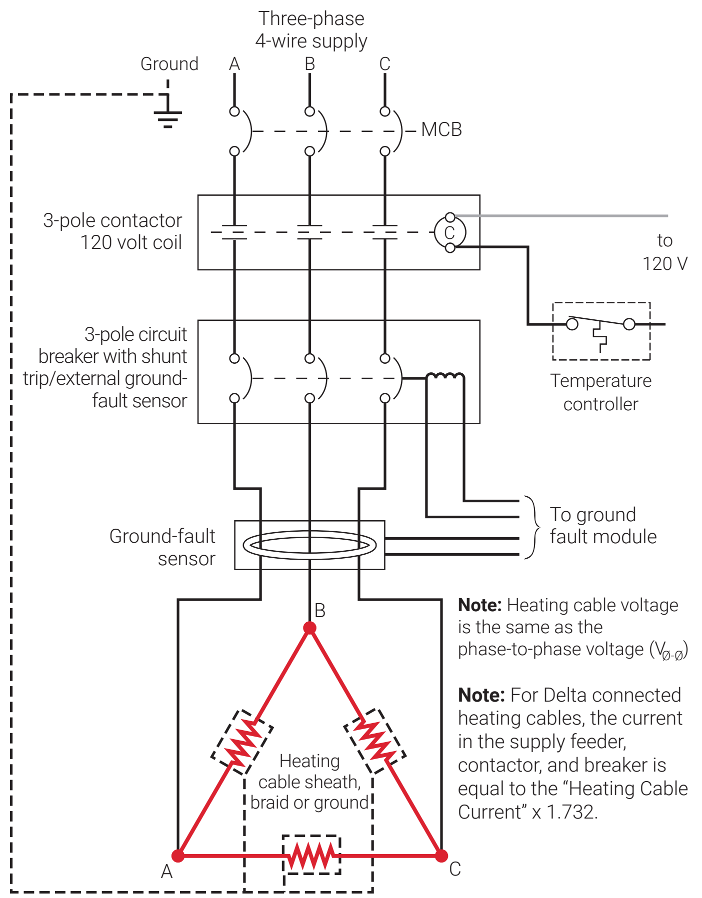


Fig. 20 Typical single circuit control for three-phase delta connected cables

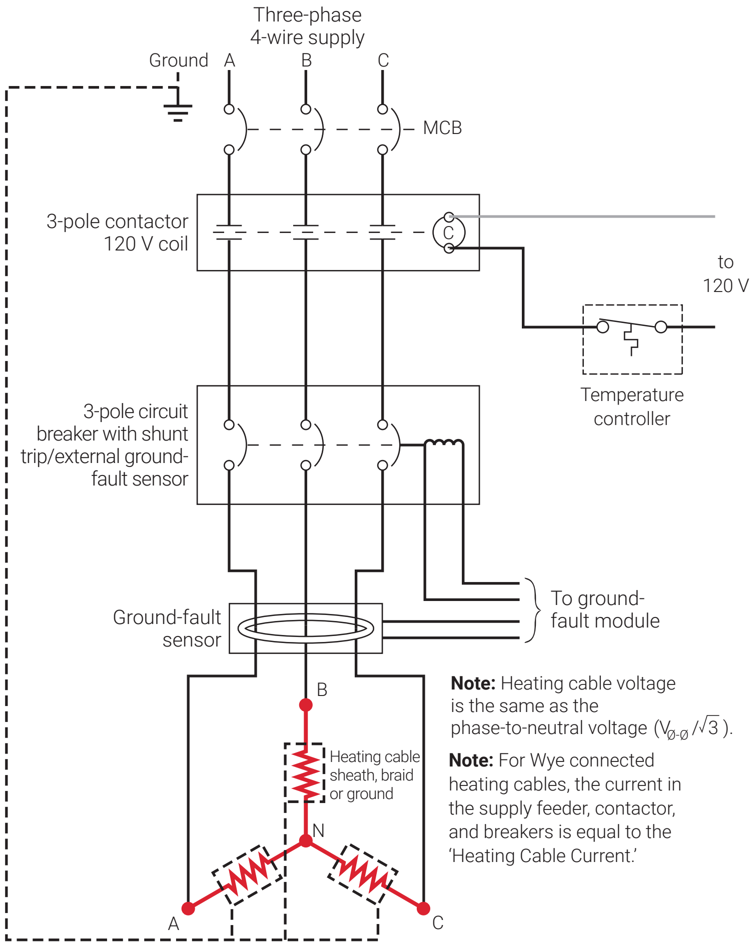


Fig. 21 Typical single circuit control for three-phase wye connected cables

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.

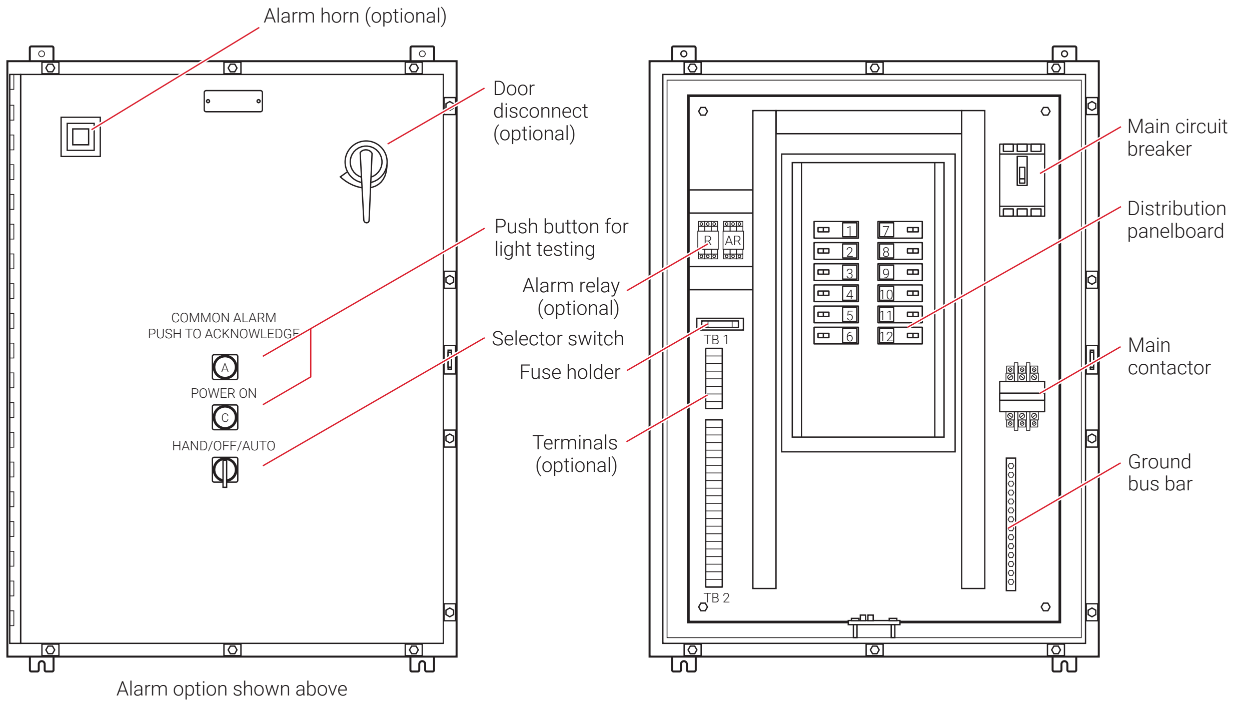


Fig. 22 HTPG power distribution panel

Three-phase, 4 wire supply (Wye)

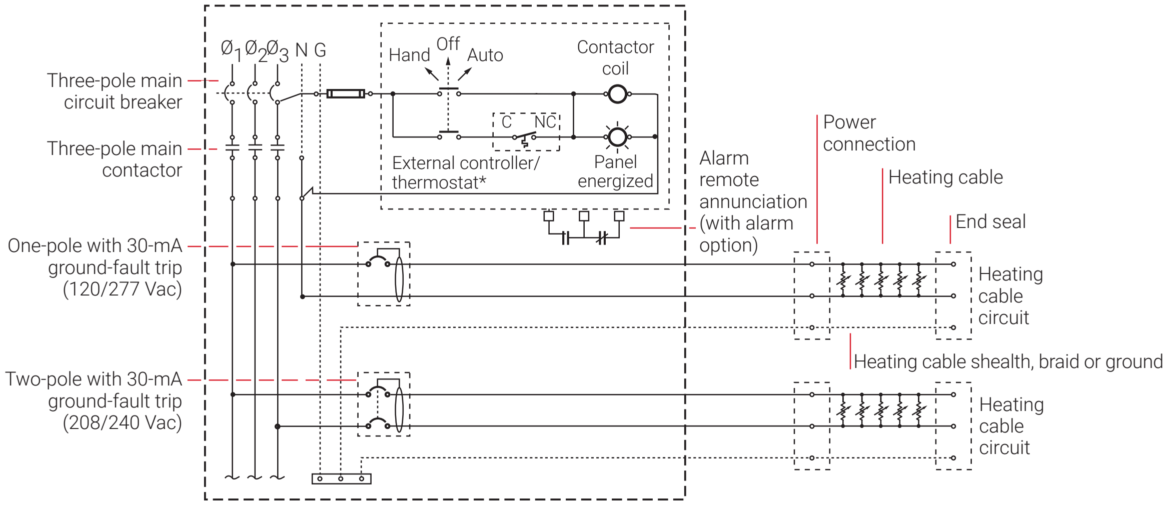
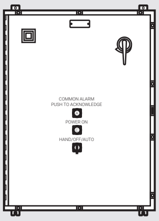


Fig. 23 HTPG power schematic

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 11)

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 59.

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 nVent for design assistance.

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 13)	**Minimum ambient design temperature**	**Insulation R-value**	**Supply voltage and phase**	**Control requirements**
______ 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** Side A (length) (ft/m) X **40 ft** Side B (width) (ft/m) = **3200 ft^2** **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 16)

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 17)

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 (ft)**

Metric

(__________ x 100) / __________ = __________

Heated area (m^2) (from Step 3) / Heating cable spacing (cm) (from Step 4.2) = **Estimated heating cable length (m)**

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 18)

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 19)

End allowance

Number of circuits (from Step 4.4)	x	ft/m per end (from Table 6)	x	Number of ends	=	**End allowance (ft/m)**

Connection kit allowance

Number of kits	x	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 17 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 37.

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 14)	**Minimum ambient design temperature**	**Insulation R-value**	**Supply voltage and phase**	**Control requirements**
________ Total area (ft^2/m^2) – ________ Permanent fixture (ft^2/m^2) = ________ **Heated area (ft^2/m^2)**	______°F/°C	________ $ft^2·°F·hr/Btu$	______Volts ______ Phase	________ ________

Example: Raysol heating cables for comfort floor heating

34 ft (Side A, see Figure 10) x 20 ft (Side B, see Figure 10) = **680 ft^2** (**Total area**)

680 ft^2 (Total area) – (22 ft^2 counter + 11 ft^2 columns) (Permanent fixture space, see Figure 10) = **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 appropriate RaySol heating cable (see Table 3 on page 16)

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 20)

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 Table 7)

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 21)

Imperial

(________ x 12) / ________ = ________

Heated area (ft²) (from Step 3) | Heating cable spacing (in) (from Step 4.2) | **Estimated heating cable length (ft)**

Metric

(________ x 100) / ________ = ________

Heated area (m²) (from Step 3) | Heating cable spacing (cm) (from Step 4.2) | **Estimated heating cable length (m)**

Example: RaySol heating cables for comfort floor heating

Estimate the heating cable length

(**647 ft²** 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 21)

________ / ________ = ________

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 19)

End allowance

_______ x _______ x _______ = _______

Number of circuits (from Step 4.4) x ft/m per end (from Table 6) x Number of ends = **End allowance (ft/m)**

Connection kit allowance

_______ x _______ = _______

Number of kits x 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) x ft/m per end (from Table 6) x Number of ends = **End allowance**

Connection kit allowance

4 x **4** = **16 ft**

Number of kits x 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 17 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** (Circuit breaker rating) x **0.8** x **208 V** (Supply voltage)) / **1000** ————→ = **Rounded to 5 kW** (**Circuit breaker load (kW)**)

5 kW (Circuit breaker load (kW)) x **4** (Number of breakers) ————→ = **20 kW** (**Total transformer load (kW)**)

Step 6 Select the connection kits and accessories

RaySol connection kits	Quantity
❑ FTC-P	________
❑ FTC-XC	________
❑ FTC-HST-PLUS	________
❑ 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 43)

Control system	Quantity
❑ ECW-GF	________
❑ ECW-GF-DP	________
❑ MI-GROUND-KIT	________
❑ C910-485	________
❑ ACS-UIT3	________
❑ ACS-PCM2-5	________
❑ ProtoNode-RER	________
❑ RTD10CS	________
❑ RTD-200	________
❑ RTD50	________

Example: RaySol heating cables for heat loss replacement

✓ **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 49)

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.

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 13)	**Minimum ambient design temperature**	**Insulation R-value**	**Supply voltage and phase**	**Control requirements**
____ Side A (length) (ft/m) x ____ Side B (width) (ft/m) = ____ **Heated area (ft²/m²)**	_____°F/°C	____ ft²·°F·hr/Btu	______Volts ______ Phase	______ ______

Example: MI heating cables for heat loss replacement

80 ft Side A (length) (ft/m) X **40 ft** Side B (width) (ft/m) = **3200 ft²** **Heated area (ft²/m²)**	**–10°F**	**R-20 (20 ft²·°F·hr/Btu)**	**208 V Three-phase**	**Electronic thermostat, monitoring requested**

Step 4 Determine the heating cable spacing, layout and length

Select heating cable (For design power, see Table 9 on page 25; for heating cable selection, see Table 10 on page 28.)

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 25)
Subsection area: ______________ (from Step 4)

Determine the power requirement:

Single-phase supply

____________ x ____________ = ____________
Design power (W/ft²) (W/m²) | Total area or subsection area (ft²/m²) | **Power required (W)**

Three-phase supply

____________ x ____________ = ____________
Design power (W/ft²) (W/m²) | Subsection area (ft²/m²) | **Power required (for each subsection) (W)**

Select the heating cable

Heating cable catalog number: ______________ (from Table 10 on page 28)
Cable wattage: ______________ (from Table 10 on page 28)
Cable voltage: ______________ (from Table 10 on page 28)
Heating cable length: ______________ (from Table 10 on page 28)
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 ft^2 (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/ft^2 (from Table 9 on page 25)
Subsection area:	1067 ft^2 (from Step 4)

Determine the power requirement:

Three-phase supply (see Fig. 16 on page 27)

$$\frac{2.2\ W/ft^2}{\text{Design power}} \times \frac{1067\ ft^2}{\text{Subsection area}} = \frac{\mathbf{2347\ W}}{\textbf{Power required (for each subsection)}}$$

Heating cable catalog number:	HLR24 (from Table 10 on page 28)
Cable wattage:	5150 W (from Table 10 on page 28)
Cable voltage:	208 V (from Table 10 on page 28)
Heating cable length:	420 ft (from Table 10 on page 28)
Number of cables:	3 (one cable required for each subsection)

Determine the heating cable spacing

Imperial

$$\left(\frac{}{\text{Area } (ft^2)} \times 12\ in\right) / \frac{}{\text{Heating cable length (ft)}} = \frac{}{\textbf{Cable spacing (in)}}$$

Metric

$$\left(\frac{}{\text{Area } (m^2)} \times 100\ cm\right) / \frac{}{\text{Heating cable length (m)}} = \frac{}{\textbf{Cable spacing (cm)}}$$

Example: MI heating cables for heat loss replacement

Subsection area:	1067 ft^2 (from Step 4)
Heating cable catalog number:	HLR24 (from Step 4)
Heating cable length:	420 ft (from Table 10)

$$\left(\frac{1067\ ft^2}{\text{Subsection area}} \times 12\ in\right) / \frac{420\ ft}{\text{Heating cable length}} = \frac{\textbf{31 in (rounded)}}{\textbf{Cable spacing (in)}}$$

Advance Step 5 on page 64.

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 14)	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	______ $ft^2 \cdot °F \cdot hr/Btu$	______ Volts ______ Phase	______ ______

Example: Raysol heating cables for comfort floor heating

34 ft	x	20 ft	=	**680 ft^2**
Side A (see Figure 10)		Side B (see Figure 10)		**Total area**
680 ft^2	–	(22 ft^2 counter + 11 ft^2 columns)	=	**647 ft^2**
Total area		Permanent fixture space (see Figure 10)		**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

Select the heating cable (see Table 11 on page 31 and Table 12 on page 32)

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 31 or Table 12 on page 32)
Cable wattage: ______ (from Table 11 on page 31 or Table 12 on page 32)
Cable voltage: ______ (from Table 11 on page 31 or Table 12 on page 32)
Heating cable length: ______ (from Table 11 on page 31 or Table 12 on page 32)
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 30)

647 ft^2	/	2	=	**324 ft^2**
Heated area (ft^2/m^2)		Number of subsections		**Subsection area (ft^2/m^2)**

Heating cable catalog number: FH21 (from Table 12 on page 32)
Cable wattage: 3390 W (from Table 12 on page 32)
Cable voltage: 208 V (from Table 12 on page 32)
Heating cable length: 425 ft (from Table 12 on page 32)
Number of cables: 2 (one cable required for each subsection)

Step 4 Determine the heating cable spacing, layout, and length

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)
Heating cable catalog number:	FH21 (from Step 4)
Heating cable length:	425 ft (from Table 12)

(324 ft² / Area x 12 in) / 425 ft / Heating cable length = **9 in (rounded)** / **Cable spacing (in)**

Advance Step 5 on page 64.

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 15)	**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 11) x 20 ft / Side B (see Figure 11) = **680 ft²** / **Total area**

680 ft² / Total area – (22 ft² counter + 11 ft² columns) / Permanent fixture space (see Figure 11) = **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

Select the heating cable

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)**

Btu requirement: ______________ (from Step 3)

Power required:

______________ / 3.412 = ______________

Btu/hr | **Power requirement (W)**

Power per subsection: ______________

Heating cable catalog number: ______________ (from Table 11 on page 31 or Table 12 on page 32)

Cable wattage: ______________ (from Table 11 on page 31 or Table 12 on page 32)

Cable voltage: ______________ (from Table 11 on page 31 or Table 12 on page 32)

Heating cable length: ______________ (from Table 11 on page 31 or Table 12 on page 32)

Number of cables: ______________

Example: MI heating cables for radiant space heating

Note: In this example, the subsections are equal heated areas.

Heated area: 647 ft^2

Supply voltage and phase: 208 V, single-phase (from Step 3)

Subsection area: (see Fig. 18 on page 34)

647 ft^2 / 3 = **216 ft^2**

Heated area (ft^2/m^2) | Number of subsections | **Subsection area (ft^2/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 32)

Cable wattage: 3390 W (from Table 12 on page 32)

Cable voltage: 208 V (from Table 12 on page 32)

Heating cable length: 425 ft (from Table 12 on page 32)

Number of cables: 3 (one cable required for each subsection)

Step 4 Determine the heating cable spacing, layout, and length

Determine the heating cable spacing

Imperial

(____________ x 12 in) / ________________ = ____________
Area (ft^2) Heating cable length (ft) **Cable spacing (in)**

Metric

(____________ x 100 cm) / ________________ = ____________
Area (m^2) Heating cable length (m) **Cable spacing (cm)**

Example: MI heating cables for radiant space heating

Subsection area:	216 ft^2	(from Step 4)
Catalog number:	FH21	(from Step 4)
Heating cable length:	425 ft	(from Table 12)

(216 ft^2 / Subsection area x 12 in) / 425 ft / Heating cable length = **6 in (rounded)** / **Cable spacing (in)**

Step 5 Determine the electrical parameters

Determine the number of circuits

Single-phase circuits (see Fig. 19 on page 46) ____________________

Three-phase circuits (see Fig. 20 on page 46 and Fig. 21 on page 47) ____________________

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)**

____________ / 0.8 = ____________
Load current (A) **Circuit breaker rating**

Step 5 Determine the electrical parameters

Determine the transformer load

For cables of equal wattage

(______ Cable (W) x ______ Number of cables) / 1000 → = ______ **Transformer load (kW)**

When cable wattages are not equal

(______ $Cable_1$ (W) + ______ $Cable_2$ (W) + ______ $Cable_3$ (W)... + ______ $Cable_N$ (W)) / 1000 → = ______ **Total transformer load (kW)**

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 on page 28)
Load current:

Delta-connected three-phase circuit

24.8 A (Heating cable current) x 1.732 = **43 A (rounded)** (**Load current**)

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)
Number of cables: 3 (from Step 4)
Transformer load:

(5150 W (Cable power output) x 3 (Number of cables)) / 1000 = **15.5 kW (rounded)** (**Transformer load**)

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 on page 32)
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)
Number of cables: 2 (from Step 4)
Transformer load:

(3390 W (Cable power output) x 2 (Number of cables)) / 1000 = **6.8 kW (rounded)** (**Transformer load**)

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 on page 32)
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)
Number of cables: 3 (from Step 4)
Transformer load:

(3390 W (Cable power output) x 3 (Number of cables)) / 1000 = **10.2 kW (rounded)** (**Transformer load**)

Step 6 Select the connection kits and accessories

MI accessories		Quantity
❑ MIJB-864-A	Fiberglass junction box (for MI cable only)	___________
❑ MIJB-1086-B	Fiberglass junction box (for MI cable only)	___________
❑ SPACERGALV	Galvanized steel prepunched strapping	___________
❑ 107826-000	Stainless steel prepunched strapping (use for Heat Loss Replacement applications)	___________

Example: MI heating cables for heat loss replacement

✓ **MIJB-864-A**	**1**
✓ **107826-000**	**16**

Example: MI heating cables for comfort floor heating

✓ **MIJB-864-A**	**1**
✓ **SPACERGALV**	**4**

Example: MI heating cables for radiant space heating

✓ **MIJB-864-A**	**3**
✓ **SPACERGALV**	**4**

Step 7 Select the control system (see Table 16 on page 43)

Control system	Quantity
❑ ECW-GF	___________
❑ ECW-GF-DP	___________
❑ C910-485	___________
❑ ACS-UIT3	___________
❑ ACS-PCM2-5	___________
❑ ProtoNode-RER	___________
❑ RTD10CS	___________
❑ RTD-200	___________
❑ RTD50	___________

Example: MI heating cables for heat loss replacement

✓ **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 49)

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.

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