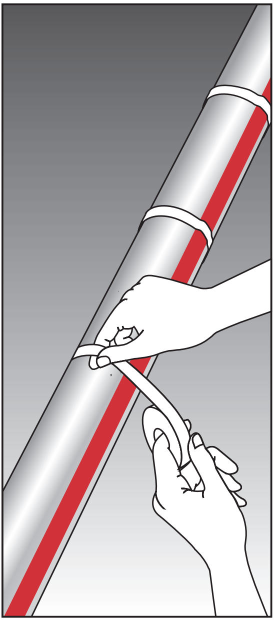
Raychem

Industrial Heat-Tracing

Installation and Maintenance Manual for Series Resistance Heating Cable Systems for Pipes



chemelex

Important Safeguards and Warnings

⚠ WARNING: FIRE AND SHOCK HAZARD.

Raychem heat-tracing 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 Chemelex requirements, agency certifications, and national electrical codes, ground-fault equipmentprotection 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 approved components and accessories. Do not use substitute parts.
- Cable ends must be kept dry before, during, and after installation.
- Damaged heating cable can cause electrical arcing or fire. Use only Chemelex-approved glass tape or cable ties to secure the cable to the pipe.
- Damaged heating cable or components must be repaired or replaced. Contact Chemelex for assistance.
- Use only fire-resistant insulation which is compatible with the application and the maximum exposure temperature of the system to be traced.
- To prevent fire or explosion in hazardous locations, verify that the maximum sheath temperature of the heating cable is below the autoignition temperature of the gases in the area. For further information, see the design documentation.
- Heating cables are capable of reaching high temperatures during operation and can cause burns when touched. Avoid contact when cables are powered. Insulate the pipe before energizing the cable. Use only properly trained personnel.
- Material Safety Data Sheets (MSDSs) are available on our website: Chemelex.com.

1. GENERAL INFORMATION

Raychem Series Resistance SC heat-tracing systems are for use on thermally insulated metal and plastic pipes. These systems must be installed in compliance with requirements established in the design documentation that Chemelex provides for each project.

We manage the heat you need at Chemelex by offering complete integrated service from original design, to product specification, to installation of the complete system. We also provide future maintenance of the installation, if required.

1.1 Use of the Manual

This manual covers the basics of installation and maintenance for Raychem Series Resistance (SC) heat-tracing systems. Use this manual in conjunction with the design documentation provided by Chemelex as well as the following:

- SC, SC/H Data Sheets (H57027)
- SC, SC/H Components and Accessories Data Sheets (H57780)

For technical support, or information regarding SC heat-tracing systems cable, please contact your Chemelex representative or Chemelex directly.

Chemelex

Tel: +1.800.545.6258

info@chemelex.com

chemelex.com

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

1.2 Safety Guidelines

The safety and reliability of any heat-tracing system depends on proper design, installation, and maintenance. Incorrect design, handling, installation, or maintenance of any of the system components can cause underheating or overheating of the pipe, or damage to the heating cable system, and may result in system failure, electric shock, or fire. The guidelines and instructions contained in this guide are important. Follow them carefully to minimize these risks and to ensure that the SC system performs reliably.

Pay special attention to the following:

- Important instructions are marked **Important**
- Warnings are marked **Warning**

1.3 Typical System

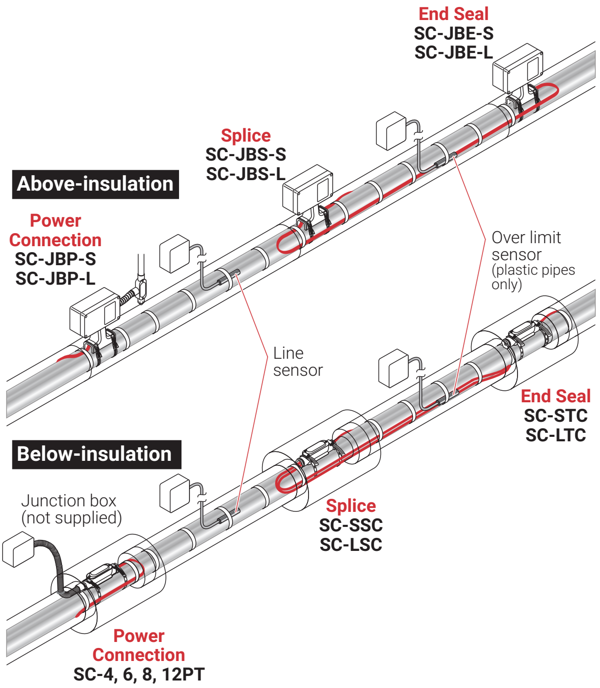


Figure 1: Typical SC heating cable system

Important: Raychem SC heating cables are engineered products. All applications require design by Chemelex.

1.4 Electrical Codes

Sections 427 (pipelines and vessels) and 500 (classified locations) of the National Electrical Code (NEC), and Part 1 of the Canadian Electrical Code, Sections 18 (hazardous locations) and 62 (Fixed Electric Space and Surface Heating), govern the installation of electrical heat-tracing systems. All heat-tracing-system installations must be in compliance with these and any other applicable national or local codes.

1.5 Warranty and Approvals

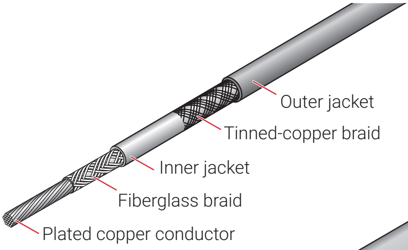
Raychem SC heating cables and components are approved for use in hazardous and nonhazardous locations. Refer to specific product data sheets for details.

10 YEAR Product warranty

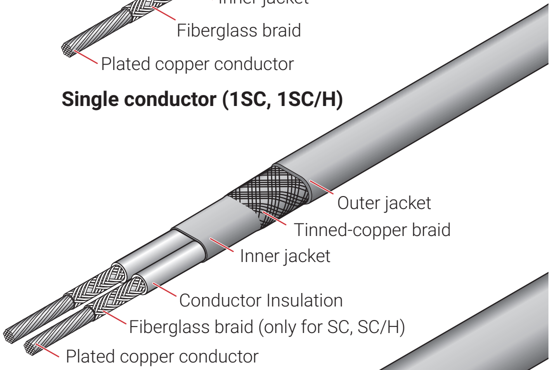
Chemelex' limited standard warranty applies to Raychem SC products. You can access the complete warranty on Chemelex.com. To qualify for an extended 10-year warranty, register online within 30 days of installation at Chemelex.com.

1.6 Heating Cable Construction

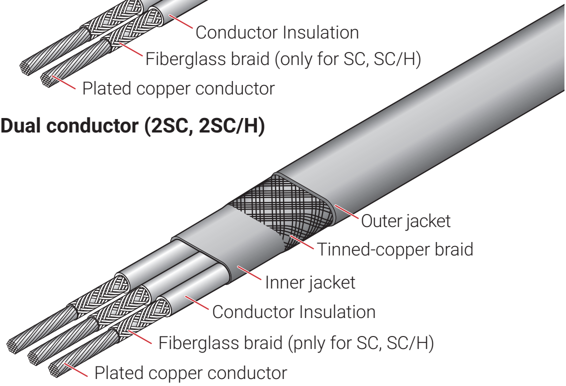
Raychem SC heating cables provide electrical freeze protection and temperature maintenance for long pipelines. These cables are available in single, dual, or triple conductor configurations as shown in Figure 2.



Single conductor (1SC, 1SC/H)



Dual conductor (2SC, 2SC/H)



Triple conductor (3SC, 3SC/H)

Figure 2: SC, SC/H heating cable construction

1.7 Heating Cable Identification

Circuit identification tags, required by approval agencies, can be ordered from Chemelex (P/N P000000311). The circuit identification tag provides information such as the heating cable catalog number, operating voltage, power output, maximum cable-sheath temperature, circuit identification number, heating cable length, and cable current rating. If the cable has been designed for a hazardous location, the area classification is printed in the 'Haz. Locations' section of the tag.

Important: The circuit identification tag must be permanently attached within 3 inches (75 mm) of the power connection.

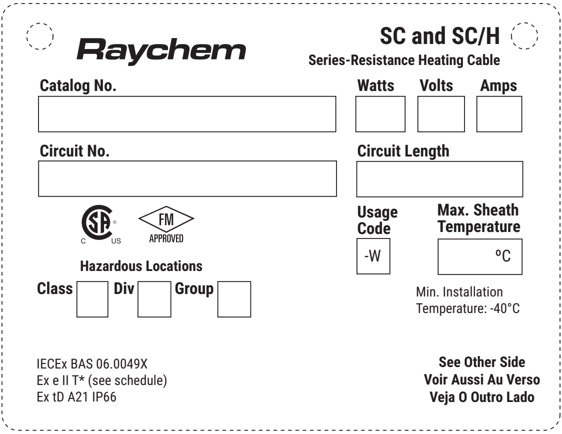


Figure 3: Typical SC cable circuit identification tag (front)

WARNING: Fire or Explosion Hazard. Ensure the SC heating cable system as identified on the circuit identification tag meets the requirements of the area classification.

1.8 General Installation Guidelines

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

- Avoid damage to the SC heating cable as follows:
  - Do not use metal pipe straps/banding to secure cable to pipe.
  - Do not install heating cable lengths other than those listed on the system design documentation.
  - Do not energize before installation is complete.
  - Do not cross, group, or overlap cables closely together. This can cause localized overheating and a risk of fire or cable failure.
  - Keep welding torches clear of cable and protect against slag falling on cables below.

- Ensure all pipes have been released by the client for tracing prior to heating cable installation.
- Install cable in a manner that permits removal of serviceable equipment such as valves, pumps, and filters, with minimum disruption to the surrounding heating cable.
- Avoid bending cable to a bend radius less than 1 inch, particularly when installing on valves, pumps, and other irregularly shaped surfaces. On small flanges and joints where it is impractical to bend the cables tightly, metal foil or metal bridging pieces can be used to fill gaps between the heating cable and the surface to be heated.
- Ensure heating cable is suitable for the continuous exposure temperature shown in Table 1.
- Apply thermal insulation as soon as possible after heat-tracing to prevent mechanical damage to the heating cables. Waterproof cladding must be installed immediately after insulation is applied to prevent the insulation from becoming wet.
- Make all connections to supply cables in above grade junction boxes and keep covers on junction boxes when not working on them.
- The minimum installation temperature is –40°F (–40°C).
- Use a temperature controller suitable for the process temperature. Chemelex supplies a wide range of temperature controllers including the Raychem series electronic monitoring controllers.

Table 1: SC, SC/H heating cable exposure temperature

SC heating cable	Maximum continuous exposure temperature
SC	400˚F (204˚C)
SC/H	480˚F (250˚C)

1.9 Heating Cable Storage

- Store heating cables in a clean dry location and protect them from mechanical damage.
- Store heating cables in their shipping container until they are installed.

2. PRE-INSTALLATION CHECKS

2.1 Check Materials Received

Review the heating cable design documentation 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 voltage, wattage, and length for each circuit are printed on the circuit identification tag.

- Ensure that the heating cable voltage rating is suitable for the source voltage available.
- Inspect the heating cable and components for in-transit damage.
- Perform continuity and insulation resistance testing (minimum 100 MΩ) on each cable as detailed in Section 9 and record the results on the Heating Cable Installation Record in Section 12.
- Verify that the conditional sheath temperature (T-Rating) on the circuit identification tag satisfies your area requirement and pipe material.

2.2 Check Piping to be Traced

- Make sure all mechanical pipe testing (i.e. hydrostatic testing/purging) is complete and the system has been cleared by the client for tracing.
- Walk the system and plan the routing of the heating cable on the pipe.
- Verify that the actual pipe length, routes, and location of pipe fittings such as valves, pipe supports, hangers, and other components match the design drawings.
- Inspect the piping and channels for burrs, rough surfaces, or sharp edges that may damage the heating cable. Remove if necessary.
- Verify that any surface coatings are dry to the touch.

2.3 Check Tools

The following tools are needed for installing SC heat-tracing systems. Additional tools are listed in the Installation Instructions for each specific component.

- Proper crimp tool
- Propane or mapp gas torch
- Proper test meters as described in Section 9 of this manual.

3. HEATING CABLE INSTALLATION

3.1 Heating Cable Payout

Paying out the cable

Make sure to use a reel holder that rotates smoothly with little tension. Pay out the cable from the reel as shown in Figure 4.

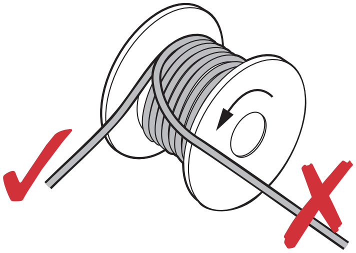


Figure 4: Payout direction

Position the reels next to the pipe to be traced.

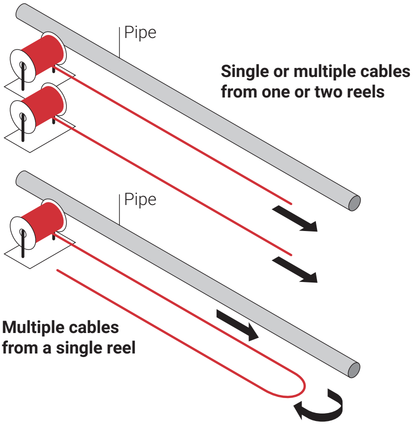


Figure 5: Paying out single and multiple SC heating cables

Paying out the cable

String the cable along the length of the pipe following the design. Ensure that the appropriate amount of heating cable is designated forcomponent installation, service loops, and pipe fixtures.

heating cable paying out tips:

- Use a reel holder that pays out smoothly with little tension. If heating cable snags, stop pulling.
- Pull heating cable by hand. No mechanized pulling.
- Keep the heating cable strung loosely but close to the pipe being traced to avoid interference with supports and equipment.
- Meter marks on the heating cable can be used to determine heater length.
- Protect all heating cable ends from moisture, contamination, and mechanical damage.

⚠ **WARNING:** Fire and Shock Hazard. Do not install damaged cable. Components and cable ends must be kept dry before and during installation.

when paying out the heating cable, AVOID:

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

Positioning heating cables

Install cables around the bottom section of pipe, avoiding bottom dead center (Figure 6).

For two cable runs, install between 30° and 45° on either side of bottom dead center (Figure 6).

For three cable runs, install bottom cable about 10° to one side of bottom dead center (Figure 6). On a vertical pipe, space cables evenly around circumference of pipe.

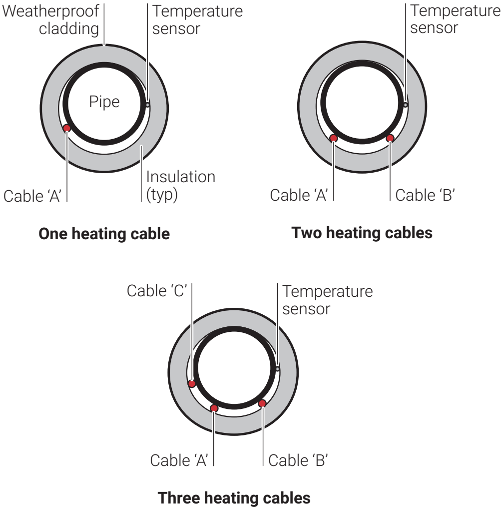


Figure 6: SC heating cable positioning (typical cross section)

Bending the cable

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

Figure 7: Bending the SC heating cable

Minimum bend radius

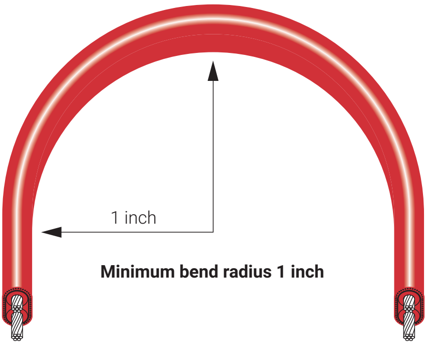


Figure 8: Minimum bend radius

Crossing the cable

Do not cross, overlap, or group the heating cables.

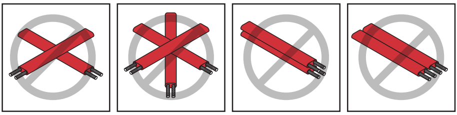


Figure 9: Crossing, overlapping, and grouping

Cutting the cable

Before cutting, confirm that the as-built pipe matches design specifications.

Important: Any change to designed circuit length will change power output and design must be reconfirmed. Do not cut the cable to any length other than the design length.

Attaching the cable

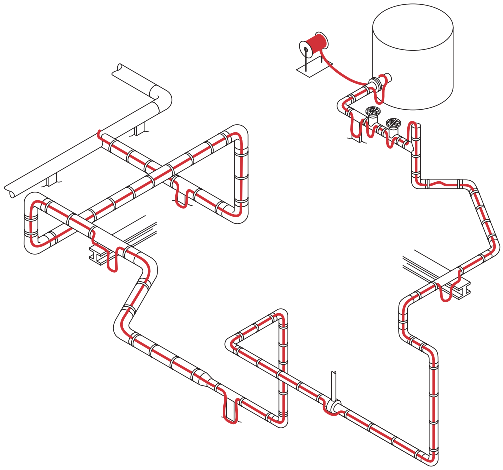


Figure 10: Typical heating cable attachment

Starting from the end opposite the reel, tape the heating cable on the pipe at every foot, as shown in the figure above. If aluminum tape is used, apply it over the entire length of the heating cable after the cable has been secured with glass tape. Work back to the reel. Leave extra heating cable at the power connection, at all sides of splices and tees, and at the end seal to allow for future servicing.

Allow a loop of extra cable for each heat sink, such as pipe supports, valves, flanges, and instruments, as detailed by the design. Refer to Section 3.4 for attaching heating cable to heat sinks.

Important: Install heating cable components immediately after attaching the heating cable. If immediate installation is not possible, protect the heating cable ends from moisture.

3.2 Installation Directly on Pipes

Chemelex requires that you complete the Heating Cable Installation Record during the installation of the heating cable and thermal insulation and keep this record for future reference.

- Install all ancillary equipment onto pipe via brackets before installing heating cables.
- Where feasible, lay the heating cable alongside the pipe section to be traced.

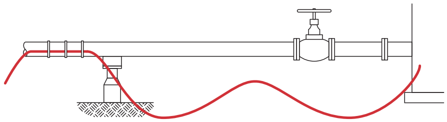


Figure 11: Paying out heating cable

- Attach heating cables to the pipe with glass tape at 12–18 inch (300–450 mm) intervals.
- Allow extra cable per design specifications at all pipe fixtures.

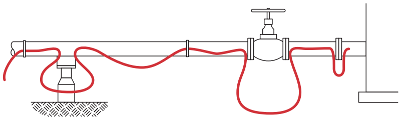


Figure 12: Allowances for valves, flanges, and pipe supports

- Install cable on pipe fixtures per installation details in Section 3.4.
- Install power connections, splices, and end terminations per instructions in component kits.

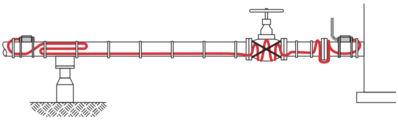


Figure 13: Completed SC heating cable installation

Important: AT-180 aluminum tape can be used over SC heating cables to improve heat transfer. Refer to design documentation.

WARNING: Fire and Shock Hazard. Do not install damaged cable. It must be replaced.

3.3 Installation in Channel

Confirm that the correct number, size and location of the channel are as specified on the design documentation.

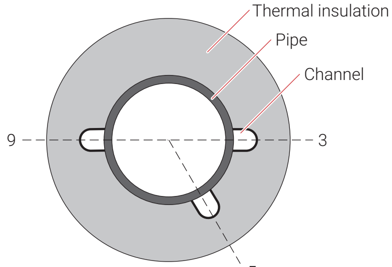


Figure 14: Channel size and position on pipe

> ⚠ **WARNING:** To avoid overheating, install only one SC cable in a channel.

Pulling method

Feed and pull heating cable by hand. Do not use mechanized pulling.

To avoid jacket damage while pulling, make sure the ends of the channel are free of burrs. Chamfer the edges or use a guide to route the cable.

Important: Channels must be aligned and free of dirt or debris to avoid damaging the heating cable.

Splicing and components

- The number of splices and spacing interval depends on the engineered system design and reel lengths. The insulation must be opened and channel interrupted to install the components. Select and install the components in accordance with the design documentation provided.
- Use AT-180 Aluminum tape to attach SC heating cable to the pipe in any areas outside of the channel, such as pipe joints.

Important: Buried pipes must use below-insulation components. See Figure 19 on page 22.

- Replace the thermal insulation, to the design thickness, and the waterproof cladding after component installation.
- Use oversized insulation after installing below-insulation components.

3.4 Typical Installation Details

Wrap pipe fittings, equipment, and supports as shown in the following examples to properly compensate for higher heat-loss at heat sinks and to allow easy access for maintenance. The exact amount of heating cable needed is determined in the design.

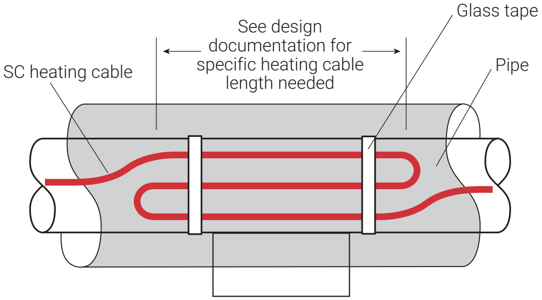


Figure 15: Pipe support

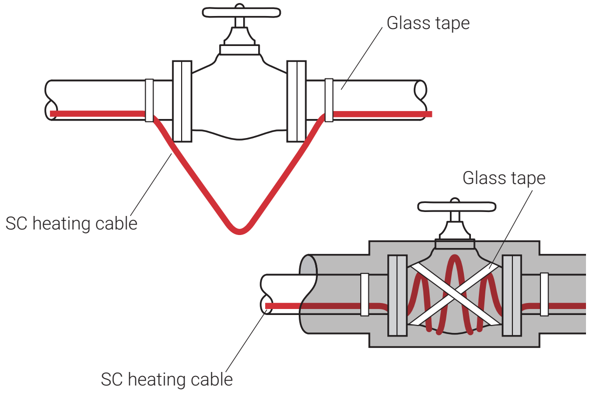


Figure 16: Valves

> ⚠ **WARNING:** Overlapped cables can overheat and create a risk of damaged cable or fire.

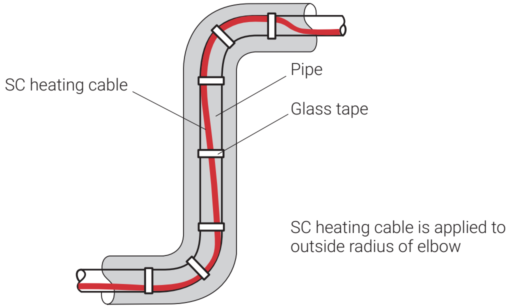


Figure 17: Installation at 90° elbow

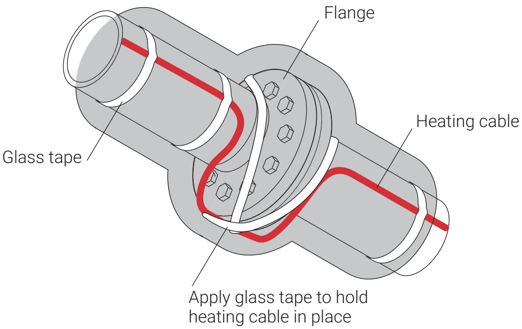


Figure 18: Flanges

⚠ **WARNING:** Overlap cables can overheat and create a risk of damaged cable or fire.

4. COMPONENT INSTALLATION

4.1 General Component Installation

Raychem SC components must be used with Raychem SC heating cables. A complete circuit requires a power connection and an end seal. Splices and accessories are used as needed. Refer to the system design documentation for the components required for your system.

Above-insulation SC power connections include the necessary junction box, cold leads and connections. Below-insulation SC powerconnections include the hot-to-cold lead transition but do not include the junction box, which must be supplied by others.

Installation instructions are included with the component kit. Steps for preparing the heating cable and connecting to components must be followed.

⚠ **WARNING:** Connections can overheat. Wire connections must be crimped and soldered.

Component Installation Tips

- Connection kits should be mounted on top of the pipe when practical. Electrical conduit leading to power connection kits should have low-point drains to keep condensation from accumulating in the conduit. All heating cable connections must be mounted above grade level.
- Be sure to leave a service loop at all components for future maintenance.
- Locate junction boxes for easy access but not where they may be exposed to mechanical abuse.
- Heating cables must be installed over, not under, pipe straps that are used to secure components.
- Make sure junction box lids, plugs, and glands are firmly tightened to prevent water ingress.
- Conduit drains should be installed in above-insulation components.

⚠ **WARNING:** Conductors must not be damaged. Damaged conductors can overheat or short. Do not break conductor strands when stripping the heating cable.

Raychem SC components

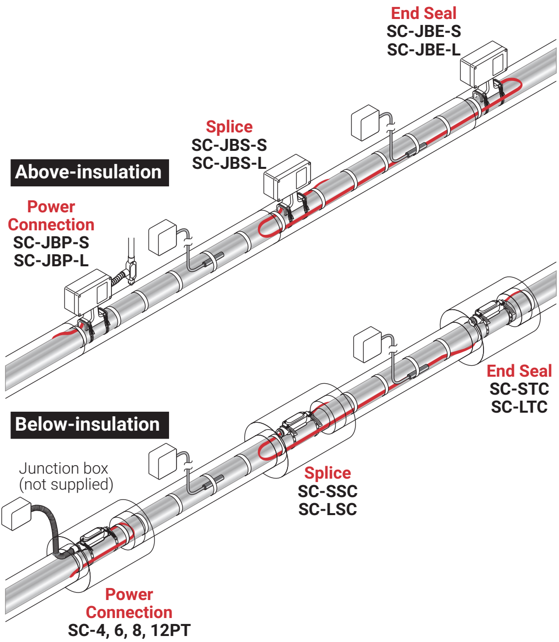


Figure 19: SC heating cable components

> ⚠ **WARNING:** Fire and Shock Hazard. Raychem SC components must be used. Do not substitute parts or use vinyl electrical tape.

5. CONTROL AND MONITORING

5.1 General Information

Raychem control and monitoring products are designed for use with SC heat-tracing systems. Thermostats, controllers, and control and monitoring systems are available. Compare features of these products in the table below. For additionalinformation on each product, refer to the Industrial Product Selection and Design Guide or contact your Chemelex representative.

Refer to the installation instructions supplied with control and monitoring products. Control and Monitoring systems may require installation by a certified electrician.

Chemelex Control and Monitoring Products

	Thermostats		Controllers				
		AMC-F5 AMC-1B AMC-2B-2 E507S-LS E507S-2LS-2	Raychem Series [1, 2]				
	AMC-F5 AMC-1A AMC-1H		Elexant 3500i	Elexant 4010i & 4020i	920	NGC-30	NGC-40
Control							
Ambient sensing	■		●	●	●	●	●
Line-sensing		■	●	●	●	●	●
PASC				●	●	●	●
Monitoring							
Ambient temperature			●	●	●	●	●
Pipe temperature			●	●	●	●	●
Ground fault			●	●	●	●	●
Current			●	●	●	●	●
Location							
Local	■	■	●	●	●	●	●
Remote			●	●	●	●	●
Hazardous	**AMC-1H**	**E507S**	●	●	●	●	●
Communications							
Local display				●	●	●	●
Remote display			●	●	●	●	●
Network to DCS			●	●	●	●	●

1 Raychem controllers used in CID1 areas require the use of appropriate hazardous area enclosures or Z-purge systems.

2 Please refer to Raychem Controller literature for maximum current and control voltage values.

5.2 Temperature Sensor Installation on Pipes

Secure the temperature sensor to the pipe using glass tape. Position the sensor element parallel to the pipe and in a location where it will not be affected by the heating cable (Figure 20). It is essential that the temperature sensor be positioned in accordance with design documentation.

Important: Temperature sensor should not be positioned at the end of a pipe, on a heat sink, or on a flowing section of pipe when other sections are stagnant.

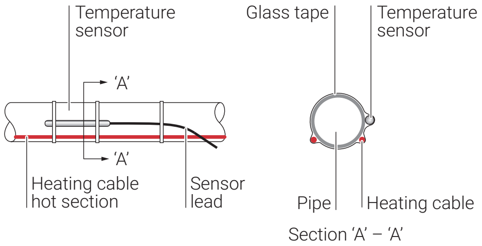


Figure 20: Temperature sensor and SC heating cable positioning

The temperature sensor should be taped in good thermal contact with the pipe and protected so that insulating materials cannot become trapped between it and the heated surface. Install temperature sensor with care as damage may cause a calibration error.

5.3 High Temperature Cut-Out Installation on Plastic Pipes

⚠ **WARNING:** To prevent overheating, a high temperature cut-out sensor must be installed for SC cable applications on plastic pipe.

High temperature cut-out sensor placement

Attach the high temperature cut-out sensor directly to the back surface of the heating cable, away from the pipe, as shown in Figure 21.

The sensor should be located in the hottest region of the pipeline, considering the following:

- Upstream in direction of flow
- Away from the heat sinks
- Accessible for maintenance
- At top of vertical pipes
- In direction of other heat sources
- Refer to the design documentation

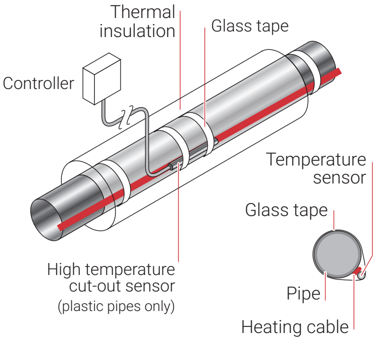


Figure 21: High temperature cut-out sensor placement

6. THERMAL INSULATION AND MARKING

6.1 Pre-Insulation Checks

Visually inspect the heating cable and components for possible damage or incorrect installation. Damaged cable must be removed and replaced.

Perform continuity and insulation resistance testing, known as a Megger test, on each cable following the procedure in Section 9.2. Confirm the results meet the minimum requirement stated in Test A and Test B and record them on the Heating Cable Installation Record in Section 12.

6.2 Insulation Installation Hints

- Make sure all of the piping is insulated according to the design documentation, including valves, flanges, pipe supports, and pumps.
- Ensure thermal insulation is suitable for the temperatures involved and for the location of the pipe (i.e. outdoors or below grade).
- Check insulation type and thickness against the design documentation.
- Insulation must be properly installed and kept dry.
- To minimize potential heating cable damage, insulate as soon as possible after tracing.
- Check that pipe fittings, wall penetrations, and other irregular areas have been completely insulated.
- When installing waterproof cladding, be sure drills, screws, and sharp edges do not damage the heating cable. The cladding must be installed immediately after insulation is applied to prevent the insulation from becoming wet.
- To weatherproof the insulation, seal around all fixtures that extend through the cladding. Check around valve stems, support brackets, and thermostat capillaries and sensor leads.

- Oversized insulation may be required to limit heat loss over SC components (see Figure 22).

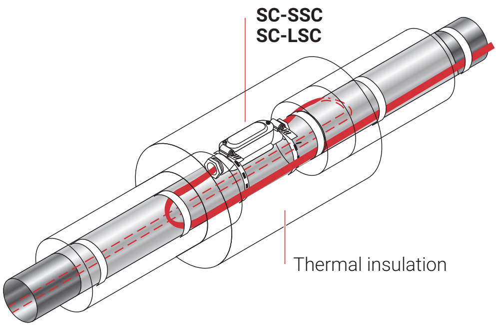


Figure 22: Oversized insulation

- Ensure that insulation is not trapped between cable and pipe, blocking heat transfer.
- To minimize "chimney effect" on vertical lengths of piping when using oversized insulation, install baffles between the thermal insulation and the pipe at maximum 8-foot (2.45 m) intervals.
- To prevent localized overheating, do not allow thermal insulation or other material to become lodged between the cable and the pipe. If urethane foam insulation is applied over heating cable, special care must be taken to ensure that the urethane does not get between the SC heating cable and the pipe. This can be accomplished by applying a strip of AT-180 aluminum tape longitudinally to the pipe over the cable.

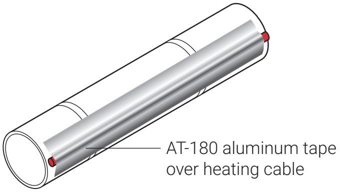


Figure 23: AT-180 aluminum tape

⚠ **WARNING:** Use only fire-resistant insulation.

6.3 Marking

Apply "Electric Traced," or similar, warning labels along piping at 10-foot (3 m) intervals on alternate sides, and on equipment requiring periodic maintenance, such as valves, pumps, filters, and so on, to indicate presence of electric heating cables.

6.4 Post-Insulation Testing

After the insulation is complete, perform a resistance/continuity and insulation resistance test on each circuit to confirm that the cable has not been damaged (refer to Section 9).

7. POWER SUPPLY AND ELECTRICAL PROTECTION

7.1 Voltage Rating

Verify that the source voltage corresponds to the SC heating cable voltage rating printed on the circuit identification tag and specified by the design documentation.

7.2 Electrical Loading

Size the over-current protective devices according to the design documentation. If devices other than those identified are used, refer to the current rating (amps) on the circuit identification tag to determine the electrical load.

Ground-fault protection

Chemelex recommends 30-mA ground-fault protection on all SC heating cable circuits.

Chemelex, the U.S. National Electrical Code, and the Canadian Electrical Code require both ground-fault protection of equipment and a grounded metallic covering on all heating cables. All Raychem products meet the metallic covering requirement.

Following are some of the ground fault breakers that satisfy this equipment protection requirement for 1SC and 2SC heating cables: Square D Type GFPD EHB-EPD (277 Vac); Cutler Hammer (Westinghouse) Type QBGFEP. Raychem series electronic monitoring controllers incorporate adjustable ground-faultprotection, eliminating the need for separate ground-fault breakers.

For 3SC heating cable, ground-fault protection can be provided with 3-pole 30-mA GFPD breakers or by using a ground-fault relay system as detailed in Figure 24 on page 28. For more details, contact your Chemelex sales representative.

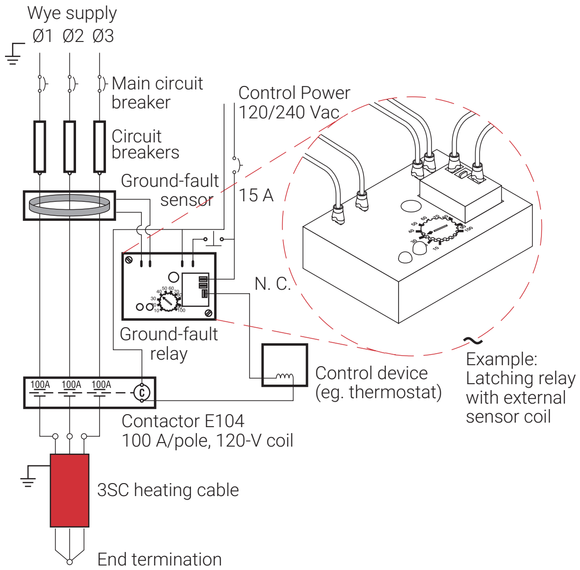


Figure 24: Three phase ground-fault protection with relay system

⚠ **WARNING:** Fire and Shock Hazard To minimize the danger of fire from sustained electrical arcing if the heating cable is damaged or improperly installed, and to comply with Chemelex 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:** Shock Hazard Disconnect all power before making connections to the heating cable.

⚠ **WARNING:** For ground-fault protection to be effective, the power must be supplied from a Wye transformer configuration with a solid ground reference.

7.3 Temperature Control Wiring

Wiring diagrams for typical temperature controllers are supplied with the controller. A contactor may be used to switch loads greater than the maximum current or voltage rating of the controller. Contact Chemelex for details.

Contactor current ratings: Always ensure that current ratings of the switch contacts are not exceeded.

⚠ **WARNING:** Fire Hazard in Hazardous Locations. Megger tests can produce sparks. Be sure there are no flammable vapors in the area before performing this test.

Chemelex 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. Record and maintain results for the life of the system, utilizing the Heating Cable Commissioning Record (refer to Section 12).

8. COMMISSIONING AND PREVENTIVE MAINTENANCE

8.1 Commissioning Tests

A brief description of each test is found below. Detailed test procedures are found in Section 9.

Visual inspection

Visually inspect the pipe, insulation, and connections to the heating cable for physical damage. Check that no moisture is present in junction boxes, electrical connections are tight and grounded, insulation is dry and sealed, and control and monitoring systems are operational and properly set. Damaged heating cable must be replaced. See Section 9.1 for more information.

Insulation resistance (Megger) test

Insulation resistance (IR) testing checks the integrity of the electrical insulating barrier between the resistive heating element and the cable jacket. IR testing is analogous to pressure testing a pipe and detects damage to the heating jacket or termination. 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. IR testing is recommended at five stages during the installation process, as part of regular system inspection, and after any maintenance or repair work. See Section 9.2 for more information.

Resistance and continuity test

Resistance and continuity testing measurements ensure that the correct product at the specified circuit length is installed and the conductors are connected properly. Continuity testing is recommended at commissioning, prior to system start-up, as part of regular system inspection, and after any maintenance or repair work. See Section 9.3 for more information.

Capacitance test

The length of the installed SC heating cable can be confirmed by measuring the capacitance between the heating conductors and the braid. Capacitance testing should be performed at the same time as the resistance and continuity test. See Section 9.4 for more information.

Power check

Power check verifies that the installed SC heating cable circuit produces the power output specified in the design documentation, and that the circuit breaker is sized correctly. This test also verifies that the ground-fault protection and system control are functioning. See Section 9.5 for more information.

8.2 Preventive Maintenance

Recommended maintenance for Chemelex SC heat-tracing systems consists of performing the commissioning tests on a regular basis, preferably at least once a year. Systems should be checked prior to each winter season.

If the SC heat-tracing system is found to be non-functioning, refer to Section 11 for troubleshooting assistance. Make the necessary repairs and replace any damaged part of the heat-tracing system.

The recommended cable installation methods allow for extra cable at all pipe fixtures (such as valves, pumps, and pressure gauges) so that the cable does not need to be cut when performing maintenance work.

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

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

Maintenance records

Chemelex requires that the Installation and Inspection Record (refer to Section 12) be completed during all inspections and kept for future reference.

Repairs

Use only Raychem SC heating cable and components when replacing any damaged cable. Replace the thermal insulation to its original condition or replace with new insulation and water proof coverings, if damaged.

Retest the system after repairs.

> ⚠ **WARNING:** Damage to cables or components can cause sustained electrical arcing or fire. Do not energize cables that have been damaged. Damaged heating cable and components must be replaced. Damaged cable should be replaced by a qualified person.

9. TEST PROCEDURES

Chemelex requires that the Installation and Inspection Record be completed during testing and kept for future reference.

9.1 Visual Inspection

- Visually inspect the pipe and connections to the heating cable for physical damage. Damaged heating cable must be replaced.
- Check that no moisture is present in junction boxes and that electrical connections are tight and grounded.
- Verify that all junction boxes are appropriate for the area classification and correctly sealed.
- Check for damaged or wet thermal insulation, damaged, missing or cracked lagging and weather-proofing.
- Check control and monitoring systems and high temperature cut-out sensors for moisture, corrosion, set point, switch operation, sensor or capillary damage, and ensure that they are operational and properly set.
- Check circuit breaker sizing and the supply voltage to verify that it is suitable for the heating cable voltage and amperage printed on the circuit identification tag and design documentation.
- Check the electrical connections to be sure the conductors are insulated over their full length.

9.2 Insulation Resistance (Megger) Test

Frequency

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

- Before installing the cable
- Before installing components
- Before installing the thermal insulation
- After installing the thermal insulation

- Prior to the initial start-up (commissioning)
- As part of the regular system inspection
- After any maintenance or repair work

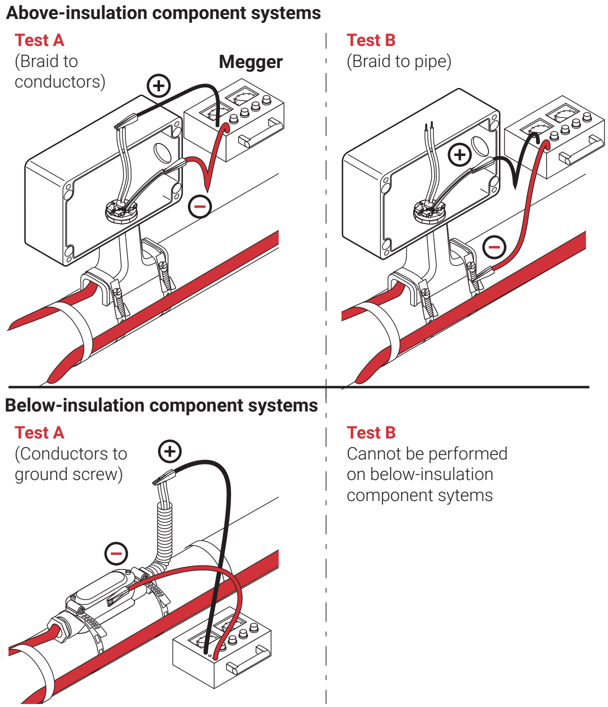


Figure 25: Megger testing for above and below-insulation components

9.3 Resistance and Continuity Test

Resistance and continuity testing is performed using a standard Digital Multimeter (DMM) and measures the resistance between the conductors of terminated circuits.

Test Criteria

Measure the resistance of the SC heating cable with the DMM. Most SC heating cable resistances are less than 100 ohms. The approximate resistance can be calculated using the formula: Resistance (ohms) = Volts / Amps. Voltage and amps can be found on the circuit identification tag and design documentation.

- If the resistance measurement is more than 20% higher than the calculated value, consult Section 11, Troubleshooting Guide.

Important: This measured value is the resistance at 68°F (20°C); the calculated value is the resistance at the operating temperature and may be higher than the measured value.

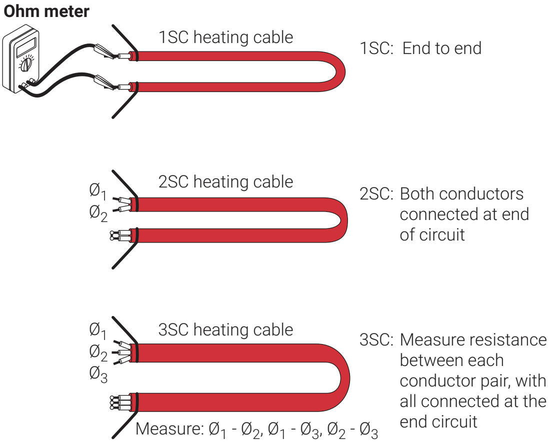


Figure 26: Resistance and continuity test

9.4 Capacitance Test

Connect the capacitance meter negative lead to the conductors and the positive lead to the braid wire. Set the meter to the 200nF range. Multiply the meter reading by the Capacitance factor for the correct heating cable shown in Table 2 to determine the total circuit length.

Length (ft or m) = Capacitance (nF) x Capacitance factor (ft or m/nF)

Compare the calculated circuit length to the design documentation and circuit breaker sizing tables.

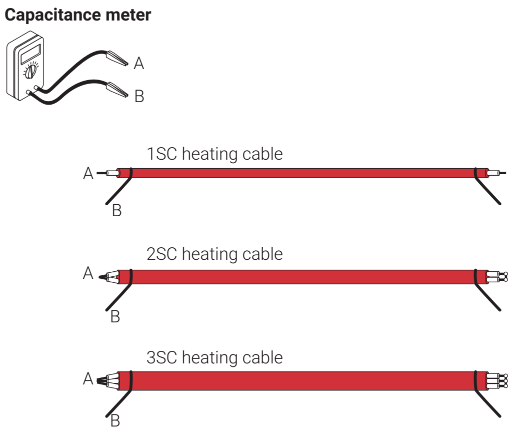


Figure 27: Capacitance (circuit length) test

Table 2: Capacitance factors

SC Heating Cable	Capacitance Factor	
	Ft/nF	m/nF
1SC30	25.4	7.7
1SC40	23.5	7.2
1SC50	22.6	6.9
1SC60	19.9	6.1
1SC70	18.1	5.5
1SC80	12.6	3.8
2SC30	22.1	6.7
2SC40	21.4	6.5
2SC50	20.6	6.3
2SC60	19.1	5.8
2SC70	16.1	4.9
2SC80	12.4	3.8
3SC30	15.9	4.9
3SC40	15.2	4.6
3SC50	13.6	4.2
3SC60	12.9	3.9
3SC70	12.1	3.7
3SC80	9.0	2.8

Important: The above capacitance factors are applicable to SC, SC/H heating cables.

Power Check

Energize the circuit breaker and after the current has stabilized, measure the circuit current using a clamp-on or panel ammeter. The measured value should be approximately the number shown under “Amps” on the circuit identification tag or design documentation. Variations of 10% to 20% are possible due to deviations in measurement equipment, supply voltage, and cable resistance. Raychem series electronic monitoring controllers can perform this function.

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

Power (watts) = Volts (Vac) x Current (Amps)

Compare the calculated wattage to the wattage indicated on the circuit identification tag or design documentation.

Important: For 3SC heating cables, the current of all three phases must be measured. Calculate the power of each phase. Then combine for calculating the total circuit power.

Circuit Power =

(Volts Ø-Ø / √3) x Amps Ø1=________ Watts Ø1

(Volts Ø-Ø / √3) x Amps Ø2=________ Watts Ø2

(Volts Ø-Ø / √3) x Amps Ø3=________ Watts Ø3

Ground-fault test

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

Procedure

Insulation resistance testing (using a megohmmeter) should be conducted at three voltages: 500, 1000, and 2500 Vdc. Significant problems may not be detected if testing is done only at 500 and 1000 volts.

First measure the resistance between the heating cable conductors and the braid (Test A) then measure the insulation resistance between the braid and the metal pipe (Test B). Test B cannot be conducted on plastic pipes or after installing below-insulation components. Do not allow test leads to touch the junction box, which can cause inaccurate readings.

1. De-energize the circuit.
2. Disconnect the thermostat or controller, if installed.
3. Disconnect conductors from the terminal block, if installed.
4. Set the test voltage at 0 Vdc.
5. Connect the negative (–) lead to the heating cable metallic braid.
6. Connect the positive (+) lead to all heating cable conductors simultaneously.
7. Turn on the megohmmeter and set the voltage to 500 Vdc; apply the voltage for several minutes. Meter needle should stop moving. Rapid deflection indicates a short. Record the insulation resistance value in the Inspection Record.
8. Repeat Steps 4–7 at 1000 and 2500 Vdc.
9. Turn off the megohmmeter.
10. If the megohmmeter does not self-discharge, discharge the phase connection to the ground with a suitable grounding rod. Disconnect the megohmmeter.
11. Repeat this test between the braid and metal pipe where possible.
12. Reconnect conductors to the terminal block.
13. Reconnect the thermostat.

Important: 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 a control and monitoring system is being used and Megger testing is being performed, remove the control equipment from the circuit and conduct the test directly from the heating cable.

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.

Insulation resistance criteria

A clean, dry, properly installed circuit should measure hundreds of megohms, regardless of the heating cable length or measuring voltage (0–2500 Vdc).

- All insulation resistance values should be greater than 100 megohms. If the reading is lower, consult Section 11, Troubleshooting Guide.

Important: Insulation resistance values for Tests A and B 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 Chemelex for assistance.

10. TROUBLESHOOTING GUIDE

This section describes how to locate SC heating cable faults detected during commissioning or preventative maintenance testing. SC heating cable faults can be of three different types: interrupted conductors, conductor to conductor shorts or conductor to ground shorts. The

Mode 1: Conductors/Heating Cable Interrupted

Symptom: No current, fail power check test, may pass megger.

Cause: Severed wires, component not installed, improperly installed crimps.

Case A: Entire cable interrupted

Data Measurements

- Megger to braid/ground: Pass Megger
- Resistance: Ohm readings show open (∞)
- Capacitance Test: Stable reading

Actions:

- Calculate circuit length from capacitance and compare todesign documentation, or measure capacitance from each end and use the ratio to locate the fault.
- Open thermal insulation at calculated distance to interruption then inspect heating cable and replace damaged cable and components as necessary.

<u>Case B: SC heating cable only partially interrupted (at least one conductor connected)</u>

Data Measurements

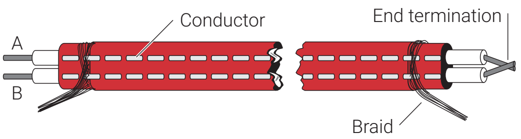
- Megger to braid/ground: Pass Megger
- Resistance: Ohm readings show open (A to B= ∞) on 1SC and 2SC. 3SC may have one complete phase connected.
- Capacitance Test: Stable reading

following sections describe how the test procedures in Section 9 reveal the different fault modes.

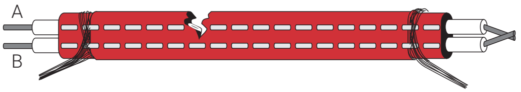
When a fault is discovered, the heating cable and/or components must be replaced or repaired until the circuit passes the required testing.

Mode 1: Interrupted conductor fault

Case A: Entire cable



Case B: Single conductor



2SC heating cable shown for example

Actions:

- If only one heating cable conductor is interrupted the capacitance reading from all conductors to ground will include entire installed length not the location of the interruption. The end termination must be removed. Capacitance test must be run on each conductor individually to ground to determine approximate location of the fault:

  Measure capacitance from each conductor to ground, from both ends of the circuit, where:

  $$\text{Ratio} = \text{Front nF} / (\text{front nF} + \text{back nF})$$

  Approximate Distance = Design length * Ratio

- Open thermal insulation at calculated distance to interruption then inspect heating cable and replace damaged cable and components as necessary.

Mode 2: Conductors Shorted Together

Symptom: **High Current, Possible CB trip, fail power check test**

Cause: **Mechanical damage, improperly installed components**

<u>Case A: One conductor to conductor short</u>

Data Measurements

• Megger to braid/ground:	Pass Megger
• Resistance:	Ohm readings low
• Capacitance Test:	Stable reading

Actions:

- Compare circuit resistance to design documentation, use the ratio of the two readings to estimate the approximate location of the short from the power connection.

$$\text{approximate distance} = \text{design length} * \left(\text{measured } \Omega / \text{design } \Omega \right)$$

- Open the thermal insulation at calculated distance to the fault then inspect the heating cable and replace damaged cable and components as necessary.

<u>Case B: Multiple conductor-conductor shorts</u>

Data Measurements

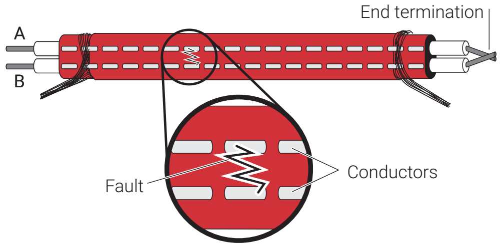
• Megger to braid/ground:	Pass Megger
• Resistance:	Ohm readings low
• Capacitance Test:	Stable reading

Actions:

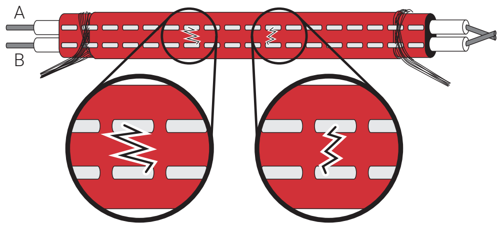
- Open thermal insulation at calculated distance to interruption then inspect heating cable and replace damaged cable and components as necessary.
- If there are multiple conductor-conductor shorts the distance to subsequent faults must be determined by repeating the measurements and calculation in Case A after each repair is made, until all the shorts are located and damaged heating cable and components are replaced.

Mode 2: Conductor to conductor fault

Case A: Single fault



Case B: Multiple faults



2SC heating cable shown for example

Mode 3: Conductor to Ground Fault

Symptom: **High Current, Possible CB trip, fail power check test, fail megger test**

Cause: **Mechanical Damage, improperly installed components**

Case A, B and C: Conductor to ground fault

Data Measurements

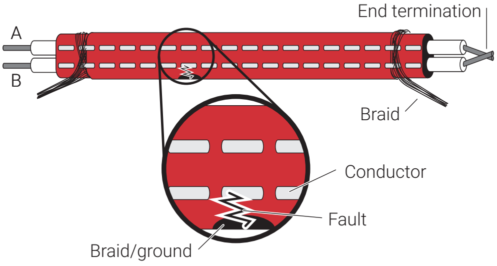
- Megger: Fail Megger
- Resistance: Ohm readings appear normal or low
- Capacitance: Cannot be tested since the conductors are shorted to ground

Actions:

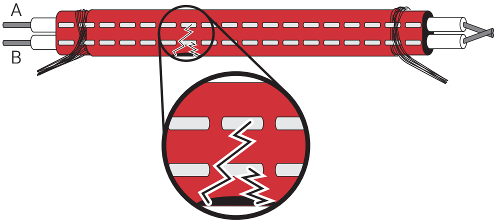
- Remove the end seal and measure the resistance and capacitance between each conductor and ground from both ends.
- If there is no fault to ground on the individual conductor the resistance reading will be open (∞) and the capacitance will give a stable reading
- Where a fault to ground is detected use the ratio method for resistance to ground between the front and back readings to estimate the fault location.
- If multiple faults are present, repeat the ratio tests until all of the faults are located and the necessary heating cable and components are replaced

Mode 3: Conductor to ground fault

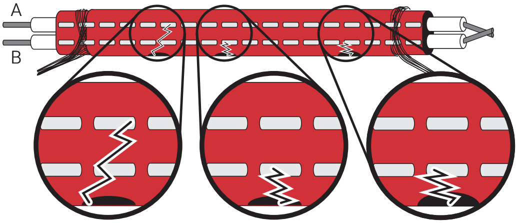
Case A: Single conductor-ground fault



Case B: Multiple conductor-ground faults single location



Case C: Multiple conductor-ground faults multiple locations



2SC heating cable shown for example

Symptom	Probable Causes
Low or inconsistent insulation resistance	Nicks or cuts in the heating cable. Short between the braid and heating cable bus wires or the braid and pipe.
	Testing braid to pipe (Test B) on below-insulation components.
	Arcing due to damaged heating cable insulation.
	Moisture present in the components. Test leads touching the junction box/condulet.
	High pipe temperature may cause low IR reading. **Reference tests:**

Symptom	Probable Causes
Circuit breaker trips	Circuit breaker is undersized. Heating cable is too short. Connections and/or splices are shorting out.
	Physical damage to heating cable is causing a direct short.
	Nick or cut exists in heating cable or power feed wire with moisture present or moisture in connections GFPD is undersized (5 mA used instead of 30 mA) or miswired.
	Reference tests:

Corrective Action
Check power, splice, and end connections for cuts, improper stripping distance, and signs of moisture. If heating cable is not yet insulated, visually inspect the entire length for damage, especially at elbows and flanges and around valves. If the system is insulated, disconnect heating cable section between power kits, splices, etc., and test again to isolate damaged section.
The braid is grounded to the pipe in these components so Test B cannot be performed.
Replace damaged heating cable sections and restrip any improper or damaged connections.
If moisture is present, dry out the connections and retest. Be sure all conduit entries are sealed, and that condensate in conduit cannot enter power connection boxes. If heating cable bus wires are exposed to large quanities of water, replace the heating cable. Clear the test leads from junction box/condulet and restart. Retest. Retest at ambient, if necessary.

Insulation Resistance Test, Visual Inspection

Corrective Action
Recheck the design current loads. Do not install cable length shorter than indicated on the circuit ID tag. Check to see if existing power wire sizing is compatible with circuit breaker. Replace the circuit breaker, if defective or improperly sized. Visually inspect the power connections, splices, and end seals for proper installation; correct as necessary.
Check for visual indications of damage around the valves, pump, and any area where there may have been maintenance work. Look for crushed or damaged insulation lagging along the pipe. Replace damaged sections of heating cable.
Replace the heating cable as necessary. Dry out and reseal the connections and splices. using a megohmmeter, retest insulation resistance. Replace undersized GFPD with 30 mA GFPD. Check the GFPD wiring instructions.

Insulation Resistance Test, Fault Location Test, Visual Inspection

Symptom	Probable Causes
Low pipe temperature	Pipe temperature measured while colder fluid is flowing.
	Insulation is wet or missing.
	Heating cable cicuit too long.
	Insufficient heating cable was used on valves, supports, and other heat sinks.
	Temperature controller was set incorrectly. Improper thermal design used. Improper voltage applied.
	Temperature sensor installed too close to the SC heating cable. **Reference tests:**

Symptom	Probable Causes
High pipe temperature	Temperature sensor is not in contact with pipe.
	Temperature controller was set incorrectly. **Reference tests:**

Symptom	Probable Causes
Low or no power output	Low or no input voltage applied. The circuit is longer than the design shows due to splices or tees not being connected, or the heating cable having been severed. Improper component connection causing a high-resistance connection.
	Control thermostat is wired in normally open position.
	The heating cable has been exposed to excessive temperature, moisture, or chemicals. **Reference tests:**

Corrective Action

Measure temperature when pipe is static.

Remove wet insulation and replace with dry insulation, and secure it with proper weatherproofing.

Longer heating cable circuits result in lower power output. Confirm the circuit length agrees with the design documentation.

Splice in additional heating cable but do not exceed circuit length indicated on the design documentation.

Reset the controller.

Contact your Pentair Thermal Management representative to confirm the design and modify as recommended.

Relocate the temperature sensor away from the heating cable.

Power Check, Visual Inspection

Corrective Action

Reinstall the temperature sensor on the pipe.

Reset the controller.

Power Check, Capacitance, Visual Inspection

Corrective Action

Repair the electrical supply lines and equipment.

Check the routing and length of heating cable (use as "as built" drawings to reference actual pipe layout). Locate and replace any damaged heating cables, Then recheck the power output.

Check for loose wiring connections and rewire if necessary. Verify that all crimps were connected using the proper crimp tool and solder.

Rewire the thermostat in the normally closed position.

Replace damaged heating cable. Repeat the commissioning tests.

Power Check, Fault Location Test, Visual Inspection

11. INSTALLATION AND INSPECTION RECORDS

Heating Cable Installation Record

Location ______________________ Ref. drawings(s) ______________________
Area classification ______________________ Auto ignition temp. ______________________
Circuit number ______________________ Circuit amp. ______________________
Heating cable manufacturer ______________________ Heating cable cat. no. ______________________

Megohmmeter manufacturer / model no. ________
Multimeter manufacturer / model no. ________ Last calibration date ________
Capacitance meter manufacturer / model no. ________ Last calibration date ________

TESTING: Note: Minimum acceptable insulation resistance shall be 100 MΩ.

1.	Receipt of heating cable	
	Insulation Resistance Test	(Test A/Test B)
	Capacitance (Circuit length)	Cap. Factor:
2.	After installing cable on pipe (or pulling through channel)	
	Insulation Resistance Test	(Test A/Test B)
	Capacitance (Circuit length)	Cap. Factor:
3.	After installing components (Circle components installed add kit name)	
	Insulation Resistance Test	(Test A/Test B)
	Capacitance (Circuit length)	Cap. Factor:
	Resistance	Calculated from ID tag:
4.	Visual Inspection before installing thermal insulation	
	Heating cable installed correctly on pipe/channel Y/N	
	Heater correctly installed at valves, pipe supports, other heat sinks Y/N	
	Components correctly installed and cable terminated Y/N	
	Installation agrees with manufacturers instructions and circuit design Y/N	
5.	After installing thermal insulation	
	Continuity test	
	Insulation Resistance Test	(Test A/Test B)
	Capacitance (Circuit length)	Cap. Factor:
	Resistance	Calculated from ID tag:
6.	Tagging and identification complete (panel, field components, pipe labels) Y/N	
7.	Circuit Identification tag connected within 3 inches of power? Y/N	
8.	Heating cable effectively grounded Y/N	
9.	Thermal insulation weather tight (all penetrations sealed)	
10.	Drawings, documentation marked as–built	

Performed by ______________________ Company ________
Witnessed by ______________________ Company ________
Accepted by ______________________ Company ________
Approved by ______________________ Company ________

Project number ______________ Line number ______________

Panel number ______________ Breaker number ______________

Circuit length ______________

Heater wattage ______________ Source voltage ______________

Voltage setting ______________V

Resistance range ______________Ω

Capacitance range ______________nF

Test Value / Remarks	Date	Initials
A: 500 V: 1000 V: 2500 V: B: 500 V: 1000 V: 2500 V:		
nF: Circuit Length:		
A: 500 V: 1000 V: 2500 V: B: 500 V: 1000 V: 2500 V:		
nF: Circuit Length:		
Power Kit Splice End Termination		
A: 500 V: 1000 V: 2500 V: B: 500 V: 1000 V: 2500 V:		
nF: Circuit Length:		
Measured:		
A: 500 V: 1000 V: 2500 V: B: 500 V: 1000 V: 2500 V:		
nF: Circuit Length:		
Measured:		

______________ Date ______________

______________ Date ______________

______________ Date ______________

______________ Date ______________

Heating Cable Commissioning and Annual Testing Record

Location ______________________ Ref. drawings(s) ______

Area classification ______________________ Auto ignition temp. ______

Circuit number ______________________ Circuit amp ______

Heating cable manufacturer ______________________ Heating cable ______

Design Information:

Total design length ______________________ Total installed length ______

Thermal insulation type ______

Maintain pipe temperature ______

Heating Cable Testing:

Instrument models and calabration date ______________________

Capacitance (Circuit length) Capacitance factor: ______________

Continuity/Resistance (Ω) ______________

Insulation Resistance (100 MΩ minimum) 500 V: ________

Performance Data:	Volts AC		
	Panel	Field	1 phase
			Line
Startup			
Second test			
Third test			
Ambient temperature			
Pipe temperature			
Calculated Total Watts			

Temperature Control: (degrees)	Ambient sensing	Set point
Model:		
Location:		
Programmed Y/N:		
Controls Operation Verified Y/N:		

Alarms/Monitoring: Type:	
	Temperature
	Current
	Ground fault
	Loss of voltage
Ground fault protection type:	Trip level (mA)

Performed by ______________________

Witnessed by ______________________

Accepted by ______________________

Approved by ______________________

Project number ____________ Line number ____________
Panel number ____________ Breaker number ____________
Circuit length ____________ Source voltage ____________
Catalog no. ____________ Heater wattage ____________

Thermal insulation thickness ____________

Circuit length (ft)

1000 V: ________ 2500 V: ____________

Current in Amperes			
3 phase			
Phase A	Phase B	Phase C	Neutral

Pipe sensing	Set point	Overlimit	Set point

High setting	Low setting	Operation verified Y/N

Measured current	Tested for operation

Company ____________ Date ____________
Company ____________ Date ____________
Company ____________ Date ____________
Company ____________ Date ____________

North America
Tel +1 800 545 6258
info@chemelex.com

Latin America
Tel +1 713 868 4800
info@chemelex.com

Europe, Middle East, Africa, India
Tel +32 16 213 511
Fax +32 16 213 604
info@chemelex.com

Asia Pacific
Tel +86 21 2412 1688
infoAPAC@chemelex.com

chemelex.com

Raychem Tracer Pyrotenax Nuheat

RAYCHEM-IM-H57772-SeriesResistanceHT-EN-2504