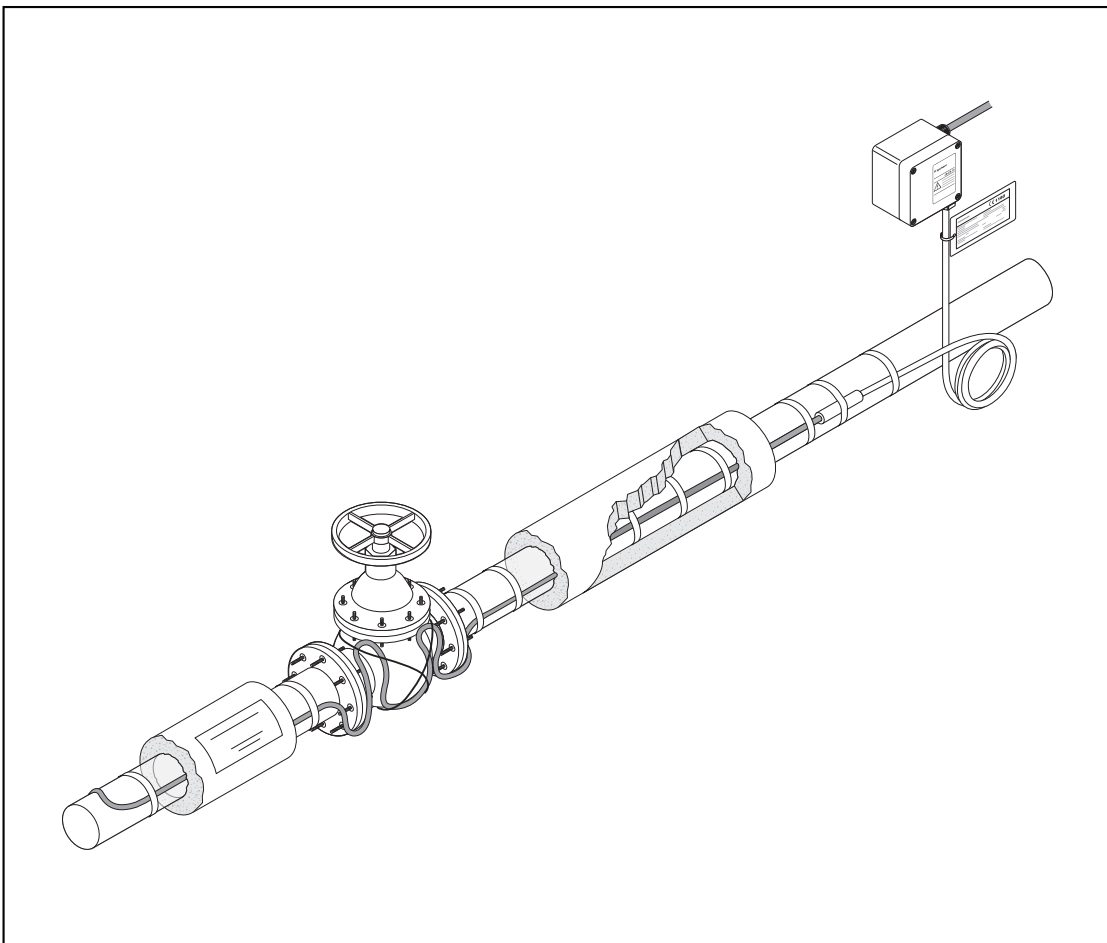
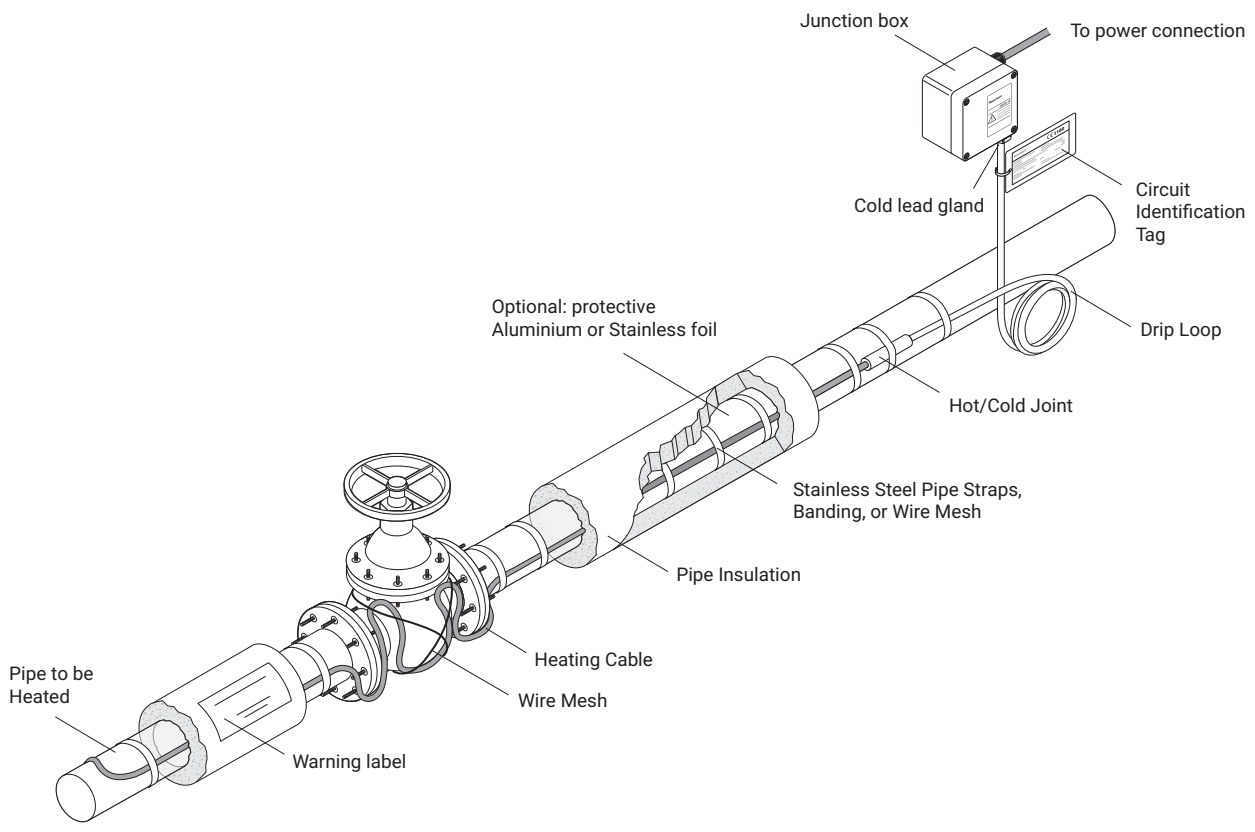


## Assembly and Repair Guide

Mineral Insulated heating cable heat-tracing unit



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# 1. GENERAL INFORMATION

## 1.1. Introduction

The purpose of these instructions is to provide a procedure for the assembly, repair or modification of MI heating units using joints and end caps for Raychem Mineral Insulated (MI) heating units manufactured by Chemelex. They must be completely read, understood and carefully followed to ensure that the MI heating unit performs safely and as intended for its specific application.

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

The successful repair or modification of these heating units is a specialized procedure. Only qualified and experienced personnel at industrial establishments, with the necessary competency, are permitted to repair or modify MI heating units. 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 trained and qualified engineer using design tools provided by the manufacturer.

For assistance, technical support, or other information regarding the repair of Raychem Mineral Insulated heating units, please contact your Chemelex representative or Chemelex.

Chemelex  
Tel: +32.16.213.511  
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www.chemelex.com

## 1.2. Safety Guidelines



The safety and reliability of any heat tracing system depends on both the quality of the products selected and the manner in which they are installed and maintained. Incorrect design, handling, installation, or maintenance of any of the system components can cause damage to the heating cable system, and may result in system failure, electric shock, or fire. The guidelines and instructions contained in this manual are important. Follow them carefully to minimize these risks and to ensure that the MI system performs reliably.

## 1.3. Electrical Regulations



For the Chemelex warranty to apply, the instructions that are included in this manual and product packages must be followed. The installation must also be in accordance with local National requirements applicable to electrical heat tracing systems, as well as the requirements of other International Standards. For installations in hazardous area IEC / EN 60079-30 applies.

## 1.4. Special requirements for hazardous areas



There are special requirements for repairs of trace heaters in hazardous areas defined in IEC 60079-30-2:

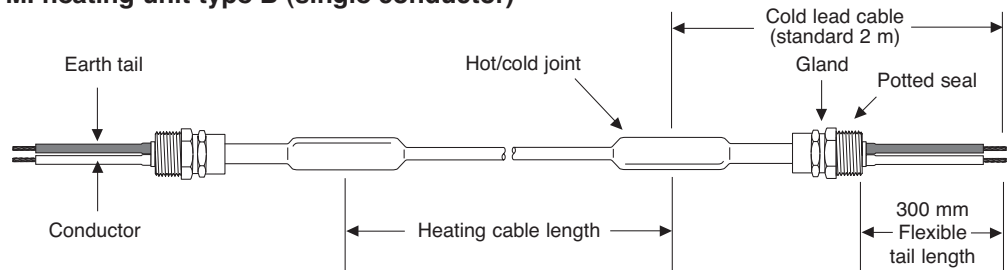
- When a fault occurs in an electrical trace-heating system, it is necessary first to determine the cause. Most faults are caused by mechanical damage, corrosion, overheating or ingress of moisture.
- Only when the cause has been eliminated should the defects be rectified by site repair. Site repair should be carried out only if all of the following conditions all are satisfied:
  - The electrical component will perform its designated function without undue change in electrical characteristic;
  - Design and construction characteristics of the component are maintained, for example mechanical strength and bending radius;
  - The repair is carried out according to this document;
  - No local hazard will be created in carrying out the repair;
  - It does not invalidate the ATEX EC-type examination certificate for the certified heating units.

- Mechanical damage: If the fault is found only after electrical connection and the damage is confined to a small area, visual inspection of the trace heater for 1 meter on either side of the fault should be undertaken to show whether the electrical insulation is affected other than at the point of mechanical damage.
- Damage due corrosion: If the electrical trace heater has been damaged at more than one point or the damaged area is extensive, it should be replaced. If the cause of corrosion cannot be removed, the trace heater should either be replaced by one capable of withstanding the corrosive effects, or be re-routed.
- Damage due to overheating: Repairs should be carried out only when the signs of overheating are local. For larger areas, a system design error or controller failure could be the cause. If a system design fault is suspected, the trace-heating system designer should be consulted.

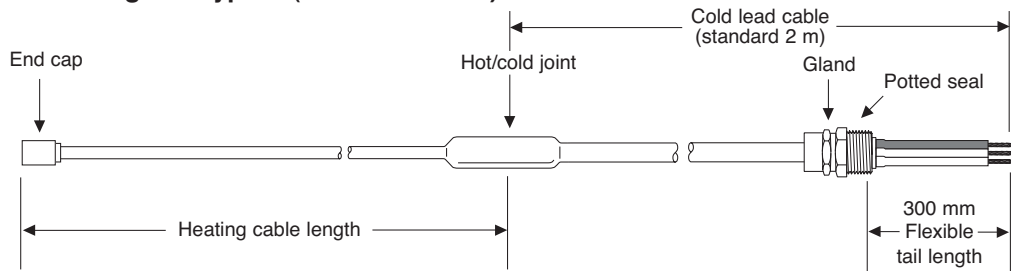
## 1.5. Heating Unit Construction

This manual covers the field assembly, repair or modification of the heating unit designs shown below.

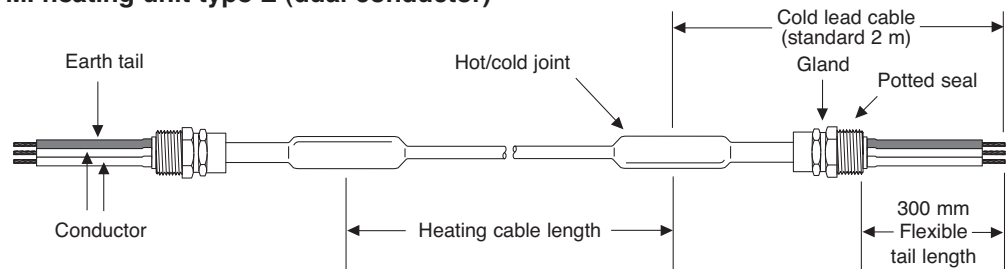
### MI heating unit type B (single conductor)



### MI heating unit type D (dual conductor)

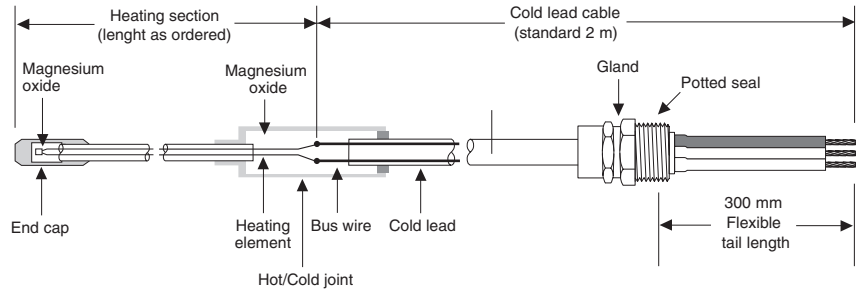


### MI heating unit type E (dual conductor)



## MI Heating Unit Designs covered in this manual

A sectional view of a type D MI heating unit is shown below. All of the units include both a heating section and a non-heating cold lead section. These sections are joined in 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 unit, the conductors of type D units are joined and hermetically sealed within an end cap.



## 1.6. Heating Unit Identification

Every assembled heating unit must be equipped with an identification tag. Each factory supplied MI heating unit is delivered with an identification tag on which the heating cable order reference is permanently printed. In addition to its identification purposes, the order reference provides information regarding the heating cable length, power output, and operating voltage. Also printed on the tag are the designer's circuit identification number, serial number and maximum cable withstand temperature. If the unit has been designed for a hazardous location, the area classification is printed on the tag.

If the resistance of a heating unit is altered by more than 5% from its original design value a new identification tag is required. The MI Heating Unit Field Modification Approval Request Form in Appendix A must be filled in and reviewed by Chemelex before proceeding with the repair or modification.

<b>Raychem</b>		<b>CE 1180</b>
MI Unit Reference: <b>B/HSQ1M1000/43M/1187/230/2M/SC1H2.5/X/M20/EX</b>		
Heating Cable Ref.: <b>HSQ1M1000</b>	Element Length:	<b>43 m</b>
Year of Manufacture: <b>2006</b>	Circuit Length (if different):	
Grade: <b>II (high)</b>	Design Temperature Class:	<b>T1 Zone1</b>
Design Method: <b>Limiter-Lockout</b>	Maximum Withstand Temperature:	<b>450°C</b>
Max. Sheath Temperature: <b>331°C</b>	Sheath Reference Temperature:	<b>200°C</b>
Nom. Power Output @ 230 V: <b>1187 W @ Maintain Temperature</b>		
Order No:	Customer Order No:	
Batch number: <b>XXXXXX</b>	Circuit Reference:	
Type Examination No:	<b>Baseefa02ATEX0046X</b>	
<b>(Ex) II 2 G EEx e II T1</b>		
<b>Follow installation and operating instructions for safe use in hazardous areas!</b>		
<b>THIS TAG MUST NOT BE REMOVED</b>		

- MI Unit Reference is the order reference following the nomenclature of MI heating units
- Heating Cable Ref. is the type of MI heating cable
- Element length is the heated length of the MI unit
- Year of Manufacture is the manufacturing year
- Circuit length (if different) informs about the "total circuit length" in case of multiple elements being connected in series
- Design Temperature Class states the "T-class" or "Auto Ignition Temperature" including the "Zone" classification, which the unit is designed for
- Design method informs about the method of temperature control, which has been used for the design and must be installed to control the heating unit

**Examples:**

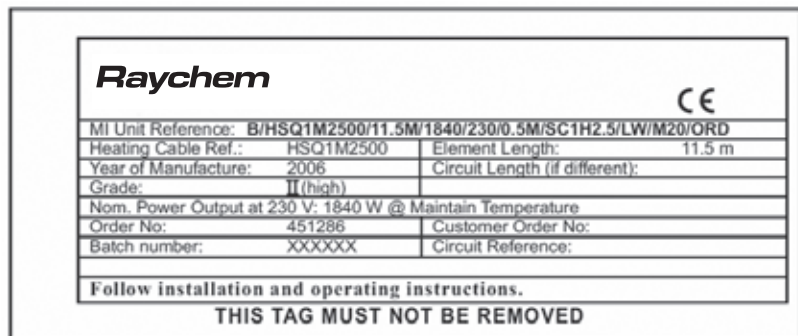
1) "Stabilized" indicates that the design method used is "stabilised design". All parameters used in the design of the application must be respected in order to comply with the hazardous area requirements (e.g. pipe diameters, insulation thickness, process, ambient conditions ...). The reference temperature for the sheath temperature calculations is either the calculated "max. uncontrolled temperature" or the "max. process temperature", whichever is higher.

2) "Control limited" (zone 2 applications) indicates that the design method used is "control limited design". The reference temperature for the sheath temperature calculations is the control limited design temperature and must be assured by the use of an alarm capable control unit making sure the heating element is switched off, when the pipe/equipment exceed this temperature. The use of a wrong control device or a change of the temperature setting will invalidate the design calculation.

3) "Limiter-Lockout" (zone 1 / zone 2 applications) indicates that the design method used assumes the installation of an approved limiter (typically a safety temperature limiter which sensor is installed on the heating cable surface using an "artificial hotspot"). The set point of the limiter must be below the T-class (-10K for T2 and T1, -5K for T6, T5, T4 and T3) of the area and may require an additional down-adjustment for potential falsifying of the measured temperature, refer to the instructions given by the manufacturer of the limiter.

- Maximum Withstand Temperature is the max. withstand temperature of the heating cable and the hot-cold joint used, it may also be limited by the hazardous area approval
- Max. Sheath Temperature is the max. sheath temperature of the MI heating cable based on the application design data
- Sheath Reference Temperature is the reference temperature, which the "max. sheath temperature" calculated in the design of the system is based upon, (also see "Design Method")
- Power Output refers to the expected power of the heating unit at the specified voltage/configuration. It is based on the desired maintain temperature and may be significantly lower than during start-up phase, in particular for heating cables using conductors with a high temperature coefficient (e.g. copper conductor). Refer to the design information for proper sizing of the circuit breaker and power supply. The design calculation must always be in compliance with the application design and the ambient parameters.

Please consult the IEC / EN 60079-30 standard for detailed information on the terminology being used in this document.



## PRE-REPAIR INFORMATION

### 1.7. General

Both Single and Dual conductor MI heating units can be field assembled, repaired or modified. The Field Repair Components can be used to complete the following:

- to assemble or replace a joint in the heating cable (hot-hot joint)

- to assemble or replace a joint between the heating cable and the non-heating cold lead section (hot-cold joint)
- to assemble or replace the end cap

For stainless steel and Alloy 825 sheath cables Chemelex recommends to use stainless steel joints and end caps with a maximum exposure temperature of 450°C. Brass joints can be used for Copper and Cupronickel sheathed cables with a lower maximum exposure temperature dependant on the cable type (see cable datasheets for more details).

The removal of a damaged section of trace heater should not significantly alter the performance of the trace heater from its original design characteristics. Care should be taken to insure that an in-line splice is not subjected to stresses in operation. This may be achieved, for example, by providing an expansion loop on either side of the joint. The tracer heater 150 mm on either side of the joint should not be bent when re-applied to the workpiece and good thermal contact should be ensured.

NOTE: If the attempted repair cannot be done successfully, please contact Chemelex.

### 1.8. Safety Precautions

- Safety glasses must be worn when making field repair joints
- Take care 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
- When drying out cable, care must be taken not to trap moisture as this could cause the cable to burst, possibly causing injury.
- Check whether hot work permit would be required.

### 1.9. Changing heating cable length

If the resistance of a heating unit is altered by more than 5% from its original design value a new identification tag is required. Where the change of the heating unit is leading to more deviation, a new MI identification tag must be ordered. In these instances, the MI Heating Unit Field Modification Approval Request Form in Appendix A must be filled in and reviewed by Chemelex before proceeding with the repair or modification and a permanent record of the modification must be retained.

**Caution:** Shortening the heating cable length will decrease the resistance, resulting in an increase in wattage and current draw. In such circumstances, the series heating unit would run hotter than originally designed, with the potential of starting a fire or early failure of the heating element. Similarly, increasing the length of the heating cable increases the resistance, resulting in a decrease in wattage and current draw. Special attention must be paid to the over-current protective device and cross-section of the power cable to ensure that they conform to the requirements of national and local codes when such modifications are made to heating units.

**Warning:** Shortening heating cables for hazardous areas can cause the heater to exceed the temperature class for which it was originally designed. In that case the permission to re use the heater is lost and a total new design is imposed.

### 1.10. Tools and materials required

**TABLE 1.1. Tools and Materials**

Insulation Resistance meter (1000 Volt DC Megohm meter)	Small hammer
Ohmmeter (Multi-meter)	Needle nose pliers
Drill press and bits	Steel Rule
Vernier calliper (or Micrometer)	Flat file
Small tube cutter (e.g. Chemelex ZR)	Round file
Diagonal edge cutters – 6" and 8"	Hacksaw
An oxy-acetylene torch with No. 0 welding tip	Flat nose pliers
Knife (to strip HDPE jacketed copper cable)	Scribe or pick
Vice grip pliers or vice (Chemelex vice grips)	Cotton cloth or rag
Small screwdriver with flat blade	Bottle of water

Medium Grit Emery Cloth (80 Grit)	Packing Rod
Steel repair jig or equivalent and two 'C' clamps to hold cable firm when welding (see Appendix G)	

## 1.11. Repair Components

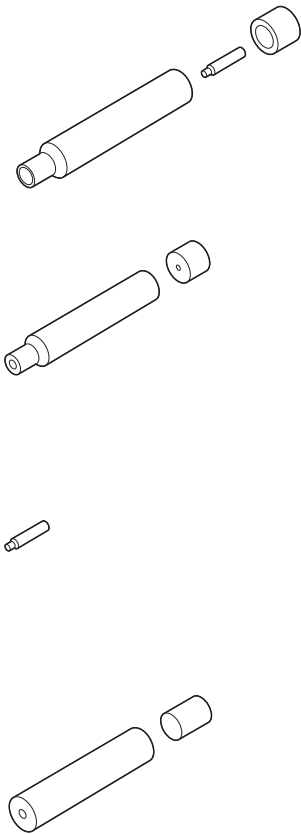
Only use original Articles/Items from Chemelex. See as well TTC DOC-606 for further options.

**TABLE 1.2. Repair Components**

For TTC MI Heating cables:

The selection of the correct joint and / or end cap depends on the cable type to repair and the nature of the repair (Hot/Hot or Hot/Cold). Please refer to tables 3.1 and 3.2 on p14 to select the appropriate joint and / or end cap. This information can also be found in DOC-606.

ARTICLE-NUMBER	DESCRIPTION	DESCRIPTION
1235-41909002	SABAG13-PACK	Silver Solder for Brazed Joints, use for Conductor - pack of 10 sticks
1235-41909003	SABAG14-PACK	Silver Solder for Brazed Joints, use for Joint Body - pack of 10 sticks
SABF	SABF	Brazing Flux – 250g
SMP-300	SMP-300	Magnesium Oxide Powder - 250g



### SJK

Hot/cold joint for brazed connection of MI heating cables and cold leads. Joints are factory drilled to diameter for best fit of MI cable. For more details such as compatibility with various heating cables and order references, refer to tables 2–8 (pages 4–10).

### SJK-PILOT...

Universal hot/cold joint for brazed connection of MI heating cables and cold leads. Universal joints have a pilot hole that must be drilled to match the exact diameter of the heating cable or cold lead during the termination operation. For more details such as compatibility with various heating cables and order references, refer to tables 2–8 (pages 4–10). The preferred solution to join two heating cables includes a short section of cold lead joined between the two MI heating cables using two hot/cold joints. Contact Chemelex for more information.

### SJK-F

Ferrules (copper) for reliable connection of MI conductors in hot/cold joints. For more details such as compatibility with various heating cables and order references, refer to tables 2–8 (pages 4–10).

### SPOT..-PILOT

End cap for termination of dual conductor MI heating cables. Universal joints have a pilot hole that must be drilled to match the exact diameter of the heating cable during the termination operation. For more details such as compatibility with various heating cables and order references, refer to tables 6–7 (pages 8–9).

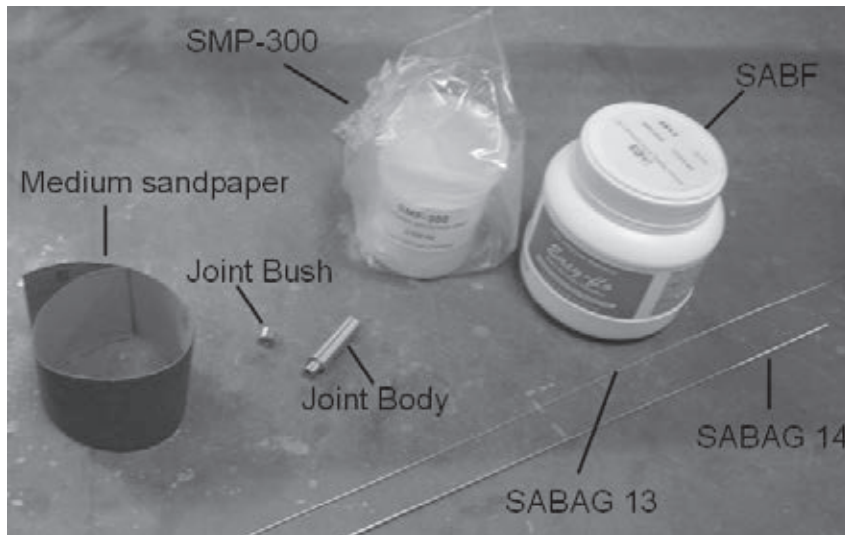


Figure 2.1 Parts Identification

### 1.12. Cross-section of completed joints

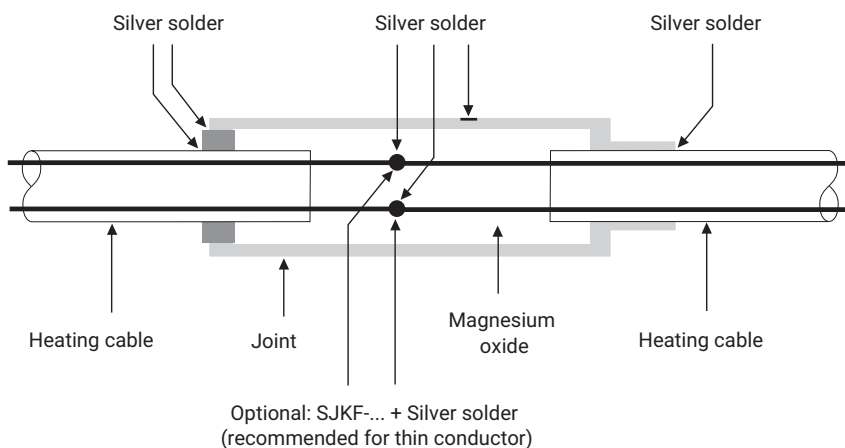


Figure 2.2 Completed heating cable/heating cable (hot-hot) joint for two conductor cable

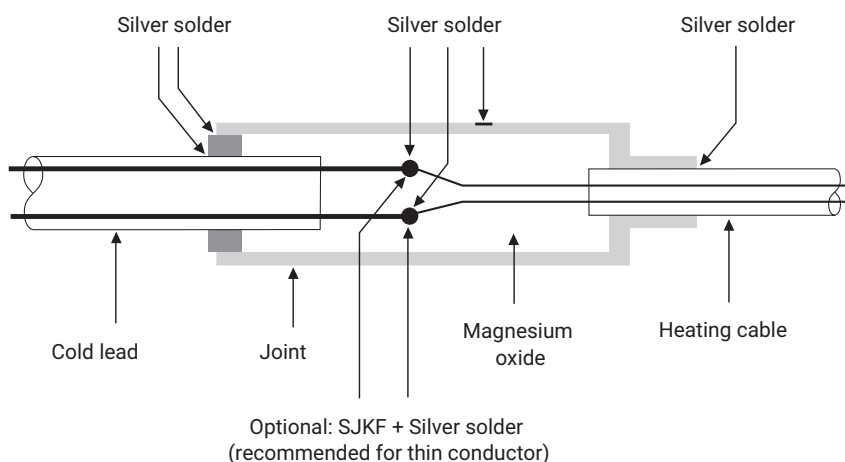


Figure 2.3 Completed heating cable/cold lead (hot-cold) joint for two conductor cable

### 1.13. Cross-section of completed end cap

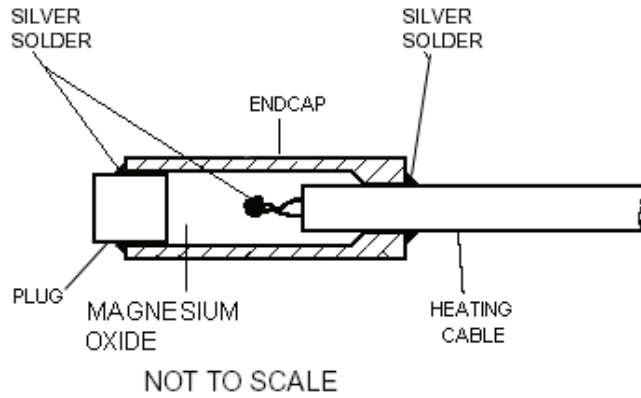


Figure 2.4 Completed end cap

## 2. HEATING UNIT REPAIR

### 2.1. General

Heating unit should be checked with an ohmmeter to ensure that it is within the specified resistance, +/- 10% of the unit's calculated resistance.

Calculated resistance = heated length x resistance/m of heating cable

Note: 'Resistance/m of heating cable' may be obtained from the product data sheets

Check continuity of both cables to be joined using the ohmmeter. If open circuited, do not attempt to fabricate joint. For two conductor heating cable, conductors on far end of cable may have to be shorted.

Check Insulation Resistance (Appendix B) of both cables to be joined with a 1000 volt d.c. megger; a value greater than 20MΩ is required. Chemelex recommends values in excess of 100MΩ. If satisfactory follow appropriated repair procedure to make a joint (section 2.4) or end cap (section 2.5), otherwise follow insulation drying procedure in Appendix C.

When silver soldering, avoid excessive heating of parts to be joined as this can lead to embrittlement of materials.

Once a joint or end cap repair has been started, it must be completed without interruptions. This will prevent the cable from absorbing moisture, lowering the Insulation Resistance.

### 2.2. Selecting the correct joint size

Use a vernier calliper or micrometer to measure the outside diameter of the heating cable and cold lead and select the correct size and type (stainless steel or brass) joint from Table 3.1. If the heating cable is polymer jacketed, strip back the jacket and measure diameter across the copper sheath.

In case of using pilot joints, fix the parts to be drilled tightly and use an automated drilling machine to enlarge the diameter of the joint and / or bush and / or end cap to the appropriate size. Drill the holes to a diameter of maximum 0.1mm larger than the measured size and ensure that the drilled holes are properly centered. Non proper centered holes will lead to uneven wall thicknesses of the different parts and could result in cable failures.

Make sure to respect the allowed diameter limitations as indicated in table 3.1 and 3.2 below. Refer to DOC-606 to find predrilled versions and conductor connectors.

Table 2.3 : Selecting joint size for type B,D, and E heating units. Use Brass joints with Copper and Cupro-Nickel sheathed MI heating cables. Use Stainless Steel joints with Stainless Steel, Inconel 600 and Alloy 825 (single and dual conductor) sheathed MI heating cables

DIAMETER FOR HEATING CABLE SIDE (LONG JOINT BODY)		DIAMETER FOR COLD LEAD / HEATING CABLE SIDE (SMALL JOINT BUSH)		JOINT SELECTION	MAX. WITHSTAND TEMPERATURE
MIN. CABLE DIAMETER	MAX. CABLE DIAMETER	MIN. CABLE DIAMETER	MAX. CABLE DIAMETER	MATERIAL	DESCRIPTION (PACK OF 10 SETS)
2.8 mm	5.4 mm	2.8 mm	5.4 mm	STAINLESS STEEL	SJKAS-PILOT-A-PACK 450° C
3.7 mm	7.9 mm	2.8 mm	7.9 mm	STAINLESS STEEL	SJKAS-PILOT-B-PACK 450° C
5.3 mm	9.1 mm	2.8 mm	10.9 mm	STAINLESS STEEL	SJKAS-PILOT-C2-PACK 450° C
2.8 mm	5.7 mm	2.8 mm	10.9 mm	STAINLESS STEEL	SJKAS-PILOT-C3-PACK 450° C
2.8 mm	5.4 mm	2.8 mm	5.4 mm	BRASS	SJK-PILOT-A-PACK 400° C
3.7 mm	7.2 mm	2.8 mm	7.9 mm	BRASS	SJK-PILOT-B-PACK 400° C
5.3 mm	9.1 mm	2.8 mm	10.9 mm	BRASS	SJK-PILOT-C2-PACK 400° C
2.8 mm	5.7 mm	2.8 mm	10.9 mm	BRASS	SJK-PILOT-C3-PACK 400° C

Note: For more Options (such as predrilled versions, brass versions and conductor connector) refer to DOC-606.

### 2.3. Selecting the end cap and plug

TABLE 2.3. Selecting end cap for type D units

MIN. HEATING CABLE DIAMETER	MAX. HEATING CABLE DIAMETER	DESCRIPTION	ARTICLENUMBER
3.0 mm	8.2 mm	SPOTAS-A-PACK	1235-27209001

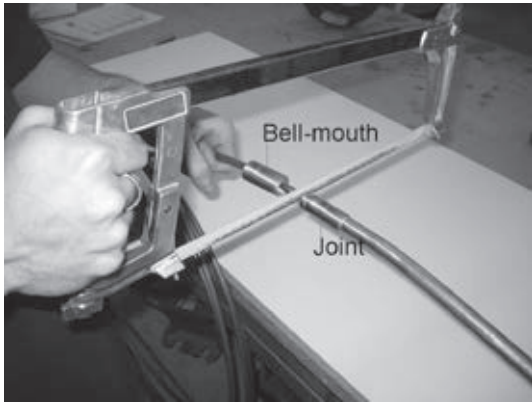
### 2.4. Joining type B, D and E Units



- The instructions following apply to both hot-hot joints and hot-cold joints.
- The hot-hot joint joins heating cable to heating cable while a hot-cold joint joins heating cable to a non-heating cold lead.
- Read these instructions completely before attempting to complete the repair 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.

Expose heating cable and/or cold lead so that 500 mm on either side of the failure point is accessible.



If replacing an old joint, remove joint by cutting through cable with a hacksaw as close as possible to the solder on the old joint. It is not necessary to reuse the bell-mouth, but when re-installing the joint on a pipe, care must be taken not to bend the cables at the joint as this will break the new weld (see Installation Instruction Manual - DOC-586 - available from our web site, [www.Chemelex.com](http://www.Chemelex.com), for installation details). If the bell-mouth is to be reused, heat the bell-mouth (if used) with the torch and use pliers to remove it, but do not remove it from the heating cable.

**Note:** If the resistance of a heating unit is altered by more than 5% from its original design value a new identification 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" (100mm) to allow access when brazing.



If heating cable and/or cold lead are polymer jacketed, remove existing heat shrink tubing and strip back 6" (150mm) of the jacket from each end as shown, taking care not to nick or damage the copper sheath.



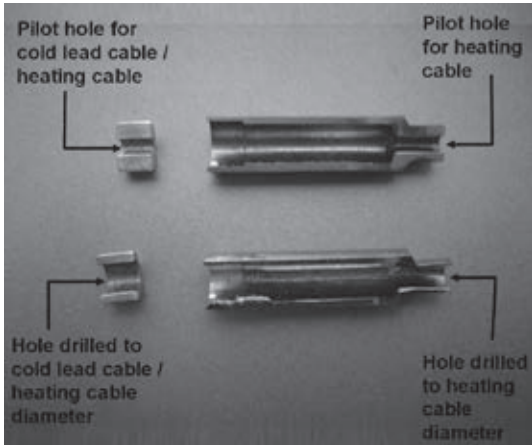
Strip Cable according to Stripping procedure in Appendix F.

Check the insulation resistance (IR) and continuity before proceeding (see Appendix B for details on testing). An IR reading greater than 20M $\Omega$  is required. Chemelex recommends values in excess of 100M $\Omega$ . If the IR is lower, refer to Appendix C and follow drying out procedure.



Using a vernier calliper (or micrometer), measure the outside diameter of the heating cable and/or cold lead (not including polymer jacket) and select the correct size from Table 3.1.

**Note:** If repairing or replacing the hot/cold joint, both the heating cable and cold lead diameters must be considered when choosing the correct size joint from Table 3.1.



**Hot-hot joint:** Select a drill bit to drill a hole max. 0,1mm larger than the cable diameter measured above. 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 fill hole is tapped.

**Hot-cold joint:** Select the drill bits to drill a hole max. 0,1mm larger than the cable diameters measured above. Using the pilot hole as a guide, drill a hole straight through the joint with the smaller diameter drill. Using the larger drill, drill the cold lead end of the joint about 6mm to 9mm past the fill hole. Check the joint to ensure there are no burrs inside and verify that fill hole is tapped.



**Hot-hot joint:** Ensure the end of each heating cable is straight for approximately 300mm.

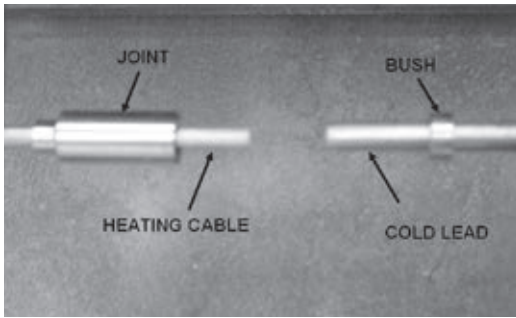
**Hot-cold joint:** Ensure the ends of the heating cable and cold lead are straight for approximately 300mm. File the face of the cold lead square using a flat file (end of conductor(s) should be clean). It is not necessary to file the face of heating cable square.



If heating cable and/or cold lead are polymer jacketed, slide 175mm lengths of heat shrinkable tubing (not provided) onto the end of each cable and move them away from the ends; place a 100mm length of heat shrink tubing on one of the ends and slide it also back. See Appendix E for sizes required and final positioning.



Using emery cloth, polish the end (approx. 50mm) of each cable to remove any oxidization. The surface must be clean for soldering.



**Hot-hot joint:** Slide the joint over the end of one heating cable and slide the bush over the other end.

**Hot-cold joint:** Slide the joint over the heating cable (smaller diameter cable) ensuring the larger hole faces the cold lead as shown in the illustration.

Slide the cable bush over the cold lead-in cable.



**Hot-hot joint:** Using the tube cutter, lightly score each end of the heating cable sheath approximately 5mm from the end of the cable as shown in the illustration. With the diagonal cutters, remove the sheath up to the score mark. See notes below.

**Hot-cold joint:** Using the tube cutter, score the cold lead sheath approximately 6 mm from the end of the cold lead. With the diagonal cutters remove the sheath up to the score mark.

Using diagonal cutters strip back the sheath of the heating cable (without the aid of the tube cutter or only lightly scored) approximately 6mm.

**Note:** Do not cut too deep with the tube cutter as this will cause the sheath to be pushed inwards where it could damage, or short, the conductors.

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



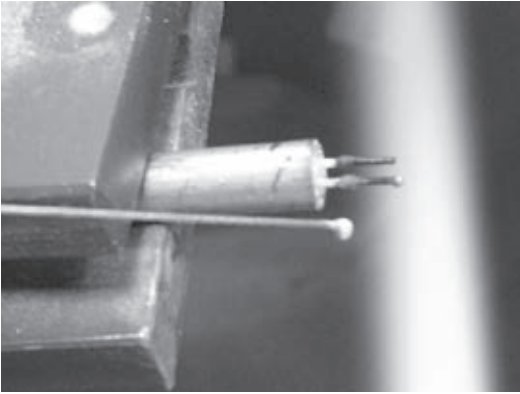
**Hot-hot joint:** Ensure that the joint and bush are drilled to max 0,1mm more than heating cable diameter and that they easily slide over both sides of the heating cable. The sheath could be flared slightly outwards and may need to be touched up with a flat file or emery cloth to allow the joint to slide over it.

**Hot-cold joint:** Ensure that the joint is drilled to max 0,1mm more than heating cable diameter and slides easily over the heating cable. Ensure that the bush is drilled to max 0,1mm more than cold lead diameter and slides over the end of the cold lead. The sheath could be flared slightly outwards and may need to be touched up with a flat file or emery cloth to allow the joint to slide over it. It is not necessary to remove the flare from the heating cable end.



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

**Note:** Do not clean the magnesium oxide from the cold lead conductors as silver solder is applied only to the face of the conductor. Contact Chemelex when using ferrules.



Heat the end of the SABAG13 brazing rod and coat it with SABF flux. **Hot-hot joint:** Using oxy-acetylene torch, heat conductor with a small flame (see Appendix D) and touch or wipe the brazing rod onto the tip of the conductor by turning the rod between the fingers. This will ensure that the SABF flux melts off the rod and onto the conductor evenly. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder.

Continue heating conductor with the oxy-acetylene torch (this does not take much heat) and at the same time touch the SABAG13 brazing rod to the end of the conductor and apply enough solder to 'tin' the end of the conductor. Repeat for remaining conductors on both cables to be joined.

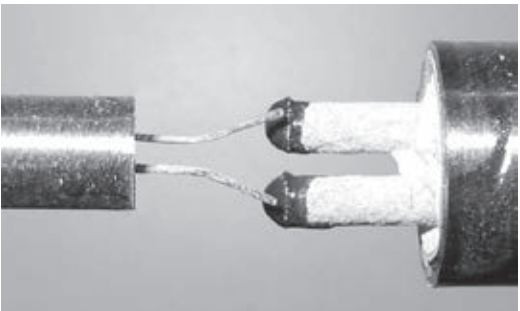
**Note:** If repairing a two conductor cable, bend the two conductors of the heating cable into a 'Y' shape to accommodate the distance apart of the cold lead conductors



**Hot-cold joint:** Using oxy-acetylene torch, apply heat to the centre of the cold lead conductor with a small flame (see Appendix D) and touch or wipe the SABAG13 brazing rod onto the face of the conductor by turning the rod between the fingers. This will ensure that the SABF flux melts off the rod and onto the conductor evenly. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder.

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

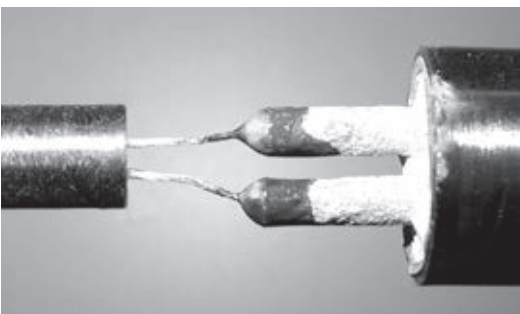
'Tin' the heating cable conductors using the procedure above for hot-hot joint.



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



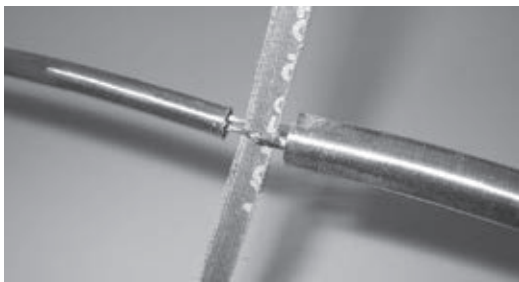
**Hot-cold joint:** Align the two cables so that the conductor tips butt together and heat the larger (cold lead) conductors, one at a time, so that the solder on the tip melts, then push the smaller (heating cable) conductor into the solder (see illustrations). **Do not add any more solder.** Remove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



**Hot-hot joint:** Ensure that the solder junction is the same diameter as the heating cable conductor. If not, the solder is still cold and you must apply more heat (or start over).

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

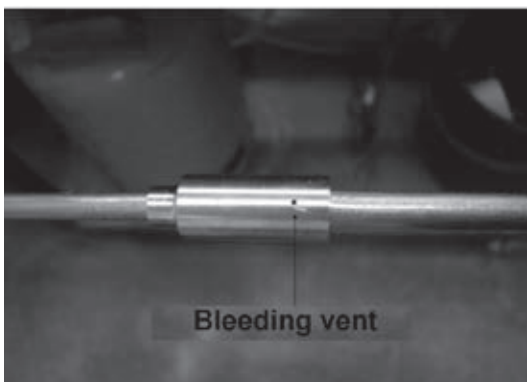
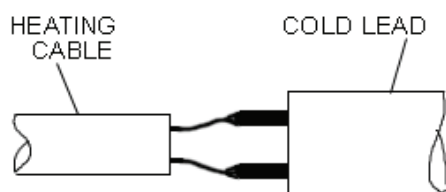
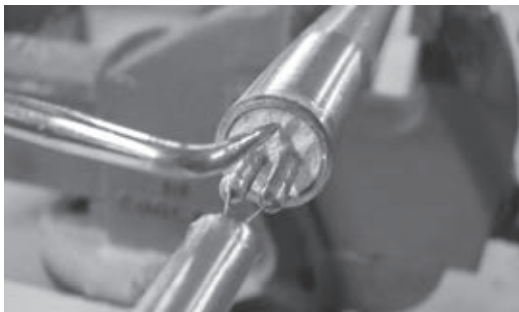
**Note:** If insufficient heat is applied to the conductors, the soldered junction may be surrounded by the ball of solder but not actually bonded and an open circuit failure will occur.



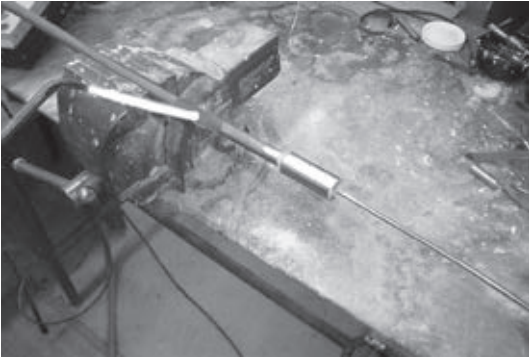
Remove all trace of flux from the conductors with the emery cloth. Straighten the conductors with needle nose pliers such that the conductors will be as far from the inside joint wall as possible. Use a pick to remove any flux or carbon which may have contaminated the magnesium oxide powder at the ends of each cable.

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

**Hot-cold joint:** For two conductor cable, conductors from cold lead to the heating cable should be formed as shown in illustration.



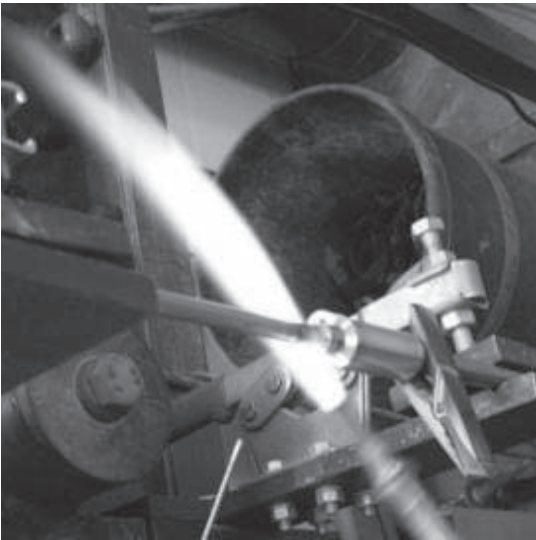
Slide the joint over the exposed conductors, ensuring that the bleeding vent faces up and is centred over the conductor junction.



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

Using a large 'sizzling' flame (see Appendix D), 'heat out' the moisture from the cable beginning 300mm back from the joint (begin 150mm back for polymer jacketed cable), stopping 13mm from the joint. Repeat procedure for cable on other side of joint. Immediately proceed to next step.

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



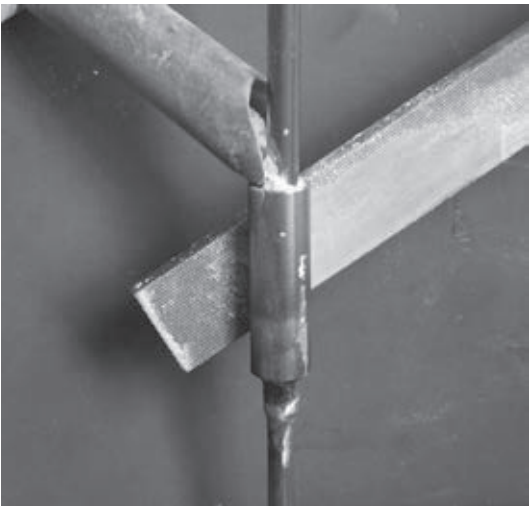
If making a hot-cold joint, solder the heating cable side of the joint first. ). If making a hot-hot joint, also solder the joint first (not the bush).

Reduce 'sizzling' flame to a large flame (see Appendix D). Using SABF flux, coat the SABAG14 brazing rod and with a touching or wiping motion of brazing rod, apply flux around end where the joint will be brazed to the cable sheath. Turning the rod between the fingers will ensure that the flux melts off the rod and onto the joint evenly. Ensure that the flux is applied around the entire junction.

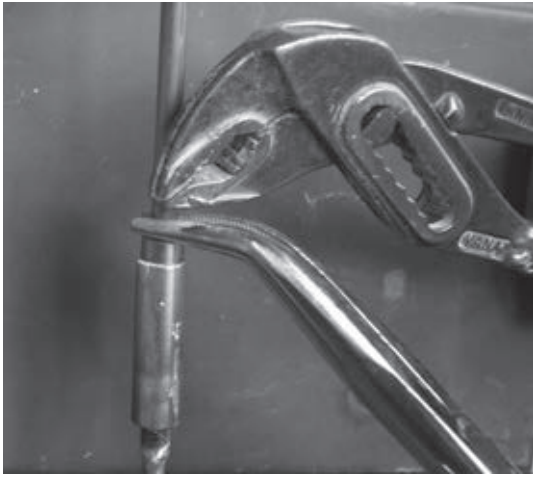
Heat the joint and heating cable sheath with a large flame. When the area to be soldered is up to temperature, deposit a large bead of silver solder on the top part of the area to be joined. Apply heat to both the joint and the cable and move the flame slowly around the circumference of the joint. This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

Repeat procedure for other side of joint so that the weld makes the full circumference of the joint.

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



While joint is still hot, fill the joint body with MgO. Gently tap the joint to evenly distribute the powder and completely fill the joint. Remove syringe (if the powder is provided in syringe) and use a small diameter packing rod to pack powder, taking care not to push in more than 3mm so as not to bend the conductors inside the joint. If required, add more powder to fill joint and repeat packing procedure. **CAUTION: Joint will be hot. Do not touch joint or cable with bare hands.**



When the joint is full and packed, the bush on the cable is tapped into the joint body to compress the MgO

Compress the powder until the bush rests in the recess in the joint body. The end of the bush should be visible over approximately 1 mm length, the rest of the bush must be embedded in the joint body.



Making a hot-cold joint cold lead-in cable, the joint is kept in the vertical position.

Using a large flame (see Appendix D). Using the SABF flux, coat on the SABAG14 brazing rod and with a touching or wiping motion of brazing rod, apply flux around the joint bush and lead-in cable sheath. Turning the rod between the fingers will ensure that the flux melts off the rod and onto the joint bush evenly. Ensure that the flux is applied around the entire junction.

Heat the joint bush and heating cable sheath with a large flame. When the area to be soldered is up to temperature, deposit a large bead of silver solder on the area to be joined. Apply heat to both the joint bush and the cable and move the flame slowly around the circumference of the joint. This will cause the solder to 'wick' its way around the joining area and also draw the solder inside the joint making a stronger weld. Add more solder as needed. Ensure a continuous weld around the entire joint. Repeat the same procedure to weld the joint bush to the joint.

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



Check the insulation resistance (IR) of the heating unit at this point using a 1000 volt megger (see Appendix B for details on testing). This test checks for the presence of moisture in the magnesium oxide insulation. A value greater than 20 MΩ should be attained (greater than 100MΩ is preferred). If the IR is lower, remove the moisture from the cable by following the 'drying out' procedure in Appendix C. Repeat IR test.



This final 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 solder.

Using oxy-acetylene torch with a small flame, heat joint and apply a small amount of SABF flux, using the SABAG14 brazing rod, over the bleeding vent hole. Continue heating until the silver solder flows freely when touched to the joint, completely filling recessed area; then remove the heat.



Use the emery cloth to clean flux from each solder joint and visually inspect to ensure that there are no pinholes or gaps which could allow moisture to enter. Ensure that all flux is removed from all soldered areas.

Touch up pinholes as necessary by cleaning the area and applying more solder.

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



Again, test the insulation resistance with a 1000 volt megger. Minimum IR should be 20 MΩ (greater than 100MΩ is preferred). With Megger still connected, reheat joint, but not hot enough to discolour the metal. Quench with a rag soaked in water by wrapping it tightly around the joint. Leave on for 4 to 5 minutes. If there are any remaining pinholes, moisture will be absorbed into the joint as it cools and the reading on the megger will drop.

**Note:** If the megger reading declines, file off all solder from over the vent hole and drive out the moisture from the cable as described in Appendix C; the Megger reading will increase when the cable is dry. Once the moisture is removed, touch up the solder as necessary and retest. If still low, replace joint.

**CAUTION: JOINT WILL BE HOT. DO NOT TOUCH JOINT OR CABLE WITH BARE HANDS.**



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

If repairing a hot-cold joint and reusing the bell-mouth, place a few drops of a suitable retaining compound (such as Loctite® 648) on the inside of the bell-mouth, slide it onto the new joint and let set. If heat shrink tubing was used above, follow instructions in Appendix E to complete heat shrink installation.

Expose heating cable such that approximately 500mm of cable and end cap is exposed to work with.

## 2.5 End Cap Procedure



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

**Note:** If the resistance of a heating unit is altered by more than 5% from its original design value a new identification 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 100mm to allow access when brazing.



If heating cable is polymer jacketed, strip back 150mm of the jacket as shown, taking care not to nick or damage the copper sheath.

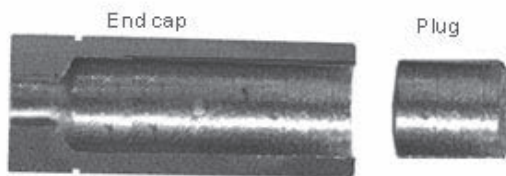


Strip Cable according to Stripping procedure in Appendix F.

Check the insulation resistance (IR) and continuity before proceeding (see Appendix B for details on testing). An IR reading greater than 20MΩ should be obtained (greater than 100MΩ is preferred). If the IR is lower, refer to Appendix C and follow drying out procedure



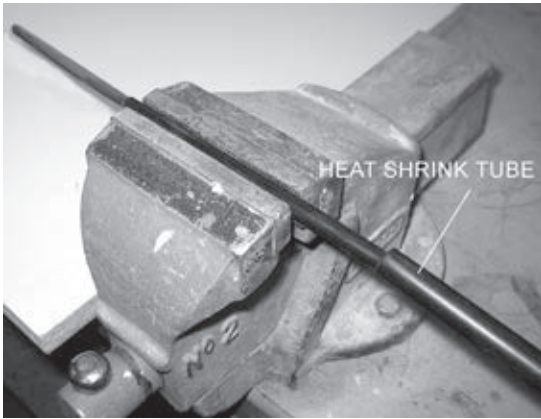
Using a vernier calliper (or micrometer), measure the outside diameter of the heating cable (not including polymer jacket) and select the stainless steel end cap and plug for Alloy 825 sheath cables (Table 3.2).



Select the drill bits to drill a hole max. 0,1mm larger than the cable diameters measured above. Drill a hole straight through the end cap using the pilot hole (smaller hole) as a guide, and check it for burrs.



Polish the end (about 50mm) of the sheath with emery cloth.



If heating cable is polymer jacketed, slide heat shrinkable tubing (not provided) onto the cable and move it away from the end. See Appendix E for sizes required.



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

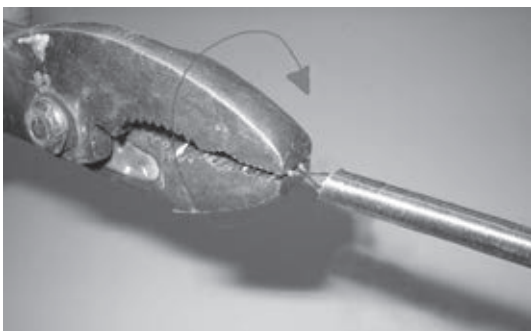


Using side cutters, strip the sheath back about 9mm – 13mm taking care to flare the sheath of the cable slightly outward.

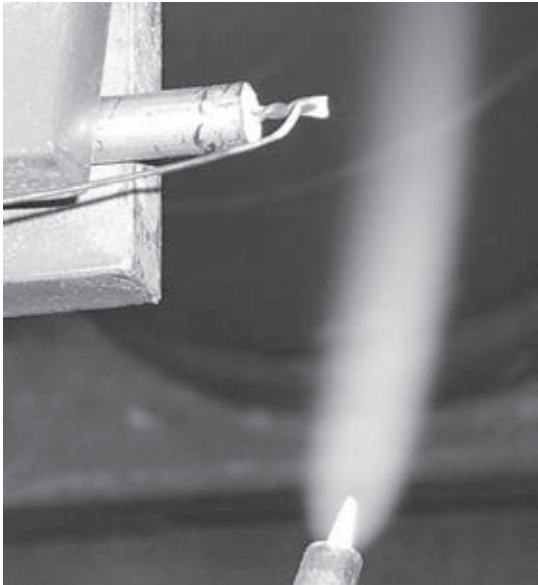
**Note:** See Appendix F for detailed instructions on stripping cable sheath.



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



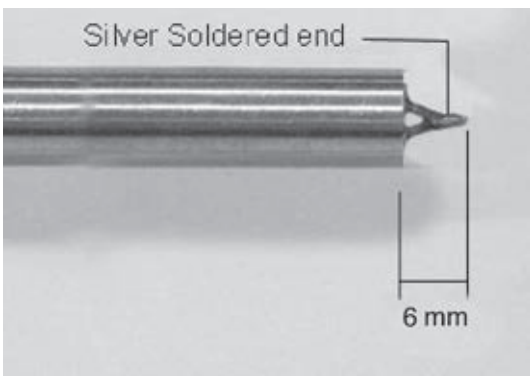
Using pliers, twist conductors together through approximately two full 360° turns.



Using oxy-acetylene torch with a small flame, heat the twisted conductors and apply a small amount of SABF flux, using the SABAG13 brazing rod. Ensure that there is an even coating of SABF flux on the conductors. Take care not to get any flux near the end of the cable where it might contaminate the magnesium oxide powder. Continue heating until the silver solder flows freely when touched to the conductors and apply enough SABAG13 to form a small bead.

Slightly 'fan' torch back and forth several times to draw the silver solder backwards, about 6mm, along the twisted conductors. Remove heat.

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



Break away the flux from the solder and snip off the end of the conductors leaving 6mm exposed.



Use a pick to remove any flux or carbon which may have contaminated the magnesium oxide powder.

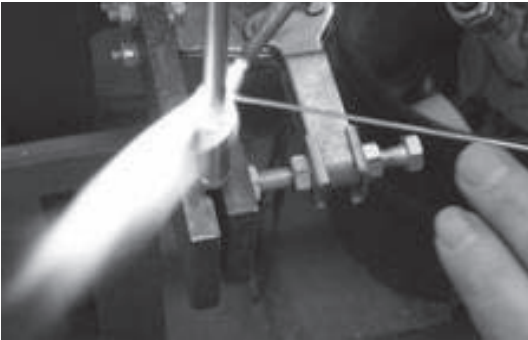


Slide the end cap as far forward as possible (the flare on the cable sheath will stop it), then back it up 5 mm to ensure proper placement of the heating cable in the end cap (see cross section).



You are now ready to solder the end cap to the cable sheath. Using a large 'sizzling' flame (see Appendix D), 'heat out' the moisture from the cable beginning 300mm back from the end cap (begin 150mm back for polymer jacketed cable), stopping 13mm from the end cap. Immediately proceed to next step.

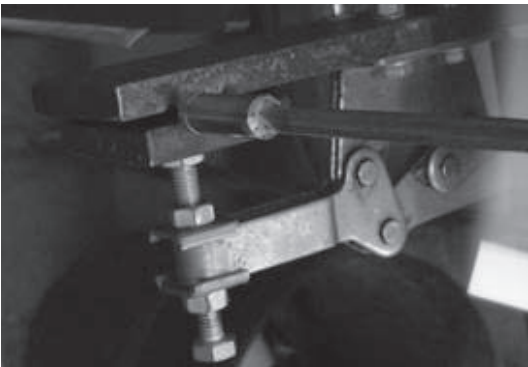
**Note:** Details on 'heating out' (drying out) the cable may be found in Appendix C.



Reduce 'sizzling' flame to a large flame (see Appendix D). Using SABF flux, coat the SABAG14 brazing rod and with a touching or wiping motion of brazing rod, apply flux around end where the end cap will be brazed to the cable sheath. Turning the rod between the fingers will ensure that the flux melts off the rod and onto the joint evenly. Ensure that the flux is applied around the entire junction.

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

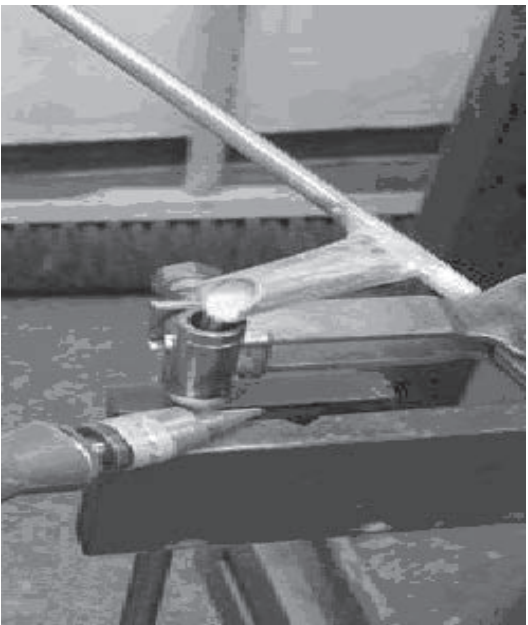
**Note:** While soldering, it is important to avoid using excess heat on the portion to be soldered. Direct flame contact can oxidize the metal surface, preventing the solder from adhering to the metal. Care must also be taken not to overheat the end cap, which can cause the conductor joint (junction)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



Reposition end cap facing upwards.

While end cap is still hot, fill end cap to approximately 5mm below the end of the cap opening while gently tapping the side of the end cap to compress magnesium oxide powder.

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





Insert the plug and gently tap it down.



Check the insulation resistance (IR) of the heating unit at this point using a 1000 volt megger (see Appendix B for details on testing). This test checks for the presence of moisture in the magnesium oxide insulation. A value greater than 20 M $\Omega$  should be attained (greater than 100M $\Omega$  is preferred). If the IR is lower, remove the moisture from the cable by following the 'drying out' procedure in Appendix C. Repeat IR test.



Using oxy-acetylene torch with a large flame, apply heat to the end cap sweeping, with flame, from the bottom to the top of end cap 4 to 5 times. This will aid in removing any moisture trapped in the powder. Continue, heating the top of the plug, and using SABF flux, coat the end of the SABAG14 brazing rod, apply flux around area where the plug will be joined to the end cap. Ensure that the flux is applied around the entire junction and solder the plug to the end cap using the technique above.

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



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



Again, test the insulation resistance with a 1000 volt megger. Minimum IR should be 20 M $\Omega$  (greater than 100M $\Omega$  is preferred) . Clean end cap to remove all flux. Gently reheat end cap but not hot enough to discolour the metal. With Megger still connected, quench with a rag soaked in water by wrapping it tightly around the joint. Leave on for 4 to 5 minutes. If there are any remaining pinholes, moisture will be absorbed into the end cap as it cools and the reading on the megger will drop.

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

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

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

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If heat shrink tubing was used above, follow instructions in Appendix E to complete heat shrink installation.

# Appendix A: MI Heating Cable Field Modification Approval Request Form



## MI HEATING CABLE FIELD MODIFICATION APPROVAL REQUEST FORM

Caution: For field modifications, where the resistance of a heating unit is altered by more than 5% from its original design value, the change must be reviewed by Chemelex and a new cable identification tag must be ordered.

Please fill in this form and fax to +49 6221 3043 43.

Chemelex will review the change and advise if the modification is appropriate.

### Sender Information

Contact name:	Company:
Address:	Telephone:
	Fax:
	Email:
Ship to address for 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 identification tag attached to the cold lead. // = Do NOT fill in this area

	Original Tag Information	New Tag Information	For Internal Use Only
Batchnumber		////////////////////////////////////	
Order No		////////////////////////////////////	
Maximum Withstand Temperature			
MI Unit Reference			
Element Length	Meter	Meter	
Output Power @ maintain temperature	@ Watt °C	@ Watt °C	
Volts			
Cold Lead Length	Meter	Meter	
Maintain Temp (°C)			

Additional information required if cable is used in Hazardous Locations			
Design Temperature Class		////////////////////////////////////	
Design Method		////////////////////////////////////	
Max. Sheath Temp.		////////////////////////////////////	
Sheath Reference Temp.		////////////////////////////////////	

### For Internal Use Only

Cable Manufacture Review:			
	Print name	Signature	Date
Tag Part No.			
Sales Order No.			
If you have any questions regarding this form, please contact Chemelex tel.: ++49 6221 3043 0.			

## Appendix B: Heating Unit Testing

### Testing:

A 1000 volt dc insulation tester (Megger™) is used to check insulation resistance. A reading greater than 20 MΩ should be obtained when testing the insulation resistance between the conductors (tails) and the cable sheath (greater than 100MΩ is preferred). A digital multi-meter or ohmmeter is used to check the continuity. To ensure that the joint is waterproof it may be submerged in water for approximately 24 hours. This treatment will remove soldering flux from possible pin holes in the solder, thereby, revealing a moisture leak which might not otherwise show up for some time. If this is not practical, a damp cloth should be wrapped around the joint while it is still hot - this procedure is used in the installation instructions for both the joint and end cap. If there is any decrease in insulation resistance the joint/end cap should be cut out and a new one made. 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 joint/end cap.

### Test Equipment:

Insulation Resistance Test: 1000 V dc Megger

Continuity Test: Digital Multi-meter (DMM)

### Insulation Resistance (Megger) Test – Test 1:

Insulation resistance is measured between the heating cable sheath and the tails. Chemelex recommends that insulation resistance testing (using a Megger) be conducted at a 1000 Vdc.

Test Criteria: The minimum insulation resistance for a clean, dry, properly installed joint should be 20 MΩ (greater than 100MΩ is preferred).

### Continuity (Resistance) Test – Test 2:

Continuity testing is conducted using a Digital Multi-meter (DMM) and measures the resistance between the cold lead tails.

Test Criteria: Measure the resistance of the MI heating unit with the DMM. Most MI heating unit resistances are less than 100 ohms. If the heating cable length has not been altered, the approximate resistance can be calculated using the formula:

$$\text{Resistance (ohms)} = \text{Volts}^2 / \text{Watts}.$$

Voltage and wattage can be found on the heating cable identification tag.

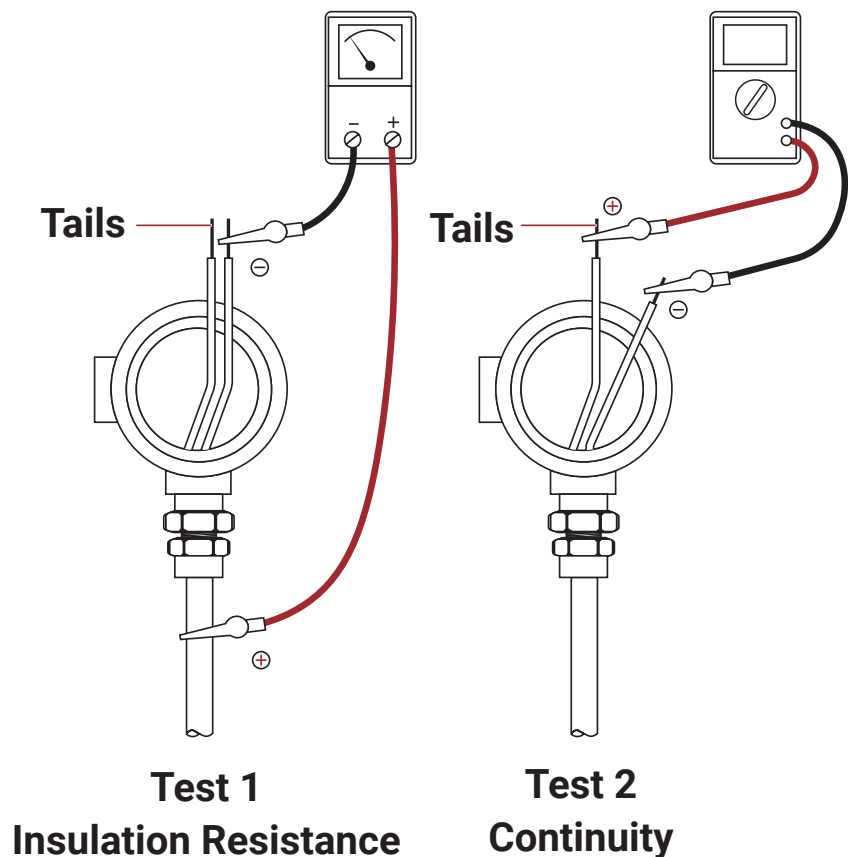
**Note:** This measured value is the resistance at the ambient air temperature; the calculated value is the resistance at the operating temperature and may be higher than the measured value.

## Test Procedures

### Insulation Resistance and Continuity Test

1. De-energize the circuit.
2. Disconnect the temperature controller or thermostat if installed.
3. Disconnect tails from terminal block, if installed.
4. Set Megger test voltage at 0 V DC.
5. Connect the positive (+) (earth) lead to the heating cable sheath.
6. Connect the negative (-) (line) lead to both heating cable tails simultaneously.
7. Turn on the Megger 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 M $\Omega$ . (greater than 100M $\Omega$  is preferred)
8. Turn off the Megger.
9. If the Megger does not self-discharge, discharge phase connection to ground with a suitable grounding rod. Disconnect the Megger.
10. Using the multi-meter, check the continuity (resistance) of the heating unit between the two tails. Note the resistance value and compare to the calculated value.
11. Disconnect the multi-meter.
12. Reconnect heating unit and temperature controller or thermostat once repairs are completed.

**WARNING:** Fire hazard in hazardous locations. Megger tests can produce sparks. Be sure there are no flammable vapours in the area before performing this test. Check if hot work permit is required.



## Appendix C: Drying out (heating out) procedure

This procedure is used to remove moisture from the magnesium oxide insulation.

If moisture is detected in the cable, use the oxy-acetylene torch with a large 'sizzling' flame (Appendix D) and dry out the cable beginning 300mm back from the joint or end cap (heat cold lead first if making a hot-cold joint). If repairing polymer jacketed heating cable and/or cold leads, begin 150mm back from the joint or end cap to avoid melting the polymer jacket. Alloy 825 sheath cable should be heated to a dull red colour and copper sheath cables should be heated to a bluish-grey colour.

Use a short sweeping motion of the torch and heat about 50mm of cable at a time, repeating 4 to 5 times. Stroke the flame towards the joint or end cap as shown in Fig D.1. Do not stroke the flame in the opposite direction as this will drive the moisture into the cable. Gradually move the flame toward the joint, while maintaining the short sweeping motion of the torch, stopping 1/2" (13mm) from the joint (Fig. D.2). If you heat toward the joint too quickly you may skip over the moisture and drive it further back into the cable.

The megger reading will initially decline, but will increase once the cable cools.

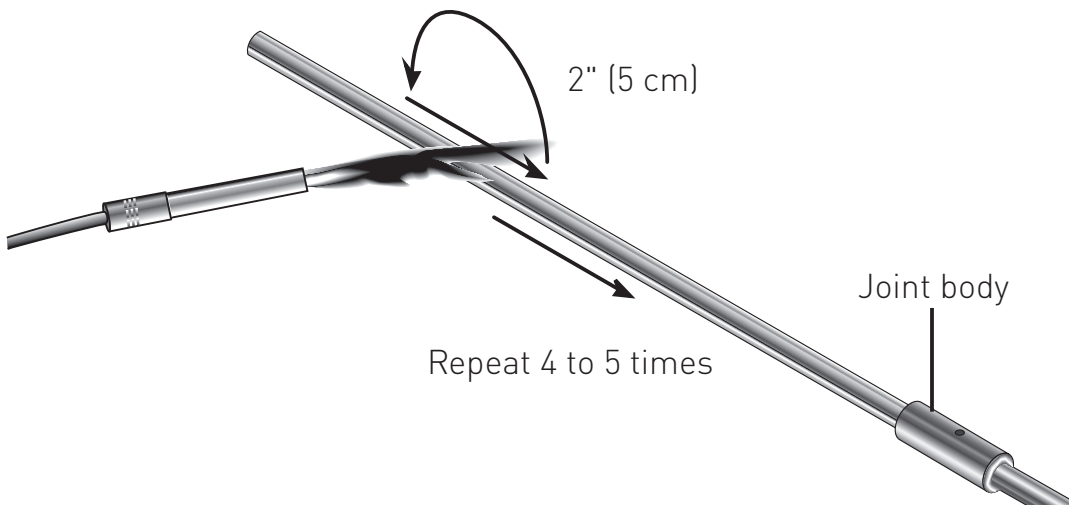


Figure D.1 Use sweeping motion of torch

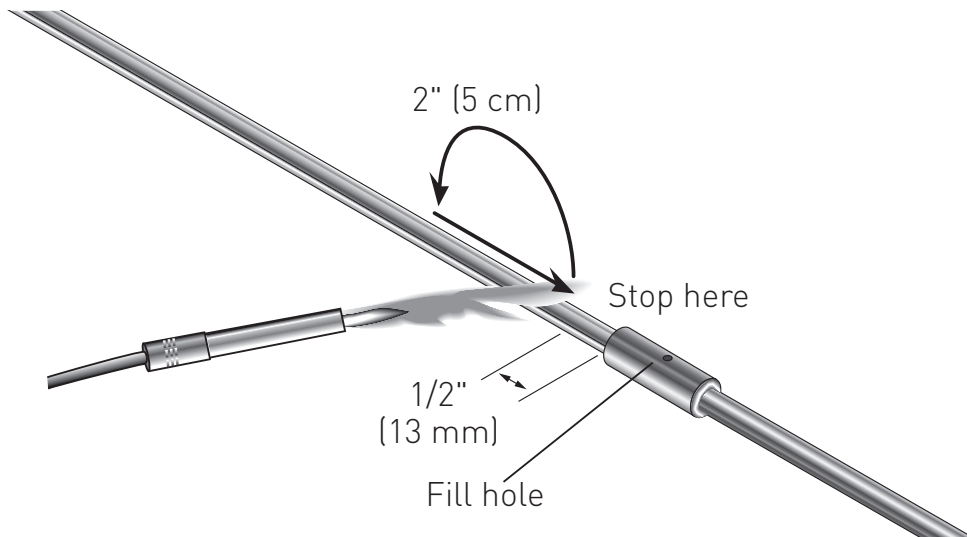


Figure D.2 Sweep flame to end stopping 13mm (1/2") from end of joint/end cap

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

## Appendix D: Flame size for Oxy-acetylene torch

### Small (oxidizing) flame

Use the small flame when soldering the conductors together.

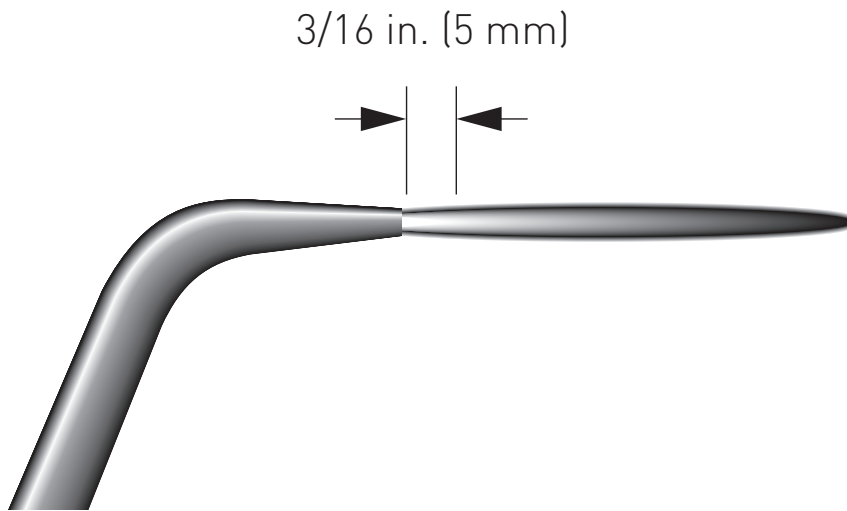


Figure E.1: Small (oxidizing) flame

### Large (neutral) flame

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



Figure E.2: Large (neutral) flame

### Sizzling (reducing/carbonizing) flame

Use the 'sizzling' flame to dry out the cable.

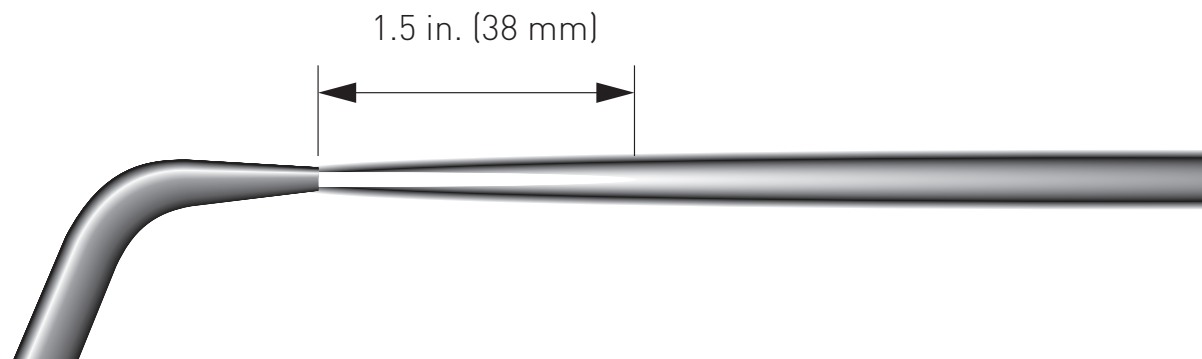


Figure E.3: Sizzling (reducing/carbonizing) flame

## Appendix E: Additional material required to repair polymer jacketed copper sheath cables

If repairing copper sheath heating cables and cold leads with an outer polymer jacket, several pieces of heat shrink tubing will be required.

If repairing or replacing a 1/2" joint:

- 2 pieces QPC19 3/8" dia. x 7" long heat shrink tube (4:1 shrink ratio)
- 1 piece QPC20 1/2" dia. x 4" long heat shrink tube (4:1 shrink ratio)

**Note:** use appropriate size shrink tube for 3/4" joint

Heat shrink is installed over completed joint as follows:

Slide 3/8" x 7" pieces of heat shrink tubing (previously installed) forward to completely cover bare copper sheath of cable. Using heat gun, shrink the tubing over the exposed copper (Fig F.1).

Slide 1/2" x 4" piece of heat shrink forward and centre over joint; heat shrink should overlap 3/8" x 7" heat shrink and ends of joint equally. Using heat gun, shrink the tubing over the joint (see Fig. F.2).

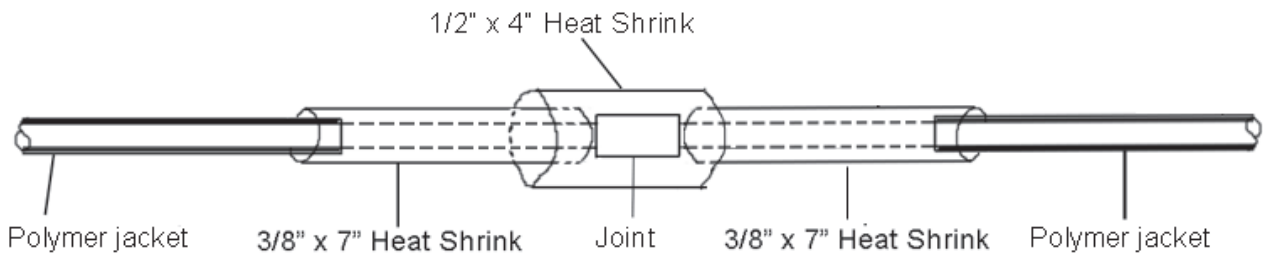


Fig. F.1 Heat shrink exposed copper heating cable

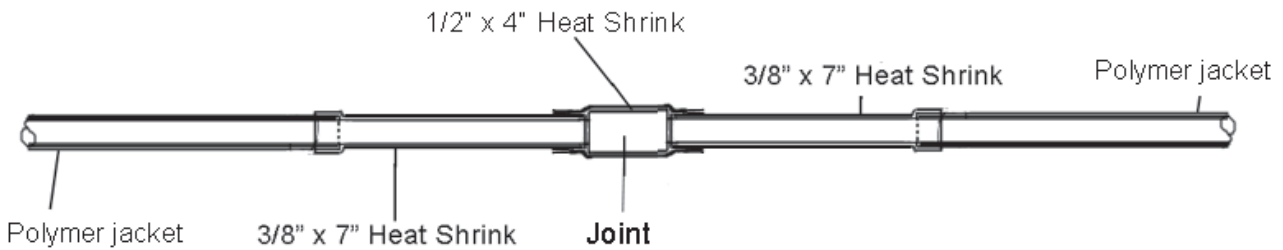


Fig. F.2 Completed joint with heat shrink seal

If repairing or replacing an end cap:

- 1 piece QPC19 3/8" dia. x 7" long heat shrink tube (4:1 shrink ratio)
- 1 piece QPC20 1/2" dia. x 4" long heat shrink tube (4:1 shrink ratio)

Heat shrink is installed over completed end cap as follows:

Slide 3/8" x 7" piece of heat shrink tubing (previously installed) forward to completely cover bare copper sheath cable. Using heat gun, shrink the tubing over the exposed copper (Fig. F.3).

Slide 1/2" x 4" piece of heat shrink forward and centre over end cap; heat shrink should overlap 3/8" x 7" heat shrink and ends of end cap equally. Using heat gun, shrink the tubing over the end cap. Use needle nose pliers to crimp section of tubing past end cap to form a seal as shown in Fig F.4.

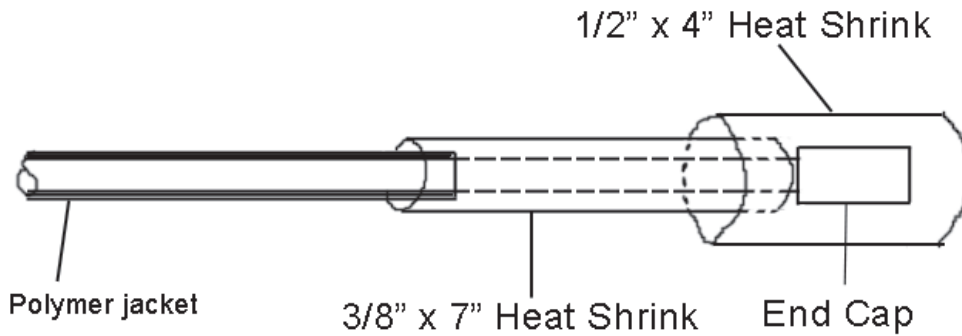


Fig. F.3 Heat shrink exposed copper heating cable

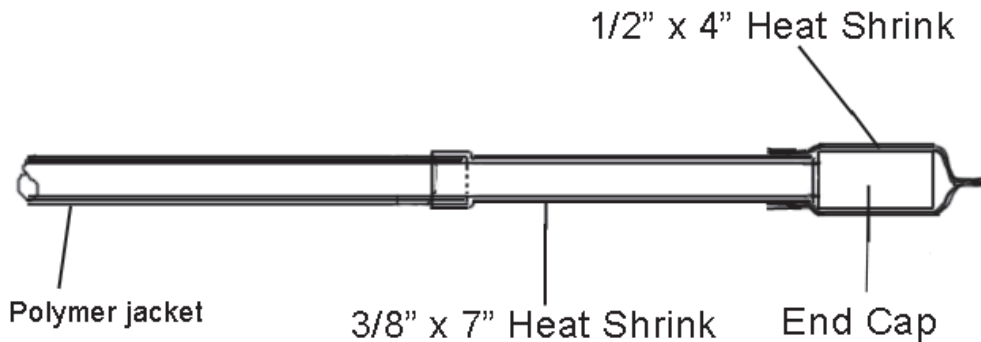
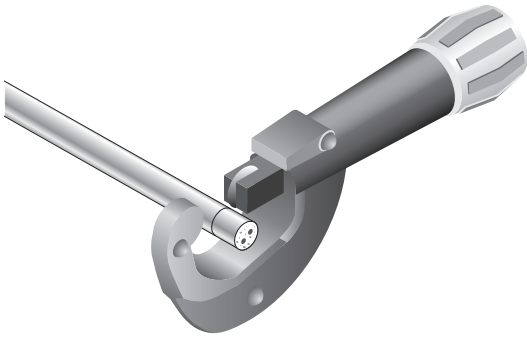


Fig. F.4 Completed end cap with heat shrink seal. Appendix F: Stripping the Cable Sheath

## Appendix F: Stripping the Cable Sheath

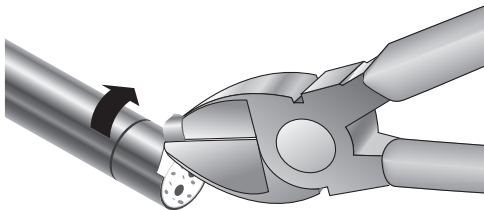
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Use a tube cutter (Chemelex ZR or similar) to score around the cable sheath the required length from the end. This will cause the sheath to peel away at the score providing a smooth end when the cable sheath is stripped. The correct depth of score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

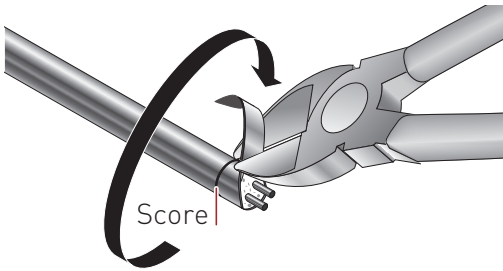
Note: Do not cut too deep with the tube cutter as this will cause the sheath to be pushed inwards towards the conductors, possibly resulting in cable failure.

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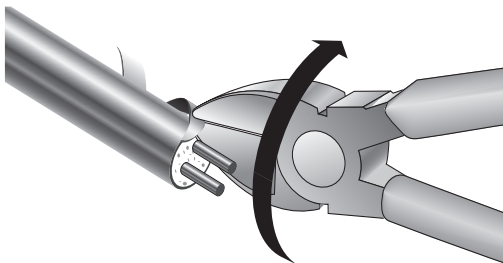
Grip the edge of the sheath between the jaws of the sidecutters edge cutter and twist clockwise, then take a new grip and rotate through a small angle.

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

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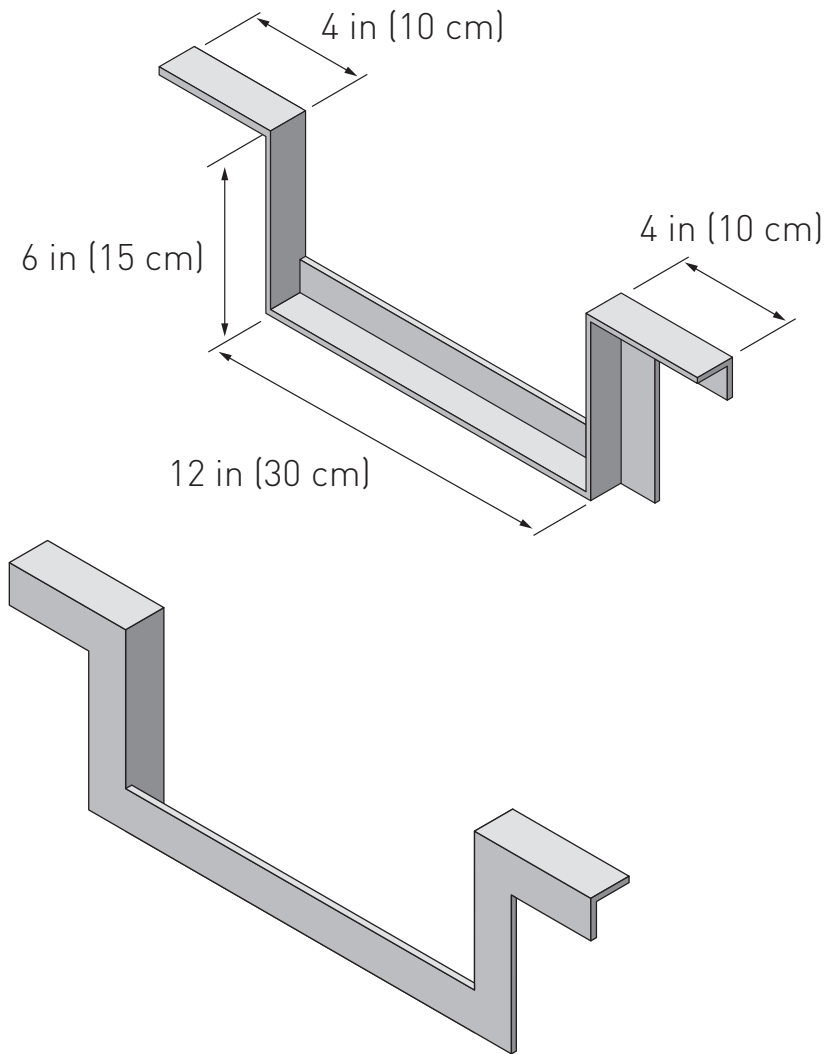


Continue removing the sheath to the score mark. When about to break into the score, bring sidecutters to right angle with cable. Finish off with point of sidecutters held parallel to the cable. The sheath will peel away leaving a clean cut when the score mark is reached. Ensure that the sheath is not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

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## Appendix G: Typical repair jig

Repair jig is made from angle iron welded to form shape as shown. Each cable is clamped to the hundred millimetres (100mm) upper surface and meet in the middle. If working on a pipe, middle section may be clamped to the pipe



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