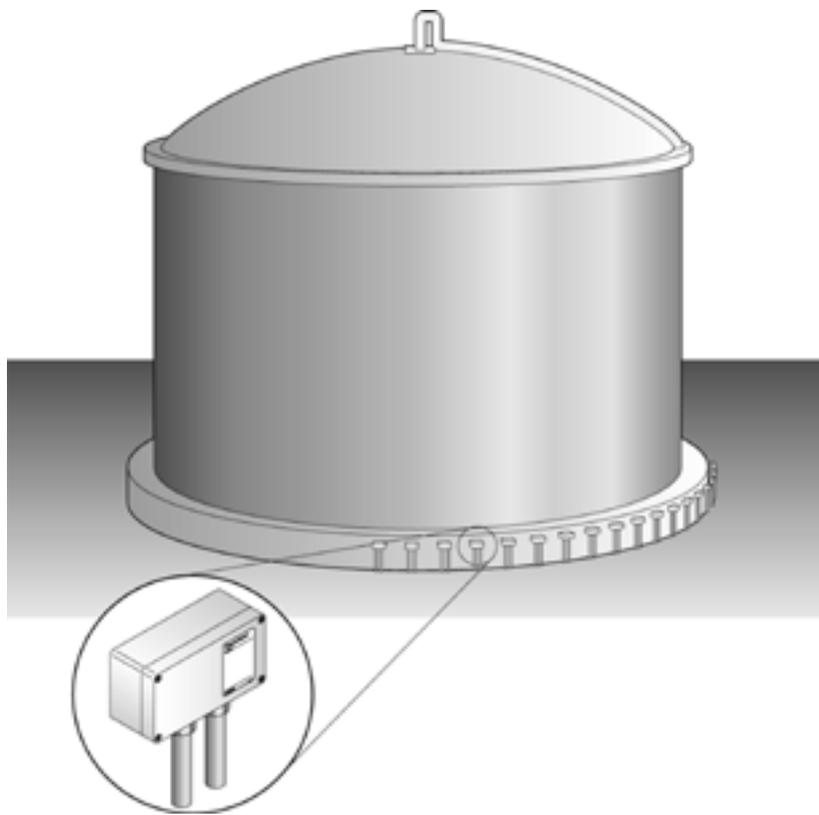


Raychem Frost Heave Protection System Installation and Operation Manual

FHPC CONSTANT POWER DENSITY HEATING CABLE SYSTEMS



 **WARNING: FIRE AND SHOCK HAZARD.**

Raychem® frost heave protection systems must be installed correctly to ensure proper operation and to prevent 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 Pentair Thermal Management requirements, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit breakers.

- Approvals and performance of the heat-tracing systems are based on the use of Pentair Thermal Management-specified parts only. Do not use substitute parts or vinyl electrical tape.
- Conductors will short if they contact each other. Keep conductors separated.
- Components, heating cable ends, and heating elements must be kept dry before and during installation to prevent shorts.
- Damaged conductors can overheat or short. Do not break conductor strands when preparing the heating cable for connection.
- Damaged heating cable can cause electrical arcing or fire. Do not use metal attachments such as pipe straps or tie wire. Use only Pentair Thermal Management approved tapes and cable ties, if necessary.
- Do not attempt to repair or energize damaged cable. Remove damaged cable at once and replace with a new length. Replace damaged components.
- To prevent fire or explosion in hazardous locations, verify that the maximum sheath temperature of the heating cable is below the temperature classification in the area. For further information, see the design documentation.
- Material Safety Data Sheets (MSDSs) are available from Pentair Thermal Management.

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1 GENERAL INFORMATION

Frost Heave Protection systems are heat management systems engineered by Pentair Thermal Management and designed to prevent frost heaving in the foundations of cryogenic tanks. Typical Frost Heave Protection systems consist of Raychem® FHPC constant power density (parallel constant wattage) heating cables, components, temperature sensors and a power / control panel. FHPC heating cables are installed inside conduit embedded in the concrete slabs/walls/beams or dry sand that form a part of the tank foundation. Approved Raychem components, or Pentair Thermal Management approved alternatives, must be used for power connections and end terminations.

These systems are designed to meet project-specific requirements, and therefore must be installed in compliance with requirements established in the installation instructions and the project-specific engineering documentation that Pentair Thermal Management provides.

1.1 Use of the Manual

This manual covers the basic installation and operation of the Frost Heave Protection system using Raychem FHPC constant power density (parallel constant wattage) heating cables. Use this manual in conjunction with any project-specific instructions that are included in the engineering package provided by Pentair Thermal Management.

For more information regarding the application, design assistance or project support, contact your Pentair Thermal Management representative or Pentair Thermal Management directly.

1.2 Safety Guidelines

The safety and reliability of any heat-tracing system depends on proper design, installation and maintenance. Incorrect handling, installation, or maintenance of any of the system components can cause underheating or overheating of the foundation or cause damage to the heating cable system and may result in system failure, electric shock, or fire.

1.3 Approvals and Codes

Conditions for Safe Use: Refer to Hazardous Area certification. Certificate No. and Coding

 II 2 GD EEx e II T* (see schedule)	Baseefa04ATEX0388X
Ex e II T* (see schedule) DIP DIP A21	IECEX BAS 05.0022X
 Ex e II T ⁽¹⁾	04.1617344X

⁽¹⁾T-class by Design.

All heat-tracing-systems must be installed in compliance with all national or local electrical regulations and codes of practice.

1.4 FHPC Specifications

Supply Voltage	120 Vac
FHPC4	230 Vac
FHPC5	400 Vac
FHPC6	480 Vac
FHPC7	
Minimum bend radius	20 mm (0.75 in)
Minimum installation temperature	-40°C (-40°F)
Maximum maintain or continuous exposure temperature (power on)	90°C (194°F)
Maximum exposure temperature (power off)	200°C (392°F)
Temperature classification	Application dependent. Established using principles of stabilized design. Contact Pentair Thermal Management for assistance.

1.4 Warranty

Pentair Thermal Management' limited standard warranty applies to Raychem FHPC heating cable system products. You can access the complete warranty on www.thermal.pentair.com

Important: For the Pentair Thermal Management warranty and agency approvals to apply, the instructions in this manual and product packages, and the installation instructions and project-specific engineering documentation provided by Pentair Thermal Management must be followed.

1.5 General Installation Notes

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

- Read all installation instructions to familiarize yourself with the products.
- Ensure all conduits in the tank foundation have been released by the client for tracing prior to installation of the heating cables.
- Maintain the 20 mm (3/4 inch) minimum bending radius for Raychem FHPC heating cables.
- Do not energize heating cable when it is coiled or on the reel.
- Ensure the installation temperature for heating cables is above -40°C (-40°F).

1.6 Typical Tank Heating System Detail

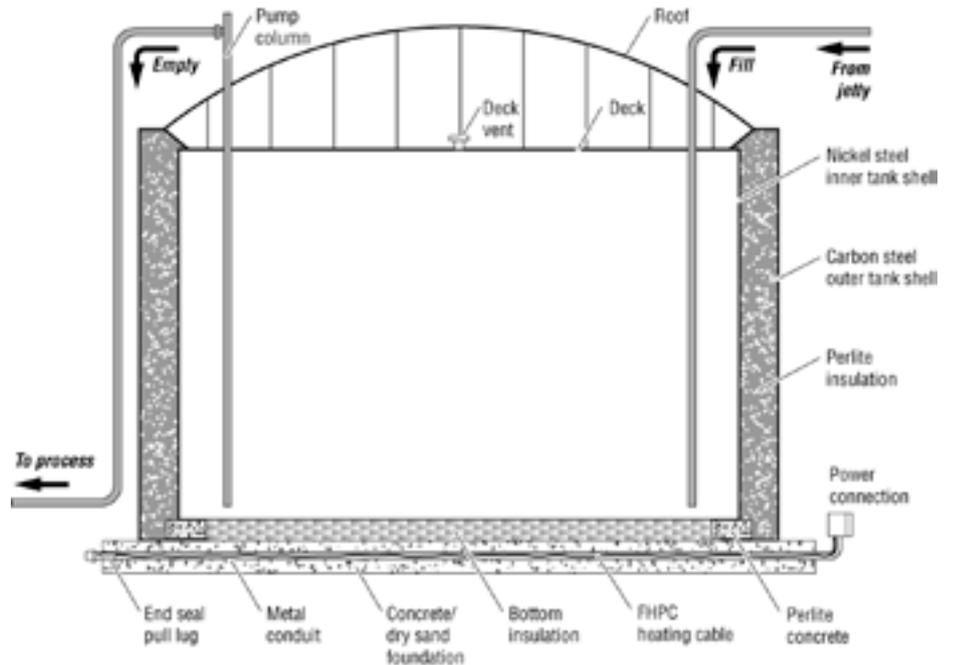


Figure 1: Typical tank cross-section

2 HEATING CABLE CONDUIT

2.1 Type

Pentair Thermal Management specifies in the engineering system design the type of conduit that will best suit your application. Ensure that you are using the type of conduit that was specified in the engineering package provided by Pentair Thermal Management.

Connect conduit sections together using non-tapered threaded connection or by welding. Ensure that conduits are not laid below the water table and are kept watertight. It is important to keep the conduits dry and to protect them from corrosion, as this can also affect the long-term reliability of the foundation and heating system.

2.2 Assembly

All conduit ends should be deburred before assembly to prevent damage to the heating cable. Exposed threaded ends should be coated with a rust-preventing compound after assembly. All conduit connections should be watertight and electrically continuous. Straight sections should be joined by threaded couplers or equivalent. Bends should be made by suitable equipment to prevent flattening of the conduit. Bends should be assembled with watertight connections (see figure below). Conduit ends should be capped to prevent ingress when concrete is being poured.

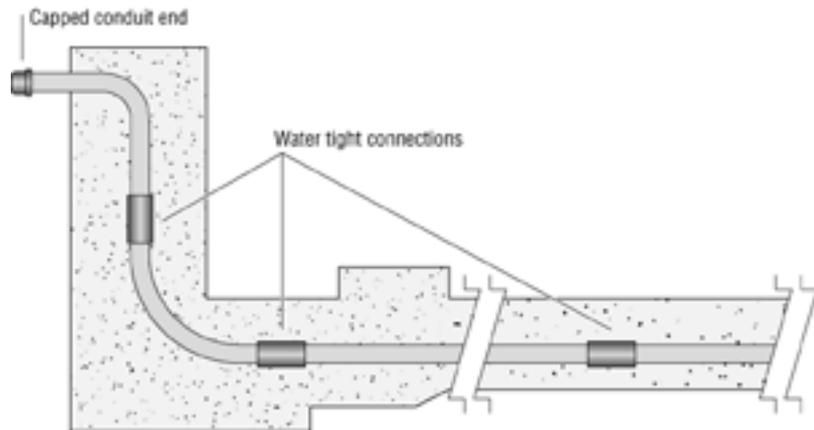


Figure 2: Assembly

Conduits should extend above ground level in order to ensure that the components remain dry. Refer to your project-specific engineering documentation for details. For U-shaped conduits on Double Integrity Tanks (DIT) tanks, a pulling wire must be installed as the conduit sections are assembled.

3 HEATING CABLE INSTALLATION

3.1 Heating Cable Storage

- Store the heating cable in a clean, dry place. Temperature range: -40°C (-40°F) to 60°C (140°F).
- Protect the heating cable from mechanical damage.
- Keep heating cable ends dry.

3.2 Pre-Installation Checks

Check materials received:

- Review the heating cable design 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 type and voltage is printed on its jacket.
- Ensure that the heating cable voltage rating is suitable for the service voltage available.
- Inspect the heating cable and components for in-transit damage.
- Verify that there are no holes in the heating cable jackets by conducting the insulation resistance test (refer to Section 7) on each reel of cable.

3.3 Preparation

Heating cable paying out tips:

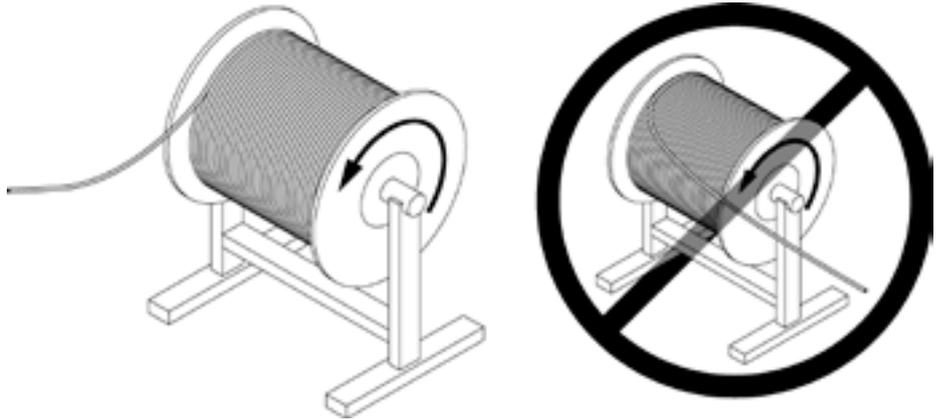


Figure 3: Paying out the cable

- Use a reel holder that pays out smoothly with little tension. This will aid in the feeding of the heating cable when it is pulled through the conduit. If the heating cable snags, stop pulling immediately.
- The meter marks on the heating cable can be used to estimate the heating cable length.
- Protect all heating cable ends from moisture, contamination and mechanical damage.
- Pull the heating cable straight from the reel.

When paying out the heating cable, AVOID:

- Sharp edges
- Excessive pulling force or jerking, or pulling to the side
- Kinking and crushing
- Walking on it, or running over it with equipment

Heating cable preparation

A pulling lug must be fabricated at the end of the heating cable on the outside of the spool for attachment to the pull rope or wire. Refer to Raychem FHP-PL-E, pulling lug end seal installation instructions for proper instructions.

Conduit preparation

Prior to pulling the heating cable, clear the conduit of any moisture or dirt.

3.4 Heating Cable Pulling

After installing the FHP-PL-E end seal, tie the pull rope or wire to the heating cable pulling lug. Cover the knot area with layers of tape to make a smooth transition (see figure 4).

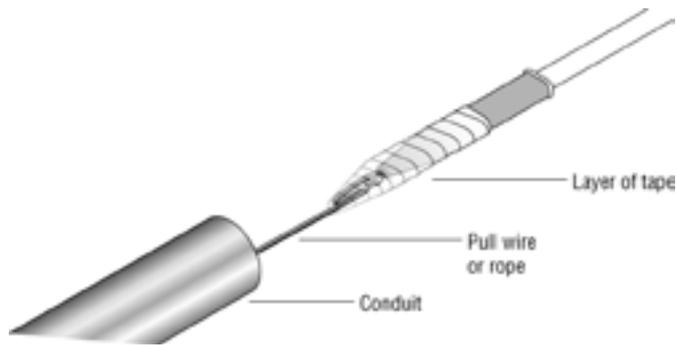


Figure 4: Heating cable pulling

Pull the heating cable from the power end to the termination end of the conduit. Feeding must be done by guiding the heating cable through the protective housing. The heating cable must enter and exit the conduit in a straight line with the conduit. The pull force must not exceed 23 kg (50 lbs), which means you should not use power devices—pull manually. Straight runs of conduit typically require less than 20kg (44 lbs).

Pull the heating cable until the end seal (pulling lug) extends at least 30 cm (1 ft). Also make sure that you have enough length to accommodate the termination of the heating cable in the power connection box (depending on the location of the junction box, we typically recommend a minimum termination allowance of 1 m (3 ft) of heating cable at the power connection end).

For the termination of the heating cable in the power connection, please refer to the appropriate power connection installation instructions.

⚠ WARNING: Fire and Shock Hazard.

Do not cut or damage the pulling lug end seal. It seals the cable and prevents arcing and shorting.

Do not install or repair damaged cable. Damaged cable must be replaced.

Keep components and cable ends dry before and during installation.

3.5 Bending the cable

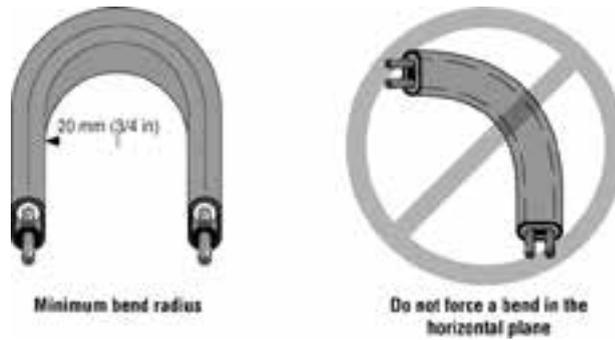


Figure 5: Bending the heating cable

When positioning the heating cable, do not bend tighter than a radius of 20 mm (3/4 in).

The heating cable does not bend easily in the horizontal plane. Do not force such a bend, as the heating cable may be damaged.

4 HEATING CABLE COMPONENTS

Raychem FHPC heating cables must only be used with Pentair Thermal Management approved components. A complete heating circuit requires at least one power connection and one end seal. Also refer to the project-specific engineering documentation from Pentair Thermal Management for further information.

Installation instructions are included with the component kits. The installation must be done by suitably trained personnel. Steps for preparing the heating cable and connection to components must be followed with care. Raychem FHPC heating cables are parallel circuit design. Do not twist the conductors together as this will result in a short circuit.

5 CONTROL AND MONITORING

Pentair Thermal Management DigiTrace® control and monitoring products are designed for use with Raychem FHPC heat-tracing systems. Temperature controllers and control and monitoring systems are available.

Refer to the installation instructions supplied with control and monitoring products. Control and Monitoring systems require installation by qualified personnel.

6 POWER SUPPLY AND ELECTRICAL PROTECTION

6.1 Voltage Rating

Verify that the source voltage corresponds to the heating cable rating printed on the cable jacket and specified by the design.

6.2 Electrical Loading

Overcurrent protection devices are selected according to the heating cable type, source voltage, and circuit length to allow start-up at the designed ambient temperatures. The design specifies the size and type of overcurrent device.

6.3 Ground-Fault Protection

If the heating cable is improperly installed, or physically damaged to the point that water contacts the conductors, sustained arcing or fire could result. If arcing does occur, the fault current may be too low to trip conventional circuit breakers. Therefore, a 30-mA residual current device or ground leakage circuit breaker must be used to provide protection from arcing or fire and to comply with warranty requirements, agency certifications, and national electrical codes. Where properly installed circuits result in a higher leakage current due to their long length, devices with higher trip currents, to a maximum of 300-mA, may be used. Suitable ground-fault breakers include Square D Type QO-EPD and QOB-EPD, Pentair Thermal Management GFPD EHB-EPD (277 Vac) and Cutler Hammer (Westinghouse) Type QBGFEP.

 **WARNING:**

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

 **WARNING:**

Disconnect all power before making connections to the heating cable.

7 COMMISSIONING AND PREVENTATIVE MAINTENANCE

Pentair Thermal Management requires a series of tests be performed on the heat-tracing system upon commissioning. These tests are also recommended at regular intervals for preventive maintenance. Results must be recorded and maintained for the life of the system.

7.1 Tests

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

Visual inspection

Visually inspect the connections to the heating cable for physical damage. Ensure that no moisture is present, electrical connections are tight and grounded, and control and monitoring systems are operational and properly set. Damaged heating cable must be replaced.

Insulation Resistance

Insulation Resistance (IR) testing is used to verify the integrity of the heating cable inner and outer jackets. IR testing is analogous to pressure testing a pipe and detects if a hole exists in the jacket. 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 heating cable power per foot (meter) is calculated by dividing the total wattage by the total length of the circuit. The current, voltage, and length must be known. Circuit length can be determined from "as built" drawings, meter marks on the heating cable or the capacitance test.

$$\text{Power (W/unit)} = \text{Volts (Vac)} \times \text{Current (A)} / \text{Length (m or ft)}$$

The watts per foot (meter) can be compared to the heating cable output indicated on the product data sheet. This gives a good indication of heating cable performance.

Ground-fault test

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

7.2 Preventative Maintenance

Recommended maintenance for Pentair Thermal Management heat-tracing systems consists of performing the commissioning tests on a regular basis, and at least once a year.

If the heat-tracing system fails any of the tests, make the necessary repairs and replace any damaged heating cable immediately. Contact Pentair Thermal Management for trouble shooting assistance.

De-energize or isolate all circuits that may be affected by maintenance.

Protect the heating cable from mechanical or thermal damage during maintenance work.

Maintenance records

An Installation and Inspection Record should be filled out during all maintenance and repair work, and kept for future reference.

Repairs

The system cannot be repaired. Damaged heating cables must be replaced. See section 7.3 for more details.

WARNING:

Damage to heating cables or components can cause sustained electrical arcing or fire. Do not attempt to repair damaged heating cable. Do not energize heating cables that have been damaged by fire. Replace damaged heating cable at once by removing the entire segment of the cable in the conduit. Do not splice heating cable sections.

7.3 Heating cable replacement

Damaged heating cable must be replaced. Use only Raychem heating cable and components when replacing any damaged heating cable.

If you are replacing a heating cable, disconnect the power end and attach a pulling wire to the pulling lug of the end seal. Install plastic bushing or similar material to protect ends of conduit. Pull the heating cable out of the conduit from the termination end.

Install new heating cable according to the procedures given in earlier section.

Retest the system after repairs.

8 TEST PROCEDURES

8.1 Visual Inspection

- Check heating cable components for proper installation, overheating, corrosion, moisture, and loose connections.
- Check the electrical connections to ensure that ground and conductors are insulated over their full length.

8.2 Insulation Resistance (Megger™) Test



WARNING: Fire hazard in hazardous locations.

Megger™ test can produce sparks. Be sure there are no flammable vapors in the area before performing this test.

Frequency

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

- Before installing the heating cable
- Before installing power connection and end seal
- Prior to initial start-up (commissioning)
- As part of the regular system inspection (yearly at a minimum)
- After any maintenance

Procedure

Insulation resistance testing (using a megohmmeter) should be conducted at 2500 Vdc.

First measure the resistance between the heating cable conductors and the braid. Then measure the insulation resistance between the braid and the conduit.

Do not allow test leads to touch the junction box, as this can cause inaccurate readings.

1. De-energize the circuit.
2. Disconnect the controller if installed.
3. Disconnect conductors from terminal block, if installed.
4. Set test voltage at 0 Vdc.
5. Connect the negative (-) lead to the heating cable metallic braid.
6. Connect the positive (+) lead to both heating cable conductors simultaneously.
7. Turn on the megohmmeter and set the voltage to 2500 Vdc; apply the voltage for 1 minute. Meter needle should stop moving. Rapid deflection indicates a short or the presence of moisture. Record the insulation resistance value in the Inspection Record.
8. Turn off the megohmmeter.
9. If the megohmmeter does not self-discharge, discharge phase connection to ground with a suitable grounding rod. Disconnect the megohmmeter.
10. Repeat this test between braid and conduit.
11. Reconnect conductors to terminal block.

Note: System checkout and regular maintenance procedures require that Megger™ testing be performed from the distribution panel unless a control and monitoring system is in use. If no control system is being used, remove both power feed wires from the breaker and proceed as if testing heating cable conductors. If a control and monitoring system is being used, remove the control equipment from the circuit and conduct the test directly from the heating cable.

Insulation resistance criteria

A clean, dry, properly installed circuit should measure thousands of megohms, regardless of the heating cable length or measuring voltage (2500 Vdc). The following criteria are provided to assist in determining the acceptability of an installation where optimum conditions may not apply.

- All insulation resistance values should be greater than 1000 megohms. If the reading is lower, contact Pentair Thermal Management for assistance.

Note: Insulation resistance values for any particular circuit, should not vary more than 25 percent as a function of measuring voltage. Greater variances may indicate a problem with your heat-tracing system, confirm proper installation and/or contact Pentair Thermal Management for assistance.

8.3 Power Check

The power output for each FHPC heating cable circuit can be determined as follows:

1. Power the heating cable and allow it to stabilize for 10 minutes, then measure current and voltage at the junction box. If a controller is used, refer to details below.
2. Calculate the power (Watts/units) of the heating cable by multiplying the current by the input voltage and dividing by the actual circuit length.

$$\text{Power (W/unit)} = \text{Volts (Vac)} \times \text{Current (A)} / \text{Length (m or ft)}$$

Control and Monitoring Systems

Set the temperature controller to the desired control temperature, or if the slab/sand temperature is above the control temperature, set the temperature high enough to turn the circuit on.

- Turn on the main circuit breaker.
- Turn on the branch circuit breakers.
- Allow the system to reach the control point. This may take days
- for most circuits.
- Measure the voltage and amperage for each circuit and record
- the values in the "Installation Record Sheet" (see next section). This information is needed for future maintenance and troubleshooting.
- When the system is completely checked out, reset the controller to the proper temperature.
- Refer to the installation instructions supplied with the product for commissioning tests and records.

INSTALLATION RECORD

Circuit No.									
-------------	--	--	--	--	--	--	--	--	--

Installation Records For:

Circuit breaker number									
Drawing reference number									
Circuit length									
Megger test on reel before pulling (bypass temperature controller if applicable). (2500 Vdc)	Reading								
	Initial								
	Date								
Megger test after pulling (bypass temperature controller if applicable). (2500 Vdc)	Reading								
	Initial								
	Date								
Circuit voltage	Panel								
	Connection terminal								
Circuit Amps									
Ground-fault device operational									
Installation completed	Initial								
	Date								

Remarks & Comments:

Performed by:	Company	Date
Witnessed by:	Company	Date
Approved by:	Company	Date

INSPECTION & MAINTENANCE RECORD

Circuit No.									
-------------	--	--	--	--	--	--	--	--	--

Maintenance Checks For:

Month/Year:

No signs of overheating, moisture or corrosion	Initial								
	Date								
In connection systems: - Heating cable and cable glands tight - Connection terminals tight - Earth connection tight	Initial								
	Date								
Temperature controls are set properly and RTDs are protected	Initial								
	Date								
Megger test (bypass temperature controller if applicable). (2500 Vdc)	Reading								
	Initial								
	Date								
Circuit voltage	Panel								
	Connection terminal								
Circuit Amps	Initial								
	Date								
Ground-fault device operational	Initial								
	Date								
All boxes and temperature controllers have been firmly closed	Initial								
	Date								

Remarks & Comments:

Performed by:	Company	Date
Witnessed by:	Company	Date
Approved by:	Company	Date

TROUBLESHOOTING GUIDE

<p>A Symptom: Overcurrent protection trips or blows</p> <p>Probable Causes</p> <ol style="list-style-type: none"> 1 Electrical fault at: <ul style="list-style-type: none"> • damaged heating cable • end seal • power connection 2 Circuit oversized 3 Defective electrical protection 	<p>Corrective Action</p> <ol style="list-style-type: none"> 1 Investigate and remedy (see note 1) 2 Resize or redesign 3 Replace
<p>B Symptom: Circuit breaker trips</p> <p>Probable Causes</p> <ol style="list-style-type: none"> 1 Earth fault at: <ul style="list-style-type: none"> • damaged heating cable • end seal • power connection 2 Excessive moisture in: <ul style="list-style-type: none"> • junction boxes • end seals 3 High leakage currents due to a combination of excessive lengths of power cable and heating cable 4 Imbalance of 3 phase transformer 5 Defective circuit breaker 	<p>Corrective Action</p> <ol style="list-style-type: none"> 1 Investigate and remedy (see note 1) 2 Dry out and reseal or remake immediately. Perform insulation resistance test. (10 MΩ minimum) 3 Redesign 4 Redesign distribution 5 Replace
<p>C Symptom: No power output</p> <p>Probable Causes</p> <ol style="list-style-type: none"> 1 Loss of supply voltage due to: <ul style="list-style-type: none"> • overcurrent or residual current protection operating • loose terminals in junction box • loss of supply cable continuity (e.g., open circuited from damage) 2 Temperature controller is connected in the normally open position or limit temperature controller is tripped 3 High resistance connection at junction boxes or terminals 	<p>Corrective Action</p> <ol style="list-style-type: none"> 1 Restore supply voltage Locate damage and repair 2 Reconnect to normally closed position 3 Locate and remedy by retightening
<p>D Symptom: Low temperature</p> <p>Probable Causes</p> <ol style="list-style-type: none"> 1 Incorrect setting or operation of controls e.g. temperature controller 2 Design error 	<p>Corrective Action</p> <ol style="list-style-type: none"> 1 Reset or repair to correct level of operation 2 Check engineering design
<p>Note:</p> <ol style="list-style-type: none"> 1. Visually inspect the power connections and end seals for correct installation or signs of damage. 2. If fault has not been located, then contact Pentair Thermal Management for assistance. 	



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