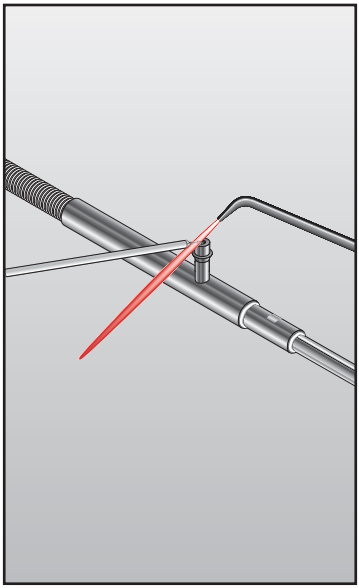
nVent

RAYCHEM

Low Temperature Sheath MI Heating Cable

XMI-L Heat Tracing 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 and/or corrugated sheath can cause electrical arcing or fire. Repair or replace damaged heating cable, corrugated sheath, or terminations. Contact factory for assistance.**
- **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 nVent RAYCHEM XMI-L mineral insulated (MI) heating cables with a corrugated sheath manufactured by nVent. They must be carefully followed to ensure that the heating cable performs safely and as intended.

During the installation of XMI-L cables or during plant maintenance processes, the cables may be damaged, cut or broken. In the event that it is not possible to return the cable to the manufacturer, field repair may be necessary.

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 (proficiency in silver brazing with an oxy-acetylene torch is a prerequisite), are permitted to repair or modify XMI-L 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 field service, assistance, technical support, or other information regarding the repair of XMI-L 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 XMI-L system performs reliably.

1.3 Electrical Codes

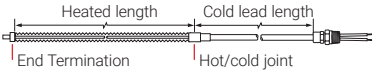
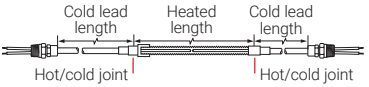
Refer to the appropriate sections of the National Electrical Code (NEC) and Canadian Electrical Code (CEC) regarding the field repair or modification of MI electrical heat tracing cables. The repair of MI heat tracing cables must comply with all national and local codes.

1.4 Heating Cable Configurations

The Field Repair Kit includes components to allow for field repair or modification of the heating cable configurations shown in Table 1.

1 General Information

TABLE 1: MI HEATING CABLE CONFIGURATION

XMI-L cable design	Number of conductors	Configuration
D	Dual conductor (XMI-L32 & XMI-L62 series)	
E	Dual conductor (XMI-L32 & XMI-L62 series)	

A sectional view of a Design D XMI-L heating cable is shown in Figure 1. All of the cables include both a heated section and a non-heating cold lead section. These sections are joined at the hot-cold joint where the heating element is spliced into larger bus wires. A final transition at the end of the cold lead section provides an environmental seal and tails for the electrical connection. At the opposite end of the cable, the conductors of Design D cables are joined and hermetically sealed within an end cap. The entire heated section of the cable is then enclosed in a hermetically sealed flexible corrugated conduit sheath.

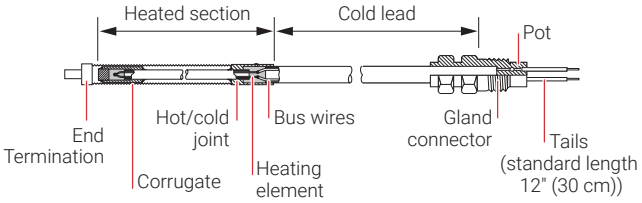


Figure 1: Sectional view of Design D XMI-L cable

1 General Information

1.5 Heating Cable Identification

Each XMI-L heating cable is supplied with an identification tag (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), 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.

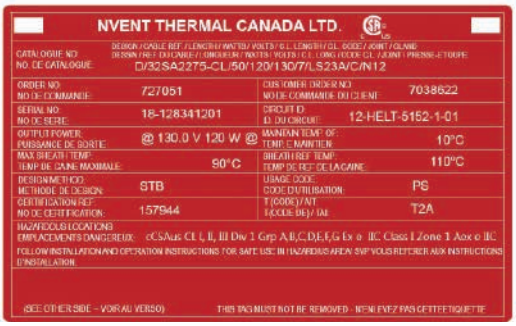


Figure 2: Typical XMI-L heating cable tag (front)

2 Pre-Repair Information

2.1 General

XMI-L cables can be field repaired or modified only by qualified personnel. An appropriate field repair kit can be used to complete one of the following:

- The Hot/Hot (H/H) Repair Kit includes the components required to perform a repair in the heated section on either a D or E configuration.
- The Hot/Cold (H/C) Repair Kit includes the components required to perform a repair at the Hot/Cold joint, or to replace a cold lead, on either a D or E configuration.
- The End Termination Repair Kit includes the components required to perform a repair on the end cap for a D configuration.

Stainless steel joints and end caps are used to repair or modify XMI-L heating cables and are suitable for exposure temperatures up to 842°F (450°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

⚠ 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 XMI-L cable tag must be ordered. In these cases, the XMI-L 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

1000 V DC Megohmmeter
Small hammer
Ohmmeter (multimeter)
Needle nose pliers
Drill press and bits (see Appendix C)
Ruler or tape measure
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
Vise grip pliers or nVent PYROTENAX Handvise
Scribe or pick
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 G)
Engraving tool (Dremel® Model 290-01 or equivalent)
Compressed air supply 5 to 40 psi maximum with 1/4" female ARO fitting
Liquid leak detector or soapy water

2 Pre-Repair Information

2.5 Repair Kit Components

Six different repair kits are available, depending on size of corrugate and type of repair being done. The corrugate is available in small, 0.49 in (12.4 mm) OD, and large, 0.57 in (14.5 mm) OD.

- The small corrugate has an ID of 0.31 in (8 mm).
- The large corrugate has an ID of 0.39 in (10 mm).
- The repair kit is specific to a corrugate size.
- The repair kit is also specific for the type of repair.
- H/H kits are for repairs requiring a heating cable in-line joint, called a hot/hot repair.
- H/C kits are for repairs requiring replacement of the joint between the heating cable and the cold lead, called a hot/cold repair.
- End termination kits are for repairs requiring replacement of the end cap for D design cables, called an end termination repair.

Each kit contains the parts for the small or large corrugate and the type of repair needed. The six repair kits are:

REPKITCSHH – H/H repair kit for small corrugate

REPKITCSHC – H/C repair kit for small corrugate

REPKITCSEND – End termination repair kit for small corrugate

REPKITCLHH – H/H repair kit for large corrugate

REPKITCLHC – H/C repair kit for large corrugate

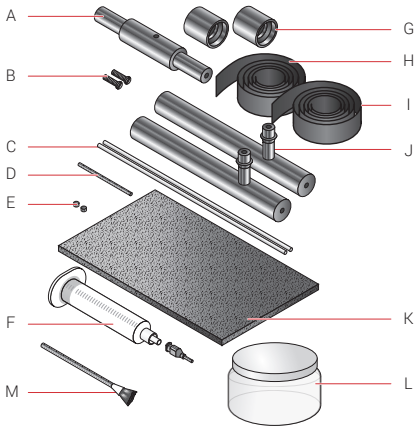
REPKITCLEND – End termination repair kit for large corrugate

2 Pre-Repair Information

TABLE 3: FIELD REPAIR KIT FOR XMI-L HOT/HOT JOINT

REPKITCSHH or REPKITCLHH

Item	Qty	Description
A	1 ea	1/2 in (12.7 mm) XMI-L H/H joint body
B	2 ea	#6-32 brass machine screw
C	2 ea	10 in (25 cm) A-56T silver braze rod
D	1 ea	Joint packing rod
E	2 ea	Pressure port plug
F	1 ea	Syringe assembly with MgO and steel needle (vacuum sealed)
G	2 ea	Corrugate union
H	1 ea	24 in (61 cm) fine grit emery cloth (180 grit)
I	1 ea	24 in (61 cm) medium grit emery cloth (80 grit)
J	2 ea	4.5 in (11.4 cm) long repair sleeve
K	1 ea	Nylon mesh sanding pad
L	1 ea	Jar of white flux
M	1 ea	Flux brush MSDS for white flux and silver braze rod (not shown)

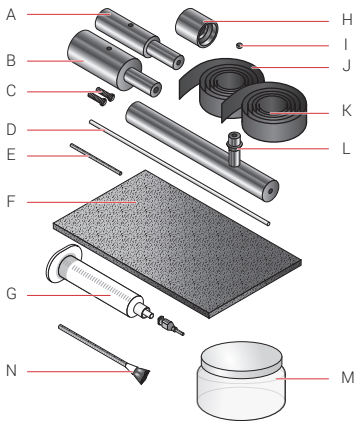


2 Pre-Repair Information

TABLE 4: FIELD REPAIR KIT FOR XMI-L HOT/COLD JOINT

REPKITCSHC or REPKITCLHC

Item	Qty	Description
A	1 ea	1/2 in (12.7 mm) XMI-L H/C joint body
B	1 ea	3/4 in (19 mm) XMI-L H/C joint body
C	2 ea	#6-32 brass machine screw
D	1 ea	10 in (25 cm) A-56T silver braze rod
E	1 ea	Joint packing rod
F	1 ea	Nylon mesh sanding pad
G	1 ea	Syringe assembly with MgO and steel needle (vacuum sealed)
H	1 ea	Corrugate union
I	1 ea	Pressure port plug
J	1 ea	24 in (61 cm) fine grit emery cloth (180 grit)
K	1 ea	24 in (61 cm) medium grit emery cloth (80 grit)
L	1 ea	4.5 in (11.4 cm) long repair sleeve
M	1 ea	Jar of white flux
N	1 ea	Flux brush MSDS for white flux and silver braze rod (not shown)

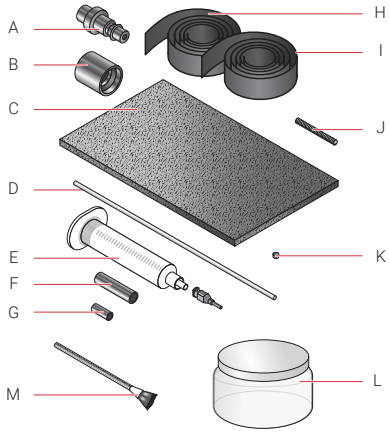


2 Pre-Repair Information

TABLE 5: FIELD REPAIR KIT FOR XMI-L END TERMINATION

REPKITCSEND or REPKITCLEND

Item	Qty	Description
A	1 ea	Corrugate plug (1/4" ARO fitting)
B	1 ea	Corrugate union
C	1 ea	Nylon mesh sanding pad
D	1 ea	10 in (25 cm) A-56T silver braze rod
E	1 ea	Syringe assembly with MgO and steel needle (vacuum sealed)
F	1 ea	End cap body
G	1 ea	Threaded end cap plug
H	1 ea	24 in (61 cm) fine grit emery cloth (180 grit)
I	1 ea	24 in (61 cm) medium grit emery cloth (80 grit)
J	1 ea	1 in (25 mm) threaded stud
K	1 ea	Pressure port plug
L	1 ea	Jar of white flux
M	1 ea	Flux brush MSDS for white flux and silver braze rod (not shown)



2 Pre-Repair Information

2.6 Cross-section of Completed Joints and End Cap

Figures 3, 4 and 5 show cross sections for the hot/hot joint, hot/cold joint and end termination.

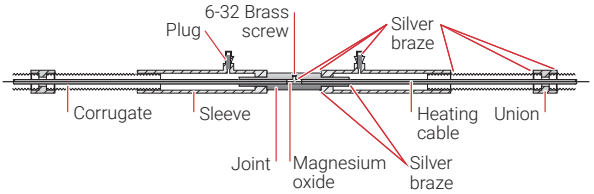


Figure 3: Completed hot/hot joint

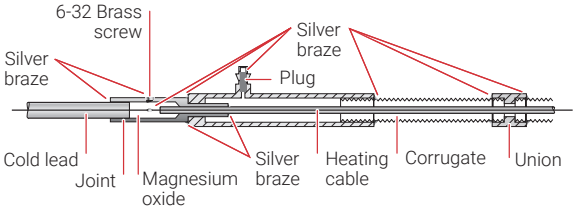


Figure 4: Completed hot/cold joint

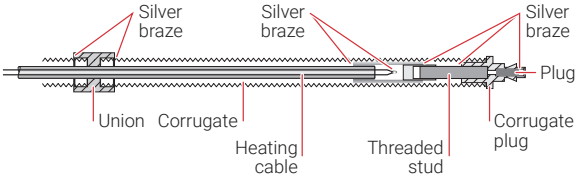


Figure 5: Completed end termination

3 Heating Cable Repair

3.1 General

- Before commencing field modifications/repairs, heating cable resistance should be checked with an ohmmeter to ensure that it is within ± 10% of the cable's calculated resistance. Record the measured value for comparison with the measured value on completion of repairs.

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 sheet H59079 for XMI-L heating cables.

- For field repairs, check continuity of both sections of cable to be joined using the ohmmeter. If open circuited, do not attempt to fabricate the joint.
  - For two conductor heating cable, conductors on far end of cable may have to be shorted together.
- Check insulation resistance (IR) of both cables to be joined with a 1000 V DC Megohmmeter (Appendix B); a value greater than 20 megohms should be attained. If satisfactory follow appropriate repair procedure to make a joint (Section 3.3) or end cap (Section 3.4), otherwise follow insulation drying procedure in Appendix D before proceeding.
- When silver brazing, avoid excessive heating of parts to be joined as this can lead to embrittlement of materials and take care not to overheat the joint body as the braze at the conductor joint may melt. Also avoid overheating the corrugate as excessive heat can damage the corrugate.
- 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 Hot/cold Joint

When repairing a hot/cold joint or replacing the cold lead, a hot/cold repair kit is required. Each repair kit is supplied with a 1/2 in (12.7 mm) and a 3/4 in (19 mm) joint body. Use a vernier caliper or micrometer to measure the outside diameter of the MI cold lead and select the 1/2 in (13 mm) or 3/4 in (19 mm) joint body from Table 6.

TABLE 6: SELECT HOT/COLD JOINT BODY

	Max diameter of cold lead cable
1/2" (12.7 mm) joint body	0.360 in
3/4 in (19 mm) joint body	0.543 in

3 Heating Cable Repair

3.3 In-line Hot/hot Joint and Hot/cold Joint Repair Procedure

The instructions following apply to both hot/hot and hot/cold joint repairs. Read these instructions completely before attempting to complete the repair or modification and refer to the Appendices for additional information where indicated. Where appropriate, the instructions which 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.

Remove insulation and banding from heating cable so that 12 in (30 cm) on either side of the joint or failure point is accessible.

Ensure that the portion of the cable being worked on can be moved away from the surface at least 4 in (10 cm) to allow access when brazing (see repair jig in Appendix G).

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).

Hot/hot joint: Using the tube cutter, cut through the corrugate at the damaged area. Pull back the corrugate to expose the MI heating cable; it will be necessary to release and retighten the clamps on to the corrugate to keep it in position. Next, use a hacksaw to cut the heating cable at the damaged area (Figure 6).

3 Heating Cable Repair

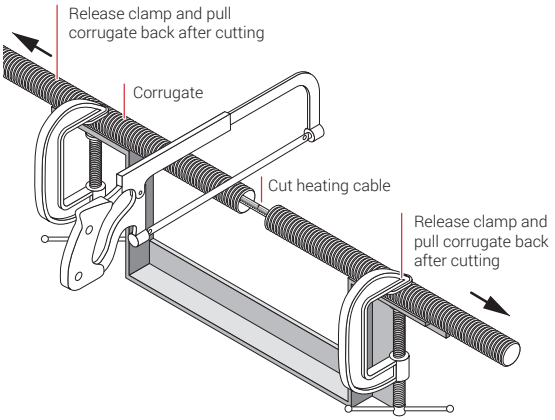


Figure 6: Cut Heating cable as close to damaged location as possible

Hot/cold joint: Using a hacksaw, cut through the cold lead just behind the joint. Next, use a tube cutter to cut the corrugate about 1 in (25 mm) from the joint and then cut the MI heating cable with the hacksaw and remove the joint (Figure 7).

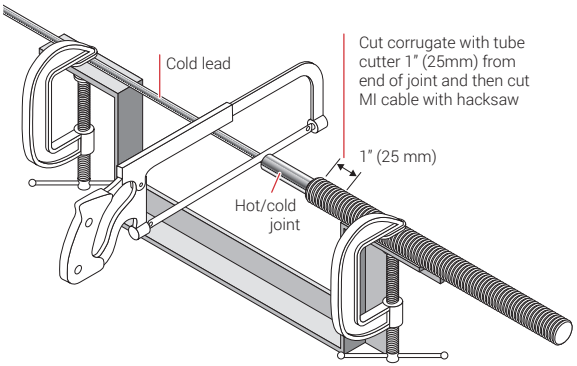


Figure 7: Cut Cold lead and corrugate close to hot/cold joint

3 Heating Cable Repair

Hot/hot joint: Using the tube cutter, cut the corrugate 5 in (12.7 cm) back from both cut ends. Remove the cut corrugate and discard (Figure 8).

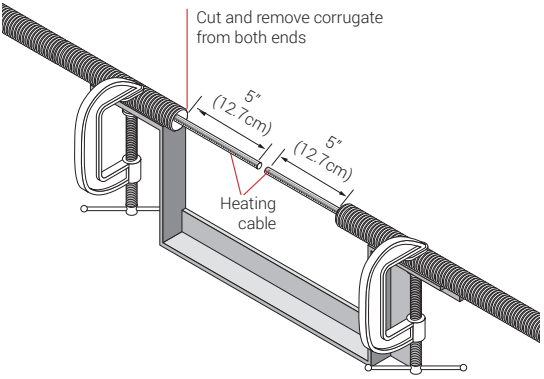


Figure 8: Cut and remove corrugate from both ends

Hot/cold joint: Using the tube cutter, cut the corrugate 5 in (12.7 cm) back from the cut end. Remove the cut corrugate and discard (Figure 9).

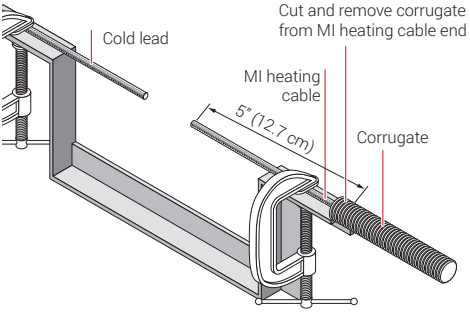


Figure 9: Cut and remove corrugate from MI heating cable end

3 Heating Cable Repair

Hot/hot and Hot/cold joint: Use the tube cutter to lightly score the sheath on the exposed MI heating cable approx. 3/16" (4.8 mm) from end of the cable (for a hot/hot repair, this is necessary for both ends). With diagonal cutters, remove the sheath up to the score mark (Figure 10). Refer to Appendix F for details on stripping the cable sheath.

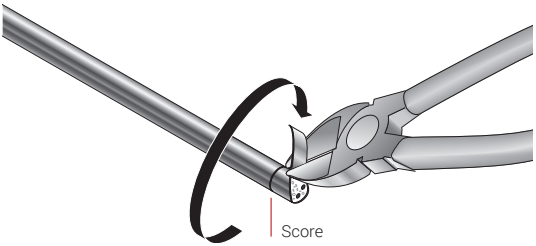


Figure 10: Stripping the MI heating cable sheath

Verify continuity of all conductors using a multimeter or ohmmeter. See Appendix B for details.

Check the insulation resistance (IR) of the cable sections at this point using a 1000 V DC Megohmmeter (Figure 11). Further details on IR testing can be found in Appendix B. The IR test checks for the presence of moisture in the magnesium oxide insulation. 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. Ensure IR is 20 MΩ minimum before proceeding.

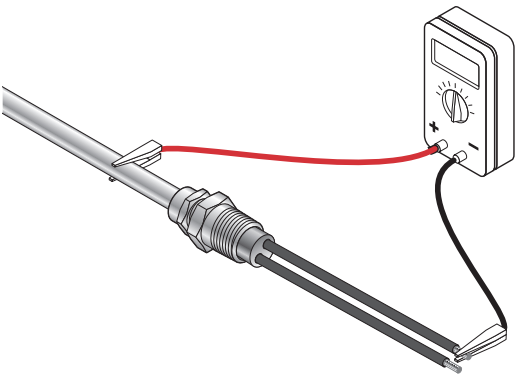


Figure 11: Measure the insulation resistance.

3 Heating Cable Repair

If IR is 20 MΩ or greater, skip the following two steps and continue with the step (prior to Figure 14) to measure the outside diameter of the cables. If IR is still low after drying out the MI heating cable, continue with the additional steps following.

If IR is still low, it will be necessary to temporarily remove a longer section of corrugate so that the inner MI heating cable can be heated out. Use the tube cutter to cut the corrugate an additional 10 in (25 cm) back from the end. This will expose an extra 10 in (25 cm) of the MI heating cable. Do not discard the corrugate; it will be reused after the moisture has been removed from the MI heating cable (see Appendix D on removing moisture from the MI cable).

Once the MI heating cable is heated out and IR is at an acceptable value, slide a corrugate union (only required if an extra 10" of corrugate was removed) and the 10 in (25 cm) section of corrugate back onto the heating cable. Prior to fitting the parts together, polish both ends of the corrugate and the corrugate union with the nylon mesh sanding pad (Figure 12). The surfaces must be clean for the silver braze to adhere to them. Next, using flux brush, apply flux to the ends of the corrugate and the corrugate union. Fit the parts together so that both ends of the corrugate butt against the center-stop in the corrugate union (Figure 12).

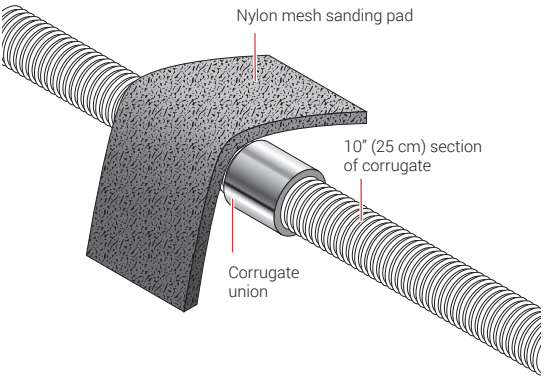


Figure 12: Polish corrugate and corrugate union

3 Heating Cable Repair

Apply more flux completely around both ends of the corrugate, about 1/4 in (6 mm) past the end of the corrugate union; this will help prevent discoloration of the corrugate. Next, braze the corrugate to both ends of the corrugate union using a large flame (see Appendix E). To avoid damage to the thin corrugate, hold the flame on the corrugate union, not on the corrugate (Figure 13). Approximately 1 in (25 mm) of braze rod should be used for each side of the union/corrugate joint.

Once the union has been brazed, use emery cloth and the nylon mesh sanding pad to clean the corrugate union and corrugate. Use only the nylon mesh sanding pad on the corrugate; it has a thin sheath and can be easily damaged. Emery cloth may be used on the corrugate union. Remove all flux.

Note: Always ensure all flux has been removed from the corrugate to prevent corrosion. Hot water may be used to remove the flux.

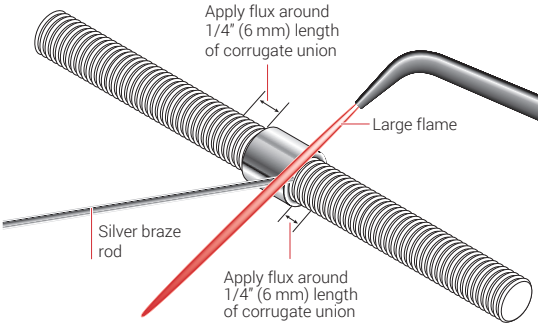


Figure 13: Braze corrugate union to corrugate

3 Heating Cable Repair

Hot/hot and Hot/cold joint: Continue with this step only when IR is 20 MΩ or greater. The joints in the repair kits are supplied with pilot holes so it is necessary to drill the pilot hole to the proper size to match the diameter of the MI heating cable and cold lead. Using a vernier caliper (or micrometer), measure the outside diameter of the heating cable and cold lead cable (Figure 14).

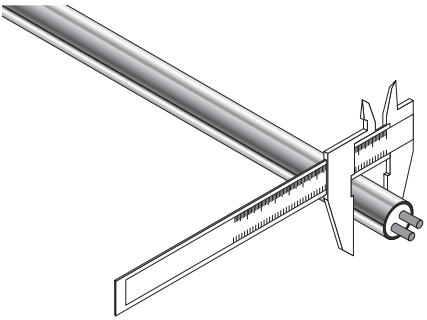


Figure 14: Measure cable diameters

Hot/hot joint: Using the table in Appendix C, select the correct drill bit size for the MI heating 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 (Figure 15).

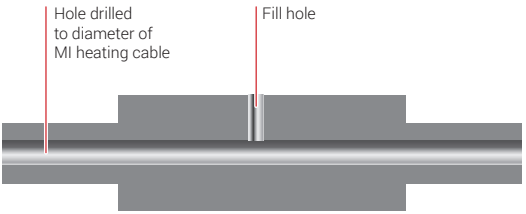


Figure 15: Cross section of drilled hot/hot joint

3 Heating Cable Repair

Hot/cold joint: Based on the diameter of the cold lead cable measured above, select the 1/2 in (12.7 mm) or 3/4 in (19 mm) joint body from Table 6 in Section 3.2.

Using the table in Appendix C, select the correct drill bit sizes for the MI heating cable and cold lead 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 bit. With the larger drill bit, drill the larger diameter 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 (Figure 16).

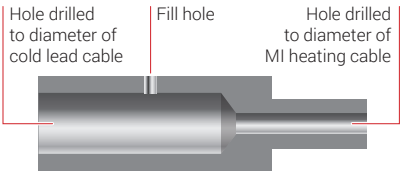


Figure 16: Cross section of drilled hot/cold joint

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 cable square using a flat file, filing in the forward direction only as shown in Figure 17 (end of conductors should be clean). The end of the MI heating cable was prepared earlier in this procedure.

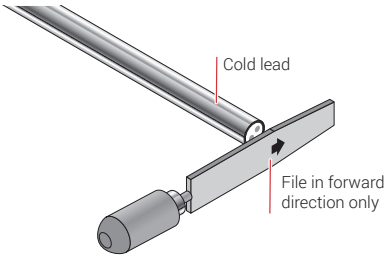


Figure 17: File face of cold lead cable

3 Heating Cable Repair

Next, using the tube cutter, score the sheath of the cold lead cable approximately 1/4 in (6 mm) from the end of the cable and use the diagonal cutters to remove the sheath up to the score mark (Figure 18). Refer to Appendix F for details on stripping the cable sheath.

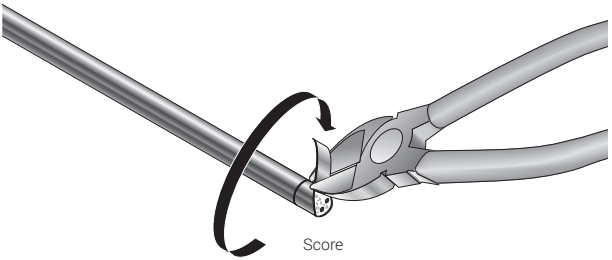


Figure 18: Remove sheath from cold lead cable

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

Hot/hot and Hot/cold joint: Polish about 2 in (5 cm) of each end of the cable sheaths with emery cloth (Figure 19).The surface must be clean for brazing.

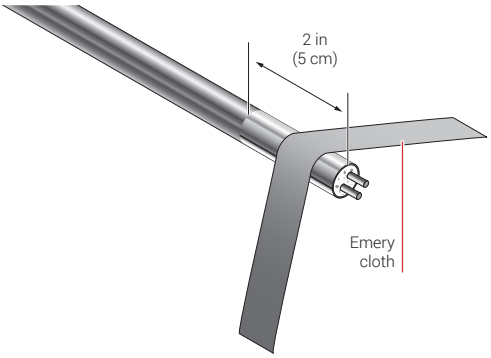


Figure 19: Polish ends of cable sheaths

3 Heating Cable Repair

Hot/hot and Hot/cold joint: Polish the final 3 in (8 cm) of each end of the corrugate with the nylon mesh pad (Figure 20). This surface must be clean for brazing.

Note: Do not use emery cloth on the corrugate.

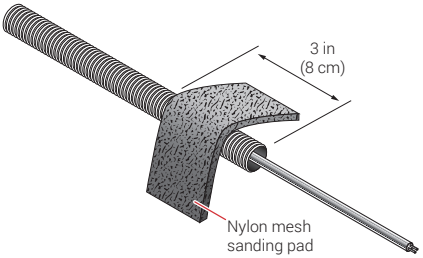


Figure 20: Clean final 3 in (8 cm) of corrugate

Hot/hot joint: Slide a repair sleeve (larger hole first) over the end of each section of MI heating cable to be joined and over the corrugate until it stops (Figure 21). Next, slide the joint body over either end of the MI heating cable and make sure that it will easily slide over the other end. If the MI heating cable sheaths flare out and bind on the joint body, touch up with flat file or emery cloth to allow the joint body to slide over both ends.

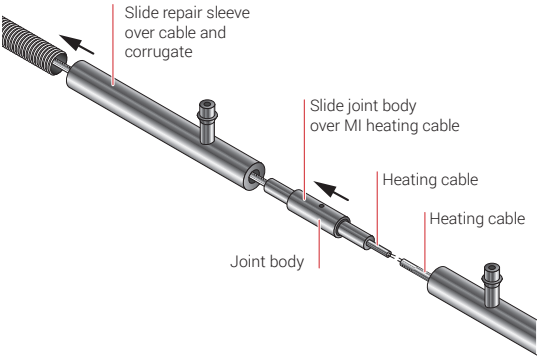


Figure 21: Place repair sleeves and joint body on cable

3 Heating Cable Repair

Hot/cold joint: Slide the repair sleeve, larger hole first, over the end of the MI heating cable (smaller diameter cable) and over the corrugate until it stops (Figure 22). Next, slide the appropriate size joint body over the MI heating cable ensuring that the larger hole faces the cold lead. Ensure joint will easily slide over the end of the cold lead. If the sheaths flare out and bind on the joint body, touch up with flat file or emery cloth to allow the joint body to slide over both ends.

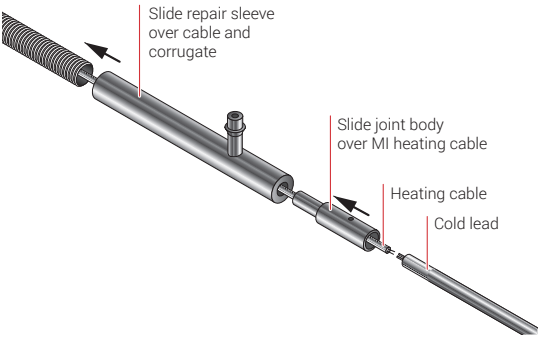


Figure 22: Place repair sleeve and joint body on cable

Hot/hot and Hot/cold joint: If heating cable conductors are longer than 3/16 in (5 mm), done to read IR in some cases, trim conductors to 3/16 in (5 mm).

Before brazing the conductors, take a moment to confirm that all parts are on the cables and test fit them together to make sure you have the correct parts for your corrugate size (Figure 23). Once you begin brazing the parts together, it is very difficult to correct. To ensure proper brazing of the conductors, move all parts away from the joint being brazed after test fitting the parts.

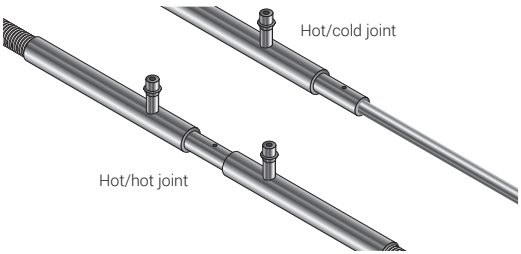


Figure 23: Test fit parts together

3 Heating Cable Repair

Hot/hot and Hot/cold joint: Clean magnesium oxide powder from the conductors of the MI heating cables with emery cloth or use side cutters to lightly scrape conductor surface (Figure 24). Conductor surface must be free of powder for silver braze to bond. Do not clean the surface of the cold lead conductors.

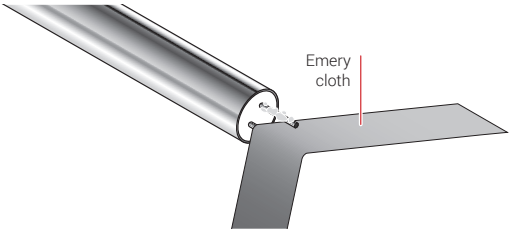


Figure 24: Clean MI heating cable conductors

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

Hot/hot joint: Apply a small amount of white flux to the **tip** of the conductor. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder.

Using a small flame (see Appendix E), heat the conductor with the oxy-acetylene torch (this does not take much heat) and at the same time touch silver braze rod to the end of the conductor and apply enough braze to tin the end of the conductor (Figure 25). Repeat for remaining conductors on both cables to be joined.

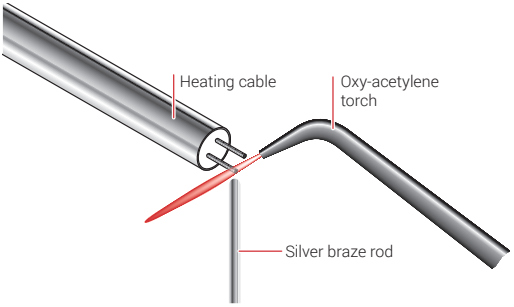


Figure 25: Tin heating cable conductors

3 Heating Cable Repair

Hot/cold joint: Apply a small amount of white flux to the **face** of the cold lead conductor. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder.

Using a small flame (see Appendix E), heat the cold lead conductor with the oxy-acetylene torch (this does not take much heat) and at the same time touch silver braze rod to the face of the conductor and apply enough braze to form a small **bead** on the conductor face (Figure 26). Repeat for remaining cold lead conductor.

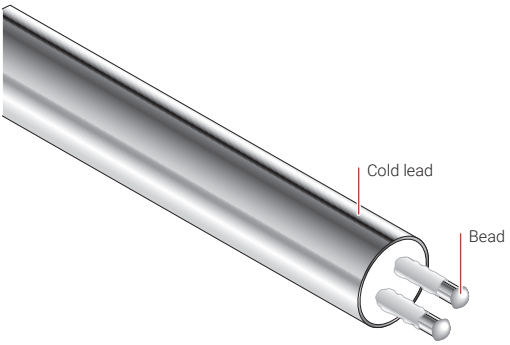


Figure 26: Form bead on cold lead conductors

Tin the conductors on the MI heating cable using the procedure above for the hot/hot joint.

Note: Bend the two conductors of the MI heating cable into a 'Y' shape so that the ends are the same distance apart as the cold lead conductors (see Figure 28).

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 (Figure 27). The braze on both ends will melt and draw together. Do not add any more braze. 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 you must apply more heat (or start over). Remove the heat and hold for two seconds until the braze hardens. Care should be taken not to overheat the conductors during this process. Pull lightly to test for strength.

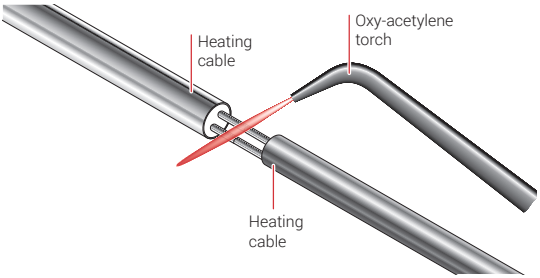


Figure 27: Braze hot/hot joint conductors

Hot/cold joint: 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 braze on the tip melts, then push the smaller (heating cable) conductors into the braze (Figure 28). Do not add any more braze. Remove the heat and hold for two seconds until the braze hardens. Care should be taken not to overheat the conductors during this process. Pull lightly to test for strength.

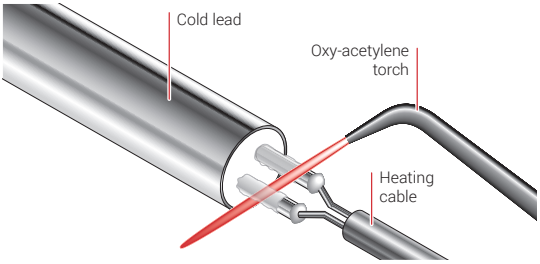


Figure 28: Braze hot/cold joint conductors

3 Heating Cable Repair

Hot/cold joint: Ensure that the braze has formed a **cone** from the large to small diameter conductor (see Figure 29). If not, the braze is still cold and you must apply more heat.

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

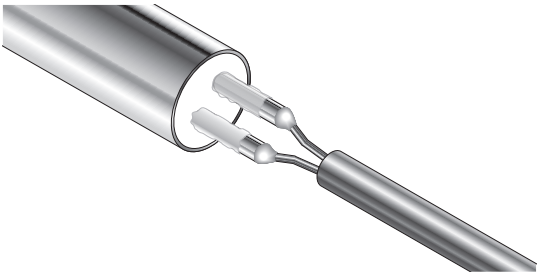


Figure 29: Completed hot/cold junction

Hot/hot and Hot/cold joint: Remove all trace of flux from the conductors with the emery cloth (Figure 30). Straighten the conductors with needle nose pliers such that the conductors will be as far from the inside wall of the joint body as possible. This must be done delicately. Avoid bending the conductors with the emery cloth.

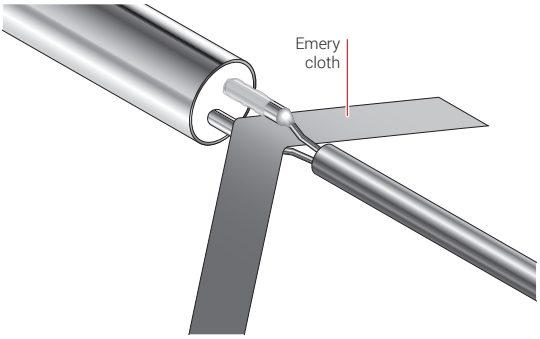


Figure 30: Gently remove flux with emery cloth

3 Heating Cable Repair

Hot/hot and Hot/cold joint: Use a pick to remove any flux or carbon which may have contaminated the magnesium oxide powder at the ends of each cable.

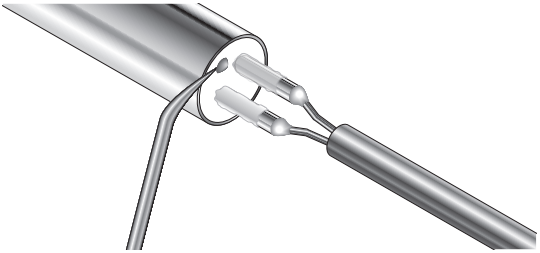


Figure 31: Clean face of cable

Hot/hot joint: Ensure that the conductors are the same distance from each other as they are in the cable.

Hot/cold joint: Conductors from cold lead to the heating cable should be formed as shown in Figure 31.

Hot/hot and Hot/cold joint: Slide the joint body over the exposed conductors, ensuring that the fill hole faces up and is centered over the conductor junction (Figure 32). Use caution when sliding the joint body. If the joint body sticks or binds on the cable, gently free it. Avoid damaging the delicate brazed conductors.

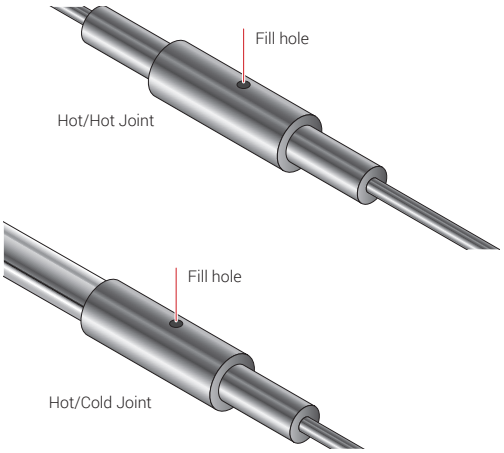


Figure 32: Center joint body over conductors

3 Heating Cable Repair

You are now ready to braze the joint body to the cable sheath. If making a hot/cold joint, begin with the cold lead cable (hot/cold joint repair is shown in the illustrations).

Hot/hot and Hot/cold joint: Using a large **sizzling** flame (see Appendix E), **heat out** the moisture from the exposed MI heating cable (about 3 in (7.5 cm) of heating cable should be exposed), stopping 1/2 in (13 mm) from the joint body (Figure 33); heat out 4.5 in (11 cm) on the cold lead side. Repeat procedure for cable on other side of joint body. Immediately proceed to next step.

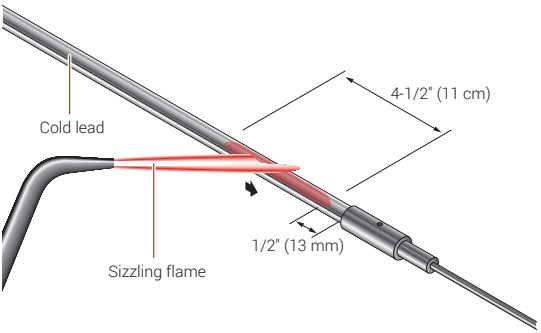


Figure 33: Heat out the cable on both sides of the joint

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

Next, the joint body will be brazed to the cable sheaths. If making a hot/cold joint, braze the MI heating cable side (smaller cable) of the joint first.

3 Heating Cable Repair

Apply flux around ends where the joint will be brazed to the cable sheath. Ensure that the flux is applied around the entire junction (Figure 34).

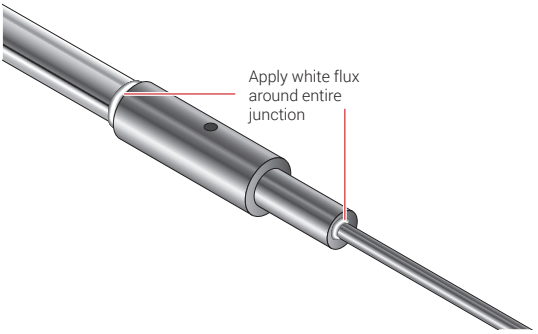


Figure 34: Apply flux to areas to be brazed

Heat the joint body and MI heating cable using a large flame. When the area to be brazed is up to temperature, deposit a large bead of silver braze on the top part of the area to be joined. Apply heat to both the joint body and the cable and move the flame slowly around the circumference of the joint body (Figure 35). This will cause the braze to **wick** its way around the joining area and also draw the braze inside the joint body making a stronger braze. Add more braze as needed. Ensure that the braze flows to the bottom of the joint body to ensure a continuous braze around the entire junction.

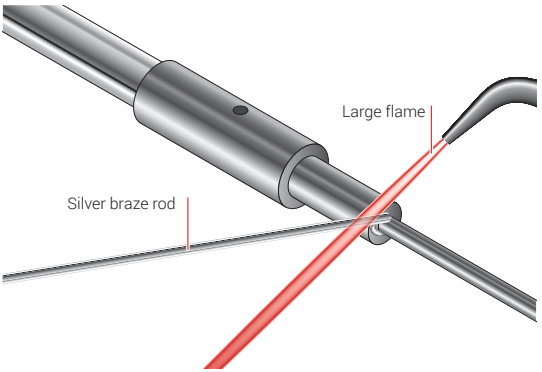


Figure 35: Braze the heating cable to the joint body

Repeat procedure for other side of joint body. If making a hot/cold joint, the joint body will be brazed to the cold lead 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 braze from adhering to the metal. Care must also be taken not to overheat the joint body as this 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 not remove red cap.

While joint body 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 (Figure 36). If using an engraving tool, reverse the engraving bit so that the blunt end is visible and place the bit against the joint body. Using an engraving tool or other vibration method will evenly distribute the powder and ensure that it is well packed.

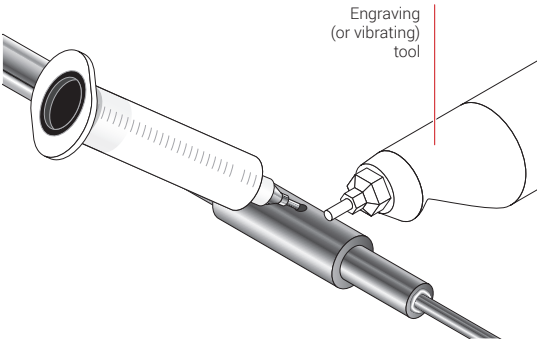


Figure 36: Fill the joint body with MgO powder

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

3 Heating Cable Repair

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 body. If required, add more powder to fill joint body and repeat packing procedure using both the vibrating tool and the packing rod until the joint body is completely full (Figure 37).

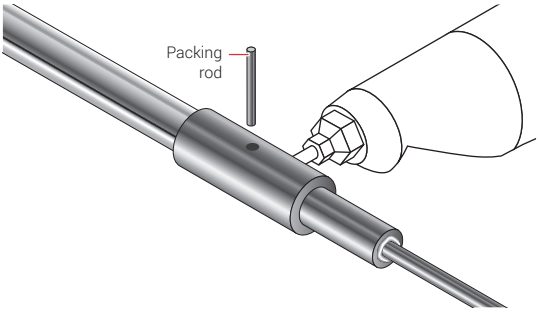


Figure 37: Pack MgO powder

With pliers, 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 38).

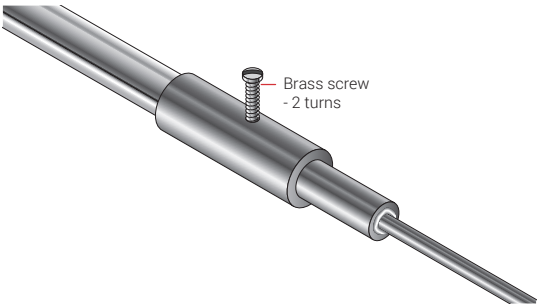


Figure 38: Insert brass screw

3 Heating Cable Repair

Saw off the screw flush with the joint body. Using the edge of a flat file, groove a recessed area over and around the screw, filing in one direction only (Figure 39). The recess should be about 1/4" (6 mm) square.

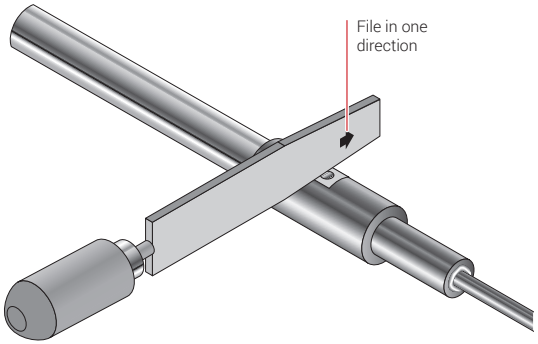


Figure 39: File groove

Check the insulation resistance (IR) again (Figure 40). 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.

If it is necessary to dry out the cable, do not heat above a dull red color. Higher heat could re-melt the braze and create a defect.

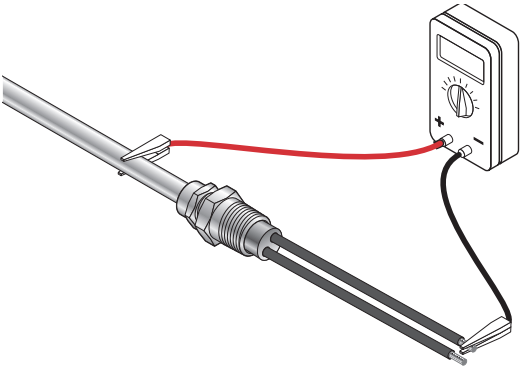


Figure 40: Check insulation resistance

3 Heating Cable Repair

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 braze.

Using the oxy-acetylene torch with a small flame, heat the joint body and apply a small amount of white flux over the screw. Continue heating and completely fill the recessed area with silver braze, then remove the heat (Figure 41).

Holding the heat on the joint body for very long will lead to outgassing from the MgO and this can cause pinholes in the braze. If this occurs, allow joint body to cool for a couple of minutes and then repair.

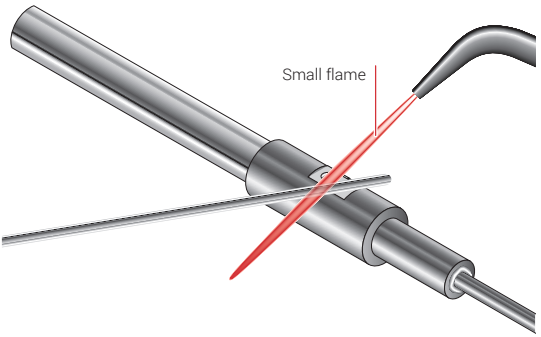


Figure 41: Apply flux and braze over fill hole

3 Heating Cable Repair

Use the emery cloth to clean flux from each brazed area and visually inspect to ensure that there are no pinholes or gaps which could allow moisture to enter (Figure 42).

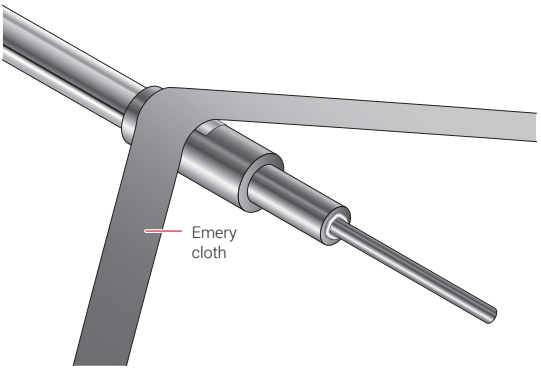


Figure 42: Clean and inspect brazed areas

If pinholes are found, touch up pinholes as necessary by cleaning the area and applying more braze. Ensure that all flux is removed from all brazed areas.

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

Again, test the insulation resistance with a 1000 V DC Megohmmeter (Figure 43). Minimum IR should be 20 MΩ. Quench with a rag soaked in water by wrapping it tightly around the joint (Figure 44). Be careful to not get water inside the repair sleeve or corrugate. If needed, a rag can be tied around the MI heating cable at the sleeve to prevent water from running down the cable. 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.

3 Heating Cable Repair

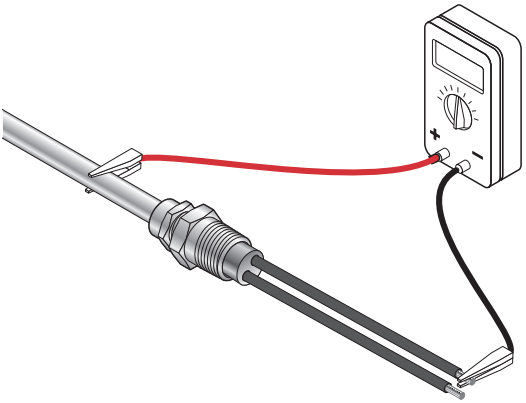


Figure 43: Check insulation resistance

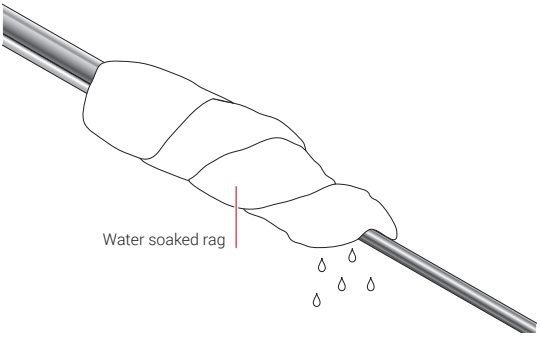


Figure 44: Wrap joint with water soaked rag

3 Heating Cable Repair

Note: If the Megohmmeter reading declines, file off all braze 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 braze as necessary and retest. If still low, replace joint.

Check resistance of heating cable using an ohmmeter and compare with the measured value recorded in Section 3.1. The resistance should not be any more than 3% lower than the value measured previously. If open circuit, cut off joint and repeat procedure.

The finished joint (hot/cold joint) is shown in Figure 45.

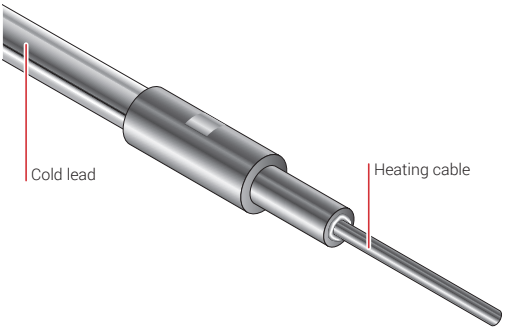


Figure 45: Completed joint

Hot/hot and Hot/cold joint: The steps following show the procedure to braze the repair sleeve for the hot/cold repair. For a hot/hot repair, it will be necessary to braze the two repair sleeves to the joint body, one at a time.

Once the joint has been successfully installed, slide the repair sleeve over the shoulders of the joint with the pressure port facing up.

3 Heating Cable Repair

Apply white flux to the joint/sleeve interface. Using a large flame, braze the sleeve to the joint taking care to not overheat the joint (Figure 46).

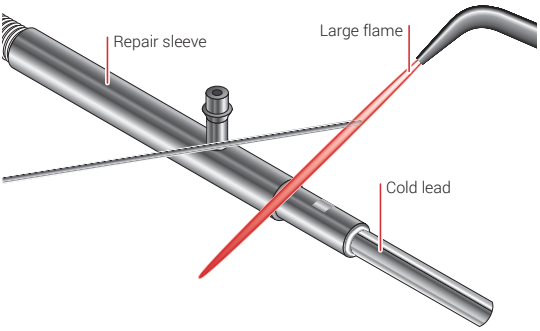


Figure 46: Braze repair sleeve to joint

Next, apply flux to the sleeve/corrugate interface. Then braze the repair sleeve to the corrugate (on heating cable side of joint) taking care to apply the majority of the heat to the sleeve; this will help draw braze into the joining area and prevent damage to the corrugate (Figure 47). Approximately 1 in (25 mm) of the brazing rod should be used to complete this joint.

⚠ Caution: The corrugate is thin and can quickly overheat if directly heated with the flame. Apply heat only to the repair sleeve.

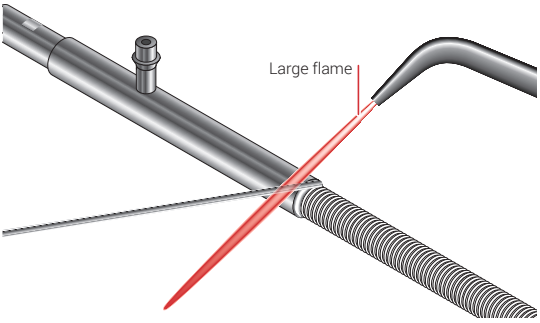


Figure 47: Braze repair sleeve to the corrugate

3 Heating Cable Repair

Cool and clean the brazed joints. Use only the nylon mesh sanding pad on the corrugate (Figure 48). Emery cloth is too aggressive for the corrugate. If using water to cool the joint, it is critical that no water gets inside the repair sleeves and corrugate. Water inside the corrugate can lead to corrosion and early failure of the sheath.

Note: Always ensure all flux has been removed from the corrugate to prevent corrosion. Hot water may be used to remove the flux.

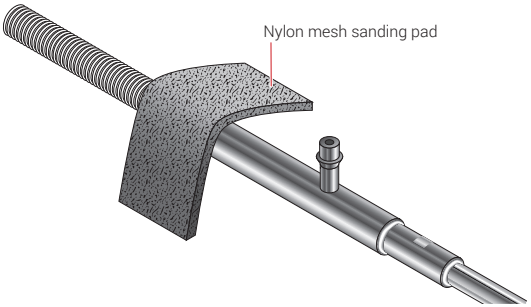


Figure 48: Clean brazed areas

When the joints are clean and cooled, attach the air fitting to the pressure port and pressurize the corrugate to 5 psi minimum to 40 psi maximum (Figure 49).

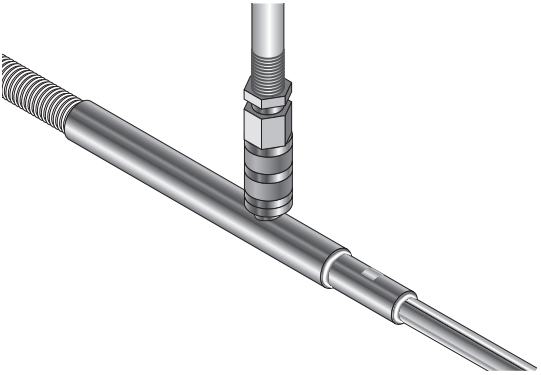


Figure 49: Pressurize joint

3 Heating Cable Repair

Note: Some working environments may have restrictions on allowable pressures. Any pressure above 5 psi will show leaks.

Use liquid leak detector or soapy water to look for leaks in any of the brazed sleeve joints (sleeve to joint body and sleeve to corrugate). Be careful not to introduce excessive bubbles when applying liquid leak detector or soapy water from bottle (Figure 50).

If bubbles are found, release the pressure, unhook the air fitting, and repair the braze.

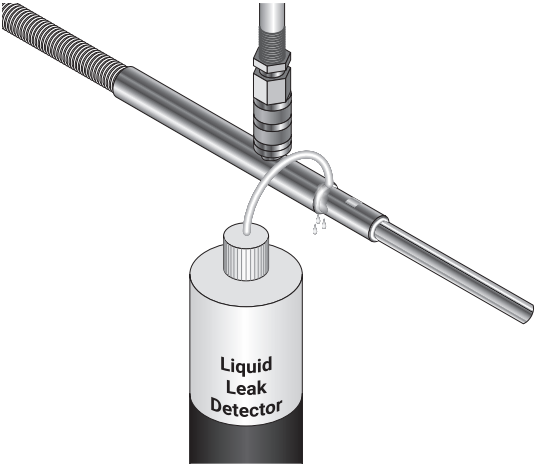


Figure 50: Test brazed areas for leaks

If bubbles are not found, release the pressure and disconnect the fitting.

Place a pressure port plug into the pressure port (Figure 51).

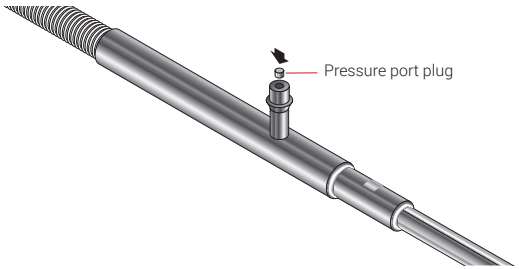


Figure 51: Insert pressure port plug

Apply a small amount of flux over the pressure port plug. Next, using a small flame, fill the pocket above the pressure port plug with braze material until the pocket is full, with a smooth, slightly concave dome of braze material over the pressure port plug and along the inside walls of the port (Figure 52).

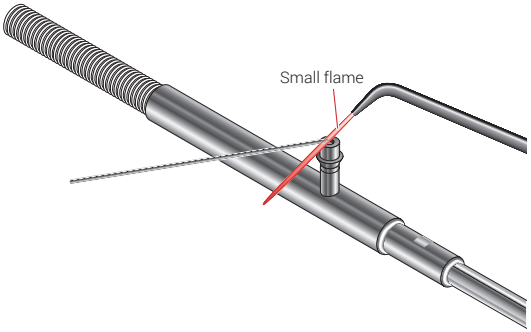


Figure 52: Seal pressure port

Using the nylon mesh sanding pad, clean the pressure port. The hot/cold repair is now complete. If making a hot/hot repair, follow the same procedure to complete the repair sleeve on the other side of the joint body.

3 Heating Cable Repair

3.4 End Termination Procedure

Note: Shield work area from environmental factors such as wind as it will cool the joint temperature making brazing difficult.

Remove insulation and banding from heating cable so that 12 in (30 cm) of cable and end cap is accessible.

Ensure that the portion of the cable being worked on can be moved away from the surface at least 4 in (10 cm) to allow access when brazing (see repair jig in Appendix G).

Using the tube cutter, cut the corrugate 1/2 in (13 mm) from the corrugate plug (ARO fitting). Once cut, turn the plug counter-clockwise to unscrew the plug from the heating cable end cap (Figure 53).

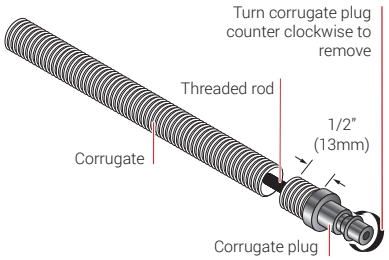


Figure 53: Cut corrugate and unscrew corrugate plug

Using the tube cutter, cut off 12 in (30 cm) of the corrugate (Figure 54). Save this 12 in (30 cm) piece of corrugate for reuse later in this procedure.

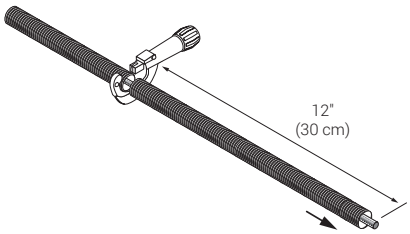


Figure 54: Remove 12 in (30 cm) corrugate

3 Heating Cable Repair

Remove old end cap by cutting through cable with a hacksaw as close as possible to the back of the end cap (Figure 55).

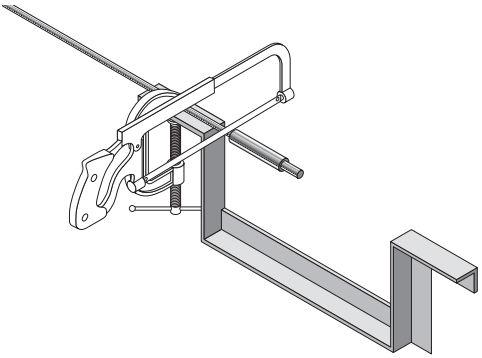


Figure 55: Remove old end cap

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 XMI-L 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 4 in (10 cm) to allow access when brazing.

3 Heating Cable Repair

Check the insulation resistance (IR) of the cable at this point using a 1000 V DC Megohmmeter (Figure 56) Details on testing can be found in Appendix B. This test checks for the presence of moisture in the magnesium oxide insulation. 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.

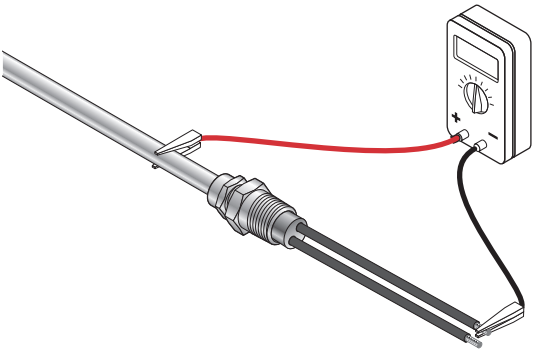


Figure 56: Check insulation resistance

Verify continuity of conductors using a multimeter or ohmmeter.

Using a vernier caliper (or micrometer), measure the outside diameter of the MI heating cable (Figure 57). Select the end cap body and threaded end cap plug from the repair kit (see Table 5 in Section 2).

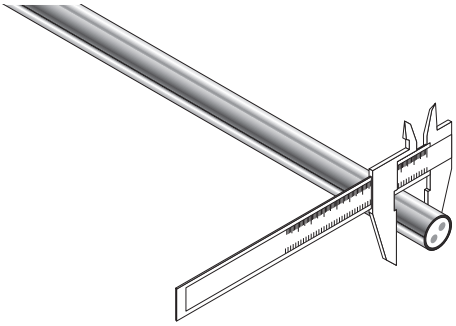


Figure 57: Measure MI heating cable diameter

3 Heating Cable Repair

Using 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 body using the pilot hole (smaller hole) as a guide and check it for burrs (Figure 58).

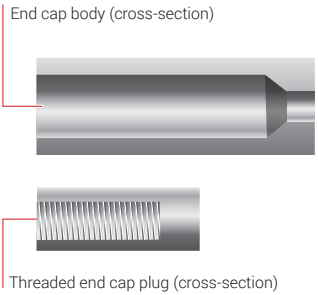


Figure 58: Drill end cap body

Polish the end (about 2 in (5 cm)) of the MI heating cable sheath with emery cloth (Figure 59). The surface must be clean for brazing.

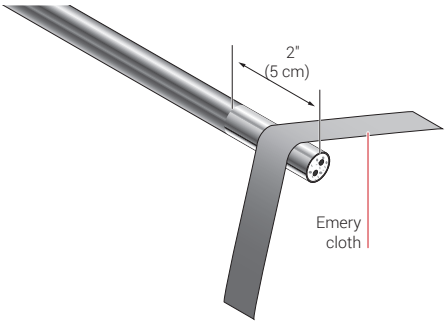


Figure 59: Polish cable sheath

3 Heating Cable Repair

Check inside of end cap body for burrs and if present, remove with round file. Slide the end cap body onto the cable making sure the plug end (end with the largest hole) faces outwards (Figure 60).

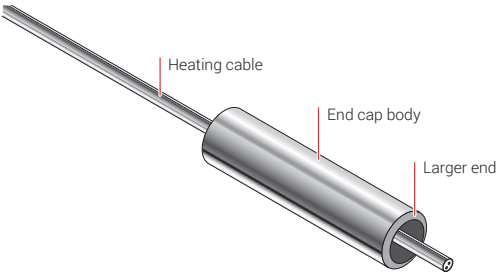


Figure 60: Place end cap body on cable

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 (Figure 61). See Appendix F for detailed instructions on stripping cable sheath.

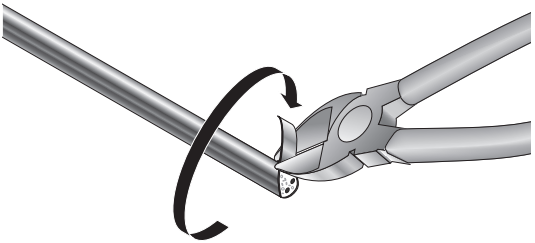


Figure 61: Remove MI heating cable sheath

Clean magnesium oxide powder from the conductors with emery cloth or use side cutters to lightly scrape conductor surface (Figure 62); conductor surface must be free of powder for silver braze to bond.

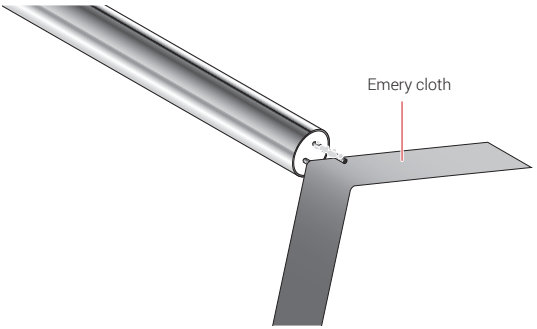


Figure 62: Clean conductors

Using pliers, twist conductors together through approximately two full 360° turns (Figure 63).

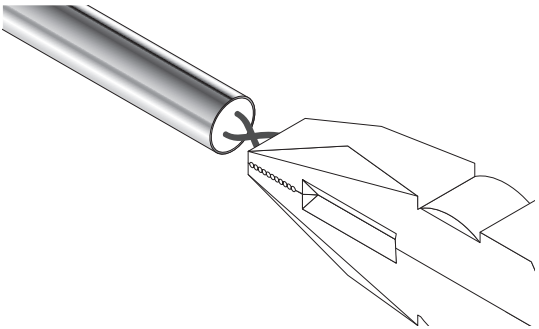


Figure 63: Twist conductors

3 Heating Cable Repair

Apply a small amount of flux to the twisted conductors. Avoid contaminating the magnesium oxide at the face of the cable with flux as this will lead to failure during testing.

Heat conductors with the oxy-acetylene torch (this does not take much heat) and at the same time, touch the brazing rod to the end of the twisted conductors and apply enough braze to form a small bead (Figure 64).

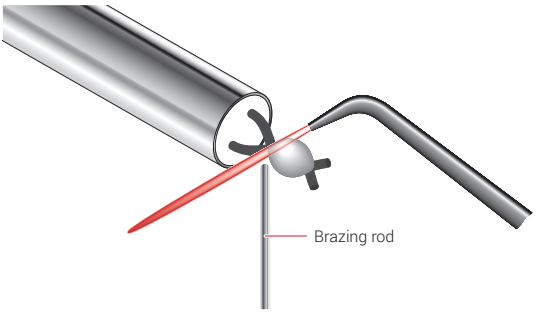


Figure 64: Braze twisted conductors

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

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

3 Heating Cable Repair

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 65).

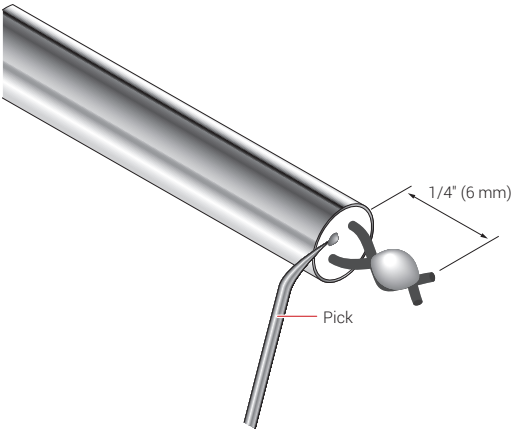


Figure 65: Remove contaminants

Slide the end cap body 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 body (see cross section in Figure 66).

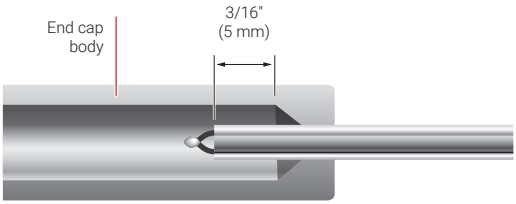


Figure 66: Position end cap body for brazing

3 Heating Cable Repair

You are now ready to braze the end cap body 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 body and stopping 1/2 in (13 mm) from the end cap body (Figure 67). Immediately proceed to next step.

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

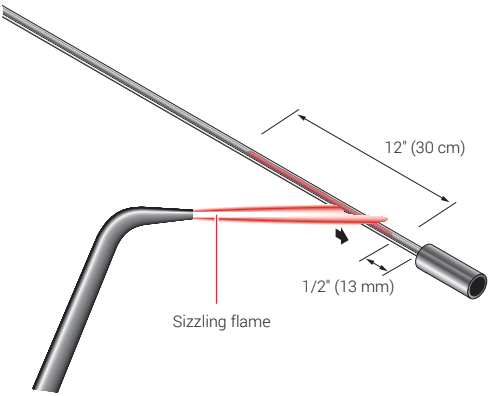


Figure 67: Heat out cable

Reduce **sizzling** flame to a **large** flame (see Appendix E). Apply white flux around end where the end cap body will be brazed to the cable sheath. Ensure that the flux is applied around the entire junction.

3 Heating Cable Repair

Heat the end cap body and cable sheath with a large flame. When the area to be brazed is up to temperature, deposit a large bead of silver braze on the top part of the area to be joined. Apply heat to both the end cap body and the cable and move the flame slowly around the circumference of the end cap body (Figure 68). This will cause the braze to wick its way around the joining area and also draw the braze inside the end cap body making a stronger braze (Figure 68). Add more braze as needed. Ensure that the braze flows to the bottom of the end cap body to ensure a continuous braze around the end cap body.

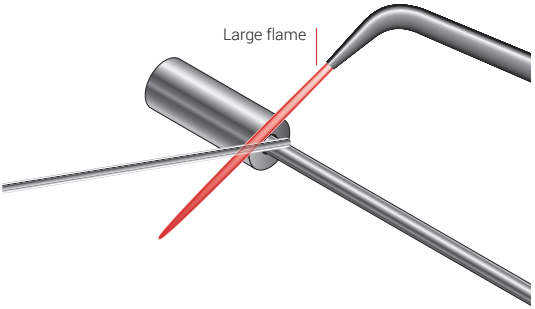


Figure 68: Braze end cap body to cable

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 braze from adhering to the metal. Care must also be taken not to overheat the end cap body, which can cause the conductor joint (junction) to melt.

Reposition end cap body 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.

While the end cap body is still hot, fill end cap body to approximately 3/16 in (5 mm) below the opening. 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 body (Figure 69). Using an engraving tool or other vibration method will ensure that the powder is well packed.

⚠ Caution: End cap body and cable will be hot. Do not touch with bare hands.

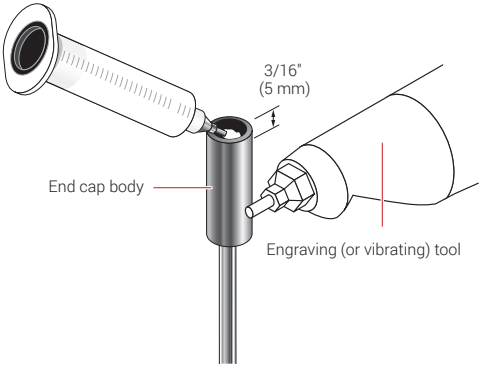


Figure 69: Fill end cap body with MgO powder

Insert the threaded end cap plug (with threaded hole facing up) and firmly and gently tap it down to further compress the powder (Figure 70). Do not strike too hard as this may deform the threaded hole which is needed later in this process.

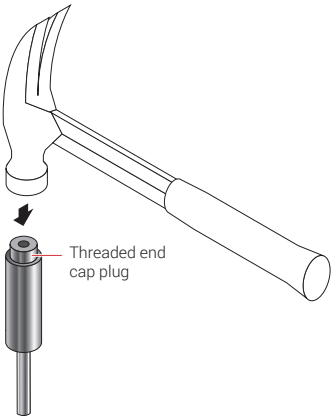


Figure 70: Gently tap plug into place

3 Heating Cable Repair

Check the insulation resistance (IR) again (Figure 71). 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.

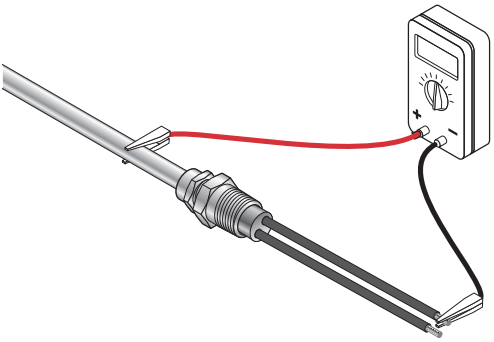


Figure 71: Recheck insulation resistance

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.

Apply white flux around area where the plug will be brazed to the end cap body. Using the silver solder, braze the plug to the end cap body (Figure 72).

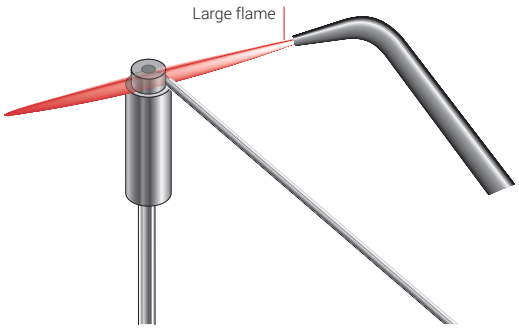


Figure 72: Braze plug to end cap body

3 Heating Cable Repair

Do not apply excess heat at this time, as excess heat will cause the air within the end cap body to expand and cause a pinhole in the braze. If a pinhole does develop, the surface should be cleaned and filed before attempting to re-braze the end cap body. The cross-section below shows placement of the cable, end cap body and plug (Figure 73).

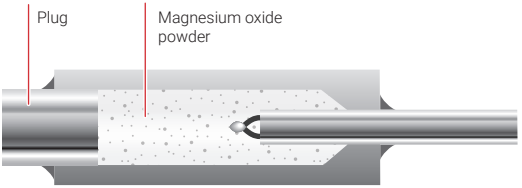


Figure 73: Cross-section of completed end cap

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 braze 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.

3 Heating Cable Repair

Test the insulation resistance with a 1000 V DC Megohmmeter (Figure 74). Minimum IR should be 20 MΩ. Leave Megohmmeter connected for next step.

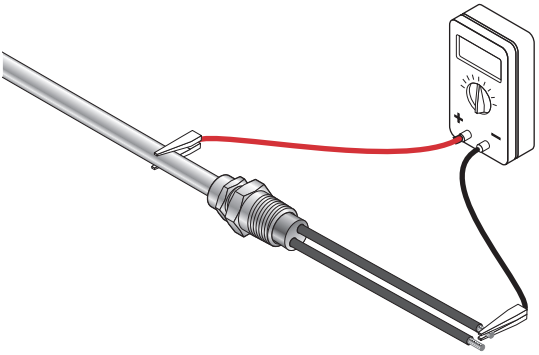


Figure 74: Check insulation resistance

Clean end cap to remove all flux. Gently reheat end cap but not hot enough to discolor the metal. With Megohmmeter still connected, quench with a rag soaked in water by wrapping it tightly around the end cap (Figure 75). Be careful to not get water inside the braze sleeve or corrugated sheath. If needed, a piece of rag can be tied around the heating cable at the sleeve to prevent water from running down the cable. Also, the cable can be repositioned in a horizontal or downward orientation. 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.

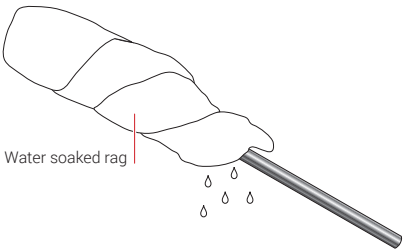


Figure 75: Soak end cap

3 Heating Cable Repair

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 braze 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 and compare with the measured value recorded in Section 3.1. The resistance should not be any more than 3% lower than the value measured previously. If open circuit, cut off end cap and repeat procedure.

The completed end cap is shown below (Figure 76).

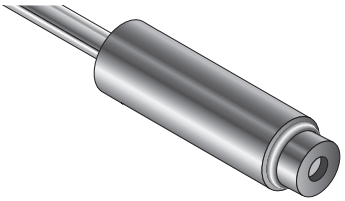


Figure 76: Completed end cap

Install corrugate union and reinstall 12 in (30 cm) piece of corrugate previously removed (Figure 77).

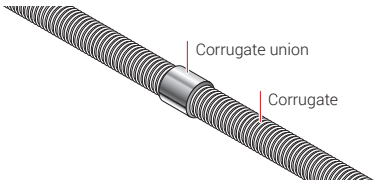


Figure 77: Install union and corrugate

Clean and polish both ends of the corrugate and the corrugate union with the nylon mesh sanding pad. The surfaces must be clean for the silver braze to adhere to them.

3 Heating Cable Repair

Note: Do not use emery cloth on corrugate. Use only the nylon mesh sanding pad.

Next, apply flux to the ends of the corrugate and the corrugate union. Fit the parts together so that both ends of the corrugate butt against the center-stop in the corrugate union.

Apply more flux completely around both ends of the corrugate about 1/4 in (6 mm) past the ends of the corrugate union; this will help prevent discoloration of the corrugate. Next, braze the corrugate to both ends of the corrugate union using a large flame (see Appendix E). To avoid damage to the thin corrugate, hold the flame on the corrugate union, not on the corrugate (Figure 78). Approximately 1 in (25 mm) of braze rod should be used for each side of the union/corrugate joint.

Once the union has been brazed, use emery cloth to clean the corrugate union and the nylon mesh sanding pad to clean the corrugate. Use only the nylon mesh sanding pad on the corrugate; it has a thin sheath and can be easily damaged. Emery cloth may be used on the corrugate union. Remove all flux.

Note: Always ensure all flux has been removed from the corrugate to prevent corrosion. Hot water may be used to remove the flux.

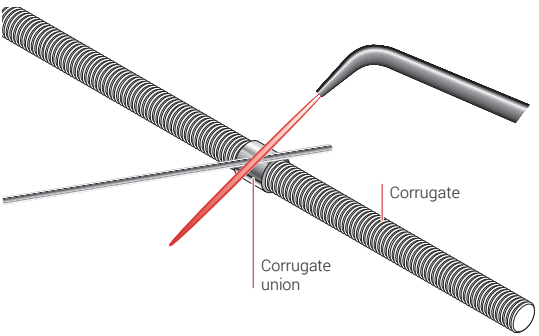


Figure 78: Clean, flux and braze union

3 Heating Cable Repair

Using the tube cutter, cut the end of corrugate so that it projects 3/4 in (19 mm) beyond the end cap. Flare the inside of the cut corrugate with needle nose pliers - so that the corrugate plug will fit inside (Figure 79).

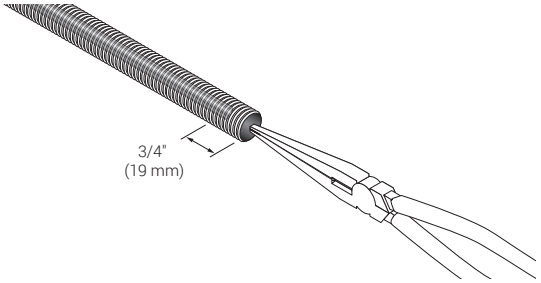


Figure 79: Flare end of corrugate

Screw the threaded stud into the corrugate plug; a minimum of 5 threads is to be engaged (Figure 80).

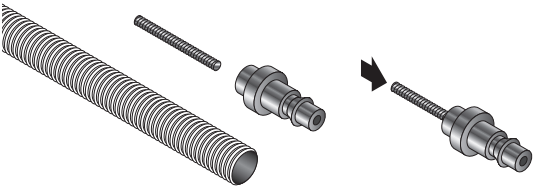


Figure 80: Screw stud into corrugate plug

Thread assembly into the end cap so that the corrugate is seated against the shoulder of the corrugate plug (Figure 81).

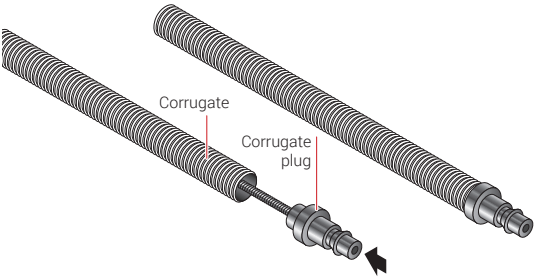


Figure 81: Screw assembly into end cap

3 Heating Cable Repair

Apply flux, then using a neutral flame, braze the corrugate plug to the corrugate keeping the flame on the plug (Figure 82).

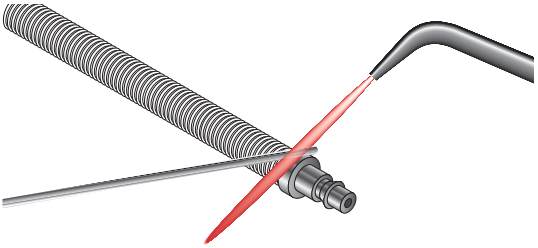


Figure 82: Braze plug to corrugate

Use emery cloth to clean the corrugate plug and the nylon mesh sanding pad to clean the corrugate. Do not use emery cloth on the corrugate - it has a thin sheath and can be easily damaged.

Note: Always ensure all flux has been removed from the corrugate to prevent corrosion. Hot water may be used to remove the flux.

When the joint is clean and cooled, attach the air fitting to the plug port and pressurize the corrugate to a maximum of 40 psi (Figure 83).

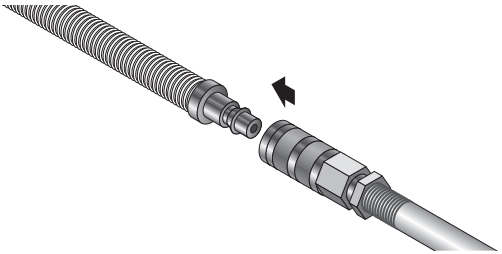


Figure 83: Pressurize corrugate

Note: Some working environments may have restrictions on allowable pressures. Any pressure above 5 psi will show leaks.

3 Heating Cable Repair

Use soapy water/liquid leak detector to look for air leaks in all of the brazed joints (corrugate plug to corrugate and corrugate union to corrugate). Be careful not to introduce excessive bubbles from liquid leak detector hose (Figure 84).

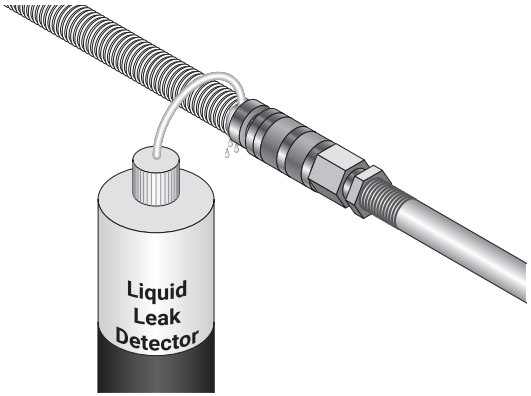


Figure 84: Check for air leaks

If bubbles are found, release the pressure from the corrugate, unhook the air fitting, and repair the braze.

If bubbles are not found, release the pressure and disconnect the fitting.

Place a pressure port plug into the pressure port (Figure 85).

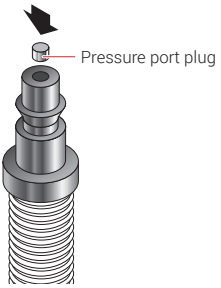


Figure 85: Insert pressure port plug

Apply a small amount of flux over the pressure port plug. Next, using a small flame, fill the pocket above the pressure port plug with braze material until the pocket is full, with a smooth, slightly concave dome of braze material over the pressure port plug and along the inside walls of the port (Figure 86).

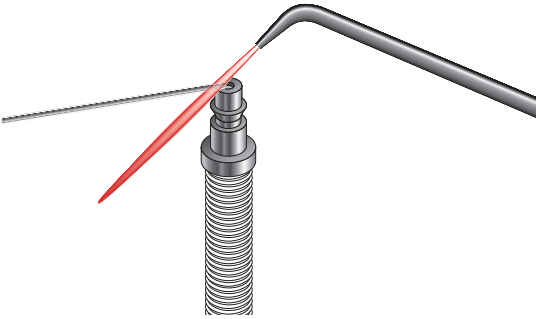


Figure 86: Seal pressure port

Clean the corrugate plug with the nylon mesh sanding pad. The repair is now complete.

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.

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.	
Measured Resistance after Repair (ohms)	

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 1.800.545.6258.

Please fill in this form and e-mail to ntm-techsupport@nVent.com. nVent will review the change and advise if the modification is appropriate.

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 1000 V DC 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). If a 1000 V DC Megohmmeter is unavailable, it is acceptable to use a 500 V DC Megohmmeter.

A digital multimeter or ohmmeter is used to check the continuity.

To ensure that brazed joints are waterproof, they may be submerged in water for approximately 24 hours. This treatment will remove brazing 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 in-line hot/hot joint and hot/cold joint repair and the end termination repair. 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:	1000 V DC 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 1000 V DC.

5 Appendix B: Heating Cable Testing

Test Criteria

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

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 1000 V DC; 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.

5 Appendix B: Heating Cable Testing

8. Turn off the Megohmmeter.
9. Repeat Steps 6 through 8 for other tail conductor.
10. Check insulation resistance between the two conductors. 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.
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.

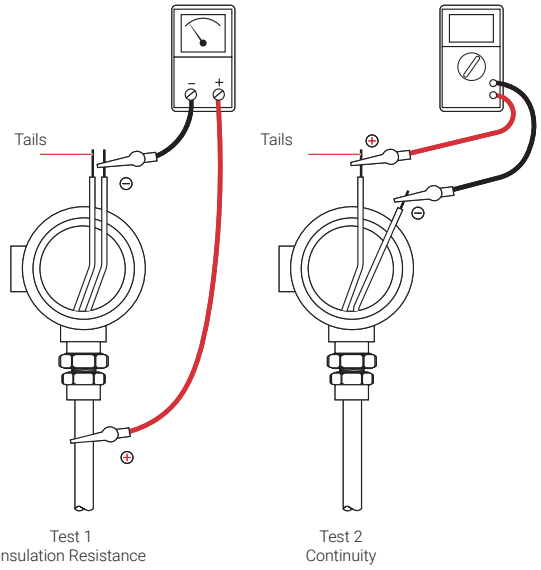


Figure B1: Checking insulation resistance and continuity

6 Appendix C: Cable Size vs Drill Bit Selection Chart

Drill bit selection chart

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

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 5 in (13 cm) back from the end of the cable (heat cold lead first if making a hot/cold joint). If IR is still low and it was necessary to remove an additional 10 in (25 cm) to 12 in (30 cm) of cable, begin heating out the cable 12 in (30 cm) back from the end of the cable. Alloy 825 sheath cable should be heated to a dull red 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 body 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.

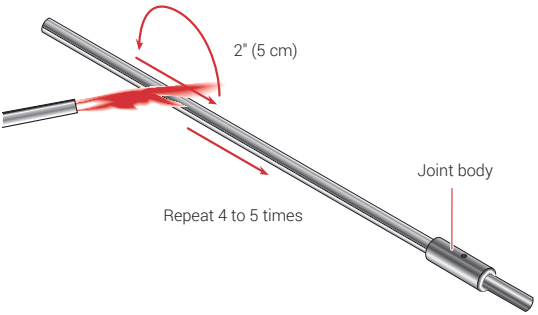


Figure D1: Use sweeping motion of torch

7 Appendix D: Drying Out Procedure

Gradually move the flame toward the joint body or end cap, while maintaining the short sweeping motion of the torch. When initially checking insulation resistance after the damaged joint body or end cap has been removed, continue the sweeping motion of the torch past the end of the cable (Note: If heating out the cable prior to brazing the joint body or end cap to the cable sheath, stop the sweeping motion of the torch 1/2 in (13 mm) from the joint body or end cap as shown in 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.

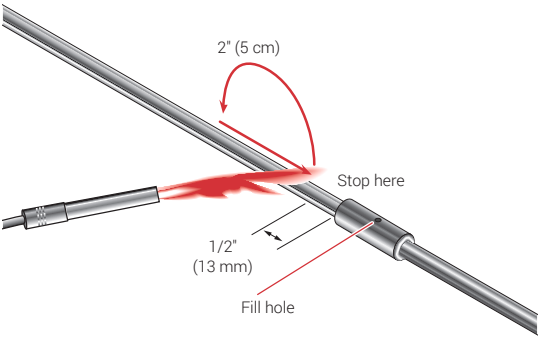


Figure D2: Sweep flame to end of cable

On completion, check IR with a 1000 V DC 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 brazing the conductors together.

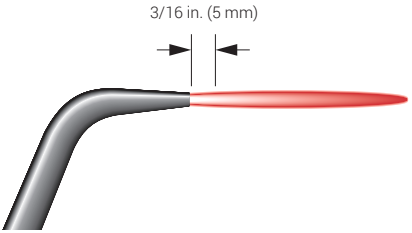


Figure E1: Small (oxidizing) flame

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

Figure E2: Large (nefutral) flame

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

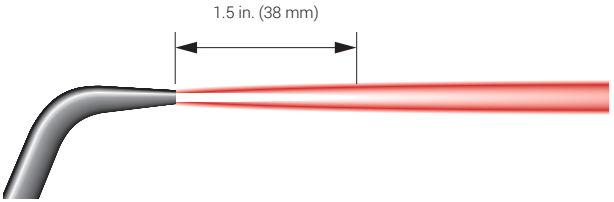


Figure E3: Sizzling (reducing/carbonizing) flame

9 Appendix F : Stripping the Cable Sheath

Use a tube cutter to score around the cable sheath the required length from the end (Figure F1). 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 deep with the tube cutter as this will cause the sheath to be pushed inwards towards the conductors, possibly resulting in cable failure.

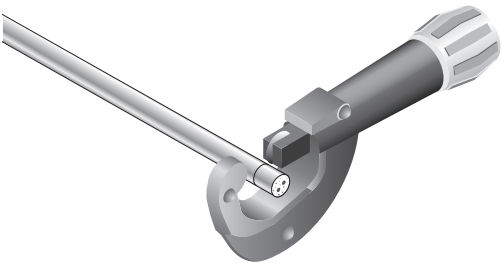


Figure F1: Score cable sheath

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 F2).

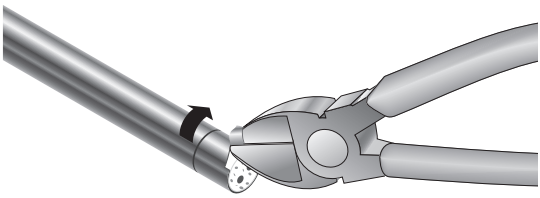


Figure F2: Grip sheath with sidecutters

9 Appendix F : 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 F3).

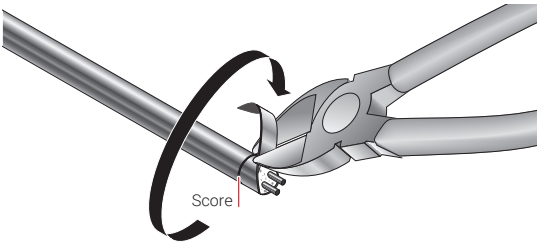


Figure F3: Strip cable sheath

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 (Figure F4). The sheath will peel away leaving a clean cut when the score mark is reached. Ensure that the sheath is not flared inward.

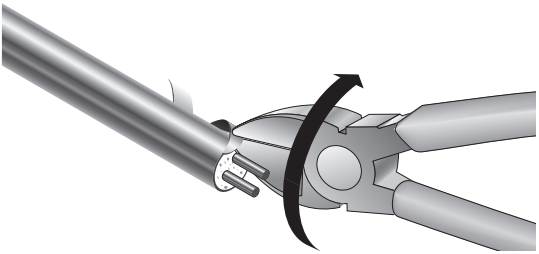


Figure F4: Sidecutter angle for final stripping

9 Appendix F : Stripping the Cable Sheath

The cable sheath is correctly stripped, with the sheath flared slightly outwards, shown in Figure F5 (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.

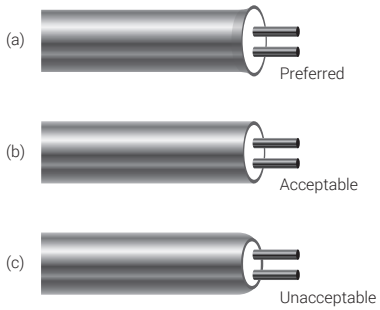


Figure F5: Cable end preparation

10 Appendix G: Typical Repair Jig

Repair jig is made from angle iron welded to form shape as shown in Figures G1 and G2. 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.

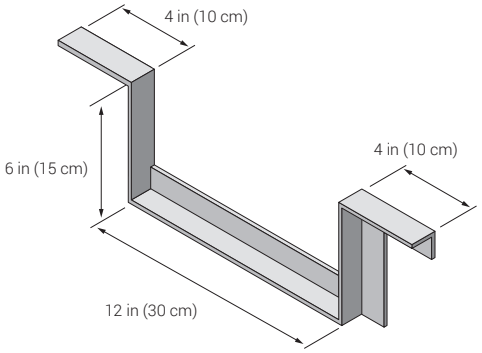


Figure G1: Front of repair jig

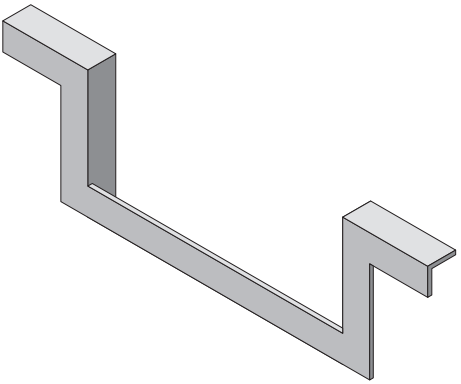


Figure G2: Back of repair jig

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