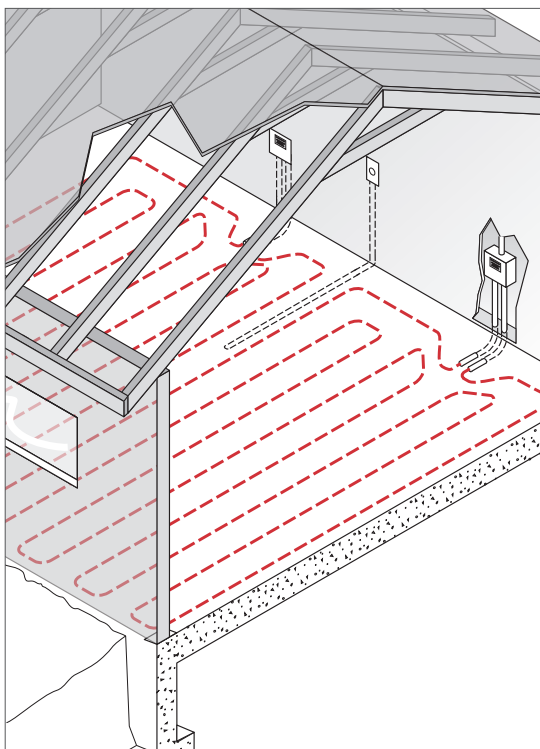


MI Heating Cable System

Installation and Operation Manual
for Heat Loss Replacement, Freezer Frost
Heave Prevention, Comfort Floor Heating
and Radiant Space Heating



Important Safeguards and Warnings

WARNING: FIRE AND SHOCK HAZARD.

These heating systems must be installed correctly to ensure proper operation and to prevent electrical shock and fire. Read these important warnings and carefully follow all the installation instructions.

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 Chemelex, 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.

- To avoid damage to the heating cables, do not energize cables until the installation has been completed.
- Approvals and performance of Chemelex Raychem mineral insulated heating cable systems are based on the use of approved components and accessories.
- Cable terminations must be kept dry before, during, and after installation.
- Damaged heating cable can cause electrical arcing or fire. Repair or replace damaged heating cable or terminations. Contact factory for assistance.
- Use only fire-resistant insulation materials such as fiberglass board or flame-retardant foams.
- If the heating cable sheath is stainless steel, the cable must be grounded, but cannot be used to ground any other equipment.

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1. GENERAL INFORMATION

1.1 Use of the Manual

This installation and maintenance manual covers the installation, testing, and maintenance of Raychem MI heating cables for floor heating and freezer frost heave prevention applications. The manual covers general heating cable installation procedures and specific installation details. The manual also discusses controls, testing, and periodic maintenance.

This manual assumes that the proper floor heating or freezer frost heave prevention designs have been completed according to the Heat Loss Replacement Design Guide (H58157) and the Freezer Frost Heave Prevention Design Guide (H58139). The instructions in this manual and the installation instructions included with the control systems, power distribution systems, and accessories must be followed for the Chemelex warranty to apply.

For design assistance, technical support, or information regarding other applications not shown here, please contact your Chemelex representative or contact us directly.

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Important: For the Chemelex warranty and agency approvals to apply, the instructions that are included in this manual and with associated products must be followed.

1.2 Applications

This manual will discuss the installation, testing, and periodic maintenance of MI heating cable systems for the applications listed below:

- Heat loss replacement
- Comfort floor heating
- Radiant space heating
- Freezer frost heave prevention

For heating cable applications other than those listed above, please see your Chemelex representative or call us directly at 800-545-6258.

1.3 Installation Methods

The MI system may be installed as shown in Table 1 below:

Table 1: Installation Summary

Applications	Installation Method
Heat loss replacement	Attached to bottom of the concrete floor
Comfort floor heating	Embedded in mortar or concrete
Radiant space heating	Embedded in mortar or concrete
Freezer frost heave prevention	Placed in conduit buried in the subfloor underneath the insulation or directly embedded in the subfloor underneath the insulation

1.4 Typical Floor Heating System

A typical Raychem floor heating system is shown in Figure 1. The heating cable is supplied as a factory terminated assembly ready to install for a wide range of floor heating and freezer frost heave prevention applications. The cold leads can be connected directly to the junction box using the NPT threaded connectors provided. For optimum control and energy efficiency, a floor sensing temperature controller (thermostat) should be used to control the heating cables.

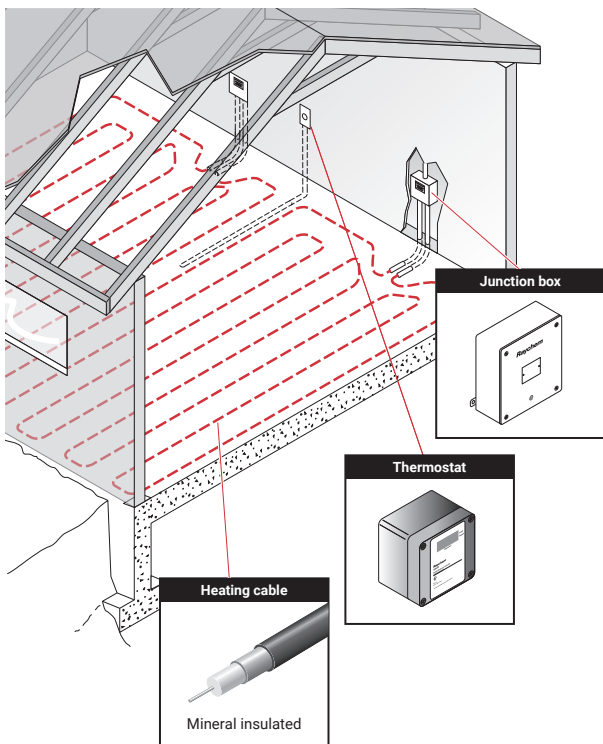


Figure 1: Typical floor heating system

1.5 Safety Guidelines

As with any electrical equipment, the safety and reliability of any floor heating or freezer frost heave prevention 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 heating 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.

Pay special attention to the following:

- Important instructions are marked  **Important**
- Warnings are marked  **WARNING**

1.6 Electrical Codes

Article 424 of the National Electrical Code (NEC) and Section 62 of the Canadian Electrical Code (CEC) govern the installation of space heating systems. All installations must be in compliance with these and any other applicable national and local codes.

1.7 Approvals

Raychem MI heating cables are approved for freezer frost heave prevention, comfort floor heating and radiant space heating applications. For a complete list of approvals, refer to the product data sheets available on our web site at Chemelex.com or contact your Chemelex representative.

Available Data Sheets:

- MI Heating Cable for Freezer Frost Heave Prevention Data Sheet (H58207)
- MI Heating Cable for Heat Loss Replacement, Floor Heating and Radiant Space Heating Data Sheet (H58208)
- MI Heating Cable for Surface Snow Melting in concrete, asphalt, and pavers Data Sheet (H56990)



MI heating cables and heating cable sets are cCSAus Certified for freezer frost heave protection and floor heating applications as shown below.

Comfort Floor Heating and Radiant Space Heating (Embedded in Concrete and Mortar Floors)

-PS/C

Heat Loss Replacement (Attached to the Bottom of Concrete Floors)

-PS/B

Freezer Frost Heave Protection (Cables in Conduit Embedded in Sand or Concrete)

-PS,X/D

Freezer Frost Heave Protection (Cables Directly Embedded in Sand or Concrete)

-PS/C



FM applies only to the bare copper and stainless steel cable for Freezer Frost Heave installation inside of conduits.



Important: For heat loss replacement applications where the cable is attached to the bottom of the concrete floor, contact Chemelex for additional information.

1.8 Warranty



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

1.9 Heating Cable Construction

Mineral insulated (MI) heating cables are comprised of one or two conductors surrounded by magnesium oxide insulation and a solid copper or Alloy 825 sheath. Copper sheath cables

are covered with an extruded low-smoke zero-halogen (LSZH) jacket that protects the copper sheath from corrosive elements that can exist when cables are directly embedded in concrete or mortar. All of the cables include both a heated section (heated length) and a nonheating cold lead section. These sections are joined at the hot/cold joint where the heating element is spliced into larger bus wires. A final transition at the end of the cold lead section provides an environmental seal and tails for the electrical connection. The heating cables are available as factory terminated configurations shown in Figure 2.

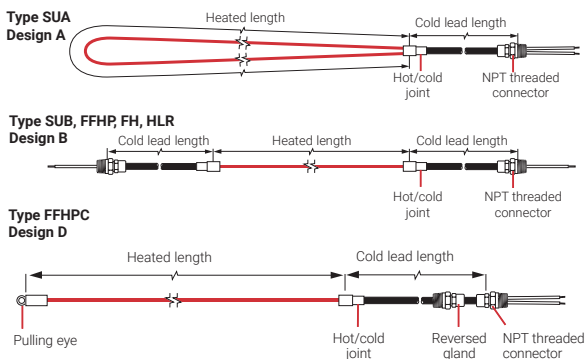


Figure 2: MI heating cable configuration

1.10 Heating Cable Identification

Each MI heating cable is supplied with an identification tag on which the heating cable catalog number is permanently printed. In addition to its identification purposes, the catalog number provides information regarding the heating cable length, power output, and operating voltage. Also printed on the tag are the serial number and temperature code.



Important: If the metal tag is removed during cold lead installation, it must be reinstalled on the cold lead within 3 in (7.5 cm) of the end of the cold lead/power connections.

Figure 3 shows a typical identification tag supplied with SUA/ SUB heating cables (SUA1 through SUB22). These heating cables are designed to be used for several different applications depending on the supply voltage selected. Figure 4 shows a typical identification tag supplied with FFHP, HLR, FH and FFHPC heating cables.



Figure 3: Typical SUA/SUB MI heating cable identification tag (front)



Important: Ensure that the heating cable is connected to the correct voltage for the intended application. Example: For freezer frost heave prevention applications, the cable must be connected to the voltage shown for “FROST HEAVE PROTECTION / PS, C” (Figure 3).



Figure 4: Typical heating cable identification tag for FFHP, HLR, FH and FFHPC cables (front)

1.11 Heating Cable Catalog Number Decoder

The heating cable catalog number may be broken out as shown in Figure 5 below.

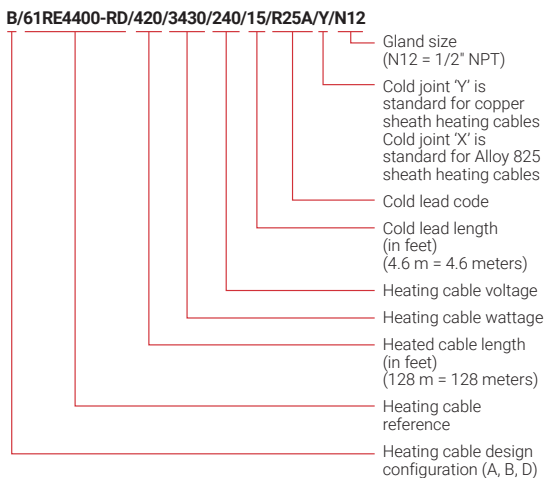


Figure 5: MI heating cable catalog number

2. GENERAL INSTALLATION GUIDELINES

2.1 Before You Start

The floor heating and freezer frost heave prevention system is an engineered system

that has been designed for your application.

To ensure a smooth, efficient installation and start-up, obtain all the relevant engineering

information before starting. Contact the general contractor, owner, or owner's representative to obtain a statement of the project design basis and project specifications.

These guidelines are provided to assist the installer throughout the installation process and should be reviewed before the installation begins.

2.2 References

Chemelex provides two design guides to help you verify the system design, and to obtain the best performance from your floor heating or freezer frost heave prevention system:

- Freezer Frost Heave Prevention Design Guide (H58139)
- Heat Loss Replacement Design Guide (H58157)

In addition, the installation should be in accordance with the instructions in this manual and the specific requirements of national and local electrical codes.

2.3 Heating Cable Storage

- Store the heating cables in a clean, dry location, in their shipping containers.
- Temperature range: -40°F to 140°F (-40°C to 60°C).
- Protect the heating cable from mechanical damage.

2.4 Tools Required

- The following tools are recommended for installing MI heating cables.
- Pliers
- 500 Vdc or 1000 Vdc megohmmeter (1000 Vdc recommended)
- Multimeter
- Large adjustable wrench
- Torque wrench
- Pay-off reel (to uncoil long cables)

2.5 Cable Testing Guidelines

Insulation resistance (IR) testing is recommended at four stages during the installation process and as part of regularly scheduled maintenance. Further details on IR testing can be found in Section 8.

- When received (prior to installation)
 - minimum 100 MΩ
- Continuously during placement of concrete, mortar, etc.
 - minimum 20 MΩ
- After the cables have been installed
 - minimum 20 MΩ
- Prior to initial start-up (commissioning) – minimum 20 MΩ including branch circuit wiring
- As part of the regular system inspection
- After any maintenance or repair work

2.6 General Installation Guidelines

Avoid damage to the MI heating cable as follows:

- Do not energize cables before the installation is complete.
- Use a pay-off reel to uncoil heating cable during installation; do not pull cable out into a spiral (Figure 6).

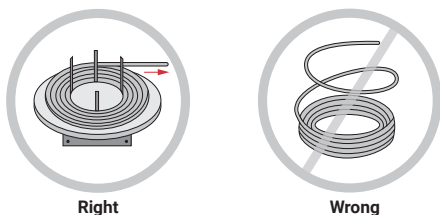


Figure 6: Unreeling/uncoiling cable

- Do not alter cable length.
- Avoid damaging heating cables by cutting or crushing (Figure 7).

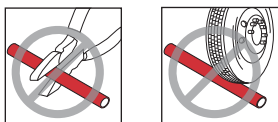


Figure 7: Avoid cutting and crushing the heating cable

- Do not install cables if the temperature is below -4°F (-20°C).
- Do not cross, overlap, or group heating cables (Figure 8). Grouped heating cables can cause localized overheating with a risk of fire or cable failure.



Figure 8: Do not cross, overlap, or group heating cables

- Do not repeatedly bend and straighten the cable.
- Space heating cable at least 1/2 in (13 mm) from any combustible surface.
- Install heating cable at the recommended spacing to ensure correct watt density.
- Use a plank to tip wheelbarrow on.
- Handle the hot/cold joint carefully. Support the joint on both sides when moving and positioning the cold lead.
- Position hot/cold joints 6 in (15 cm) in from edge of heated area and spaced at least 3 in (7.5 cm) apart from each other (do not bunch hot/cold joints – see Figure 9).

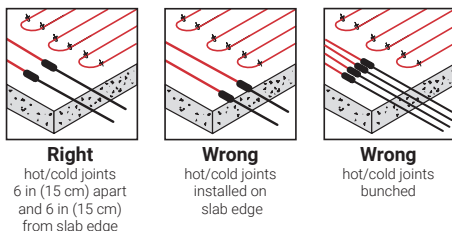


Figure 9: Positioning hot/cold joints

- During installation, protect tails from breaking where they emerge from brass pot by taping over tails and pot with electrical tape.
- Do not bend the heating cable or cold lead within 6 in (15 cm) of a splice, the hot/cold joint, or the end cap.
- Do not bend cable to an inside radius less than 6 times the outside diameter of the cable.
- Do not space runs of heating cable closer than 1 in (2.5 cm) together.
- Do not cross expansion joints
- Do not walk on the heating cable or do anything else that may damage the heating cable.
- Do not use sharp objects such as shovels, rakes, etc. when installing the cable (Figure 10).

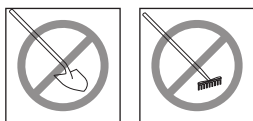


Figure 10: Avoid damage by not using shovels or rakes

2.7 Junction Boxes and Electrical Connections

- Make all electrical connections to supply cables in above grade junction boxes.
- Keep covers on junction boxes to prevent moisture from entering them.

2.8 Protecting the Heating Cable

On many projects, there is a delay between installation of the heating cables and placement of the concrete or mortar. If there is any delay at all, take the following precautions to protect the installation until the heating cables can be completely covered.

- Do not energize the heating cables.
- Mechanically protect the heating cables so that they cannot be damaged by being walked on, run over, painted, sandblasted, burned, welded, or cut.

2.9 Check Materials Received

Review the project specifications, drawings, and schedules and compare the list of materials to the catalog numbers of heating cables and components received to confirm that proper materials are on site. The heating cable catalog number, voltage, wattage, and length are printed on the metal tag attached to the cold lead.

- Ensure that the heating cable voltage rating is suitable for the power supply voltage available.
- Inspect the heating cable and components for in-transit damage.

2.10 Review the Design

Hold a project coordination meeting. Review the design at this meeting and ensure that the cables supplied meet the design requirements for the floor heating or freezer frost heave prevention application. This can be verified in conjunction with the appropriate design guide. During the meeting, discuss the role of each trade and the contractor.

Review the installation instructions in Section 3 for your specific application. This section gives details on the minimum and maximum concrete or mortar thickness required over the heating cables, cable testing requirements during installation, and other specific installation details. It is important that the heating cable depth and spacing be maintained for proper operation of the system. The installation details in Section 3 will be helpful in preparing the heating cable layout drawing.

For floor heating, radiant space heating and heat loss replacement systems, the area is generally divided into equal subsections, allowing for installation of a single cable in each subsection. For a three-phase supply, the area is generally divided into a multiple of three equal subsections, with a single cable installed in each subsection, resulting in a balanced electrical heating load.

The heating cables for freezer frost heave prevention systems may have been designed to be installed in conduit or directly embedded in a sand or concrete layer under the insulation. Section 3.4 and Section 3.5 cover the installation of heating cables in conduit and directly embedded in the subfloor. For large freezers using embedded cables, the recommended layout is to interlace the heating cables as shown in Figure 24, Section 3.5.

Mark the locations of all joints on the layout drawing. Plan the general layout of the heating cables to avoid crossing expansion joints. In some cases, the placement of these joints may have to be relocated in order to divide the area equally since the quantity of heating cables supplied may have been based on equal subsection areas.

Ensure that the cold lead length is sufficient to reach the junction box. The standard cold lead length for Design B cables is 15 feet, but heating cables may have been custom designed using longer cold leads. Plan the location of all junction boxes and supply points so that they are located within reach of the heating cable cold leads. Refer to Section 4 for further details.



Important: Retain the heating cable layout drawing for future reference.

Cable spacing may be confirmed as follows:

English

$$\text{Cable Spacing (in)} = \frac{\text{Heated Area (ft}^2\text{)} \times 12}{\text{Heating Cable Length (ft)}}$$

Metric

$$\text{Cable Spacing (cm)} = \frac{\text{Heated Area (m}^2\text{)} \times 100}{\text{Heating Cable Length (m)}}$$



Important: The heating cable spacing may have to be adjusted to ensure uniform coverage over the area to be heated.

In floor heating installations using a single concrete pour, the heating cable may be attached to the reinforcement using plastic tie wraps, providing that the reinforcement is close enough to the surface so that the finished concrete cover over the heating cables will not exceed the maximum recommended thickness (see Section 3.2). If the reinforcement is well below the finished surface, the cables should be attached to mesh and supported at a level such that the maximum recommended concrete cover is not exceeded.

For two-pour concrete installations, a base slab is first poured and allowed to set-up. Prepunched strapping is attached to the base slab at 30 in (76 cm) intervals, perpendicular to the runs of heating cable. The tabs on the prepunched strapping are bent backwards over the cable to hold the cable in place (Figure 11).

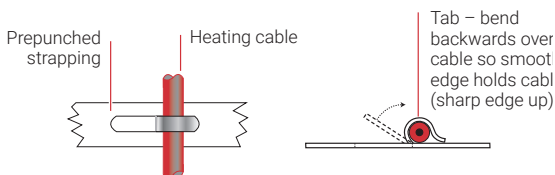


Figure 11: Method of bending tabs on prepunched strapping

2.11 Temperature Controller

Use a temperature controller to regulate the temperature for all floor heating, radiant space heating, heat loss replacement, and freezer frost heave prevention applications.

Floor heating systems should use a temperature controller with the sensor installed in the floor between two runs of heating cable. Freezer frost heave prevention systems require that the sensor be installed in the sand bed or concrete, underneath the insulation, between two runs of heating cable. For radiant space heating systems, an ambient temperature control, with an over-limit sensor installed in the floor, is recommended.

For embedded applications, install the sensor in metal conduit; this allows for easy replacement if the sensor fails. Ensure that bends in the conduit are gradual to allow the sensor to pass through them (do not use manufactured elbows). Cap the buried end of the conduit so that it is watertight and install the conduit midway between two runs of heating cable and away from high concentrations of cables. The conduit should be long enough to extend out to approximately the middle of the area being heated (see Figure 12).

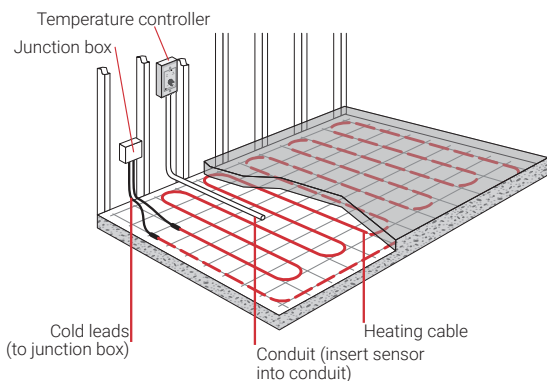


Figure 12: Typical temperature controller installation

2.12 Visual Inspection

A visual inspection of the heating system should be made before placement of the concrete or mortar to ensure that it is properly installed.

- Verify that there is no mechanical damage to the heating cables (cuts, breaks, burns, scrapes, etc.).
- Verify proper heating cable spacing and depth (if embedded) for the application.
- Verify proper heating cable fastening method (do not use tie wire to secure embedded cables).
- Verify that the cold leads are protected where they emerge from the heated slab.
- Ensure that the heating cable does not cross expansion joints.
- Verify that junction boxes are mounted above grade so that moisture cannot enter them. Inspect the junction box gasket.



WARNING: Fire Hazard. Damaged heating cable can cause arcing or fire. Do not energize damaged heating cable; repair or replace it.

For installation assistance or technical support, please contact your Chemelex representative or contact Chemelex directly at 800-545-6258.

3. HEATING CABLE INSTALLATION

This section provides instructions for installing heating cables for comfort floor heating and radiant space heating, freezer frost heave prevention, and heat loss replacement applications. The system being installed should have already been designed using the appropriate design guide (see Section 1.1). Read and follow these instructions to ensure that the system performs reliably and as intended.

3.1 Installation Methods

The MI heating cables may be installed in four distinct ways. Table 2 summarizes each method and indicates which section in the manual contains the installation instructions for that particular method.

Table 2: Installation Method and Applicable Manual Section

Applications	Installation Method	Applicable Manual Section
Comfort floor heating	Embedded in mortar or concrete	3.2
Radiant space heating	Embedded in mortar or concrete	3.2
Heat loss replacement for concrete floors above unheated spaces	Attached to the bottom of the concrete floor	3.3
Freezer frost heave prevention	Placed in conduit buried in the concrete subfloor underneath the insulation	3.4
	Directly embedded in the concrete subfloor or in a sand bed underneath the insulation	3.5

3.2 Comfort Floor Heating and Radiant Space Heating (Embedded in Concrete and Mortar Floors)

Section 3.2 covers the installation of MI heating cables embedded in concrete or mortar floors for comfort floor heating and radiant space heating applications. Read and follow these instructions to ensure that the system performs reliably and as intended.

Review and understand the requirements in Section 2 prior to installing the heating cables.

A successful design and installation must conform to the following requirements:

Comfort Floor Heating

- 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.
- The 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.

Radiant Space Heating

- The BTU requirement and total heated area are provided by the customer.
- The bottom of the floor is insulated or located on grade.
- The MI heating cables are embedded in a concrete floor or embedded in a mortar layer, at least 3/4 in (2 cm) thick, under ceramic tile or natural stone.



Important: Divide BTU/hr by 3.412 to convert to watts.

Precautions

- To ensure a long lasting, dependable system, the heating cable must be embedded in a structurally sound setting-bed. A setting-bed that crumbles, settles, or cracks can damage the heating cable. Always design the setting-bed to applicable local codes, reinforce with wire mesh or rebar, and use high quality materials.
- The recommended installation procedure is to attach the heating cable to the wire mesh or rebar. Do not staple the heating cable directly to a wooden subfloor. Heating cables must be anchored securely to maintain the correct spacing and depth.



Important: Allow for setting-bed expansion. If the floor tiles are constrained, they will crack or pop loose when the heating cable is energized. Therefore, be sure to allow a 1/2 in (1.3 cm) gap between the tile's edge and all room walls.

Positioning the Heating cable

When positioning the cable, follow these instructions:

- Arrange the heating cable in a serpentine pattern to uniformly cover the area to be heated.
- Do not extend the heating cable beyond the room or area in which it originates.
- Maintain the design heating cable spacing within 1 in (2.5 cm).
- Provide a setting bed at least 3/4 in (2 cm) thick.
- For single pour installations, use plastic cable ties to attach the heating cable to reinforcing mesh approximately every 30 in (76 cm). The reinforcement edges are sharp and can damage the heating cable. Tension the cable ties by hand and avoid walking on the cables once installed on the reinforcement.
- For two-pour installations, attach the heating cable to the prepunched strapping every 30 in (76 cm).

- Do not route the heating cable closer than 4 in (10 cm) to the edge of the setting bed, drains, anchors, pipes, or other material in the setting bed.
- Terminate the cold leads in a UL Listed or CSA Certified junction box.
- Do not cross expansion joints.
- Do not install the heating cable in ceilings or walls.
- Do not install the cable under shower floors, under tubs and spas, cupboards, or under other permanent fixtures.

Installing the Heating Cable

Follow the appropriate instructions in each step below for a single-pour or two-pour installation. Where a step does not differentiate between a single-pour or two-pour installation, the instructions are common to both.

1. Mark the location of control and expansion joints on the edge forms and on the heating cable layout drawings. Do not cross expansion joints.
2. Install the junction boxes (see Section 4 and Figure 13 for details). For single conductor cables (Design B – see Section 1.9), the cable layout should begin and end at the junction box to allow both cold leads to be connected to the junction box.

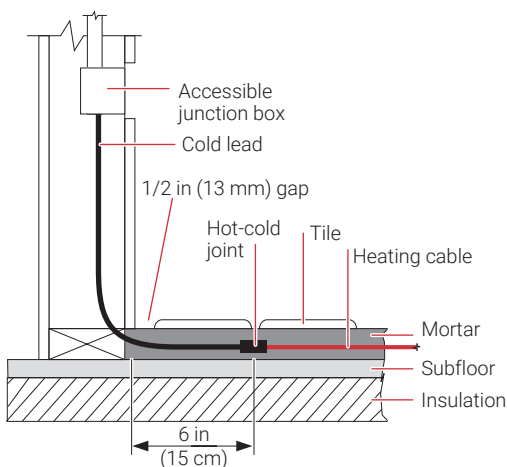


Figure 13: Typical junction box installation

3. **Single-pour:** If supporting cable on the reinforcement, ensure that the concrete thickness over the cable will not exceed 2 in (5 cm). Refer to Section 2.10 and Figure 15 for further details. If installing the heating on a wooden subfloor, cover the subfloor with metal lath. Ensure edges butt together, but do not overlap (Figure 14).

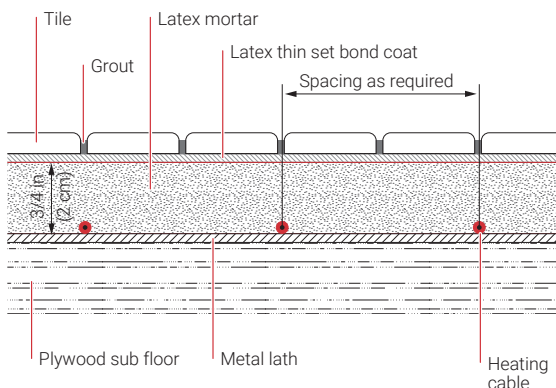


Figure 14: Typical installation on wooden subfloor

Two-pour: Install prepunched strapping at 30 in (76 cm) intervals on the base slab with additional runs, where required, to hold cable loops securely. Fasten the strapping to the concrete base using an appropriate fastening method (see Section 2.10). Ensure that the concrete thickness over the cable will not exceed 2 in (5 cm). Refer to Figure 15 for further details.

4. Lay out the heating cable in a serpentine pattern, at the predetermined spacing as specified in the design requirements, to uniformly cover the area to be heated (see Section 2.10). For single pour installations, fasten the cable to the reinforcement (or metal lath) with plastic tie wraps at 30 in (76 cm) intervals. For two-pour installations, use the tabs on the prepunched strapping to secure the cable at the predetermined spacing. Stay at least 4 in (10 cm) from edges and outer walls. Refer to Figure 16 if crossing control joints.



Important: Cable spacing will generally not exceed 9 in (23 cm).

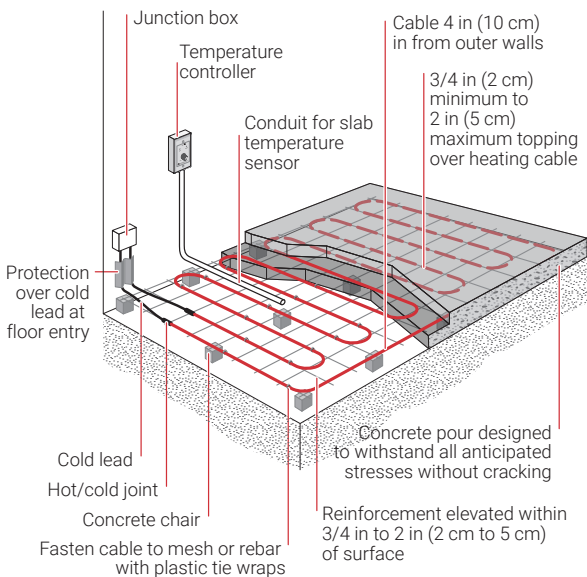


Figure 15: Typical single pour concrete floor installation

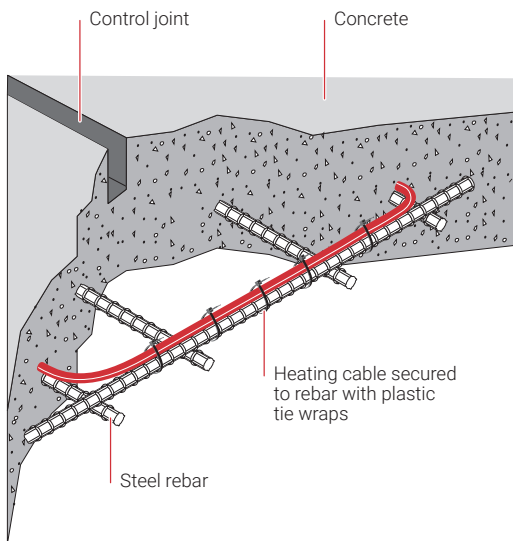


Figure 16: Method of crossing control joints



Important: Reinforcing rod, mesh or other materials used for the support of, or on which the heating cables are installed, must be grounded in accordance with CSA Standard C22.1, Section 10 or the National Electrical Code as applicable.

5. Install hot/cold joints so that they are at least 6 in (15 cm) in from the edge of the slab; ensure that they will be completely embedded in the concrete. Protect the cold leads where they emerge from the slab.
6. Install a 1/2 in (1.3 cm) minimum metal conduit for the slab temperature sensor between two runs of heating cable (see Section 2.11 for further details). An Raychem RTD sensor will require a larger diameter conduit. Ensure that the sensor will pass through all bends before continuing with the next step.



Important: Do not permanently install the temperature sensor at this time.

7. Visually inspect the heating cables, cold leads, and junction

boxes (see Section 2.12) and record the results in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10.

8. Check the insulation resistance before the concrete or mortar is poured to verify that the cables were not damaged during installation (see Section 8 for details). Record the results of the tests in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10. Damaged cables must be repaired before installation can continue.
9. Cover the heating cable with a minimum 3/4 in (2 cm) to maximum 2 in (5 cm) concrete or mortar topping. During the pour, do not use sharp tools such as rakes, shovels, etc. that might damage the heating cable. Continuously check the insulation resistance as the concrete or mortar is being poured to verify that the cables are not damaged during the pour.
10. Allow the concrete to cure following the specifications in the contract documents. Do not energize the heating cables during the curing period. Do not allow traffic on the new completed surface until adequate stability has been attained and the material has cured sufficiently.



Important: Use caution when saw cutting control joints to avoid damaging the heating cables. Consult with the electrical contractor or cable installer before cutting or drilling to determine cable depth.

3.3 Heat Loss Replacement (Attached to the Bottom of Concrete Floors)

Section 3.3 covers the installation of MI heating cables attached to the bottom of concrete floors for heat loss replacement applications. Read and follow these instructions to ensure that the system performs reliably and as intended.

Review and understand the requirements in Section 2 prior to installing the heating cables.

Positioning the Heating Cable

When positioning the cable, follow these instructions:

- Arrange the heating cable in a serpentine pattern to uniformly cover 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 concrete floor, drains, anchors, or other material in the concrete.
- Terminate the cold leads in a UL Listed or CSA Certified junction box.

Attaching the Heating Cable to the Bottom of the Floor

The heating cable may be installed using one of the two methods following:

1. a) Using foil backed fiberglass board rigid insulation to hold the cable in contact with the floor. The heating cable is fastened in place with prepunched strapping and tie wire as shown in Figure 17. If necessary, the fiberglass board insulation may be held in place with insulation pins as shown in Figure 19.

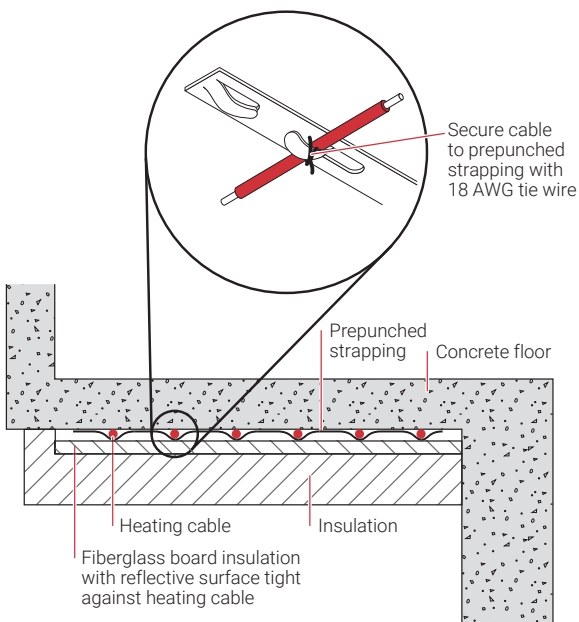


Figure 17: Heating cable held in place by rigid floor insulation

b) When there is equipment space below the floor, the heating cable is secured to the bottom of the floor and the insulation is supported by a drop ceiling below the equipment (Figure 18).

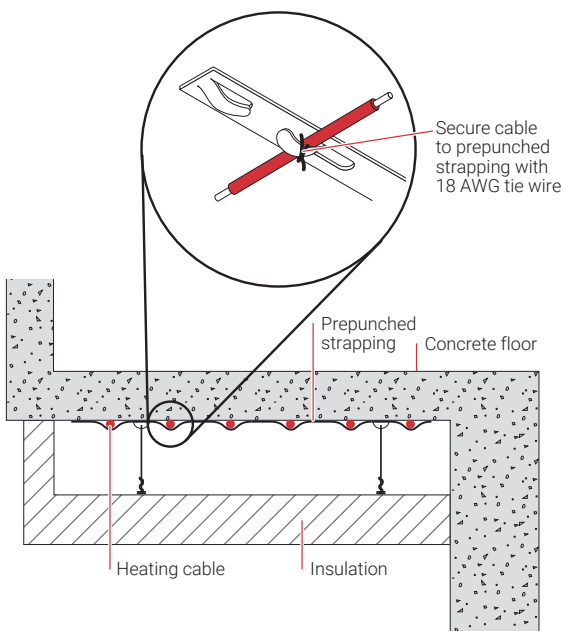


Figure 18: Heating cable when equipment space is below the floor

2. Install the junction boxes. For single conductor cables, the cable layout should begin and end at or close to the junction box to allow the cold leads to be fed back to the junction box. Refer to Section 4 for junction box details.
3. Attach prepunched strapping to the bottom of the concrete floor on approximately 30 in (76 cm) centers, perpendicular to the intended runs of heating cable. If using insulation pins or equivalent to secure the insulation (Figure 19), install the insulation pins over the entire area to be heated in accordance with the manufacturer's recommendations, prior to installing the prepunched strapping (pins must be in straight rows to allow installation of the prepunched strapping).

4. Lay out the heating cable in a serpentine pattern at the predetermined spacing as specified in the design requirements (see Section 2.10). Use the clips on the prepunched strapping to hold the cables in place and secure the cable to the strapping using #18 AWG tie wire or equivalent (Figure 17 and Figure 18). This will prevent the cable from coming loose from the pre-punched strapping as it expands and contracts during the heating and cooling cycles.

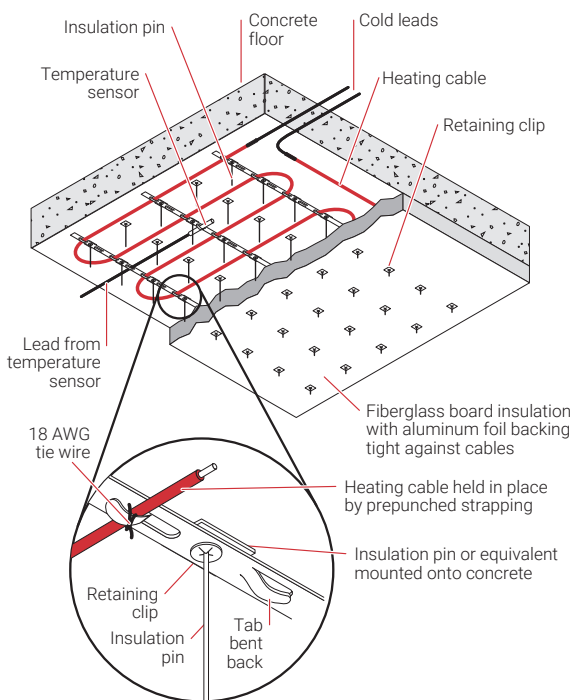


Figure 19: Rigid insulation held in place using insulation pins

5. Install the hot/cold joints so that they are at least 6 in (15 cm) in from the edge of the heated area and will be located under the insulation. The cold leads can be connected to the junction box without any additional protection. If exposed to mechanical damage, the cold leads should be protected with conduit (see Section 4.1 for details).
6. Install the temperature sensor from the thermostat between two runs of heating cable and secure to the floor.
7. Visually inspect the heating cables, cold leads, and junction boxes (see Section 2.12) and record the results in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10.
8. Check the insulation resistance before installing the insulation to verify that the cables were not damaged during installation (see Section 8 for details). Record the results of the tests in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10. Damaged cables must be repaired before installation can continue.

Installing Thermal Insulation

Insufficient insulation will increase heat loss from the floor and may lead to lower floor temperatures. The insulation type and thickness should be shown in the design specifications. If the insulation is being used to hold the heating cable to the floor (Figure 17 and Figure 19), use rigid fiberglass board insulation with a foil backing on one side and ensure that the insulation is supported so that all points along the heating cable circuit are firmly in contact with the bottom of the floor. Contact Chemelex if other types of insulating materials have been specified.

Immediately after insulation installation, check the insulation resistance of the heating cables (see Section 8 for details). Repair or replace damaged cables.



WARNING: Fire Hazard. Damaged heating cables can cause arcing or fire. Do not energize a damaged heating cable; repair or replace it.

3.4 Freezer Frost Heave Protection (Cables in Conduit Embedded in Sand or Concrete)

Section 3.4 covers the installation of MI heating cables in conduit embedded in sand or concrete for freezer frost heave prevention applications. Read and follow these instructions to ensure that the system performs reliably and as intended.

Review and understand the requirements in Section 2 prior to installing the heating cables.

Positioning and Installing the Conduit

When positioning the conduit, follow these instructions:

- Arrange the conduit to uniformly cover the area to be heated.
- Maintain the center-to-center conduit spacing within 1 in (2.5 cm).
- Use only UL Listed or CSA Certified 3/4 in (2 cm) or larger diameter rigid galvanized steel or rigid aluminum electrical conduit. Consult your local electrical code for any other specific requirements.
- Do not route the conduit closer than 4 in (10 cm) to drains, anchors, or other material in the concrete.
- Install straight runs of conduit only.
- Install only one run of heating cable per conduit.

Installing the Heating Cable

1. Prepare the conduits in accordance with Figure 20. The “stub up” at the far end from the power supply allows long runs of heating cable to be pulled into the conduit. Conduits should be finished on the far end with a male NPT thread to allow a cap to be installed. The power supply end should be terminated with suitably sized female NPT thread to allow the reversed gland supplied on the heating cable (usually 3/4 in NPT) to make a liquidtight/airtight connection.



Important: If straight runs of conduit without the “stub-up” are used, the ends of the conduit must be accessible from a trench in the floor.



Important: Make all conduit bends with as large a radius as practical (minimum 12 in (30 cm) radius recommended). Seal all conduit ends and joints to prevent sand or concrete entry during placement of the floor.

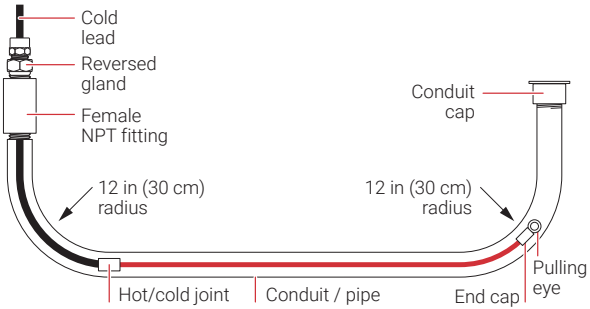


Figure 20: Typical conduit preparation

2. Install conduits uniformly spaced across the width (or length) of the freezer as per design drawings. The heating cable is supplied with a “Reversed Gland” which is used to make a liquidtight/airtight seal where the cold lead enters the conduit. Observe good trade practices and the requirements of the National Electrical Code (NEC) and Canadian Electrical Code (CEC) for electrical conduit.
3. Install a 1/2 in (1.3 cm) minimum metal conduit for the temperature sensor between two runs of conduit installed in the previous step (see Section 2.11 for further details). An RTD sensor will require a larger diameter conduit. Ensure that the sensor will pass through all bends before continuing with the next step.



Important: Do not permanently install the temperature sensor at this time.

4. Cover the conduits with a minimum 3 in (7.5 cm) layer of sand and compact before installing insulation.



Important: Conduits can also be installed in a concrete base rather than a sand base.

5. Install rigid insulation over the compacted sand as per design schedule (see Figure 21). Insulation thickness is based on the design parameters and is usually between 2 in to 6 in (5 cm to 15 cm) thick. **Using insulation with the wrong R-value will increase heat loss, possibly causing the subsoil to freeze, leading to freezer floor damage.**

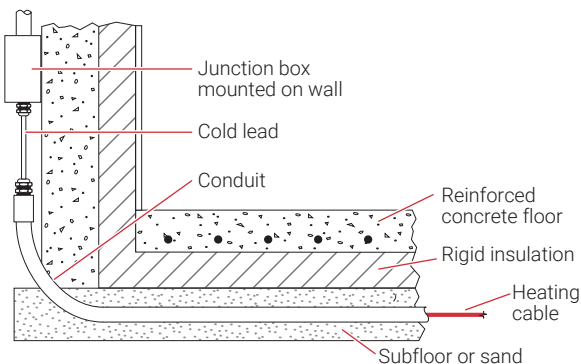
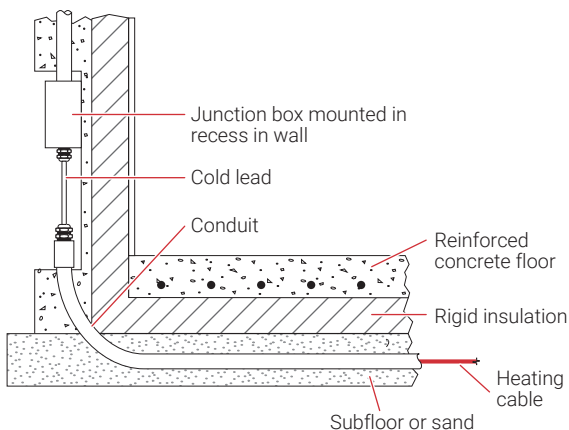


Figure 21: Typical conduit and junction box installation

6. Pour a high quality concrete floor to thickness and strength required for the application.
7. Install heating cables in conduit. The heating cable is supplied with a "pulling eye" that is used to pull the cable into the conduit. This is usually a two person operation and one person should feed the cable from the power supply end while the second person pulls the heating cable into the conduit from the other end.

8. After installing all heating cables, cap the far end of the conduits. Tighten the reversed gland into the power supply end of the conduit.
9. Before connecting the cold leads to the junction boxes, check the insulation resistance of the heating cables to verify that the cables were not damaged during installation (see Section 8 for details). Record the results of the tests in the Heat Loss Replacement & Freezer Frost Heave Prevention Installation Record in Section 10.

3.5 Freezer Frost Heave Protection (Cables Directly Embedded in Sand or Concrete)

Section 3.5 covers the installation of MI heating cables directly embedded in sand or concrete for freezer frost heave prevention applications. Read and follow these instructions to ensure that the system performs reliably and as intended.

Review and understand the requirements in Section 2 prior to installing the heating cables.

Positioning the Heating Cable

When positioning the cable, follow these instructions:

- Arrange the heating cable in a serpentine pattern to uniformly cover 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 drains, anchors, pipes, or other material in the floor.
- Terminate the cold leads in a UL Listed or CSA Certified junction box.
- Do not cross expansion joints.
- Do not install the heating cable in ceilings or walls.

Installing the Heating Cable

1. For large freezers exceeding 40 ft (12 m) in width or length, it is recommended that the heating cables be installed in a sand bed (subfloor). For smaller freezers, the heating cable can be installed directly in a sand or concrete subfloor.

2. Install the junction boxes (see Section 4 for details). For single-phase circuits using Design B cables (see Section 1.9), the cable layout should begin and end at the junction box to allow both cold leads to be connected to the junction box (Figure 23). For three-phase circuits where the heating cables are Wye connected to the power supply, the junction boxes may be located at opposite ends of the freezer as shown in Figure 24. Refer to the design drawings for exact junction box locations.
3. Prepare initial sand base and compact to conform to accepted engineering specifications to maintain structural stability. This base must be approximately 2 in (5 cm) thick after compaction. Another 2 in (5 cm) layer will be required after the cables have been installed (see Figure 22).

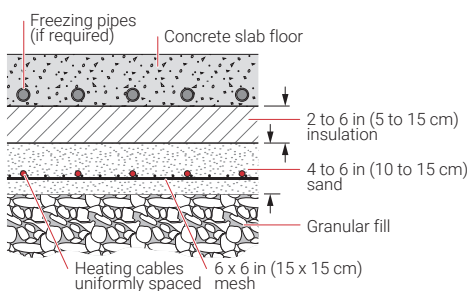


Figure 22: Typical cross section of heating cable in freezer floor

4. Cover the area with 6 in x 6 in (15 cm x 15 cm) mesh. The heating cables will be attached to the mesh to maintain the required spacing.



Important: For large freezers or ice arenas, 1 in (2.5 cm) deep grooves may be placed in the compacted sand base at the required cable spacing. The heating cable can then be set into the grooves to maintain the cable spacing.

5. Lay out the heating cable in a serpentine pattern, at the predetermined spacing as specified in the design requirements, to uniformly cover the area to be heated (see Section 2.10). Stay 12 to 24 in (30 to 60 cm) from outer walls. Fasten the heating cables to the mesh, if used, at 30 in (76 cm) intervals using plastic cable ties or equal. Typical cable spacing ranges between 18 to 60 in (46 cm to 152 cm) on centers. Figure 23 and Figure 24 show typical single-phase and three-phase heating cable layouts.



Important: For single-phase circuits, if the heating cable is laid out parallel to one side and the cable length is not an even multiple of the length of that side, it will be necessary to change the direction of the last run of cable (see Figure 23). This is necessary to maintain the proper spacing between cable runs and to allow the second cold lead to return to the junction box.



Important: For three-phase Wye connected circuits, the cable runs are generally interlaced as shown in Figure 24. If the heating cable is laid out parallel to one side and the cable length is not a multiple of the length of that side, it will be necessary to change the direction of the last run of cable in order to maintain the proper spacing between cable runs.

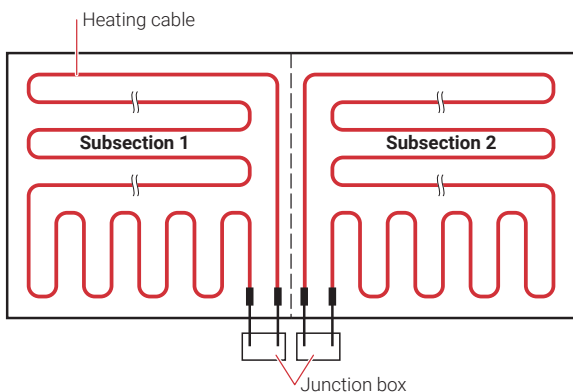


Figure 23: Typical layout for single-phase connected cables

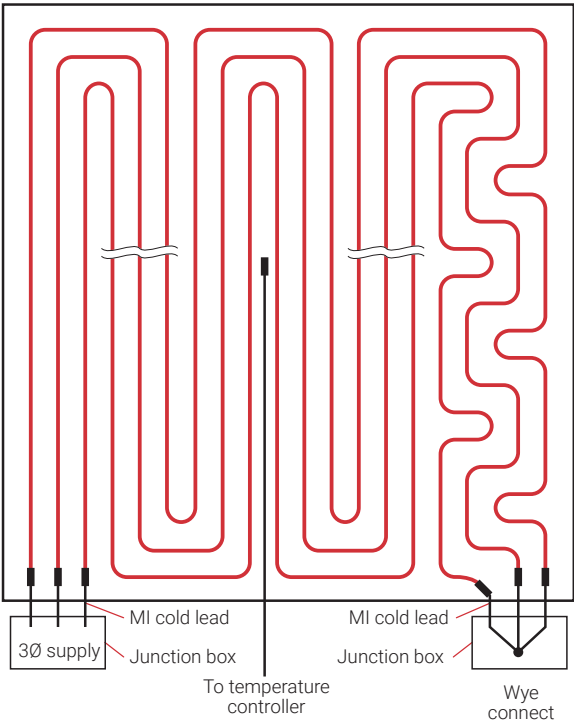


Figure 24: Typical layout for three-phase Wye connected cables

6. Install hot/cold joints so that they are at least 12 to 24 in (30 to 60 cm) in from the edge of the heated area; ensure that they will be completely embedded in the sand bed. Protect the cold leads where they emerge from the slab.
7. Install a 1/2 in (1.3 cm) minimum metal conduit for the temperature sensor between two runs of heating cable (see Section 2.11 for further details). Ensure that the sensor will pass through all bends before continuing with the next step.



Important: Do not permanently install the temperature sensor at this time.

8. Visually inspect the heating cables, cold leads, and junction boxes (see Section 2.10) and record the results in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10.
9. Check the insulation resistance before covering the cables to verify that the cables were not damaged during installation (see Section 8 for details). Record the results of the tests in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10. Damaged cables must be repaired before installation can continue.
10. Place sand over the heating cables to completely embed the cables. This layer should also be approximately 2 in (5 cm) thick after compaction. Continuously check the insulation resistance as the sand is placed to verify that the cables are not damaged while placing and leveling the sand.
11. Install rigid insulation over the compacted sand as per design schedule. Insulation thickness is based on the design parameters and is usually between 2 in to 6 in (5 cm to 15 cm) thick. **Using insulation with the wrong R-value will increase heat loss, possibly causing the subsoil to freeze, leading to freezer floor damage.**
12. Pour a high quality concrete floor to thickness and strength required for the application per engineering specifications.

4. COMPONENT INSTALLATION

4.1 Junction Boxes

MI heating cables must be connected to UL Listed or CSA Certified junction boxes suitable for the location (UL Listed heating cables must be connected to UL Listed junction boxes). Metallic junction boxes with threaded entries, such as aluminum junction boxes, are recommended.

Mount the junction box in or on a wall, above grade level, adjacent to the heated area. Embedding junction boxes in the floor slab or too low to the ground may allow moisture to enter the junction box, resulting in cable failure.

Screw the threaded connector on the cold lead into the junction box (Figure 25) until it is tight. When using a metallic junction box with knockouts, secure the threaded connector to the junction box using locknuts on both sides of the connector.

Install the cold lead “pot” so that it extends 2 in (5 cm) above the bottom of the junction box as shown in Figure 25 and Figure 27. Tighten the compression nut (back nut) to the torque setting indicated on the tag attached to the NPT threaded connector to ensure that the cable sheath is properly grounded. This will complete the ground path from the cable sheath to the junction box.



Important: Minimize handling the tails to avoid breakage.

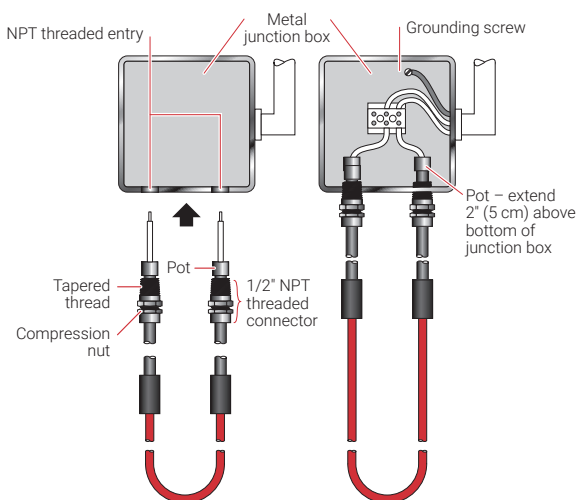


Figure 25: Metal junction box with threaded entries (Design B cable shown)

When using nonmetallic junction boxes, the NPT threaded connectors must be properly grounded using ground hubs (see Figure 26). Use a 1/2 in NPT ground hub or a 3/4 in NPT ground hub with a 1/2 in reducer. A typical installation detail is shown in Figure 27.

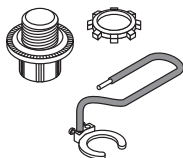


Figure 26: Typical ground hub

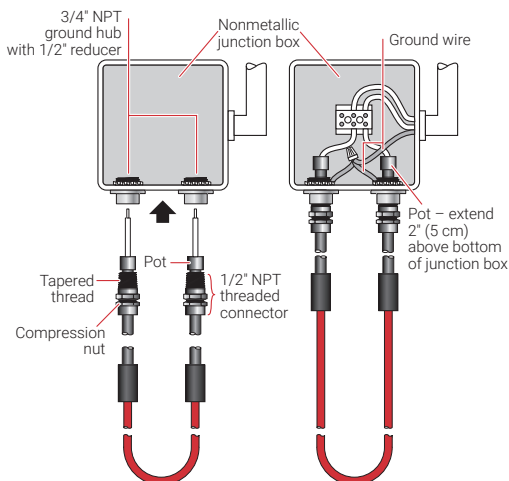


Figure 27: Nonmetallic junction box with ground hubs (Design B cable shown)

If required, the cold leads may be fed through nonmetallic conduit when making connections to the junction box. The conduit must be of large enough size to allow the threaded connectors to fit through the conduit. Exposed cold leads must be protected with a metal guard to prevent them from being damaged.



Important: It is recommended that the cold leads be fed through nonmetallic conduit. If using metal conduit, ensure that both cold leads on single conductor cables are fed through the same conduit.



Important: Do not feed more than six single conductor cold leads (from three heating cables), or three two-conductor cold leads through the same conduit.

4.2 Temperature Controller Sensor Installation

For applications where the heating cable is embedded in concrete, mortar or sand, insert the temperature sensor from the controller into the conduit that was previously installed (see Section 2.11). For heat loss replacement applications, the sensor should have been installed between two runs of heating cable and secured to the slab surface. Mount the controller on a wall close to the conduit for the sensor and high enough off the floor to allow easy adjustment. Set the temperature as specified in the design requirements.

5. CONTROL SYSTEMS

For optimum control and energy efficiency, a temperature controller should be used to regulate the floor heating, freezer frost heave prevention, or heat loss replacement system. Where temperature control and temperature monitoring is desired, an Raychem C910-485 or ACS-30 controller is recommended.

Table 3: Control Systems

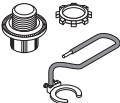
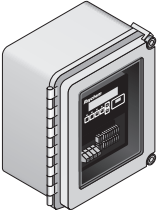
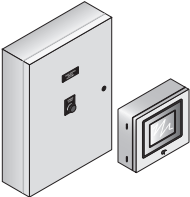
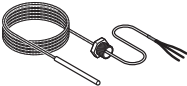
Description	
Electronic thermostats and accessories	
 ECW-GF	The ECW-GF is an ambient or slab-sensing electronic controller with 30-mA ground-fault protection. The controller can be programmed to maintain temperatures up to 200°F (93°C) at voltages from 100 to 277 V and can switch current up to 30 Amperes. The ECW-GF is complete with a 25-ft (7.6-m) temperature sensor and is housed in a NEMA 4X rated enclosure. The controller features an AC/DC dry alarm contact relay.
 ECW-GF-DP	An optional 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.
 MI-GROUND-KIT	Grounding kit for ECW-GF and C910-485 controllers.

Table 3: Control Systems

Description	
Continued	
Electronic controllers and sensors	
 C910-485	The C910-485 is a compact, full-featured, microprocessor-based, single-point commercial heating cable control system with integrated equipment ground-fault protection. The C910-485 provides control and monitoring of electric heating cable circuits for commercial heating applications. The C910-485 can be set to monitor and alarm for high and low temperature, low current, and ground-fault level. The C910-485 includes a communication module to remotely configure, control and monitor the heating cable circuits through a building management system (BMS).
 ACS-30 ACS-PCM2-5	The ACS-30 Advanced Commercial Control System is a multipoint electronic control and monitoring system for heat-tracing used in commercial freeze protection and flow maintenance applications. The ACS-30 system can control up to 260 circuits with multiple networked ACS-PCM2-5 panels. 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.
 RTD10CS	Stainless steel jacketed three-wire RTD (Resistance Temperature Detector) used with C910-485 and ACS-30 controllers. RTD10CS: temperature sensor with a 10-ft (3 m) flexible armor, 18-in (457 mm) lead wire and 1/2-inch NPT bushing.

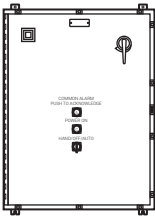
5.1 Power Distribution

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 Raychem HTPG power distribution panel

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

Table 4: Power Distribution

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

6. POWER SUPPLY AND ELECTRICAL PROTECTION

6.1 Voltage Rating

Check the incoming electrical supply to verify that the voltage to be connected to the heating cable is correct. The heating cable voltage rating is printed on the cable tag. For a Wye connected three-phase system, the heating cable voltage rating printed on the tag will equal the phase-to-phase supply voltage divided by the square root of 3 ($V_{\phi-\phi} / \sqrt{3}$).

6.2 Circuit Breaker Sizing

Size circuit breakers according to electrical code requirements. Single-phase connected heating cables require single-pole circuit breakers if one leg of the circuit is wired to a neutral, otherwise two-pole breakers are required. For three-phase connected heating cables, 3-pole circuit breakers are required. Generally, heating cable current draw, supply voltage, and wiring configuration are required to size circuit breakers. Refer to the heating cable tag for the electrical characteristics of the heating cable.

The minimum breaker size may be determined as follows:

Single-Phase Circuit

For a single-phase connected heating cable circuit, the minimum breaker size can be calculated using the following formula:

$$\text{Breaker size} = \text{Heating cable current}^* \times 1.25$$

*Heating cable current = Watts/Volts (see cable ID tag)

Balanced Three-Phase Circuit

For a Delta connected heating cable circuit, the minimum breaker size can be calculated using the following formula:

$$\text{Breaker size} = \text{Heating cable current}^* \times \sqrt{3} \times 1.25$$

For a Wye connected heating cable circuit, the minimum breaker size can be calculated using the following formula:

$$\text{Breaker size} = \text{Heating cable current}^* \times 1.25$$

*Heating cable current = Watts/Volts (see cable ID tag)

6.3 Ground-Fault Protection

Use circuit breakers with ground-fault protection on all heating cable circuits. If commercially available ground-fault circuit breakers are not available for the voltage and current rating of the circuit, ground-fault protection may be accomplished using a shunt trip breaker and ground-fault sensor (see Figure 34 on page 54 and Figure 35 on page 55) or using an HTPG series power distribution and control panel.

Ground-fault equipment protection (GFEP) is required for all floor heating, freezer frost heave prevention and heat loss replacement installations to prevent arcing or fire if the cable is improperly installed or damaged. To minimize the risk of fire, Chemelex and national electrical codes require both ground-fault protection of equipment and a grounded metallic covering on all heating cables. Ground-fault protection must be provided by the installer.



WARNING: Fire Hazard. 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 Chemelex, 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.



WARNING: Fire Hazard. To prevent shock or personal injury, disconnect all power before making connections to the heating cable.

6.4 Junction Box Wiring

Typical junction box wiring for a single-phase connected heating cable is shown in Figure 28. Balanced three-phase connected heating cables (cables are the same voltage and wattage) are shown in Figure 29 and Figure 30. In the delta connected circuit shown in Figure 29, the three heating cables are connected to a single junction box, but could be connected to individual junction boxes and three-phase connected at the contactor or electrical supply panel.

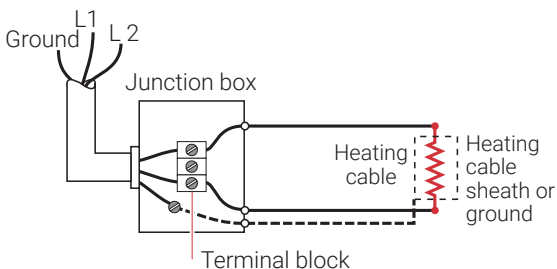


Figure 28: Typical single-phase connection

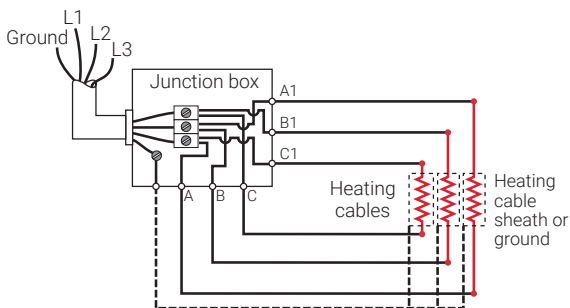


Figure 29: Typical three-phase Delta connection

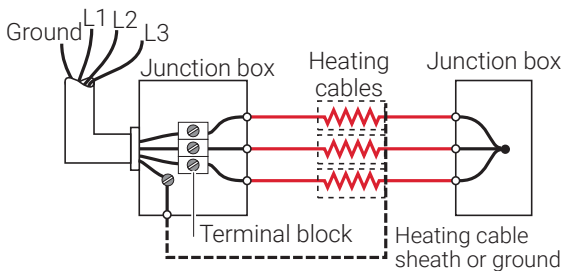


Figure 30: Typical three-phase Wye connection

6.5 Heating Cable and Controller Wiring

MI heating cable circuits that do not exceed the current rating of the selected controller can be switched directly as shown in Figure 31 and Figure 32. Use a contactor when switching loads greater than the maximum current or voltage rating of the temperature controller.

For group control, multiple single-phase and three-phase heating cable circuits may be controlled by a single temperature controller through a contactor, as shown in Figure 33.

Alternatively, a customized ACS-30 electronic controller may be used to individually control, or group control, two or more single-phase or three-phase circuits.

Temperature controller wiring diagrams can be found in the manufacturer's instructions supplied with the controller. In addition, follow all requirements of national and local electrical codes when connecting heating cables and controllers.

When connecting heating cables in a three-phase Delta configuration, the heating cable voltage must equal the phase-to-phase supply voltage; e.g., on a 480 V, three-phase supply, the heating cable voltage must equal 480 V (Figure 34). In a three-phase Wye configuration, the heating cable voltage must equal the phase-to-neutral supply voltage; e.g., on a 480 V, three-phase supply, the heating cable voltage must equal 277 V (Figure 35). For wiring configurations outside the scope of this manual, please contact your Chemelex representative for assistance.

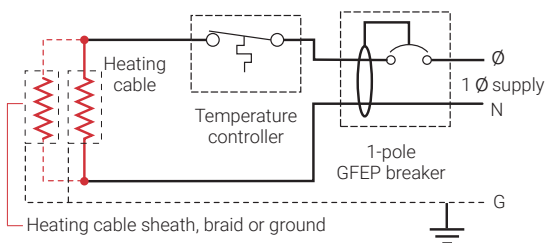


Figure 31: Single circuit control (cables connected phase-to-neutral)

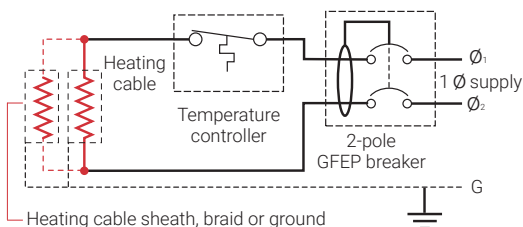


Figure 32: Single circuit control (cables connected phase-to-phase)

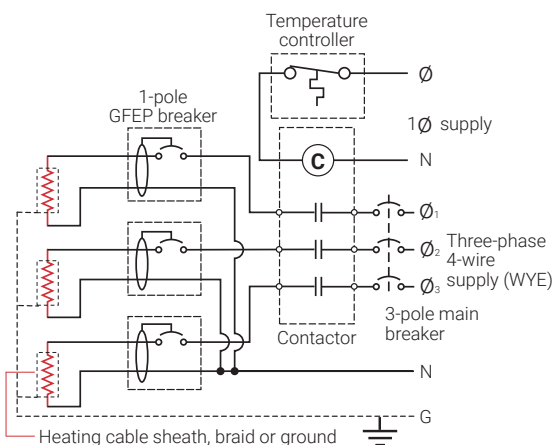


Figure 33: Group control

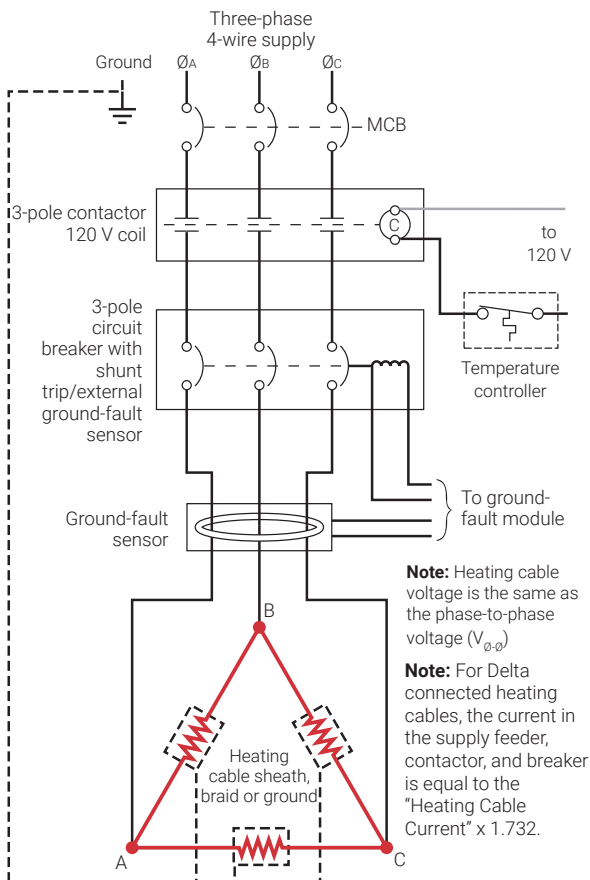


Figure 34: Typical single circuit control for three-phase Delta connected cables

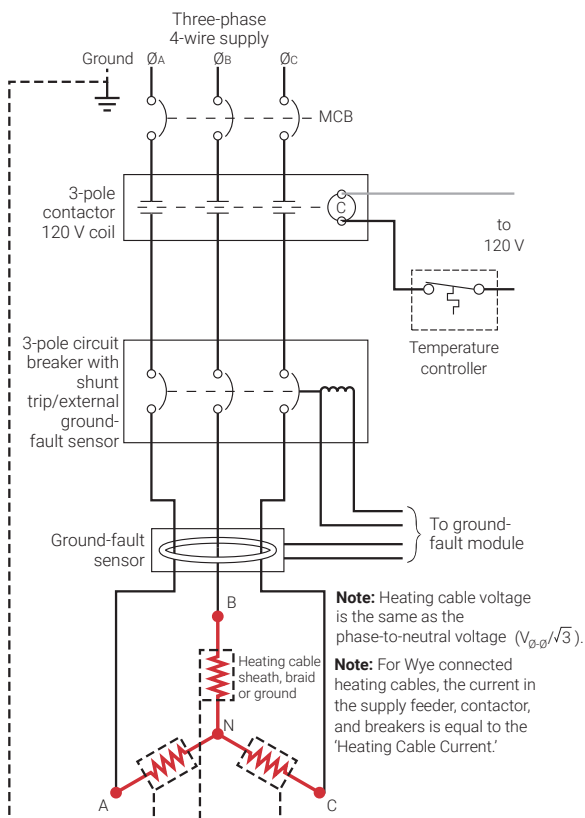


Figure 35: Typical single circuit control for three-phase Wye connected cables

7. COMMISSIONING AND PREVENTIVE MAINTENANCE

Chemelex requires that a series of commissioning tests be performed on floor heating, freezer frost heave prevention, and heat loss replacement systems. These tests are also recommended annually for preventive maintenance. Results must be recorded and maintained for the life of the system, utilizing the Heat Loss Replacement & Freezer Frost Heave Prevention Installation Record (refer to Section 10). Submit this manual with initial commissioning test results to the owner.

7.1 System Tests

A brief description of each test is found below. Detailed test procedures are found in Section 8.

Visual Inspection

Visually inspect all system electrical components. Inspect all wiring for conformance to design drawings and applicable codes. Inspect the junction boxes, cable terminations, and connections to the cable for physical damage. Inspect the cold leads from the point where they exit the slab to the junction boxes for physical damage. Check that moisture is not present in the junction boxes, that electrical connections are tight, and that the NPT threaded connectors are tight and properly grounded.



Important: Damaged cold leads and terminations must be repaired or replaced.

Continuity and Insulation Resistance

Continuity and insulation resistance (IR) testing is recommended at four stages during the installation process, as part of regular system inspection, and after any maintenance or repair work. Continuity testing checks the integrity of the resistive heating element inside the heating cable. IR testing checks the integrity of the electrical insulating barrier between the resistive heating element and the cable sheath. IR testing can also be used to isolate the damage to a single run of heating cable. Fault location can be used to further locate damage.

Power Check

The power check is used to verify that the system is generating the correct power output. This test can be used in commissioning to confirm that the circuit is functioning correctly. For ongoing maintenance, compare the power output to previous readings.

The heating cable power output (watts) is printed on the identification tag attached to the heating cable. The SUA and SUB series of heating cables are designed to be used for a variety of applications including snow melting, floor and space heating, and pipe tracing. Ensure that the heating cable is connected to the correct voltage for the intended application. For freezer frost heave prevention and floor heating applications, check the metal tag attached to the cold lead to find the correct voltage for the application (see Figure 3 in Section 1).

Energize the circuit breaker and measure the heating cable current using a clamp-on or in-line ammeter. Measure the voltage across the heating cable using a volt meter. Calculate the heating cable wattage using the measured voltage and current.

The calculated wattage can be compared to the wattage indicated on the heating cable tag. This gives a good indication of heating cable performance.

Ground-Fault Test

Test all ground-fault breakers per manufacturer's instructions.

7.2 Preventive Maintenance

Chemelex recommends performing the commissioning tests on a regular basis to detect changes or damage that might affect the operation of the system. If the system fails any of the tests, refer to Section 9 for troubleshooting assistance. Make the necessary repairs and replace any part of the system if it has been found to be defective. Protect the cold leads from mechanical damage during maintenance work.

Periodically inspect the system controls. Test the controls to ensure that they function properly. Electrical equipment such as circuit breakers should be checked periodically. The ground-fault protection device should be tested monthly. Record the test results for future reference.



Important: De-energize all circuits that may be affected by maintenance.

Maintenance Records

The Maintenance Log Record in Section 10 should be filled out during all inspections and kept for future reference.

Repairs

Use only MI cable and components when replacing any damaged cable. Repairs should be performed only by qualified personnel and to Chemelex requirements. Retest the system after all repairs or replacements.



WARNING: Fire Hazard. Damage to cables or components can cause sustained electrical arcing or fire. Do not energize cables that have been damaged. Repair or replace damaged heating cable or terminations before energizing the circuit.

8. TEST PROCEDURES

Chemelex recommends that the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10 be completed during testing and kept for future reference.

8.1 Visual Inspection

- Inspect all wiring for conformance to applicable codes.
- Check circuit breaker sizing for each circuit to make sure it is suitable for the circuit current and voltage.
- Verify that the contactor coil operating voltage is correct for the control device used.
- Verify that the temperature controller sensor is correctly installed, sensor lead is not damaged, and ensure that controller is operational and set to the correct temperature as specified in the design project specifications.
- Visually inspect junction boxes, cold leads, terminations, and electrical connections to the cable for physical damage. Repair or replace damaged cable and terminations.
- Verify that the cable glands are correctly fitted into junction boxes, tightened, and properly grounded.
- Check that no moisture is present in junction boxes and that electrical connections are tight.
- Verify that all junction boxes are appropriate for the location and properly sealed.

8.2 Insulation Resistance Test – Test 1

Insulation resistance is measured between the heating cable sheath and the tails. Chemelex recommends that the insulation resistance test be conducted using a test voltage of 1000 Vdc, however in the absence of equipment with this capability, a 500 Vdc test is suitable to detect most installation related concerns.

Frequency

Insulation resistance testing is recommended at four stages during the installation process and as part of regularly scheduled maintenance.

- When received – minimum 100 MΩ
- Continuously during placement of concrete, mortar, etc. – minimum 20 MΩ
- After the cables have been installed – minimum 20 MΩ
- Prior to initial start-up (commissioning) – minimum 20 MΩ* including branch circuit wiring
- As part of the regular system inspection
- After any maintenance or repair work

Under adverse weather conditions, or when the tails or terminal connections have evidence of moisture, lower insulation resistances may be encountered. Wipe tails, face of pot, and all terminal connections with a clean dry rag to eliminate moisture and retest.

Test Criteria

The minimum insulation resistance for a clean, dry, properly installed heating cable should reflect the values shown above, regardless of the heating cable length.

8.3 Continuity (Resistance) Test – Test 2

Continuity testing is conducted using a standard Digital Multimeter (DMM) and measures the resistance between the cold lead tails. This test should also be done after any maintenance or repair work.

Test Criteria

Measure the resistance of the MI heating cable with the DMM. Most MI heating cable resistances are less than 100 ohms. The approximate resistance can be calculated using the formula: Resistance (ohms) = Volts² / Watts. Voltage and wattage are printed on the heating cable identification tag.

8.4 Insulation Resistance and Continuity Test Procedure

1. De-energize the circuit.
2. Disconnect the heating cable tails from supply wires or terminal block.
3. Set megohmmeter test voltage to 0 Vdc or off.
4. Connect the positive (+) lead to the heating cable sheath.
5. Connect the negative (–) lead to both heating cable tails simultaneously.
6. Turn on the megohmmeter and set the voltage to 1000 Vdc; apply the voltage for 1 minute. Meter needle should stop moving. Rapid deflection indicates a short. Record the insulation resistance value in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10.
7. Turn off the megohmmeter.
8. If the megohmmeter does not self-discharge, discharge phase connection to ground with a suitable grounding rod. Disconnect the megohmmeter.
9. Check the continuity (resistance) of the heating cable between the two tails. Record the resistance value in Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10.

10. Disconnect the multimeter.

11. Reconnect heating cable tails to the supply wires or terminal block.

If the heating cable fails either the insulation resistance or continuity test, stop and follow the troubleshooting instructions in Section 9.

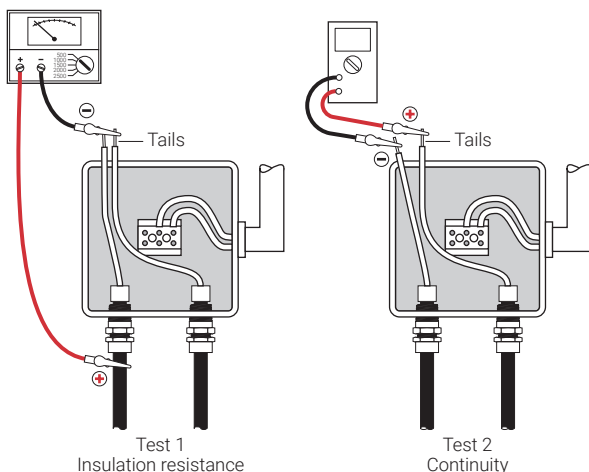


Figure 36: Insulation resistance and continuity test

8.5 Power Check

The power for single and three-phase circuits can be calculated as shown following. For clarity, circuit breakers, and junction boxes have been omitted.

Single-Phase Circuits

Energize the circuit and measure the supply line current using a clamp-on or in-line ammeter; if an in-line ammeter is used, it must be series connected in the circuit (see Figure 37). Measure the voltage across the heating cable using a voltmeter. Record the values in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10. This information is needed for future maintenance and troubleshooting.

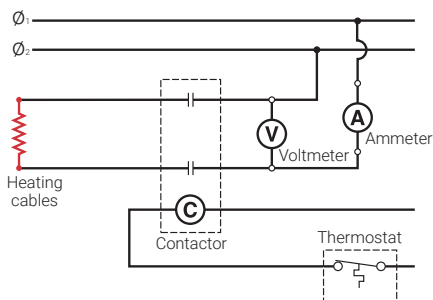


Figure 37: Using voltmeter and ammeter to measure voltage and current in a single-phase circuit

The heating cable power (watts) can be calculated by multiplying the measured voltage (volts) by the measured current (amperes) using the following formula:

$$\text{Power (W)} = \text{Volts (V)} \times \text{Current (A)}$$

Compare the calculated wattage to the wattage printed on the heating cable tag. This gives a good indication of heating cable performance. Variations of 10% to 20% are possible due to deviations in measurement equipment, supply voltage, and cable resistance.

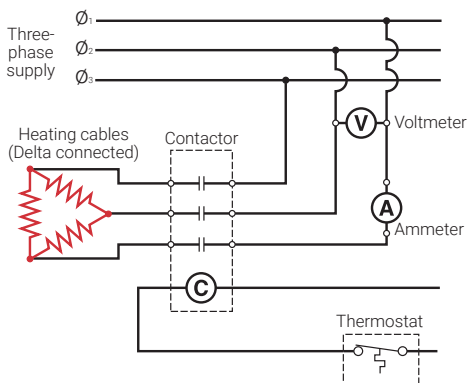
Balanced Three-Phase Circuits

Energize the circuit and measure the supply line current for each phase of the circuit using a clamp-on or in-line ammeter; if an in-line ammeter is used, it must be series connected in the circuit (see Figure 38). The three current measurements should be approximately equal. Measure the voltage across each phase-to-phase pair (Ø1-Ø2, Ø2-Ø3, Ø1-Ø3) using a voltmeter. The three voltage measurements should be equal. Record the values in the Heat Loss Replacement and Freezer Frost Heave Prevention Installation Record in Section 10. This information is needed for future maintenance and troubleshooting.



Important: For a Wye connected three-phase circuit, the voltage across each heating cable will equal the phase-to-phase supply voltage, measured in Figure 38, divided by the square root of 3 ($V_{\phi-\phi}/\sqrt{3}$).

Delta connected circuit



Wye connected circuit

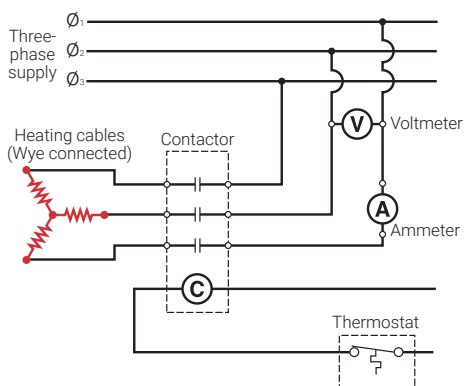


Figure 38: Using voltmeter and ammeter to measure voltage and current in a three-phase circuit

For balanced Delta and Wye connected three-phase circuits, the heating cable power (watts), for each cable, can be calculated by multiplying the measured voltage by the measured current and dividing this result by the square root of 3 using the following formula:

$$\text{Power/cable (W)} = \frac{\text{Volts (V)} \times \text{Current (A)}}{\sqrt{3}}$$

If the voltage measurement is taken directly across each heating cable in a Wye connected circuit, the power can be calculated simply by multiplying this measured voltage by the measured current using the following formula:

$$\text{Power/cable (W)} = \text{Volts (V)} \times \text{Current (A)}$$

The calculated wattage can be compared to the wattage printed on the heating cable identification tag. This gives a good indication of heating cable performance. Variations of 10% to 20% are possible due to deviations in measurement equipment, supply voltage, and cable resistance.

9. TROUBLESHOOTING GUIDE

Symptom

Probable Causes

Insulation resistance less than expected

1. High humidity.
2. Nicks or cuts in heating cable or cold lead sheath, with moisture present.
3. Kinked or crushed heating cable or cold lead.
4. Physical damage to heating cable or cold lead is causing a direct short from conductor to sheath.
5. Presence of moisture in terminations or connections.
6. Damaged termination.

Symptom

Probable Causes

Circuit breaker trips

1. Circuit breaker undersized.
2. Defective circuit breaker.
3. Short circuit in electrical connections.
4. Excessive moisture in connection boxes.
5. Nicks or cuts in heating cable or cold lead sheath, moisture present.
6. Kinked or crushed heating cable or cold lead.
7. GFEP device trip level too low (5 mA used instead of 30 mA) or miswired.

Corrective Action

- (1) Dry tails and face of seal. Inspect power connection box for moisture or signs of tracking. Dry out connections and retest.
- (2, 3) Fault locate to find damaged section of cable. If damaged, repair or replace heating cable or cold lead.
- (4) Check for visual indications of damage around any area where there may have been maintenance work. Look for cracked or damaged concrete or any evidence of work in the area of the heating cables. Repair or replace damaged sections of heating cable, cold lead or terminations.
- (5) Dry out cold lead and/or connections and replace termination if necessary.
- (6) Replace termination.

Corrective Action

- (1) Recalculate circuit load current. Resize breaker and wiring as required.
- (2) Repair or replace breaker.
- (3) Locate and repair the incorrect connections.
- (4) Install drains in connection boxes as required. Dry cold lead and replace terminations if required.
- (5,6) Fault locate to find damaged section of cable. Repair or replace damaged sections of heating cable, cold lead, or terminations.
- (7) Replace 5 mA GFEP device with 30 mA GFEP device. Check the GFEP wiring instructions.

Symptom**Probable Causes**

Power output appears correct but temperature appears to increase too slowly

1. Temperature controller set incorrectly.
2. Thermal time delay.
3. Inadequate watt density (W/sq ft; W/sq m).
4. Wrong cable installed.

Symptom**Probable Causes**

Power output is zero or incorrect

1. Temperature controller inoperative.
2. Temperature controller wired in the normally open (N.O.) position.
3. No input voltage.
4. Broken or damaged heating cable, cold lead, or hot/cold joint.
5. Circuit breakers tripped.
6. Improper voltage used.
7. Wrong cable installed.



Important: If the corrective actions above do not resolve the problem, contact your Chemelex representative for further assistance.

Corrective Action

- (1) Set temperature controller to required temperature per design.
- (2) Heating cables not energized soon enough. Check system controls. Adjust or modify operation.
- (3,4) Verify installation as per design. Contact Chemelex for assistance.

Corrective Action

- (1) Verify electrical connections to controller, verify operation, and repair or replace controller if necessary.
 - (2) Confirm wiring using the normally closed (N.C.) terminals so that contacts close with falling temperature.
 - (3) Repair electrical supply lines and equipment.
 - (4) Repair or replace heating cable or cold lead.
 - (5) See above symptom under "Circuit breaker trips."
 - (6) Verify voltage and connect to proper voltage, if necessary.
 - (7) Verify installation as per design. Contact Chemelex for assistance.
-

10.INSTALLATION AND INSPECTION RECORDS

Heat Loss Replacement & Freezer Frost Heave Prevention Installation Record

INSTALLATION LOCATION

Project name: _____

Reference drawing: _____

Company: _____

Address _____

State/Province: _____

Installation environment: ☐ Commercial ☐ Industrial ☐ Residential

INSTALLED BY

Company: _____

Address _____

State/Province: _____

Name _____

VISUAL INSPECTION (check for all heating cables and cold leads)

Cold Lead:

The hot/cold joints are 6 in (15 cm) in from edge of heated area? Yes ☐

The cold lead is protected where it emerges from the heated area? Yes ☐

Hot/cold joints are spaced at least 3 in (7.5 cm) apart? Yes ☐

All junction boxes are mounted above grade, and installed so that water cannot enter them? Yes ☐

The cable sheath is securely connected to ground? Yes ☐

NPT threaded connectors must be properly grounded.

Installation date _____

Area size _____ sq ft ☐ sq m ☐

City _____

Postal code _____

City _____

Postal Code _____

Phone _____

Heating Cable:

Cable spacing is as specified for the design? Yes ☐

Enter spacing: _____ in ☐ cm ☐

Rebar or mesh is adequately supported? Yes ☐

Heating cable is fastened to rebar or mesh using plastic tie-wraps? Yes ☐
(Single pour concrete installation only)

Location of all concrete crack control/expansion joints identified before pouring? Yes ☐

Heating cable does not cross expansion joints? Yes ☐

Heating cable jacket is not damaged? Yes ☐

Heating cables are not grouped, touching or crossed? Yes ☐

Heating cables are not spaced closer than 1 in (2.5 cm) apart? Yes ☐

Heating cables are not in contact with insulating material? Yes ☐

Heating cables are installed in accordance with manufacturer's recommendations? Yes ☐

ELECTRICAL TESTING

Note: Minimum acceptable insulation resistance shall be 20 MΩ (100 MΩ upon receipt) Recommended insulation resistance test voltage is 1000 Vdc (bypass controller if applicable)

Megohmmeter manufacturer/model _____

Multimeter manufacturer/model _____

1 Receipt of Material

	Heating Cable Catalog No. /Tag No.	Insulation Resistance (MΩ)	Continuity (Ω)
Cable #1	_____	_____	_____
Cable #2	_____	_____	_____
Cable #3	_____	_____	_____
Cable #4	_____	_____	_____
Cable #5	_____	_____	_____
Cable #6	_____	_____	_____
Cable #7	_____	_____	_____
Cable #8	_____	_____	_____
Cable #9	_____	_____	_____
Cable #10	_____	_____	_____
Cable #11	_____	_____	_____
Cable #12	_____	_____	_____

3 Initial Start-up (Commissioning)

 **WARNING:** Disconnect all power before conducting insulation resistance and continuity tests.

	Heating Cable Catalog No. /Tag No.	Heating Cable Location	Breaker Number
Cable #1	_____	_____	_____
Cable #2	_____	_____	_____
Cable #3	_____	_____	_____
Cables 1,2,3 three phase connected	Yes ☐ No ☐	Delta ☐	Wye ☐
Cable #4	_____	_____	_____
Cable #5	_____	_____	_____
Cable #6	_____	_____	_____
Cables 4,5,6 three phase connected	Yes ☐ No ☐	Delta ☐	Wye ☐
Cable #7	_____	_____	_____
Cable #8	_____	_____	_____
Cable #9	_____	_____	_____
Cables 7,8,9 three phase connected	Yes ☐ No ☐	Delta ☐	Wye ☐
Cable #10	_____	_____	_____
Cable #11	_____	_____	_____
Cable #12	_____	_____	_____
Cables 10,11,12 three phase connected	Yes ☐ No ☐	Delta ☐	Wye ☐
Ground-fault protection (type)	_____		
Test ground fault	_____		
Test controller	_____		
Test temperature controller	_____		
Topping material (check one):	Concrete ☐	Mortar ☐	Sand ☐
Contractor's signature:	_____		
Accepted by:	_____		
Date:	_____		

Contact your Chemelex Representative or call +1 800 545 6258 to apply for 10-year Limited Warranty Extension

Megohmmeter date of last calibration _____
Ohm setting _____

2 After cable installation (before covering cables)

Heating Cable Catalog No. /Tag No.	Insulation Resistance(MΩ)
Cable #1	
Cable #2	
Cable #3	
Cable #4	
Cable #5	
Cable #6	
Cable #7	
Cable #8	
Cable #9	
Cable #10	
Cable #11	
Cable #12	

Insulation Resistance (MΩ)	Continuity (Ω)	Supply Voltage (V)	Current (A)

Ground-fault trip setting _____mA

Witnessed by: _____
Approved by: _____

Maintenance Log Record

Area location: _____

CIRCUIT INFORMATION

Breaker panel number: _____

VISUAL

Heat Loss Replacement and Freezer Frost Heave Prevention System

Enclosures, junction boxes, contactors sealed _____

Presence of moisture _____

Signs of corrosion _____

Damage to cold lead or termination _____

ELECTRICAL TESTING

Recommended insulation resistance test voltage is 1000 Vdc
(bypass controller if applicable)



WARNING: Disconnect all power before conducting insulation resistance and continuity tests.

Heating Cable Catalog No. /Tag No.	Heating Cable Location	Breaker Number
Cable #1 _____	_____	_____
Cable #2 _____	_____	_____
Cable #3 _____	_____	_____
Cables 1,2,3 three phase connected Yes ☐ No ☐	Delta ☐	Wye ☐
Cable #4 _____	_____	_____
Cable #5 _____	_____	_____
Cable #6 _____	_____	_____
Cables 4,5,6 three phase connected Yes ☐ No ☐	Delta ☐	Wye ☐
Cable #7 _____	_____	_____
Cable #8 _____	_____	_____
Cable #9 _____	_____	_____
Cables 7,8,9 three phase connected Yes ☐ No ☐	Delta ☐	Wye ☐
Cable #10 _____	_____	_____
Cable #11 _____	_____	_____
Cable #12 _____	_____	_____
Cables 10,11,12 three phase connected Yes ☐ No ☐	Delta ☐	Wye ☐
Ground-fault protection (type) _____		
Test ground fault _____		
Test temperature controller _____		

Comments and actions _____

Prepared by: _____

Approved by: _____

System _____ Reference drawing(s) _____

Supply voltage _____ Phase _____

Temperature controller setpoint
Thermostat setpoint _____
Sensor and lead not damaged _____

Insulation Resistance (MΩ)	Continuity (Ω)	Supply Voltage (V)	Current (A)
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

Ground-fault trip setting _____mA

Company _____ Date _____

Company _____ Date _____

North America

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chemelex
excellence is everything

chemelex.com

Raychem Tracer Pyrotenax Nuheat

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