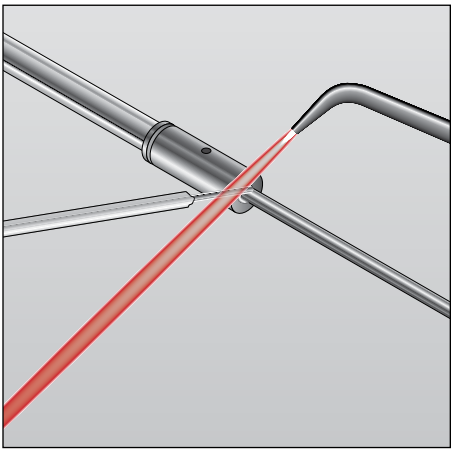
nVent

RAYCHEM

Mineral Insulated Cable

Heating Cable Repair Guide



Important Safeguards

⚠ WARNING: Fire and shock hazard. nVent RAYCHEM heating cables 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 nVent, agency certifications, and national electrical codes, ground-fault equipment protection must be used on each heating cable branch circuit. Arcing may not be stopped by conventional circuit protection.**
- **Damaged heating cable can cause electrical arcing or fire. Repair or replace damaged heating cable or terminations. Contact factory for assistance.**
- **To prevent shock or personal injury, disconnect all power before repairing or modifying the heating cable.**
- **When drying out cable, care must be taken not to trap moisture as this could cause the cable to burst, possibly causing injury.**

Table of Contents

1 General Information

1.1 Introduction

The purpose of these instructions is to provide a procedure for the repair or modification of RAYCHEM Copper and Alloy 825 sheath mineral insulated (MI) heating cables manufactured by nVent. They must be carefully followed to ensure that the MI cable performs safely and as intended.

During the installation of MI cables or during plant maintenance processes, the cables are occasionally damaged, cut or broken. It is usually impractical to remove these cables and return them to the manufacturer for repair. The field repair of these cables is therefore, the only feasible alternative.

The successful repair or modification of these cables is a specialized procedure, and as such, only qualified personnel at industrial establishments, with the necessary competency, are permitted to repair or modify MI heating cable sets. Where the work involves a change to the existing design, participation in the redesign is required by the manufacturer; or alternately, the design may be carried out by a professional engineer using design tools provided by the manufacturer.

For assistance, technical support, or other information regarding the repair of RAYCHEM MI cables, please contact your nVent representative or nVent directly.

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1 General Information

1.2 Safety Guidelines

The safety and reliability of any heat tracing system depends on both 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 can cause damage to the heating cable system, and may result in system failure, electric shock, or fire. The guidelines and instructions contained in this manual are important. Follow them carefully to minimize these risks and to ensure that the MI system performs reliably.

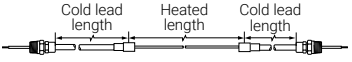
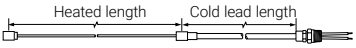
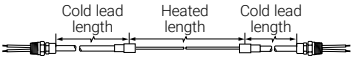
1.3 Electrical Codes

Refer to the appropriate sections of the National Electrical Code (NEC) and Canadian Electrical Code (CEC) regarding the field repair or modification of MI electrical heat tracing cables. The repair of MI heat tracing cables must comply with all national and local codes.

1.4 Heating Cable Configurations

The Field Repair Kit includes two joints and an end cap to allow for field repair or modification of the heating cable configurations shown in Table 1.

TABLE 1: MI HEATING CABLE CONFIGURATION

MI cable design	Number of conductors	Configuration
B	single conductor (61 series)	
D	dual conductor (32 & 62 series)	
E	dual conductor (32 & 62 series)	

A sectional view of a Design D MI heating cable is shown in Figure 1. All of the cables include both a heated section and one or two non-heating cold lead sections. 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. At the opposite end of the cable, the conductors of Design D cables are joined and hermetically sealed within an end cap.

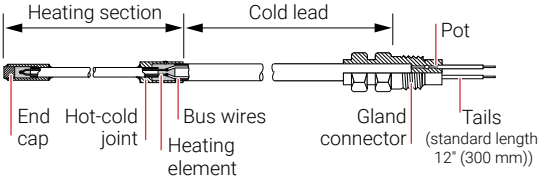


Figure 1: Sectional view of Design D MI cable

1.5 Heating Cable Identification

Each MI heating cable is supplied with an identification tag (see Figure 2) 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 designer's circuit identification number (optional), the cable current rating, serial number and maximum cable sheath temperature.
If the cable has been designed for a hazardous location, the area classification is printed in the 'Haz. Locations' section of the tag.

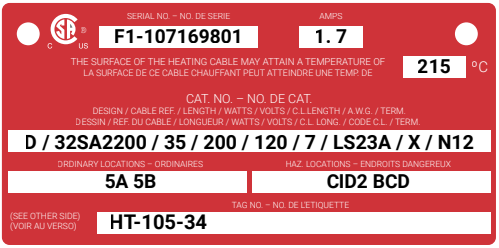


Figure 2: Typical MI heating cable tag (front)

2 Pre-Repair Information

2.1 General

Both single conductor and dual conductor copper sheath and Alloy 825 sheath cables can be field repaired or modified. The field repair kits can be used to complete the following:

- To repair or replace a joint in the heated section (hot-hot joint)
- To repair or replace a joint between the heated section and the non-heating cold lead section (hot-cold joint)
- To repair or replace the end cap for Design D cables

Brass joints and end caps are used to repair or modify heating cables with a copper sheath heated section and copper sheath cold lead section and are suitable for exposure temperatures up to 392°F (200°C).

Stainless steel joints and end caps are used to repair or modify heating cables with an Alloy 825 sheath heated section and Alloy 825 sheath cold lead section and are suitable for exposure temperatures up to 1022°F (550°C). They are also used to repair or modify heating cables with an Alloy 825 sheath heated section and copper sheath cold lead section for exposure temperatures up to 482°F (250°C).

Note: If the attempted repair cannot be done successfully, please contact nVent for assistance.

2.2 Safety Precautions

- Safety glasses and gloves must be worn when making field repair joints
- Take care to avoid burns when handling welding torches and hot work pieces
- Wear a welding apron when working with welding torches
- Follow all safety instructions supplied with the equipment you are using
- Disconnect all power before repairing or modifying the heating cable

CAUTION: When drying out cable, care must be taken not to trap moisture as this could cause the cable to burst, possibly causing injury.

2 Pre-Repair Information

2.3 Changes to the Heating Cable Length

A new tag is not required for repaired or modified heating cables provided the total length of the heated section of the cable is not changed by more than 3%. Where the heated section of the cable set is changed by more than 3%, to facilitate the repair or where the cable is modified, then a new MI cable tag must be ordered. In these cases, the MI Heating Cable Field Modification Approval Request Form in Appendix A must be filled in and reviewed by nVent before proceeding with the repair or modification and a permanent record of the modification must be retained.

⚠ Caution: Shortening the length of the heated section will decrease the resistance, resulting in increased current draw and wattage. Similarly, increasing the length of the heated section will increase the resistance, resulting in decreased current draw and wattage. Pay special attention to the over-current protective device to ensure that it will still conform to the requirements of national and local codes when such modifications are made to heating cables.

⚠ WARNING: A significant decrease in the length of the heated section may result in a considerable increase in wattage and cable sheath temperature with the potential of starting a fire. Verify the cable design before applying power.

2 Pre-Repair Information

2.4 Tools and Materials Required

TABLE 2: TOOLS AND MATERIALS

500 Vdc Megohmmeter
Small hammer
Ohmmeter (multimeter)
Needle nose pliers
Drill press and bits (see Appendix C)
Steel rule
Vernier caliper (or Micrometer)
Flat file (3/16 in thick)
Small tube cutter
Round file
Diagonal (side) cutters
Hacksaw
An oxy-acetylene torch with No. 0 welding tip or equivalent
Flat nose pliers
Knife (to strip jacketed copper cable)
Scribe or pick
Vise grip pliers or Handvise tool
Cotton cloth or rag
Small screwdriver with flat blade
Bottle of water
Steel repair jig or equivalent and two ‘C’ clamps to hold cable firm when welding (see Appendix H)
Engraving tool (Dremel® Model 290-01 or equivalent)

2 Pre-Repair Information

2.5 Repair Kit Components

TABLE 3: FIELD REPAIR KIT FOR COPPER SHEATH CABLES

Item	Qty	Description
A	1 ea	3/4 in (19 mm) brass joint (grooved)
B	1 ea	1/2 in (13 mm) brass joint (grooved)
C	1 ea	7/16 in (11 mm) brass end cap (grooved)
D	1 ea	Brass end cap plug
E	10 in	A-56T flux coated silver solder (orange color)
F	1 ea	3/8 in heat shrink tubing 13.7 in (35 cm) long
G	1 ea	3/4 in heat shrink tubing 6.9 in (18 cm) long
H	1 ea	1/2 in heat shrink tubing 6.9 in (18 cm) long
I	3 ea	# 6-32 brass machine screw
J	24 in	Fine grit emery cloth (180 grit)
K	1 ea	Syringe assembly with MgO and steel needle (vacuum sealed)
L	1 ea	Joint packing rod

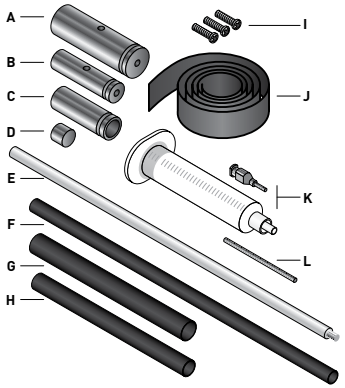


Figure 3: Kit contents for copper sheath cables

2 Pre-Repair Information

TABLE 4: FIELD REPAIR KIT FOR ALLOY 825 SHEATH CABLES

Item	Qty	Description
A	1 ea	3/4 in (19 mm) stainless steel joint (grooved)
B	1 ea	1/2 in (13 mm) stainless steel joint (grooved)
C	1 ea	7/16 in (11 mm) stainless steel end cap (grooved)
D	1 ea	stainless steel end cap plug
E	10 in	A-56T flux coated silver solder (orange color)
F	24 in	Medium grit emery cloth (80 grit)
G	3 ea	# 6-32 brass machine screw
H	1 ea	Syringe assembly with MgO and steel needle (vacuum sealed)
I	1 ea	Joint packing rod

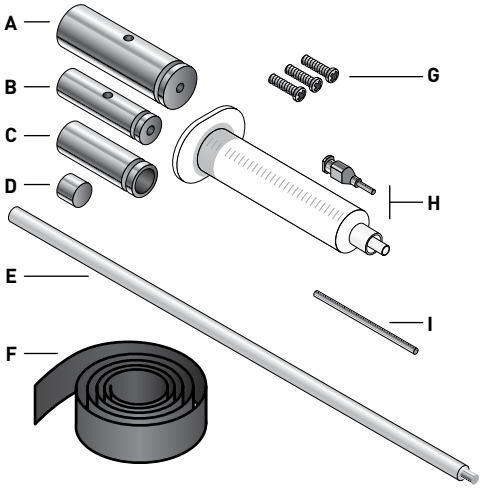


Figure 4: Kit contents for Alloy 825 sheath cables

2 Pre-Repair Information

2.6: Cross-section of completed joints and end cap

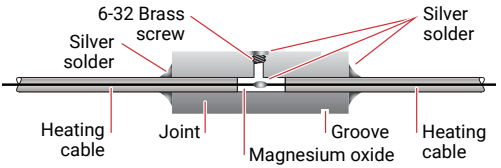


Figure 5: Completed heated-section to heated-section joint for single conductor cable

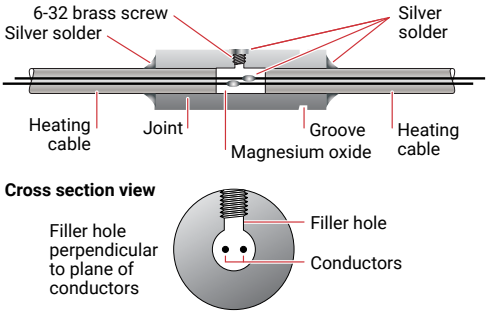


Figure 6: Completed heated-section to heated-section joint for two conductor cable

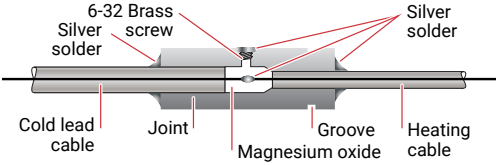


Figure 7: Completed heated-section to cold-section joint for single conductor cable

2 Pre-Repair Information

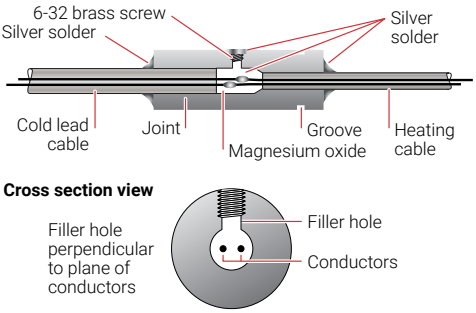


Figure 8: Completed heated-section to cold-section joint for two conductor cable

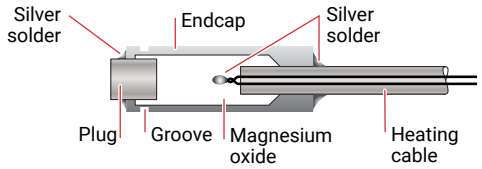


Figure 9: Completed end cap

3 Heating Cable Repair

3.1 General

- For field modifications, heating cable resistance should be checked with an ohmmeter to ensure that it is within ± 10% of the cable's calculated resistance.

  Calculated resistance = heated length (ft) x Ω/foot; (heated length (m) x Ω/meter)

Note: Ω/foot (Ω/meter) of heating cable may be obtained from the product data sheets, H56870 for Alloy 825 sheath heating cables and H56990 for copper sheath heating cables.

- For field repairs, check continuity of both sections of cable to be joined using the ohmmeter. If open circuited, other faults may exist in the cable.

– For two conductor heating cable, conductors or tails on far end of cable may have to be shorted together.

– For single conductor heating cable, the conductor or tail on far end can be shorted to the sheath and continuity checked between the conductor and sheath on opposite end.

- Follow appropriate repair procedure to make a joint (Section 3.3) or end cap (Section 3.4).
- When brazing, avoid excessive heating of parts to be joined as this can lead to embrittlement of materials and **cause the silver solder at the conductor joint to melt.**
- Once a joint or end cap installation has been started, it must be completed without interruptions. This will prevent the cable from absorbing moisture and causing a decrease in the insulation resistance.

3 Heating Cable Repair

3.2 Selecting the Correct Size of Joint and/or End Cap

Use a vernier caliper or micrometer to measure the outside diameter of the heated section and/or the cold lead section. Select the 1/2 in (13 mm) or 3/4 in (19 mm) stainless steel or brass joint from Table 5 or Table 6. If the heating cable is polymer jacketed, strip back the jacket and measure the diameter of the bare copper cable.

TABLE 5: SELECTING JOINT SIZE FOR DESIGN B, D, OR E ALLOY 825 SHEATH HEATING CABLES

1/2 in (13 mm) stainless steel joint

For heated-section to heated-section joint	For heated-section to cold lead section joint	
Max. diameter heated-section cable	Max. diameter heated-section cable	Max. diameter cold lead section cable
0.325 in	0.292 in	0.325 in

3/4 in (19 mm) stainless steel joint

For heated-section to heated-section joint	For heated-section to cold lead section joint	
Max. diameter heated-section cable	Max. diameter heated-section cable	Max. diameter cold lead section cable
0.543 in	0.480 in	0.543 in

Note: If heated section is Alloy 825 sheath and the cold lead section is copper sheath, use the stainless steel joint.

3 Heating Cable Repair

TABLE 6: SELECTING JOINT SIZE FOR DESIGN B, D, OR E COPPER SHEATH HEATING CABLE

1/2 in (13 mm) brass joint

For heated-section to heated-section joint	For heated-section to cold lead section joint	
Max. diameter heated-section cable	Max. diameter heated-section cable	Max. diameter cold lead section cable
0.325 in	0.292 in	0.325 in

3/4 in (19 mm) brass joint

For heated-section to heated-section joint	For heated-section to cold lead section joint	
Max. diameter heated-section cable	Max. diameter heated-section cable	Max. diameter cold lead section cable
0.543 in	0.480 in	0.543 in

The end cap supplied with the kit is suitable to repair the majority of MI heating cables. Select the appropriate end cap and plug from Table 7. In those instances where the heating cable diameter exceeds 0.300 in, contact nVent technical support for assistance.

TABLE 7: SELECTING END CAP FOR DESIGN D CABLES

Max. diameter of heated section	Alloy 825 sheath cables	Copper sheath cables	End cap Size
0.300 in	Use stainless steel end cap and plug	Use brass end cap and plug	7/16 in (11 mm)

3 Heating Cable Repair

3.3 Joining Design B, D, and E Cables

The instructions following apply to both heated section-heated section (hot-hot) joints and heated section-cold lead section (hot-cold) joints. Read these instructions completely before attempting to complete the repair or modification and refer to the Appendices for additional information where indicated. The instructions that apply specifically to a hot-hot or hot-cold joint are clearly identified and must be followed.

Note: Shield work area from environmental factors such as wind as it will cool the joint temperature making brazing difficult and disconnect power from the heating cable before attempting any repairs or modifications to the heating cable.

Ensure that the portion of the cable being worked on can be moved away from the surface at least 6 in (15 cm) to allow access when brazing (see repair jig in Appendix H).

Expose heated section and/or cold lead section so that 12 in (30 cm) minimum on either side of the joint or failure point is accessible.

If replacing an old joint, heat the bell-mouth (strain relief fitting on heating cable end of joint) with the torch and use pliers to separate it from the joint. Use a hacksaw to remove old joint from cable.

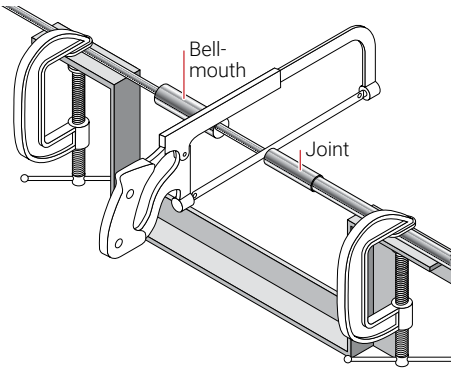


Figure 10: Remove joint

3 Heating Cable Repair

Note: Do not remove more than 3% of length of heated section. If more than 3% must be removed to facilitate the repair or modification, a new MI cable tag must be ordered (see Section 2.3).

If the bell-mouth is not re-used, care must be taken not to bend the cable at the joint as this will break the cable at the new braze.

Note: If replacing a 5/8 in (15.9 mm) diameter joint with a new 3/4 in (19 mm) diameter joint, it will not be possible to reuse the 5/8 in (15.9 mm) bell-mouth.

If heated section and/or cold lead section is polymer jacketed, remove heat shrink tubing and strip back 6 in (15 cm) of the jacket from each end, taking care not to nick or damage the copper sheath.

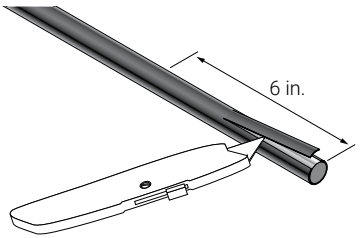


Figure 11: Remove polymer jacket

Check the insulation resistance (IR) of the cable at this point using a 500 volt Megohmmeter (see Appendix B for details on testing). This test checks for the presence of moisture in the magnesium oxide insulation. A value greater than 20 MΩ should be attained before proceeding. If the IR is lower, remove the moisture from the cable by following the **drying out** procedure in Appendix D. Repeat IR test.

Note: If the insulation resistance (IR) for a polymer jacketed cable is still low after drying out the cable (see Appendix D), it will be necessary to remove a a longer length of the polymer jacket and begin drying out the cable further back from the end.

3 Heating Cable Repair

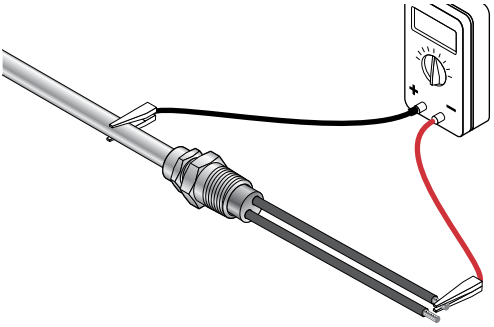


Figure 12: Check insulation resistance

Verify continuity of conductors using a multimeter or ohmmeter.

Using a vernier caliper (or micrometer), measure the outside diameter of the heated section and/or cold lead section (not including polymer jacket) and select the 1/2 in (13 mm) or 3/4 in (19 mm) joint from Table 5 or Table 6.

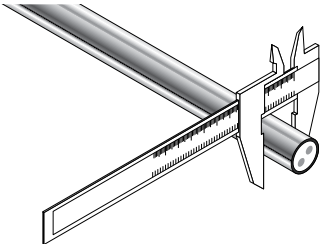


Figure 13: Check cable diameter

Note: If replacing the hot-cold joint, the diameters of both the heated section and cold lead section must be considered when choosing the correct size joint from Table 5 or Table 6.

3 Heating Cable Repair

Hot-hot joint: From the table in Appendix C, select the correct drill bit size for the cable diameter measured above (the drill bit should be 4/1000 in (0.1 mm) to 10/1000 in (0.25 mm) larger than the cable diameter). Drill a hole straight through the joint using the pilot hole as a guide. Check the joint to ensure there are no burrs inside and verify that the fill hole is tapped (6/32 thread).

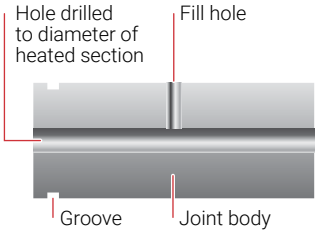


Figure 14: Cross-section of hot-hot joint

Hot-cold joint: From the table in Appendix C, select the correct drill bit sizes for the cable diameters measured above (the drill bit should be 4/1000 in (0.1 mm) to 10/1000 in (0.25 mm) larger than the cable diameter). Using the pilot hole as a guide, drill a hole straight through the joint with the smaller diameter drill. Using the larger drill, drill one end of the joint about 1/4 to 3/8 in (6 to 9 mm) past the fill hole. Check the joint to ensure there are no burrs inside and verify that fill hole is tapped (6/32 thread).

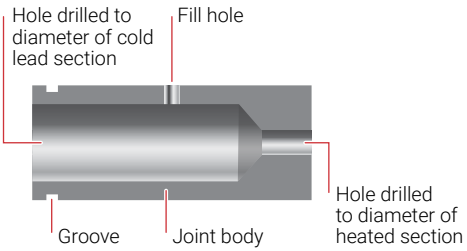


Figure 15: Cross-section of hot-cold joint

3 Heating Cable Repair

Hot-hot joint: Ensure the end of each heated section is straight for approximately 12 in (30 cm).

Hot-cold joint: Ensure the ends of the heated section and cold lead section are straight for approximately 12 in (30 cm). File the face of the cold lead section square using a flat file, filing in the forward direction only (end of conductor(s) should be clean). It is not necessary to file the face of heated section square.

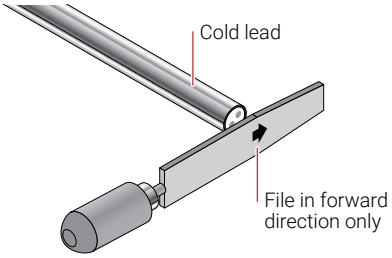


Figure 16: File face of cold lead

Sand about 2 in (5 cm) of each end of the cable sheath with emery cloth. The surface must be clean for brazing.

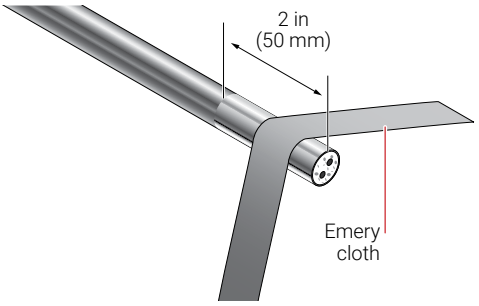


Figure 17: Sand cable sheath

3 Heating Cable Repair

If heated section and/or cold lead section is polymer jacketed, place 6.9 in (18 cm) lengths of heat shrinkable tubing onto the end of each cable and move clear of ends (heat will cause the heat shrinkable tubing to recover); place a 6.9 in (18 cm) length of larger diameter heat shrinkable tubing on one of the cable ends. See Appendix F for sizes required and detailed instructions.

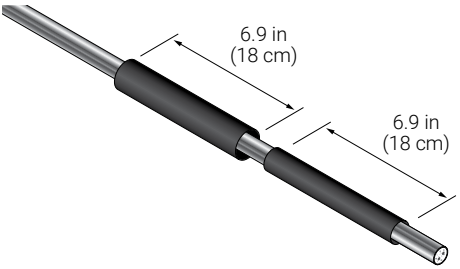


Figure 18: Place heat shrink on cable

Hot-hot joint: Slide the joint over either end of the heated section cables. Ensure that the joint will easily slide over both ends. Use a flat file or emery cloth to touch up the ends of the cables if necessary.

Hot-cold joint: Slide the joint over the heated section cable (smaller diameter cable) ensuring the larger hole faces the cold lead section. Make sure joint will slide over the end of the cold lead section. Use a flat file or emery cloth to touch up the ends of the cables if necessary.

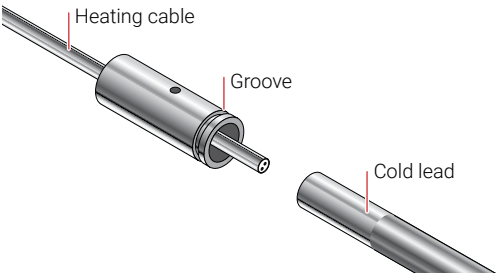


Figure 19: Place joint on cable

3 Heating Cable Repair

Hot-hot joint: Using the tube cutter, **lightly** score the sheath on each end of the heated section cables approximately 3/16 in (5 mm) from the end of each cable. With the diagonal cutters, remove the sheath up to the score mark. See note below.

Hot-cold joint: Using the tube cutter, score the sheath of the cold lead section approximately 1/4 in (6 mm) from the end of the cable. With the diagonal cutters remove the sheath up to the score mark.

Using diagonal cutters strip back the sheath of the heated section, without the aid of the tube cutter, approximately 1/4 in (6 mm).

Note: Do not cut too deeply with the tube cutter as this will cause the sheath to be pushed inwards towards the conductors, possibly resulting in cable failure. See Appendix G for detailed instructions on stripping cable sheath.

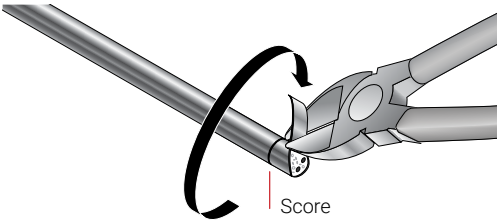


Figure 20: Strip cable sheath

Clean magnesium oxide powder from the conductors of the heated section cables with emery cloth or use side cutters to lightly scrape conductor surface. Conductor surface must be free of powder for silver solder to bond.

3 Heating Cable Repair

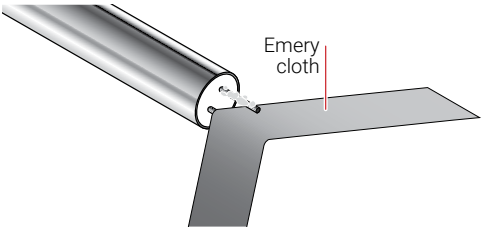


Figure 21: Clean conductors

Note: Do not clean the magnesium oxide powder from the conductors of the cold lead section as silver solder is applied only to the face of the conductor.

With pliers, break away 1/2 in (13 mm) of flux from end of flux coated brazing rod. This will help prevent excess flux from contaminating the magnesium oxide powder. There should be enough flux left on the brazing rod to allow proper brazing.

Hot-hot joint: Using oxy-acetylene torch, heat conductor with a small flame (see Appendix E) and touch or wipe brazing rod onto the **tip** of the conductor by turning the rod between the fingers. This will ensure that the flux melts off the rod and onto the conductor evenly. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder.

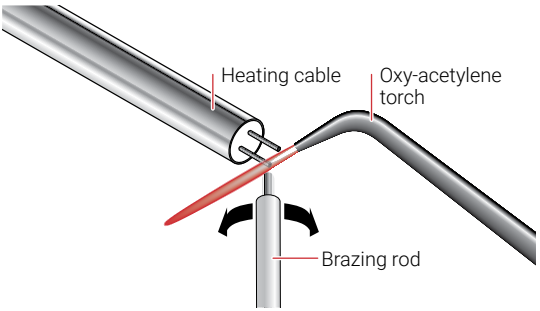


Figure 22: Tin heating cable conductor

3 Heating Cable Repair

Continue heating conductor with the oxy-acetylene torch (this does not take much heat) and at the same time touch brazing rod to the end of the conductor and apply enough silver solder to tin the end of the conductor. Repeat for remaining conductors on both cables to be joined.

Hot-cold joint: Using oxy-acetylene torch, apply heat to the center of the cold lead conductor with a small flame (see Appendix E) and touch or wipe brazing rod onto the **face** of the conductor by turning the rod between the fingers. This will ensure that the flux melts off the rod and onto the conductor evenly. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder.

Continue heating cold lead conductor with the oxy-acetylene torch (this does not take much heat) and at the same time touch brazing rod to the face of the conductor and apply enough silver solder to form a small **bead** on the conductor face. If repairing two conductor cable, repeat for remaining cold lead conductor.

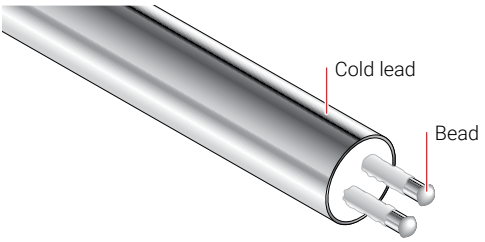


Figure 23: Cold lead conductor

Tin the conductors on the heated section using the procedure above for hot-hot joint.

Note: If repairing a two conductor cable, bend the two conductors of the heated section cable into a 'Y' shape (see Figure 25) to accommodate the distance apart of the cold lead conductors.

3 Heating Cable Repair

Hot-hot joint: Align the two cables so that the conductor tips butt together and touch the tip of the flame to the tinned conductors. The solder on both ends will melt and draw together. **Do not add any more silver solder.** Remove the heat and hold for two seconds until the solder hardens. Care should be taken not to overheat the conductors during this process. Pull lightly to test for strength.

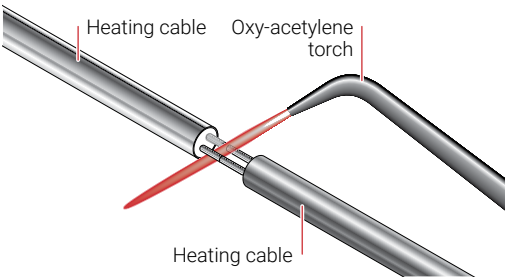


Figure 24: Brazing a hot-hot joint

Hot-cold joint: Apply some flux to the conductors of the heated section. Align the two cables so that the conductor tips butt together and heat the larger (cold lead) conductors, one at a time, so that the solder on the tip melts, then push the smaller (heated section) conductors into the solder. **Do not add any more silver solder**. Remove the heat and hold for two seconds until the solder hardens. Care should be taken not to overheat the conductors during this process. Pull lightly to test for strength.

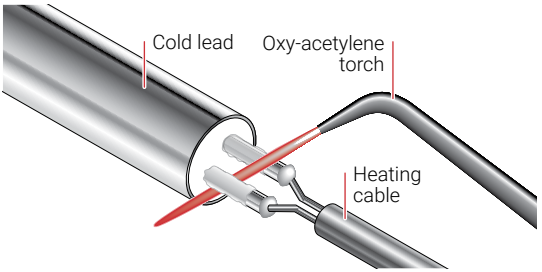


Figure 25: Brazing a hot-cold joint

3 Heating Cable Repair

Hot-hot joint: Ensure that the brazed junction is the same diameter as the heating cable conductor. If not, the brazed junction may be a cold joint and it will be necessary to remake it.

Hot-cold joint: Ensure that the brazed junction has formed a **cone** from the large to small diameter conductor. If not, the brazed junction may be a cold joint and it will be necessary to remake it.

Note: If insufficient heat is applied to the conductors, the brazed junction may be surrounded by the ball of silver solder but not actually bonded and an open circuit failure will occur.

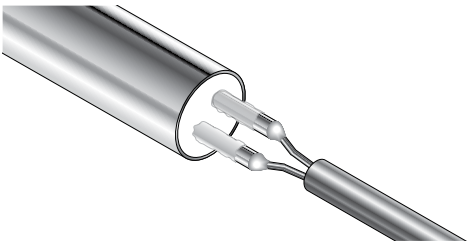


Figure 26: Hot-cold junction

Remove all trace of flux from the conductors with the emery cloth. Straighten the conductors with needle nose pliers such that the conductors will be as far from the inside wall of the joint as possible.

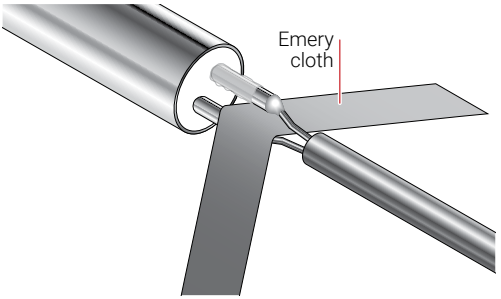


Figure 27: Clean conductors

3 Heating Cable Repair

Use a pick to remove any flux or carbon which may have contaminated the magnesium oxide powder at the ends of each cable.

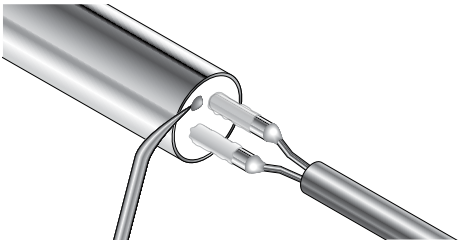


Figure 28: Clean face of cable

Hot-hot joint: For two conductor cable, ensure that the conductors are the same distance from each other as they are in the cable.

Hot-cold joint: For two conductor cable, conductors from the heating cable to the cold lead should be formed in a "Y" shape as shown in the previous step. This will prevent the conductors in the heating cable from shorting to the sheath.

Slide the joint over the exposed conductors, ensuring that the fill hole faces up and is centered over the conductor junction.

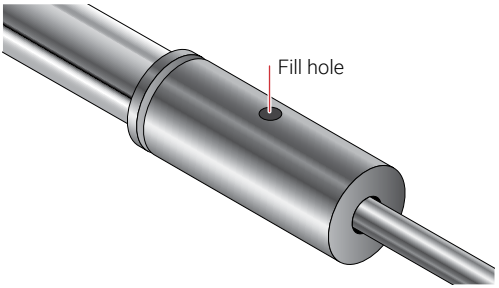


Figure 29: Center joint over conductors

You are now ready to braze the joint to the cable sheath. If making a hot-cold joint, begin with the cold lead section.

3 Heating Cable Repair

Using a large **sizzling** flame (see Appendix E), **heat out** the moisture from the cable beginning 12 in (30 cm) back from the joint (begin 4 in (10 cm) back for polymer jacketed cables), stopping 1/2 in (13 mm) from the joint. If making a hot-cold joint, heat out the cold lead first. Repeat procedure for cable on other side of joint. Immediately proceed to next step.

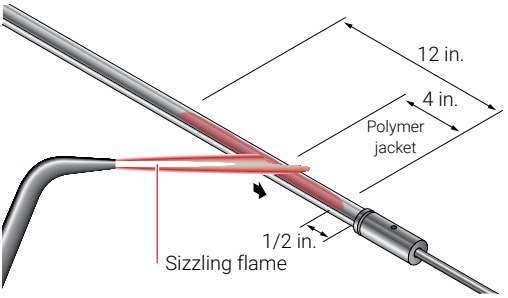


Figure 30: Heat out cable

Note: Details on heating out (drying out) the cable may be found in Appendix D.

If making a hot-cold joint, solder the heated section side (smaller cable) of the joint first.

Reduce **sizzling** flame to a **large** flame (see Appendix E). Using flux coated brazing rod and with a touching or wiping motion of rod, apply flux around end where the joint will be brazed to the cable sheath. Turning the rod between the fingers will ensure that the flux melts off the rod and onto the joint evenly. Ensure that the flux is applied around the entire junction.

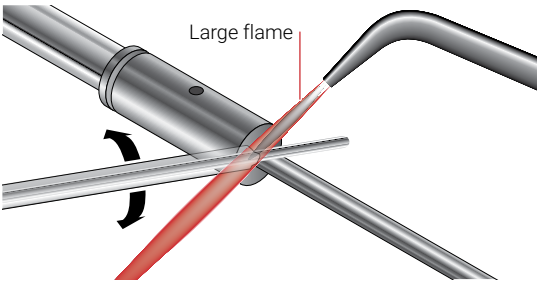


Figure 31: Apply flux to joining area

3 Heating Cable Repair

Heat the joint and heated section cable using a large flame. When the area to be brazed is up to temperature, deposit a large bead of silver solder on the top part of the area to be joined. Apply heat to both the joint and the cable and move the flame slowly around the circumference of the joint. This will cause the solder to **wick** its way around the joining area and also draw the solder inside the joint making a stronger braze. Add more silver solder as needed. Ensure that the solder flows to the bottom of the joint to ensure a continuous braze around the entire joint.

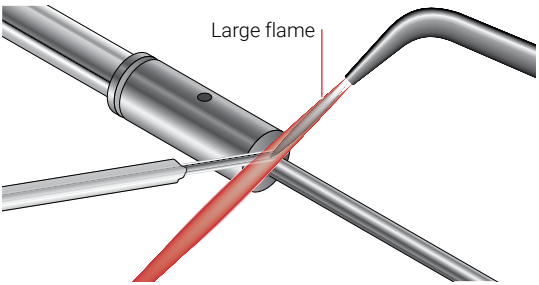


Figure 32: Braze joint to cable

Repeat procedure for other side of joint.

Note: While brazing, it is important to avoid using excess heat on the portion to be brazed. Direct flame contact can oxidize the metal surface, preventing the silver solder from adhering to the metal. Care must also be taken not to overheat the joint, which can cause the conductor joints (junction) to melt.

Assemble powder filled syringe by unscrewing the plastic tip cap and replace with 1-1/4 in (3.2 cm) long steel needle, keeping syringe facing upwards until ready to use. Do no remove red cap.

3 Heating Cable Repair

While joint is still hot, use syringe to fill the joint with magnesium oxide powder. Use an engraving tool or other vibration method to pack the powder. If using an engraving tool, reverse the engraving bit so that the blunt end is visible and place the bit against the joint. Using an engraving tool or other vibration method will evenly distribute the powder and ensure that it is well packed.

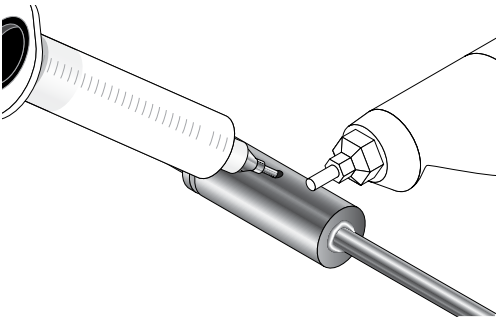


Figure 33: Fill joint with powder

⚠ CAUTION: Joint will be hot. Do not touch joint or cable with bare hands.

Remove syringe and use 1-1/2 in (3.8 cm) long packing rod (supplied with kit) to pack powder, taking care not to push in more than 1/8 in (3 mm) so as not to bend the conductors inside the joint. If required, add more powder to fill joint and repeat packing procedure using both the vibrating tool and the packing rod until the joint is completely full.

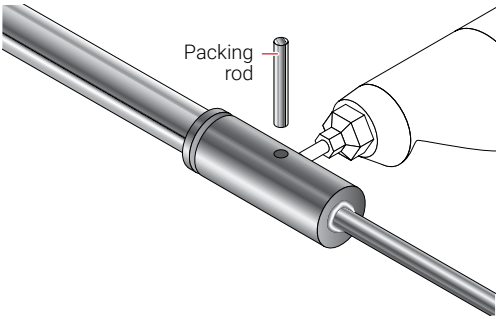


Figure 34: Pack powder

3 Heating Cable Repair

Insert the brass screw approximately 2 full turns into the fill hole, ensuring that the screw does not protrude into the joint and touch the conductors.

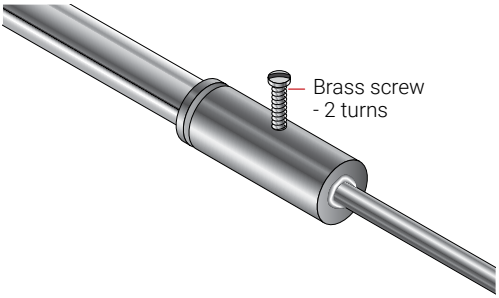


Figure 35: Insert brass screw

Saw off the screw flush with the joint. Using the edge of a flat file, groove a recessed area over and around the screw, filing in one direction only. The recess should be about 1/4" (6 mm) square.

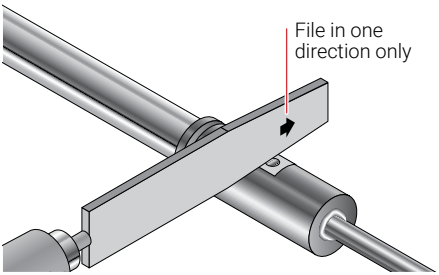


Figure 36: File groove

3 Heating Cable Repair

Check the insulation resistance (IR) again. A value greater than 20 MΩ should be attained. If the IR is lower, remove the moisture from the cable by following the **drying out** procedure in Appendix D and then repeat IR test.

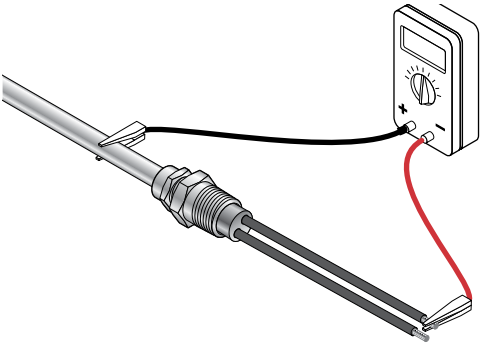


Figure 37: Check insulation resistance

This step must be done with great care as excess heat will cause the air within the joint to expand and cause a pinhole in the silver solder.

Using oxy-acetylene torch with a small flame, heat joint and apply a small amount of flux over the screw using flux coated brazing rod. Continue heating until the silver solder flows freely when touched to the joint, completely filling recessed area, then remove the heat.

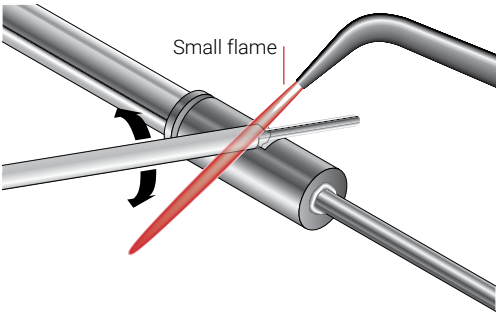


Figure 38: Fill recessed area with silver solder

3 Heating Cable Repair

Use a flat file and then emery cloth to clean flux from all brazed areas and visually inspect to ensure that there are no pinholes or gaps which could allow moisture to enter.

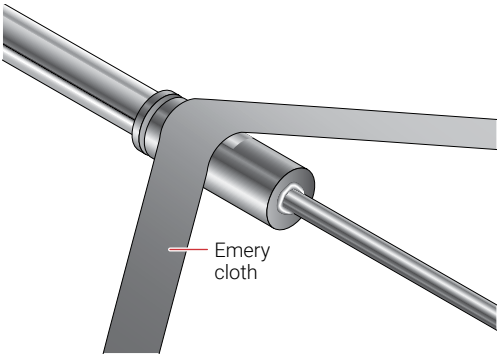


Figure 39: Clean joint

If necessary, touch up pinholes by cleaning the area and applying more silver solder. Ensure that all flux is removed from all brazed areas.

⚠ CAUTION: Joint will be hot. Do not touch joint or cable with bare hands.

3 Heating Cable Repair

Again, test the insulation resistance with a 500 volt Megohmmeter. Minimum IR should be 20 MΩ. Quench with a rag soaked in water by wrapping it tightly around the joint. Leave on for 4 to 5 minutes. If there are any remaining pinholes, moisture will be absorbed into the joint as it cools and the reading on the Megohmmeter will drop. Joint must be cool to get a proper IR reading.

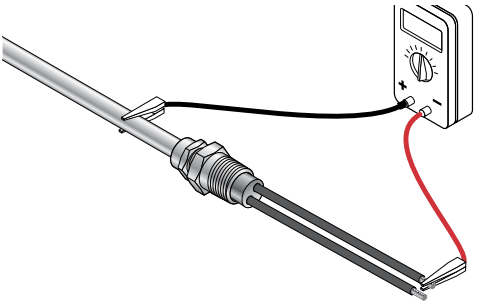


Figure 40: Check insulation resistance

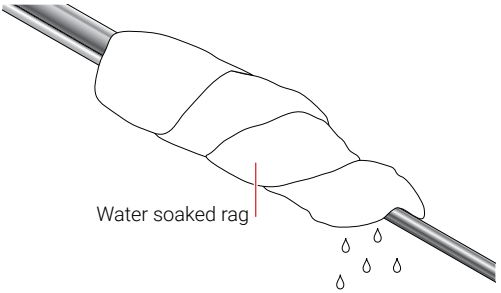


Figure 41: Wrap joint with water soaked rag

Note: If the Megohmmeter reading declines, file off all solder from over brass screw and drive out the moisture from the cable as described in Appendix D; the Megohmmeter reading will increase when the cable is dry. Once the moisture is removed, touch up the solder as necessary and retest. If still low, repeat procedure once more and retest. If still low, replace joint.

3 Heating Cable Repair

Check resistance of heating cable using an ohmmeter – it should be within 10% of specifications. If open circuit, cut off joint and repeat procedure.

The finished joint is shown below.

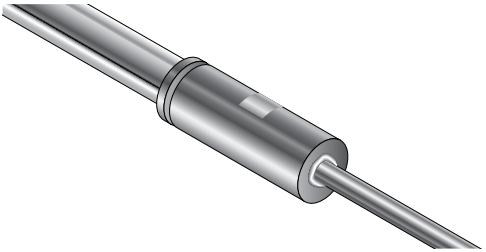


Figure 42: Completed joint

If repairing a hot-cold joint and reusing 1/2 in (13 mm) or 3/4 in (19 mm) bell-mouth, place a few drops of a suitable retaining compound (such as Loctite® 648) on the inside of the bell-mouth. Slide bellmouth onto the new joint and let set.

If heat shrink tubing was used above (copper sheath cables only), follow instructions in Appendix F to complete heat shrink installation.

3 Heating Cable Repair

3.4 End Cap Procedure

Note: Shield work area from environmental factors such as wind as it will cool the joint temperature making brazing difficult and disconnect power from the heating cable before attempting any repairs or modifications to the heating cable.

Expose heated section such that approximately 12 in (30 cm) minimum of cable and end cap is accessible.

Remove old end cap by cutting through cable with a hacksaw as close as possible to the solder on the end cap.

Note: Do not remove more than 3% of length of heated section. If more than 3% must be removed to facilitate the repair or modification, a new MI cable tag must be ordered (see Section 2.3).

Note: Ensure that the portion of the cable being worked on can be moved away from the surface at least 6 in (15 cm) to allow access when brazing.

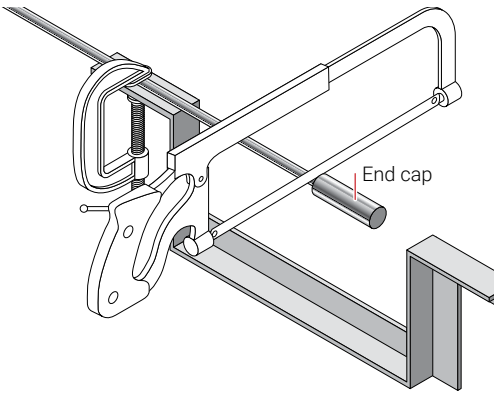


Figure 43: Remove end cap

If cable is polymer jacketed, strip back 6 in (15 cm) of the jacket as shown, taking care not to nick or damage the copper sheath.

3 Heating Cable Repair

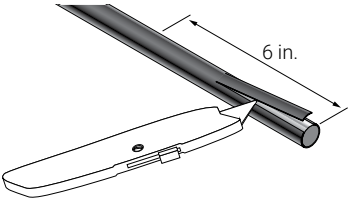


Figure 44: Remove polymer jacket

Check the insulation resistance (IR) of the cable at this point using a 500 volt Megohmmeter (see Appendix B for details on testing). This test checks for the presence of moisture in the magnesium oxide insulation. A value greater than 20 MΩ should be attained before proceeding. If the IR is lower, remove the moisture from the cable by following the **drying out** procedure in Appendix D. Repeat IR test.

Verify continuity of conductors using a multimeter or ohmmeter.

Note: If the insulation resistance (IR) for a polymer jacketed cable is still low after drying out the cable (see Appendix D), it will be necessary to remove a a longer length of the polymer jacket and begin drying out the cable further back from the end.

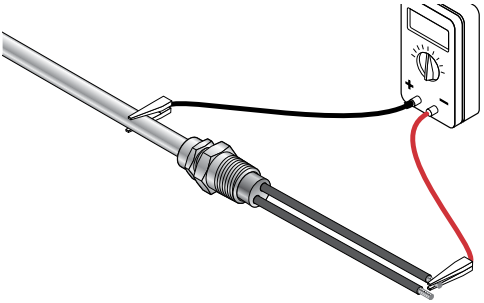


Figure 45: Check insulation resistance

Using a vernier caliper (or micrometer), measure the outside diameter of the heated section (not including polymer jacket) and select the stainless steel end cap and plug for Alloy 825 sheath cables or the brass end cap and plug for copper sheath cables from Table 7.

3 Heating Cable Repair

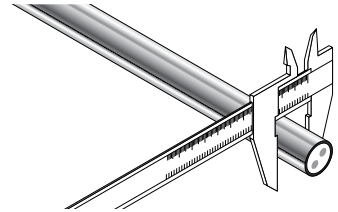


Figure 46: Check cable diameter

From the table in Appendix C, select the correct drill bit size for the cable diameter measured above (the drill bit should be 4/1000 in (0.1 mm) to 10/1000 in (0.25 mm) larger than the cable diameter). Drill a hole straight through the end cap using the pilot hole (smaller hole) as a guide and check it for burrs.

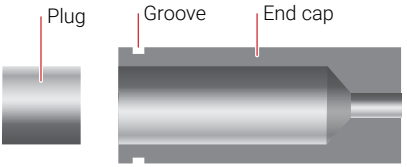


Figure 47: Cross-section of end cap

Sand about 2 in (5 cm) of the end of the cable sheath with emery cloth. The surface must be clean for soldering.

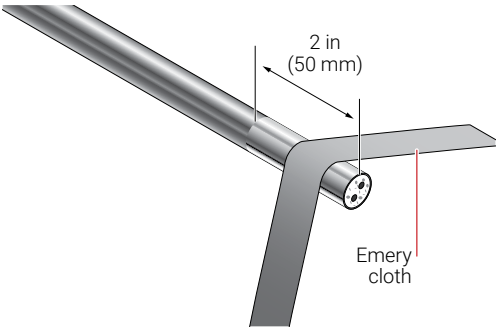


Figure 48: Sand cable sheath

3 Heating Cable Repair

If heated section is polymer jacketed, place a 6.9 in (18 cm) length of small diameter and a 6.9 in (18 cm) length of larger diameter heat shrinkable tubing onto the end of the cable and move clear of end; See Appendix F for sizes required and detailed instructions.

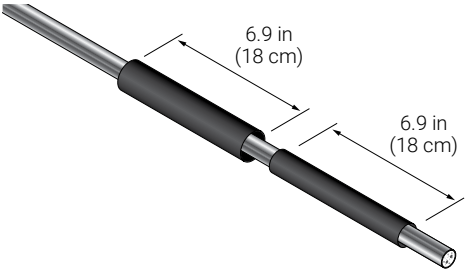


Figure 49: Place heat shrink on cable

Check inside of end cap for burrs and if present, remove with round file. Slide the end cap onto the cable making sure the plug end (larger end) faces outwards.

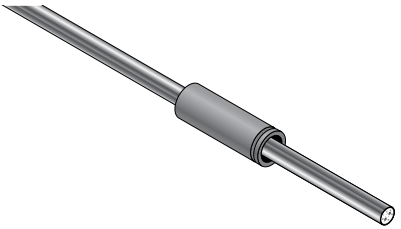


Figure 50: Place end cap on cable

Using side cutters, strip the sheath back about 3/8 – 1/2 in (9 – 13 mm) taking care to flare the sheath of the cable slightly outward.

Note: See Appendix G for detailed instructions on stripping cable sheath.

3 Heating Cable Repair

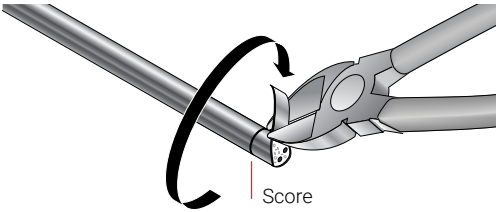


Figure 51: Strip cable sheath

Clean magnesium oxide powder from the conductors with emery cloth or use side cutters to lightly scrape conductor surface. Conductor surface must be free of powder for silver solder to bond.

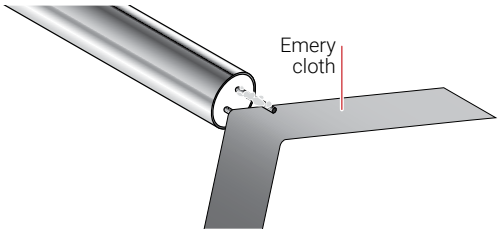


Figure 52: Clean conductors

Using pliers, twist conductors together through approximately two full 360° turns.

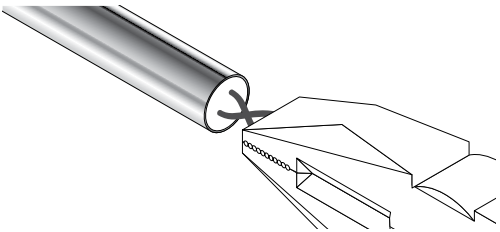


Figure 53: Twist conductors

With pliers, break away 1/2 in (13 mm) of flux from end of flux coated brazing rod. This will help prevent excess flux from contaminating the magnesium oxide powder. There should be enough flux left on the brazing rod to allow proper brazing.

3 Heating Cable Repair

Using oxy-acetylene torch, apply heat to the **tip** of the twisted conductors with a small flame (see Appendix E) and touch or wipe brazing rod onto the tip by turning the rod between the fingers. This will ensure that the flux melts off the rod and onto the conductors evenly. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder.

Continue heating conductor with the oxy-acetylene torch (this does not take much heat) and at the same time touch brazing rod to the end of the twisted conductors and apply enough silver solder to form a small bead.

Slightly **fan** torch back and forth several times to draw the silver solder backwards, about 1/4 in (6 mm), along the twisted conductors. Remove heat.

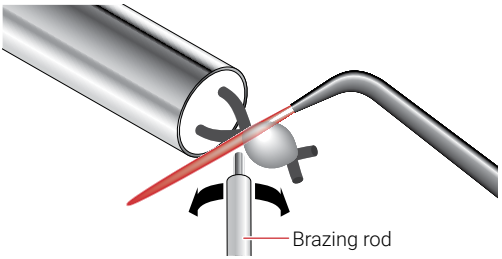


Figure 54: Join conductors

Care must be taken to avoid over-heating the conductors and to avoid depositing an excessive amount of solder on the twisted conductors.

Break away the flux from the brazed conductors and snip off the end of the conductors leaving 1/4 in (6 mm) exposed. Use a pick to remove any flux or carbon which may have contaminated the magnesium oxide powder.

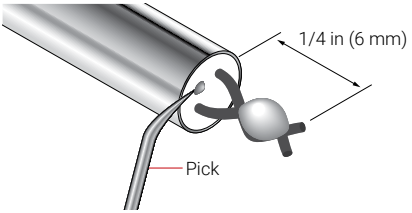


Figure 55: Clean face of cable

3 Heating Cable Repair

Slide the end cap as far forward as possible (the flare on the cable sheath will stop it), then move it back 3/16 in (5 mm) to ensure proper placement of the heating cable in the end cap (see cross section).

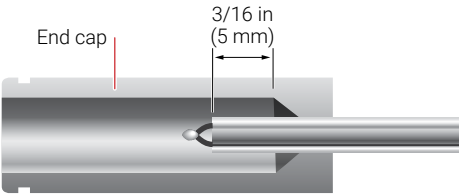


Figure 56: Placement of cable in end cap

You are now ready to braze the end cap to the cable sheath.

Using a large sizzling flame (see Appendix E), heat out the moisture from the cable beginning 12 in (30 cm) back from the end cap (begin 4 in (10 cm) back for polymer jacketed cable), stopping 1/2 in (13 mm) from the end cap. Immediately proceed to next step.

Note: Details on heating out (drying out) the cable may be found in Appendix D.

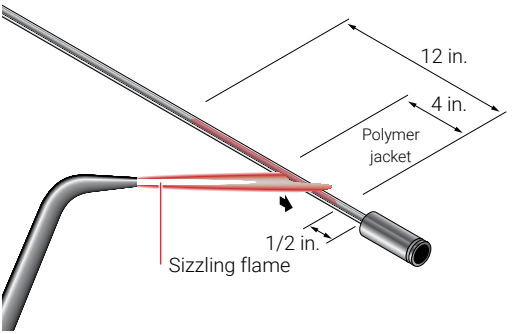


Figure 57: Heat out cable

3 Heating Cable Repair

Reduce sizzling flame to a large flame (see Appendix E). Using flux coated brazing rod and with a touching or wiping motion of rod, apply flux around end where the end cap will be brazed to the cable sheath. Turning the rod between the fingers will ensure that the flux melts off the rod and onto the joint evenly. Ensure that the flux is applied around the entire junction.

Heat the end cap and cable sheath with a large flame. When the area to be brazed is up to temperature, deposit a large bead of silver solder on the top part of the area to be joined. Apply heat to both the end cap and the cable and move the flame slowly around the circumference of the end cap. This will cause the solder to wick its way around the joining area and also draw the solder inside the end cap making a stronger braze. Add more silver solder as needed. Ensure that the solder flows to the bottom of the end cap to ensure a continuous braze around the end cap.

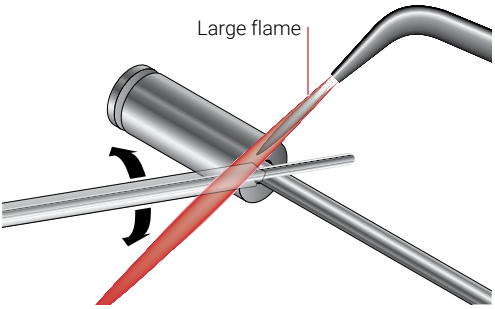


Figure 58: Braze end cap to cable

Note: While brazing, it is important to avoid using excess heat on the portion to be brazed. Direct flame contact can oxidize the metal surface, preventing the silver solder from adhering to the metal. Care must also be taken not to overheat the end cap, which can cause the conductor joint (junction) to melt.

Reposition end cap facing upwards. Assemble powder filled syringe by unscrewing plastic tip cap and replace with 1-1/4 in (3.2 cm) long steel needle, keeping syringe facing upwards until ready to use. Do not remove red cap.

3 Heating Cable Repair

While the end cap is still hot, fill end cap to approximately 3/16 in (5 mm) below the opening at the top of the end cap. Use an engraving tool or other vibration method to pack the powder. If using an engraving tool, reverse the engraving bit so that the blunt end is visible and place the bit against the end cap. Using an engraving tool or other vibration method will ensure that the powder is well packed.

⚠ **CAUTION: End cap will be hot. Do not touch end cap or cable with bare hands.**

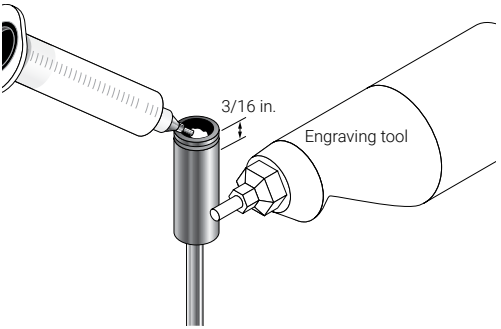


Figure 59: Fill end cap with powder

Insert the plug and firmly and gently tap it down to further compress the powder.

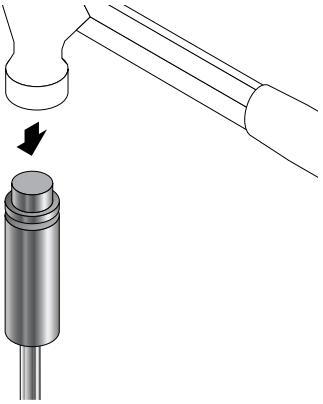


Figure 60: Insert plug

3 Heating Cable Repair

Check the insulation resistance (IR) again. A value greater than 20 MΩ should be attained. If the IR is lower, remove the moisture from the cable by following the drying out procedure in Appendix D. Repeat IR test.

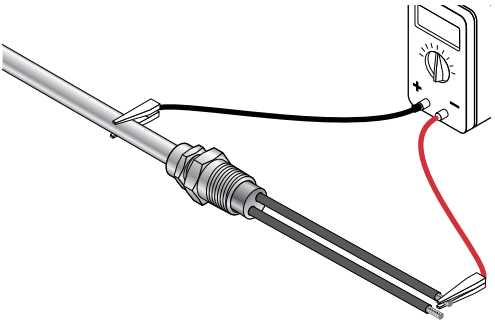


Figure 61: Check insulation resistance

Using oxy-acetylene torch with a large flame, apply heat to the end cap sweeping the flame from bottom to top of end cap 4 to 5 times. This will aid in removing any moisture trapped in the powder.

Heat the top of the plug and apply flux around area where the plug will be brazed to the end cap using flux coated brazing rod. Ensure that the flux is applied around the entire junction and braze the plug to the end cap.

Do not apply excess heat at this time, as excess heat will cause the air within the end cap to expand and cause a pinhole in the silver solder. If a pinhole does develop, the surface should be cleaned and filed before attempting to re-solder the end cap.

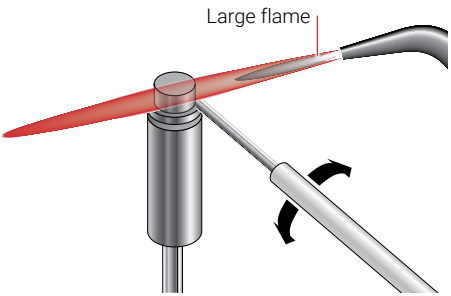


Figure 62: Braze plug to end cap

3 Heating Cable Repair

Note: While brazing, it is important to avoid using excess heat on the portion to be brazed. Direct flame contact can oxidize the metal surface, preventing the silver solder from adhering to the metal. Care must also be taken not to overheat the end cap, which can cause the conductor joint (junction) to melt.

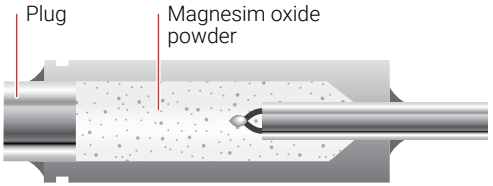


Figure 63: Cross-section of completed end cap

Test the insulation resistance with a 500 volt Megohmmeter. Minimum IR should be 20 MΩ. Clean end cap to remove all flux. With Megohmmeter still connected, quench with a rag soaked in water by wrapping it tightly around the joint. Leave on for 4 to 5 minutes. If there are any remaining pinholes, moisture will be absorbed into the end cap as it cools and the reading on the Megohmmeter will drop.

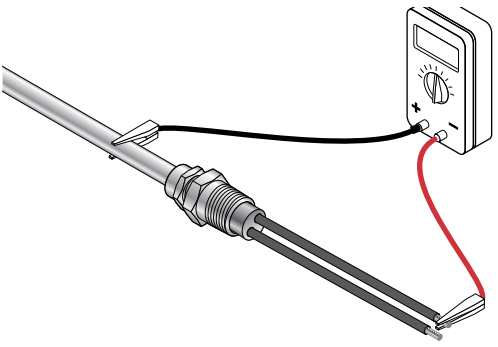


Figure 64: Check insulation resistance

3 Heating Cable Repair

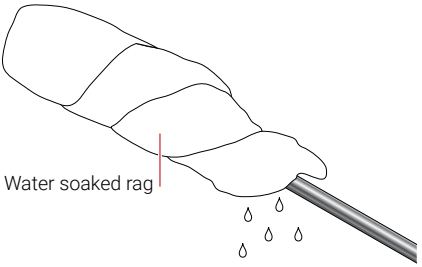


Figure 65: Wrap end cap with water soaked rag

Note: If the Megohmmeter reading declines, remove wet rag and visually inspect end cap for pinholes. If pinholes exist, dry out cable according to procedure in Appendix D, being careful not to trap any moisture. Any remaining moisture will escape through the pinhole. Once the moisture is removed, touch up the solder as necessary and retest. If still low or if no pinholes are visible replace end cap.

CAUTION: Endcap will be hot. Do not touch endcap or cable with bare hands.

Check resistance of heating cable using an ohmmeter – it should be within 10% of specifications. If open circuit, cut off end cap and repeat procedure.

The finished end cap is shown below.

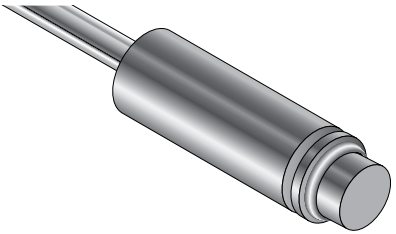


Figure 66: Completed end cap

If heat shrink tubing (for copper sheath cables only) was used above, follow instructions in Appendix F to complete heat shrink installation.

4 Appendix A: Field Modification Approval Request Form

MI Heating Cable Field Modification Approval Request Form

For field modifications, where the heating cable length is changed by more than three percent (3%), the change must be reviewed by nVent and a new cable identification tag must be ordered. Please fill in this form and fax to 1-800-272-7808. nVent will review the change and advise if the modification is appropriate.

SENDER INFORMATION

Contact Name:

Address:

Ship to address for Metal Tag (if different than above):

Reason for Cable Modification:

CABLE INFORMATION AND DESCRIPTION OF CHANGE (All Fields MUST be Completed)

'Original Tag Information' may be found on the metal identification tag attached to the cold lead. = Do NOT fill in this area

Original Tag information

Serial No		
Amps		
Max Surface Temp (°C)		
Cable Design		
Cable Reference		
Cable Length	☐ Ft	☐ Meter
Watts		
Volts		
Cold Lead Length	☐ Ft	☐ Meter
Cold Lead Code (or AWG)		
Joint Type		
Connector		
Ordinary Location Desig		
Haz. Location Desig	Haz. Groups	
Tag no.		

ADDITIONAL INFORMATION REQUIRED IF CABLE IS USED IN HAZ. LOCATIONS

Maintain Temp (°C)

Auto Ignition Temp (°C)

FOR INTERNAL USE ONLY

Cable Manufacture Review: _____ Print Name

Metal Tag Part No.

Sales Order No.

If you have any questions regarding this form, please contact nVent at 650-474-7709.

4 Appendix A: Field Modification Approval Request Form

Company:
Telephone:
Fax:
Email:

New Tag Information

For Internal Use Only

☐ Ft ☐ Meter

Signature

Date

5 Appendix B: Heating Cable Testing

5.1 Testing:

A 500 volt insulation tester (Megohmmeter) is used to check insulation resistance. A minimum value of 20 megohms should be obtained when testing the insulation resistance between the conductors/tails and the cable sheath, and between conductors (2-conductor cable only). A digital multimeter or ohmmeter is used to check the continuity. To ensure that the joint is waterproof it may be submerged in water for approximately 24 hours. This treatment will remove soldering flux from possible pin holes in the braze and may possibly reveal a moisture leak which might not otherwise show up for some time. If this is not practical, a rag soaked in water should be wrapped around the joint while it is still hot - this procedure is used in the installation instructions for both the joint and end cap. A decrease in insulation resistance indicates the presence of pin holes that must be fixed before proceeding. A final careful visual inspection of the joint should be made to ensure the work conforms to the high quality required for this type of procedure.

Test Equipment

Insulation Resistance Test:	500 Vdc Megohmmeter
Continuity Test:	Standard Digital Multimeter (DMM)

5.2 Insulation Resistance (Megohmmeter) Test – Test 1

Insulation resistance is measured between the conductors/tails and the cable sheath, and between conductors. nVent recommends that insulation resistance testing be conducted at 500 Vdc.

Test Criteria

The minimum insulation resistance for a clean, dry, properly installed joint is 20 megohms.

5 Appendix B: Heating Cable Testing

5.3 Continuity (Resistance) Test – Test 2

Continuity testing is conducted using a standard Digital Multimeter (DMM) and measures the resistance between the cold lead tails or between conductors.

Test Criteria

Measure the resistance of the MI heating cable with the DMM. Most MI heating cable resistances are less than 100 ohms. If the heating cable length has not been altered, the approximate resistance can be calculated using the formula: Resistance (ohms) = $Volts^2$ / Watts. Voltage and wattage can be found on the heating cable identification tag.

Note: This measured value is the resistance at the ambient air temperature; the calculated value is the resistance at the operating temperature and may be higher than the measured value.

Test Procedures

Insulation Resistance and Continuity Test

1. De-energize the circuit.
2. Disconnect the temperature controller or thermostat if installed.
3. Disconnect the heating cable from supply wires or terminal block, if installed.
4. Set Megohmmeter test voltage at 0 Vdc or off.
5. Connect the positive (+) lead to the heating cable sheath.
6. Connect the negative (–) lead to one of the heating cable tails (or bare conductor).
7. Turn on the Megohmmeter and set the voltage to 500 Vdc; apply the voltage for 1 minute. Meter needle should stop moving. Rapid deflection indicates a short. Note the insulation resistance value. It should be greater than 20 MΩ.
8. Turn off the Megohmmeter.
9. Repeat Steps 6 through 8 for other tail/conductor (for 2-conductor cable only).
10. Check insulation resistance between the conductors (for 2-conductor cable only). It should be greater than 20 MΩ.
11. If the Megohmmeter does not self-discharge, discharge phase connection to ground with a suitable grounding rod. Disconnect the Megohmmeter.

5 Appendix B: Heating Cable Testing

12. Using the multimeter, check the continuity (resistance) of the heating cable between the two tails or between the conductors (conductors at far end may have to be shorted). Note the resistance value and compare to the calculated value.
13. Disconnect the multimeter.
14. Reconnect heating cable and temperature controller or thermostat once repairs are completed.

⚠ WARNING: Fire hazard in hazardous locations. Megohmmeter tests can produce sparks. Be sure there are no flammable vapors in the area before performing this test.

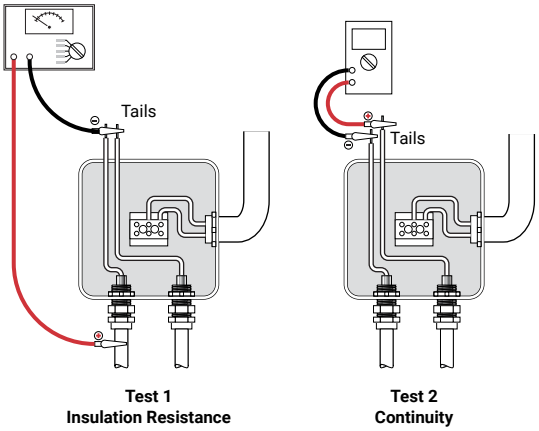


Figure 67: Insulation resistance and continuity test

6 Appendix C: Cable Size vs Drill Bit Selection Chart

Drill bit selection chart

Cable Diameter (in)	Drill Identifier	Cable Diameter (in)	Drill Identifier
0.124 – 0.131	30	0.262 – 0.263	H
0.132 – 0.135	29	0.264 – 0.267	6.8mm
0.136 – 0.139	28	0.268 – 0.272	I
0.140 – 0.142	27	0.273 – 0.276	J
0.143 – 0.144	26	0.277 – 0.280	K
0.145 – 0.147	25	0.281 – 0.285	7.25mm
0.148 – 0149	24	0.286 – 0.290	L
0.150 – 0.151	23	0.291 – 0.292	M
0.152	5/32	0.293 – 0.297	19/64
0.153 – 0.154	22	0.298 – 0.302	N
0.155 – 0.158	21	0.303 – 0.307	7.8mm
0.159 – 0.161	20	0.308 – 0.311	5/16
0.162 – 0.164	19	0.312 – 0.314	O
0.165 – 0.167	18	0.315 – 0.318	8.1mm
0.168	11/64	0.319 – 0.323	P
0.169 – 0.172	17	0.324 – 0.327	21/64
0.173 – 0.175	16	0.328 – 0.334	Q
0.176 – 0.177	15	0.335 – 0.339	R
0.178 – 0.180	14	0.340	11/32
0.181 – 0.182	13	0.341 – 0.343	8.5mm
0.183 – 0.184	3/16	0.344 – 0.349	S
0.185 – 0.186	12	0.350 – 0.353	9.0mm
0.187 – 0.188	11	0.354	T
0.189 – 0.191	10	0.355 – 0.359	23/64
0.192 – 0.194	9	0.360 – 0.363	9.25mm
0.195 – 0.196	8	0.364 – 0.370	U
0.197 – 0.198	7	0.371 – 0.372	3/8
0.199	13/64	0.373 – 0.377	V
0.200	6	0.378 – 0.381	9.7mm
0.201 – 0.204	5	0.382 – 0.385	W
0.205 – 0.208	4	0.386 – 0.389	25/64
0.209 – 0.214	3	0.390 – 0.392	10.0mm
0.215 – 0.216	7/32	0.393 – 0.399	X
0.217 – 0.219	2	0.400 – 0.401	Y
0.220 – 0.223	5.7mm	0.402 – 0.408	13/32
0.224 – 0.227	1	0.409 – 0.417	Z
0.228 – 0.229	5.9mm	0.418 – 0.432	27/64
0.230 – 0.233	A	0.433 – 0.448	7/16
0.234 – 0.237	B	0.449 – 0.464	29/64
0.238 – 0.241	C	0.465 – 0.479	15/32
0.242 – 0.245	D	0.480 – 0.495	31/64
0.246 – 0.247	1/4	0.496 – 0.542	1/2
0.248 – 0.252	6.4mm	0.543 – 0.620	35/64
0.253 – 0.256	F	0.621 – 0.635	5/8
0.257 – 0.260	G	0.636	41/64
0.261	17/64		

7 Appendix D: Drying Out Procedure

IMPORTANT: Wear full face shield when drying out MI cable.

Damage to the cable sheath or a damaged or missing joint or end cap will cause the magnesium oxide insulation (white powder) to absorb moisture, resulting in low IR readings. The cable must be "heated out" to remove the moisture and bring the IR back to an acceptable level.

If moisture is detected in the cable, use the oxy-acetylene torch with a large sizzling flame (Appendix E) and dry out the cable beginning 12 in (30 cm) back from the joint or end cap (heat cold lead first if making a hot-cold joint). If repairing polymer jacketed heating cable and/or cold leads, begin 4 in (10 cm) back from the joint or end cap to avoid melting the polymer jacket. Alloy 825 sheath cable should be heated to a dull red color and copper sheath cables should be heated to a bluish-gray color.

Use a short sweeping motion of the torch and heat about 2 in (5 cm) of cable at a time, repeating 4 to 5 times. Move the flame towards the joint or end cap as shown in Figure D1. Do not sweep the flame in the opposite direction as this will drive the moisture into the cable.

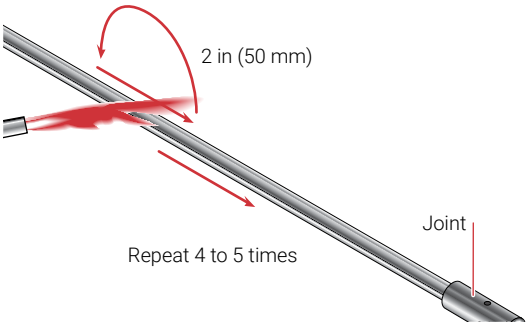


Figure 68: Use sweeping motion of torch

7 Appendix D: Drying Out Procedure

Gradually move the flame toward the joint, while maintaining the short sweeping motion of the torch. When initially checking insulation resistance after the damaged joint or end cap has been removed, continue the sweeping motion of the torch past the end of the cable. When heating out the cable prior to brazing the joint or end cap to the cable sheath, stop the sweeping motion of the torch 1/2 in (13 mm) from the joint or end cap (Figure D2). If you heat toward the end of the cable too quickly, you may skip over the moisture and drive it further back into the cable.

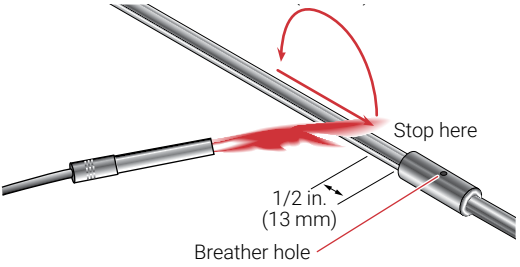


Figure 69: Sweep flame to end of cable

On completion, check IR with a 500V insulation tester (Megohmmeter). Test between the tails/conductors and the sheath, and between the tails/conductors for 2-conductor cables.

⚠ **WARNING: When drying out cable, care must be taken not to trap moisture as this could cause the cable to burst, possibly causing injury.**

8 Appendix E: Flame Size for Oxy-acetylene Torch

Use the small (oxidizing) flame when soldering the conductors together.

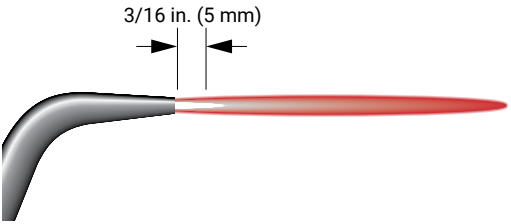


Figure 70: Small (oxidizing) flame

Use a large (neutral) flame when soldering the joint or end cap to the sheath of the cable.

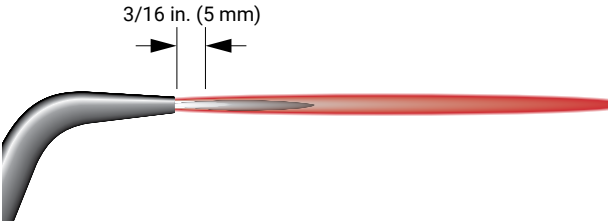


Figure 71: Large (neutral) flame

Use a sizzling (reducing/carbonizing) flame to dry out the cable.

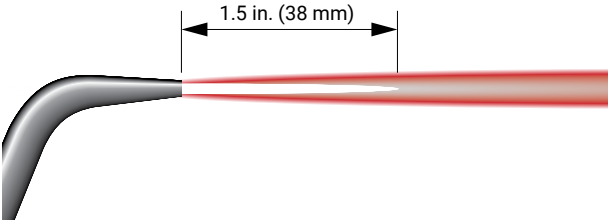


Figure 72: Sizzling (reducing/carbonizing) flame

9 Appendix F: Heat Shrink Tubing Installation for Polymer Jacketed Cables

9.1 Cables using a 1/2 in (13 mm) joint:

Hot-hot joint:

2 pieces	3/8 in (9 mm) dia. x 6.9 in (18 cm) long heat shrinkable tubing for heating cable
1 piece	3/4 in (19 mm) dia. x 6.9 in (18 cm) long heat shrinkable tubing for joint

Hot-cold joint:

1 piece	3/8 in (9 mm) dia. x 6.9 in (18 cm) long heat shrinkable tubing for heating cable
1 piece	1/2 in (13 mm) dia. x 6.9 in (18 cm) long heat shrinkable tubing for cold lead
1 piece	3/4 in (19 mm) dia. x 6.9 in (18 cm) long heat shrinkable tubing for joint

Note: Cut heat shrink tubing into 2 pieces if necessary.

Note: For the rare instances where a 3/4 in (19 mm) joint is required, use 1/2 in (13 mm) heat shrinkable tubing in place of the 3/8 in (9 mm) tubing and 3/4 in (19 mm) tubing in place of the 1/2 (13 mm) tubing. It will be necessary to locally source a 1 in (25 mm) diameter heat shrinkable tubing (adhesive lined) to cover the joint. Follow procedure below to complete joint.

Heat shrink is installed over completed 1/2 in (13 mm) joint as follows:

Hot-hot joint:

Move 3/8 in (9 mm) dia. x 6.9 in (18 cm) long pieces of heat shrinkable tubing (previously installed) forward to completely cover bare copper sheath cable. Using heat gun, shrink the tubing over the bare copper cable by applying heat from the center, then outwards to the ends
(see Figure F1).

Slide 3/4 in (19 mm) dia. x 6.9 in (18 cm) long piece of heat shrink forward and center over joint; heat shrink should overlap both ends of joint equally. Using heat gun, shrink the tubing over the joint by applying heat from the center, then outwards to the ends. Figure F2 shows the completed joint.

9 Appendix F: Heat Shrink Tubing Installation for Polymer Jacketed Cables

Hot-cold joint:

Move 3/8 in (9 mm) dia. x 6.9 in (18 cm) long piece of heat shrinkable tubing (previously installed) forward to completely cover bare heating cable sheath. Cover the bare cold lead with the 1/2 in (13 mm) tubing (previously installed). Using heat gun, shrink the tubing over the exposed copper cable by applying heat from the center, then outwards to the ends (see Figure F1).

Slide 3/4 in (19 mm) dia. x 6.9 in (18 cm) long piece of heat shrink forward and center over joint; heat shrink should overlap both ends of joint equally. Using heat gun, shrink the tubing over the joint by applying heat from the center, then outwards to the ends. Figure F2 shows the completed joint.

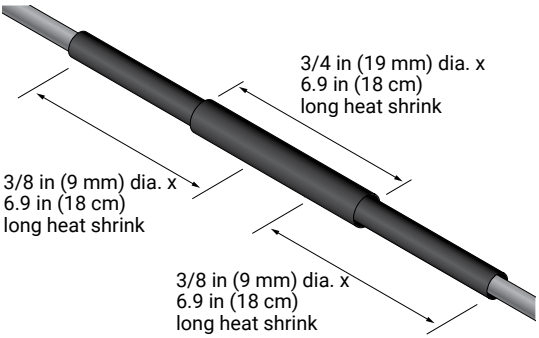


Figure 73: Heat shrink over exposed copper cable and 1/2 in joint

Figure 74: Completed joint with heat shrink seal

9 Appendix F: Heat Shrink Tubing Installation for Polymer Jacketed Cables

9.2 Installation for end cap

1 piece	3/8 in (9 mm) dia. x 6.9 in (18 cm) long heat shrink tube
1 piece	1/2 in (13 mm) dia. x 6.9 in (18 cm) long heat shrink tube

Heat shrink is installed over completed end cap as follows:

1. Slide 3/8 in (9 mm) dia. x 6.9 in (18 cm) long piece of heat shrinkable tubing (previously installed) forward to completely cover bare copper sheath cable (Figure F3). Using heat gun, shrink the tubing over the exposed copper.
2. Slide 1/2 in (13 mm) dia. x 6.9 in (18 cm) long piece of heat shrink forward and center over end cap; heat shrink should equally overlap both ends of end cap. Using heat gun, shrink the tubing over the end cap. Use needle nose pliers to crimp section of tubing past end cap to form a seal as shown in Figure F4.

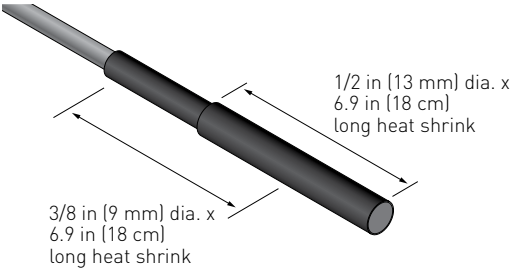


Figure 75: Heat shrink over exposed copper cable

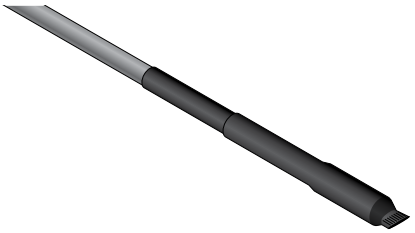


Figure 76: Completed end cap with heat shrink seal.

10 Appendix G: Stripping the Cable Sheath

Use a tube cutter to score around the cable sheath the required length from the end. This will cause the sheath to peel away at the score providing a smooth end when the cable sheath is stripped. The correct depth of score one third the thickness of the sheath.

Note: Do not cut too deeply with the tube cutter as this will cause the sheath to be pushed inwards towards the conductors, possibly resulting in cable failure.

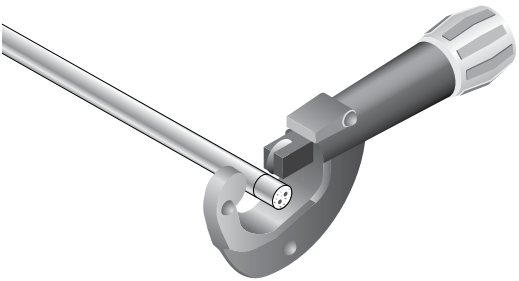


Figure 77: Score cable sheath

Grip the edge of the sheath between the jaws of the sidecutters and twist clockwise, then take a new grip and rotate through a small angle.

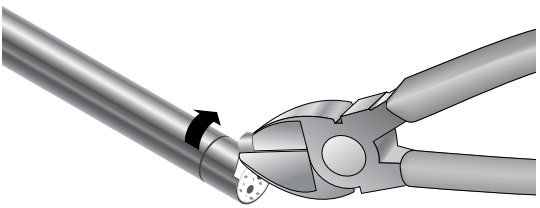


Figure 78: Grip sheath with sidecutters

10 Appendix G: Stripping the Cable Sheath

Continue this motion in a series of short 'rips', keeping the sidecutters at about 45° to the line of the cable, removing sheath spirally.

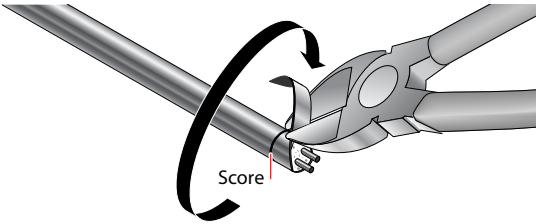


Figure 79: Strip cable sheath

Continue removing the sheath to the score mark. When about to break into the score, bring sidecutters to right angle with cable. Finish off with point of sidecutters held parallel to the cable.The sheath will peel away leaving a clean cut when the score mark is reached. Ensure that the sheath is not flared inward.

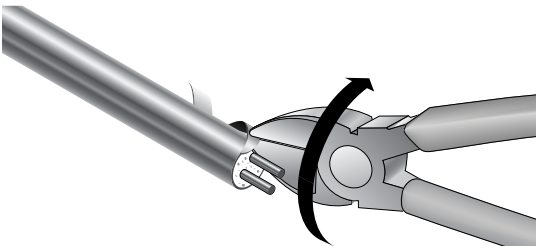


Figure 80: Sidecutter angle for final stripping

10 Appendix G: Stripping the Cable Sheath

The cable sheath is correctly stripped, with the sheath flared slightly outwards, as shown in (a).

In (b) the sheath is neither flared outwards nor beveled inwards, but is acceptable.

Ensure that the sheath is not curved or beveled inward as shown in (c). This will occur if the score made with the tube cutter is too deep. In this case, remove a further 1/4 in (6 mm) of sheath.

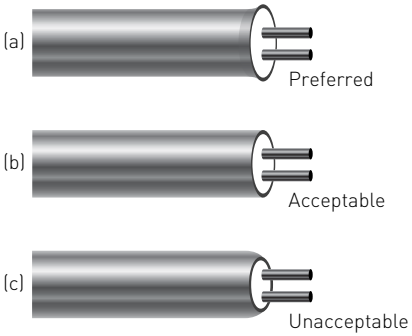


Figure 81: Correct end preparation

11 Appendix H: Typical Repair Jig

Repair jig is made from angle iron welded to form shape as shown in Figures H1 and H2. Each cable is clamped to the 4 in (10 cm) upper surface and meet in the middle. If working on a pipe, middle section may be clamped to the pipe.

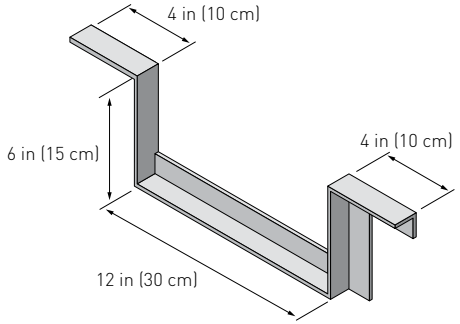


Figure 82: Front of repair jig

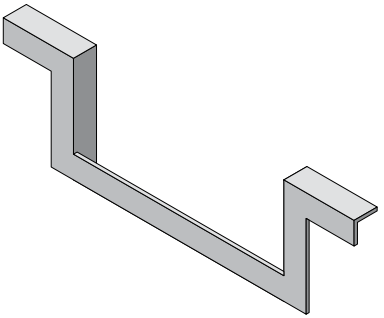


Figure 83: Back of repair jig

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